3.4.4.2 Maximum Internal Pressure for the Canistered Fuel Configuration

The maximum internal operating pressure for the canistered fuel configuration is calculated for the canister and for the NAC-STC cavity. The calculated average temperature of the helium gas is 442°F based on the thermal analysis results using the 3-D canister model described in Section 3.4.1.2. The pressure calculation is conservatively based on an average temperature of 450°F.

The internal pressure is a function of rod-fill, fission and backfill gases. The design basis fuel assembly for the internal pressure calculation is the Combustion Engineering Type A assembly. This assembly has the highest rod back-fill pressure (315 psig) and received the highest burnup (36,000 MWd/MTU). There are three different gases contributing to the canister internal pressure and four gases contributing to the cavity internal pressure. The canister gases are the fuel rod back-fill and fission gases, and the canister backfill gas. The cavity gases are these plus the cavity backfill gas. All of the gases except the fission gases are assumed to be helium. The total pressure for each volume are found by calculating the molar quantity of each gas and summing those directly.

The number of moles of the backfill gases are calculated using the Ideal Gas Law, PV = NRT. Backfill gases for the canister and cavity are assumed to be initially at 1 atmosphere absolute. The quantity of fission gas is derived using $0.25 \frac{\text{Atoms of Gas}}{\text{Fission}}$ (Olander). The release of fission gas is as assumed for directly loaded fuel. For normal operating conditions, 3% of the fuel rods are assumed to fail, releasing 30% of their total fission gas and all of the backfill helium.

The fuel rod plenum volume is:

$$V_1 = \pi r^2 L - \frac{M_{Spring}}{r}$$

$$V_1 = \pi\left\{\left(\frac{0.317\ \text{inches}}{2}\right)^2 \times 1.942\ \text{inches}\right\} - \frac{\left(3.3\ \text{g} \times 2.2046 \times 10^{-3}\ \frac{\text{lb}}{\text{g}}\right)}{0.288\ \frac{\text{lb}}{\text{inch}^3}} = 0.1280\ \text{inches}^3$$

The pellet clad gap volume is

$$V_2 = \pi L\left(r^2_{Clad\ ID} - r^2_{Pellet\ OD}\right)$$

$$V_2 = \pi \times (91\ \text{inches}) \times \left(\frac{(0.317\ \text{inches})^2}{4} - \frac{(0.3105\ \text{inches})^2}{4}\right) = 0.2915\ \text{inches}^3$$

The fuel rod lower plenum volume is:

$$V_3 = \pi \times r^2_{Clad\ ID} \times L$$

$$V_3 = \pi \times \frac{(0.317\ \text{inches})^2}{4} \times 2.458\ \text{inches} = 0.1940\ \text{inches}^3$$

The total fuel rod backfill volume is:

$$V_{Rod\ Back\text{-}Fill} = V_1 + V_2 + V_3$$

$$V_{Rod\ Back\text{-}Fill} = 0.128\ \text{inches}^3 + 0.2915\ \text{inches}^3 + 0.194\ \text{inches}^3 = 0.6135\ \text{inches}^3$$

For the loaded canister the total backfill gas volume is:

$$0.6135\ \text{inches}^3 \times 231\ \frac{\text{rods}}{\text{assembly}} \times 36\ \frac{\text{assemblies}}{\text{Cask}} \times \left(2.54\ \frac{\text{cm}}{\text{inch}}\right)^3 \times \frac{0.001\ \ell}{\text{cm}^3} = 83.605\ \frac{\ell}{\text{Cask}}$$

From the rod back-fill volume and pressure the quantity of rod backfill gas is calculated using the ideal gas law:

$$N = \frac{Pv}{RT}$$

The volume of the bottom spacer is:

$$V_{Bottom\ Spacer} = \frac{\left(M_{Bottom\ Spacer} - M_{Bottom\ Spacer\ Honeycomb}\right)}{\Gamma_{Aluminum}} + \frac{M_{Bottom\ Spacer\ Honeycomb}}{\Gamma_{Honeycomb}}$$

$$V_{Bottom\ Spacer} = \frac{(350\ \text{lb} - 137.56\ \text{lb})}{0.098\ \frac{\text{lb}}{\text{in}^3}} + \frac{137.56\ \text{lb}}{0.0026\ \frac{\text{lb}}{\text{in}^3}}$$

$$V_{Bottom\ Spacer} = 55{,}075.45\ \text{inches}^3$$

The volume of the canister is:

$$V_{Canister} = \left(\pi \frac{\left(d_{TSC\ OD}\right)^2}{4} L_{Canister}\right) - \left(\pi \frac{\left(d_{TSC\ ID}\right)^2}{4} L_{Gap}\right)$$

$$V_{Canister} = \left(\pi \times \frac{(70.64\ \text{inches})^2}{4} \times 122.50\ \text{inches}\right) - \left(\pi \times \frac{(69.39\ \text{inches})^2}{4} \times 0.2\ \text{inches}\right)$$

$$V_{Canister} = 479{,}388.85\ \text{inches}^3$$

The NAC-STC cavity free gas volume is:

$$V^{STC}_{Free\ Gas\ Volume} = \left(\pi \times \frac{D^2_{STC\ ID}}{4} \times L^{STC}_{Cavity}\right) - V_{Canister} - V_{Top\ Spacer} - V_{Bottom\ Spacer}$$

$$V^{STC}_{Free\ Gas\ Volume} = \left(\pi \times \frac{(71.00)^2}{4} \times 165.00\right) - 479{,}388.85 - 110{,}125.36 - 55{,}075.45$$

$$V^{STC}_{Free\ Gas\ Volume} = 8{,}677.04\ \text{inches}^3$$

$$V^{STC}_{Free\ Gas\ Volume} = 8{,}677.04\ \frac{inches^3}{Cask} \times \frac{1\ \ell}{61.02\ inches^3} = 142.20\ \frac{\ell}{Cask}$$

$$N = \frac{1\ atm \times 142.20\ \frac{\ell}{Cask}}{0.0821\ \frac{atm\ \ell}{Mole\ K} \times 293\ K} = 5.91\ \frac{Moles\ of\ STC\ Back\text{-}Fill\ Gas}{Cask}$$

The maximum normal operating pressure (MNOP) in the canister is calculated using the ideal gas law where

$$N = N_{TSC\ Back\text{-}Fill} + 0.03\left(N_{Rod\ Back\text{-}Fill}\right) + 0.3(0.03)\left(N_{Fission\ Gas}\right)$$

$$N = 202.78\ \frac{Moles}{Cask} + 0.03\left(77.95\ \frac{Moles}{Cask}\right) + 0.3(0.03)\left(338.74\ \frac{Moles}{Cask}\right)$$

$$N = 208.17\ \frac{Moles}{Cask}$$

The canister free gas volume was found above to be:

$$V^{Loaded\ TSC}_{Free\ Gas\ Volume} = 4{,}877.93\ \frac{\ell}{Cask}$$

and the maximum normal operating condition canister internal pressure is:

$$P = \frac{\left(208.17\ \frac{Moles}{Cask}\right) \times \left(0.0821\ \frac{atm\ \ell}{mole\ K}\right) \times 505.37\ K}{\left(4{,}877.93\ \frac{\ell}{Cask}\right)} = 1.77\ atm \approx 26.01\ psia \approx 11.31\ psig$$

Figure 3.4-23 Fuel Tube Model for Canistered Fuel

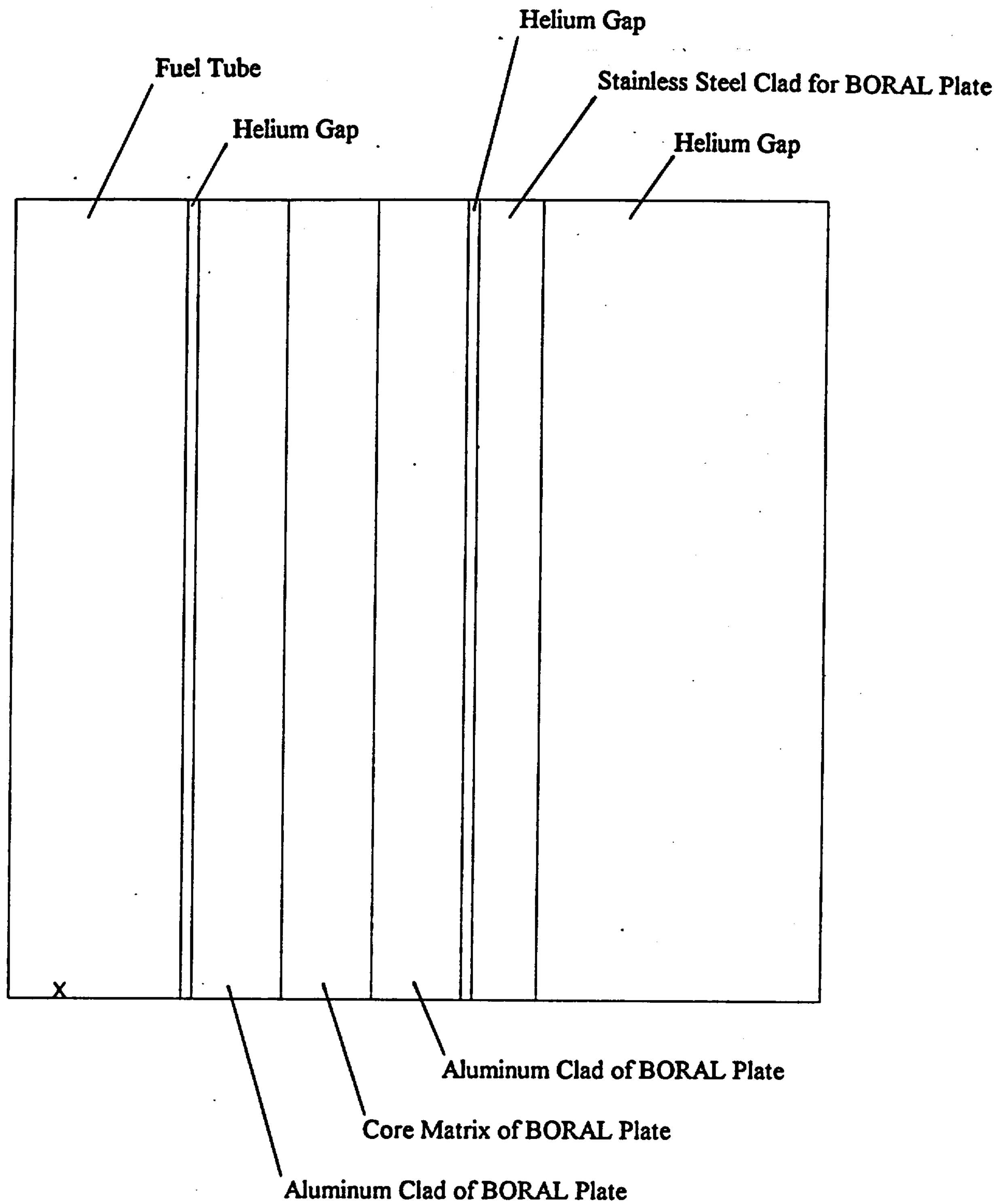


Figure 3.4-24 Two Dimensional Reconfigured Fuel Assembly Model

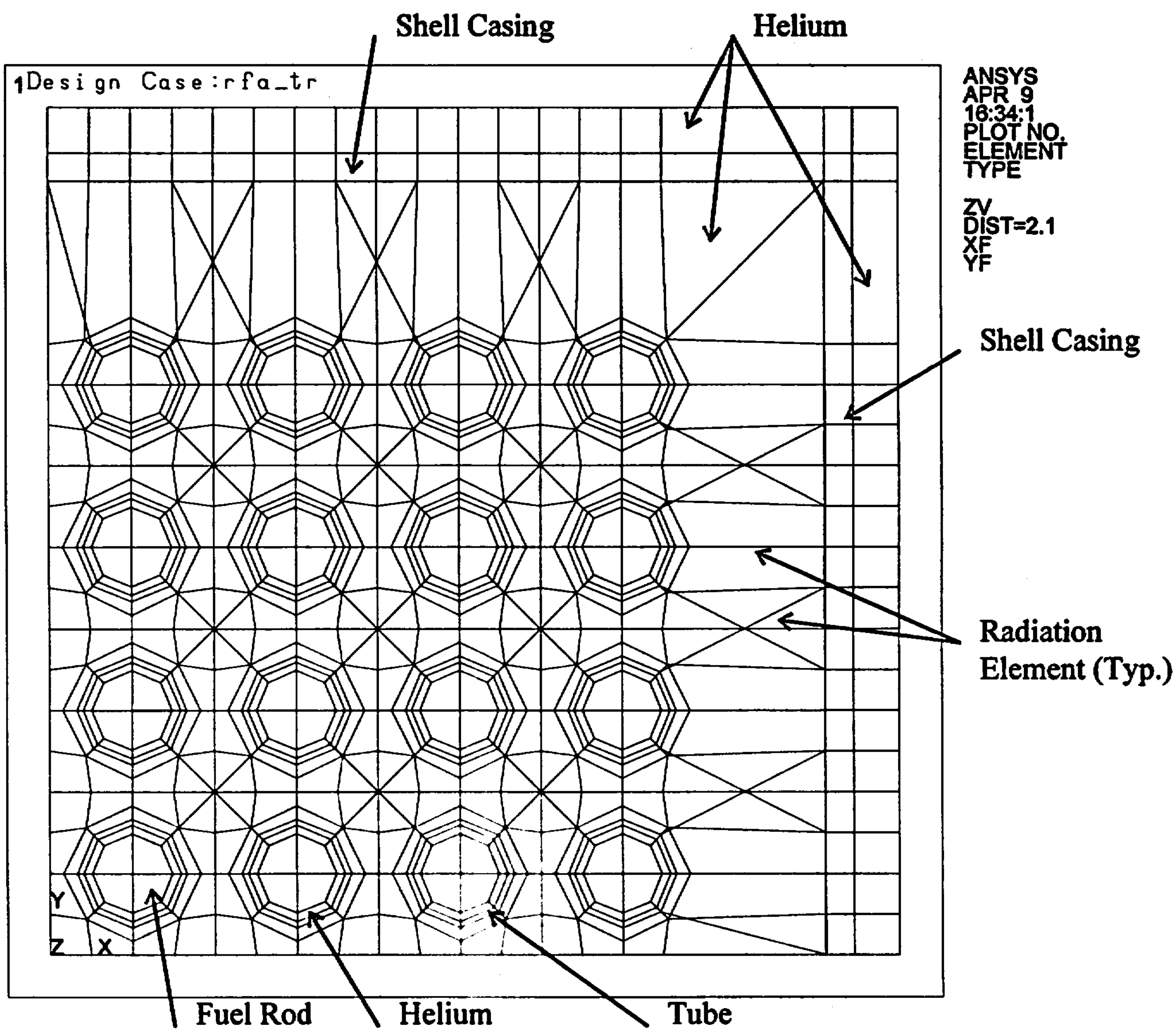


Table 3.4-1 Maximum Component Temperatures - Normal Transport Conditions, Maximum Decay Heat, Maximum Ambient Temperature - Directly Loaded and Canistered Configuration

Conditions: 100°F Ambient Temperature, Full Solar Insolance
Decay Heat Load: 22.1 kW for Uncanistered Fuel; 12.5 kW for Canistered Fuel

	Directly Loaded (Uncanistered) Fuel			Canistered Fuel	
	Cavity Gas			Cavity Gas	
Component	Air (°F)	Helium (°F)	Note	Helium (°F)	Note
Outer Lid O-Ring	178	176	(1)	176	(4)
BTFE O-Rings	211	210	(1)	210	(4)
Metallic O-Rings	190	189	(1)	189	(4)
Cask Radial Outer Surface	241	243	(2)	243	(5)
Top Neutron Shield	181	175	(1)	175	(4)
Bottom Neutron Shield	403	379	(1)	379	(4)
Radial Neutron Shield	284	285	(2)	270	(5)
Lead Gamma Shield	314	315	(2)	281	(5)
Aluminum Disk Exterior	338	337	(2)	---	
Aluminum Disk Interior	491	487	(2)	536	(5)
Steel Support Disk Exterior	356	344	(2)	---	
Steel Support Disk Interior	498	495	(2)	539	(5)
Canister Shell	---	---		338	(5)
Canister Lid	---	---		209	(5)
Canister Bottom Plate	---	---		255	(5)
Maximum Fuel Rod Cladding	588 (309°C)	544 (284°C)	(3)	575	(5)

Notes:
(1) Temperatures are determined from the analysis of the three dimensional quarter symmetry model of the entire cask.
(2) Temperatures are determined from the analysis of the three dimensional 180-degree section model of the entire cask.
(3) Temperatures are determined from the analysis of the two dimensional detailed model of the fuel assembly.
(4) Component not explicitly modeled in the 3-D model for canistered fuel. Temperature results from the helium case of the directly loaded fuel used (conservative).
(5) Temperatures are determined from the 3-D model for canistered fuel.

This Page Intentionally Left Blank

3.5 Hypothetical Accident Thermal Evaluation

The objective of the thermal analysis of the NAC-STC under hypothetical accident conditions is to demonstrate that the cask containment boundary structural components are maintained within their safe operating temperature ranges.

Since the fire accident is considered to be at short duration, the limits for maximum cladding temperature are higher. A cladding temperature limit of 1200°F is established based on experimental work by Gwenther (PNL-4555). Similarly for the 6061-T6 aluminum comprising the aluminum heat transfer disk, the temperature limit is considered to be 800°F. The tests specified in 10 CFR 71.73 are to be performed or analyzed in sequence, to determine their cumulative effect on the package. Thus, the NAC-STC is analyzed for the fire transient, specified in 10 CFR 71.73(c)(4), assuming that the package is in a form consistent with the damage sustained in the free drop and puncture tests of 10 CFR 71.73.

3.5.1 Thermal Model

3.5.1.1 Analytical Models

The NAC-STC is analyzed for the hypothetical accident conditions using the ANSYS finite element computer code. An axisymetrical model of the cask body was generated using the ANSYS code, as shown in Figure 3.5-1. Material properties used for the cask components are listed in Tables 3.2-1 to 3.2-7.

The impact limiters are included in the model for the fire analysis. The scale model test program described in Section 2.10.6 demonstrates that the impact limiters remain on the cask after the 30 foot drop imposed by the hypothetical accident condition.

The decay heat of 22.1 kilowatts from the contents is applied along the radial inner surface of the cask, with an axial distribution as shown in Figure 3.4-2. It also bounds the heat load of 12.5 kilowatts for the canistered fuel configuration. The average heat generation rate is multiplied by the values derived from Figure 3.4-2 for each node along the active fuel region of the model.

3.5.1.1.1 Directly Loaded and Canistered Fuel and GTCC Waste Baskets

The directly loaded fuel basket, and the canister and canister fuel baskets are not modeled explicitly in the hypothetical accident condition analysis. However, the maximum temperatures for the fuel cladding and basket components for the fire accident condition are determined by adding a ΔT to the maximum fuel clad and basket temperatures for normal conditions. The ΔT is considered to be the differential between the maximum lead temperature for normal condition and maximum lead temperature for the fire accident condition.

The canistered GTCC waste basket is fabricated entirely of stainless steel and contains only stainless steel containers whose contents are stainless steel. Consequently, the post accident temperatures are not limited by component allowable temperature ranges. (See Section 3.1.3)

3.5.1.1.2 Multiwall Body

The body of the cask is modeled as three concentric shells: the inner stainless steel shell, the lead shielding, and the outer stainless steel shell. Due to contraction in the lead after the lead pour operation, a gap may occur, most likely forming between the lead and the outer shell. In the thermal analysis, this gap is not modeled to permit maximum exposure of the lead to the fire condition. The portions of the lead region which extend above and below the neutron shield are protected by a layer of BISCO FPC "fireblock" material. The fireblock is a very low conductivity material which effectively insulates the lead from the heat of the fire.

Heat transfer across the region consists of conduction through the inner shell, the lead, and conduction through the outer shell. Heat transfer from the surface of the body consists of conduction into the neutron shield, and convection and radiation to the environment, at locations on the body of the cask above and below the neutron shield.

3.5.1.1.3 Radial Neutron Shield

A synthetic borated solid material used to absorb neutrons covers most of the outer shell. The composition of the neutron shield region is discussed fully in Section 3.4.1.1.1.3. The effective

conductivity of the radial neutron shield is calculated to be 0.339 Btu/hr-in-°F. At the end of the fire transient, the neutron shield is considered to be voided of NS4FR, leaving only the stainless steel/copper fins and stainless steel shell. The effective conductivity for this arrangement can be calculated as in Section 3.4.1.1.1.3, substituting air for the NS4FR material. The effective conductivity for the voided radial neutron shield is calculated to be 0.237 Btu/hr-in-°F.

The heat transfer mechanisms for the radial neutron shield are conduction through the shield itself, and radiation and convection from the surface of the neutron shield shell to the environment.

3.5.1.1.4 Top and Bottom Ends

The top end of the cask consists of the inner and outer lids, with a small gap between the lids. The inner lid consists of two stainless steel plates with NS4FR neutron shielding material between them. The outer lid is made solely of stainless steel.

The bottom end of the cask consists of two stainless steel plates, with a plate of NS4FR between them.

Heat transfer in the ends of the cask consists of conduction through the stainless steel and NS4FR. The ends are covered by the limiters and prevent heat transfer into or out of the ends of the cask.

3.5.1.2 Test Model

NAC did not create a thermal test model. The methods previously described have been used in prior transport licensing and are sufficient to show that the NAC-STC meets the criteria set forth in Section 3.5.

3.5.2 Package Conditions and Environment

The NAC-STC sustains no major damage as a result of the free drop and puncture tests.

The emissivity of stainless steel is 0.36. However, during the fire transient, the emissivity is assumed to be 0.9, as required by 10 CFR 71.73(c)(4). Also, the emissivity of the fire is assumed to be 1.0. [redacted]

At the end of the fire, the NS4FR in the neutron shield is assumed to be lost, resulting in a lower conductivity, and thus a greater resistance to heat leaving the cask. The emissivity of stainless steel is again assumed to be 0.36, also providing a greater resistance to heat leaving the cask. The cooldown period is analyzed for a period of 18 hours after the end of the fire. At this time, all cask components have reached their maximum temperatures and have begun the cooldown to their postfire, steady state temperatures.

3.5.3 Package Temperatures

The NAC-STC is evaluated for the hypothetical accident fire using the ANSYS computer code. A steady state initial temperature profile is calculated and used as input for the 30 minute fire transient. This is followed by an 18-hour cooldown period.

The safe operating temperature range of the components specified in Section 3.3.2 are also evaluated for the fire accident. These components include the seals, lead gamma shielding, and the radial neutron shield. The radial neutron shield temperature is not considered to be significant, as its loss is assumed in this accident. The shielding consequences of the loss of the radial neutron shield are evaluated in Section 5.1.4.

The maximum component temperatures during the hypothetical fire accident and cooldown period for the directly loaded fuel and the canistered fuel are listed in Table 3.5-1. The temperature histories of major cask components for directly loaded fuel are shown in Figure 3.5-2. None of the safety-related components, with the exception of the radial neutron shield as described above, exceed their safe operating temperature as a result of the fire accident.

The temperature results for the cask components as shown in Table 3.5-1 are obtained from the finite element analysis results using a heat load of 22.1 kW (design basis heat for the directly

loaded fuel). The maximum decay heat load for the canistered configuration is 12.5 kilowatts. This total heat load is much less than the assumed directly loaded basket heat load of 22.1 kilowatts. Consequently, when transporting canistered fuel, cask component steady state temperatures are lower than those for directly loaded fuel. The fire accident transient of the hypothetical accident conditions imposes a large, but short duration heat load on the NAC-STC. The fire accident causes the cask component temperatures to rise, but because they initially start at a lower temperature (compared to the directly loaded fuel configuration), the maximum post fire accident conditions are also lower. Consequently, the 22.1 kilowatt heat load evaluation bounds the conditions that result from the 12.5 kilowatt canistered fuel and the 2.9 kilowatt canistered GTCC waste.

Based on the method described in Section 3.5.1.1.1, the maximum temperatures for the basket components and the fuel clad for the directly loaded fuel are established by adding a ΔT of 141°F to the normal condition basket and clad temperatures as listed in Table 3.4-1 (air case). The ΔT is the differential between the lead temperature for fire accident condition (455°F) and the lead temperature for normal condition (314°F). Similarly, the maximum temperatures for basket components and the fuel clad for canistered fuel are determined using a ΔT of 174°F, which is the differential between the lead temperature for the fire accident condition (455°F) and the lead temperature for the normal condition (281°F).

The canister may contain one or more reconfigured fuel assemblies. Using the thermal model described in Section 3.4.1.2.4, the maximum calculated temperatures for the reconfigured fuel assembly shell casing, fuel tube and the fuel clad for the fire accident condition are 718°F, 734°F and 734°F, respectively.

3.5.4 Maximum Internal Pressure

3.5.4.1 Maximum Internal Pressure Due to Directly Loaded Fuel

From Section 3.4.4, it is known that the maximum pressure in the cask cavity is 60.0 psia, for a cavity gas temperature of 232°C. The maximum fuel rod cladding temperature during the fire transient is 402°C, as listed in Table 3.5-1. Thus, the maximum hypothetical accident pressure can be calculated based on the ratio of these temperatures as follows:

$$P_2 = P_1 \frac{T_2}{T_1}$$

$$P_2 = 60\left(\frac{675}{505}\right)$$

$$P_2 = 80.2 \text{ psia}$$

3.5.4.2 Maximum Internal Pressure Due to Canistered Fuel

The maximum internal pressure for the canistered fuel configuration is calculated for the canister and for the NAC-STC cavity. The calculated maximum post fire accident temperature of the helium gas is 616°F determined by the method discussed in Section 3.5.1.1.1 (442°F for normal condition + 174°F). A temperature of 650°F is conservatively used to calculate the maximum pressure in the NAC-STC.

The internal pressure is a function of rod-fill, fission and backfill gases. The design basis fuel assembly for the internal pressure calculation is the Combustion Engineering Type A assembly. This assembly has the highest rod back-fill pressure (315 psig) and received the highest burnup (36,000 MWD/MTU). There are three different gases contributing to the canister internal pressure and four gases contributing to the cavity internal pressure. The canister gases are the fuel rod back-fill and fission gases, and the canister backfill gas. The cavity gases are these plus the cavity backfill gas. All of the gases except the fission gases are assumed to be helium. The

otal pressure for each volume are found by calculating the molar quantity of each gas and summing those directly.

The number of moles of the backfill gases are calculated using the Ideal Gas Law, Pv = NRT. Backfill gases for the canister and cavity are assumed to be initially at 1 atmosphere. The quantity of fission gas is derived using $0.25 \frac{\text{Atoms of Gas}}{\text{Fission}}$ (Olander). The release of fission gas is as assumed for directly loaded fuel. In accident conditions, 100 % of the rods are hypothetically assumed to fail releasing 30% of the total fission gas and all of the backfill helium.

The number of moles of gas in the canister is:

$$N = N_{\text{TSC Back-Fill}} + N_{\text{Rod Back-Fill}} + 0.3\left(N_{\text{Fission Gas}}\right)$$

The number of moles of helium contained in the canister, as backfill, and the number of moles of gas in the fuel rods (as helium backfill and fission products) was calculated in Section 3.4.4.2.

The number of moles of gas due to the hypothetical failure of 100% of the fuel rods is:

$$N = 202.78 \frac{\text{Moles}}{\text{Cask}} + 77.95 \frac{\text{Moles}}{\text{Cask}} + 0.3\left(338.74 \frac{\text{Moles}}{\text{Cask}}\right)$$

$$N = 382.35 \frac{\text{Moles}}{\text{Cask}}$$

Based on an assumed maximum temperature of 650°F, the maximum pressure in the canister is:

$$P = \frac{\left(382.35 \frac{\text{Moles}}{\text{Cask}}\right) \times \left(0.0821 \frac{\text{atm}\,\ell}{\text{mole K}}\right) \times 616.48\text{ K}}{\left(4{,}877.93 \frac{\ell}{\text{Cask}}\right)} = 3.97\text{ atm} \approx 58.34\text{ psia} \approx 43.64\text{ psig}$$

No credit is taken for the canister for containment in transport. The maximum NAC-STC cavity pressure, assuming the absence of the canister containment is:

$$P = \frac{\left(214.08\ \frac{\text{Moles}}{\text{Cask}}\right) \times \left(0.0821\ \frac{\text{atm}\ \ell}{\text{mole K}}\right) \times 616.48\ \text{K}}{\left(5{,}020.13\ \frac{\ell}{\text{Cask}}\right)} = 2.16\ \text{atm} \approx 31.74\ \text{psia} \approx 17.04\ \text{psig}$$

where the volume of the NAC-STC cavity was determined in Section 3.4.4.2 to be 5,020.13 liters.

3.5.5 Maximum Thermal Stresses

The maximum thermal stresses in the cask resulting from the hypothetical accident fire are reported in Section 2.7.3.

3.5.6 Evaluation of Package Performance for Hypothetical Accident Thermal Conditions

The NAC-STC thermal performance has been assessed for the hypothetical accident fire transient, as specified in 10 CFR 71. All cask components important to safety remain within their safe operating ranges except the radial neutron shield, which is assumed to be lost, whenever this assumption results in higher temperatures. The ability of the cask to safely contain its radioactive contents is not compromised.

Figure 3.5-1 NAC-STC Hypothetical Accident Conditions ANSYS Model for Directly Loaded Fuel

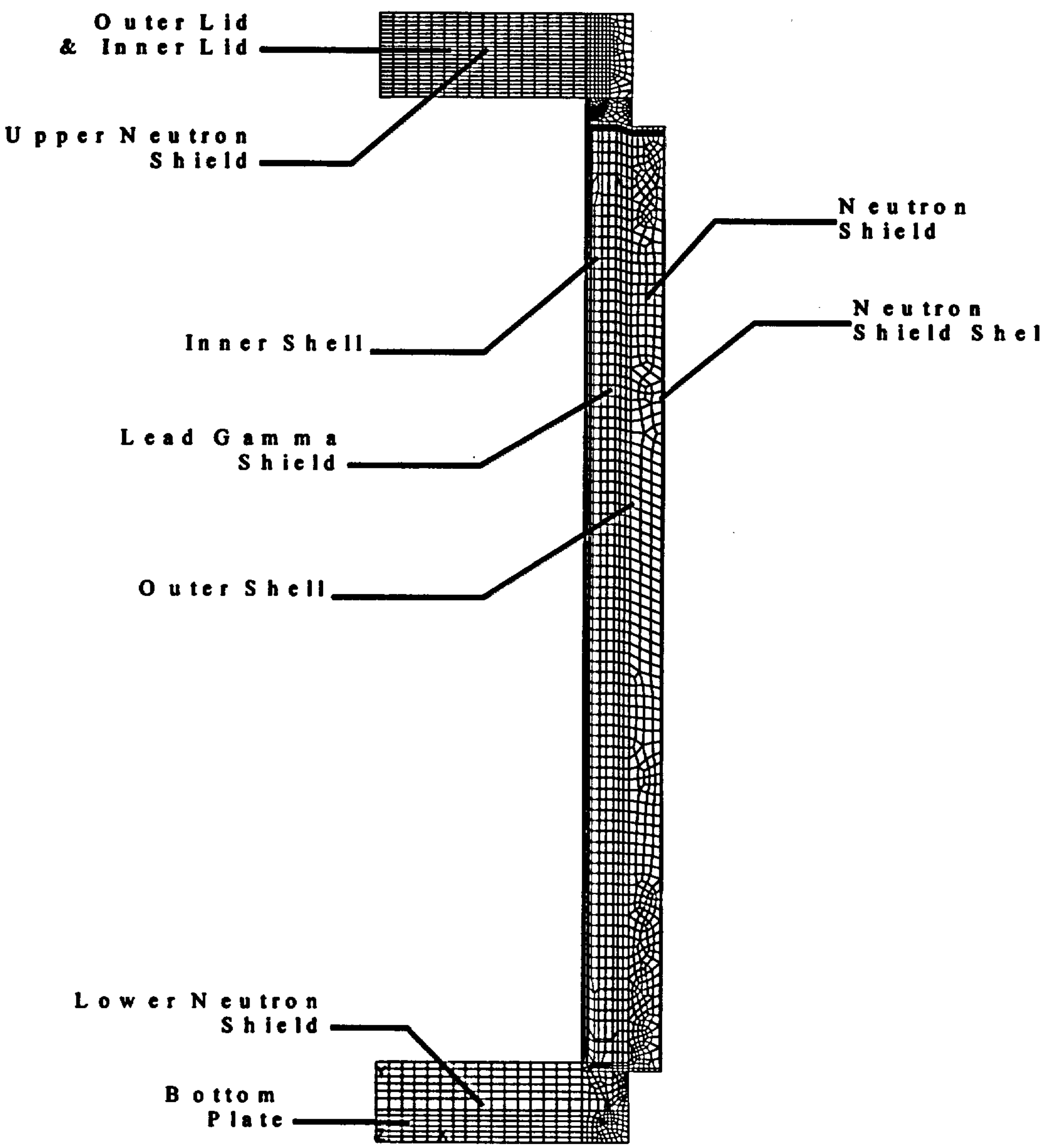


Figure 3.5-2 NAC-STC Hypothetical Accident Conditions Temperature History for the Directly Loaded Basket

1. Maximum temperature of the lead gamma shield
2. Maximum temperature of the inner surface of the inner shell

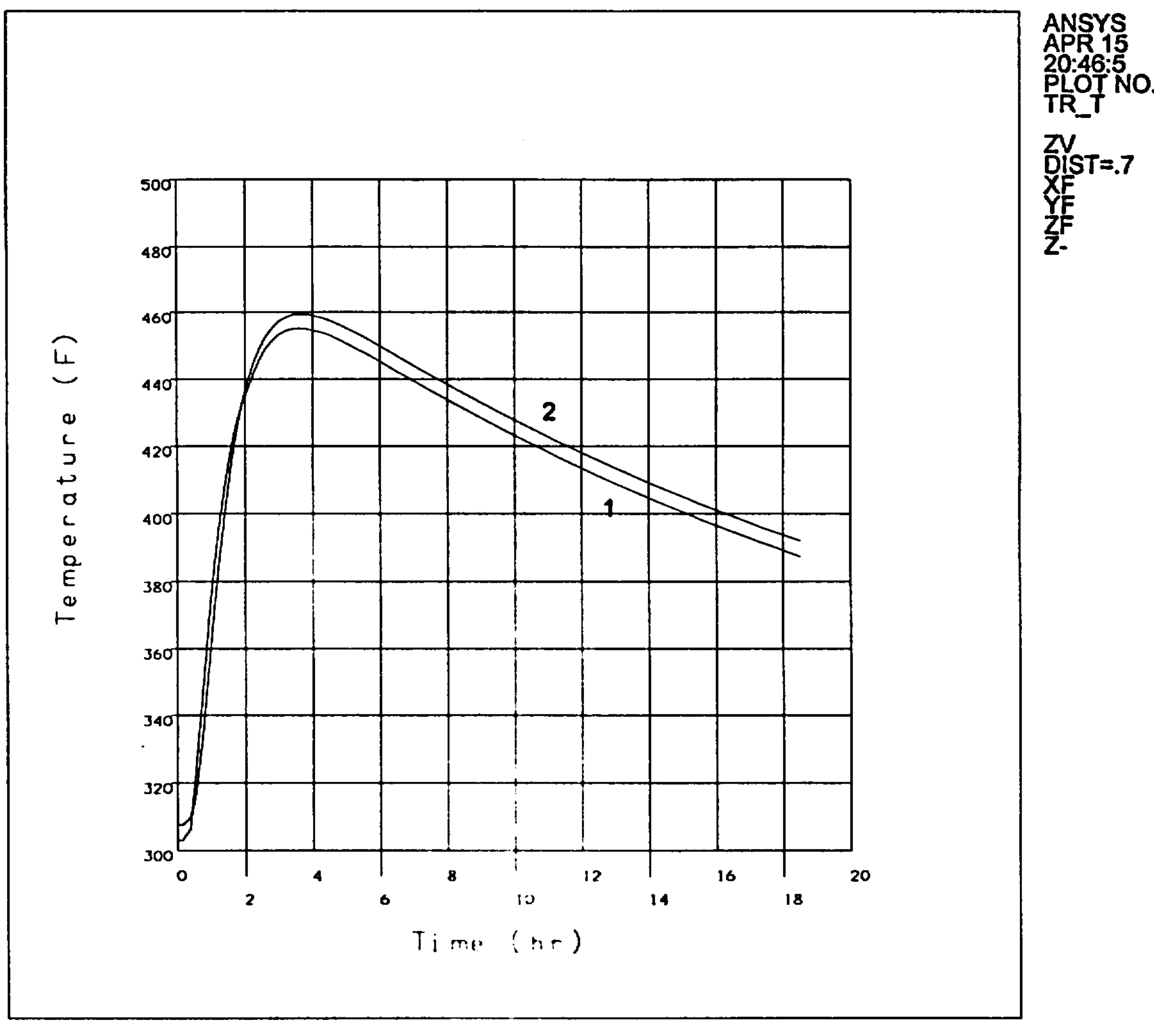


Figure 3.5-2 NAC-STC Hypothetical Accident Conditions Temperature History for the Directly Loaded Basket

1. Maximum temperature of the lead gamma shield
2. Maximum temperature of the inner surface of the inner shell

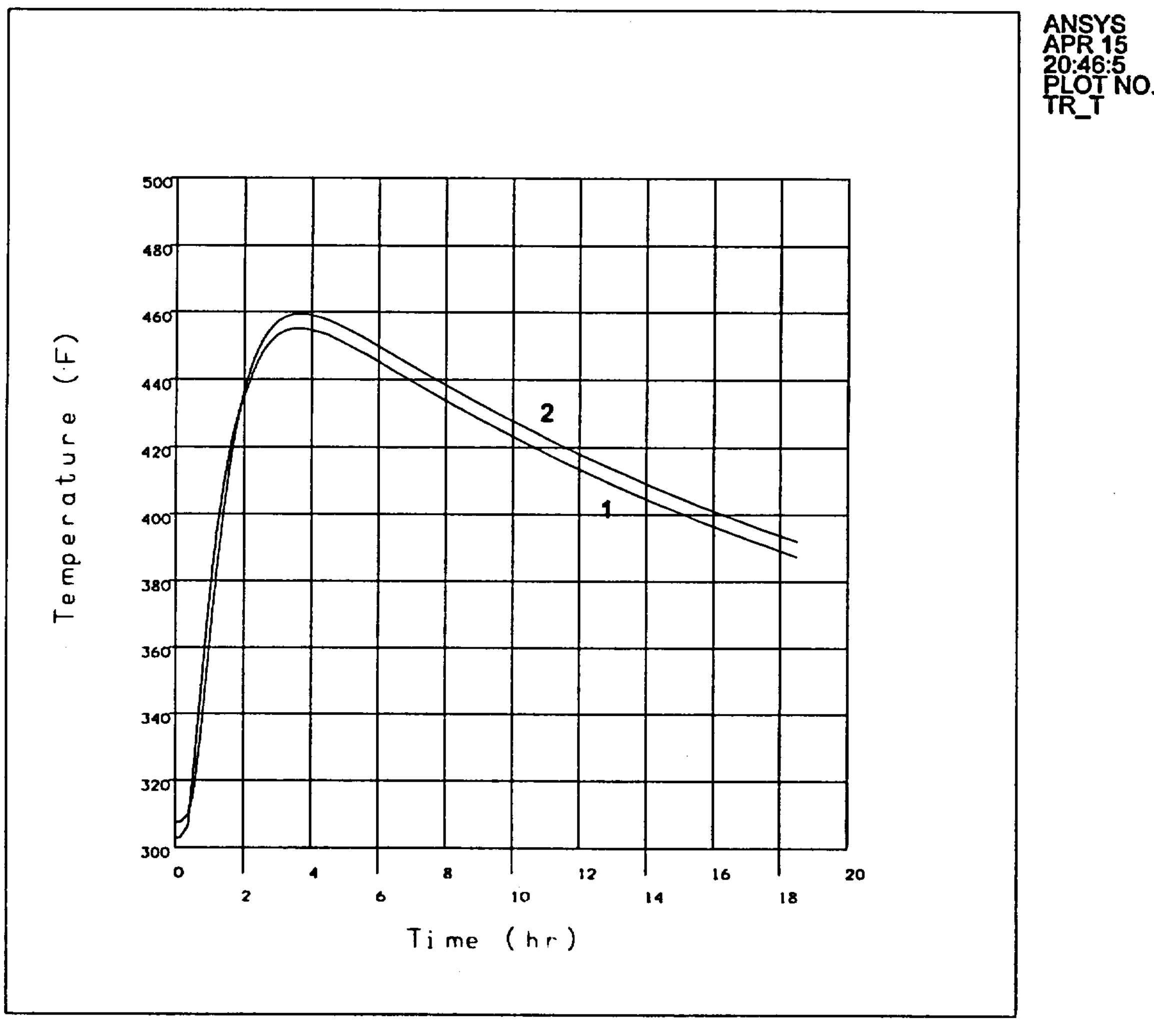


Figure 3.5-2 NAC-STC Hypothetical Accident Conditions Temperature History for the Directly Loaded Baske (continued)

1. Maximum temperature of the radial port cover seals
2. Maximum temperature of the inner lid seals
3. Maximum temperature of the outer lid seals
4. Maximum temperature of the inner lid port cover seals

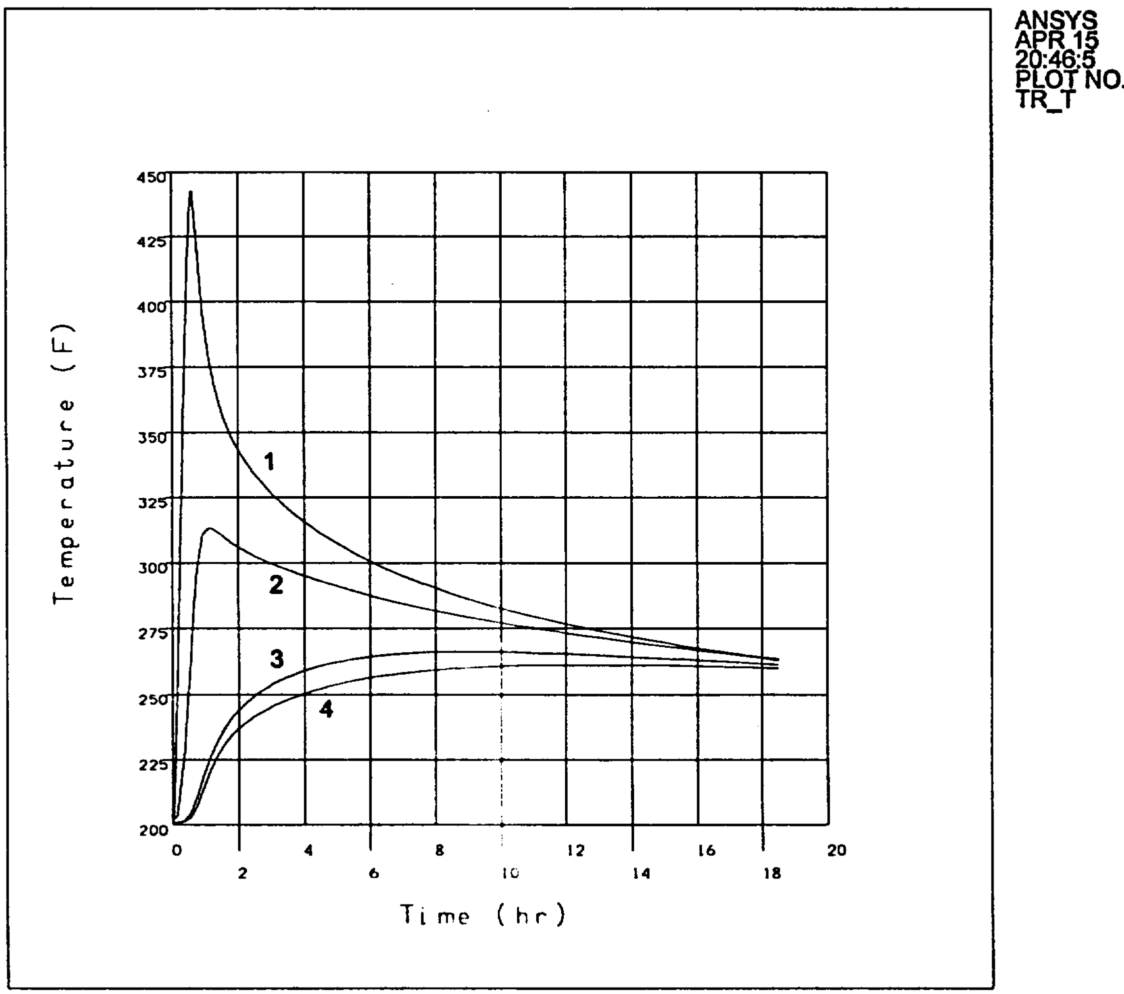


Figure 3.5-2 NAC-STC Hypothetical Accident Conditions Temperature History for the Directly Loaded Basket (continued)

1. Maximum temperature of the inner lid bolts
2. Maximum temperature of the outer lid bolts

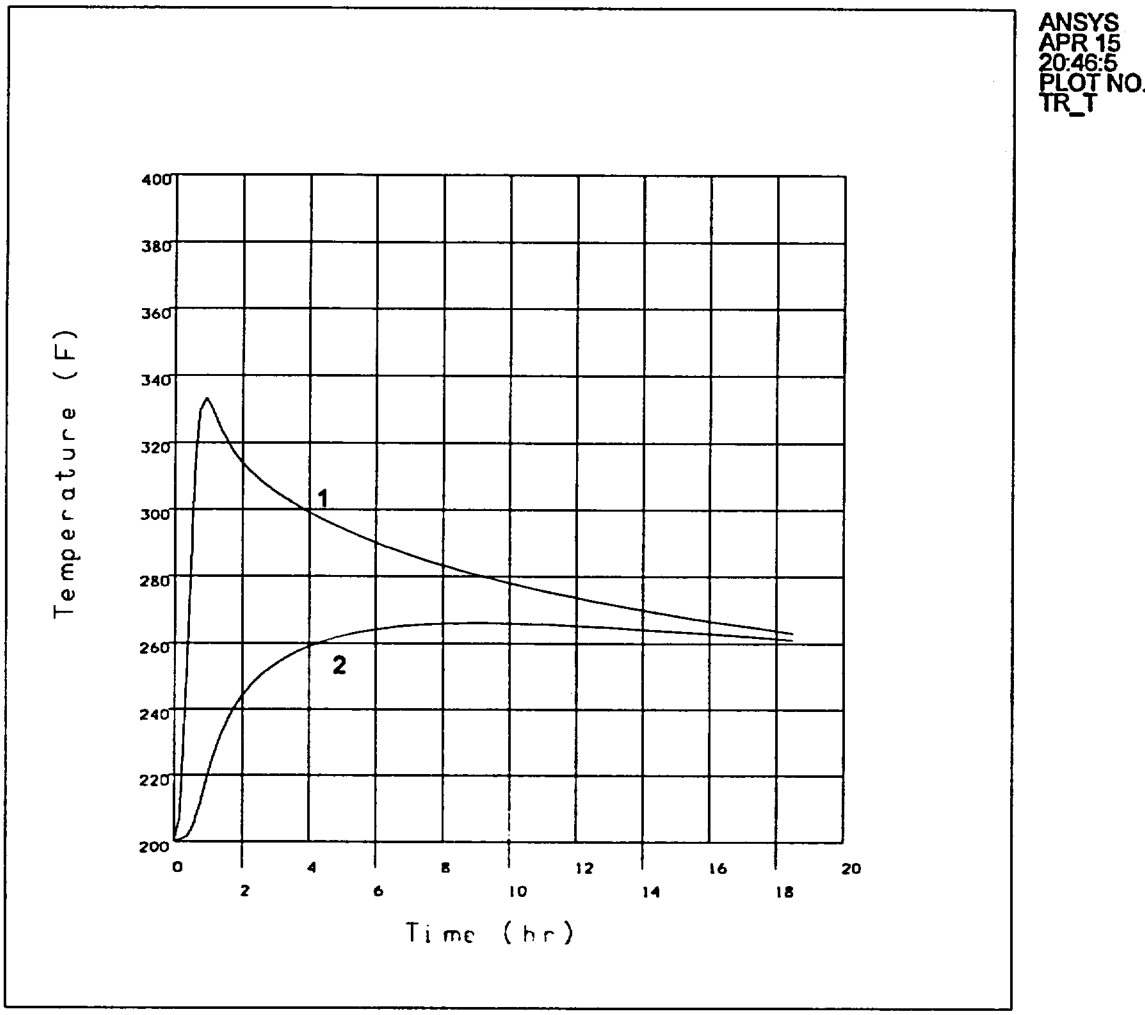


Table 3.5-1 Maximum Component Temperatures - Hypothetical Accident Conditions Fire Transient

Conditions: 30 minute, 1475°F Fire
22.1 kW decay heat for Directly Loaded Fuel
12.5 kW decay heat for Canistered Fuel

Component	Temperature (°F)	Time (hours)	Temperature Limit (°F)
Inner Lid Bolt	335	0.9	
Metallic O-rings	314	1.1	500
Cask Radial Outer Surface	1347	0.5	--
Radial Neutron Shield[1]	[illegible]	[illegible]	[illegible]
Lead Gamma Shield	455	3.6	600
Steel Disk Interior			
Directly Loaded Fuel	639		
Canistered Fuel	713		
Aluminum Disk Interior			
Directly Loaded Fuel	632		800
Canistered Fuel	710		800
Maximum Fuel Rod Cladding			
Directly Loaded Fuel	729		1200
Canistered Fuel	749		1200

1 The radial neutron shield is assumed to be lost at the end of the fire for conservatism. The axial neutron shields are not components important to safety as discussed in Section 3.3.2.

2 The maximum temperature is used to determine the allowable stress in the structural analyses.

Table of Contents

List of Tables

4.0 CONTAINMENT

4.1 Containment Boundary

The NAC-STC transport containment boundary is defined by the following components: (1) Inner shell, and upper and lower inner shell rings (transition sections); (2) Bottom inner forging; (3) Top forging; (4) Inner lid, inner lid bolts and inner lid outer metallic o-ring; (5) Inner lid interseal test port threaded plug with metallic o-ring; (6) Vent port coverplate, vent port coverplate bolts, and vent port coverplate outer metallic o-ring; (7) Vent port coverplate interseal test hole threaded plug with metallic o-ring; (8) Drain port coverplate, drain port coverplate bolts, and drain port coverplate outer metallic o-ring; and (9) Drain port coverplate interseal test hole threaded plug with metallic o-ring.

Referring to NAC Drawing No. 423-800 for design details, the three possible paths for the escape of radioactive material from the NAC-STC during transport operation and the containment components for each are: (1) past the inner metallic o-ring in the inner lid where containment is provided by the outer metallic o-ring in the inner lid and the interseal test port plug; (2) through the inner metallic o-ring on the vent port coverplate where containment is provided by the outer metallic o-ring in the vent port coverplate and the vent port coverplate interseal test plug; and (3) through the inner metallic o-ring on the drain port coverplate where containment is provided by the outer metallic o-ring in the drain port coverplate and the drain port coverplate interseal test plug. The NAC-STC dual lid design permits periodic verification of the inner lid containment boundary after loading and prior to transport by removing the outer lid and pressurizing the inner lid interseal region with helium through the interseal test port. A leak detector is used to verify leakage less than 1.2×10^{-4} std cm^3/second at the circumference of the inner lid. Similarly, the interseal region of the vent and drain port coverplates is pressurized with helium and the leak detector used to verify leakage less than 1.2×10^{-4} std cm^3/second. Following containment verification, the outer lid o-ring is replaced and the outer lid is reinstalled. This is a summary of the process used to verify the cask containment for transport.

For the canistered fuel or canistered GTCC waste configurations of the NAC-STC, no containment credit is taken for the transportable storage canister during transport. This is a conservative assumption since the canister is welded closed and is verified to be leak tight when it is initially closed. The canister will not leak under any of the normal conditions of transport or the hypothetical accident conditions.

4.1.1 Containment Vessel

The primary containment vessel for the NAC-STC consists of a 71.0-inch inside diameter, 1.5-inch thick inner shell, two 1.5-inch to 2.0-inch transition sections, a 6.2-inch thick bottom inner forging, and a 7.85-inch thick top forging. The containment vessel components, except for the transition sections, are fabricated from ASME Boiler and Pressure Vessel Code, Type 304 stainless steel nuclear pressure vessel material. The two transition sections are ASME Boiler and Pressure Vessel Code, Type XM-19 stainless steel nuclear pressure vessel material.

4.1.2 Containment Penetrations

The NAC-STC primary containment boundary is described in Section 4.1. The penetrations in the NAC-STC primary containment vessel are the vent and drain ports in the inner lid (including bolts, o-rings, and o-ring test plugs). The inner lid (including bolts, o-ring, and o-ring test plug) also is a penetration in the primary containment boundary. The penetrations are designed to seal the boundary and to ensure that the leakage from the cavity does not exceed 1.2 x 10[illegible] std cm^3/second. The quick-disconnect valved nipples installed in the vent and drain openings and in the interseal test port in the inner lid are not considered to be part of the containment boundary. The vent and drain port coverplates are fabricated from SA-240, Type 304 stainless steel.

4.1.3 Seals and Welds

4.1.3.1 Seals

The metallic o-rings of the inner lid, the vent port coverplate, and the drain port coverplate are the seals that provide primary containment, as described in Section 4.1. Section 4.5 contains the specifications that describe the BTFE o-rings and the metallic o-rings. Also included in Section 4.5 are the manufacturer's technical data bulletins for the expansion foam and the Fireblock Protective Coating (FPC) used in the NAC-STC. Leakage testing of the cask is performed prior to acceptance from the manufacturer. Leakage testing is also performed following fuel loading. These tests are described in the following sections.

4.1.3.1.1 Containment System Fabrication Verification

Upon completion of fabrication, a Containment System Fabrication Verification shall be performed on the cask containment as described in Section 8.1.3. This leak test verifies that the leakage rate of the assembled containment does not exceed the maximum allowable leakage rate of 2×10^{-7} std cm^3/second. The maximum allowable leakage rate, and the corresponding test sensitivity, are discussed in Section 4.2.3.1.

4.1.3.1.2 Containment System Periodic Verification

The Containment System Periodic Verification shall be performed on the NAC-STC package containment boundary seals and components prior to each shipment, in accordance with the leak test acceptance criteria established for the Containment System Fabrication Verification. For cask transport immediately after loading, the leakage test shall be performed in accordance with the procedures and acceptance criteria described in Section 7.2.1. For cask shipments following storage, the verification leak test shall be performed in accordance with the procedures and acceptance criteria described in Section 7.2.2.

Whenever a containment seal or component is replaced, the o-ring or containment component shall be leak tested following replacement using the Containment System Periodic Verification (Section 8.2.2.2). This test will verify that the replacement seal or component has been properly installed and that the leakage rate is less than the allowable leak rate established for the Containment System Fabrication Verification specified in Section 4.2.3.2.

4.1.3.2 Welds

A limited number of circumferential and longitudinal welds will be used to fabricate the inner shell and to attach it to the inner shell rings, which are also attached to the top forging and to the bottom inner forging. The longitudinal welds in the cylindrical sections will be staggered circumferentially by 90 degrees or 180 degrees. Containment vessel welds shall be full penetration bevel or groove welds to ensure structural integrity. Upon completion of the inner shell welds, the welds will be radiograph inspected and accepted per ASME Section III Code Article 5320 requirements.

Upon completion of containment vessel fabrication, the NAC-STC containment boundary will be hydrostatically tested in accordance with ASME Code requirements to ensure the integrity of the welds and containment components (Section 8.1.2.3). Following hydrostatic testing, all containment vessel welds will be visually inspected by the dye penetrant examination method and evaluated in accordance with ASME Code requirements. Following visual inspection, the containment cavity vessel welds shall be helium leak tested to verify the integrity of the welds to a leakage rate less than [redacted] std cm^3/second. Test equipment and methods shall be selected to assure a minimum test sensitivity of [redacted] std cm^3/second.

4.1.4 Closure

The primary closure assembly for the NAC-STC for transport consists of the inner lid, bolts, and o-rings. The inner lid is recessed and bolted into the top forging of the cask body. The 9.0-inch thick, 79.00-inch diameter inner lid is made of SA-336, Type 304 stainless steel. The inner lid is retained by 42 inner lid bolts that are 1 1/2 - 8 UN socket head cap screws fabricated from SB-637, Grade N07718 nickel alloy steel bolting material. The initial torque for installation of the inner lid bolts is specified in Table.7.0-1. The 5.25-inch thick, 86.7-inch diameter outer lid is made of SA-705, Type 630, H1150, 17-4 PH stainless steel. The outer lid is retained by 36 outer lid bolts that are 1 - 8 UNC socket head cap screws fabricated from SA-564, Type 630, H1150, 17-4 PH stainless steel. The initial torque for installation of the outer lid bolts is specified in Table.7.0-1. The bottom surface of the outer lid is sealed to the top forging of the cask body by a metallic o-ring.

The vent port and the drain port are recessed into the inner lid. The vent and drain port coverplates are secured by four 1/2 - 13 UNC bolts fabricated from SA-193, Grade B6, Type 410 stainless steel. Each coverplate is sealed to the inner lid by a metallic o-ring, with a second, concentric metallic o-ring, providing an annulus to test the seal.

The interlid and pressure ports, which are located in the top forging, are protected by port covers. For transport operations, solid port covers with no penetrations are installed in the interlid and pressure ports. These port covers are secured by three 3/8 - 16 UNC bolts, fabricated from SA-193, Grade B6, Type 410 stainless steel material. Each cover is sealed to the cask body by two "piston-type" (bore seal) BTFE o-rings, with a test port located between the o-rings.

4.2 Containment Requirements for Normal Conditions of Transport

The NAC-STC has been designed to safely transport spent fuel assemblies in two configurations. The fuel assemblies may be sealed in a transportable storage canister (canistered), or loaded directly into a fuel basket installed in the cask cavity. The NAC-STC is also designed to transport canistered GTCC waste. In the canistered configuration, the NAC-STC can transport up to 36 fuel assemblies, depending on the mix of fuel assembly types within the canister, or up to 24 canisters of GTCC waste.

For directly loaded fuel, the Westinghouse 17 x 17 fuel assembly is the limiting assembly, because it will result in a higher cavity pressure due to its relatively large gas volume. Thus, the 17 x 17 assembly is used in the leakage calculations. For a given burnup, the 3.7 w/o uranium-235 results in more limiting source terms than occur with an initial enrichment of 4.2 w/o. A burnup of 40,000 MWD/MTU is not likely to be achieved with an initial enrichment lower than 3.7 weight percent. Therefore, the 3.7 w/o initial enrichment source terms are used in this analysis for directly loaded fuel.

For canistered fuel, the Combustion Engineering Type A fuel assembly has the highest burnup and, therefore, represents the limiting assembly for the design basis Yankee Class fuels. As previously noted, for the purposes of the containment evaluation, no credit is taken for the presence of the welded canister. Consequently, fission and fill gas within the canister are assumed to act on the NAC-STC containment boundary.

The canistered GTCC waste consists primarily of irradiated and surface contaminated, stainless steel hardware and core components. The waste is separately enclosed in containers having the same external dimensions as the Yankee Class fuel. There are no radioactive gases associated with the GTCC waste.

The NAC-STC must maintain a radioactivity release rate of not more than 10^{-6} A_2 per hour. As shown in Section 4.2.3, the maximum allowable leak rate for directly loaded fuel is 1.22×10^{-4} std cm^3/sec, and is 1.21×10^{-4} std cm^3/sec for canistered fuel. A maximum allowable leak rate of 1.2×10^{-4} std cm^3/second is applied to bound the calculated leak rates for the directly loaded, and canistered, fuel configurations. The leak rate sensitivity is 6.0×10^{-5} cm^3/sec.

4.2.1 Containment of Radioactive Material

The NAC-STC is designed to maintain a release rate of less than 10^{-6} A_2 per hour under the normal conditions of transport, as required by 10 CFR 71.51 and IAEA Safety Series No. 6 (paragraph 548). As shown in Section 4.2.3.2 below, this corresponds to a maximum leakage rate of 1.2 x 10[illegible] std cm^3/second.

4.2.2 Pressurization of Containment Vessel

The maximum pressure in the cask during normal transport conditions is calculated, based on 3 percent failure of the fuel rods, using the methodology presented in Section 3.4.4. The cask cavity under normal transport conditions is backfilled to one atmosphere with 99.9 percent pure helium gas. To determine the limiting temperature conditions, it has been assumed that the helium gas could possibly be replaced by one atmosphere of air. Therefore, the normal operating pressure is determined for both gas conditions. From Section 3.4.4, the free gas volume, fuel fill gas volume, and fuel fission gas volumes for the two spent fuel configurations are presented below.

4.2.2.1 Containment Pressurization due to Directly Loaded Fuel

V_{gv} = Free Gas Volume in Cask Cavity
= 461,128 in^3

V_{fg} = Fuel Fill Gas Volume
= 300,417 in^3

V_{fp} = Fuel Fission Gas Volume
= 328,917 in^3

Assuming a 3 percent fuel rod failure resulting in the release of the fill gas and fission gas from the failed fuel, the total gas volume can be calculated.

V_{tg} = Total Gas Volume
$= V_{gv} + 0.03V_{fg} + 0.03V_{fp}$
= 480,008 in^3

Based on a bulk average gas temperature of 450°F when air is in the cavity (Section 3.4.4), the pressure within the cask cavity is:

$$P_2 = 1\left(\frac{480{,}008}{461{,}128}\right)\left(\frac{505}{293}\right)$$
$$= 1.79 \text{ atm} = 26.39 \text{ psia}$$

Based on a bulk average gas temperature of 401°F when helium is the cover gas (Section 3.4.4), the pressure within the cask cavity is:

$$P_2 = 1\left(\frac{480{,}008}{461{,}128}\right)\left(\frac{478}{293}\right)$$
$$= 1.70 \text{ atm} = 25.0 \text{ psia}$$

4.2.2.2 Pressurization of Containment due to Canistered Fuel

The maximum normal conditions pressure in the transportable storage canister was calculated in Section 3.4.4, and found to be 1.77 atmospheres, or 11.31 psig. This pressure was conservatively calculated at 450°F, compared to the calculated maximum normal conditions temperature of 442°F. This pressure assumes the rupture of 3 percent of the fuel rods.

The maximum normal conditions pressure in the free volume of the cavity of the NAC-STC is calculated to also be 1.77 atmospheres, or 11.31 psig, as shown in Section 3.4.4.

4.2.3 Containment Criterion for Normal Conditions of Transport

The NAC-STC is designed to meet the containment criteria of 10 CFR 71 and IAEA Safety Series No. 6. The 10 CFR 71 limit for the release of radioactive material under normal conditions of transport is 10^{-6} A_2 per hour. The A_2 value for the mixture of radionuclides assumed available for release is determined using the method described in 10 CFR 71, Appendix A.

For normal transport conditions, 3 percent of the fuel rods are assumed to fail. Regulatory Guide 1.25 suggests that 10 percent of the tritium and 30 percent of the krypton-85 should be assumed to be available to escape each failed fuel rod. It is conservatively assumed that 30 percent of both tritium and krypton-85 escape each failed fuel rod. Other radiologically important gaseous

nuclides are present only in negligible amounts after the [redacted] 6.5-year minimum cooling period [redacted].

[redacted]

Fuel assemblies develop a coating of impurities [redacted] deposited by cooling water during power generation. Crud contains mostly non-radioactive elements, but does contain a significant amount of cobalt-60. A study [redacted] has estimated the range of cobalt-60 concentrations on spent fuel assemblies to be from 0.1 to 140 µCi/square centimeter at initial discharge. For conservatism, this analysis for directly loaded fuel assumes the cobalt-60 concentration to be the maximum of that range, adjusted for a fuel cool time of 6.5 years. The surface area of the design basis directly loaded fuel, the Westinghouse 17 x 17 fuel assembly, is calculated to be 3.5 x 10^5 square centimeters. The calculated surface area of the canistered Combustion Engineering Type A fuel assembly is 2.03 x 10^5 square centimeters.

Based on the surface area of 26 directly loaded design basis fuel assemblies, the cobalt-60 inventory at discharge is 1274 curies. After a 6.5-year decay time, the cobalt inventory is estimated to be 541 curies. The corresponding values for the 36 canistered fuel assemblies cooled 8.0 years are 1023 Ci at discharge and 373 Ci after 8.0 years. Under normal conditions of transport, 15 percent of this cobalt-60 is assumed to be released from the fuel assemblies (NUREG/CR-3285) and is conservatively assumed to be in aerosol form.

NUREG/CR-6487 also postulates the release of radionuclides categorized as fines from the fuel rods in the event of failure of the rod. These radionuclides are considered to include all those not identified as gas, volatile, or crud. The postulated release fraction for fines is 3 x 10^{-5}, or 0.003% of the remaining radionuclide inventory.

The total inventory of the principal fission product gases, volatiles, fines and crud for directly loaded and canistered spent fuel is shown in Table 4.2-1. The fission gas, volatile and fine radionuclide inventories were calculated using the SAS2H sequence (Hermann, 1990) of the SCALE-4 system (SCALE). The releasable inventory of radioactive fission gas, volatiles, fines

and crud in the cask, is calculated by applying the release fractions for the constituents as described above.

The A_2 value for the releasable gases, volatiles, and fines for the design basis fuels is calculated in Appendix 4.5.5. Crud is assumed to be composed of Cobalt-60, having an A_2 value of 10.8.

The A_2 value for the postulated mixture of gases, volatiles, fines and crud is calculated in Table 4.2-2 for directly loaded fuel, and in Table 4.2-3 for canistered fuel. For directly loaded fuel, the composite A_2 value is 25.1 curies. For canistered fuel, the composite A_2 value is 22.2 curies.

Since the maximum permissible leakage rate for normal conditions, (R_n) is $10^{-6} A_2$, the allowable release rate for directly loaded fuel is:

$$R_{nd} = 2.51 \times 10^{-5} \text{ curies/ hour} = 6.97 \times 10^{-9} \text{ curies/ sec}$$

For canistered fuel, the permissible release rate is:

$$R_{nc} = 2.22 \times 10^{-5} \text{ curies/ hour} = 6.17 \times 10^{-9} \text{ curies/ sec}$$

The allowable volumetric leak rate for either configuration is:

$$L_n = \frac{R_n}{C_n}$$

The concentration, C_n, is the activity postulated to be available for release, S_n, divided by the free volume of the cavity, V_n.

The total activity concentration, C_n, is:

$$C_n = C_{FissionGas} + C_{Volatiles} + C_{Crud} + C_{Fines}$$

The activity concentration of each of the radionuclide groups that contributes to the releasable activity is a function of the assumed release fraction of the nuclides in each fuel assembly, and

the number of fuel assemblies. The assumed release fractions for normal conditions for each group were described above, but are summarized as:

Radionuclide Group	Fraction
Volatiles releasable	0.0002
Fission gas releasable	0.3
Rod fines released	0.00003
Crud spallation factor	0.15
Rods assumed to breach	0.03

These factors were applied to establish the releasable activity for directly loaded fuel as shown in Table 4.2-2, and in Table 4.2-3 for canistered fuel. The methodology used to calculate the activity concentration is presented in Section 4.5.5.1.

4.2.3.1 Permissible Release Rate for Directly Loaded Fuel

The allowable release rate for directly loaded fuel is calculated using:

$$L_{ndl} = \frac{R_n}{C_n}$$

where:

$$C_n = \frac{S_n}{V_{fg}}$$

The free volume, V_{fg}, of the cask cavity is given in Section 3.3.4 as 7.56×10^6 cm^3. The quantity of radionuclides, S_n, is the sum of the radionuclide inventories that are assumed to be releasable. From Table 4.2-2, S_n is found to be 902 curies. Therefore:

$$C_n = 9.02 \times 10^2 / 7.56 \times 10^6$$
$$= 1.2 \times 10^{-4} \text{ Curies/cm}^3$$

From Section 4.2.3, the allowable release rate is:

Therefore:

$$L_{ndl} = \frac{R_n}{C_n} = \frac{6.97 \times 10^{-9}}{1.2 \times 10^{-4}}$$

$$= 5.8 \times 10^{-5}\ cm^3/sec$$

4.2.3.2 Permissible Release Rate for Canistered Fuel

The permissible release rate for canistered fuel is calculated using the same method as was used for directly loaded fuel above.

The free volume, V_{fg}, of the canister is given in Section 3.4.4 as $5.02 \times 10^6\ cm^3$. The quantity of radionuclides, S_n, is the sum of the radionuclide inventories that are assumed to be releasable. From Table 4.2-3, S_n is found to be 544 curies. Therefore:

$$C_n = 5.44 \times 10^2 / 5.02 \times 10^6$$
$$= 1.1 \times 10^{-4}\ Curies/cm^3$$

From Section 4.2.3, the allowable release rate is:

$$R_{nc} = 2.22 \times 10^{-5}\ curies/hour = 6.17 \times 10^{-9}\ curies/sec$$

Therefore:

$$L_{ndl} = \frac{R_n}{C_n} = \frac{6.17 \times 10^{-9}}{1.1 \times 10^{-4}}$$

$$= 5.6 \times 10^{-5}\ cm^3/sec$$

4.2.3.3 Permissible Release Rate for Canistered GTCC Waste

GTCC waste consists of irradiated and surface contaminated material, primarily stainless steel. The waste is enclosed in containers that have the same external dimensions as the Yankee Class

GTCC waste consists of irradiated and surface contaminated material, primarily stainless steel. The waste is enclosed in containers that have the same external dimensions as the Yankee Class fuel assemblies. The container shell has two small screened holes at each end. These holes allow water draining, but preclude the release of gross material from the container. The waste does not generate or release radioactive gases. The waste contains dross material from underwater sawing operations that partitioned the steel plates into sections that could be placed within the waste containers. The dross material is separately packaged.

Since the containers are enclosed, release of surface contamination and gross particulate material from the waste is not readily available. However, particulate material could pass through the screen at the lower end of the container and be released to the canister.

The estimated quantity of crud that could be available for release is assumed to be similar to that assumed for the canistered fuel, or 140μCi per square cm as Cobalt-60 (Section 4.2.3.). If the waste is conservatively assumed to have the same surface area as the spent fuel, and if all of the surface crud is assumed to be released, then from Table 4.3-2, the number of curies of Cobalt-60 per container is 15.5 curies, or about 373 curies per canister/cask.

This is much less than the 902 curies of total activity (Section 4.2.3.2) postulated to be available for release in normal conditions, even if all of the crud (Co-60) was simultaneously released. Consequently, the maximum permissible leakage rate for the GTCC waste containers is bounded by the canistered fuel configuration.

4.2.3.4 Correlation to Air Standard Conditions

The evaluation of permissible leakage rate in Sections 4.2.3.1, 4.2.3.2, and 4.2.3.3 shows that the smallest permissible leak rate occurs for canistered fuel. This leak rate, 5.6×10^{-5} cm^3/sec, is established as the bounding leak rate for correlation to air standard conditions.

The maximum permissible release must be correlated to an equivalent air leak rate at standard conditions, which depend on gas temperatures, pressures, and leakage path. This correlation requires calculation of the capillary diameter through which the postulated leak occurs. Depending on pressure and physical parameters of the leak path, the flow regime may be continuum, molecular or a combination of both.

The continuum volumetric flow rate of the gas (cm³/sec), L_c, is given by:

$$L_c = F_c(P_u - P_d) = \frac{2.48x10^6 D^4}{a\mu}(P_u - P_d)$$

where:

F_c	=	coefficient for continuum flow [cm³/atm-s]
D	=	capillary diameter [cm]
a	=	capillary length, 0.635 cm
μ	=	fluid viscosity (helium), 0.028 cP
P_u	=	upstream pressure, 1.77 atm
P_d	=	downstream pressure, 1.0 atm

The molecular volumetric flow rate of the gas (cm³/sec), L_m, is given by:

$$L_m = F_m(P_u - P_d) = \frac{3.81x10^3 D^3 \sqrt{\frac{T}{M}}}{aP_a}(P_u - P_d)$$

where:

F_m	=	coefficient for molecular flow [cm³/atm-s]
D	=	capillary diameter [cm]
T	=	gas temperature, 505°K
M	=	gas molecular weight, 4 g/mole
P_a	=	average pressure $(P_u+P_d)/2$, 1.38 atm

For this analysis, the gas temperature used for molecular flow analysis is the upstream temperature.

The allowable leak is assumed to be comprised of continuum and molecular flow. The leak is driven by the pressure difference that exists between the inside of the canister or cask, (P_u), and atmosphere (P_d). Consequently:

$$L_n = (F_c + F_m)(P_u - P_d)$$

where

$L_m = 5.6 \times 10^{-5}\ cm^3/sec$

If the expressions provided above are substituted for F_c and F_m respectively, the equation for total leak rate can be solved for the diameter, D, of the postulated leak path. Using iteration, the diameter of the postulated leak path is

$D = 8.3 \times 10^{-4}\ cm$

On the basis of the flow regime and capillary diameter (continuum/molecular flow regime) the standard leak rate is determined from ANSI 14.5-1987 equation B12. This equation is solved using the calculated value of D, and the standard conditions. The standard conditions are

Pu = 1.0 atm	T = 298°K	M = 29
Pd = 0.01 atm	Pa = 0.505 atm	υ = 0.0185 (air)

Using these substitutions in the following equation

$$L_R = 0.99\left[F_c\left(\frac{\mu}{0.0185}\right) + F_m\sqrt{\left(\frac{298}{T}\right)\left(\frac{M}{29}\right)} \times \left(\frac{P_a}{0.505}\right)\right]\ \text{std cm}^3/\text{s}$$

The reference air leak rate is found to be:

$L_{Rair} = 1.21 \times 10^{-4}$ std cm^3/sec

A reference air leak rate of 1.2×10^{-4} std cm^3/sec is selected as the design basis test leak rate. The sensitivity of the leak test shall be $6.0 \times 10^{-5}\ cm^3/sec$

Table 4.2-1 Principal Radionuclide Inventory - Design Basis Fuel

Constituent	Inventory - Directly Loaded Fuel[1]		Inventory - Canistered Fuel[2]	
Gases	Curies/Assembly	Curies/ Cask	Curies/Assembly	Curies/ Cask
Tritium	212	5,512	80.3	2,890
Krypton-85	3,390	88,140	1,390	50,000
Iodine-129	0.02	0.5	0.0	0.0
Crud				
Cobalt-60	20.8[3]	541[3]	15.5[3]	373[3]
Volatiles				
Cesium-134	8,410	218,660	2,880	103,680
Cesium-137	51,700	1,344,200	23,400	842,400
Ruthenium-106	2,250	58,500	605	21,780
Strontium-90	36,300	943,800	16,500	594,000
Fines				
Americium-241	784	20,384	502	18,072
Barium-137M	46,100	1,198,600	22,100	795,600
Cerium-144	1,000	26,000	240	8,640
Curium-244	1,240	32,240	464	16,704
Europium-154	3,630	94,380	1,550	55,800
Europium-155	1,530	39,780	697	25,092
Promethium-147	13,000	338,000	5,000	180,000
Plutonium-238	1,780	46,280	825	29,700
Plutonium-241	52,800	1,372,800	29,700	1,069,200
Rhodium-106	2,250	58,500	605	21,780
Antimony-125	693	18,018	271	9,756
Yttrium-90	36,400	946,400	16,500	594,000

(1) Based on 3.7 w/o initial enrichment, 40,000 MWD/MTU burnup, and 6.5 year cool time.
(2) Based on 3.7 w/o initial enrichment, 36,000 MWD/MTU burnup, and 8.0 year cool time.
(3) Section 4.2.3.1.

Table 4.2-2 Composite A_2 Value for Directly Loaded Fuel - Normal Conditions

	Crud	Gas	Volatiles	Fines	Total
Total Activity per Assembly (Ci)	3.12E+00	3.43E+03	9.87E+04	1.69E+05	2.72E+05
Releasable Activity per Cask (Ci)	8.13E+01	8.01E+02	1.54E+01	3.97E+00	9.02E+02
Cask Volumetric Activity (Ci/cm^3)	1.08E-05	1.06E-04	2.04E-06	5.25E-07	1.19E-04
A2 Value (Ci)	1.08E+01	2.81E+02	5.39E+00	1.74E-01	2.98E+02
Fraction of Activity	9.01E-02	8.88E-01	1.71E-02	4.40E-03	1.00E+00
Fraction of Activity / A2 (1/Ci)	8.34E-03	3.16E-03	3.17E-03	2.52E-02	3.99E-02
		Mixture A2 Value (Ci)			2.51E+01

Table 4.2-3 Composite A_2 Value for Canistered Fuel - Normal Conditions

	Crud	Gas	Volatiles	Fines	Total
Total Activity per Assembly (Ci)	1.55E+00	1.47E+03	4.34E+04	7.91E+04	1.24E+05
Releasable Activity per Cask (Ci	5.59E+01	4.76E+02	9.37E+00	2.56E+00	5.44E+02
Cask Volumetric Activity (Ci/c	1.11E-05	9.49E-05	1.87E-06	5.11E-07	1.08E-04
A2 Value (Ci)	1.08E+01	2.82E+02	5.31E+00	1.61E-01	2.98E+02
Fraction of Activity	1.03E-01	8.75E-01	1.72E-02	4.71E-03	1.00E+00
Fraction of Activity / A2 (1/Ci)	9.51E-03	3.11E-03	3.24E-03	2.92E-02	4.51E-02
		Mixture A2 Value (Ci)			2.22E+01

4.3 Containment Requirements For Hypothetical Accident Conditions

The NAC-STC has been designed to safely transport 26 design basis directly loaded PWR fuel assemblies, or in the canister configuration, up to 36 Yankee Class fuel assemblies or 24 containers of GTCC waste. The structural integrity of the cask containment during hypothetical accident conditions is demonstrated in Chapter 2. Therefore, the cask containment is maintained under hypothetical accident conditions. As described in Section 4.1, no containment credit is taken for the canister, even though the canister does not fail in the hypothetical accident conditions. As shown in Section 4.2.3.1.3, the only potential release from the GTCC waste canister is surface crud. The amount of crud (373 Ci) is very small compared to the potential release as shown in Tables 4.2-2 and 4.2-3 from either spent fuel transport configuration. Consequently, the canistered GTCC waste configuration is not evaluated.

4.3.1 Fission Gas Products

The calculated amounts of fission gases contained by the design basis directly loaded PWR fuel assembly for both normal and hypothetical accident conditions are reported in Table 4.2-1. The calculated values are reported in Table 4.2-1 for the design basis canistered fuel. The accident conditions for maximum fission gas release assume 100-percent fuel rod failure with 30 percent of the tritium and 30 percent of the krypton-85 available being released to the cask cavity. In addition, it is conservatively assumed that 100 percent of the cobalt-60 in the crud on the fuel assemblies is available for release as an aerosol. The analysis conservatively includes radionuclides categorized as volatiles and fission gas products.

4.3.2 Containment of Radioactive Material

The NAC-STC is designed to maintain a release rate of less than one A_2/week for the hypothetical accident conditions, as required by 10 CFR 71.51. A_2 for a mixed gas is determined using the method described in 10 CFR 71, Appendix A. A release rate of 10 A_2 curies/week of krypton-85 is allowed by 10 CFR 71.51(a)(2), in addition to the other radioactive isotopes. However, no credit is taken for this provision.

4.3.3 Containment Criterion for Accident Conditions

The NAC-STC is designed to meet the containment criteria of 10 CFR 71, which limits the release rate in accident conditions to A_2 per week. For hypothetical accident conditions, 100 percent of the fuel rods are assumed to fail and 30 percent of the tritium and krypton-85 is assumed to escape each failed rod. Other radiologically important gaseous nuclides are present only in negligible amounts. Additionally, 100 percent of the crud on the fuel assemblies is conservatively assumed to be available for release as an aerosol. NUREG/CR-6487 postulates the release of radionuclides categorized as volatile and fines from fuel rods that fail in the accident sequence of events. The postulated release fractions for volatiles and fines are the same as for normal conditions. The assumed release fractions are:

Radionuclide Origin	Fraction
Volatiles releasable	0.0002
Fission gas releasable	0.3
Rod fines released	0.00003
Crud spallation factor	1.0
Fuel rods that breach	1.0

These factors were applied to establish the releasable activity for directly loaded fuel as shown in Table 4.3-1, and in Table 4.3-2 for canistered fuel. The methodology used to calculate the activity concentration is presented in Section 4.5.5.1. The calculation of the A2 value for accident conditions is as described in Section 4.2.3.

The A_2 value for the postulated mixture of gases, volatiles, fines and crud is calculated in Table 4.3-1 for directly loaded fuel, and in Table 4.2-3 for canistered fuel. The composite A_2 value is 298 curies for both directly loaded and canistered fuel.

Since from 10 CFR 71.51 (a)(2), the maximum permissible leakage rate for accident conditions, (R_A), is: A_2 per week, the allowable release rate for directly loaded and canistered fuel is:

$$R_{adl} = R_{ac} = 298 \text{ curies/ week} = 4.9 \times 10^{-4} \text{ curies/ sec}$$

4.3.3.1 Permissible Leakage Rate for Directly Loaded Fuel

The allowable release rate for directly loaded fuel is calculated using:

$$L_{adl} = \frac{R_a}{C_a}$$

where:

$$C_a = \frac{S_a}{V_{fg}}$$

The free volume, V_{fg}, of the cask cavity is given in Section 3.3.4 as 7.56×10^6 cm^3. The quantity of radionuclides, S_a, is the sum of the radionuclide inventories that are assumed to be releasable. From Table 4.3-1, S_a is found to be 27,900 curies. Therefore:

$$C_a = 2.79 \times 10^4 / 7.56 \times 10^6$$
$$= 3.7 \times 10^{-3} \text{ Curies/ cm}^3$$

From Section 4.3.3, the allowable release rate is:

$$R_{adl} = 4.9 \times 10^{-4} \text{ curies/ sec}$$

Therefore:

$$L_{adl} = \frac{R_a}{C_a} = \frac{4.9 \times 10^{-4}}{3.7 \times 10^{-3}}$$

$$= 0.13 \text{ cm}^3\text{/sec}$$

4.3.3.2 Permissible Release Rate for Canistered Fuel

The allowable release rate for canistered fuel is calculated using the same method as was used for directly loaded fuel above.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

$$L^{c}_{nc} = \frac{R_A}{C_A} = \frac{4.9 \times 10^{-4}}{3.3 \times 10^{-3}}$$

$$= 0.15 \text{ cm}^3/\text{sec}$$

4.3.3.3 Maximum Permissible Leak Rate for Accident Conditions

The maximum permissible leak rate for accident conditions are 0.13 cm³/sec for directly loaded fuel and 0.15 cm³/sec for canistered fuel. These leak rates are significantly larger than those permitted for normal conditions. Consequently, the normal conditions leak rate requirements bound the accident condition leak rate requirement.

The reference leak rate for testing is established by the normal conditions of transport.

Table 4.3-1 Composite A_2 Value for Directly Loaded Fuel - Accident Conditions

	Crud	Gas	Volatiles	Fines	Total
Total Activity per Assembly (Ci)	N/C	3.43E+03	9.87E+04	1.69E+05	2.72E+05
Releasable Activity per Cask (Ci)	5.42E+02	2.67E+04	5.13E+02	1.32E+02	2.79E+04
Cask Volumetric Activity (Ci/cm³)	7.17E-05	3.53E-03	6.79E-05	1.75E-05	3.69E-03
A2 Value (Ci)	1.08E+01	2.81E+02	5.39E+00	1.74E-01	2.98E+02
Fraction of Activity	1.94E-02	9.57E-01	1.84E-02	4.74E-03	1.00E+00
Fraction of Activity / A2 (1/Ci)	1.80E-03	3.40E-03	3.41E-03	2.72E-02	3.58E-02
		Mixture A2 Value (Ci)			2.80E+01

Table 4.3-2 Composite A_2 Values for Canistered Fuel - Accident Conditions

	Crud	Gas	Volatiles	Fines	Total
Total Activity per Assembly (Ci)	N/C	1.47E+03	4.34E+04	7.91E+04	1.24E+05
Releasable Activity per Cask (Ci)	3.73E+02	1.59E+04	3.12E+02	8.55E+01	1.66E+04
Cask Volumetric Activity (Ci/cm³)	7.42E-05	3.16E-03	6.22E-05	1.70E-05	3.32E-03
A2 Value (Ci)	1.08E+01	2.82E+02	5.31E+00	1.61E-01	2.98E+02
Fraction of Activity	2.24E-02	9.54E-01	1.88E-02	5.13E-03	1.00E+00
Fraction of Activity / A2 (1/Ci)	2.07E-03	3.39E-03	3.53E-03	3.18E-02	4.08E-02
		Mixture A2 Value (Ci)			2.45E+01

This Page Intentionally Left Blank

4.5.5 Calculation of the A_2 Values for the Design Basis Fuel

SAS2H output is provided on a per assembly basis for the design basis directly loaded fuel (WE 17x17) and canistered fuel (CE 16 x 16) assemblies. Radionuclides are grouped into fission gases, volatiles, and fines. Volatiles and gases are defined as those radionuclides listed in NUREG/CR-6487. All remaining radionuclides are grouped as fines. A2 values were obtained from 10 CFR 71.

Table 4.5-1 A_2 Value for Fission Gas for Directly Loaded Fuel

Isotope	Curies	Fraction of Source	A2 Value	Frac/A2	A2
H 3	1.85E+02	5.40E-02	1080	5.00E-05	
I129	1.80E-02	5.26E-06	1E+60	5.26E-66	
KR 85	3.24E+03	9.46E-01	270	3.50E-03	
Total	3.43E+03			3.55E-03	281.401

Table 4.5-2 A_2 Value for Volatiles for Directly Loaded Fuel

Isotope	Curies	Fraction of Source	A2 Value	Frac/A2	A2
CS134	8.41E+03	8.52E-02	13.5	6.31E-03	
CS135	2.70E-01	2.74E-06	24.3	1.13E-07	
CS137	5.17E+04	5.24E-01	13.5	3.88E-02	
RU106	2.25E+03	2.28E-02	5.41	4.22E-03	
SR 90	3.63E+04	3.68E-01	2.7	1.36E-01	
Total	9.87E+04			1.86E-01	5.387

Table 4.5-3 A_2 Value for Fuel Fines for Directly Loaded Fuel

Isotope	Curies	Fraction of Source	A2 Value	Frac/A2	A2
TL208	9.26E-03	5.46E-08	5.00E-01	1.09E-07	
PB212	2.58E-02	1.52E-07	8.11E+00	1.88E-08	
BI212	2.58E-02	1.52E-07	8.11E+00	1.88E-08	
PO212	1.65E-02	9.74E-08	5.41E-04	1.80E-04	
PO216	2.58E-02	1.52E-07	5.41E-04	2.81E-04	
RN220	2.58E-02	1.52E-07	5.41E-04	2.81E-04	
RA224	2.58E-02	1.52E-07	1.62E+00	9.40E-08	
TH228	2.56E-02	1.51E-07	1.08E-02	1.40E-05	
TH231	7.77E-03	4.58E-08	2.43E+01	1.89E-09	
TH234	1.47E-01	8.67E-07	5.41E+00	1.60E-07	
PA233	1.94E-01	1.14E-06	2.43E+01	4.71E-08	
PA234M	1.47E-01	8.67E-07	5.00E-01	1.73E-06	
U232	3.24E-02	1.91E-07	8.11E-03	2.36E-05	
U234	4.38E-02	2.58E-07	2.70E-02	9.57E-06	
U235	7.77E-03	4.58E-08	1.00E+60	4.58E-68	
U236	1.46E-01	8.61E-07	2.70E-02	3.19E-05	
U237	1.26E+00	7.43E-06	5.00E-01	1.49E-05	
U238	1.47E-01	8.67E-07	1.00E+60	8.67E-67	
NP235	2.09E-04	1.23E-09	1.08E+03	1.14E-12	
NP237	1.94E-01	1.14E-06	5.41E-03	2.12E-04	
NP238	3.14E-02	1.85E-07	5.00E-01	3.71E-07	
NP239	1.35E+01	7.97E-05	1.35E+01	5.90E-06	
PU236	1.50E-01	8.85E-07	1.89E-02	4.68E-05	
PU238	1.78E+03	1.05E-02	5.41E-03	1.94E+00	
PU239	1.59E+02	9.38E-04	5.41E-03	1.73E-01	
PU240	2.38E+02	1.40E-03	5.41E-03	2.60E-01	
PU241	5.28E+04	3.12E-01	2.70E-01	1.15E+00	
PU242	1.15E+00	6.79E-06	5.41E-03	1.25E-03	
AM241	7.84E+02	4.63E-03	5.41E-03	8.55E-01	
AM242M	6.98E+00	4.12E-05	5.41E-03	7.61E-03	
AM242	6.95E+00	4.10E-05	5.41E-03	7.58E-03	
AM243	1.35E+01	7.97E-05	5.41E-03	1.47E-02	
CM242	6.34E+00	3.74E-05	2.70E-01	1.39E-04	
CM243	1.39E+01	8.20E-05	8.11E-03	1.01E-02	
CM244	1.24E+03	7.32E-03	1.08E-02	6.77E-01	
CM245	1.40E-01	8.26E-07	5.41E-03	1.53E-04	
CM246	3.97E-02	2.34E-07	5.41E-03	4.33E-05	

Table 4.5-3 A2 Value for Fuel Fines for Directly Loaded Fuel (continued)

Isotope	Curies	Fraction of Source	A2 Value	Frac/A2	A2
SE 79	3.80E-02	2.24E-07	5.41E+01	4.14E-09	
Y 90	3.64E+04	2.15E-01	5.41E+00	3.97E-02	
ZR 93	6.72E-01	3.96E-06	5.41E+00	7.33E-07	
NB 93M	2.16E-01	1.27E-06	1.62E+02	7.87E-09	
NB 95	1.34E-06	7.91E-12	2.70E+01	2.93E-13	
TC 99	7.51E+00	4.43E-05	2.43E+01	1.82E-06	
RH102	1.60E-01	9.44E-07	1.35E+01	6.99E-08	
RH106	2.25E+03	1.33E-02	5.00E-01	2.66E-02	
PD107	6.52E-02	3.85E-07	1.00E+60	3.85E-67	
AG108M	4.41E-03	2.60E-08	1.62E+01	1.61E-09	
AG110	2.32E-02	1.37E-07	5.00E-01	2.74E-07	
AG110M	1.71E+00	1.01E-05	1.08E+01	9.34E-07	
CD113M	1.16E+01	6.84E-05	2.43E+00	2.82E-05	
SN119M	5.55E-02	3.27E-07	1.08E+03	3.03E-10	
SN121	9.15E-01	5.40E-06	2.43E+01	2.22E-07	
SN121M	1.18E+00	6.96E-06	2.43E+01	2.87E-07	
SN123	2.83E-04	1.67E-09	1.35E+01	1.24E-10	
SB125	6.93E+02	4.09E-03	2.43E+01	1.68E-04	
TE125M	1.69E+02	9.97E-04	2.43E+02	4.10E-06	
SN126	3.07E-01	1.81E-06	8.11E+00	2.23E-07	
SB126	4.30E-02	2.54E-07	1.08E+01	2.35E-08	
SB126M	3.07E-01	1.81E-06	1.35E+01	1.34E-07	
TE127	5.38E-04	3.17E-09	1.35E+01	2.35E-10	
TE127M	5.49E-04	3.24E-09	1.35E+01	2.40E-10	
BA137M	4.61E+04	2.72E-01	5.00E-01	5.44E-01	
CE144	1.00E+03	5.90E-03	5.41E+00	1.09E-03	
PR144	1.00E+03	5.90E-03	5.00E-01	1.18E-02	
PR144M	1.40E+01	8.26E-05	5.00E-01	1.65E-04	
PM145	6.12E-02	3.61E-07	1.89E+02	1.91E-09	
SM145	4.25E-03	2.51E-08	5.41E+02	4.64E-11	
PM146	1.01E+00	5.96E-06	5.00E-01	1.19E-05	
PM147	1.30E+04	7.67E-02	2.43E+01	3.16E-03	
SM151	1.92E+02	1.13E-03	1.08E+02	1.05E-05	
EU152	2.65E+00	1.56E-05	2.43E+01	6.43E-07	
GD153	6.16E-03	3.63E-08	1.35E+02	2.69E-10	
EU154	3.63E+03	2.14E-02	1.35E+01	1.59E-03	
EU155	1.53E+03	9.03E-03	5.41E+01	1.67E-04	
Total	1.69E+05			6.28E-01	1.591E+00

Table 4.5-4 A_2 Value for Gas for Canistered Fuel

Isotope	Curies	Fraction of Source	A2 Value	Frac/A2	A2
H 3	8.03E+01	5.46E-02	1.08E+03	5.06E-05	
I129	8.33E-03	5.67E-06	1.00E+60	5.67E-66	
KR 85	1.39E+03	9.45E-01	2.70E+02	3.50E-03	
Total	1.47E+03			3.55E-03	2.82E+02

Table 4.5-5 A_2 Value for Volatiles for Canistered Fuel

Isotope	Curies	Fraction of Source	A2 Value	Frac/A2	A2
CS134	2.88E+03	6.64E-02	1.35E+01	4.92E-03	
CS135	1.30E-01	3.00E-06	2.43E+01	1.23E-07	
CS137	2.34E+04	5.39E-01	1.35E+01	4.00E-02	
RU106	6.05E+02	1.39E-02	5.41E+00	2.58E-03	
SR 90	1.65E+04	3.80E-01	2.70E+00	1.41E-01	
Total	4.34E+04			1.88E-01	5.31E+00

Table 4.5-6 A_2 Value for Fuel Fines for Canistered Fuel

Isotope	Curies	Fraction of Source	A2 Value	Frac/A2	A2
TL208	4.93E-03	6.23E-08	5.00E-01	1.25E-07	
PB212	1.37E-02	1.73E-07	8.11E+00	2.13E-08	
BI212	1.37E-02	1.73E-07	8.11E+00	2.13E-08	
PO212	8.78E-03	1.11E-07	5.41E-04	2.05E-04	
PO216	1.37E-02	1.73E-07	5.41E-04	3.20E-04	
RN220	1.37E-02	1.73E-07	5.41E-04	3.20E-04	
RA224	1.37E-02	1.73E-07	1.62E+00	1.07E-07	
TH228	1.37E-02	1.73E-07	1.08E-02	1.60E-05	
TH231	5.46E-03	6.90E-08	2.43E+01	2.84E-09	
TH234	7.53E-02	9.52E-07	5.41E+00	1.76E-07	
PA233	9.81E-02	1.24E-06	2.43E+01	5.10E-08	
PA234M	7.53E-02	9.52E-07	5.00E-01	1.90E-06	
U232	1.65E-02	2.09E-07	8.11E-03	2.57E-05	
U234	2.27E-02	2.87E-07	2.70E-02	1.06E-05	
U235	5.46E-03	6.90E-08	1.00E+60	6.90E-68	
U236	7.08E-02	8.95E-07	2.70E-02	3.31E-05	
U237	7.11E-01	8.98E-06	5.00E-01	1.80E-05	
U238	7.53E-02	9.52E-07	1.00E+60	9.52E-67	
NP237	9.81E-02	1.24E-06	5.41E-03	2.29E-04	
NP238	1.64E-02	2.07E-07	5.00E-01	4.14E-07	
NP239	5.57E+00	7.04E-05	1.35E+01	5.21E-06	
PU236	6.12E-02	7.73E-07	1.89E-02	4.09E-05	
PU238	8.25E+02	1.04E-02	5.41E-03	1.93E+00	
PU239	1.00E+02	1.26E-03	5.41E-03	2.34E-01	
PU240	1.14E+02	1.44E-03	5.41E-03	2.66E-01	
PU241	2.97E+04	3.75E-01	2.70E-01	1.39E+00	
PU242	4.70E-01	5.94E-06	5.41E-03	1.10E-03	
AM241	5.02E+02	6.34E-03	5.41E-03	1.17E+00	
AM242M	3.64E+00	4.60E-05	5.41E-03	8.50E-03	
AM242	3.63E+00	4.59E-05	5.41E-03	8.48E-03	
AM243	5.57E+00	7.04E-05	5.41E-03	1.30E-02	
CM242	3.06E+00	3.87E-05	2.70E-01	1.43E-04	
CM243	6.03E+00	7.62E-05	8.11E-03	9.40E-03	
CM244	4.64E+02	5.86E-03	1.08E-02	5.43E-01	
CM245	6.21E-02	7.85E-07	5.41E-03	1.45E-04	
CM246	1.27E-02	1.60E-07	5.41E-03	2.97E-05	

Table 4.5-6 A_2 Values for Fuel Fines for Canistered Fuel (continued)

Isotope	Curies	Fraction of Source	A2 Value	Frac/A2	A2
Y 90	1.65E+04	2.09E-01	5.41E+00	3.85E-02	
ZR 93	3.08E-01	3.89E-06	5.41E+00	7.19E-07	
NB 93M	1.04E-01	1.31E-06	1.62E+02	8.11E-09	
TC 99	3.45E+00	4.36E-05	2.43E+01	1.79E-06	
RH102	6.20E-02	7.83E-07	1.35E+01	5.80E-08	
RH106	6.05E+02	7.65E-03	5.00E-01	1.53E-02	
PD107	2.97E-02	3.75E-07	1.00E+60	3.75E-67	
AG108M	2.04E-03	2.58E-08	1.62E+01	1.59E-09	
AG110	4.36E-03	5.51E-08	5.00E-01	1.10E-07	
AG110M	3.21E-01	4.06E-06	1.08E+01	3.76E-07	
CD113M	5.08E+00	6.42E-05	2.43E+00	2.64E-05	
SN119M	1.29E-02	1.63E-07	1.08E+03	1.51E-10	
SN121	4.19E-01	5.29E-06	2.43E+01	2.18E-07	
SN121M	5.40E-01	6.82E-06	2.43E+01	2.81E-07	
SN123	2.35E-05	2.97E-10	1.35E+01	2.20E-11	
SB125	2.71E+02	3.42E-03	2.43E+01	1.41E-04	
TE125M	6.62E+01	8.37E-04	2.43E+02	3.44E-06	
SN126	1.41E-01	1.78E-06	8.11E+00	2.20E-07	
SB126	1.98E-02	2.50E-07	1.08E+01	2.32E-08	
SB126M	1.41E-01	1.78E-06	1.35E+01	1.32E-07	
TE127	3.04E-05	3.84E-10	1.35E+01	2.85E-11	
TE127M	3.10E-05	3.92E-10	1.35E+01	2.90E-11	
BA137M	2.21E+04	2.79E-01	5.00E-01	5.59E-01	
CE144	2.40E+02	3.03E-03	5.41E+00	5.61E-04	
PR144	2.40E+02	3.03E-03	5.00E-01	6.07E-03	
PR144M	3.35E+00	4.23E-05	5.00E-01	8.47E-05	
PM145	2.21E-02	2.79E-07	1.89E+02	1.48E-09	
SM145	8.37E-04	1.06E-08	5.41E+02	1.96E-11	
PM146	4.65E-01	5.88E-06	5.00E-01	1.18E-05	
PM147	5.00E+03	6.32E-02	2.43E+01	2.60E-03	
SM151	1.17E+02	1.48E-03	1.08E+02	1.37E-05	
EU152	1.30E+00	1.64E-05	2.43E+01	6.76E-07	
GD153	7.03E-04	8.88E-09	1.35E+02	6.58E-11	
EU154	1.55E+03	1.96E-02	1.35E+01	1.45E-03	
EU155	6.97E+02	8.81E-03	5.41E+01	1.63E-04	
TOTAL	7.91E+04			6.23E-01	1.60E+00

4.5.5.1 Calculation of Radionuclide Concentration

The calculation of radionuclide concentration applies the methodology suggested by NUREG/CR-6487. The variables used in the calculation of the contribution of each of the assumed radionuclide groups is presented below. The results of the calculations are shown in Tables 4.2-2 for directly loaded fuel, and 4.2-3 for canistered fuel for normal conditions of transport, and in Tables 4.3-1 and 4.3-2, respectively, for accident conditions.

The total activity concentration, C_n, is

$$C_n = C_{Crud} + C_{Volatiles} + C_{FissionGas} + C_{Fines}$$

and

$$C_{Crud} = \frac{f_C M_T}{V} = \frac{f_C S_C N_A (N_R S_{AR} + S_{CT})}{V}$$

where

C_{crud}	=	activity density inside containment vessel resulting from crud spallation [Ci/cm³]
M_T	=	total crud activity inventory [Ci]
f_C	=	crud spallation factor
V	=	free volume inside containment vessel [cm³]
S_C	=	crud surface activity [Ci/cm²]
N_R	=	number of fuel rods per assembly
N_A	=	number of assemblies
S_{AR}	=	surface area per rod [cm²]

$$C_{fines} = \frac{f_F W_R A_R N_R N_A f_B}{V}$$

where:

C_{fines}	=	activity concentration inside containment vessel resulting from fines released from cladding breaches [Ci/cm³]
f_E	=	fraction of fuel rod's mass released as fines resulting from cladding breach
f_B	=	fraction of fuel rods that develop cladding breach
W_R	=	mass of the fuel in fuel rod [g]
N_R	=	number of fuel rods per assembly

N_A = number of assemblies

A_R = specific activity of fines emitted from cladding breach in fuel rod [Ci/g]

V = containment vessel void volume [cm³]

$$C_{vol\&gas} = C_{vol} + C_{gas} = \frac{N_R N_A f_B W_R (A_V f_V + A_G f_G)}{V}$$

where

$C_{vol\&gas}$ = releasable activity concentration inside the containment vessel resulting from gases and volatiles released from cladding breaches [Ci/cm³]

C_{vol} = releasable activity concentration inside the containment vessel resulting from volatiles released from cladding breaches [Ci/cm³]

C_{gas} = releasable activity concentration inside the containment vessel resulting from gases released from cladding breaches [Ci/cm³]

W_R = mass of the fuel in a fuel rod [g]

N_R = number fuel rods per assembly

N_A = number of assemblies

f_B = fraction of rods that develop cladding breaches

A_V = specific activity of volatiles in fuel rod [Ci/g]

f_V = fraction of volatiles in fuel rod released if rod develops cladding breach

A_G = specific activity of gas in fuel rod [Ci/g]

f_G = fraction of gas that would escape from fuel rod that develops cladding breach

V = is the void volume inside containment vessel [cm³].

4.5.5.2 Activity Values for Radionuclides

A_2 values used in this analysis (based on 10 CFR 71 Appendix A) are listed in Section 4.5.5.1 for all radionuclides produced by the SAS2H analysis (plus Co^{60}). For those isotopes for which no specific A_2 values are given, the generic values listed in 10 CFR 71, Table A.2, are applied. A_2 values for gases of mixed isotopes are calculated from the following:

$$A_2 = \frac{1}{\sum \frac{F_i}{A_2^i}}$$

where

$$F_i = \frac{S_i}{S_n}$$

and

F_i = The fraction of isotope i with respect to the entire mixture
S_i = The activity of isotope i (Ci)
S_n = Total gas activity (Ci)

Mixture A_2 values are determined for gas, volatile, fine, and crud mixtures and are then combined for a total cask mixture A_2 value. Tables 4.2-2 and 4.2-3 provide the source terms and A_2 values for design basis directly loaded and canistered fuel release rate calculations for normal and accident conditions.

5.0 SHIELDING EVALUATION

The NAC-STC is designed to safely transport intact spent fuel assemblies in two configurations. The fuel assemblies may be placed directly into a fuel basket installed in the cask cavity (uncanistered), or sealed in a transportable storage canister (canistered). The design basis fuels for the uncanistered configuration are the Westinghouse 17 x 17 or 15 x 15 PWR fuel assemblies. These fuels bound smaller array Westinghouse, and similar Babcock & Wilcox, and Combustion Engineering PWR fuel assemblies. The design basis fuel for the canistered configuration is the Yankee Class Combustion Type A 16 x 16 fuel assembly. In the uncanistered configuration, the NAC-STC can transport 26 directly loaded PWR fuel assemblies. In the canistered configuration, the NAC-STC can transport up to 36 Yankee Class fuel assemblies.

The NAC-STC can also safely transport Greater Than Class C (GTCC) waste. The GTCC waste is contained in a canister (see Drawing 455-888 Section 1.3.2) that is the same size as to the fuel loaded canister. Thus, the GTCC canister may be loaded in the NAC-STC for transport. The GTCC canister contains 24 GTCC waste containers inserted in a basket with eight support disks. The maximum radiation source term of a GTCC canister is shown in Table 5.2-6.

The NAC-STC is assigned a nominal Transport Index of 20 (TI = 20) based on the requirement of 10 CFR 71.4 and the analysis of Section 5.1.4. As shown in Table 5.1-10, the maximum dose rate at 1 meter from the NAC-STC in normal conditions of transport is 19.5 mrem per hour. This dose rate is based on the design basis fuel and the actual measured dose rate is expected to be less.

The NAC-STC uses an optimized multiwall design to provide the most efficient shielding arrangement possible, and to comply with 10 CFR 71 limits. This chapter provides a description of the NAC-STC shield design and the conservative shielding analyses used to determine the transport dose rates. This analysis is based on the transport of 26 directly loaded (uncanistered) fuel assemblies. The analysis for canistered fuel demonstrates that the radiation source term for the canistered configuration is less than that for the directly loaded (uncanistered) configuration. Consequently, the canistered configuration shielding evaluation is bounded by the uncanistered fuel evaluation. This bounding shielding evaluation does not consider the additional shielding from the canister shell, lids, and bottom plate, and the additional self-shielding due to the more compact array of the canistered configuration. Also, the dose rates for the canistered GTCC

waste are shown to be less than those for the directly loaded fuel configuration for both normal and accident conditions.

The shielding analyses use the SAS2H sequence (Hermann, 1990) of the SCALE4 package (SCALE) to calculate radiation sources. This sequence uses the computer code ORIGEN-S (Hermann, 1989) to calculate the source terms. The QAD-CGGP (QAD-CGGP), XSDRNPM

(Greene, 1983), XSDOSE (Bucholz, 1981) and MORSE (West) computer codes are used to calculate the cask dose rates for normal transport and hypothetical accident conditions. The shielding analyses show that the dose rates are below the regulatory limits stated in 10 CFR 71 and IAEA Safety Series No. 6.

The shielding calculation dose rate results for a large array of detector points are presented in Tables 5.1-10 through 5.1-12 for the all-aluminum directly loaded basket with the borated aluminum tube design models presented in this chapter. As described in Chapter 1, and as shown on the License Drawings in Section 1.3.2, the NAC-STC directly loaded basket has been modified to incorporate Type 17-4 PH stainless steel disks and rods as the structural components of the basket. In addition, the 26 borated aluminum tubes have been replaced with fuel tubes manufactured from Type 304 stainless steel sheets encasing 0.075-inch thick BORAL sheets. Twenty 5/8-inch thick aluminum disks are located between the 0.5-inch thick Type 17-4 PH stainless steel disks in the central axial region of the basket to provide improved heat transfer. Therefore, the overall basket design concept of solid tubes supported by disks is maintained. The all-aluminum directly loaded basket design and corresponding shielding analysis model contained 27 aluminum disks while the stainless steel/aluminum basket utilizes 33 Type 17-4 PH stainless steel disks and 20 6061-T6 aluminum heat transfer disks. The overall design similarity allows a reasonable comparative analysis to be performed to evaluate the shielding effectiveness of the two directly loaded basket designs. In addition, the minimum cool time for the design basis PWR fuel assembly has been increased from 5 years to 6.5 years, which results in reduced neutron and gamma source terms. The new source terms for the longer cooled design basis fuel assembly are provided in Table 5.1-5. Comparison of 5 and 6.5 years cooled source terms shows a 15 percent reduction in heat load, approximately 22 percent reduction in fission product source, a 5 percent reduction in neutron source and a 27 percent reduction in hardware activation source. All of these reductions in source terms will lead to lower dose rates relative to the 5-year cooled source terms.

Evaluations have been performed to allow conclusions to be made that the calculated dose rates reported in Tables 5.1-10 through 5.1-12 for the all-aluminum directly loaded basket containing 26 design basis PWR fuel assemblies cooled for 5 years are representative of, or enveloping for the dose rates of the NAC-STC with the stainless steel/aluminum directly loaded basket containing 26 design basis fuel assemblies cooled 6.5 years. It should also be noted that the gamma radiation is shielded primarily by the stainless steel/lead/stainless steel cask body, and

This Page Intentionally Left Blank

5.1 Discussion and Results

The radiation protection provided by the NAC-STC is in the form of solid multi-walled shielding materials which totally surround the fuel. These shielding materials include steel and lead for gamma shielding and a borated polymer (BISCO NS4FR) for neutron shielding. The multi-walled arrangement of steel and lead in the NAC-STC provides optimal weight for gamma attenuation. The NS4FR neutron shielding material has a hydrogen density close to that of water and serves to moderate fast neutrons which are then captured in the boron. Boron capture in the neutron shield minimizes the contribution of secondary capture gammas to surface dose rates.

The NAC-STC uses a multi-walled arrangement for both radial and axial shields. The arrangement of the radial gamma shielding in the cask body is a 1.5-inch thick stainless steel inner shell and a 2.65-inch thick stainless steel outer shell with a 3.70-inch thick lead filled annulus between them. The radial neutron shield is arranged around the outer steel shell with a 5.5-inch thick NS4FR layer which is covered by a 0.25-inch (6 mm) thick neutron shield shell. The bottom of the cask contains a steel/NS4FR/steel shield arrangement with the two stainless steel components providing 11.65 inches of gamma shielding and 2 inches of NS4FR neutron shielding. The top of the cask has shields in the form of two closure lids. The inner lid also has a steel/NS4FR/steel arrangement with 6.0 inches of steel below 2 inches of NS4FR and 1.0 inch of steel above it. The outer lid is a 5.25-inch thick steel disk.

5.1.1 Design Criteria

The shielding design criteria for the NAC-STC meet the requirements of 10 CFR 71 and IAEA Safety Series No. 6. The dose rate limits specified in 10 CFR 71.47 and paragraph 469 of IAEA Safety Series No. 6 for normal transport conditions are 200 mrem/hour on the surface of the package and 10 mrem/hour at 2 meters from the vertical planes represented by the outer lateral surfaces of the transport vehicle. The design objective for the NAC-STC limits the radial surface dose rate to 50 mrem/hour. This design objective has been achieved at all radial surfaces except at the port covers and at small areas near the top and bottom of the neutron shield. The surface dose rates at all locations except the port covers are less than 200 mrem/hour. The dose rate at the personnel barrier, which is the accessible surface of the package, adjacent to the port cover region, is significantly less than 200 mrem/hr. The 10 mrem/hour criterion has also been met at all locations 2 meters from the railcar. The 10 CFR 71.51 and IAEA Safety Series No. 6 (paragraph 542) dose rate limits for the hypothetical accident conditions are 1000 mrem/hour at 1 meter from the surface of the cask. This criterion has also been met at all locations.

The accessible surface of the package is defined as a personnel barrier that will be on the same plane as the outer radial surface of the top half of the impact limiters. The personnel barrier will attach to the edge of the railcar between the impact limiters. The personnel barrier location is shown in NAC Drawing No. 423-901 (Section 1.3.2).

The transportable storage canister may contain one or more reconfigured fuel assemblies. The reconfigured fuel assembly is designed to confine Yankee Class spent fuel rods, or portions thereof, which have been classified as failed. Each assembly can accommodate up to a total of 64 fuel pins. Due to the low number of pins, the reconfigured assembly fuel mass is significantly less than the fuel mass contained in the design basis assemblies presented in sections 5.1.2.1 and 5.1.2.2. Because source term (neutron and gamma) is directly proportional to fuel mass, for a given burnup, the reconfigured assembly source term is bounded by that of the design basis Yankee Class fuel assemblies. Consequently, a rigorous shielding analysis is not required for the reconfigured fuel assembly.

5.1.2 Design Basis Fuel

The NAC-STC has two configurations for transport of design basis fuel. The first is for fuel loaded directly into a basket in the cask cavity, referred to as the uncanistered configuration. The design basis fuel for the uncanistered configuration is described in Section 5.1.2.1. The second configuration is for canistered Yankee Class fuel. The design basis fuel for shielding for this configuration is described in Section 5.1.2.2.

5.1.2.1 Design Basis Directly Loaded Fuel

The design basis fuel in the NAC-STC for shielding purposes is the Westinghouse 17 x 17 PWR assembly with an initial enrichment of 3.7 percent, a uranium mass of 469 kilograms, a burnup of 40,000 MWD/MTU and 5.0 years cooling time. The source terms for this Westinghouse 17 x 17 PWR assembly are higher than the other Westinghouse PWR assemblies and the Combustion Engineering and Babcock & Wilcox fuel assemblies to be shipped in the NAC-STC.

The NAC-STC can transport up to 26 intact PWR fuel assemblies. The 5-year cooled design basis fuel characteristics are given in Table 5.1-1. The design basis fuel characteristics for the 6.5-year cool time are given in Table 5.1-2. The design basis fuel physical parameters are presented in Table 5.1-3.

For fuel assemblies with a burnup of 40,000 MWD/MTU, the fuel requires a minimum of 5 years of cooling after discharge to meet the neutron and gamma source, and the decay heat limits specified in Table 5.1-4. Table 5.1-5 contains the source terms for the design basis fuel with a burnup of 40,000 MWD/MTU and a 6.5-year cool time. Fuel assemblies with burnups of 45,000 MWD/MTU and 10 years cooling time can also be accommodated in the NAC-STC. The source characteristics of this fuel are given in Table 5.1-6. These source terms were calculated for an initial enrichment of 4.0 w/o, the minimum expected value of enrichment that will achieve a burnup of 45,000 MWD/MTU.

This Page Intentionally Left Blank

Table 5.1-10 Combined Dose Rates for Normal Transport Conditions (26 PWR assemblies, 40,000 MWD/MTU, 5-year cool time)

Location	Detector I.D.	Radiation	Normal Dose Rate (mrem/hr)
Radial Surface, fuel midplane!	1	Neutron Fuel Gamma Grid Spacer Gamma TOTAL	6.58 29.15 7.04 42.77
Radial, 1m from cask surface, fuel midplane!	2	Neutron Fuel Gamma Grid Spacer Gamma TOTAL	2.67 13.53 3.28 19.48
Radial, 2m from transport vehicle, fuel midplane!	3	Neutron Fuel Gamma Grid Spacer Gamma TOTAL	1.20 5.43 1.33 7.96
Bottom impact limiter surface, axial centerline	4	Neutron Fuel Gamma Grid Spacer Gamma End-Fitting Gamma TOTAL	0.01 0.94 0.15 2.09 3.19
Bottom, 2m from surface of impact limiter, axial centerline	5	Neutron Fuel Gamma Grid Spacer Gamma End-Fitting Gamma TOTAL	0.003 0.37 0.06 0.82 1.25

! A neutron peaking factor of $(1.2)^{4.2} = 2.15$ is applied to the detector locations at or near the radial midplane of the fuel region.

Table 5.1-10 Combined Dose Rates for Normal Transport Conditions (continued) (26 PWR assemblies, 40,000 MWD/MTU, 5-year cool time)

Location	Detector I.D.	Radiation	Normal Dose Rate (mrem/hr)
Top impact limiter surface, axial centerline	6	Neutron	0.003
		Fuel Gamma	0.11
		Grid Spacer Gamma	0.009
		End-Fitting Gamma	0.23
		Plenum Spring Gamma	0.13
		TOTAL	0.48
Top, 2m from surface of impact limiter, axial centerline	7	Neutron	0.001
		Fuel Gamma	0.04
		Grid Space Gamma	0.003
		End-Fitting Gamma	0.05
		Plenum Spring Gamma	0.09
		TOTAL	0.18
Top end fitting midplane, radial surface	8	Neutron	0.63
		Fuel Gamma	2.07
		Grid Spacer Gamma	0.89
		End-Fitting Gamma	5.86
		Plenum Spring Gamma	9.77
		TOTAL	19.22
Radial surface, above the neutron and gamma shields	9	Neutron	97.62
		Fuel Gamma	1.36
		Grid Spacer Gamma	0.20
		End-Fitting Gamma	17.76
		Plenum Spring Gamma	79.24
		TOTAL	196.18
Surface of the interlid and pressure port covers	9a	Neutron	75.84
		Fuel Gamma	0.17
		Grid Spacer Gamma	0.19
		End-Fitting Gamma	258.03
		Plenum Spring Gamma	7.36
		TOTAL	341.59

Table 5.1-10 Combined Dose Rates for Normal Transport Conditions (continued) (26 PWR assemblies, 40,000 MWD/MTU, 5-year cool time)

Location	Detector I.D.	Radiation	Normal Dose Rate (mrem/hr)
Surface of personnel barrier (32cm from port cover surfaces) at interlid and pressure port covers	9b	Neutron Fuel Gamma Grid Spacer Gamma End-Fitting Gamma Plenum Spring Gamma TOTAL	14.76 1.87 0.40 22.32 4.48 43.83
Radial surface, midplane of the bottom end-fittings	10	Neutron Fuel Gamma Grid Spacer Gamma End-Fitting Gamma TOTAL	9.27 3.02 1.04 5.86 19.19
Radial surface above rotation trunnion recess	10a	Neutron Fuel Gamma Grid Spacer Gamma End-Fitting Gamma TOTAL	48.93 0.64 0.18 0.15 49.90
Radial, above the neutron and gamma shields, 2m from the transport vehicle	11	Neutron Fuel Gamma Grid Spacer Gamma End-Fitting Gamma Plenum Spring Gamma TOTAL	1.02 2.64 0.57 0.77 0.69 5.69
Radial, below the neutron and gamma shields, 2m from the transport vehicle	12	Neutron Fuel Gamma Grid Spacer Gamma End-Fitting Gamma TOTAL	0.52 2.07 0.60 0.36 3.55

Table 5.1-11 Hypothetical Accident - Loss of Neutron Shielding (26 PWR assemblies, 40,000 MWD/MTU, 5-year cool time)

Location	Detector I.D.	Radiation	Normal Dose Rate (mrem/hr)
Radial, 1m from cask surface, fuel midplane, without neutron shield	2a	Neutron	485.74
		Fuel Gamma	37.33
		Grid Spacer Gamma	10.49
		TOTAL	533.56
Bottom, 1m from cask surface, axial centerline, without neutron shield (assumes loss of impact limiter)	4	Neutron	112.30
		Fuel Gamma	9.66
		Grid Spacer Gamma	3.02
		End-Fitting Gamma	42.11
		TOTAL	167.09
Top, 1m from cask surface, axial centerline, without neutron shield (assumes loss of impact limiter)	6	Neutron	52.88
		Fuel Gamma	1.24
		Grid Spacer Gamma	0.18
		End-Fitting Gamma	4.23
		Plenum Spring Gamma	2.21
		TOTAL	60.74
Radial, 1m from cask surface, fuel midplane (side drop)	2	Neutron	2.67
		Fuel Gamma	62.10
		Grid Spacer Gamma	15.06
		TOTAL	79.83
Radial, 1m from cask surface, top end-fitting (end drop)	13	Neutron	7.21
		Fuel Gamma	2.77
		Grid Spacer Gamma	0.80
		End-Fitting Gamma	173.15
		Plenum Spring Gamma	8.62
		TOTAL	192.55

A complete loss of neutron shielding is not credible for the NAC-STC. However, because of the elevated fire accident temperatures, the neutron shields exceed their safe operating limits and some neutron shielding capability may be lost.

A neutron peaking factor of $(1.2)^{4.2} = 2.15$, is applied to the detector locations at or near the radial midplane of the fuel region.

Table 5.1-12 Hypothetical Accident - Lead Slump

(26 PWR assemblies, 40,000 MWD/MTU, 5-year cool time)

Location	Detector I.D.	Radiation	Normal Dose Rate (mrem/hr)
Radial, 1m from cask surface, fuel midplane (side drop)[1]	2	Neutron	2.67
		Fuel Gamma	62.10
		Grid Spacer Gamma	15.06
		TOTAL	79.83
Radial, 1m from cask surface, top end-fitting (end drop)	13	Neutron	7.21
		Fuel Gamma	2.77
		Grid Spacer Gamma	0.80
		End-Fitting Gamma	173.15
		Plenum Spring Gamma	8.62
		TOTAL	192.55

1 A neutron peaking factor of $(1.2)^{4.2} = 2.15$, is applied to the detector locations at or near the radial midplane of the fuel region.

Table 5.1-13 - Canistered GTCC Waste Normal Transport Conditions Dose Rate

Detector Location	Detector Number (Figure 5.4-3)	Normal Condition Dose Rate (mr/hr)
Top end, surface	1	0.00
Top end, 1 meter	2	0.00
Top end, 2 meters	3	0.00
Top end, 4 meters	4	0.00
Bottom end, surface	5	2.54
Bottom end, 1 meter	6	1.14
Bottom end, 2 meters	7	0.46
Bottom end, 4 meters	8	0.12
Midplane, surface	9	7.03
Midplane, 1 meter	10	3.17
Midplane, 2 meters	11	1.78
Midplane, edge railcar	12	1.49
Midplane, 3 meters	13	1.09

regions considered in these radial calculations must be homogeneous. The one-dimensional radial geometry used with XSDRNPM is described in Section 5.3-1. The material densities used are described in Section 5.3-3. The cavity is modeled as two regions: the fuel region, using the effective fuel radius; and the homogenized basket-disk region, comprising the annulus between the fuel region and the inner shell. Separate runs are needed for the fuel neutrons and gammas and for the grid spacer gammas. Dose rates are calculated on the surface of the cask, at one meter away from the surface (Locations 1 and 2 in Figure 5.1-1) and at two meters from the personnel barrier (Location 3 in Figure5.1-1). In actuality, the fuel source has an axial cosine distribution, with the peak around the fuel midplane, as shown in Figure 5.3-5 and detailed in Table5.4-1. This axial peaking results in higher dose rates near the cask midplane which can be accounted for by a correction factor. These factors can be determined by the use of a three-dimensional code. The QAD-CGGP code is used for this purpose by calculating homogeneous-to-heterogeneous geometry and axial peaking-to-flat flux correction factors which are used to correct the XSDRNPM/XSDOSE results. The iron buildup factor was used in all of the QAD-CGGP calculations. Two QAD-CGGP runs are performed. The first run is performed using a flat axial source distribution and homogeneous modeling of the basket disk region. The second run is performed with a discrete axial source distribution and heterogeneous modeling of the basket disk region. The correction factors are determined by dividing the heterogeneous peaked source dose rates, by the homogeneous flat source dose rates. The previously calculated XSDRNPM/XSDOSE dose rate contributions from fuel neutrons, fuel gammas, and grid spacer gammas are multiplied by these source-specific correction factors to calculate conservative dose rates at locations along the midplane of the cask.

The loss of neutron shield radial calculations were performed using the same one-dimensional radial model and methodology described for normal transport conditions but with the radial neutron shield region voided. The higher neutron dose rates that resulted from this calculation are shown in Table 5.1-11.

The radial transition region dose rate calculations are performed using the three-dimensional MORSE computer code. An explicitly detailed three-dimensional model of the NAC-STC is developed, including the port cover void in the upper transition region, and the rotation trunnion recess in the lower transition region. The basket disks are modeled explicitly in the basket disk region of the model, and the fuel source region is conservatively assumed to have a flat axial distribution. Two series of runs are performed to determine the dose rates around the upper and lower transition regions. For the dose points near the upper transition regions, five separate runs

are performed. The runs performed are for the fuel neutron, fuel gamma, grid spacer gamma, plenum spring gamma, and upper end-fitting gamma source terms. The results of each of these runs are summed to determine the total dose rate at each detector location. For the lower transition region calculation, four runs were needed. The runs modeled the fuel neutron, fuel gamma, grid spacer gamma, and lower end-fitting gamma source terms. Additional detectors are located along the cask midplane. These dose locations were used to compare the MORSE dose rates with the corrected XSDRNPM/XSDOSE dose rates to verify consistency in the calculational techniques. The dose rates calculated by the different methods agreed well, with differences typically less than five percent. The end drop lead slump accident was also analyzed using the MORSE computer code and the three-dimensional model described in Section 5.3.1 (Figure 5.3-8). The results are presented in Table 5.1-12.

5.4.3 Axial Shielding Calculations

The one-dimensional XSDRNPM computer code was used to calculate fluxes in the axial directions. The top and bottom geometry models and the densities used are described in Sections 5.3.2 and 5.3.3, respectively. A buckling factor, equal to the diameter of the cask, is used in the XSDRNPM input to account for the particle leakage associated with the finite radial dimensions of the cask not described in an infinite slab model. For the top axial model, separate runs are performed for the fuel neutron, fuel gamma, grid spacer gamma, plenum spring gamma, and upper end-fitting gamma source terms. For the bottom axial model, separate runs are performed for the fuel neutron, fuel gamma, grid spacer gamma, and lower end-fitting gamma source terms. The fuel region sources in both models are conservatively assumed to have a flat axial profile.

The fluxes calculated by XSDRNPM are then used in XSDOSE to calculate dose rates at the surface, and two meters away from the surface of the top and bottom impact limiters (positions 4 through 7 of Figure 5.1-1 and Table 5.1-10). As indicated in Tables 5.1-10, 5.1-11, and 5.1-12, a neutron peaking factor of 2.15 ($(1.2)^{4.2}$) is applied in radial midplane dose rate calculations. XSDOSE uses a circular disk source for both the top end and bottom end calculations, with the actual diameter of the cask as the diameter of the disk source. The results obtained from these calculations were compared to results calculated by the QAD-CGGP and MORSE three-dimensional codes. The results of these three-dimensional calculations showed good agreement with those calculated using XSDRNPM/XSDOSE. In all cases, as would be expected, the one-dimensional analyses resulted in higher dose rates than those calculated using the three-dimensional codes.

6.0 CRITICALITY EVALUATION

6.1 Discussion and Results

The NAC-STC is designed to safely transport intact spent fuel assemblies in two configurations. The fuel assemblies may be sealed in a transportable storage canister (canistered), or placed directly into a fuel basket installed in the cask cavity (uncanistered). In the canistered configuration, the NAC-STC can transport up to 36 Yankee Class fuel assemblies and 24 Greater Than Class C waste canisters. The design basis fuels for the uncanistered configuration are the Westinghouse 17 x 17 or 15 x 15 PWR fuel assemblies. These fuels bound smaller array Westinghouse, and similar Babcock & Wilcox, and Combustion Engineering PWR fuel assemblies. In the uncanistered configuration, the NAC-STC can transport 26 directly loaded PWR fuel assemblies. Greater Than Class C waste does not contain fissionable isotopes and does not require a criticality evaluation.

This chapter demonstrates that the NAC-STC with the design basis payloads meets the criticality requirements of 10 CFR 71 Sections 71.55 and 71.59, and IAEA Safety Series No. 6. As demonstrated by the criticality analyses presented in Section 6.4 and summarized below, the NAC-STC is subcritical under all conditions and is assigned a nuclear criticality control transport index of 0 (N = 0) in accordance with 10 CFR 71.59(b).

6.1.1 Directly Loaded Uncanistered Fuel

The NAC-STC is designed to transport 26 design basis PWR fuel assemblies with an initial enrichment of 4.2 w/o uranium-235, that are directly loaded into a basket within the NAC-STC cavity. Criticality control in the NAC-STC is achieved using a flux trap principle. Each of the basket tubes in the NAC-STC are surrounded by four BORAL sheets which are held in place by steel cladding. The BORAL sheets have a minimum 0.01 g B^{10}/cm^2 loading in the core. The spacing of the basket tubes is maintained by the steel support disks. These disks provide water gap spacings between tubes of 1.64 inch and 3.46 inch. When the cask is flooded with water, fast neutrons leaking from the fuel assemblies are thermalized in the water gaps, and are absorbed in the BORAL sheets before causing a fission in an adjacent fuel assembly.

The SCALE CSAS25 (Landers and Petrie) calculational sequence is used to perform the NAC-STC criticality analysis. This sequence includes KENO-Va (Petrie) Monte Carlo analysis to determine the NAC-STC effective neutron multiplication factor (k_{eff}) under normal and accident conditions. The 27 group neutron library is used in all calculations, including those used to

evaluate the sensitivity of the package to a range of moderator density and center-to-center spacing. The analyses yielded the following maximum results:

Condition	$k_{eff} \pm \sigma$	k_s
Normal Conditions:		
Loading - Moderator inside and outside	0.92658 ± 0.00227	0.9457
Transport - Dry Inside and moderator outside	0.44743 ± 0.00171	0.4662
Hypothetical Accident Conditions:		
Dry inside and moderator outside	0.50321 ± 0.00139	0.5219

Conservatisms contained in these analyses included: (1) most reactive PWR fuel assembly class with maximum U loading; (2) 75 percent of the nominal B^{10} loading in the BORAL; (3) infinite array of casks in the X-Y plane; (4) infinite fuel length with no inclusion of end leakage effects; (5) no structural material present in the assembly; (6) no dissolved boron in the cask cavity or surrounding loading or storage area; and (7) no credit taken for fuel burnup or for the buildup of fission product neutron poisons.

6.1.2 Canistered Fuel

The NAC-STC may transport a transportable storage canister containing up to 36 design basis Yankee Class fuel assemblies that are loaded into a basket within the canister. Criticality control in the canister basket is also achieved using the flux trap principle. Each of the basket tubes in the canister basket are surrounded by four BORAL sheets which are held in place by steel cladding. The BORAL sheets have a minimum 0.01 g B^{10}/cm^2 loading in the core. The spacing of the basket tubes is maintained by the steel support disks. These disks provide water gap spacings between tubes of 0.75, 0.81 or 0.875 inches, depending on the tube placement within the basket. When the cask is flooded with water, fast neutrons leaking from the fuel assemblies are thermalized in the water gaps, and are absorbed in the BORAL sheets before causing a fission in an adjacent fuel assembly.

The transportable storage canister may contain one or more reconfigured fuel assemblies. The reconfigured fuel assembly is designed to confine the Yankee Class spent fuel rods, or portions thereof, which are classified as failed fuel. The total number of full length pins in a reconfigured fuel assembly is less than the number contained in a Yankee Class fuel assembly (maximum of 64 versus 256 rods). Consequently, the reactivity of the reconfigured fuel assembly, even with the most reactive fuel rods, is less than the design basis fuel assembly used in criticality.

The SCALE 4.3 CSAS25 (Scale 4.3 and Landers and Petrie, 1995) calculational sequence is used to perform the NAC-STC canistered fuel criticality analysis, based on the use of the most

This Page Intentionally Left Blank

6.4 Criticality Calculation

The licensing requirements for criticality analyses for shipment of radioactive material are provided in 10 CFR 71.55 and 10 CFR 71.59.

10 CFR 71.55 and 10 CFR 71.59 require that the fissile material package be subcritical under any credible condition, e.g. optimum interior/exterior moderation and reflection and credible configuration of the material. A criticality transport index is to be assigned to the fissile material package. This transport index must be based on the number of packages (casks in this context) remaining subcritical in an array configuration.

Additional requirements imposed include the reduction in poison plate B^{10} from 100 to 75 percent and water in the pellet-to-cladding gap.

Undamaged Cask

Compliance with the requirements of paragraphs (b) and (d) of 10 CFR 71.55 is shown by modeling an undamaged cask surrounded by water. Requirements of paragraphs (a) through (c) of 10 CFR 71.59 are satisfied by providing a value of "N" equal to infinity and a criticality transport index of 0 by imposing reflecting boundary conditions on the sides of the model simulating an infinite array of undamaged casks. Optimum interior and exterior moderation, including exterior full reflection by more than 20 cm of water, shows compliance with 10 CFR 55 paragraphs (b)(2), (b)(3) and (d)(3). Normal operating conditions for the transport cask include a dry canister cavity. The canister is loaded, dried, and seal welded inside a transfer cask. Only after the canister is dried and sealed is it placed into the transport cask. A limited set of exterior moderator density and cask pitch criticality evaluations show compliance with 10 CFR 71 under dry cavity conditions.

Damaged Cask

Compliance with the requirements of paragraph (e) of 10 CFR 71.55 is shown by modeling a damaged cask surrounded by water. Compliance with 10 CFR 71.59 is automatically demonstrated by imposing reflection boundary conditions on the sides of the model to simulate an infinite array of damaged casks, thereby resulting in a criticality transport index of 0. Optimum interior and exterior moderation, including exterior full reflection by more than 20 cm

of water, shows compliance with 10 CFR 55 paragraphs (e)(2) and (e)(3) and 10 CFR 59 paragraph (a)(2).

A damaged transport cask is defined as having been subjected to the hypothetical accident conditions specified in 10 CFR 71. Under these conditions the cask containment is maintained, and the cavity therefore remains dry. However, to show the cask's capability to remain subcritical under optimum internal and external moderation, an internally wet cask is analyzed. During the accident, the radial neutron shield is assumed to be lost as a result of fire and is replaced by the external moderator. Even though the fuel is assumed to remain intact following the cask drop, the pellet-to-clad gap is assumed to be filled by the internal-to-cask moderator. Introducing additional moderator into the normally under-moderated fuel assembly lattice increases reactivity.

6.4.1 Fuel Loading Optimization

The NAC-STC cask is designed to transport design basis PWR fuel assemblies in two (2) configurations. The criticality evaluation for directly loaded, uncanistered fuel is presented in Section 6.4.2. The analysis for canistered Yankee Class fuel is presented in Section 6.4.3. The analyses presented show that the maximum fuel loading along with the most reactive configuration have been analyzed for each configuration. The configuration of fresh fuel into the cask under water with no dissolved boron, and with the cask surrounded by water, is assumed to ensure that the maximum credible reactivity is simulated.

6.4.2 Criticality Results for Directly Loaded, Uncanistered Fuel

6.4.2.1 Most Reactive Assembly

A simplified KENO-Va calculation of the two design basis assemblies for the directly loaded, uncanistered fuel condition described in Table 6.2-1, is performed to determine the most reactive. In this simplified model, a unit cell of the NAC-STC basket with the steel and aluminum webbing properly spaced axially is described. Reflecting boundary conditions are imposed on the sides, top and bottom simulating an infinite array of basket cells. In one case, the 15x15 fuel assembly is modelled, and in the other, the 17x17 fuel assembly is modelled. Both fuel assemblies are at the same fuel density, 95.9% of theoretical and at 4.2 w/o U^{235} initial enrichment. The k-infinity of the 15x15 fuel assembly in the NAC-STC basket is 0.9526 ±

0.0024, and the k-infinity of the 17x17 fuel assembly in the NAC-STC basket is 0.9455 ± 0.0025. Thus, the 15x15 is the most limiting assembly of the two design basis assemblies and is used in subsequent cask criticality analysis.

An additional evaluation of the Westinghouse 17x17 OFA assembly loaded into the NAC-STC basket gave a k-infinity of 0.9575 ± .0024. Lowering the enrichment of the OFA design to 4.1 w/o U^{235} gave a k-infinity of 0.9504 ± .0024 which is below the 15x15 fuel assembly design at 4.2 w/o U^{235} initial enrichment. Thus, in the case of the OFA fuel assembly, the maximum allowable enrichment to allow placement in the NAC-STC is 4.1 w/o U^{235}.

This Page Intentionally Left Blank

6.4.2.2 Normal Conditions

Criticality results under normal conditions include variations in moderator density from 1.0 g/cc to 0.0001 g/cc (dry) and cask center-to-center spacing from 249.36 cm (touching) to 400 cm. The results are shown in Tables 6.4-1 and 6.4-2. Table 6.4-1 shows the expected reactivity conditions during loading, i.e. wet inside and outside, as well as variation in moderator density due to draining and drying. Also, shown in Table 6.4-1 is the reactivity penalty from assuming 75% of nominal boron. This is approximately a 2% Δk penalty. Table 6.4-1 shows that cask reactivity is insensitive to variations in cask center-to-center spacing, but that the touching condition is the most reactive. This results in a k_{eff} of 0.9266 ± 0.0023. The CSAS25 input and output for this case is shown in Figures 6.6-1 and 6.6-2, respectively. Simultaneous variation in moderator density inside and outside the cask shows a monotonic decrease in reactivity. There appears to be no optimum at low density conditions. The k_{eff} in the dry situation is 0.4420 ± 0.0009.

Table 6.4-2 shows the expected reactivity conditions during normal transport, i.e. dry inside and possibly wet outside. When the cask cavity is dry, k_{eff} of the package is very low and is insensitive to variations of moderator density outside and cask center-to-center spacing. The maximum k_{eff} for this situation is 0.4470 ± 0.0014.

Including statistical and method uncertainties, all results for the normal condition are below the 0.95 NRC criticality safety limit. Thus, compliance with 10 CFR 71.55 (b) and (d) as well as 10 CFR 71.75 (a) is demonstrated.

6.4.2.3 Hypothetical Accident Conditions

Criticality results under hypothetical accident conditions include variations in exterior moderator density from 1.0 g/cc to 0.0001 g/cc (dry) as well as cask center-to-center spacing from 249.36 cm (touching) to 300 cm. The results are shown in Table 6.4-3. Under accident conditions, moderator is allowed in the neutron shield region and outside the cask. Again, with the cask cavity dry, the k_{eff} of the package is very low and is insensitive to moderator density and cask spacing variation. The maximum k_{eff} for this situation is 0.5032 ± 0.0014. The CSAS25 input and output for this case is shown in Figure 6. 6-3 and 6. 6-4, respectively.

Including statistical and method uncertainties, all results for the accident condition are well below the 0.95 NRC criticality safety limit. Thus, compliance with 10 CFR 71.55 (e) as well as

10 CFR 71.75 (b) is demonstrated. Additionally, the results of both normal and accident conditions satisfy the requirements for a Fissile Class I package.

6.4.3 Criticality Results for Canistered Yankee Class Fuel

6.4.3.1 Most Reactive Assembly

A simplified KENO-Va calculation of the Yankee Class design basis assemblies, described in Tables 6.2-1 and 6.2-2, is performed to determine the most reactive assembly. In this simplified model, a unit cell of the NAC-STC canister basket, with the stainless steel and aluminum webbing properly spaced axially, is described. Reflecting boundary conditions are imposed on the sides, top and bottom simulating an infinite array of basket cells. Using the basket cell model, a k_{eff} value was obtained for each assembly type. The results of the evaluation are shown below.

Assembly	Initial Enrichment ($w/o\ U^{235}$)	k_{eff}	σ
Westinghouse Type A	4.94	0.8642	0.00105
Westinghouse Type B	4.94	0.8664	0.00102
United Nuclear Type A	4.00	0.8974	0.00087
United Nuclear Type B	4.00	0.8974	0.00106
Exxon - ANF Type A	4.00	0.8870	0.00111
Exxon - ANF Type B	4.00	0.8877	0.00111
Combustion Engineering Type A	3.90	0.8943	0.00060
Combustion Engineering Type B	3.90	0.8939	0.00163

Based on this evaluation, the United Nuclear Type A and B assembly was the most limiting assembly of the Yankee Class design basis assemblies. For simplification, United Nuclear Type A was used in subsequent cask criticality analysis.

6.4.3.2 Normal Conditions

Yankee Class fuel assemblies will be sealed inside of a canister that is welded shut. Consequently, the canistered fuel is dry under normal conditions of loading and transport. The k_{eff} variation in loading conditions are bounded by the results in 6.4.2.2, since the most reactive k_{eff}, including uncertainties, is low (0.8902). Criticality results under normal conditions exclude

variations in moderator density, but include cask center-to-center spacing from 250.698 cm (touching) to 300 cm. Moderator density is taken to be 0.0001 g/cc (dry). The results for normal conditions of transport are shown in Table 6.4-4. Table 6.4-4 shows that cask reactivity is insensitive to variations in cask center-to-center spacing, but center to center spacing at 250.698 cm is the most reactive. This results in a k_{eff} of 0.4580 ± 0.0006. The CSAS25 input and output for this case is shown in Figures 6.6-5 and 6.6-6, respectively.

Including statistical and method uncertainties, all results for the normal condition are below the 0.95 NRC criticality safety limit. Thus, compliance with 10 CFR 71.55 (b) and (d) as well as 10 CFR 71.75 (a) is demonstrated.

6.4.3.3 Hypothetical Accident Conditions

Criticality results under hypothetical accident conditions include variations in moderator density from 1.0 g/cc to 0.1 g/cc (dry) as well as cask center-to-center spacing from 250.698 cm (touching) to 300 cm. The results are shown in Table 6.4-5. Under accident conditions, the cask and fuel is considered to be fully moderated as described in Section 6.1.2. The maximum k_{eff}, including uncertainties, for this situation is 0.8974. The CSAS25 input and output for this case is shown in Figures 6.6-7 and 6.6-8, respectively.

Including statistical and method uncertainties, all results for the accident condition are well below the 0.95 NRC criticality safety limit. Thus, compliance with 10 CFR 71.55 (e) is demonstrated.

Table 6.4-1 Criticality Results for Normal Conditions of Direct Fuel Loading

Cask Pitch	H_2O Inside	H_2O Outside	Neutron Shield	B^{10}	k_{eff}	s	k_s
300cm	1.0	1.0	Yes	100%	0.90777	0.00251	0.92702
249.36	1.0	1.0	Yes	75%	0.92658	0.00227	0.94568
279.36	1.0	1.0	Yes	75%	0.92194	0.00230	0.94106
300cm	1.0	1.0	Yes	75%	0.92063	0.00246	0.93985
350cm	1.0	1.0	Yes	75%	0.92450	0.00245	0.94371
400cm	1.0	1.0	Yes	75%	0.92239	0.00228	0.94149
300cm	0.7	0.7	Yes	75%	0.83797	0.00241	0.85716
300cm	0.5	0.5	Yes	75%	0.76677	0.00229	0.78588
300cm	0.2	0.2	Yes	75%	0.62643	0.00174	0.64524
300cm	0.1	0.1	Yes	75%	0.56786	0.00137	0.58652
300cm	0.05	0.05	Yes	75%	0.53165	0.00118	0.55024
300cm	0.0001	0.0001	Yes	75%	0.44195	0.00093	0.46047

Figure 6.6-5. CSAS25 Input for Canistered Fuel Normal Conditions Criticality Analysis

```
=CSAS25
TRANSPORT CRITICALITY: NORMAL CONDITIONS (PITCH = 250.698 cm) (EXT. MOD. VF = 0.6)
'
'       THIS IS A MODEL OF THE NAC-MPC BASKET
'   LOADED WITH 36 UNITED NUCLEAR TYPE A ASSEMBLIES
'
'
'       INTERIOR MODERATOR VOLUME FRACTION = 0.0001
'       EXTERIOR MODERATOR VOLUME FRACTION = 0.6
'           CASK TO CASK PITCH = 250.698 cm
'
27GROUPNDF4 LATTICECELL
UO2         1               0.95    293.0 92235 4.0 92238 96.0 END
ZIRCALLOY   2               1.0     293.0                      END
H2O         3               0.0001  293.0                      END
AL          4               1.0     293.0                      END
SS304       5               1.0     293.0                      END
B-10        6  DEN=2.6226 0.0450    293.0                      END
B-11        6  DEN=2.6226 0.2736    293.0                      END
C           6  DEN=2.6226 0.0927    293.0                      END
AL          6  DEN=2.6226 0.5737    293.0                      END
PB          7               1.0     293.0                      END
H           8  DEN=1.6291 0.060     293.0                      END
O           8  DEN=1.6291 0.425     293.0                      END
C           8  DEN=1.6291 0.277     293.0                      END
N           8  DEN=1.6291 0.020     293.0                      END
AL          8  DEN=1.6291 0.214     293.0                      END
B-10        8  DEN=1.6291 0.001     293.0                      END
B-11        8  DEN=1.6291 0.004     293.0                      END
H2O         9               0.6     293.0                      END
END COMP
SQUAREPITCH  1.1887 0.7887 1 3 0.9271 2 0.8052 0 END
TRANSPORT CRITICALITY: NORMAL CONDITIONS (PITCH = 250.698 cm) (EXT. MOD. VF = 0.6)
READ PARAM RUN=YES PLT=NO GEN=203 NPG=1000 TME=500 END PARAM
READ GEOM
'
'  WATER LEVEL UNIT CELLS
'
UNIT  1
COM='FUEL PIN CELL - BETWEEN DISKS'
CYLINDER  1 1  0.3943    2P2.1400
CYLINDER  0 1  0.4026    2P2.1400
CYLINDER  2 1  0.4635    2P2.1400
CUBOID    3 1  4P0.5944  2P2.1400
UNIT  2
COM='WATER CELL - BETWEEN DISKS'
CUBOID    3 1  4P0.5944  2P2.1400
UNIT  3
COM='DISPLACEMENT CELL - BETWEEN DISKS'
CYLINDER  2 1  0.4635    2P2.1400
CUBOID    3 1  4P0.5944  2P2.1400
UNIT  4
COM='INSTRUMENT TUBE CELL - BETWEEN DISKS'
CYLINDER  3 1  0.4998    2P2.1400
CYLINDER  5 1  0.5442    2P2.1400
CUBOID    3 1  4P0.5944  2P2.1400
'
'  DISK LEVEL UNIT CELLS (BOTH SS AND AL)
'
UNIT  5
COM='FUEL PIN CELL - WITH SS DISK'
CYLINDER  1 1  0.3943    2P0.6604
CYLINDER  0 1  0.4026    2P0.6604
CYLINDER  2 1  0.4635    2P0.6604
CUBOID    3 1  4P0.5944 2P0.6604
UNIT  6
COM='WATER CELL - WITH SS DISK'
CUBOID    3 1  4P0.5944 2P0.6604
UNIT  7
COM='DISPLACEMENT CELL - WITH SS DISK'
CYLINDER  2 1  0.4635    2P0.6604
CUBOID    3 1  4P0.5944 2P0.6604
UNIT  8
COM='INSTRUMENT TUBE CELL - WITH SS DISK'
CYLINDER  3 1  0.4998    2P0.6604
CYLINDER  5 1  0.5442    2P0.6604
CUBOID    3 1  4P0.5944 2P0.6604
'
'  WATER LEVEL BORAL SHEETS
'
UNIT 14
COM='X-X BORAL SHEET BETWEEN DISKS'
CUBOID 6 1 2P9.144 2P0.0318 2P2.1400
CUBOID 4 1 2P9.144 2P0.0953 2P2.1400
UNIT 15
COM='Y-Y BORAL SHEET BETWEEN DISKS'
CUBOID 6 1 2P0.0318 2P9.144 2P2.1400
```

Figure 6.6-5 CSAS25 Input for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
CUBOID 4 1 2P0.0953 2P9.144 2P2.1400
'
'  DISK LEVEL BORAL SHEETS (AL AND SS)
'
UNIT 16
COM='X-X BORAL SHEET WITH SS DISK'
CUBOID 6 1 2P9.144 2P0.0318 2P0.6604
CUBOID 4 1 2P9.144 2P0.0953 2P0.6604
UNIT 17
COM='Y-Y BORAL SHEET WITH SS DISK'
CUBOID 6 1 2P0.0318 2P9.144 2P0.6604
CUBOID 4 1 2P0.0953 2P9.144 2P0.6604
'
' WATER LEVEL WEB MATERIAL
'
UNIT 20
COM='WATER LEVEL WEB MATERIAL (SMALL) X-X'
CUBOID    3 1 2P10.4635 2P0.9716 2P2.1400
UNIT 21
COM='WATER LEVEL WEB MATERIAL (MEDIUM) X-X'
CUBOID    3 1 2P10.4635 2P1.0478 2P2.1400
UNIT 22
COM='WATER LEVEL WEB MATERIAL (LARGE) X-X'
CUBOID    3 1 2P10.4635 2P1.1208 2P2.1400
UNIT 23
COM='WATER LEVEL WEB MATERIAL (LONG) Y-Y'
CUBOID    3 1 2P1.1208 2P79.5249 2P2.1400
'
'  SUPPORT DISK WEB MATERIAL
'
UNIT 30
COM='SUPPORT DISK WEB MATERIAL (SMALL) X-X'
CUBOID    5 1 2P10.4635 2P0.9716 2P0.6604
UNIT 31
COM='SUPPORT DISK WEB MATERIAL (MEDIUM) X-X'
CUBOID    5 1 2P10.4635 2P1.0478 2P0.6604
UNIT 32
COM='SUPPORT DISK WEB MATERIAL (LARGE) X-X'
CUBOID    5 1 2P10.4635 2P1.1208 2P0.6604
UNIT 33
COM='SUPPORT DISK WEB MATERIAL (LONG) Y-Y'
CUBOID    5 1 2P1.1208 2P79.5249 2P0.6604
'
'  HEAT TRANSFER DISK WEB MATERIAL
'
UNIT 40
COM='HEAT TRANSFER DISK WEB MATERIAL (SMALL) X-X'
CUBOID    4 1 2P10.4635 2P0.9716 2P0.6604
UNIT 41
COM='HEAT TRANSFER DISK WEB MATERIAL (MEDIUM) X-X'
CUBOID    4 1 2P10.4635 2P1.0478 2P0.6604
UNIT 42
COM='HEAT TRANSFER DISK WEB MATERIAL (LARGE) X-X'
CUBOID    4 1 2P10.4635 2P1.1208 2P0.6604
UNIT 43
COM='HEAT TRANSFER DISK WEB MATERIAL (LONG) Y-Y'
CUBOID    4 1 2P1.1208 2P79.5249 2P0.6604
'
'  WATER LEVEL ASSEMBLY ARRAYS
'
UNIT 50
COM='FUEL TUBE AND ASSEMBLY - WATER LEVEL'
ARRAY  1  -9.5104 -9.5104 -2.1400
CUBOID 3 1 4P9.9441                              2P2.1400
CUBOID 5 1 4P10.0661                             2P2.1400
CUBOID 3 1 4P10.25681                            2P2.1400
HOLE  14   0.0       10.1615  0.0
HOLE  14   0.0      -10.1615  0.0
HOLE  15   10.1615  0.0       0.0
HOLE  15   -10.1615 0.0       0.0
CUBOID 5 1 4P10.3051                             2P2.1400
UNIT 51
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -Y'
CUBOID 3 1 4P10.4635                             2P2.1400
HOLE  50   0.0       -0.1584      0.0
UNIT 52
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS Y'
CUBOID 3 1 4P10.4635                             2P2.1400
HOLE  50   0.0       0.1584       0.0
UNIT 53
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -X'
CUBOID 3 1 4P10.4635                             2P2.1400
HOLE  50   -0.1584   0.0          0.0
UNIT 54
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS X'
CUBOID 3 1 4P10.4635                             2P2.1400
HOLE  50   0.1584    0.0          0.0
UNIT 55
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS X Y'
CUBOID 3 1 4P10.4635                             2P2.1400
HOLE  50   0.1584    0.1584       0.0
UNIT 56
```

Figure 6.6-5 - CSAS25 Input for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -X Y'
CUBOID 3 1 4P10.4635                                2P2.1400
HOLE  50   -0.1584   0.1584        0.0
UNIT 57
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS X -Y'
CUBOID 3 1 4P10.4635                                2P2.1400
HOLE  50   0.1584   -0.1584        0.0
UNIT 58
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -X -Y'
CUBOID 3 1 4P10.4635                                2P2.1400
HOLE  50   -0.1584   -0.1584        0.0
UNIT 59
COM='CENTRAL HOLE'
CUBOID 3 1 4P10.4636                                2P2.1400
'
'   SUPPORT DISK LEVEL ASSEMBLY ARRAYS
'
UNIT 60
COM='FUEL TUBE AND ASSEMBLY - SUPPORT DISK LEVEL'
ARRAY  2  -9.5104 -9.5104 -0.6604
CUBOID 3 1 4P9.9441                                 2P0.6604
CUBOID 5 1 4P10.0661                                2P0.6604
CUBOID 3 1 4P10.25681                               2P0.6604
HOLE  16   0.0       10.1615  0.0
HOLE  16   0.0       -10.1615 0.0
HOLE  17   10.1615  0.0       0.0
HOLE  17   -10.1615 0.0       0.0
CUBOID 5 1 4P10.3051                                2P0.6604
UNIT 61
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -Y'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  60   0.0       -0.1584      0.0
UNIT 62
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS Y'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  60   0.0       0.1584       0.0
UNIT 63
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -X'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  60   -0.1584   0.0          0.0
UNIT 64
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS X'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  60   0.1584   0.0           0.0
UNIT 65
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS X Y'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  60   0.1584   0.1584        0.0
UNIT 66
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -X Y'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  60   -0.1584   0.1584        0.0
UNIT 67
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS X -Y'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  60   0.1584   -0.1584        0.0
UNIT 68
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -X -Y'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  60   -0.1584   -0.1584        0.0
UNIT 69
COM='CENTRAL HOLE'
CUBOID 3 1 4P10.4636   2P0.6604
'
'   HEAT TRANSFER DISK LEVEL ASSEMBLY ARRAYS
'
UNIT 70
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS'
ARRAY  2  -9.5104 -9.5104 -0.6604
CUBOID 3 1 4P9.9441                                 2P0.6604
CUBOID 5 1 4P10.0661                                2P0.6604
CUBOID 3 1 4P10.25681                               2P0.6604
HOLE  16   0.0       10.1615  0.0
HOLE  16   0.0       -10.1615 0.0
HOLE  17   10.1615  0.0       0.0
HOLE  17   -10.1615 0.0       0.0
CUBOID 5 1 4P10.3051                                2P0.6604
UNIT 71
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -Y'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  70   0.0       -0.1584      0.0
UNIT 72
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS Y'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  70   0.0       0.1584       0.0
UNIT 73
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -X'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  70   -0.1584   0.0          0.0
UNIT 74
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS X'
CUBOID 3 1 4P10.4635                                2P0.6604
```

Figure 6.6-5 - CSAS25 Input for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
HOLE  70   0.1584   0.0          0.0
UNIT 75
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS X Y'
CUBOID 3 1 4P10.4635                        2P0.6604
HOLE  70   0.1584   0.1584       0.0
UNIT 76
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -X Y'
CUBOID 3 1 4P10.4635                        2P0.6604
HOLE  70   -0.1584   0.1584       0.0
UNIT 77
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS X -Y'
CUBOID 3 1 4P10.4635                        2P0.6604
HOLE  70   0.1584   -0.1584       0.0
UNIT 78
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -X -Y'
CUBOID 3 1 4P10.4635                        2P0.6604
HOLE  70   -0.1584   -0.1584      0.0
UNIT 79
COM='CENTRAL HOLE'
CUBOID 3 1 4P10.4636                        2P0.6604
'
'  WATER LEVEL BASKET ARRAYS
'
UNIT 80
COM='5X1 WATER LEVEL ARRAY (SMALL ARRAY -X)'
ARRAY 20 -10.4636 -33.6323 -2.1400
UNIT 81
COM='5X1 WATER LEVEL ARRAY (SMALL ARRAY X)'
ARRAY 21 -10.4636 -33.6323 -2.1400
UNIT 82
COM='9X1 WATER LEVEL ARRAY (MEDIUM ARRAY -X)'
ARRAY 22 -10.4636 -56.6549 -2.1400
UNIT 83
COM='9X1 WATER LEVEL ARRAY (MEDIUM ARRAY X)'
ARRAY 23 -10.4636 -56.6549 -2.1400
UNIT 84
COM='13X1 WATER LEVEL ARRAY (LARGE ARRAY-X)'
ARRAY 24 -10.4636 -79.5251 -2.1400
UNIT 85
COM='13X1 WATER LEVEL ARRAY (MIDDLE LARGE ARRAY)'
ARRAY 25 -10.4636 -79.5251 -2.1400
UNIT 86
COM='13X1 WATER LEVEL ARRAY (LARGE ARRAY X)'
ARRAY 26 -10.4636 -79.5251 -2.1400
'
'  SUPPORT DISK LEVEL BASKET ARRAYS
'
UNIT 90
COM='5X1 SUPPORT DISK LEVEL ARRAY (SMALL ARRAY -X)'
ARRAY 30 -10.4636 -33.6323 -0.6604
UNIT 91
COM='5X1 SUPPORT DISK LEVEL ARRAY (SMALL ARRAY  X)'
ARRAY 31 -10.4636 -33.6323 -0.6604
UNIT 92
COM='9X1 WATER LEVEL ARRAY (MEDIUM ARRAY -X)'
ARRAY 32 -10.4636 -56.6549 -0.6604
UNIT 93
COM='9X1 WATER LEVEL ARRAY (MEDIUM ARRAY X)'
ARRAY 33 -10.4636 -56.6549 -0.6604
UNIT 94
COM='13X1 SUPPORT DISK LEVEL ARRAY (LARGE ARRAY -X)'
ARRAY 34 -10.4636 -79.5251 -0.6604
UNIT 95
COM='13X1 SUPPORT DISK LEVEL ARRAY (MIDDLE LARGE ARRAY)'
ARRAY 35 -10.4636 -79.5251 -0.6604
UNIT 96
COM='13X1 SUPPORT DISK LEVEL ARRAY (LARGE ARRAY -X)'
ARRAY 36 -10.4636 -79.5251 -0.6604
'
'  HEAT TRANSFER DISK LEVEL BASKET ARRAYS
'
UNIT 100
COM='5X1 HEAT TRANSFER DISK LEVEL ARRAY (SMALL ARRAY -X)'
ARRAY 40 -10.4636 -33.6323 -0.6604
UNIT 101
COM='5X1 HEAT TRANSFER DISK LEVEL ARRAY (SMALL ARRAY X)'
ARRAY 41 -10.4636 -33.6323 -0.6604
UNIT 102
COM='9X1 HEAT TRANSFER DISK LEVEL ARRAY (MEDIUM ARRAY -X)'
ARRAY 42 -10.4636 -56.6549 -0.6604
UNIT 103
COM='9X1 HEAT TRANSFER DISK LEVEL ARRAY (MEDIUM ARRAY  X)'
ARRAY 43 -10.4636 -56.6549 -0.6604
UNIT 104
COM='13X1 HEAT TRANSFER DISK LEVEL ARRAY (LARGE ARRAY -X)'
ARRAY 44 -10.4636 -79.5251 -0.6604
UNIT 105
COM='13X1 HEAT TRANSFER DISK LEVEL ARRAY (MIDDLE LARGE ARRAY)'
ARRAY 45 -10.4636 -79.5251 -0.6604
UNIT 106
COM='13X1 HEAT TRANSFER DISK LEVEL ARRAY (LARGE ARRAY X)'
ARRAY 46 -10.4636 -79.5251 -0.6604
```

Figure 6.6-5 CSAS25 Input for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
'
' BASKET ARRAY IN TRANSPORT CASK OVERPACK (LEVEL CONSTRUCTION)
'
UNIT 110
COM='BASKET ARRAY IN TRANSPORT CASK OVERPACK - WATER LEVEL'
ARRAY 50 -33.6323 -79.5251 -2.1400
CYLINDER 3 1 88.1253      2P2.1400
HOLE 80      -69.0614 0.0 0.0
HOLE 82      -46.1912 0.0 0.0
HOLE 81       69.0614 0.0 0.0
HOLE 83       46.1912 0.0 0.0
CYLINDER 5 1 89.7128      2P2.1400
CYLINDER 3 1 90.170       2P2.1400
CYLINDER 5 1 93.98        2P2.1400
CYLINDER 7 1 103.4288     2P2.1400
CYLINDER 5 1 110.109      2P2.1400
CYLINDER 8 1 124.714      2P2.1400
CYLINDER 5 1 125.349      2P2.1400
CUBOID   9 1 4P125.349    2P2.1400
UNIT 111
COM='BASKET ARRAY IN TRANSPORT CASK OVERPACK - SUPPORT DISK LEVEL'
ARRAY 51 -33.6323 -79.5251 -0.6604
CYLINDER 5 1 87.6046      2P0.6604
HOLE 90      -69.0614 0.0 0.0
HOLE 92      -46.1912 0.0 0.0
HOLE 91       69.0614 0.0 0.0
HOLE 93       46.1912 0.0 0.0
CYLINDER 3 1 88.1253      2P0.6604
CYLINDER 5 1 89.7128      2P0.6604
CYLINDER 3 1 90.170       2P0.6604
CYLINDER 5 1 93.98        2P0.6604
CYLINDER 7 1 103.4288     2P0.6604
CYLINDER 5 1 110.109      2P0.6604
CYLINDER 8 1 124.714      2P0.6604
CYLINDER 5 1 125.349      2P0.6604
CUBOID   9 1 4P125.349    2P0.6604
UNIT 112
COM='BASKET ARRAY IN TRANSPORT CASK OVERPACK - HEAT TRANSFER DISK LEVEL'
ARRAY 52 -33.6323 -79.5251 -0.6604
CYLINDER 4 1 87.2490      2P0.6604
HOLE 100     -69.0614 0.0 0.0
HOLE 102     -46.1912 0.0 0.0
HOLE 101      69.0614 0.0 0.0
HOLE 103      46.1912 0.0 0.0
CYLINDER 3 1 88.1253      2P0.6604
CYLINDER 5 1 89.7128      2P0.6604
CYLINDER 3 1 90.170       2P0.6604
CYLINDER 5 1 93.98        2P0.6604
CYLINDER 7 1 103.4288     2P0.6604
CYLINDER 5 1 110.109      2P0.6604
CYLINDER 8 1 124.714      2P0.6604
CYLINDER 5 1 125.349      2P0.6604
CUBOID   9 1 4P125.349    2P0.6604

'
' GLOBAL UNIT
'
GLOBAL UNIT 120
ARRAY 60 -175.349 -175.349 0.0
END GEOM
READ ARRAY
ARA=1 NUX=16 NUY=16 NUZ=1  FILL
1 1 1 1 1 1 1 1 3 2 2 2 2 2 2 2 2
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2 1 1 1 1 1 1 1 4 1 1 1 1 1 1 1
2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
END FILL
ARA=2 NUX=16 NUY=16 NUZ=1  FILL
5 5 5 5 5 5 5 7 6 6 6 6 6 6 6 6
5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
7 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
6 5 5 5 5 5 5 5 8 5 5 5 5 5 5 5
6 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
6 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
6 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
```

Figure 6.6-5 CSAS25 Input for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
6 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
6 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
6 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
6 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
END FILL
'
'  WATER LEVEL ARRAYS
'
ARA=20  NUX=1 NUY=5 NUZ=1
FILL
55
22
54
22
57
END FILL
ARA=21  NUX=1 NUY=5 NUZ=1
FILL
56
22
53
22
58
END FILL
ARA=22  NUX=1 NUY=9 NUZ=1
FILL
55
21
55
22
54
22
57
21
57
END FILL
ARA=23  NUX=1 NUY=9 NUZ=1
FILL
56
21
56
22
53
22
58
21
58
END FILL
ARA=24  NUX=1 NUY=13 NUZ=1
FILL
55
20
55
21
55
22
54
22
57
21
57
20
57
END FILL
ARA=25  NUX=1 NUY=13 NUZ=1
FILL
52
20
52
21
52
22
59
22
51
21
51
20
51
END FILL
ARA=26  NUX=1 NUY=13 NUZ=1
FILL
56
20
56
21
56
22
53
22
58
21
```

Figure 6.6-5 CSAS25 Input for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
58
20
58
END FILL
'
'  SUPPOR DISK LEVEL ARRAYS
'
ARA=30  NUX=1 NUY=5 NUZ=1
FILL
65
32
64
32
67
END FILL
ARA=31  NUX=1 NUY=5 NUZ=1
FILL
66
32
63
32
68
END FILL
ARA=32  NUX=1 NUY=9 NUZ=1
FILL
65
31
65
32
64
32
67
31
67
END FILL
ARA=33  NUX=1 NUY=9 NUZ=1
FILL
66
31
66
32
63
32
68
31
68
END FILL
ARA=34  NUX=1 NUY=13 NUZ=1
FILL
65
30
65
31
65
32
64
32
67
31
67
30
67
END FILL
ARA=35  NUX=1 NUY=13 NUZ=1
FILL
62
30
62
31
62
32
69
32
61
31
61
30
61
END FILL
ARA=36  NUX=1 NUY=13 NUZ=1
FILL
66
30
66
31
66
32
63
32
68
31
68
```

Figure 6.6-5 CSAS25 Input for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
30
68
END FILL
'
'  HEAT TRANSFER DISK LEVEL ARRAYS
'
ARA=40  NUX=1 NUY=5 NUZ=1
FILL
75
42
74
42
77
END FILL
ARA=41  NUX=1 NUY=5 NUZ=1
FILL
76
42
73
42
78
END FILL
ARA=42  NUX=1 NUY=9 NUZ=1
FILL
75
41
75
42
74
42
77
41
77
END FILL
ARA=43  NUX=1 NUY=9 NUZ=1
FILL
76
41
76
42
73
42
78
41
78
END FILL
ARA=44  NUX=1 NUY=13 NUZ=1
FILL
75
40
75
41
75
42
74
42
77
41
77
40
77
END FILL
ARA=45  NUX=1 NUY=13 NUZ=1
FILL
72
40
72
41
72
42
79
42
71
41
71
40
71
END FILL
ARA=46  NUX=1 NUY=13 NUZ=1
FILL
76
40
76
41
76
42
73
42
78
41
78
40
```

Figure 6.6-5 CSAS25 Input for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
78
END FILL
'
'  MAJOR ARRAYS
'
ARA=50 NUX=5 NUY=1 NUZ=1
FILL
84 23 85 23 86
END FILL
ARA=51 NUX=5 NUY=1 NUZ=1
FILL
94 33 95 33 96
END FILL
ARA=52 NUX=5 NUY=1 NUZ=1
FILL
104 43 105 43 106
END FILL
'
'  GLOBAL ARRAY
'
ARA=60 NUX=1 NUY=1 NUZ=4
FILL
112
110
111
110
END FILL
END ARRAY
READ BOUNDS ZFC=PER YXF=MIR END BOUNDS
READ PLOT
SCR=YES PIC=MAT LPI=10
UAX=1.0 VDN=-1.0 NAX=1500
'
' WHOLE BASKET HORIZONTAL SLICES
'
TTL='BASKET X-Y CROSS SECTION AT Z= 0.635 HEAT TRANSFER DISK LEVEL'
XUL=  -130 YUL=  130  ZUL= 0.635
XLR=   130 YLR= -130  ZLR= 0.635
UAX=1.0 VDN=-1.0 NAX=1500 END
TTL='BASKET X-Y CROSS SECTION AT Z= 3.44 WATER LEVEL'
XUL=  -130 YUL=  130  ZUL= 3.44
XLR=   130 YLR= -130  ZLR= 3.44
UAX=1.0 VDN=-1.0 NAX=1500 END
TTL='BASKET X-Y CROSS SECTION AT Z= 6.236 SS DISK LEVEL'
XUL=  -130 YUL=  130  ZUL= 6.236
XLR=   130 YLR= -130  ZLR= 6.236
UAX=1.0 VDN=-1.0 NAX=1500 END
'
' HEAT TRANSFER DISK LEVEL BASKET QUADRANTS
'
TTL='BASKET X-Y QUADRANTD I HEAT TRANSFER DISK'
XUL=  12.   YUL= 80     ZUL= 0.635
XLR=  80.0  YLR= 12.0   ZLR= 0.635
UAX=1.0 VDN=-1.0 NAX=1500 END
TTL='BASKET X-Y QUADRANT II HEAT TRANSFER DISK'
XUL=  12.0 YUL= -12.0   ZUL= 0.635
XLR=  80   YLR= -80     ZLR= 0.635
UAX=1.0 VDN=-1.0 NAX=1500 END
TTL='BASKET X-Y QUADRANT III HEAT TRANSFER DISK'
XUL= -80.0  YUL= -12.0  ZUL= 0.635
XLR= -12.0  YLR= -80.0  ZLR= 0.635
UAX=1.0 VDN=-1.0 NAX=1500 END
TTL='BASKET X-Y QUADRANT IV HEAT TRANSFER DISK'
XUL= -80.0  YUL= 80.0   ZUL= 0.635
XLR= -12.0  YLR= 12.0   ZLR= 0.635
UAX=1.0 VDN=-1.0 NAX=1500 END
'
' WATER LEVEL BASKET QUADRANTS
'
TTL='BASKET X-Y QUADRANT I WATER LEVEL'
XUL=  12.    YUL=  80     ZUL= 3.44
XLR=  80.0   YLR=  12.0   ZLR= 3.44
UAX=1.0 VDN=-1.0 NAX=1500 END
TTL='BASKET X-Y QUADRANT II WATER LEVEL'
XUL=  12.0   YUL= -12.0   ZUL= 3.44
XLR=  80     YLR= -80     ZLR= 3.44
UAX=1.0 VDN=-1.0 NAX=1500 END
TTL='BASKET X-Y QUADRANT III WATER LEVEL'
XUL= -80.0   YUL= -12.0   ZUL= 3.44
XLR= -12.0   YLR= -80.0   ZLR= 3.44
UAX=1.0 VDN=-1.0 NAX=1500 END
TTL='BASKET X-Y QUADRANT IV WATER LEVEL'
XUL= -80.0   YUL= 80.0    ZUL= 3.44
XLR= -12.0   YLR= 12.0    ZLR= 3.44
UAX=1.0 VDN=-1.0 NAX=1500 END
'
'  VERTICAL SLICES
'
TTL='BASKET X-Z CROSS SECTION ALUMINUM LEVEL (MIDDLE OF FUEL PIN)'
XUL= -90  YUL=0.4   ZUL= 1.27
XLR=  90  YLR=0.4   ZLR= -.1
UAX=1.0 WDN=-1.0 NAX=1500 END
```

Figure 6.6-5 CSAS25 Input for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
TTL='BASKET X-Z CROSS SECTION WATER LEVEL (MIDDLE OF FUEL PIN)'
XUL= -90  YUL=0.4   ZUL= 4.318
XLR=  90  YLR=0.4   ZLR= 1.27
UAX=1.0 WDN=-1.0 NAX=1500 END
TTL='BASKET X-Z CROSS SECTION SS LEVEL (MIDDLE OF FUEL PIN)'
XUL= -90  YUL=0.4   ZUL= 6.858
XLR=  90  YLR=0.4   ZLR= 5.588
UAX=1.0 WDN=-1.0 NAX=1500 END
TTL='BASKET X-Z CROSS SECTION ENTIRE MODEL (MIDDLE OF FUEL PIN)'
XUL= -90  YUL=0.4   ZUL= 12
XLR=  90  YLR=0.4   ZLR= 0
UAX=1.0 WDN=-1.0 NAX=1500 END
END PLOT
END DATA
END
```

Figure 6.6-6 CSAS25 Output for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
*****************************************************************************
*****************************************************************************
*****************************************************************************
*****                                                                   *****
*****                 PROGRAM VERIFICATION INFORMATION                  *****
*****                                                                   *****
*****               CODE SYSTEM:  SCALE-PC VERSION:  4.3                *****
*****                                                                   *****
*****************************************************************************
*****************************************************************************
*****                                                                   *****
*****                                                                   *****
*****              PROGRAM:  CSAS                                       *****
*****                                                                   *****
*****        CREATION DATE:  03-08-96                                   *****
*****                                                                   *****
*****              VOLUME:  ENG                                         *****
*****                                                                   *****
*****             LIBRARY:  G:\scale43\exe                              *****
*****                                                                   *****
*****                                                                   *****
*****      PRODUCTION CODE:  CSAS                                       *****
*****                                                                   *****
*****              VERSION:  3.1                                        *****
*****                                                                   *****
*****              JOBNAME:  SCALE-PC                                   *****
*****                                                                   *****
*****    DATE OF EXECUTION:  11/13/96                                   *****
*****                                                                   *****
*****    TIME OF EXECUTION:  00:51:47                                   *****
*****                                                                   *****
*****                                                                   *****
*****************************************************************************
*****************************************************************************
*****************************************************************************
```

Figure 6.6-6 CSAS25 Output for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
TRANSPORT CRITICALITY: NORMAL CONDITIONS (PITCH = 250.698 CM) (EXT. MOD. VF = 0.

**** PROBLEM PARAMETERS ****

LIB 27GROUPNDF4  LIBRARY
MXX             9 MIXTURES
MSC            18 COMPOSITION SPECIFICATIONS
IZM             4 MATERIAL ZONES
GE  LATTICECELL  GEOMETRY
MORE            0 0/1 DO NOT READ/READ OPTIONAL PARAMETER DATA
MSLN            0 FUEL SOLUTIONS

**** PROBLEM COMPOSITION DESCRIPTION ****

SC   UO2             STANDARD COMPOSITION
MX               1 MIXTURE NO.
VF          0.9500 VOLUME FRACTION
ROTH       10.9600 THEORETICAL DENSITY
NEL              2 NO. ELEMENTS
ICP              1 0/1 MIXTURE/COMPOUND
TEMP         293.0 DEG KELVIN
             92000        1.00 ATOM/MOLECULE
                               92235      4.000 WT%
                               92238     96.000 WT%
              8016        2.00 ATOMS/MOLECULE
END

SC   ZIRCALLOY       STANDARD COMPOSITION
MX               2 MIXTURE NO.
VF          1.0000 VOLUME FRACTION
ROTH        6.5600 THEORETICAL DENSITY
NEL              1 NO. ELEMENTS
ICP              1 0/1 MIXTURE/COMPOUND
TEMP         293.0 DEG KELVIN
             40302        1.00 ATOM/MOLECULE
END

SC   H2O             STANDARD COMPOSITION
MX               3 MIXTURE NO.
VF          0.0001 VOLUME FRACTION
ROTH        0.9982 THEORETICAL DENSITY
NEL              2 NO. ELEMENTS
ICP              1 0/1 MIXTURE/COMPOUND
TEMP         293.0 DEG KELVIN
              1001        2.00 ATOMS/MOLECULE
              8016        1.00 ATOM/MOLECULE
END

SC   AL              STANDARD COMPOSITION
MX               4 MIXTURE NO.
VF          1.0000 VOLUME FRACTION
ROTH        2.7020 THEORETICAL DENSITY
NEL              1 NO. ELEMENTS

ICP              1 0/1 MIXTURE/COMPOUND
TEMP         293.0 DEG KELVIN
             13027        1.00 ATOM/MOLECULE
END

SC   SS304           STANDARD COMPOSITION
MX               5 MIXTURE NO.
VF          1.0000 VOLUME FRACTION
ROTH        7.9200 THEORETICAL DENSITY
NEL              4 NO. ELEMENTS
ICP              0 0/1 MIXTURE/COMPOUND
TEMP         293.0 DEG KELVIN
             24304     19.000 WT%
             25055      2.000 WT%
             26304     69.500 WT%
             28304      9.500 WT%
END

SC   B-10            STANDARD COMPOSITION
MX               6 MIXTURE NO.
VF          0.0450 VOLUME FRACTION
ROTH        2.6226 SPECIFIED DENSITY
NEL              1 NO. ELEMENTS
ICP              1 0/1 MIXTURE/COMPOUND
TEMP         293.0 DEG KELVIN
              5010        1.00 ATOM/MOLECULE
END

SC   B-11            STANDARD COMPOSITION
MX               6 MIXTURE NO.
VF          0.2736 VOLUME FRACTION
ROTH        2.6226 SPECIFIED DENSITY
NEL              1 NO. ELEMENTS
ICP              1 0/1 MIXTURE/COMPOUND
TEMP         293.0 DEG KELVIN
              5011        1.00 ATOM/MOLECULE
END
```

Figure 6.6-6 CSAS25 Output for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
SC   C            STANDARD COMPOSITION
MX              6 MIXTURE NO.
VF         0.0927 VOLUME FRACTION
ROTH       2.6226 SPECIFIED DENSITY
NEL             1 NO. ELEMENTS
ICP             1 0/1 MIXTURE/COMPOUND
TEMP        293.0 DEG KELVIN
             6012          1.00 ATOM/MOLECULE
END

SC   AL           STANDARD COMPOSITION
MX              6 MIXTURE NO.
VF         0.5737 VOLUME FRACTION
ROTH       2.6226 SPECIFIED DENSITY
NEL             1 NO. ELEMENTS
ICP             1 0/1 MIXTURE/COMPOUND
TEMP        293.0 DEG KELVIN
            13027          1.00 ATOM/MOLECULE
END

SC   PB           STANDARD COMPOSITION
MX              7 MIXTURE NO.
VF         1.0000 VOLUME FRACTION
ROTH      11.3440 THEORETICAL DENSITY
NEL             1 NO. ELEMENTS
ICP             1 0/1 MIXTURE/COMPOUND
TEMP        293.0 DEG KELVIN
            82000          1.00 ATOM/MOLECULE
END

SC   H            STANDARD COMPOSITION
MX              8 MIXTURE NO.
VF         0.0600 VOLUME FRACTION
ROTH       1.6291 SPECIFIED DENSITY
NEL             1 NO. ELEMENTS
ICP             1 0/1 MIXTURE/COMPOUND
TEMP        293.0 DEG KELVIN
             1001          1.00 ATOM/MOLECULE
END

SC   O            STANDARD COMPOSITION
MX              8 MIXTURE NO.
VF         0.4250 VOLUME FRACTION
ROTH       1.6291 SPECIFIED DENSITY
NEL             1 NO. ELEMENTS
ICP             1 0/1 MIXTURE/COMPOUND
TEMP        293.0 DEG KELVIN
             8016          1.00 ATOM/MOLECULE
END

SC   C            STANDARD COMPOSITION
MX              8 MIXTURE NO.
VF         0.2770 VOLUME FRACTION
ROTH       1.6291 SPECIFIED DENSITY
NEL             1 NO. ELEMENTS
ICP             1 0/1 MIXTURE/COMPOUND
TEMP        293.0 DEG KELVIN
             6012          1.00 ATOM/MOLECULE
END

SC   N            STANDARD COMPOSITION
MX              8 MIXTURE NO.
VF         0.0200 VOLUME FRACTION
ROTH       1.6291 SPECIFIED DENSITY
NEL             1 NO. ELEMENTS
ICP             1 0/1 MIXTURE/COMPOUND
TEMP        293.0 DEG KELVIN
             7014          1.00 ATOM/MOLECULE
END

SC   AL           STANDARD COMPOSITION
MX              8 MIXTURE NO.
VF         0.2140 VOLUME FRACTION
ROTH       1.6291 SPECIFIED DENSITY
NEL             1 NO. ELEMENTS
ICP             1 0/1 MIXTURE/COMPOUND
TEMP        293.0 DEG KELVIN
            13027          1.00 ATOM/MOLECULE
END

SC   B-10         STANDARD COMPOSITION
MX              8 MIXTURE NO.
VF         0.0010 VOLUME FRACTION
ROTH       1.6291 SPECIFIED DENSITY
NEL             1 NO. ELEMENTS
ICP             1 0/1 MIXTURE/COMPOUND
TEMP        293.0 DEG KELVIN
             5010          1.00 ATOM/MOLECULE
END

SC   B-11         STANDARD COMPOSITION
MX              8 MIXTURE NO.
VF         0.0040 VOLUME FRACTION
ROTH       1.6291 SPECIFIED DENSITY
NEL             1 NO. ELEMENTS
```

Figure 6.6-6 CSAS25 Output for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
ICP             1 0/1 MIXTURE/COMPOUND
TEMP        293.0 DEG KELVIN
             5011       1.00 ATOM/MOLECULE
END

SC  H2O          STANDARD COMPOSITION
MX              9 MIXTURE NO.
VF         0.6000 VOLUME FRACTION
ROTH       0.9982 THEORETICAL DENSITY
NEL             2 NO. ELEMENTS
ICP             1 0/1 MIXTURE/COMPOUND
TEMP        293.0 DEG KELVIN
             1001       2.00 ATOMS/MOLECULE
             8016       1.00 ATOM/MOLECULE
END

**** PROBLEM GEOMETRY ****

CTP SQUAREPITCH  CELL TYPE
PITCH      1.1887 CM CENTER TO CENTER SPACING
FUELOD     0.7887 CM FUEL DIAMETER OR SLAB THICKNESS
MFUEL           1 MIXTURE NO. OF FUEL
MMOD            3 MIXTURE NO. OF MODERATOR
CLADOD     0.9271 CM CLAD OUTER DIAMETER
MCLAD           2 MIXTURE NO. OF CLAD
GAPOD      0.8052 CM GAP OUTER DIAMETER
MGAP            0 MIXTURE NO. OF GAP

ZONE SPECIFICATIONS FOR LATTICECELL GEOMETRY

               ZONE  1 IS FUEL
               ZONE  2 IS GAP
               ZONE  3 IS CLAD
               ZONE  4 IS MOD
```

Figure 6.6-6 CSAS25 Output for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
                  ************************************************************************
                  ************************************************************************
                  ************************************************************************
                  *****                                                              *****
                  *****               PROGRAM VERIFICATION INFORMATION               *****
                  *****                                                              *****
                  *****           CODE SYSTEM:  SCALE-PC VERSION:  4.3               *****
                  *****                                                              *****
                  ************************************************************************
                  ************************************************************************
                  *****                                                              *****
                  *****                                                              *****
                  *****              PROGRAM:  000002                                *****
                  *****                                                              *****
                  *****        CREATION DATE:  09-28-95                              *****
                  *****                                                              *****
                  *****               VOLUME:  ENG                                   *****
                  *****                                                              *****
                  *****              LIBRARY:  G:\scale43\exe                        *****
                  *****                                                              *****
                  *****                                                              *****
                  *****      PRODUCTION CODE:  NITAWL                                *****
                  *****                                                              *****
                  *****              VERSION:  3.0                                   *****
                  *****                                                              *****
                  *****              JOBNAME:  SCALE-PC                              *****
                  *****                                                              *****
                  *****    DATE OF EXECUTION:  11/13/96                              *****
                  *****                                                              *****
                  *****    TIME OF EXECUTION:  00:51:51                              *****
                  *****                                                              *****
                  *****                                                              *****
                  ************************************************************************
                  ************************************************************************
                  ************************************************************************

       -1Q ARRAY HAS      1 ENTRIES.

        0Q ARRAY HAS      9 ENTRIES.

        1Q ARRAY HAS     12 ENTRIES.

SELECT 25 NUCLIDES FROM THE MASTER  LIBRARY ON LOGICAL  1
        0 NUCLIDES FROM THE WORKING LIBRARY ON LOGICAL  2
        0 NUCLIDES FROM THE WORKING LIBRARY ON LOGICAL  3
          TO CREATE THE NEW WORKING LIBRARY ON LOGICAL  4

        4 RESONANCE CALCULATIONS HAVE BEEN REQUESTED
       -1 OUTPUT OPTION FOR AMPX FORMATTED CROSS SECTION DATA
     2001 MAXIMUM NUMBER OF RESONANCE MESH INTERVALS
        2 ORDER OF RESONANCE LEVEL PROCESSING

THE STORAGE ALLOCATED FOR THIS CASE IS    100000 WORDS

        2Q ARRAY HAS     25 ENTRIES.

        3Q ARRAY HAS     60 ENTRIES.

        4Q ARRAY HAS     25 ENTRIES.

 GENERAL INFORMATION CONCERNING CROSS SECTION LIBRARY
   TAPE IDENTIFICATION NUMBER                    4321
   NUMBER OF NUCLIDES ON TAPE                      26
   NUMBER OF NEUTRON ENERGY GROUPS                 27
   FIRST THERMAL NEUTRON ENERGY GROUP              15
   NUMBER OF GAMMA ENERGY GROUPS                    0

   DIRECT ACCESS UNIT NUMBER  9 REQUIRES 117 BLOCKS OF LENGTH  1680 WORDS
 XSDRN TAPE    4321
                         SCALE 4.2 - 27 GROUP NEUTRON GROUP LIBRARY
                            BASED ON ENDF-B VERSION 4 DATA
                               COMPILED FOR NRC      1/27/89
                                  LAST UPDATED                                        08/12/94
                                     L.M.PETRIE   -   ORNL

 NUCLIDES FROM XSDRN TAPE
    1      HYDROGEN        ENDF/B-IV MAT 1269/THRM1002             UPDATED 08/12/94     3001001
    2      HYDROGEN        ENDF/B-IV MAT 1269/THRM1002             UPDATED 08/12/94     8001001
    3      HYDROGEN        ENDF/B-IV MAT 1269/THRM1002             UPDATED 08/12/94     9001001
    4     B-10 1273 218NGP 042375 P-3 293K                         UPDATED 08/12/94     6005010
    5     B-10 1273 218NGP 042375 P-3 293K                         UPDATED 08/12/94     8005010
    6      BORON-11        ENDF/B-IV MAT 1160                      UPDATED 08/12/94     6005011
    7      BORON-11        ENDF/B-IV MAT 1160                      UPDATED 08/12/94     8005011
    8      CARBON-12       ENDF/B-IV MAT 1274/THRM1065             UPDATED 08/12/94     6006012
    9      CARBON-12       ENDF/B-IV MAT 1274/THRM1065             UPDATED 08/12/94     8006012
   10      NITROGEN-14     ENDF/B-IV MAT 1275                      UPDATED 08/12/94     8007014
   11      OXYGEN-16       ENDF/B-IV MAT 1276                      UPDATED 08/12/94     1008016
   12      OXYGEN-16       ENDF/B-IV MAT 1276                      UPDATED 08/12/94     3008016
   13      OXYGEN-16       ENDF/B-IV MAT 1276                      UPDATED 08/12/94     8008016
   14      OXYGEN-16       ENDF/B-IV MAT 1276                      UPDATED 08/12/94     9008016
   15     AL-27 1193 218 GP 040375(5)                              UPDATED 08/12/94     4013027
   16     AL-27 1193 218 GP 040375(5)                              UPDATED 08/12/94     6013027
   17     AL-27 1193 218 GP 040375(5)                              UPDATED 08/12/94     8013027
   18     CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'         UPDATED 08/12/94     5024304
```

Figure 6.6-6 CSAS25 Output for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
   19      MANGANESE-55   ENDF/B-IV MAT 1197                          UPDATED 08/12/94     5025055
   20     FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'            UPDATED 08/12/94     5026304
   21     NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'            UPDATED 08/12/94     5028304
   22      ZIRCALLOY        ENDF/B-IV MAT 1284                        UPDATED 08/12/94     2040302
   23     PB    1288 218NGP 042375 P-3 293K                           UPDATED 08/12/94     7082000
   24      URANIUM-235      ENDF/B-IV MAT 1261                        UPDATED 08/12/94     1092235
   25      URANIUM-238      ENDF/B-IV MAT 1262                        UPDATED 08/12/94     1092238

 HYDROGEN       ENDF/B-IV MAT 1269/THRM1002          UPDATED 08/12/94    3001001      TEMPERATURE=    293.00
                                                          PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 HYDROGEN       ENDF/B-IV MAT 1269/THRM1002          UPDATED 08/12/94    8001001      TEMPERATURE=    293.00
                                                          PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 HYDROGEN       ENDF/B-IV MAT 1269/THRM1002          UPDATED 08/12/94    9001001      TEMPERATURE=    293.00
                                                          PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

B-10 1273 218NGP 042375 P-3 293K                     UPDATED 08/12/94    6005010      TEMPERATURE=    293.00
                                                          PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

B-10 1273 218NGP 042375 P-3 293K                     UPDATED 08/12/94    8005010      TEMPERATURE=    293.00
                                                          PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 BORON-11       ENDF/B-IV MAT 1160                   UPDATED 08/12/94    6005011      TEMPERATURE=    293.00
                                                          PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 BORON-11       ENDF/B-IV MAT 1160                   UPDATED 08/12/94    8005011      TEMPERATURE=    293.00
                                                          PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 CARBON-12      ENDF/B-IV MAT 1274/THRM1065          UPDATED 08/12/94    6006012      TEMPERATURE=    293.00
                                                          PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 CARBON-12      ENDF/B-IV MAT 1274/THRM1065          UPDATED 08/12/94    8006012      TEMPERATURE=    293.00
                                                          PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 NITROGEN-14    ENDF/B-IV MAT 1275                   UPDATED 08/12/94    8007014      TEMPERATURE=    293.00
                                                          PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 OXYGEN-16      ENDF/B-IV MAT 1276                   UPDATED 08/12/94    1008016      TEMPERATURE=    293.00
                                                          PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 OXYGEN-16      ENDF/B-IV MAT 1276                   UPDATED 08/12/94    3008016      TEMPERATURE=    293.00
                                                          PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 OXYGEN-16      ENDF/B-IV MAT 1276                   UPDATED 08/12/94    8008016      TEMPERATURE=    293.00
                                                          PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 OXYGEN-16      ENDF/B-IV MAT 1276                   UPDATED 08/12/94    9008016      TEMPERATURE=    293.00
                                                          PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

AL-27 1193 218 GP 040375(5)                          UPDATED 08/12/94    4013027      TEMPERATURE=    293.00
                                                          PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

AL-27 1193 218 GP 040375(5)                          UPDATED 08/12/94    6013027      TEMPERATURE=    293.00
                                                          PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

AL-27 1193 218 GP 040375(5)                          UPDATED 08/12/94    8013027      TEMPERATURE=    293.00
                                                          PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'     UPDATED 08/12/94    5024304      TEMPERATURE=    293.00
                                                          PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 MANGANESE-55   ENDF/B-IV MAT 1197                   UPDATED 08/12/94    5025055      TEMPERATURE=    293.00

GEOMETRY HAS BEEN SET TO HOMOGENEOUS AS LBAR IS  0.0000E+00

RESONANCE DATA FOR THIS NUCLIDE

MASS NUMBER (A)          =    54.466           TEMPERATURE(KELVIN)        =   293.000

POTENTIAL SCATTER SIGMA  =     2.590           LUMPED NUCLEAR DENSITY     = 1.7363295E-03

SPIN FACTOR (G)          =    14.448           LUMP DIMENSION (A-BAR)     = 0.0000000E+00

INNER RADIUS             = 0.0000000E+00       DANCOFF CORRECTION (C)     = 0.0000000E+00

THE ABSORBER WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.

MASS OF MODERATOR-1    =    55.845            SIGMA(PER ABSORBER ATOM)= 3.4663022E+02

MODERATOR-1 WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.

MASS OF MODERATOR-2    =    55.925            SIGMA(PER ABSORBER ATOM)= 1.2557598E+02

MODERATOR-2 WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.

THIS RESONANCE MATERIAL WILL BE TREATED AS A 0-DIMENSIONAL OBJECT.

VOLUME FRACTION OF LUMP IN CELL USED TO ACCOUNT FOR SPATIAL SELF-SHIELDING=1.00000

GROUP        RES ABS         RES FISS         RES SCAT
  8       -5.518788E-04    0.000000E+00    -3.944190E-01
  9       -2.797993E-03    0.000000E+00    -2.293471E+00
 10       -3.291452E-01    0.000000E+00    -3.820862E+01
 11       -2.680562E+00    0.000000E+00    -1.159996E+02
```

Figure 6.6-6 CSAS25 Output for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
EXCESS RESONANCE INTEGRALS

                    RESOLVED

ABSORPTION        3.33719E+00

FISSION           0.00000E+00
                                                              PROCESS NUMBER 1007 IS AT TEMPERATURE=   293.00

FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'          UPDATED 08/12/94    5026304      TEMPERATURE=   293.00
                                                              PROCESS NUMBER 1007 IS AT TEMPERATURE=   293.00

NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'          UPDATED 08/12/94    5028304      TEMPERATURE=   293.00
                                                              PROCESS NUMBER 1007 IS AT TEMPERATURE=   293.00

 ZIRCALLOY      ENDF/B-IV MAT 1284                         UPDATED 08/12/94    2040302      TEMPERATURE=   293.00

RESONANCE DATA FOR THIS NUCLIDE

MASS NUMBER (A)             =     90.436          TEMPERATURE(KELVIN)         =   293.000

POTENTIAL SCATTER SIGMA  =      6.385          LUMPED NUCLEAR DENSITY      = 4.3307818E-02

SPIN FACTOR (G)             =      1.079          LUMP DIMENSION (A-BAR)      = 4.6355000E-01

INNER RADIUS                = 4.0259999E-01      DANCOFF CORRECTION (C)      = 8.4757560E-01

THE ABSORBER WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.

THIS RESONANCE MATERIAL WILL BE TREATED AS A 2-DIMENSIONAL OBJECT.

VOLUME FRACTION OF LUMP IN CELL USED TO ACCOUNT FOR SPATIAL SELF-SHIELDING=1.00000

GROUP        RES ABS          RES FISS          RES SCAT
  8      -8.795965E-04    0.000000E+00    -6.970308E-01
  9      -4.269687E-02    0.000000E+00    -1.811447E+00
 10      -4.621373E-02    0.000000E+00    -1.032856E+00
 11      -1.360111E-01    0.000000E+00    -6.097271E-01

EXCESS RESONANCE INTEGRALS

                    RESOLVED

ABSORPTION        3.93040E-01
FISSION           0.00000E+00
                                                              PROCESS NUMBER 1007 IS AT TEMPERATURE=   293.00

PB   1288 218NGP 042375 P-3 293K                            UPDATED 08/12/94    7082000      TEMPERATURE=   293.00
                                                              PROCESS NUMBER 1007 IS AT TEMPERATURE=   293.00

 URANIUM-235    ENDF/B-IV MAT 1261                         UPDATED 08/12/94    1092235      TEMPERATURE=   293.00

RESONANCE DATA FOR THIS NUCLIDE

MASS NUMBER (A)             =    233.025          TEMPERATURE(KELVIN)         =   293.000

POTENTIAL SCATTER SIGMA  =     11.500          LUMPED NUCLEAR DENSITY      = 9.4064139E-04

SPIN FACTOR (G)             = 15171.100          LUMP DIMENSION (A-BAR)      = 3.9434999E-01

INNER RADIUS                = 0.0000000E+00      DANCOFF CORRECTION (C)      = 9.5888901E-01

THE ABSORBER WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.

MASS OF MODERATOR-1      =     15.991          SIGMA(PER ABSORBER ATOM)= 1.9199110E+02

MODERATOR-1 WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.

MASS OF MODERATOR-2      =    238.051          SIGMA(PER ABSORBER ATOM)= 2.9209552E+02

MODERATOR-2 WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.

THIS RESONANCE MATERIAL WILL BE TREATED AS A 2-DIMENSIONAL OBJECT.

VOLUME FRACTION OF LUMP IN CELL USED TO ACCOUNT FOR SPATIAL SELF-SHIELDING=1.00000

GROUP        RES ABS          RES FISS          RES SCAT
 12      -1.115460E+01   -6.910128E+00    -1.682605E-01
 13      -2.879944E+01   -1.404006E+01    -4.031188E-01
 14      -2.298467E+01   -1.317284E+01    -4.264960E-02
 15      -3.215079E-03   -2.431171E-03     3.882847E-05

EXCESS RESONANCE INTEGRALS

                    RESOLVED

ABSORPTION        1.49929E+02
FISSION           9.24167E+01
                                                              PROCESS NUMBER 1007 IS AT TEMPERATURE=   293.00

 URANIUM-238    ENDF/B-IV MAT 1262                         UPDATED 08/12/94    1092238      TEMPERATURE=   293.00

RESONANCE DATA FOR THIS NUCLIDE
```

Figure 6.6-6 CSAS25 Output for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
MASS NUMBER (A)           =   236.006          TEMPERATURE(KELVIN)      =   293.000
POTENTIAL SCATTER SIGMA  =    10.599           LUMPED NUCLEAR DENSITY   = 2.2290209E-02
SPIN FACTOR (G)           =   656.527          LUMP DIMENSION (A-BAR)   = 3.9434999E-01
INNER RADIUS              = 0.0000000E+00      DANCOFF CORRECTION (C)   = 9.5888901E-01
THE ABSORBER WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.
MASS OF MODERATOR-1     =    15.991          SIGMA(PER ABSORBER ATOM)= 8.1019773E+00
MODERATOR-1 WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.
MASS OF MODERATOR-2     =   235.044          SIGMA(PER ABSORBER ATOM)= 5.0228214E-01
MODERATOR-2 WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.
THIS RESONANCE MATERIAL WILL BE TREATED AS A 2-DIMENSIONAL OBJECT.
VOLUME FRACTION OF LUMP IN CELL USED TO ACCOUNT FOR SPATIAL SELF-SHIELDING=1.00000

GROUP       RES ABS          RES FISS        RES SCAT
  9     -8.035530E-02    0.000000E+00   -7.473816E-01
 10     -1.506941E+00   -6.750685E-05   -8.777449E+00
 11     -1.070745E+01    0.000000E+00   -2.894283E+01
 12     -4.478590E+01    0.000000E+00   -5.118077E+01
 13     -5.544063E+01    0.000000E+00   -1.758312E+01
 14     -1.076790E+02    0.000000E+00   -5.655300E+00
 15     -6.314348E-05    0.000000E+00    1.227886E-04

EXCESS RESONANCE INTEGRALS

                 RESOLVED

ABSORPTION      7.05643E+00
FISSION         4.17667E-04
                                          PROCESS NUMBER 1007 IS AT TEMPERATURE=     293.00
     THIS XSDRN WORKING TAPE WAS CREATED 11/13/96 AT 00:51:51
     THE TITLE OF THE PARENT CASE IS AS FOLLOWS
     SCALE 4.2 - 27 GROUP NEUTRON GROUP LIBRARY
        BASED ON ENDF-B VERSION 4 DATA
           COMPILED FOR NRC      1/27/89
         TAPE ID                        4321         NUMBER OF NUCLIDES                  25
         NUMBER OF NEUTRON GROUPS         27         NUMBER OF GAMMA GROUPS               0
         FIRST THERMAL GROUP              15         LOGICAL UNIT                         4
                                 TABLE OF CONTENTS
        HYDROGEN        ENDF/B-IV MAT 1269/THRM1002            UPDATED 08/12/94       ID   3001001
        HYDROGEN        ENDF/B-IV MAT 1269/THRM1002            UPDATED 08/12/94       ID   8001001
        HYDROGEN        ENDF/B-IV MAT 1269/THRM1002            UPDATED 08/12/94       ID   9001001
       B-10 1273 218NGP 042375 P-3 293K                       UPDATED 08/12/94       ID   6005010
       B-10 1273 218NGP 042375 P-3 293K                       UPDATED 08/12/94       ID   8005010
        BORON-11        ENDF/B-IV MAT 1160                     UPDATED 08/12/94       ID   6005011
        BORON-11        ENDF/B-IV MAT 1160                     UPDATED 08/12/94       ID   8005011
        CARBON-12       ENDF/B-IV MAT 1274/THRM1065            UPDATED 08/12/94       ID   6006012
        CARBON-12       ENDF/B-IV MAT 1274/THRM1065            UPDATED 08/12/94       ID   8006012
        NITROGEN-14     ENDF/B-IV MAT 1275                     UPDATED 08/12/94       ID   8007014
        OXYGEN-16       ENDF/B-IV MAT 1276                     UPDATED 08/12/94       ID   1008016
        OXYGEN-16       ENDF/B-IV MAT 1276                     UPDATED 08/12/94       ID   3008016
        OXYGEN-16       ENDF/B-IV MAT 1276                     UPDATED 08/12/94       ID   8008016
        OXYGEN-16       ENDF/B-IV MAT 1276                     UPDATED 08/12/94       ID   9008016
       AL-27 1193 218 GP 040375(5)                            UPDATED 08/12/94       ID   4013027
       AL-27 1193 218 GP 040375(5)                            UPDATED 08/12/94       ID   6013027
       AL-27 1193 218 GP 040375(5)                            UPDATED 08/12/94       ID   8013027
       CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'       UPDATED 08/12/94       ID   5024304
        MANGANESE-55    ENDF/B-IV MAT 1197                     UPDATED 08/12/94       ID   5025055
       FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'       UPDATED 08/12/94       ID   5026304
       NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'       UPDATED 08/12/94       ID   5028304
        ZIRCALLOY       ENDF/B-IV MAT 1284                     UPDATED 08/12/94       ID   2040302
       PB    1288 218NGP 042375 P-3 293K                       UPDATED 08/12/94       ID   7082000
        URANIUM-235     ENDF/B-IV MAT 1261                     UPDATED 08/12/94       ID   1092235
        URANIUM-238     ENDF/B-IV MAT 1262                     UPDATED 08/12/94       ID   1092238

         TAPE COPY USED        0 I/O'S, AND TOOK      0.33 SECONDS
```

Figure 6.6-6 CSAS25 Output for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
*************************************************************************
*************************************************************************
*************************************************************************
*****                                                               *****
*****               PROGRAM VERIFICATION INFORMATION                *****
*****                                                               *****
*****             CODE SYSTEM:  SCALE-PC VERSION:  4.3              *****
*****                                                               *****
*************************************************************************
*************************************************************************
*****                                                               *****
*****                                                               *****
*****               PROGRAM:  000009                                *****
*****                                                               *****
*****         CREATION DATE:  03-08-96                              *****
*****                                                               *****
*****                VOLUME:  ENG                                   *****
*****                                                               *****
*****               LIBRARY:  G:\scale43\exe                        *****
*****                                                               *****
*****                                                               *****
*****       PRODUCTION CODE:  KENOVA                                *****
*****                                                               *****
*****               VERSION:  3.1                                   *****
*****                                                               *****
*****               JOBNAME:  SCALE-PC                              *****
*****                                                               *****
*****     DATE OF EXECUTION:  11/13/96                              *****
*****                                                               *****
*****     TIME OF EXECUTION:  00:52:03                              *****
*****                                                               *****
*****                                                               *****
*************************************************************************
*************************************************************************
*************************************************************************
```

Figure 6.6-6 CSAS25 Output for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
TRANSPORT CRITICALITY: NORMAL CONDITIONS (PITCH = 250.698 CM) (EXT. MOD. VF = 0.

****** NUMERIC PARAMETERS ******

TME   MAXIMUM PROBLEM TIME (MIN)              500.00
TBA   TIME PER GENERATION (MIN)                 0.50
GEN   NUMBER OF GENERATIONS                      203
NPG   NUMBER PER GENERATION                     1000
NSK   NUMBER OF GENERATIONS TO BE SKIPPED          3
BEG   BEGINNING GENERATION NUMBER                  1
RES   GENERATIONS BETWEEN CHECKPOINTS              0
X1D   NUMBER OF EXTRA 1-D CROSS SECTIONS           1
NBK   NEUTRON BANK SIZE                         1025
XNB   EXTRA POSITIONS IN NEUTRON BANK              0
NFB   FISSION BANK SIZE                         1000
XFB   EXTRA POSITIONS IN FISSION BANK              0
WTA   DEFAULT VALUE OF WEIGHT AVERAGE         0.5000
WTH   WEIGHT HIGH FOR SPLITTING               3.0000
WTL   WEIGHT LOW FOR RUSSIAN ROULETTE         0.3333
RND   STARTING RANDOM NUMBER            BB827100001
NB8   NUMBER OF D.A. BLOCKS ON UNIT  8           200
NL8   LENGTH OF D.A. BLOCKS ON UNIT  8           512
ADJ   MODE OF CALCULATION                    FORWARD
      INPUT DATA WRITTEN ON RESTART UNIT          NO
      BINARY DATA INTERFACE                      YES
```

Figure 6.6-6 CSAS25 Output for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
***************************************************************************************************
***                                                                                             ***
***                TRANSPORT CRITICALITY: NORMAL CONDITIONS (PITCH = 250.698 CM) (EXT. MOD. VF = 0.***
***                                                                                             ***
***************************************************************************************************
***                           ******    LOGICAL PARAMETERS     ******                           ***
***                                                                                             ***
*** RUN  EXECUTE PROBLEM AFTER CHECKING DATA     YES       PLT  PLOT PICTURE MAP(S)                NO ***
***                                                                                             ***
*** FLX  COMPUTE FLUX                            NO        FDN  COMPUTE FISSION DENSITIES          NO ***
***                                                                                             ***
*** SMU  COMPUTE AVG UNIT SELF-MULTIPLICATION    NO        NUB  COMPUTE NU-BAR & AVG FISSION GROUP YES ***
***                                                                                             ***
*** MKU  COMPUTE MATRIX K-EFF BY UNIT NUMBER     NO        MKP  COMPUTE MATRIX K-EFF BY UNIT LOCATION  NO ***
***                                                                                             ***
*** CKU  COMPUTE COFACTOR K-EFF BY UNIT NUMBER   NO        CKP  COMPUTE COFACTOR K-EFF BY UNIT LOCATION NO ***
***                                                                                             ***
*** FMU  PRINT FISS PROD MATRIX BY UNIT NUMBER   NO        FMP  PRINT FISS PROD MATRIX BY UNIT LOCATION NO ***
***                                                                                             ***
*** MKH  COMPUTE MATRIX K-EFF BY HOLE NUMBER     NO        MKA  COMPUTE MATRIX K-EFF BY ARRAY NUMBER   NO ***
***                                                                                             ***
*** CKH  COMPUTE COFACTOR K-EFF BY HOLE NUMBER   NO        CKA  COMPUTE COFACTOR K-EFF BY ARRAY NUMBER NO ***
***                                                                                             ***
*** FMH  PRINT FISS PROD MATRIX BY HOLE NUMBER   NO        FMA  PRINT FISS PROD MATRIX BY ARRAY NUMBER NO ***
***                                                                                             ***
*** HHL  COLLECT MATRIX BY HIGHEST HOLE LEVEL    NO        HAL  COLLECT MATRIX BY HIGHEST ARRAY LEVEL  NO ***
***                                                                                             ***
*** AMX  PRINT ALL MIXED CROSS SECTIONS          NO        FAR  PRINT FIS. AND ABS. BY REGION      NO ***
***                                                                                             ***
*** XS1  PRINT 1-D MIXTURE X-SECTIONS            NO        GAS  PRINT FAR BY GROUP                 NO ***
***                                                                                             ***
*** XS2  PRINT 2-D MIXTURE X-SECTIONS            NO        PAX  PRINT XSEC-ALBEDO CORRELATION TABLES NO ***
***                                                                                             ***
*** XAP  PRINT MIXTURE ANGLES & PROBABILITIES    NO        PWT  PRINT WEIGHT AVERAGE ARRAY         NO ***
***                                                                                             ***
*** PKI  PRINT FISSION SPECTRUM                  NO        PGM  PRINT INPUT GEOMETRY               NO ***
***                                                                                             ***
*** P1D  PRINT EXTRA 1-D CROSS SECTIONS          NO        BUG  PRINT DEBUG INFORMATION            NO ***
***                                                                                             ***
***                                                        TRK  PRINT TRACKING INFORMATION         NO ***
***                                                                                             ***
***                                                                                             ***
***************************************************************************************************
***************************************************************************************************
***************************************************************************************************
                                   PARAMETER INPUT COMPLETED

TRANSPORT CRITICALITY: NORMAL CONDITIONS (PITCH = 250.698 CM) (EXT. MOD. VF = 0.

                                        MIXING TABLE

                               NUMBER OF SCATTERING ANGLES =  2
                           CROSS SECTION MESSAGE THRESHOLD =3.0E-05

MIXTURE =     1          DENSITY(G/CC) =  10.412
   NUCLIDE   ATOM-DENS.   WGT. FRAC.     ZA       AWT                NUCLIDE TITLE
   1008016  4.64617E-02  1.18487E-01    8016    15.9904     OXYGEN-16       ENDF/B-IV MAT 1276                     UPDATED
08/12/94
   1092235  9.40641E-04  3.52606E-02   92235   235.0441     URANIUM-235     ENDF/B-IV MAT 1261                     UPDATED
08/12/94
   1092238  2.22902E-02  8.46253E-01   92238   238.0510     URANIUM-238     ENDF/B-IV MAT 1262                     UPDATED
08/12/94

MIXTURE =     2          DENSITY(G/CC) =   6.5600
   NUCLIDE   ATOM-DENS.   WGT. FRAC.     ZA       AWT                NUCLIDE TITLE
   2040302  4.33078E-02  1.00000E+00   40000    91.2196     ZIRCALLOY       ENDF/B-IV MAT 1284                     UPDATED
08/12/94

MIXTURE =     3          DENSITY(G/CC) = 0.99817E-04
   NUCLIDE   ATOM-DENS.   WGT. FRAC.     ZA       AWT                NUCLIDE TITLE
   3001001  6.67692E-06  1.11927E-01    1001     1.0077     HYDROGEN        ENDF/B-IV MAT 1269/THRM1002            UPDATED
08/12/94
   3008016  3.33846E-06  8.88074E-01    8016    15.9904     OXYGEN-16       ENDF/B-IV MAT 1276                     UPDATED
08/12/94

MIXTURE =     4          DENSITY(G/CC) =   2.7020
   NUCLIDE   ATOM-DENS.   WGT. FRAC.     ZA       AWT                NUCLIDE TITLE
   4013027  6.03066E-02  1.00000E+00   13027    26.9818     AL-27 1193 218 GP 040375(5)                            UPDATED
08/12/94

MIXTURE =     5          DENSITY(G/CC) =   7.9200
   NUCLIDE   ATOM-DENS.   WGT. FRAC.     ZA       AWT                NUCLIDE TITLE
   5024304  1.74286E-02  1.90000E-01   24000    51.9957     CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'       UPDATED
08/12/94
   5025055  1.73633E-03  1.99999E-02   25055    54.9379     MANGANESE-55    ENDF/B-IV MAT 1197                     UPDATED
08/12/94
   5026304  5.93579E-02  6.95000E-01   26000    55.8447     FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'       UPDATED
08/12/94
   5028304  7.72070E-03  9.50001E-02   28000    58.6872     NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'       UPDATED
08/12/94

MIXTURE =     6          DENSITY(G/CC) =   2.5833
```

Figure 6.6-6 CSAS25 Output for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
   NUCLIDE  ATOM-DENS.   WGT. FRAC.    ZA      AWT             NUCLIDE TITLE
   6005010  7.09799E-03  4.56855E-02   5010    10.0130   B-10 1273 218NGP 042375 P-3 293K                       UPDATED
08/12/94
   6005011  3.92499E-02  2.77771E-01   5011    11.0096    BORON-11       ENDF/B-IV MAT 1160                     UPDATED
08/12/94
   6006012  1.22006E-02  9.41116E-02   6000    12.0001    CARBON-12      ENDF/B-IV MAT 1274/THRM1065            UPDATED
08/12/94
   6013027  3.35812E-02  5.82432E-01  13027    26.9818   AL-27 1193 218 GP 040375(5)                            UPDATED
08/12/94

MIXTURE =     7          DENSITY(G/CC) =  11.344
   NUCLIDE  ATOM-DENS.   WGT. FRAC.    ZA      AWT             NUCLIDE TITLE
   7082000  3.29690E-02  1.00000E+00  82000   207.2100   PB   1288 218NGP 042375 P-3 293K                       UPDATED
08/12/94

MIXTURE =     8          DENSITY(G/CC) =  1.6307
   NUCLIDE  ATOM-DENS.   WGT. FRAC.    ZA      AWT             NUCLIDE TITLE
   8001001  5.84084E-02  5.99323E-02   1001     1.0077    HYDROGEN       ENDF/B-IV MAT 1269/THRM1002            UPDATED
08/12/94
   8005010  9.79802E-05  9.99025E-04   5010    10.0130   B-10 1273 218NGP 042375 P-3 293K                       UPDATED
08/12/94
   8005011  3.56450E-04  3.99615E-03   5011    11.0096    BORON-11       ENDF/B-IV MAT 1160                     UPDATED
08/12/94
   8006012  2.26463E-02  2.76729E-01   6000    12.0001    CARBON-12      ENDF/B-IV MAT 1274/THRM1065            UPDATED
08/12/94
   8007014  1.40121E-03  1.99805E-02   7014    14.0033    NITROGEN-14    ENDF/B-IV MAT 1275                     UPDATED
08/12/94
   8008016  2.60749E-02  4.24574E-01   8016    15.9904    OXYGEN-16      ENDF/B-IV MAT 1276                     UPDATED
08/12/94
   8013027  7.78110E-03  2.13789E-01  13027    26.9818   AL-27 1193 218 GP 040375(5)                            UPDATED
08/12/94

MIXTURE =     9          DENSITY(G/CC) = 0.59890
   NUCLIDE  ATOM-DENS.   WGT. FRAC.    ZA      AWT             NUCLIDE TITLE
   9001001  4.00615E-02  1.11927E-01   1001     1.0077    HYDROGEN       ENDF/B-IV MAT 1269/THRM1002            UPDATED
08/12/94
   9008016  2.00308E-02  8.88074E-01   8016    15.9904    OXYGEN-16      ENDF/B-IV MAT 1276                     UPDATED
08/12/94


                  3001001     HYDROGEN        ENDF/B-IV MAT 1269/THRM1002              UPDATED 08/12/94
                  8001001     HYDROGEN        ENDF/B-IV MAT 1269/THRM1002              UPDATED 08/12/94
                  9001001     HYDROGEN        ENDF/B-IV MAT 1269/THRM1002              UPDATED 08/12/94
                  6005010    B-10 1273 218NGP 042375 P-3 293K                          UPDATED 08/12/94

                  8005010    B-10 1273 218NGP 042375 P-3 293K                          UPDATED 08/12/94
                  6005011     BORON-11        ENDF/B-IV MAT 1160                       UPDATED 08/12/94
                  8005011     BORON-11        ENDF/B-IV MAT 1160                       UPDATED 08/12/94
                  6006012     CARBON-12       ENDF/B-IV MAT 1274/THRM1065              UPDATED 08/12/94
                  8006012     CARBON-12       ENDF/B-IV MAT 1274/THRM1065              UPDATED 08/12/94
                  8007014     NITROGEN-14     ENDF/B-IV MAT 1275                       UPDATED 08/12/94
                  1008016     OXYGEN-16       ENDF/B-IV MAT 1276                       UPDATED 08/12/94
                  3008016     OXYGEN-16       ENDF/B-IV MAT 1276                       UPDATED 08/12/94
                  8008016     OXYGEN-16       ENDF/B-IV MAT 1276                       UPDATED 08/12/94
                  9008016     OXYGEN-16       ENDF/B-IV MAT 1276                       UPDATED 08/12/94
                  4013027    AL-27 1193 218 GP 040375(5)                               UPDATED 08/12/94
                  6013027    AL-27 1193 218 GP 040375(5)                               UPDATED 08/12/94
                  8013027    AL-27 1193 218 GP 040375(5)                               UPDATED 08/12/94
                  5024304    CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'          UPDATED 08/12/94
                  5025055     MANGANESE-55    ENDF/B-IV MAT 1197                       UPDATED 08/12/94
                  5026304    FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'          UPDATED 08/12/94
                  5028304    NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'          UPDATED 08/12/94
                  2040302     ZIRCALLOY       ENDF/B-IV MAT 1284                       UPDATED 08/12/94
                  7082000    PB   1288 218NGP 042375 P-3 293K                          UPDATED 08/12/94
                  1092235     URANIUM-235     ENDF/B-IV MAT 1261                       UPDATED 08/12/94
                  1092238     URANIUM-238     ENDF/B-IV MAT 1262                       UPDATED 08/12/94

                    ........    0 IO'S WERE USED MIXING CROSS-SECTIONS       ........

                     1-D CROSS SECTION ARRAY ID NUMBERS
                        1  2002  1452    27    18  1018

                    ........    0 IO'S WERE USED PREPARING THE CROSS SECTIONS    ........
```

Figure 6.6-6 CSAS25 Output for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
*******************************************************************************************
***                                                                                    ***
***        TRANSPORT CRITICALITY: NORMAL CONDITIONS (PITCH = 250.698 CM) (EXT. MOD. VF = 0.   ***
***                                                                                    ***
*******************************************************************************************
*******************************************************************************************
***                                                                                    ***
***                        ****** ADDITIONAL INFORMATION ******                        ***
***                                                                                    ***
*** NUMBER OF ENERGY GROUPS              27     USE LATTICE GEOMETRY                  YES ***
***                                                                                    ***
*** NO. OF FISSION SPECTRUM SOURCE GROUP  1     GLOBAL ARRAY NUMBER                    60 ***
***                                                                                    ***
*** NO. OF SCATTERING ANGLES IN XSECS     2     NUMBER OF UNITS IN THE GLOBAL X DIR.    1 ***
***                                                                                    ***
*** ENTRIES/NEUTRON IN THE NEUTRON BANK  33     NUMBER OF UNITS IN THE GLOBAL Y DIR.    1 ***
***                                                                                    ***
*** ENTRIES/NEUTRON IN THE FISSION BANK  26     NUMBER OF UNITS IN THE GLOBAL Z DIR.    4 ***
***                                                                                    ***
*** NUMBER OF MIXTURES USED               9     USE A GLOBAL REFLECTOR                YES ***
***                                                                                    ***
*** NUMBER OF BIAS ID'S USED              1     USE NESTED HOLES                      YES ***
***                                                                                    ***
*** NUMBER OF DIFFERENTIAL ALBEDOS USED   0     NUMBER OF HOLES                        48 ***
***                                                                                    ***
*** TOTAL INPUT GEOMETRY REGIONS        136     MAXIMUM HOLE NESTING LEVEL              3 ***
***                                                                                    ***
*** NUMBER OF GEOMETRY REGIONS USED     136     USE NESTED ARRAYS                     YES ***
***                                                                                    ***
*** LARGEST GEOMETRY UNIT NUMBER        120     NUMBER OF ARRAYS USED                  27 ***
***                                                                                    ***
*** LARGEST ARRAY NUMBER                 60     MAXIMUM ARRAY NESTING LEVEL             4 ***
***                                                                                    ***
***                                                                                    ***
*** +X BOUNDARY CONDITION               MIR     -X BOUNDARY CONDITION                 MIR ***
***                                                                                    ***
*** +Y BOUNDARY CONDITION               MIR     -Y BOUNDARY CONDITION                 MIR ***
***                                                                                    ***
*** +Z BOUNDARY CONDITION               PER     -Z BOUNDARY CONDITION                 PER ***
***                                                                                    ***
*******************************************************************************************
```

Figure 6.6-6 CSAS25 Output for Canistered Fuel Normal Conditions Criticality Analysis (continued)

TRANSPORT CRITICALITY: NORMAL CONDITIONS (PITCH = 250.698 CM) (EXT. MOD. VF = 0.

GENERATION	GENERATION K-EFFECTIVE	ELAPSED TIME MINUTES	AVERAGE K-EFFECTIVE	AVG K-EFF DEVIATION	MATRIX K-EFFECTIVE	MATRIX K-EFF DEVIATION
KENO MESSAGE NUMBER K5-132		WARNING....ONLY	494 INDEPENDENT	FISSION POINTS WERE	GENERATED	
1	4.48332E-01	3.85500E-01	1.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
KENO MESSAGE NUMBER K5-132		WARNING....ONLY	477 INDEPENDENT	FISSION POINTS WERE	GENERATED	
2	4.43293E-01	7.19500E-01	1.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
KENO MESSAGE NUMBER K5-132		WARNING....ONLY	534 INDEPENDENT	FISSION POINTS WERE	GENERATED	
3	4.51460E-01	1.05467E+00	4.51460E-01	0.00000E+00	0.00000E+00	0.00000E+00
4	4.67077E-01	1.39517E+00	4.59269E-01	7.80828E-03	0.00000E+00	0.00000E+00
5	4.55744E-01	1.73850E+00	4.58094E-01	4.65870E-03	0.00000E+00	0.00000E+00
6	4.51320E-01	2.08533E+00	4.56400E-01	3.70404E-03	0.00000E+00	0.00000E+00
7	4.57700E-01	2.43050E+00	4.56660E-01	2.88088E-03	0.00000E+00	0.00000E+00
8	4.67890E-01	2.77283E+00	4.58532E-01	3.00603E-03	0.00000E+00	0.00000E+00
9	4.63798E-01	3.12433E+00	4.59284E-01	2.64962E-03	0.00000E+00	0.00000E+00
10	4.45528E-01	3.46400E+00	4.57565E-01	2.86743E-03	0.00000E+00	0.00000E+00
11	4.61534E-01	3.79817E+00	4.58006E-01	2.56700E-03	0.00000E+00	0.00000E+00
12	4.70475E-01	4.14150E+00	4.59253E-01	2.61275E-03	0.00000E+00	0.00000E+00
13	4.53302E-01	4.47733E+00	4.58712E-01	2.42445E-03	0.00000E+00	0.00000E+00
14	4.40243E-01	4.81433E+00	4.57173E-01	2.69573E-03	0.00000E+00	0.00000E+00
15	4.57565E-01	5.15667E+00	4.57203E-01	2.47989E-03	0.00000E+00	0.00000E+00
16	4.61519E-01	5.50267E+00	4.57511E-01	2.31654E-03	0.00000E+00	0.00000E+00
17	4.64866E-01	5.84050E+00	4.58001E-01	2.21162E-03	0.00000E+00	0.00000E+00
18	4.69900E-01	6.19100E+00	4.58745E-01	2.19839E-03	0.00000E+00	0.00000E+00
19	4.58153E-01	6.52983E+00	4.58710E-01	2.06532E-03	0.00000E+00	0.00000E+00
20	4.61944E-01	6.87117E+00	4.58890E-01	1.95547E-03	0.00000E+00	0.00000E+00
21	4.59987E-01	7.20717E+00	4.58948E-01	1.85059E-03	0.00000E+00	0.00000E+00
22	4.51837E-01	7.55317E+00	4.58592E-01	1.79126E-03	0.00000E+00	0.00000E+00
23	4.57642E-01	7.89467E+00	4.58547E-01	1.70443E-03	0.00000E+00	0.00000E+00
24	4.41768E-01	8.24533E+00	4.57784E-01	1.79517E-03	0.00000E+00	0.00000E+00
25	4.50166E-01	8.58950E+00	4.57453E-01	1.74703E-03	0.00000E+00	0.00000E+00
26	4.82646E-01	8.93367E+00	4.58503E-01	1.97476E-03	0.00000E+00	0.00000E+00
27	4.68136E-01	9.28067E+00	4.58888E-01	1.93292E-03	0.00000E+00	0.00000E+00
28	4.56009E-01	9.62200E+00	4.58777E-01	1.86039E-03	0.00000E+00	0.00000E+00
29	4.56370E-01	9.95800E+00	4.58688E-01	1.79238E-03	0.00000E+00	0.00000E+00
30	4.55737E-01	1.03105E+01	4.58583E-01	1.73039E-03	0.00000E+00	0.00000E+00
31	4.59289E-01	1.06557E+01	4.58607E-01	1.66984E-03	0.00000E+00	0.00000E+00
32	4.50980E-01	1.09878E+01	4.58353E-01	1.63312E-03	0.00000E+00	0.00000E+00
33	4.53890E-01	1.13348E+01	4.58209E-01	1.58611E-03	0.00000E+00	0.00000E+00
34	4.61455E-01	1.16790E+01	4.58310E-01	1.53909E-03	0.00000E+00	0.00000E+00
35	4.45631E-01	1.20068E+01	4.57926E-01	1.54041E-03	0.00000E+00	0.00000E+00
36	4.61928E-01	1.23408E+01	4.58044E-01	1.49905E-03	0.00000E+00	0.00000E+00
37	4.65105E-01	1.26797E+01	4.58246E-01	1.46950E-03	0.00000E+00	0.00000E+00
38	4.50275E-01	1.30202E+01	4.58024E-01	1.44516E-03	0.00000E+00	0.00000E+00
39	4.51914E-01	1.33652E+01	4.57859E-01	1.41523E-03	0.00000E+00	0.00000E+00
40	4.66734E-01	1.37077E+01	4.58093E-01	1.39714E-03	0.00000E+00	0.00000E+00
41	4.53626E-01	1.40500E+01	4.57978E-01	1.36565E-03	0.00000E+00	0.00000E+00
42	4.45578E-01	1.43942E+01	4.57668E-01	1.36669E-03	0.00000E+00	0.00000E+00
43	4.59431E-01	1.47430E+01	4.57711E-01	1.33364E-03	0.00000E+00	0.00000E+00
44	4.68701E-01	1.50898E+01	4.57973E-01	1.32754E-03	0.00000E+00	0.00000E+00
45	4.61495E-01	1.54313E+01	4.58055E-01	1.29889E-03	0.00000E+00	0.00000E+00
46	4.44256E-01	1.57773E+01	4.57741E-01	1.30720E-03	0.00000E+00	0.00000E+00
47	4.47966E-01	1.61115E+01	4.57524E-01	1.29615E-03	0.00000E+00	0.00000E+00
48	4.55078E-01	1.64502E+01	4.57471E-01	1.26878E-03	0.00000E+00	0.00000E+00
49	4.57880E-01	1.67862E+01	4.57479E-01	1.24152E-03	0.00000E+00	0.00000E+00
50	4.66583E-01	1.71303E+01	4.57669E-01	1.23009E-03	0.00000E+00	0.00000E+00
51	4.54401E-01	1.74692E+01	4.57602E-01	1.20656E-03	0.00000E+00	0.00000E+00
52	4.65092E-01	1.78160E+01	4.57752E-01	1.19164E-03	0.00000E+00	0.00000E+00
53	4.56241E-01	1.81685E+01	4.57722E-01	1.16842E-03	0.00000E+00	0.00000E+00
54	4.60041E-01	1.85090E+01	4.57767E-01	1.14659E-03	0.00000E+00	0.00000E+00
55	4.73428E-01	1.88587E+01	4.58063E-01	1.16292E-03	0.00000E+00	0.00000E+00
56	4.72201E-01	1.92002E+01	4.58324E-01	1.17083E-03	0.00000E+00	0.00000E+00
57	4.33760E-01	1.95278E+01	4.57878E-01	1.23307E-03	0.00000E+00	0.00000E+00
58	4.54376E-01	1.98675E+01	4.57815E-01	1.21247E-03	0.00000E+00	0.00000E+00
59	4.64330E-01	2.02080E+01	4.57930E-01	1.19648E-03	0.00000E+00	0.00000E+00
60	4.61638E-01	2.05503E+01	4.57993E-01	1.17740E-03	0.00000E+00	0.00000E+00
61	4.68476E-01	2.08965E+01	4.58171E-01	1.17084E-03	0.00000E+00	0.00000E+00
62	4.61480E-01	2.12378E+01	4.58226E-01	1.15248E-03	0.00000E+00	0.00000E+00
63	4.57134E-01	2.15748E+01	4.58208E-01	1.13357E-03	0.00000E+00	0.00000E+00
64	4.69332E-01	2.19190E+01	4.58388E-01	1.12947E-03	0.00000E+00	0.00000E+00
65	4.43979E-01	2.22577E+01	4.58159E-01	1.13469E-03	0.00000E+00	0.00000E+00
66	4.59447E-01	2.26000E+01	4.58179E-01	1.11700E-03	0.00000E+00	0.00000E+00
67	4.46618E-01	2.29360E+01	4.58001E-01	1.11397E-03	0.00000E+00	0.00000E+00
68	4.48726E-01	2.32775E+01	4.57861E-01	1.10593E-03	0.00000E+00	0.00000E+00
69	4.54201E-01	2.36207E+01	4.57806E-01	1.09067E-03	0.00000E+00	0.00000E+00
70	4.58805E-01	2.39622E+01	4.57821E-01	1.07461E-03	0.00000E+00	0.00000E+00
71	4.48634E-01	2.43137E+01	4.57688E-01	1.06726E-03	0.00000E+00	0.00000E+00
72	4.60830E-01	2.46515E+01	4.57733E-01	1.05286E-03	0.00000E+00	0.00000E+00
73	4.62452E-01	2.49938E+01	4.57799E-01	1.04005E-03	0.00000E+00	0.00000E+00
74	4.58161E-01	2.53490E+01	4.57804E-01	1.02551E-03	0.00000E+00	0.00000E+00
75	4.58480E-01	2.56942E+01	4.57813E-01	1.01141E-03	0.00000E+00	0.00000E+00
76	4.67372E-01	2.60365E+01	4.57943E-01	1.00598E-03	0.00000E+00	0.00000E+00
77	4.58155E-01	2.63917E+01	4.57945E-01	9.92477E-04	0.00000E+00	0.00000E+00
78	4.34600E-01	2.67258E+01	4.57638E-01	1.02637E-03	0.00000E+00	0.00000E+00
79	4.50901E-01	2.70792E+01	4.57551E-01	1.01673E-03	0.00000E+00	0.00000E+00
80	4.64665E-01	2.74243E+01	4.57642E-01	1.00775E-03	0.00000E+00	0.00000E+00
81	4.59790E-01	2.77703E+01	4.57669E-01	9.95279E-04	0.00000E+00	0.00000E+00
82	4.55906E-01	2.81082E+01	4.57647E-01	9.83006E-04	0.00000E+00	0.00000E+00
83	4.65838E-01	2.84542E+01	4.57748E-01	9.76047E-04	0.00000E+00	0.00000E+00
84	4.69348E-01	2.88075E+01	4.57890E-01	9.74393E-04	0.00000E+00	0.00000E+00
85	4.61978E-01	2.91472E+01	4.57939E-01	9.63841E-04	0.00000E+00	0.00000E+00
86	4.66666E-01	2.94868E+01	4.58043E-01	9.57948E-04	0.00000E+00	0.00000E+00
87	4.58813E-01	2.98300E+01	4.58052E-01	9.46655E-04	0.00000E+00	0.00000E+00
88	4.66602E-01	3.01743E+01	4.58151E-01	9.40850E-04	0.00000E+00	0.00000E+00

Figure 6.6-6 CSAS25 Output for Canistered Fuel Normal Conditions Criticality Analysis (continued)

89	4.56168E-01	3.05083E+01	4.58128E-01	9.30252E-04	0.00000E+00	0.00000E+00
90	4.62012E-01	3.08490E+01	4.58173E-01	9.20678E-04	0.00000E+00	0.00000E+00
91	4.61616E-01	3.11867E+01	4.58211E-01	9.11097E-04	0.00000E+00	0.00000E+00
92	4.42385E-01	3.15282E+01	4.58035E-01	9.17919E-04	0.00000E+00	0.00000E+00
93	4.45441E-01	3.18705E+01	4.57897E-01	9.18265E-04	0.00000E+00	0.00000E+00
94	4.42622E-01	3.22075E+01	4.57731E-01	9.23280E-04	0.00000E+00	0.00000E+00
95	4.48923E-01	3.25360E+01	4.57636E-01	9.18196E-04	0.00000E+00	0.00000E+00
96	4.69889E-01	3.28830E+01	4.57767E-01	9.17680E-04	0.00000E+00	0.00000E+00
97	4.65123E-01	3.32318E+01	4.57844E-01	9.11264E-04	0.00000E+00	0.00000E+00
98	4.68931E-01	3.35797E+01	4.57960E-01	9.09088E-04	0.00000E+00	0.00000E+00
99	4.32937E-01	3.39102E+01	4.57702E-01	9.35920E-04	0.00000E+00	0.00000E+00
100	4.75083E-01	3.42525E+01	4.57879E-01	9.43147E-04	0.00000E+00	0.00000E+00
101	4.51684E-01	3.45930E+01	4.57816E-01	9.35667E-04	0.00000E+00	0.00000E+00
102	4.76249E-01	3.49455E+01	4.58001E-01	9.44425E-04	0.00000E+00	0.00000E+00
103	4.43920E-01	3.52805E+01	4.57861E-01	9.45364E-04	0.00000E+00	0.00000E+00
104	4.65394E-01	3.56302E+01	4.57935E-01	9.38958E-04	0.00000E+00	0.00000E+00
105	4.56583E-01	3.59707E+01	4.57922E-01	9.29890E-04	0.00000E+00	0.00000E+00
106	4.58477E-01	3.63205E+01	4.57927E-01	9.20921E-04	0.00000E+00	0.00000E+00
107	4.46813E-01	3.66582E+01	4.57822E-01	9.18230E-04	0.00000E+00	0.00000E+00
108	4.61466E-01	3.69933E+01	4.57856E-01	9.10176E-04	0.00000E+00	0.00000E+00
109	4.56823E-01	3.73412E+01	4.57846E-01	9.01681E-04	0.00000E+00	0.00000E+00
110	4.64921E-01	3.76817E+01	4.57912E-01	8.95692E-04	0.00000E+00	0.00000E+00
111	4.68324E-01	3.80305E+01	4.58007E-01	8.92563E-04	0.00000E+00	0.00000E+00
112	4.64874E-01	3.83655E+01	4.58070E-01	8.86612E-04	0.00000E+00	0.00000E+00
113	4.56108E-01	3.87143E+01	4.58052E-01	8.78766E-04	0.00000E+00	0.00000E+00
114	4.60073E-01	3.90640E+01	4.58070E-01	8.71071E-04	0.00000E+00	0.00000E+00
115	4.67658E-01	3.94118E+01	4.58155E-01	8.67488E-04	0.00000E+00	0.00000E+00
116	4.45389E-01	3.97478E+01	4.58043E-01	8.67106E-04	0.00000E+00	0.00000E+00
117	4.61144E-01	4.01012E+01	4.58070E-01	8.59956E-04	0.00000E+00	0.00000E+00
118	4.67560E-01	4.04380E+01	4.58152E-01	8.56426E-04	0.00000E+00	0.00000E+00
119	4.53482E-01	4.07840E+01	4.58112E-01	8.50012E-04	0.00000E+00	0.00000E+00
120	4.66085E-01	4.11273E+01	4.58179E-01	8.45483E-04	0.00000E+00	0.00000E+00
121	4.57045E-01	4.14623E+01	4.58170E-01	8.38402E-04	0.00000E+00	0.00000E+00
122	4.58942E-01	4.18112E+01	4.58176E-01	8.31411E-04	0.00000E+00	0.00000E+00
123	4.54475E-01	4.21535E+01	4.58146E-01	8.25078E-04	0.00000E+00	0.00000E+00
124	4.49265E-01	4.24932E+01	4.58073E-01	8.21519E-04	0.00000E+00	0.00000E+00
125	4.78256E-01	4.28447E+01	4.58237E-01	8.31171E-04	0.00000E+00	0.00000E+00
126	4.58493E-01	4.31962E+01	4.58239E-01	8.24443E-04	0.00000E+00	0.00000E+00
127	4.63676E-01	4.35458E+01	4.58283E-01	8.18977E-04	0.00000E+00	0.00000E+00
128	4.52209E-01	4.38865E+01	4.58234E-01	8.13879E-04	0.00000E+00	0.00000E+00
129	4.77728E-01	4.42352E+01	4.58388E-01	8.21906E-04	0.00000E+00	0.00000E+00
130	4.59576E-01	4.45895E+01	4.58397E-01	8.15512E-04	0.00000E+00	0.00000E+00
131	4.57866E-01	4.49337E+01	4.58393E-01	8.09176E-04	0.00000E+00	0.00000E+00
132	4.53502E-01	4.52733E+01	4.58355E-01	8.03808E-04	0.00000E+00	0.00000E+00
133	4.45038E-01	4.56128E+01	4.58254E-01	8.04101E-04	0.00000E+00	0.00000E+00
134	4.51782E-01	4.59590E+01	4.58205E-01	7.99490E-04	0.00000E+00	0.00000E+00
135	4.60021E-01	4.62948E+01	4.58218E-01	7.93574E-04	0.00000E+00	0.00000E+00
136	4.66765E-01	4.66465E+01	4.58282E-01	7.90207E-04	0.00000E+00	0.00000E+00
137	4.63688E-01	4.69907E+01	4.58322E-01	7.85353E-04	0.00000E+00	0.00000E+00
138	4.49183E-01	4.73285E+01	4.58255E-01	7.82448E-04	0.00000E+00	0.00000E+00
139	4.57541E-01	4.76772E+01	4.58250E-01	7.76734E-04	0.00000E+00	0.00000E+00
140	4.63069E-01	4.80250E+01	4.58285E-01	7.71875E-04	0.00000E+00	0.00000E+00
141	4.60385E-01	4.83683E+01	4.58300E-01	7.66451E-04	0.00000E+00	0.00000E+00
142	4.68164E-01	4.87190E+01	4.58370E-01	7.64212E-04	0.00000E+00	0.00000E+00
143	4.66874E-01	4.90695E+01	4.58431E-01	7.61165E-04	0.00000E+00	0.00000E+00
144	4.57725E-01	4.94092E+01	4.58426E-01	7.55802E-04	0.00000E+00	0.00000E+00
145	4.56155E-01	4.97525E+01	4.58410E-01	7.50666E-04	0.00000E+00	0.00000E+00
146	4.60930E-01	5.01022E+01	4.58427E-01	7.45641E-04	0.00000E+00	0.00000E+00
147	4.48704E-01	5.04390E+01	4.58360E-01	7.43511E-04	0.00000E+00	0.00000E+00
148	4.49969E-01	5.07787E+01	4.58303E-01	7.40634E-04	0.00000E+00	0.00000E+00
149	4.55845E-01	5.11183E+01	4.58286E-01	7.35769E-04	0.00000E+00	0.00000E+00
150	4.49922E-01	5.14633E+01	4.58229E-01	7.32962E-04	0.00000E+00	0.00000E+00
151	4.44525E-01	5.18048E+01	4.58138E-01	7.33813E-04	0.00000E+00	0.00000E+00
152	4.49503E-01	5.21362E+01	4.58080E-01	7.31174E-04	0.00000E+00	0.00000E+00
153	4.57337E-01	5.24758E+01	4.58075E-01	7.26332E-04	0.00000E+00	0.00000E+00
154	4.52312E-01	5.28063E+01	4.58037E-01	7.22534E-04	0.00000E+00	0.00000E+00
155	4.51315E-01	5.31468E+01	4.57993E-01	7.19139E-04	0.00000E+00	0.00000E+00
156	4.70381E-01	5.34938E+01	4.58074E-01	7.18968E-04	0.00000E+00	0.00000E+00
157	4.51343E-01	5.38380E+01	4.58030E-01	7.15633E-04	0.00000E+00	0.00000E+00
158	4.51194E-01	5.41758E+01	4.57986E-01	7.12380E-04	0.00000E+00	0.00000E+00
159	4.58894E-01	5.45337E+01	4.57992E-01	7.07852E-04	0.00000E+00	0.00000E+00
160	4.63779E-01	5.48770E+01	4.58029E-01	7.04311E-04	0.00000E+00	0.00000E+00
161	4.72445E-01	5.52340E+01	4.58119E-01	7.05715E-04	0.00000E+00	0.00000E+00
162	4.48802E-01	5.55672E+01	4.58061E-01	7.03705E-04	0.00000E+00	0.00000E+00
163	4.57398E-01	5.59087E+01	4.58057E-01	6.99332E-04	0.00000E+00	0.00000E+00
164	4.59861E-01	5.62483E+01	4.58068E-01	6.95091E-04	0.00000E+00	0.00000E+00
165	4.47229E-01	5.65815E+01	4.58002E-01	6.94007E-04	0.00000E+00	0.00000E+00
166	4.52014E-01	5.69183E+01	4.57965E-01	6.90728E-04	0.00000E+00	0.00000E+00
167	4.57747E-01	5.72498E+01	4.57964E-01	6.86530E-04	0.00000E+00	0.00000E+00
168	4.73331E-01	5.76050E+01	4.58056E-01	6.88632E-04	0.00000E+00	0.00000E+00
169	4.56556E-01	5.79520E+01	4.58047E-01	6.84555E-04	0.00000E+00	0.00000E+00
170	4.38781E-01	5.82897E+01	4.57933E-01	6.90064E-04	0.00000E+00	0.00000E+00
171	4.66030E-01	5.86367E+01	4.57981E-01	6.87640E-04	0.00000E+00	0.00000E+00
172	4.50684E-01	5.89753E+01	4.57938E-01	6.84929E-04	0.00000E+00	0.00000E+00
173	4.63556E-01	5.93242E+01	4.57971E-01	6.81704E-04	0.00000E+00	0.00000E+00
174	4.55825E-01	5.96583E+01	4.57958E-01	6.77844E-04	0.00000E+00	0.00000E+00
175	4.49008E-01	5.99952E+01	4.57906E-01	6.75898E-04	0.00000E+00	0.00000E+00
176	4.52091E-01	6.03338E+01	4.57873E-01	6.72832E-04	0.00000E+00	0.00000E+00
177	4.64346E-01	6.06863E+01	4.57910E-01	6.69999E-04	0.00000E+00	0.00000E+00
178	4.59222E-01	6.10313E+01	4.57917E-01	6.66223E-04	0.00000E+00	0.00000E+00
179	4.52591E-01	6.13738E+01	4.57887E-01	6.63131E-04	0.00000E+00	0.00000E+00
180	4.57701E-01	6.17180E+01	4.57886E-01	6.59396E-04	0.00000E+00	0.00000E+00
181	4.66480E-01	6.20687E+01	4.57934E-01	6.57457E-04	0.00000E+00	0.00000E+00
182	4.42807E-01	6.24008E+01	4.57850E-01	6.59173E-04	0.00000E+00	0.00000E+00
183	4.44915E-01	6.27470E+01	4.57779E-01	6.59405E-04	0.00000E+00	0.00000E+00

Figure 6.6-6 - CSAS25 Output for Canistered Fuel Normal Conditions Criticality Analysis (continued)

184	4.63822E-01	6.30893E+01	4.57812E-01	6.56613E-04	0.00000E+00	0.00000E+00
185	4.54129E-01	6.34280E+01	4.57792E-01	6.53325E-04	0.00000E+00	0.00000E+00
186	4.60407E-01	6.37667E+01	4.57806E-01	6.49920E-04	0.00000E+00	0.00000E+00
187	4.52227E-01	6.41145E+01	4.57776E-01	6.47100E-04	0.00000E+00	0.00000E+00
188	4.77262E-01	6.44597E+01	4.57881E-01	6.52082E-04	0.00000E+00	0.00000E+00
189	4.72561E-01	6.48140E+01	4.57959E-01	6.53320E-04	0.00000E+00	0.00000E+00
190	4.34712E-01	6.51480E+01	4.57836E-01	6.61497E-04	0.00000E+00	0.00000E+00
191	4.51545E-01	6.54877E+01	4.57802E-01	6.58829E-04	0.00000E+00	0.00000E+00
192	4.76042E-01	6.58402E+01	4.57898E-01	6.62346E-04	0.00000E+00	0.00000E+00
193	4.72495E-01	6.61953E+01	4.57975E-01	6.63286E-04	0.00000E+00	0.00000E+00
194	4.47268E-01	6.65340E+01	4.57919E-01	6.62175E-04	0.00000E+00	0.00000E+00
195	4.60527E-01	6.68755E+01	4.57932E-01	6.58874E-04	0.00000E+00	0.00000E+00
196	4.63248E-01	6.72142E+01	4.57960E-01	6.56041E-04	0.00000E+00	0.00000E+00
197	4.55099E-01	6.75565E+01	4.57945E-01	6.52833E-04	0.00000E+00	0.00000E+00
198	4.59402E-01	6.79017E+01	4.57953E-01	6.49536E-04	0.00000E+00	0.00000E+00
199	4.60671E-01	6.82458E+01	4.57966E-01	6.46378E-04	0.00000E+00	0.00000E+00
200	4.59900E-01	6.85882E+01	4.57976E-01	6.43179E-04	0.00000E+00	0.00000E+00
201	4.65762E-01	6.89398E+01	4.58015E-01	6.41134E-04	0.00000E+00	0.00000E+00
202	4.41512E-01	6.92738E+01	4.57933E-01	6.43235E-04	0.00000E+00	0.00000E+00
203	4.63288E-01	6.96208E+01	4.57959E-01	6.40581E-04	0.00000E+00	0.00000E+00

KENO MESSAGE NUMBER K5-123 EXECUTION TERMINATED DUE TO COMPLETION OF THE SPECIFIED NUMBER OF GENERATIONS.

Figure 6.6-6 CSAS25 Output for Canistered Fuel Normal Conditions Criticality Analysis (continued)

TRANSPORT CRITICALITY: NORMAL CONDITIONS (PITCH = 250.698 CM) (EXT. MOD. VF = 0.

LIFETIME = 9.45512E-06 + OR - 5.08997E-08   GENERATION TIME = 1.85503E-06 + OR - 1.01955E-08
NU BAR = 2.54494E+00 + OR - 4.16575E-04   AVERAGE FISSION GROUP = 6.81874E+00 + OR - 6.06833E-03
ENERGY(EV) OF THE AVERAGE LETHARGY CAUSING FISSION = 6.68650E+04 + OR - 4.50944E+02

NO. OF INITIAL GENERATIONS SKIPPED	AVERAGE K-EFFECTIVE	DEVIATION	67 PER CENT CONFIDENCE INTERVAL	95 PER CENT CONFIDENCE INTERVAL	99 PER CENT CONFIDENCE INTERVAL	NUMBER OF HISTORIES
3	0.45799	+ OR - 0.00064	0.45735 TO 0.45863	0.45671 TO 0.45928	0.45606 TO 0.45992	200000
4	0.45795	+ OR - 0.00064	0.45730 TO 0.45859	0.45666 TO 0.45924	0.45601 TO 0.45988	199000
5	0.45796	+ OR - 0.00065	0.45731 TO 0.45861	0.45666 TO 0.45925	0.45601 TO 0.45990	198000
6	0.45799	+ OR - 0.00065	0.45734 TO 0.45864	0.45669 TO 0.45929	0.45604 TO 0.45994	197000
7	0.45799	+ OR - 0.00065	0.45734 TO 0.45865	0.45669 TO 0.45930	0.45603 TO 0.45995	196000
8	0.45794	+ OR - 0.00065	0.45729 TO 0.45860	0.45663 TO 0.45925	0.45598 TO 0.45991	195000
9	0.45791	+ OR - 0.00066	0.45725 TO 0.45857	0.45660 TO 0.45923	0.45594 TO 0.45988	194000
10	0.45798	+ OR - 0.00066	0.45732 TO 0.45863	0.45666 TO 0.45929	0.45600 TO 0.45995	193000
11	0.45796	+ OR - 0.00066	0.45730 TO 0.45862	0.45664 TO 0.45928	0.45597 TO 0.45994	192000
12	0.45789	+ OR - 0.00066	0.45723 TO 0.45855	0.45657 TO 0.45921	0.45591 TO 0.45988	191000
17	0.45796	+ OR - 0.00067	0.45729 TO 0.45863	0.45662 TO 0.45930	0.45594 TO 0.45997	186000
22	0.45789	+ OR - 0.00068	0.45720 TO 0.45857	0.45652 TO 0.45926	0.45584 TO 0.45994	181000
27	0.45783	+ OR - 0.00068	0.45715 TO 0.45851	0.45647 TO 0.45919	0.45579 TO 0.45987	176000
32	0.45789	+ OR - 0.00070	0.45719 TO 0.45859	0.45649 TO 0.45929	0.45580 TO 0.45998	171000
37	0.45790	+ OR - 0.00071	0.45719 TO 0.45861	0.45647 TO 0.45933	0.45576 TO 0.46004	166000
42	0.45803	+ OR - 0.00073	0.45731 TO 0.45876	0.45658 TO 0.45948	0.45585 TO 0.46021	161000
47	0.45809	+ OR - 0.00074	0.45735 TO 0.45882	0.45661 TO 0.45956	0.45587 TO 0.46030	156000
52	0.45803	+ OR - 0.00076	0.45727 TO 0.45879	0.45651 TO 0.45954	0.45575 TO 0.46030	151000
57	0.45799	+ OR - 0.00075	0.45724 TO 0.45874	0.45649 TO 0.45949	0.45573 TO 0.46025	146000
62	0.45785	+ OR - 0.00077	0.45707 TO 0.45862	0.45630 TO 0.45939	0.45553 TO 0.46016	141000
67	0.45794	+ OR - 0.00079	0.45715 TO 0.45873	0.45637 TO 0.45951	0.45558 TO 0.46030	136000
72	0.45808	+ OR - 0.00081	0.45727 TO 0.45889	0.45646 TO 0.45970	0.45565 TO 0.46051	131000
77	0.45797	+ OR - 0.00084	0.45713 TO 0.45880	0.45629 TO 0.45964	0.45546 TO 0.46048	126000
82	0.45817	+ OR - 0.00085	0.45732 TO 0.45901	0.45648 TO 0.45986	0.45563 TO 0.46070	121000
87	0.45789	+ OR - 0.00087	0.45702 TO 0.45876	0.45615 TO 0.45963	0.45528 TO 0.46050	116000
92	0.45790	+ OR - 0.00089	0.45700 TO 0.45879	0.45611 TO 0.45968	0.45522 TO 0.46058	111000

Figure 6.6-6 CSAS25 Output for Canistered Fuel Normal Conditions Criticality Analysis (continued)

TRANSPORT CRITICALITY: NORMAL CONDITIONS (PITCH = 250.698 CM) (EXT. MOD. VF = 0.

NO. OF INITIAL GENERATIONS SKIPPED	AVERAGE K-EFFECTIVE	DEVIATION	67 PER CENT CONFIDENCE INTERVAL	95 PER CENT CONFIDENCE INTERVAL	99 PER CENT CONFIDENCE INTERVAL	NUMBER OF HISTORIES
97	0.45806	+ OR - 0.00090	0.45716 TO 0.45897	0.45626 TO 0.45987	0.45535 TO 0.46077	106000
102	0.45792	+ OR - 0.00087	0.45705 TO 0.45879	0.45618 TO 0.45966	0.45531 TO 0.46053	101000
107	0.45811	+ OR - 0.00089	0.45722 TO 0.45900	0.45632 TO 0.45990	0.45543 TO 0.46079	96000
112	0.45783	+ OR - 0.00093	0.45690 TO 0.45876	0.45597 TO 0.45968	0.45504 TO 0.46061	91000
117	0.45781	+ OR - 0.00096	0.45685 TO 0.45878	0.45588 TO 0.45974	0.45492 TO 0.46070	86000
122	0.45764	+ OR - 0.00101	0.45663 TO 0.45865	0.45562 TO 0.45966	0.45461 TO 0.46067	81000
127	0.45743	+ OR - 0.00103	0.45640 TO 0.45846	0.45536 TO 0.45949	0.45433 TO 0.46052	76000
132	0.45723	+ OR - 0.00106	0.45617 TO 0.45830	0.45511 TO 0.45936	0.45405 TO 0.46042	71000
137	0.45722	+ OR - 0.00111	0.45611 TO 0.45833	0.45500 TO 0.45944	0.45389 TO 0.46055	66000
142	0.45702	+ OR - 0.00117	0.45584 TO 0.45819	0.45467 TO 0.45937	0.45349 TO 0.46054	61000
147	0.45692	+ OR - 0.00126	0.45566 TO 0.45818	0.45441 TO 0.45944	0.45315 TO 0.46069	56000
152	0.45760	+ OR - 0.00133	0.45627 TO 0.45894	0.45494 TO 0.46027	0.45360 TO 0.46161	51000
157	0.45772	+ OR - 0.00144	0.45629 TO 0.45916	0.45485 TO 0.46059	0.45341 TO 0.46203	46000
162	0.45756	+ OR - 0.00154	0.45602 TO 0.45910	0.45448 TO 0.46064	0.45294 TO 0.46218	41000
167	0.45794	+ OR - 0.00172	0.45622 TO 0.45966	0.45449 TO 0.46139	0.45277 TO 0.46311	36000
172	0.45808	+ OR - 0.00180	0.45628 TO 0.45988	0.45448 TO 0.46168	0.45267 TO 0.46348	31000
177	0.45829	+ OR - 0.00208	0.45621 TO 0.46038	0.45412 TO 0.46246	0.45204 TO 0.46454	26000
182	0.45890	+ OR - 0.00243	0.45647 TO 0.46132	0.45404 TO 0.46375	0.45161 TO 0.46618	21000
187	0.46008	+ OR - 0.00300	0.45708 TO 0.46308	0.45408 TO 0.46609	0.45107 TO 0.46909	16000
192	0.45902	+ OR - 0.00257	0.45644 TO 0.46159	0.45387 TO 0.46416	0.45129 TO 0.46674	11000
197	0.45842	+ OR - 0.00352	0.45490 TO 0.46194	0.45138 TO 0.46546	0.44786 TO 0.46898	6000

RANDOM NUMBER= 51564689044D

Figure 6.6-6 CSAS25 Output for Canistered Fuel Normal Conditions Criticality Analysis (continued)

```
TRANSPORT CRITICALITY: NORMAL CONDITIONS (PITCH = 250.698 CM) (EXT. MOD. VF = 0.

                                  FREQUENCY FOR GENERATIONS    4 TO  203
0.4208 TO 0.4334      *
0.4334 TO 0.4461      *********************
0.4461 TO 0.4587      *******************************************************************************
0.4587 TO 0.4714      **********************************************************************************
0.4714 TO 0.4840      *************

                                  FREQUENCY FOR GENERATIONS   54 TO  203
0.4208 TO 0.4334      *
0.4334 TO 0.4461      ***************
0.4461 TO 0.4587      *********************************************************
0.4587 TO 0.4714      *************************************************************
0.4714 TO 0.4840      ************

                                  FREQUENCY FOR GENERATIONS  104 TO  203
0.4208 TO 0.4334
0.4334 TO 0.4461      ********
0.4461 TO 0.4587      *****************************************
0.4587 TO 0.4714      ************************************
0.4714 TO 0.4840      ********

                                  FREQUENCY FOR GENERATIONS  154 TO  203
0.4208 TO 0.4334
0.4334 TO 0.4461      *****
0.4461 TO 0.4587      *********************

0.4587 TO 0.4714      *****************
0.4714 TO 0.4840      ******
```

Figure 6.6-7 CSAS25 Input for Canistered Fuel Accident Conditions Criticality Analysis

```
=CSAS25
TRANSPORT CRITICALITY: ACCIDENT CONDITIONS (PITCH = 300 cm) (IVF = 1.0) (EVF = 1.0) (NOTE TITLE WAS CORRECTED FOR CONDITION)
'
'       THIS IS A MODEL OF THE YNPS NAC-MPC BASKET
'   LOADED WITH 36 UNITED NUCLEAR TYPE A ASSEMBLIES
'
'                STC LICENSE AMENDMENT
'
'       INTERIOR MODERATOR VOLUME FRACTION = 1.0
'       EXTERIOR MODERATOR VOLUME FRACTION = 1.0
'           CASK TO CASK PITCH = 300 cm
'               FLOODED PELLET CLAD GAP
'               NEUTRON SHIELD REMOVED
'
27GROUPNDF4 LATTICECELL
UO2         1                0.95    293.0 92235 4.0 92238 96.0 END
ZIRCALLOY   2                1.0     293.0                      END
H2O         3                1.0     293.0                      END
AL          4                1.0     293.0                      END
SS304       5                1.0     293.0                      END
B-10        6  DEN=2.6226 0.0450  293.0                         END
B-11        6  DEN=2.6226 0.2736  293.0                         END
C           6  DEN=2.6226 0.0927  293.0                         END
AL          6  DEN=2.6226 0.5737  293.0                         END
PB          7                1.0     293.0                      END
H           8  DEN=1.6291 0.060   293.0                         END
O           8  DEN=1.6291 0.425   293.0                         END
C           8  DEN=1.6291 0.277   293.0                         END
N           8  DEN=1.6291 0.020   293.0                         END
AL          8  DEN=1.6291 0.214   293.0                         END
B-10        8  DEN=1.6291 0.001   293.0                         END
B-11        8  DEN=1.6291 0.004   293.0                         END
H2O         9                1.0     293.0                      END
H2O         10               1.0     293.0                      END
END COMP
SQUAREPITCH  1.1887 0.7887 1 3 0.9271 2 0.8052 10 END
TRANSPORT CRITICALITY: ACCIDENT CONDITIONS (PITCH = 300 cm) (IVF = 1.0) (EVF = 1.0) (NOTE TITLE WAS CORRECTED FOR CONDITION)

READ PARAM RUN=YES PLT=NO GEN=1003 NPG=1000 TME=500 END PARAM
READ GEOM
'
'  WATER LEVEL UNIT CELLS
'
UNIT  1
COM='FUEL PIN CELL - BETWEEN DISKS'
CYLINDER  1 1  0.3943     2P2.1400
CYLINDER 10 1  0.4026     2P2.1400
CYLINDER  2 1  0.4635     2P2.1400
CUBOID    3 1  4P0.5944  2P2.1400
UNIT  2
COM='WATER CELL - BETWEEN DISKS'
CUBOID    3 1  4P0.5944  2P2.1400
UNIT  3
COM='DISPLACEMENT CELL - BETWEEN DISKS'
CYLINDER  2 1  0.4635     2P2.1400
CUBOID    3 1  4P0.5944  2P2.1400
UNIT  4
COM='INSTRUMENT TUBE CELL - BETWEEN DISKS'
CYLINDER  3 1  0.4998     2P2.1400
CYLINDER  5 1  0.5442     2P2.1400
CUBOID    3 1  4P0.5944  2P2.1400
'
'  DISK LEVEL UNIT CELLS (BOTH SS AND AL)
'
UNIT  5
COM='FUEL PIN CELL - WITH SS DISK'
CYLINDER  1 1  0.3943    2P0.6604
CYLINDER 10 1  0.4026    2P0.6604
CYLINDER  2 1  0.4635    2P0.6604
CUBOID    3 1  4P0.5944 2P0.6604
UNIT  6
COM='WATER CELL - WITH SS DISK'
CUBOID    3 1  4P0.5944 2P0.6604
UNIT  7
COM='DISPLACEMENT CELL - WITH SS DISK'
CYLINDER  2 1  0.4635    2P0.6604
CUBOID    3 1  4P0.5944 2P0.6604
UNIT  8
COM='INSTRUMENT TUBE CELL - WITH SS DISK'
CYLINDER  3 1  0.4998    2P0.6604
CYLINDER  5 1  0.5442    2P0.6604
CUBOID    3 1  4P0.5944 2P0.6604
'
'  WATER LEVEL BORAL SHEETS
'
UNIT 14
COM='X-X BORAL SHEET BETWEEN DISKS'
CUBOID 6 1 2P9.144 2P0.0318 2P2.1400
CUBOID 4 1 2P9.144 2P0.0953 2P2.1400
UNIT 15
COM='Y-Y BORAL SHEET BETWEEN DISKS'
CUBOID 6 1 2P0.0318 2P9.144 2P2.1400
CUBOID 4 1 2P0.0953 2P9.144 2P2.1400
```

Figure 6.6-7 CSAS25 Input for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
'
'  DISK LEVEL BORAL SHEETS (AL AND SS)
'

UNIT 16
COM='X-X BORAL SHEET WITH SS DISK'
CUBOID 6 1 2P9.144 2P0.0318 2P0.6604
CUBOID 4 1 2P9.144 2P0.0953 2P0.6604
UNIT 17
COM='Y-Y BORAL SHEET WITH SS DISK'
CUBOID 6 1 2P0.0318 2P9.144 2P0.6604
CUBOID 4 1 2P0.0953 2P9.144 2P0.6604
'
' WATER LEVEL WEB MATERIAL
'
UNIT 20
COM='WATER LEVEL WEB MATERIAL (SMALL) X-X'
CUBOID    3 1 2P10.4635 2P0.9716 2P2.1400
UNIT 21
COM='WATER LEVEL WEB MATERIAL (MEDIUM) X-X'
CUBOID    3 1 2P10.4635 2P1.0478 2P2.1400
UNIT 22
COM='WATER LEVEL WEB MATERIAL (LARGE) X-X'
CUBOID    3 1 2P10.4635 2P1.1208 2P2.1400
UNIT 23
COM='WATER LEVEL WEB MATERIAL (LONG) Y-Y'
CUBOID    3 1 2P1.1208 2P79.5249 2P2.1400
'
'  SUPPORT DISK WEB MATERIAL
'
UNIT 30
COM='SUPPORT DISK WEB MATERIAL (SMALL) X-X'
CUBOID    5 1 2P10.4635 2P0.9716 2P0.6604
UNIT 31
COM='SUPPORT DISK WEB MATERIAL (MEDIUM) X-X'
CUBOID    5 1 2P10.4635 2P1.0478 2P0.6604
UNIT 32
COM='SUPPORT DISK WEB MATERIAL (LARGE) X-X'
CUBOID    5 1 2P10.4635 2P1.1208 2P0.6604
UNIT 33
COM='SUPPORT DISK WEB MATERIAL (LONG) Y-Y'
CUBOID    5 1 2P1.1208 2P79.5249 2P0.6604
'
'  HEAT TRANSFER DISK WEB MATERIAL
'
UNIT 40
COM='HEAT TRANSFER DISK WEB MATERIAL (SMALL) X-X'
CUBOID    4 1 2P10.4635 2P0.9716 2P0.6604
UNIT 41
COM='HEAT TRANSFER DISK WEB MATERIAL (MEDIUM) X-X'
CUBOID    4 1 2P10.4635 2P1.0478 2P0.6604
UNIT 42
COM='HEAT TRANSFER DISK WEB MATERIAL (LARGE) X-X'
CUBOID    4 1 2P10.4635 2P1.1208 2P0.6604
UNIT 43
COM='HEAT TRANSFER DISK WEB MATERIAL (LONG) Y-Y'
CUBOID    4 1 2P1.1208 2P79.5249 2P0.6604
'
'  WATER LEVEL ASSEMBLY ARRAYS
'
UNIT 50
COM='FUEL TUBE AND ASSEMBLY - WATER LEVEL'
ARRAY  1  -9.5104 -9.5104 -2.1400
CUBOID 3 1 4P9.9441                              2P2.1400
CUBOID 5 1 4P10.0661                             2P2.1400
CUBOID 3 1 4P10.25681                            2P2.1400
HOLE  14   0.0       10.1615  0.0
HOLE  14   0.0      -10.1615  0.0
HOLE  15   10.1615   0.0      0.0
HOLE  15  -10.1615   0.0      0.0
CUBOID 5 1 4P10.3051                             2P2.1400
UNIT 51
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -Y'
CUBOID 3 1 4P10.4635                             2P2.1400
HOLE  50   0.0      -0.1584       0.0
UNIT 52
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS Y'
CUBOID 3 1 4P10.4635                             2P2.1400
HOLE  50   0.0       0.1584       0.0
UNIT 53
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -X'
CUBOID 3 1 4P10.4635                             2P2.1400
HOLE  50   -0.1584   0.0          0.0
UNIT 54
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS X'
CUBOID 3 1 4P10.4635                             2P2.1400
HOLE  50   0.1584    0.0          0.0
UNIT 55
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS X Y'
CUBOID 3 1 4P10.4635                             2P2.1400
HOLE  50   0.1584    0.1584       0.0
UNIT 56
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -X Y'
CUBOID 3 1 4P10.4635                             2P2.1400
HOLE  50   -0.1584   0.1584       0.0
```

Figure 6.6-7 CSAS25 Input for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
UNIT 57
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS X -Y'
CUBOID 3 1 4P10.4635                                2P2.1400
HOLE  50   0.1584   -0.1584       0.0
UNIT 58
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -X -Y'
CUBOID 3 1 4P10.4635                                2P2.1400
HOLE  50   -0.1584   -0.1584       0.0
UNIT 59
COM='CENTRAL HOLE'
CUBOID 3 1 4P10.4636                                2P2.1400
'
'   SUPPORT DISK LEVEL ASSEMBLY ARRAYS
'
UNIT 60
COM='FUEL TUBE AND ASSEMBLY - SUPPORT DISK LEVEL'
ARRAY  2  -9.5104 -9.5104 -0.6604
CUBOID 3 1 4P9.9441                                 2P0.6604
CUBOID 5 1 4P10.0661                                2P0.6604
CUBOID 3 1 4P10.25681                               2P0.6604
HOLE  16   0.0       10.1615  0.0
HOLE  16   0.0       -10.1615 0.0
HOLE  17   10.1615  0.0       0.0
HOLE  17   -10.1615 0.0       0.0
CUBOID 5 1 4P10.3051                                2P0.6604
UNIT 61
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -Y'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  60   0.0       -0.1584       0.0
UNIT 62
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS Y'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  60   0.0       0.1584        0.0
UNIT 63
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -X'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  60   -0.1584   0.0           0.0
UNIT 64
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS X'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  60   0.1584   0.0            0.0
UNIT 65
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS X Y'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  60   0.1584   0.1584         0.0
UNIT 66
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -X Y'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  60   -0.1584   0.1584        0.0
UNIT 67
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS X -Y'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  60   0.1584   -0.1584        0.0
UNIT 68
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -X -Y'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  60   -0.1584   -0.1584       0.0
UNIT 69
COM='CENTRAL HOLE'
CUBOID 3 1 4P10.4636   2P0.6604
'
'   HEAT TRANSFER DISK LEVEL ASSEMBLY ARRAYS
'
UNIT 70
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS'
ARRAY  2  -9.5104 -9.5104 -0.6604
CUBOID 3 1 4P9.9441                                 2P0.6604
CUBOID 5 1 4P10.0661                                2P0.6604
CUBOID 3 1 4P10.25681                               2P0.6604
HOLE  16   0.0       10.1615  0.0
HOLE  16   0.0       -10.1615 0.0
HOLE  17   10.1615  0.0       0.0
HOLE  17   -10.1615 0.0       0.0
CUBOID 5 1 4P10.3051                                2P0.6604
UNIT 71
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -Y'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  70   0.0       -0.1584       0.0
UNIT 72
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS Y'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  70   0.0       0.1584        0.0
UNIT 73
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -X'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  70   -0.1584   0.0           0.0
UNIT 74
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS X'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  70   0.1584   0.0            0.0
UNIT 75
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS X Y'
CUBOID 3 1 4P10.4635                                2P0.6604
HOLE  70   0.1584   0.1584         0.0
UNIT 76
```

Figure 6.6-7 CSAS25 Input for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -X Y'
CUBOID 3 1 4P10.4635                                   2P0.6604
HOLE  70   -0.1584   0.1584        0.0
UNIT 77
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS X -Y'
CUBOID 3 1 4P10.4635                                   2P0.6604
HOLE  70   0.1584   -0.1584        0.0
UNIT 78
COM='ASSEMBLY CELL WITH 4 BORAL SHEETS -X -Y'
CUBOID 3 1 4P10.4635                                   2P0.6604
HOLE  70   -0.1584   -0.1584       0.0
UNIT 79
COM='CENTRAL HOLE'
CUBOID 3 1 4P10.4636                                   2P0.6604
'
'  WATER LEVEL BASKET ARRAYS
'
UNIT 80
COM='5X1 WATER LEVEL ARRAY (SMALL ARRAY -X)'
ARRAY 20 -10.4636 -33.6323 -2.1400
UNIT 81
COM='5X1 WATER LEVEL ARRAY (SMALL ARRAY X)'
ARRAY 21 -10.4636 -33.6323 -2.1400
UNIT 82
COM='9X1 WATER LEVEL ARRAY (MEDIUM ARRAY -X)'
ARRAY 22 -10.4636 -56.6549 -2.1400
UNIT 83
COM='9X1 WATER LEVEL ARRAY (MEDIUM ARRAY X)'
ARRAY 23 -10.4636 -56.6549 -2.1400
UNIT 84
COM='13X1 WATER LEVEL ARRAY (LARGE ARRAY-X)'
ARRAY 24 -10.4636 -79.5251 -2.1400
UNIT 85
COM='13X1 WATER LEVEL ARRAY (MIDDLE LARGE ARRAY)'
ARRAY 25 -10.4636 -79.5251 -2.1400
UNIT 86
COM='13X1 WATER LEVEL ARRAY (LARGE ARRAY X)'
ARRAY 26 -10.4636 -79.5251 -2.1400
'
'  SUPPORT DISK LEVEL BASKET ARRAYS
'
UNIT 90
COM='5X1 SUPPORT DISK LEVEL ARRAY (SMALL ARRAY -X)'
ARRAY 30 -10.4636 -33.6323 -0.6604
UNIT 91
COM='5X1 SUPPORT DISK LEVEL ARRAY (SMALL ARRAY  X)'
ARRAY 31 -10.4636 -33.6323 -0.6604
UNIT 92
COM='9X1 WATER LEVEL ARRAY (MEDIUM ARRAY -X)'
ARRAY 32 -10.4636 -56.6549 -0.6604
UNIT 93
COM='9X1 WATER LEVEL ARRAY (MEDIUM ARRAY X)'
ARRAY 33 -10.4636 -56.6549 -0.6604
UNIT 94
COM='13X1 SUPPORT DISK LEVEL ARRAY (LARGE ARRAY -X)'
ARRAY 34 -10.4636 -79.5251 -0.6604
UNIT 95
COM='13X1 SUPPORT DISK LEVEL ARRAY (MIDDLE LARGE ARRAY)'
ARRAY 35 -10.4636 -79.5251 -0.6604
UNIT 96
COM='13X1 SUPPORT DISK LEVEL ARRAY (LARGE ARRAY -X)'
ARRAY 36 -10.4636 -79.5251 -0.6604
'
'  HEAT TRANSFER DISK LEVEL BASKET ARRAYS
'
UNIT 100
COM='5X1 HEAT TRANSFER DISK LEVEL ARRAY (SMALL ARRAY -X)'
ARRAY 40 -10.4636 -33.6323 -0.6604
UNIT 101
COM='5X1 HEAT TRANSFER DISK LEVEL ARRAY (SMALL ARRAY X)'
ARRAY 41 -10.4636 -33.6323 -0.6604
UNIT 102
COM='9X1 HEAT TRANSFER DISK LEVEL ARRAY (MEDIUM ARRAY -X)'
ARRAY 42 -10.4636 -56.6549 -0.6604
UNIT 103
COM='9X1 HEAT TRANSFER DISK LEVEL ARRAY (MEDIUM ARRAY  X)'
ARRAY 43 -10.4636 -56.6549 -0.6604
UNIT 104
COM='13X1 HEAT TRANSFER DISK LEVEL ARRAY (LARGE ARRAY -X)'
ARRAY 44 -10.4636 -79.5251 -0.6604
UNIT 105
COM='13X1 HEAT TRANSFER DISK LEVEL ARRAY (MIDDLE LARGE ARRAY)'
ARRAY 45 -10.4636 -79.5251 -0.6604
UNIT 106
COM='13X1 HEAT TRANSFER DISK LEVEL ARRAY (LARGE ARRAY X)'
ARRAY 46 -10.4636 -79.5251 -0.6604
'
'  BASKET ARRAY IN TRANSPORT CASK OVERPACK (LEVEL CONSTRUCTION)
'
UNIT 110
COM='BASKET ARRAY IN TRANSPORT CASK OVERPACK - WATER LEVEL'
ARRAY 50 -33.6323 -79.5251 -2.1400
CYLINDER 3 1 88.1253      2P2.1400
HOLE 80      -69.0614 0.0 0.0
HOLE 82      -46.1912 0.0 0.0
```

Figure 6.6-7 CSAS25 Input for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
HOLE 81        69.0614 0.0 0.0
HOLE 83        46.1912 0.0 0.0
CYLINDER 5 1 89.7128      2P2.1400
CYLINDER 3 1 90.170       2P2.1400
CYLINDER 5 1 93.98        2P2.1400
CYLINDER 7 1 103.4288     2P2.1400
CYLINDER 5 1 110.109      2P2.1400
CYLINDER 9 1 124.714      2P2.1400
CYLINDER 9 1 125.349      2P2.1400
CUBOID   9 1 4P150        2P2.1400
UNIT 111
COM='BASKET ARRAY IN TRANSPORT CASK OVERPACK - SUPPORT DISK LEVEL'
ARRAY 51 -33.6323 -79.5251 -0.6604
CYLINDER 5 1 87.6046      2P0.6604
HOLE 90       -69.0614 0.0 0.0
HOLE 92       -46.1912 0.0 0.0
HOLE 91        69.0614 0.0 0.0
HOLE 93        46.1912 0.0 0.0
CYLINDER 3 1 88.1253      2P0.6604
CYLINDER 5 1 89.7128      2P0.6604
CYLINDER 3 1 90.170       2P0.6604
CYLINDER 5 1 93.98        2P0.6604
CYLINDER 7 1 103.4288     2P0.6604
CYLINDER 5 1 110.109      2P0.6604
CYLINDER 9 1 124.714      2P0.6604
CYLINDER 9 1 125.349      2P0.6604
CUBOID   9 1 4P150        2P0.6604
UNIT 112
COM='BASKET ARRAY IN TRANSPORT CASK OVERPACK - HEAT TRANSFER DISK LEVEL'
ARRAY 52 -33.6323 -79.5251 -0.6604
CYLINDER 4 1 87.2490      2P0.6604
HOLE 100      -69.0614 0.0 0.0
HOLE 102      -46.1912 0.0 0.0
HOLE 101       69.0614 0.0 0.0
HOLE 103       46.1912 0.0 0.0
CYLINDER 3 1 88.1253      2P0.6604
CYLINDER 5 1 89.7128      2P0.6604
CYLINDER 3 1 90.170       2P0.6604
CYLINDER 5 1 93.98        2P0.6604
CYLINDER 7 1 103.4288     2P0.6604
CYLINDER 5 1 110.109      2P0.6604
CYLINDER 9 1 124.714      2P0.6604
CYLINDER 9 1 125.349      2P0.6604
CUBOID   9 1 4P150        2P0.6604
*
*  GLOBAL UNIT
*
GLOBAL UNIT 120
ARRAY 60 -175.349 -175.349 0.0
END GEOM
READ ARRAY
ARA=1 NUX=16 NUY=16 NUZ=1  FILL
1 1 1 1 1 1 1 3 2 2 2 2 2 2 2 2
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2 1 1 1 1 1 1 1 4 1 1 1 1 1 1 1
2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
END FILL
ARA=2 NUX=16 NUY=16 NUZ=1  FILL
5 5 5 5 5 5 5 7 6 6 6 6 6 6 6 6
5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
7 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
6 5 5 5 5 5 5 5 8 5 5 5 5 5 5 5
6 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
6 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
6 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
6 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
6 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
6 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
6 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
END FILL
*
*  WATER LEVEL ARRAYS
*
ARA=20  NUX=1 NUY=5 NUZ=1
FILL
55
22
54
```

Figure 6.6-7 CSAS25 Input for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
22
57
END FILL
ARA=21  NUX=1 NUY=5 NUZ=1
FILL
56
22
53
22
58
END FILL
ARA=22  NUX=1 NUY=9 NUZ=1
FILL
55
21
55
22
54
22
57
21
57
END FILL
ARA=23  NUX=1 NUY=9 NUZ=1
FILL
56
21
56
22
53
22
58
21
58
END FILL
ARA=24  NUX=1 NUY=13 NUZ=1
FILL
55
20
55
21
55
22
54
22
57
21
57
20
57
END FILL
ARA=25  NUX=1 NUY=13 NUZ=1
FILL
52
20
52
21
52
22
59
22
51
21
51
20
51
END FILL
ARA=26  NUX=1 NUY=13 NUZ=1
FILL
56
20
56
21
56
22
53
22
58
21
58
20
58
END FILL
'
'  SUPPOR DISK LEVEL ARRAYS
'
ARA=30  NUX=1 NUY=5 NUZ=1
FILL
65
32
64
32
67
END FILL
ARA=31  NUX=1 NUY=5 NUZ=1
```

Figure 6.6-7 CSAS25 Input for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
FILL
66
32
63
32
68
END FILL
ARA=32  NUX=1 NUY=9 NUZ=1
FILL
65
31
65
32
64
32
67
31
67
END FILL
ARA=33  NUX=1 NUY=9 NUZ=1
FILL
66
31
66
32
63
32
68
31
68
END FILL
ARA=34  NUX=1 NUY=13 NUZ=1
FILL
65
30
65
31
65
32
64
32
67
31
67
30
67
END FILL
ARA=35  NUX=1 NUY=13 NUZ=1
FILL
62
30
62
31
62
32
69
32
61
31
61
30
61
END FILL
ARA=36  NUX=1 NUY=13 NUZ=1
FILL
66
30
66
31
66
32
63
32
68
31
68
30
68
END FILL
'
'  HEAT TRANSFER DISK LEVEL ARRAYS
'
ARA=40  NUX=1 NUY=5 NUZ=1
FILL
75
42
74
42
77
END FILL
ARA=41  NUX=1 NUY=5 NUZ=1
FILL
76
42
73
```

Figure 6.6-7 CSAS25 Input for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
42
78
END FILL
ARA=42  NUX=1 NUY=9 NUZ=1
FILL
75
41
75
42
74
42
77
41
77
END FILL
ARA=43  NUX=1 NUY=9 NUZ=1
FILL
76
41
76
42
73
42
78
41
78
END FILL
ARA=44  NUX=1 NUY=13 NUZ=1
FILL
75
40
75
41
75
42
74
42
77
41
77
40
77
END FILL
ARA=45  NUX=1 NUY=13 NUZ=1
FILL
72
40
72
41
72
42
79
42
71
41
71
40
71
END FILL
ARA=46  NUX=1 NUY=13 NUZ=1
FILL
76
40
76
41
76
42
73
42
78
41
78
40
78
END FILL
'
'  MAJOR ARRAYS
'
ARA=50 NUX=5 NUY=1 NUZ=1
FILL
84 23 85 23 86
END FILL
ARA=51 NUX=5 NUY=1 NUZ=1
FILL
94 33 95 33 96
END FILL
ARA=52 NUX=5 NUY=1 NUZ=1
FILL
104 43 105 43 106
END FILL
'
'  GLOBAL ARRAY
'
ARA=60 NUX=1 NUY=1 NUZ=4
FILL
```

Figure 6.6-7 CSAS25 Input for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
112
110
111
110
END FILL
END ARRAY
READ BOUNDS ZFC=PER YXF=MIR END BOUNDS
READ PLOT
SCR=YES PIC=MAT LPI=10
UAX=1.0 VDN=-1.0 NAX=1500
'
' WHOLE BASKET HORIZONTAL SLICES
'
TTL='BASKET X-Y CROSS SECTION AT Z= 0.635 HEAT TRANSFER DISK LEVEL'
XUL=  -130 YUL=  130  ZUL= 0.635
XLR=   130 YLR= -130  ZLR= 0.635
UAX=1.0 VDN=-1.0 NAX=1500 END
TTL='BASKET X-Y CROSS SECTION AT Z= 3.44 WATER LEVEL'
XUL=  -130 YUL=  130  ZUL= 3.44
XLR=   130 YLR= -130  ZLR= 3.44
UAX=1.0 VDN=-1.0 NAX=1500 END
TTL='BASKET X-Y CROSS SECTION AT Z= 6.236 SS DISK LEVEL'
XUL=  -130 YUL=  130  ZUL= 6.236
XLR=   130 YLR= -130  ZLR= 6.236
UAX=1.0 VDN=-1.0 NAX=1500 END
'
' HEAT TRANSFER DISK LEVEL BASKET QUADRANTS
'
TTL='BASKET X-Y QUADRANTD I HEAT TRANSFER DISK'
XUL=  12.   YUL= 80     ZUL= 0.635
XLR=  80.0  YLR= 12.0   ZLR= 0.635
UAX=1.0 VDN=-1.0 NAX=1500 END
TTL='BASKET X-Y QUADRANT II HEAT TRANSFER DISK'
XUL=  12.0 YUL= -12.0   ZUL= 0.635
XLR=  80    YLR= -80    ZLR= 0.635
UAX=1.0 VDN=-1.0 NAX=1500 END
TTL='BASKET X-Y QUADRANT III HEAT TRANSFER DISK'
XUL= -80.0  YUL= -12.0  ZUL= 0.635
XLR= -12.0  YLR= -80.0  ZLR= 0.635
UAX=1.0 VDN=-1.0 NAX=1500 END
TTL='BASKET X-Y QUADRANT IV HEAT TRANSFER DISK'
XUL= -80.0  YUL= 80.0   ZUL= 0.635
XLR= -12.0  YLR= 12.0   ZLR= 0.635
UAX=1.0 VDN=-1.0 NAX=1500 END
'
' WATER LEVEL BASKET QUADRANTS
'
TTL='BASKET X-Y QUADRANT I WATER LEVEL'
XUL=  12.     YUL=  80     ZUL= 3.44
XLR=  80.0    YLR=  12.0   ZLR= 3.44
UAX=1.0 VDN=-1.0 NAX=1500 END
TTL='BASKET X-Y QUADRANT II WATER LEVEL'
XUL=  12.0    YUL= -12.0   ZUL= 3.44
XLR=  80      YLR= -80     ZLR= 3.44
UAX=1.0 VDN=-1.0 NAX=1500 END
TTL='BASKET X-Y QUADRANT III WATER LEVEL'
XUL= -80.0    YUL= -12.0   ZUL= 3.44
XLR= -12.0    YLR= -80.0   ZLR= 3.44
UAX=1.0 VDN=-1.0 NAX=1500 END
TTL='BASKET X-Y QUADRANT IV WATER LEVEL'
XUL= -80.0    YUL= 80.0    ZUL= 3.44
XLR= -12.0    YLR= 12.0    ZLR= 3.44
UAX=1.0 VDN=-1.0 NAX=1500 END
'
'  VERTICAL SLICES
'
TTL='BASKET X-Z CROSS SECTION ALUMINUM LEVEL (MIDDLE OF FUEL PIN)'
XUL= -90  YUL=0.4   ZUL= 1.27
XLR=  90  YLR=0.4   ZLR= -.1
UAX=1.0 WDN=-1.0 NAX=1500 END
TTL='BASKET X-Z CROSS SECTION WATER LEVEL (MIDDLE OF FUEL PIN)'
XUL= -90  YUL=0.4   ZUL= 4.318
XLR=  90  YLR=0.4   ZLR= 1.27
UAX=1.0 WDN=-1.0 NAX=1500 END
TTL='BASKET X-Z CROSS SECTION SS LEVEL (MIDDLE OF FUEL PIN)'
XUL= -90  YUL=0.4   ZUL= 6.858
XLR=  90  YLR=0.4   ZLR= 5.588
UAX=1.0 WDN=-1.0 NAX=1500 END
TTL='BASKET X-Z CROSS SECTION ENTIRE MODEL (MIDDLE OF FUEL PIN)'
XUL= -90  YUL=0.4   ZUL= 12
XLR=  90  YLR=0.4   ZLR= 0
UAX=1.0 WDN=-1.0 NAX=1500 END
END PLOT
END DATA
END
```

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis

```
**************************************************************************
*****                                                               *****
*****              PROGRAM VERIFICATION INFORMATION                 *****
*****                                                               *****
*****              CODE SYSTEM:  SCALE-PC VERSION:  4.3             *****
*****                                                               *****
**************************************************************************
*****                                                               *****
*****                                                               *****
*****             PROGRAM:  CSAS                                    *****
*****                                                               *****
*****       CREATION DATE:  03-08-96                                *****
*****                                                               *****
*****              VOLUME:  ENG                                     *****
*****                                                               *****
*****             LIBRARY:  G:\scale43\exe                          *****
*****                                                               *****
*****                                                               *****
*****     PRODUCTION CODE:  CSAS                                    *****
*****                                                               *****
*****             VERSION:  3.1                                     *****
*****                                                               *****
*****             JOBNAME:  SCALE-PC                                *****
*****                                                               *****
*****   DATE OF EXECUTION:  11/12/96                                *****
*****                                                               *****
*****   TIME OF EXECUTION:  16:53:43                                *****
*****                                                               *****
*****                                                               *****
**************************************************************************
**************************************************************************
**************************************************************************

TRANSPORT CRITICALITY: ACCIDENT CONDITIONS (PITCH = 300 CM) (IVF = 1.0) (EVF = 1.0

**** PROBLEM PARAMETERS ****

LIB 27GROUPNDF4  LIBRARY
MXX            10 MIXTURES
MSC            19 COMPOSITION SPECIFICATIONS
IZM             4 MATERIAL ZONES
GE  LATTICECELL  GEOMETRY
MORE            0 0/1 DO NOT READ/READ OPTIONAL PARAMETER DATA
MSLN            0 FUEL SOLUTIONS

**** PROBLEM COMPOSITION DESCRIPTION ****

SC  UO2            STANDARD COMPOSITION
MX              1 MIXTURE NO.
VF         0.9500 VOLUME FRACTION
ROTH      10.9600 THEORETICAL DENSITY
NEL             2 NO. ELEMENTS
ICP             1 0/1 MIXTURE/COMPOUND
TEMP        293.0 DEG KELVIN
            92000       1.00 ATOM/MOLECULE
                            92235      4.000 WT%
                            92238     96.000 WT%
             8016       2.00 ATOMS/MOLECULE
END

SC  ZIRCALLOY      STANDARD COMPOSITION
MX              2 MIXTURE NO.
VF         1.0000 VOLUME FRACTION
ROTH       6.5600 THEORETICAL DENSITY
NEL             1 NO. ELEMENTS
ICP             1 0/1 MIXTURE/COMPOUND
TEMP        293.0 DEG KELVIN
            40302       1.00 ATOM/MOLECULE
END

SC  H2O            STANDARD COMPOSITION
MX              3 MIXTURE NO.
VF         1.0000 VOLUME FRACTION
ROTH       0.9982 THEORETICAL DENSITY
NEL             2 NO. ELEMENTS
ICP             1 0/1 MIXTURE/COMPOUND
TEMP        293.0 DEG KELVIN
             1001       2.00 ATOMS/MOLECULE
             8016       1.00 ATOM/MOLECULE
END

SC  AL             STANDARD COMPOSITION
MX              4 MIXTURE NO.
VF         1.0000 VOLUME FRACTION
ROTH       2.7020 THEORETICAL DENSITY
NEL             1 NO. ELEMENTS
ICP             1 0/1 MIXTURE/COMPOUND
TEMP        293.0 DEG KELVIN
            13027       1.00 ATOM/MOLECULE
END
```

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
SC   SS304         STANDARD COMPOSITION
MX             5   MIXTURE NO.
VF        1.0000   VOLUME FRACTION
ROTH      7.9200   THEORETICAL DENSITY
NEL            4   NO. ELEMENTS
ICP            0   0/1 MIXTURE/COMPOUND
TEMP       293.0   DEG KELVIN
           24304      19.000 WT%
           25055       2.000 WT%
           26304      69.500 WT%
           28304       9.500 WT%
END

SC   B-10          STANDARD COMPOSITION
MX             6   MIXTURE NO.
VF        0.0450   VOLUME FRACTION
ROTH      2.6226   SPECIFIED DENSITY
NEL            1   NO. ELEMENTS
ICP            1   0/1 MIXTURE/COMPOUND
TEMP       293.0   DEG KELVIN
            5010         1.00 ATOM/MOLECULE
END

SC   B-11          STANDARD COMPOSITION
MX             6   MIXTURE NO.
VF        0.2736   VOLUME FRACTION
ROTH      2.6226   SPECIFIED DENSITY
NEL            1   NO. ELEMENTS
ICP            1   0/1 MIXTURE/COMPOUND
TEMP       293.0   DEG KELVIN
            5011         1.00 ATOM/MOLECULE
END

SC   C             STANDARD COMPOSITION
MX             6   MIXTURE NO.
VF        0.0927   VOLUME FRACTION
ROTH      2.6226   SPECIFIED DENSITY
NEL            1   NO. ELEMENTS
ICP            1   0/1 MIXTURE/COMPOUND
TEMP       293.0   DEG KELVIN
            6012         1.00 ATOM/MOLECULE
END

SC   AL            STANDARD COMPOSITION
MX             6   MIXTURE NO.
VF        0.5737   VOLUME FRACTION
ROTH      2.6226   SPECIFIED DENSITY
NEL            1   NO. ELEMENTS
ICP            1   0/1 MIXTURE/COMPOUND
TEMP       293.0   DEG KELVIN
           13027         1.00 ATOM/MOLECULE
END

SC   PB            STANDARD COMPOSITION
MX             7   MIXTURE NO.
VF        1.0000   VOLUME FRACTION
ROTH     11.3440   THEORETICAL DENSITY
NEL            1   NO. ELEMENTS
ICP            1   0/1 MIXTURE/COMPOUND
TEMP       293.0   DEG KELVIN
           82000         1.00 ATOM/MOLECULE
END

SC   H             STANDARD COMPOSITION
MX             8   MIXTURE NO.
VF        0.0600   VOLUME FRACTION
ROTH      1.6291   SPECIFIED DENSITY
NEL            1   NO. ELEMENTS
ICP            1   0/1 MIXTURE/COMPOUND
TEMP       293.0   DEG KELVIN
            1001         1.00 ATOM/MOLECULE
END
SC   O             STANDARD COMPOSITION
MX             8   MIXTURE NO.
VF        0.4250   VOLUME FRACTION
ROTH      1.6291   SPECIFIED DENSITY
NEL            1   NO. ELEMENTS
ICP            1   0/1 MIXTURE/COMPOUND
TEMP       293.0   DEG KELVIN
            8016         1.00 ATOM/MOLECULE
END

SC   C             STANDARD COMPOSITION
MX             8   MIXTURE NO.
VF        0.2770   VOLUME FRACTION
ROTH      1.6291   SPECIFIED DENSITY
NEL            1   NO. ELEMENTS
ICP            1   0/1 MIXTURE/COMPOUND
TEMP       293.0   DEG KELVIN
            6012         1.00 ATOM/MOLECULE
END

SC   N             STANDARD COMPOSITION
MX             8   MIXTURE NO.
```

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
VF           0.0200 VOLUME FRACTION
ROTH         1.6291 SPECIFIED DENSITY
NEL               1 NO. ELEMENTS
ICP               1 0/1 MIXTURE/COMPOUND
TEMP          293.0 DEG KELVIN
               7014        1.00 ATOM/MOLECULE
END

SC  AL              STANDARD COMPOSITION
MX                8 MIXTURE NO.
VF           0.2140 VOLUME FRACTION
ROTH         1.6291 SPECIFIED DENSITY
NEL               1 NO. ELEMENTS
ICP               1 0/1 MIXTURE/COMPOUND
TEMP          293.0 DEG KELVIN
              13027        1.00 ATOM/MOLECULE
END

SC  B-10            STANDARD COMPOSITION
MX                8 MIXTURE NO.
VF           0.0010 VOLUME FRACTION
ROTH         1.6291 SPECIFIED DENSITY
NEL               1 NO. ELEMENTS
ICP               1 0/1 MIXTURE/COMPOUND
TEMP          293.0 DEG KELVIN
               5010        1.00 ATOM/MOLECULE
END

SC  B-11            STANDARD COMPOSITION
MX                8 MIXTURE NO.
VF           0.0040 VOLUME FRACTION
ROTH         1.6291 SPECIFIED DENSITY
NEL               1 NO. ELEMENTS
ICP               1 0/1 MIXTURE/COMPOUND
TEMP          293.0 DEG KELVIN
               5011        1.00 ATOM/MOLECULE
END

SC  H2O             STANDARD COMPOSITION
MX                9 MIXTURE NO.
VF           1.0000 VOLUME FRACTION
ROTH         0.9982 THEORETICAL DENSITY
NEL               2 NO. ELEMENTS
ICP               1 0/1 MIXTURE/COMPOUND
TEMP          293.0 DEG KELVIN
               1001        2.00 ATOMS/MOLECULE
               8016        1.00 ATOM/MOLECULE
END

SC  H2O             STANDARD COMPOSITION
MX               10 MIXTURE NO.
VF           1.0000 VOLUME FRACTION
ROTH         0.9982 THEORETICAL DENSITY
NEL               2 NO. ELEMENTS
ICP               1 0/1 MIXTURE/COMPOUND
TEMP          293.0 DEG KELVIN
               1001        2.00 ATOMS/MOLECULE
               8016        1.00 ATOM/MOLECULE
END

**** PROBLEM GEOMETRY ****

CTP SQUAREPITCH  CELL TYPE
PITCH        1.1887 CM CENTER TO CENTER SPACING
FUELOD       0.7887 CM FUEL DIAMETER OR SLAB THICKNESS
MFUEL             1 MIXTURE NO. OF FUEL
MMOD              3 MIXTURE NO. OF MODERATOR
CLADOD       0.9271 CM CLAD OUTER DIAMETER
MCLAD             2 MIXTURE NO. OF CLAD
GAPOD        0.8052 CM GAP OUTER DIAMETER
MGAP             10 MIXTURE NO. OF GAP

ZONE SPECIFICATIONS FOR LATTICECELL GEOMETRY

                   ZONE  1 IS FUEL
                   ZONE  2 IS GAP
                   ZONE  3 IS CLAD
                   ZONE  4 IS MOD
```

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
*****                                                                        *****
*****                    PROGRAM VERIFICATION INFORMATION                    *****
*****                                                                        *****
*****                 CODE SYSTEM:  SCALE-PC VERSION:  4.3                   *****
*****                                                                        *****
**********************************************************************************
**********************************************************************************
*****                                                                        *****
*****                                                                        *****
*****                  PROGRAM:  000002                                      *****
*****                                                                        *****
*****            CREATION DATE:  09-28-95                                    *****
*****                                                                        *****
*****                   VOLUME:  ENG                                         *****
*****                                                                        *****
*****                  LIBRARY:  G:\scale43\exe                              *****
*****                                                                        *****
*****                                                                        *****
*****          PRODUCTION CODE:  NITAWL                                      *****
*****                                                                        *****
*****                  VERSION:  3.0                                         *****
*****                                                                        *****
*****                  JOBNAME:  SCALE-PC                                    *****
*****                                                                        *****
*****        DATE OF EXECUTION:  11/12/96                                    *****
*****                                                                        *****
*****        TIME OF EXECUTION:  16:53:48                                    *****
*****                                                                        *****
*****                                                                        *****
**********************************************************************************
**********************************************************************************
**********************************************************************************

       -1Q ARRAY HAS      1 ENTRIES.

        0Q ARRAY HAS      9 ENTRIES.

        1Q ARRAY HAS     12 ENTRIES.

 SELECT 27 NUCLIDES FROM THE MASTER  LIBRARY ON LOGICAL  1
         0 NUCLIDES FROM THE WORKING LIBRARY ON LOGICAL  2
         0 NUCLIDES FROM THE WORKING LIBRARY ON LOGICAL  3
           TO CREATE THE NEW WORKING LIBRARY ON LOGICAL  4

         4 RESONANCE CALCULATIONS HAVE BEEN REQUESTED
        -1 OUTPUT OPTION FOR AMPX FORMATTED CROSS SECTION DATA
      2001 MAXIMUM NUMBER OF RESONANCE MESH INTERVALS
         2 ORDER OF RESONANCE LEVEL PROCESSING

 THE STORAGE ALLOCATED FOR THIS CASE IS    100000 WORDS

        2Q ARRAY HAS     27 ENTRIES.

        3Q ARRAY HAS     60 ENTRIES.

        4Q ARRAY HAS     27 ENTRIES.

  GENERAL INFORMATION CONCERNING CROSS SECTION LIBRARY
    TAPE IDENTIFICATION NUMBER                    4321
    NUMBER OF NUCLIDES ON TAPE                      27
    NUMBER OF NEUTRON ENERGY GROUPS                 27
    FIRST THERMAL NEUTRON ENERGY GROUP              15
    NUMBER OF GAMMA ENERGY GROUPS                    0

    DIRECT ACCESS UNIT NUMBER  9 REQUIRES 117 BLOCKS OF LENGTH  1680 WORDS
  XSDRN TAPE    4321
                         SCALE 4.2 - 27 GROUP NEUTRON GROUP LIBRARY
                            BASED ON ENDF-B VERSION 4 DATA
                               COMPILED FOR NRC      1/27/89
                                  LAST UPDATED                                         08/12/94
                                     L.M.PETRIE   -    ORNL

  NUCLIDES FROM XSDRN TAPE
     1       HYDROGEN        ENDF/B-IV MAT 1269/THRM1002          UPDATED 08/12/94       3001001
     2       HYDROGEN        ENDF/B-IV MAT 1269/THRM1002          UPDATED 08/12/94       8001001
     3       HYDROGEN        ENDF/B-IV MAT 1269/THRM1002          UPDATED 08/12/94       9001001
     4       HYDROGEN        ENDF/B-IV MAT 1269/THRM1002          UPDATED 08/12/94      10001001
     5      B-10 1273 218NGP 042375 P-3 293K                      UPDATED 08/12/94       6005010
     6      B-10 1273 218NGP 042375 P-3 293K                      UPDATED 08/12/94       8005010
     7       BORON-11        ENDF/B-IV MAT 1160                   UPDATED 08/12/94       6005011
     8       BORON-11        ENDF/B-IV MAT 1160                   UPDATED 08/12/94       8005011
     9       CARBON-12       ENDF/B-IV MAT 1274/THRM1065          UPDATED 08/12/94       6006012
    10       CARBON-12       ENDF/B-IV MAT 1274/THRM1065          UPDATED 08/12/94       8006012
    11       NITROGEN-14     ENDF/B-IV MAT 1275                   UPDATED 08/12/94       8007014
    12       OXYGEN-16       ENDF/B-IV MAT 1276                   UPDATED 08/12/94       1008016
    13       OXYGEN-16       ENDF/B-IV MAT 1276                   UPDATED 08/12/94       3008016
    14       OXYGEN-16       ENDF/B-IV MAT 1276                   UPDATED 08/12/94       8008016
    15       OXYGEN-16       ENDF/B-IV MAT 1276                   UPDATED 08/12/94       9008016
    16       OXYGEN-16       ENDF/B-IV MAT 1276                   UPDATED 08/12/94      10008016
    17      AL-27 1193 218 GP 040375(5)                           UPDATED 08/12/94       4013027
    18      AL-27 1193 218 GP 040375(5)                           UPDATED 08/12/94       6013027
    19      AL-27 1193 218 GP 040375(5)                           UPDATED 08/12/94       8013027
    20      CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'      UPDATED 08/12/94       5024304
    21       MANGANESE-55    ENDF/B-IV MAT 1197                   UPDATED 08/12/94       5025055
```

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
  22     FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'        UPDATED 08/12/94     5026304
  23     NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'        UPDATED 08/12/94     5028304
  24      ZIRCALLOY       ENDF/B-IV MAT 1284                     UPDATED 08/12/94     2040302
  25     PB    1288 218NGP 042375 P-3 293K                       UPDATED 08/12/94     7082000
  26      URANIUM-235     ENDF/B-IV MAT 1261                     UPDATED 08/12/94     1092235
  27      URANIUM-238     ENDF/B-IV MAT 1262                     UPDATED 08/12/94     1092238

 HYDROGEN        ENDF/B-IV MAT 1269/THRM1002             UPDATED 08/12/94    3001001      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 HYDROGEN        ENDF/B-IV MAT 1269/THRM1002             UPDATED 08/12/94    8001001      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 HYDROGEN        ENDF/B-IV MAT 1269/THRM1002             UPDATED 08/12/94    9001001      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 HYDROGEN        ENDF/B-IV MAT 1269/THRM1002             UPDATED 08/12/94   10001001      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

B-10 1273 218NGP 042375 P-3 293K                         UPDATED 08/12/94    6005010      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

B-10 1273 218NGP 042375 P-3 293K                         UPDATED 08/12/94    8005010      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 BORON-11        ENDF/B-IV MAT 1160                      UPDATED 08/12/94    6005011      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 BORON-11        ENDF/B-IV MAT 1160                      UPDATED 08/12/94    8005011      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 CARBON-12       ENDF/B-IV MAT 1274/THRM1065             UPDATED 08/12/94    6006012      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 CARBON-12       ENDF/B-IV MAT 1274/THRM1065             UPDATED 08/12/94    8006012      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 NITROGEN-14     ENDF/B-IV MAT 1275                      UPDATED 08/12/94    8007014      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 OXYGEN-16       ENDF/B-IV MAT 1276                      UPDATED 08/12/94    1008016      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 OXYGEN-16       ENDF/B-IV MAT 1276                      UPDATED 08/12/94    3008016      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 OXYGEN-16       ENDF/B-IV MAT 1276                      UPDATED 08/12/94    8008016      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 OXYGEN-16       ENDF/B-IV MAT 1276                      UPDATED 08/12/94    9008016      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 OXYGEN-16       ENDF/B-IV MAT 1276                      UPDATED 08/12/94   10008016      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

AL-27 1193 218 GP 040375(5)                              UPDATED 08/12/94    4013027      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

AL-27 1193 218 GP 040375(5)                              UPDATED 08/12/94    6013027      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

AL-27 1193 218 GP 040375(5)                              UPDATED 08/12/94    8013027      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'         UPDATED 08/12/94    5024304      TEMPERATURE=    293.00
                                                               PROCESS NUMBER 1007 IS AT TEMPERATURE=    293.00

 MANGANESE-55    ENDF/B-IV MAT 1197                      UPDATED 08/12/94    5025055      TEMPERATURE=    293.00

GEOMETRY HAS BEEN SET TO HOMOGENEOUS AS LBAR IS  0.0000E+00

RESONANCE DATA FOR THIS NUCLIDE

MASS NUMBER (A)           =    54.466          TEMPERATURE(KELVIN)        =   293.000

POTENTIAL SCATTER SIGMA   =     2.590          LUMPED NUCLEAR DENSITY     = 1.7363295E-03

SPIN FACTOR (G)           =    14.448          LUMP DIMENSION (A-BAR)     = 0.0000000E+00

INNER RADIUS              = 0.0000000E+00      DANCOFF CORRECTION (C)     = 0.0000000E+00

THE ABSORBER WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.

MASS OF MODERATOR-1     =     55.845         SIGMA(PER ABSORBER ATOM)= 3.4663022E+02

MODERATOR-1 WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.

MASS OF MODERATOR-2     =     55.925         SIGMA(PER ABSORBER ATOM)= 1.2557598E+02

MODERATOR-2 WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.

THIS RESONANCE MATERIAL WILL BE TREATED AS A 0-DIMENSIONAL OBJECT.

VOLUME FRACTION OF LUMP IN CELL USED TO ACCOUNT FOR SPATIAL SELF-SHIELDING=1.00000
```

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
GROUP        RES ABS          RES FISS         RES SCAT
  8      -5.518788E-04    0.000000E+00    -3.944190E-01
  9      -2.797993E-03    0.000000E+00    -2.293471E+00
 10      -3.291452E-01    0.000000E+00    -3.820862E+01
 11      -2.680562E+00    0.000000E+00    -1.159996E+02

EXCESS RESONANCE INTEGRALS

                     RESOLVED

ABSORPTION        3.33719E+00
FISSION           0.00000E+00
                                                    PROCESS NUMBER 1007 IS AT TEMPERATURE=   293.00

FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'    UPDATED 08/12/94   5026304     TEMPERATURE=   293.00
                                                    PROCESS NUMBER 1007 IS AT TEMPERATURE=   293.00

NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'    UPDATED 08/12/94   5028304     TEMPERATURE=   293.00
                                                    PROCESS NUMBER 1007 IS AT TEMPERATURE=   293.00

 ZIRCALLOY      ENDF/B-IV MAT 1284                  UPDATED 08/12/94   2040302     TEMPERATURE=   293.00

RESONANCE DATA FOR THIS NUCLIDE

MASS NUMBER (A)          =     90.436          TEMPERATURE(KELVIN)        =   293.000

POTENTIAL SCATTER SIGMA  =      6.385          LUMPED NUCLEAR DENSITY     = 4.3307818E-02

SPIN FACTOR (G)          =      1.079          LUMP DIMENSION (A-BAR)     = 4.6355000E-01

INNER RADIUS             = 4.0259999E-01       DANCOFF CORRECTION (C)     = 4.8012701E-01

THE ABSORBER WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.

THIS RESONANCE MATERIAL WILL BE TREATED AS A 2-DIMENSIONAL OBJECT.

VOLUME FRACTION OF LUMP IN CELL USED TO ACCOUNT FOR SPATIAL SELF-SHIELDING=1.00000

GROUP        RES ABS          RES FISS         RES SCAT
  8      -3.660543E-04    0.000000E+00    -2.908784E-01
  9      -2.489563E-02    0.000000E+00    -1.027892E+00
 10      -2.529988E-02    0.000000E+00    -5.793766E-01
 11      -8.583183E-02    0.000000E+00    -4.082697E-01

EXCESS RESONANCE INTEGRALS

                     RESOLVED

ABSORPTION        5.46203E-01
FISSION           0.00000E+00
                                                    PROCESS NUMBER 1007 IS AT TEMPERATURE=   293.00

PB   1288 218NGP 042375 P-3 293K                    UPDATED 08/12/94   7082000     TEMPERATURE=   293.00
                                                    PROCESS NUMBER 1007 IS AT TEMPERATURE=   293.00

 URANIUM-235    ENDF/B-IV MAT 1261                  UPDATED 08/12/94   1092235     TEMPERATURE=   293.00

RESONANCE DATA FOR THIS NUCLIDE

MASS NUMBER (A)          =    233.025          TEMPERATURE(KELVIN)        =   293.000

POTENTIAL SCATTER SIGMA  =     11.500          LUMPED NUCLEAR DENSITY     = 9.4064139E-04

SPIN FACTOR (G)          = 15171.100           LUMP DIMENSION (A-BAR)     = 3.9434999E-01

INNER RADIUS             = 0.0000000E+00       DANCOFF CORRECTION (C)     = 2.9500756E-01

THE ABSORBER WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.

MASS OF MODERATOR-1    =    15.991           SIGMA(PER ABSORBER ATOM)= 1.9199110E+02

MODERATOR-1 WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.

MASS OF MODERATOR-2    =    238.051          SIGMA(PER ABSORBER ATOM)= 2.9209552E+02

MODERATOR-2 WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.

THIS RESONANCE MATERIAL WILL BE TREATED AS A 2-DIMENSIONAL OBJECT.

VOLUME FRACTION OF LUMP IN CELL USED TO ACCOUNT FOR SPATIAL SELF-SHIELDING=1.00000

GROUP        RES ABS          RES FISS         RES SCAT
 12      -4.040891E+00   -2.484752E+00    -9.599491E-02
 13      -1.260745E+01   -6.154013E+00    -2.681050E-01
 14      -9.467398E+00   -5.597835E+00    -6.275433E-02
 15      -5.487491E-04   -4.169921E-04     5.016608E-06

EXCESS RESONANCE INTEGRALS

                     RESOLVED

ABSORPTION        1.97633E+02
FISSION           1.18625E+02
                                                    PROCESS NUMBER 1007 IS AT TEMPERATURE=   293.00
```

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
URANIUM-238    ENDF/B-IV MAT 1262                UPDATED 08/12/94   1092238   TEMPERATURE=  293.00

RESONANCE DATA FOR THIS NUCLIDE

MASS NUMBER (A)          =  236.006          TEMPERATURE(KELVIN)       =  293.000

POTENTIAL SCATTER SIGMA  =   10.599          LUMPED NUCLEAR DENSITY    = 2.2290209E-02

SPIN FACTOR (G)          =  656.527          LUMP DIMENSION (A-BAR)    = 3.9434999E-01

INNER RADIUS             = 0.0000000E+00     DANCOFF CORRECTION (C)    = 2.9500756E-01

THE ABSORBER WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.

MASS OF MODERATOR-1    =   15.991           SIGMA(PER ABSORBER ATOM)= 8.1019773E+00

MODERATOR-1 WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.

MASS OF MODERATOR-2    =  235.044           SIGMA(PER ABSORBER ATOM)= 5.0228214E-01

MODERATOR-2 WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.

THIS RESONANCE MATERIAL WILL BE TREATED AS A 2-DIMENSIONAL OBJECT.

VOLUME FRACTION OF LUMP IN CELL USED TO ACCOUNT FOR SPATIAL SELF-SHIELDING=1.00000

GROUP        RES ABS          RES FISS         RES SCAT
  9      -4.868848E-02     0.000000E+00    -4.793465E-01
 10      -1.166066E+00    -2.527089E-05    -7.025325E+00
 11      -9.951198E+00     0.000000E+00    -2.725808E+01
 12      -4.311383E+01     0.000000E+00    -5.006018E+01
 13      -5.391320E+01     0.000000E+00    -1.768698E+01
 14      -1.043868E+02     0.000000E+00    -6.064470E+00
 15      -9.692318E-07     0.000000E+00     1.880502E-06

EXCESS RESONANCE INTEGRALS

                  RESOLVED

ABSORPTION       1.80430E+01
FISSION          4.90718E-04
```

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
                                                   PROCESS NUMBER 1007 IS AT TEMPERATURE=   293.00
THIS XSDRN WORKING TAPE WAS CREATED 11/12/96 AT 16:53:48
THE TITLE OF THE PARENT CASE IS AS FOLLOWS
SCALE 4.2 - 27 GROUP NEUTRON GROUP LIBRARY
   BASED ON ENDF-B VERSION 4 DATA
      COMPILED FOR NRC      1/27/89
    TAPE ID                              4321        NUMBER OF NUCLIDES                      27
    NUMBER OF NEUTRON GROUPS               27        NUMBER OF GAMMA GROUPS                   0
    FIRST THERMAL GROUP                    15        LOGICAL UNIT                             4
                                 TABLE OF CONTENTS
  HYDROGEN        ENDF/B-IV MAT 1269/THRM1002          UPDATED 08/12/94       ID   3001001
  HYDROGEN        ENDF/B-IV MAT 1269/THRM1002          UPDATED 08/12/94       ID   8001001
  HYDROGEN        ENDF/B-IV MAT 1269/THRM1002          UPDATED 08/12/94       ID   9001001
  HYDROGEN        ENDF/B-IV MAT 1269/THRM1002          UPDATED 08/12/94       ID  10001001
 B-10 1273 218NGP 042375 P-3 293K                      UPDATED 08/12/94       ID   6005010
 B-10 1273 218NGP 042375 P-3 293K                      UPDATED 08/12/94       ID   8005010
  BORON-11        ENDF/B-IV MAT 1160                   UPDATED 08/12/94       ID   6005011
  BORON-11        ENDF/B-IV MAT 1160                   UPDATED 08/12/94       ID   8005011
  CARBON-12       ENDF/B-IV MAT 1274/THRM1065          UPDATED 08/12/94       ID   6006012
  CARBON-12       ENDF/B-IV MAT 1274/THRM1065          UPDATED 08/12/94       ID   8006012
  NITROGEN-14     ENDF/B-IV MAT 1275                   UPDATED 08/12/94       ID   8007014
  OXYGEN-16       ENDF/B-IV MAT 1276                   UPDATED 08/12/94       ID   1008016
  OXYGEN-16       ENDF/B-IV MAT 1276                   UPDATED 08/12/94       ID   3008016
  OXYGEN-16       ENDF/B-IV MAT 1276                   UPDATED 08/12/94       ID   8008016
  OXYGEN-16       ENDF/B-IV MAT 1276                   UPDATED 08/12/94       ID   9008016
  OXYGEN-16       ENDF/B-IV MAT 1276                   UPDATED 08/12/94       ID  10008016
 AL-27 1193 218 GP 040375(5)                           UPDATED 08/12/94       ID   4013027
 AL-27 1193 218 GP 040375(5)                           UPDATED 08/12/94       ID   6013027
 AL-27 1193 218 GP 040375(5)                           UPDATED 08/12/94       ID   8013027
 CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'      UPDATED 08/12/94       ID   5024304
  MANGANESE-55    ENDF/B-IV MAT 1197                   UPDATED 08/12/94       ID   5025055
 FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'      UPDATED 08/12/94       ID   5026304
 NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'      UPDATED 08/12/94       ID   5028304
  ZIRCALLOY       ENDF/B-IV MAT 1284                   UPDATED 08/12/94       ID   2040302
 PB    1288 218NGP 042375 P-3 293K                     UPDATED 08/12/94       ID   7082000
  URANIUM-235     ENDF/B-IV MAT 1261                   UPDATED 08/12/94       ID   1092235
  URANIUM-238     ENDF/B-IV MAT 1262                   UPDATED 08/12/94       ID   1092238

   TAPE COPY USED       0 I/O'S, AND TOOK     0.33 SECONDS
```

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
*****************************************************************************
*****************************************************************************
*****************************************************************************
*****                                                                   *****
*****                  PROGRAM VERIFICATION INFORMATION                 *****
*****                                                                   *****
*****              CODE SYSTEM:  SCALE-PC VERSION:  4.3                 *****
*****                                                                   *****
*****************************************************************************
*****************************************************************************
*****                                                                   *****
*****                                                                   *****
*****              PROGRAM:  000009                                     *****
*****                                                                   *****
*****        CREATION DATE:  03-08-96                                   *****
*****                                                                   *****
*****               VOLUME:  ENG                                        *****
*****                                                                   *****
*****              LIBRARY:  G:\scale43\exe                             *****
*****                                                                   *****
*****                                                                   *****
*****      PRODUCTION CODE:  KENOVA                                     *****
*****                                                                   *****
*****              VERSION:  3.1                                        *****
*****                                                                   *****
*****              JOBNAME:  SCALE-PC                                   *****
*****                                                                   *****
*****    DATE OF EXECUTION:  11/12/96                                   *****
*****                                                                   *****
*****    TIME OF EXECUTION:  16:54:00                                   *****
*****                                                                   *****
*****                                                                   *****
*****************************************************************************
*****************************************************************************
*****************************************************************************
```

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
TRANSPORT CRITICALITY: ACCIDENT CONDITIONS (PITCH = 300 CM) (IVF = 1.0) (EVF = 1.0

     ******       NUMERIC PARAMETERS       ******

 TME   MAXIMUM PROBLEM TIME (MIN)                  500.00
 TBA   TIME PER GENERATION (MIN)                     0.50
 GEN   NUMBER OF GENERATIONS                         1003
 NPG   NUMBER PER GENERATION                         1000
 NSK   NUMBER OF GENERATIONS TO BE SKIPPED              3
 BEG   BEGINNING GENERATION NUMBER                      1
 RES   GENERATIONS BETWEEN CHECKPOINTS                  0
 X1D   NUMBER OF EXTRA 1-D CROSS SECTIONS               1
 NBK   NEUTRON BANK SIZE                             1025
 XNB   EXTRA POSITIONS IN NEUTRON BANK                  0
 NFB   FISSION BANK SIZE                             1000
 XFB   EXTRA POSITIONS IN FISSION BANK                  0
 WTA   DEFAULT VALUE OF WEIGHT AVERAGE             0.5000
 WTH   WEIGHT HIGH FOR SPLITTING                   3.0000
 WTL   WEIGHT LOW FOR RUSSIAN ROULETTE             0.3333
 RND   STARTING RANDOM NUMBER                BB827100001
 NB8   NUMBER OF D.A. BLOCKS ON UNIT  8               200
 NL8   LENGTH OF D.A. BLOCKS ON UNIT  8               512
 ADJ   MODE OF CALCULATION                        FORWARD
       INPUT DATA WRITTEN ON RESTART UNIT              NO
       BINARY DATA INTERFACE                          YES
```

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
*********************************************************************************************************
***                                                                                                   ***
***                    TRANSPORT CRITICALITY: ACCIDENT CONDITIONS (PITCH = 300 CM) (IVF = 1.0) (EVF = 1.0***
***                                                                                                   ***
*********************************************************************************************************
***                        ******     LOGICAL PARAMETERS      ******                                  ***
***                                                                                                   ***
*** RUN  EXECUTE PROBLEM AFTER CHECKING DATA   YES     PLT  PLOT PICTURE MAP(S)                    NO ***
***                                                                                                   ***
*** FLX  COMPUTE FLUX                           NO     FDN  COMPUTE FISSION DENSITIES              NO ***
***                                                                                                   ***
*** SMU  COMPUTE AVG UNIT SELF-MULTIPLICATION   NO     NUB  COMPUTE NU-BAR & AVG FISSION GROUP    YES ***
***                                                                                                   ***
*** MKU  COMPUTE MATRIX K-EFF BY UNIT NUMBER    NO     MKP  COMPUTE MATRIX K-EFF BY UNIT LOCATION  NO ***
***                                                                                                   ***
*** CKU  COMPUTE COFACTOR K-EFF BY UNIT NUMBER  NO     CKP  COMPUTE COFACTOR K-EFF BY UNIT LOCATION NO ***
***                                                                                                   ***
*** FMU  PRINT FISS PROD MATRIX BY UNIT NUMBER  NO     FMP  PRINT FISS PROD MATRIX BY UNIT LOCATION NO ***
***                                                                                                   ***
*** MKH  COMPUTE MATRIX K-EFF BY HOLE NUMBER    NO     MKA  COMPUTE MATRIX K-EFF BY ARRAY NUMBER   NO ***
***                                                                                                   ***
*** CKH  COMPUTE COFACTOR K-EFF BY HOLE NUMBER  NO     CKA  COMPUTE COFACTOR K-EFF BY ARRAY NUMBER NO ***
***                                                                                                   ***
*** FMH  PRINT FISS PROD MATRIX BY HOLE NUMBER  NO     FMA  PRINT FISS PROD MATRIX BY ARRAY NUMBER NO ***
***                                                                                                   ***
*** HHL  COLLECT MATRIX BY HIGHEST HOLE LEVEL   NO     HAL  COLLECT MATRIX BY HIGHEST ARRAY LEVEL  NO ***
***                                                                                                   ***
*** AMX  PRINT ALL MIXED CROSS SECTIONS         NO     FAR  PRINT FIS. AND ABS. BY REGION          NO ***
***                                                                                                   ***
*** XS1  PRINT 1-D MIXTURE X-SECTIONS           NO     GAS  PRINT FAR BY GROUP                     NO ***
***                                                                                                   ***
*** XS2  PRINT 2-D MIXTURE X-SECTIONS           NO     PAX  PRINT XSEC-ALBEDO CORRELATION TABLES   NO ***
***                                                                                                   ***
*** XAP  PRINT MIXTURE ANGLES & PROBABILITIES   NO     PWT  PRINT WEIGHT AVERAGE ARRAY             NO ***
***                                                                                                   ***
*** PKI  PRINT FISSION SPECTRUM                 NO     PGM  PRINT INPUT GEOMETRY                   NO ***
***                                                                                                   ***
*** P1D  PRINT EXTRA 1-D CROSS SECTIONS         NO     BUG  PRINT DEBUG INFORMATION                NO ***
***                                                                                                   ***
***                                                    TRK  PRINT TRACKING INFORMATION             NO ***
*********************************************************************************************************
                              PARAMETER INPUT COMPLETED

               ........   0 IO'S WERE USED READING THE PARAMETER DATA    ........

               CROSS SECTIONS READ FROM THE AMPX WORKING LIBRARY ON UNIT    4

                    TRANSPORT CRITICALITY: ACCIDENT CONDITIONS (PITCH = 300 CM) (IVF = 1.0) (EVF = 1.0

                                     MIXING TABLE

                             NUMBER OF SCATTERING ANGLES =  2
                         CROSS SECTION MESSAGE THRESHOLD =3.0E-05


MIXTURE =     1          DENSITY(G/CC) =   10.412
   NUCLIDE   ATOM-DENS.   WGT. FRAC.      ZA      AWT                NUCLIDE TITLE
   1008016  4.64617E-02  1.18487E-01    8016    15.9904     OXYGEN-16       ENDF/B-IV MAT 1276                         UPDATED
08/12/94
   1092235  9.40641E-04  3.52606E-02   92235   235.0441     URANIUM-235     ENDF/B-IV MAT 1261                         UPDATED
08/12/94
   1092238  2.22902E-02  8.46253E-01   92238   238.0510     URANIUM-238     ENDF/B-IV MAT 1262                         UPDATED
08/12/94

MIXTURE =     2          DENSITY(G/CC) =   6.5600
   NUCLIDE   ATOM-DENS.   WGT. FRAC.      ZA      AWT                NUCLIDE TITLE
   2040302  4.33078E-02  1.00000E+00   40000    91.2196     ZIRCALLOY       ENDF/B-IV MAT 1284                         UPDATED
08/12/94

MIXTURE =     3          DENSITY(G/CC) = 0.99817
   NUCLIDE   ATOM-DENS.   WGT. FRAC.      ZA      AWT                NUCLIDE TITLE
   3001001  6.67692E-02  1.11927E-01    1001     1.0077     HYDROGEN        ENDF/B-IV MAT 1269/THRM1002                UPDATED
08/12/94
   3008016  3.33846E-02  8.88074E-01    8016    15.9904     OXYGEN-16       ENDF/B-IV MAT 1276                         UPDATED
08/12/94

MIXTURE =     4          DENSITY(G/CC) =   2.7020
   NUCLIDE   ATOM-DENS.   WGT. FRAC.      ZA      AWT                NUCLIDE TITLE
   4013027  6.03066E-02  1.00000E+00   13027    26.9818    AL-27 1193 218 GP 040375(5)                                 UPDATED
08/12/94

MIXTURE =     5          DENSITY(G/CC) =   7.9200
   NUCLIDE   ATOM-DENS.   WGT. FRAC.      ZA      AWT                NUCLIDE TITLE
   5024304  1.74286E-02  1.90000E-01   24000    51.9957    CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'            UPDATED
08/12/94
   5025055  1.73633E-03  1.99999E-02   25055    54.9379     MANGANESE-55    ENDF/B-IV MAT 1197                         UPDATED
08/12/94
   5026304  5.93579E-02  6.95000E-01   26000    55.8447    FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'            UPDATED
08/12/94
   5028304  7.72070E-03  9.50001E-02   28000    58.6872    NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'            UPDATED
08/12/94

MIXTURE =     6          DENSITY(G/CC) =   2.5833
   NUCLIDE   ATOM-DENS.   WGT. FRAC.      ZA      AWT                NUCLIDE TITLE
```

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
   6005010  7.09799E-03  4.56855E-02    5010     10.0130      B-10 1273 218NGP 042375 P-3 293K                                UPDATED
08/12/94
   6005011  3.92499E-02  2.77771E-01    5011     11.0096       BORON-11          ENDF/B-IV MAT 1160                          UPDATED
08/12/94
   6006012  1.22006E-02  9.41116E-02    6000     12.0001       CARBON-12         ENDF/B-IV MAT 1274/THRM1065                 UPDATED
08/12/94
   6013027  3.35812E-02  5.82432E-01   13027     26.9818      AL-27 1193 218 GP 040375(5)                                     UPDATED
08/12/94

MIXTURE =      7          DENSITY(G/CC) =  11.344
   NUCLIDE   ATOM-DENS.   WGT. FRAC.      ZA       AWT                 NUCLIDE TITLE
   7082000  3.29690E-02  1.00000E+00   82000   207.2100      PB    1288 218NGP 042375 P-3 293K                                UPDATED
08/12/94

MIXTURE =      8          DENSITY(G/CC) =  1.6307
   NUCLIDE   ATOM-DENS.   WGT. FRAC.      ZA       AWT                 NUCLIDE TITLE
   8001001  5.84084E-02  5.99323E-02    1001      1.0077       HYDROGEN          ENDF/B-IV MAT 1269/THRM1002                 UPDATED
08/12/94
   8005010  9.79802E-05  9.99025E-04    5010     10.0130      B-10 1273 218NGP 042375 P-3 293K                                UPDATED
08/12/94
   8005011  3.56450E-04  3.99615E-03    5011     11.0096       BORON-11          ENDF/B-IV MAT 1160                          UPDATED
08/12/94
   8006012  2.26463E-02  2.76729E-01    6000     12.0001       CARBON-12         ENDF/B-IV MAT 1274/THRM1065                 UPDATED
08/12/94
   8007014  1.40121E-03  1.99805E-02    7014     14.0033       NITROGEN-14       ENDF/B-IV MAT 1275                          UPDATED
08/12/94
   8008016  2.60749E-02  4.24574E-01    8016     15.9904       OXYGEN-16         ENDF/B-IV MAT 1276                          UPDATED
08/12/94
   8013027  7.78110E-03  2.13789E-01   13027     26.9818      AL-27 1193 218 GP 040375(5)                                     UPDATED
08/12/94

MIXTURE =      9          DENSITY(G/CC) = 0.99817
   NUCLIDE   ATOM-DENS.   WGT. FRAC.      ZA       AWT                 NUCLIDE TITLE
   9001001  6.67692E-02  1.11927E-01    1001      1.0077       HYDROGEN          ENDF/B-IV MAT 1269/THRM1002                 UPDATED
08/12/94
   9008016  3.33846E-02  8.88074E-01    8016     15.9904       OXYGEN-16         ENDF/B-IV MAT 1276                          UPDATED
08/12/94

MIXTURE =     10          DENSITY(G/CC) = 0.99817
   NUCLIDE   ATOM-DENS.   WGT. FRAC.      ZA       AWT                 NUCLIDE TITLE
  10001001  6.67692E-02  1.11927E-01    1001      1.0077       HYDROGEN          ENDF/B-IV MAT 1269/THRM1002                 UPDATED
08/12/94
  10008016  3.33846E-02  8.88074E-01    8016     15.9904       OXYGEN-16         ENDF/B-IV MAT 1276                          UPDATED
08/12/94

                                     3001001      HYDROGEN        ENDF/B-IV MAT 1269/THRM1002             UPDATED 08/12/94
                                     8001001      HYDROGEN        ENDF/B-IV MAT 1269/THRM1002             UPDATED 08/12/94
                                     9001001      HYDROGEN        ENDF/B-IV MAT 1269/THRM1002             UPDATED 08/12/94
                                    10001001      HYDROGEN        ENDF/B-IV MAT 1269/THRM1002             UPDATED 08/12/94
                                     6005010     B-10 1273 218NGP 042375 P-3 293K                         UPDATED 08/12/94
                                     8005010     B-10 1273 218NGP 042375 P-3 293K                         UPDATED 08/12/94
                                     6005011      BORON-11        ENDF/B-IV MAT 1160                      UPDATED 08/12/94
                                     8005011      BORON-11        ENDF/B-IV MAT 1160                      UPDATED 08/12/94
                                     6006012      CARBON-12       ENDF/B-IV MAT 1274/THRM1065             UPDATED 08/12/94
                                     8006012      CARBON-12       ENDF/B-IV MAT 1274/THRM1065             UPDATED 08/12/94
                                     8007014      NITROGEN-14     ENDF/B-IV MAT 1275                      UPDATED 08/12/94
                                     1008016      OXYGEN-16       ENDF/B-IV MAT 1276                      UPDATED 08/12/94
                                     3008016      OXYGEN-16       ENDF/B-IV MAT 1276                      UPDATED 08/12/94
                                     8008016      OXYGEN-16       ENDF/B-IV MAT 1276                      UPDATED 08/12/94
                                     9008016      OXYGEN-16       ENDF/B-IV MAT 1276                      UPDATED 08/12/94
                                    10008016      OXYGEN-16       ENDF/B-IV MAT 1276                      UPDATED 08/12/94
                                     4013027     AL-27 1193 218 GP 040375(5)                              UPDATED 08/12/94
                                     6013027     AL-27 1193 218 GP 040375(5)                              UPDATED 08/12/94
                                     8013027     AL-27 1193 218 GP 040375(5)                              UPDATED 08/12/94
                                     5024304     CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'         UPDATED 08/12/94
                                     5025055      MANGANESE-55    ENDF/B-IV MAT 1197                      UPDATED 08/12/94
                                     5026304     FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'         UPDATED 08/12/94
                                     5028304     NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)'         UPDATED 08/12/94
                                     2040302      ZIRCALLOY       ENDF/B-IV MAT 1284                      UPDATED 08/12/94
                                     7082000     PB    1288 218NGP 042375 P-3 293K                        UPDATED 08/12/94
                                     1092235      URANIUM-235     ENDF/B-IV MAT 1261                      UPDATED 08/12/94
                                     1092238      URANIUM-238     ENDF/B-IV MAT 1262                      UPDATED 08/12/94

                                       ........     0 IO'S WERE USED MIXING CROSS-SECTIONS        ........

                                        1-D CROSS SECTION ARRAY ID NUMBERS
                                            1  2002  1452     27     18  1018

                                       ........     0 IO'S WERE USED PREPARING THE CROSS SECTIONS     ........
```

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
******************************************************************************************
***                                                                                    ***
***        TRANSPORT CRITICALITY: ACCIDENT CONDITIONS (PITCH = 300 CM) (IVF = 1.0) (EVF = 1.0  ***
***                                                                                    ***
******************************************************************************************
***                                                                                    ***
***                          ****** ADDITIONAL INFORMATION ******                      ***
***                                                                                    ***
***  NUMBER OF ENERGY GROUPS              27      USE LATTICE GEOMETRY              YES ***
***                                                                                    ***
***  NO. OF FISSION SPECTRUM SOURCE GROUP  1      GLOBAL ARRAY NUMBER                60 ***
***                                                                                    ***
***  NO. OF SCATTERING ANGLES IN XSECS     2      NUMBER OF UNITS IN THE GLOBAL X DIR.  1 ***
***                                                                                    ***
***  ENTRIES/NEUTRON IN THE NEUTRON BANK  33      NUMBER OF UNITS IN THE GLOBAL Y DIR.  1 ***
***                                                                                    ***
***  ENTRIES/NEUTRON IN THE FISSION BANK  26      NUMBER OF UNITS IN THE GLOBAL Z DIR.  4 ***
***                                                                                    ***
***  NUMBER OF MIXTURES USED               9      USE A GLOBAL REFLECTOR            YES ***
***                                                                                    ***
***  NUMBER OF BIAS ID'S USED              1      USE NESTED HOLES                  YES ***
***                                                                                    ***
***  NUMBER OF DIFFERENTIAL ALBEDOS USED   0      NUMBER OF HOLES                    48 ***
***                                                                                    ***
***  TOTAL INPUT GEOMETRY REGIONS        136      MAXIMUM HOLE NESTING LEVEL          3 ***
***                                                                                    ***
***  NUMBER OF GEOMETRY REGIONS USED     136      USE NESTED ARRAYS                 YES ***
***                                                                                    ***
***  LARGEST GEOMETRY UNIT NUMBER        120      NUMBER OF ARRAYS USED              27 ***
***                                                                                    ***
***  LARGEST ARRAY NUMBER                 60      MAXIMUM ARRAY NESTING LEVEL         4 ***
***                                                                                    ***
***                                                                                    ***
***  +X BOUNDARY CONDITION               MIR      -X BOUNDARY CONDITION             MIR ***
***                                                                                    ***
***  +Y BOUNDARY CONDITION               MIR      -Y BOUNDARY CONDITION             MIR ***
***                                                                                    ***
***  +Z BOUNDARY CONDITION               PER      -Z BOUNDARY CONDITION             PER ***
***                                                                                    ***
******************************************************************************************
```

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

START TYPE 0 WAS USED.

THE NEUTRONS WERE STARTED WITH A FLAT DISTRIBUTION IN A CUBOID DEFINED BY:
+X= 1.24651E+02 -X=-1.75349E+02 +Y= 1.24651E+02 -Y=-1.75349E+02 +Z= 1.12016E+01 -Z= 0.00000E+00
THE FLAG TO START NEUTRONS IN THE REFLECTOR WAS TURNED OFF

0.04183 MINUTES WERE REQUIRED FOR STARTING. TOTAL ELAPSED TIME IS 0.06400 MINUTES.

TRANSPORT CRITICALITY: ACCIDENT CONDITIONS (PITCH = 300 CM) (IVF = 1.0) (EVF = 1.0

GENERATION	GENERATION K-EFFECTIVE	ELAPSED TIME MINUTES	AVERAGE K-EFFECTIVE	AVG K-EFF DEVIATION	MATRIX K-EFFECTIVE	MATRIX K-EFF DEVIATION
KENO MESSAGE	NUMBER K5-132	WARNING....ONLY	920 INDEPENDENT	FISSION POINTS WERE	GENERATED	
1	8.45260E-01	1.03500E-01	1.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
KENO MESSAGE	NUMBER K5-132	WARNING....ONLY	948 INDEPENDENT	FISSION POINTS WERE	GENERATED	
2	8.75995E-01	1.43833E-01	1.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
KENO MESSAGE	NUMBER K5-132	WARNING....ONLY	952 INDEPENDENT	FISSION POINTS WERE	GENERATED	
3	8.44310E-01	1.82333E-01	8.44310E-01	0.00000E+00	0.00000E+00	0.00000E+00
4	9.03824E-01	2.21667E-01	8.74067E-01	2.97569E-02	0.00000E+00	0.00000E+00
5	9.25732E-01	2.60000E-01	8.91289E-01	2.43257E-02	0.00000E+00	0.00000E+00
6	8.52908E-01	2.99500E-01	8.81693E-01	1.96961E-02	0.00000E+00	0.00000E+00
7	9.20506E-01	3.39667E-01	8.89456E-01	1.71178E-02	0.00000E+00	0.00000E+00
8	8.74987E-01	3.78167E-01	8.87044E-01	1.41832E-02	0.00000E+00	0.00000E+00
9	9.09645E-01	4.19333E-01	8.90273E-01	1.24142E-02	0.00000E+00	0.00000E+00
10	8.48362E-01	4.58667E-01	8.85034E-01	1.19595E-02	0.00000E+00	0.00000E+00
11	9.01759E-01	4.99000E-01	8.86893E-01	1.07097E-02	0.00000E+00	0.00000E+00
12	8.91590E-01	5.38333E-01	8.87362E-01	9.59060E-03	0.00000E+00	0.00000E+00
13	8.26485E-01	5.77667E-01	8.81828E-01	1.02900E-02	0.00000E+00	0.00000E+00
14	8.67572E-01	6.18833E-01	8.80640E-01	9.46828E-03	0.00000E+00	0.00000E+00
15	8.70696E-01	6.59167E-01	8.79875E-01	8.74308E-03	0.00000E+00	0.00000E+00
16	8.80601E-01	6.97667E-01	8.79927E-01	8.09469E-03	0.00000E+00	0.00000E+00
17	8.89377E-01	7.37000E-01	8.80557E-01	7.56203E-03	0.00000E+00	0.00000E+00
18	8.75835E-01	7.75500E-01	8.80262E-01	7.07979E-03	0.00000E+00	0.00000E+00
19	8.89648E-01	8.14833E-01	8.80814E-01	6.67318E-03	0.00000E+00	0.00000E+00
20	8.78751E-01	8.54167E-01	8.80699E-01	6.29258E-03	0.00000E+00	0.00000E+00
21	8.87345E-01	8.92667E-01	8.81049E-01	5.96245E-03	0.00000E+00	0.00000E+00
22	8.89040E-01	9.32833E-01	8.81449E-01	5.67057E-03	0.00000E+00	0.00000E+00
23	8.61826E-01	9.73167E-01	8.80514E-01	5.47413E-03	0.00000E+00	0.00000E+00
24	8.76392E-01	1.01350E+00	8.80327E-01	5.22274E-03	0.00000E+00	0.00000E+00
25	8.47984E-01	1.05367E+00	8.78921E-01	5.18483E-03	0.00000E+00	0.00000E+00
26	8.31805E-01	1.09217E+00	8.76958E-01	5.33819E-03	0.00000E+00	0.00000E+00
27	8.80334E-01	1.13150E+00	8.77093E-01	5.12199E-03	0.00000E+00	0.00000E+00
28	8.70337E-01	1.17083E+00	8.76833E-01	4.92791E-03	0.00000E+00	0.00000E+00
29	8.58137E-01	1.20933E+00	8.76140E-01	4.79217E-03	0.00000E+00	0.00000E+00
30	8.61912E-01	1.24967E+00	8.75632E-01	4.64572E-03	0.00000E+00	0.00000E+00
31	8.89233E-01	1.28983E+00	8.76101E-01	4.50713E-03	0.00000E+00	0.00000E+00
32	8.58432E-01	1.33017E+00	8.75512E-01	4.39395E-03	0.00000E+00	0.00000E+00
33	8.98718E-01	1.37050E+00	8.76261E-01	4.31527E-03	0.00000E+00	0.00000E+00
34	8.43359E-01	1.40983E+00	8.75233E-01	4.30289E-03	0.00000E+00	0.00000E+00
35	8.82459E-01	1.44917E+00	8.75452E-01	4.17621E-03	0.00000E+00	0.00000E+00
36	8.73248E-01	1.48950E+00	8.75387E-01	4.05203E-03	0.00000E+00	0.00000E+00
37	8.42016E-01	1.52983E+00	8.74433E-01	4.04844E-03	0.00000E+00	0.00000E+00
38	8.60546E-01	1.57000E+00	8.74048E-01	3.95324E-03	0.00000E+00	0.00000E+00
39	8.86106E-01	1.60933E+00	8.74373E-01	3.85870E-03	0.00000E+00	0.00000E+00
40	8.82359E-01	1.64883E+00	8.74584E-01	3.76166E-03	0.00000E+00	0.00000E+00
41	9.16518E-01	1.68817E+00	8.75659E-01	3.81845E-03	0.00000E+00	0.00000E+00
42	8.75414E-01	1.72833E+00	8.75653E-01	3.72177E-03	0.00000E+00	0.00000E+00
43	8.84311E-01	1.76867E+00	8.75864E-01	3.63599E-03	0.00000E+00	0.00000E+00
44	8.32141E-01	1.80717E+00	8.74823E-01	3.69792E-03	0.00000E+00	0.00000E+00
45	9.00927E-01	1.84650E+00	8.75430E-01	3.66158E-03	0.00000E+00	0.00000E+00
46	8.35074E-01	1.88583E+00	8.74513E-01	3.69309E-03	0.00000E+00	0.00000E+00
47	8.67602E-01	1.92517E+00	8.74359E-01	3.61336E-03	0.00000E+00	0.00000E+00
48	8.73287E-01	1.96450E+00	8.74336E-01	3.53401E-03	0.00000E+00	0.00000E+00
49	8.54860E-01	2.00300E+00	8.73922E-01	3.48274E-03	0.00000E+00	0.00000E+00
50	8.77829E-01	2.04417E+00	8.74003E-01	3.41038E-03	0.00000E+00	0.00000E+00
51	8.55167E-01	2.08550E+00	8.73619E-01	3.36211E-03	0.00000E+00	0.00000E+00
52	8.59312E-01	2.12567E+00	8.73332E-01	3.30658E-03	0.00000E+00	0.00000E+00
53	8.91143E-01	2.16600E+00	8.73682E-01	3.25986E-03	0.00000E+00	0.00000E+00
54	8.96038E-01	2.20633E+00	8.74112E-01	3.22534E-03	0.00000E+00	0.00000E+00
55	8.71498E-01	2.24567E+00	8.74062E-01	3.16428E-03	0.00000E+00	0.00000E+00
56	8.65457E-01	2.28500E+00	8.73903E-01	3.10922E-03	0.00000E+00	0.00000E+00
57	8.91218E-01	2.32533E+00	8.74218E-01	3.06836E-03	0.00000E+00	0.00000E+00
58	8.54651E-01	2.36467E+00	8.73868E-01	3.03326E-03	0.00000E+00	0.00000E+00
59	8.85337E-01	2.40483E+00	8.74069E-01	2.98635E-03	0.00000E+00	0.00000E+00
60	8.80429E-01	2.44517E+00	8.74179E-01	2.93646E-03	0.00000E+00	0.00000E+00
61	9.00667E-01	2.48550E+00	8.74628E-01	2.92097E-03	0.00000E+00	0.00000E+00
62	9.14575E-01	2.52667E+00	8.75294E-01	2.94803E-03	0.00000E+00	0.00000E+00
63	8.76602E-01	2.56700E+00	8.75315E-01	2.89938E-03	0.00000E+00	0.00000E+00
64	8.67834E-01	2.60633E+00	8.75195E-01	2.85478E-03	0.00000E+00	0.00000E+00
65	9.14123E-01	2.64567E+00	8.75813E-01	2.87626E-03	0.00000E+00	0.00000E+00
66	8.65798E-01	2.68600E+00	8.75656E-01	2.83528E-03	0.00000E+00	0.00000E+00
67	8.52804E-01	2.72617E+00	8.75305E-01	2.81338E-03	0.00000E+00	0.00000E+00
68	8.47717E-01	2.76550E+00	8.74887E-01	2.80178E-03	0.00000E+00	0.00000E+00
69	8.91544E-01	2.80500E+00	8.75135E-01	2.77082E-03	0.00000E+00	0.00000E+00
70	9.18735E-01	2.84517E+00	8.75776E-01	2.80406E-03	0.00000E+00	0.00000E+00
71	8.49792E-01	2.88467E+00	8.75400E-01	2.78867E-03	0.00000E+00	0.00000E+00
72	9.00198E-01	2.92300E+00	8.75754E-01	2.77128E-03	0.00000E+00	0.00000E+00
73	9.02772E-01	2.96333E+00	8.76135E-01	2.75834E-03	0.00000E+00	0.00000E+00
74	8.58968E-01	3.00267E+00	8.75896E-01	2.73019E-03	0.00000E+00	0.00000E+00
75	8.81546E-01	3.04200E+00	8.75974E-01	2.69364E-03	0.00000E+00	0.00000E+00
76	8.79696E-01	3.08233E+00	8.76024E-01	2.65747E-03	0.00000E+00	0.00000E+00
77	9.05634E-01	3.12267E+00	8.76419E-01	2.65135E-03	0.00000E+00	0.00000E+00
78	8.53695E-01	3.16200E+00	8.76120E-01	2.63327E-03	0.00000E+00	0.00000E+00
79	7.91697E-01	3.20133E+00	8.75023E-01	2.82065E-03	0.00000E+00	0.00000E+00
80	8.51839E-01	3.24067E+00	8.74726E-01	2.80007E-03	0.00000E+00	0.00000E+00

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

81	8.92243E-01	3.28100E+00	8.74948E-01	2.77328E-03	0.00000E+00	0.00000E+00
82	8.30263E-01	3.32033E+00	8.74389E-01	2.79478E-03	0.00000E+00	0.00000E+00
83	8.86753E-01	3.35967E+00	8.74542E-01	2.76428E-03	0.00000E+00	0.00000E+00
84	8.83275E-01	3.39817E+00	8.74648E-01	2.73244E-03	0.00000E+00	0.00000E+00
85	8.65620E-01	3.43750E+00	8.74540E-01	2.70151E-03	0.00000E+00	0.00000E+00
86	8.94753E-01	3.47783E+00	8.74780E-01	2.67998E-03	0.00000E+00	0.00000E+00
87	8.83441E-01	3.51617E+00	8.74882E-01	2.65022E-03	0.00000E+00	0.00000E+00
88	8.99252E-01	3.55567E+00	8.75165E-01	2.63450E-03	0.00000E+00	0.00000E+00
89	8.96617E-01	3.59400E+00	8.75412E-01	2.61569E-03	0.00000E+00	0.00000E+00
90	8.96198E-01	3.63333E+00	8.75648E-01	2.59657E-03	0.00000E+00	0.00000E+00
91	8.35135E-01	3.67367E+00	8.75193E-01	2.60727E-03	0.00000E+00	0.00000E+00
92	8.69912E-01	3.71300E+00	8.75134E-01	2.57881E-03	0.00000E+00	0.00000E+00
93	8.48029E-01	3.75233E+00	8.74836E-01	2.56765E-03	0.00000E+00	0.00000E+00
94	8.53762E-01	3.79183E+00	8.74607E-01	2.54989E-03	0.00000E+00	0.00000E+00
95	9.00097E-01	3.83200E+00	8.74881E-01	2.53717E-03	0.00000E+00	0.00000E+00
96	8.58107E-01	3.87050E+00	8.74703E-01	2.51637E-03	0.00000E+00	0.00000E+00
97	9.35373E-01	3.91083E+00	8.75342E-01	2.57034E-03	0.00000E+00	0.00000E+00
98	8.57543E-01	3.95017E+00	8.75156E-01	2.55018E-03	0.00000E+00	0.00000E+00
99	9.56989E-01	3.99133E+00	8.76000E-01	2.66102E-03	0.00000E+00	0.00000E+00
100	8.58730E-01	4.03067E+00	8.75824E-01	2.63962E-03	0.00000E+00	0.00000E+00
101	8.67060E-01	4.07000E+00	8.75735E-01	2.61432E-03	0.00000E+00	0.00000E+00
102	8.55432E-01	4.10950E+00	8.75532E-01	2.59599E-03	0.00000E+00	0.00000E+00
103	8.67743E-01	4.14967E+00	8.75455E-01	2.57132E-03	0.00000E+00	0.00000E+00
104	8.87242E-01	4.18817E+00	8.75571E-01	2.54861E-03	0.00000E+00	0.00000E+00
105	9.38439E-01	4.22850E+00	8.76181E-01	2.59650E-03	0.00000E+00	0.00000E+00
106	8.70252E-01	4.26967E+00	8.76124E-01	2.57205E-03	0.00000E+00	0.00000E+00
107	8.82507E-01	4.30983E+00	8.76185E-01	2.54816E-03	0.00000E+00	0.00000E+00
108	9.13364E-01	4.34933E+00	8.76535E-01	2.54826E-03	0.00000E+00	0.00000E+00
109	8.98171E-01	4.38867E+00	8.76738E-01	2.53242E-03	0.00000E+00	0.00000E+00
110	9.56280E-01	4.42800E+00	8.77474E-01	2.61473E-03	0.00000E+00	0.00000E+00
111	9.00160E-01	4.46917E+00	8.77682E-01	2.59898E-03	0.00000E+00	0.00000E+00
112	8.48352E-01	4.50950E+00	8.77416E-01	2.58901E-03	0.00000E+00	0.00000E+00
113	8.33516E-01	4.54783E+00	8.77020E-01	2.59588E-03	0.00000E+00	0.00000E+00
114	8.74828E-01	4.58733E+00	8.77001E-01	2.57267E-03	0.00000E+00	0.00000E+00
115	8.72743E-01	4.62567E+00	8.76963E-01	2.55008E-03	0.00000E+00	0.00000E+00
116	8.31336E-01	4.66600E+00	8.76563E-01	2.55911E-03	0.00000E+00	0.00000E+00
117	8.95066E-01	4.70533E+00	8.76724E-01	2.54185E-03	0.00000E+00	0.00000E+00
118	8.41890E-01	4.74567E+00	8.76423E-01	2.53768E-03	0.00000E+00	0.00000E+00
119	8.88804E-01	4.78500E+00	8.76529E-01	2.51812E-03	0.00000E+00	0.00000E+00
120	8.95311E-01	4.82533E+00	8.76688E-01	2.50176E-03	0.00000E+00	0.00000E+00
121	8.68667E-01	4.86367E+00	8.76621E-01	2.48156E-03	0.00000E+00	0.00000E+00
122	8.32125E-01	4.90217E+00	8.76250E-01	2.48857E-03	0.00000E+00	0.00000E+00
123	8.86974E-01	4.94250E+00	8.76339E-01	2.46951E-03	0.00000E+00	0.00000E+00
124	8.71056E-01	4.98183E+00	8.76295E-01	2.44957E-03	0.00000E+00	0.00000E+00
125	9.01007E-01	5.02217E+00	8.76496E-01	2.43786E-03	0.00000E+00	0.00000E+00
126	8.72544E-01	5.06150E+00	8.76464E-01	2.41833E-03	0.00000E+00	0.00000E+00
127	8.84640E-01	5.10167E+00	8.76530E-01	2.39980E-03	0.00000E+00	0.00000E+00
128	8.78852E-01	5.14117E+00	8.76548E-01	2.38075E-03	0.00000E+00	0.00000E+00
129	8.69361E-01	5.18133E+00	8.76492E-01	2.36261E-03	0.00000E+00	0.00000E+00
130	8.94987E-01	5.22250E+00	8.76636E-01	2.34853E-03	0.00000E+00	0.00000E+00
131	9.08787E-01	5.26200E+00	8.76885E-01	2.34354E-03	0.00000E+00	0.00000E+00
132	8.63356E-01	5.30217E+00	8.76781E-01	2.32777E-03	0.00000E+00	0.00000E+00
133	8.90286E-01	5.34250E+00	8.76884E-01	2.31223E-03	0.00000E+00	0.00000E+00
134	9.04771E-01	5.38283E+00	8.77096E-01	2.30435E-03	0.00000E+00	0.00000E+00
135	9.26312E-01	5.42400E+00	8.77466E-01	2.31671E-03	0.00000E+00	0.00000E+00
136	9.01390E-01	5.46433E+00	8.77644E-01	2.30627E-03	0.00000E+00	0.00000E+00
137	9.32573E-01	5.50550E+00	8.78051E-01	2.32501E-03	0.00000E+00	0.00000E+00
138	8.35606E-01	5.54483E+00	8.77739E-01	2.32885E-03	0.00000E+00	0.00000E+00
139	8.92799E-01	5.58417E+00	8.77849E-01	2.31440E-03	0.00000E+00	0.00000E+00
140	8.79671E-01	5.62267E+00	8.77862E-01	2.29761E-03	0.00000E+00	0.00000E+00
141	8.37348E-01	5.66467E+00	8.77571E-01	2.29957E-03	0.00000E+00	0.00000E+00
142	8.78282E-01	5.70417E+00	8.77576E-01	2.28309E-03	0.00000E+00	0.00000E+00
143	8.88879E-01	5.74533E+00	8.77656E-01	2.26826E-03	0.00000E+00	0.00000E+00
144	8.88779E-01	5.78467E+00	8.77734E-01	2.25359E-03	0.00000E+00	0.00000E+00
145	8.73420E-01	5.82400E+00	8.77704E-01	2.23798E-03	0.00000E+00	0.00000E+00
146	8.87679E-01	5.86333E+00	8.77773E-01	2.22346E-03	0.00000E+00	0.00000E+00
147	8.83991E-01	5.90450E+00	8.77816E-01	2.20849E-03	0.00000E+00	0.00000E+00
148	8.63863E-01	5.94483E+00	8.77721E-01	2.19539E-03	0.00000E+00	0.00000E+00
149	8.91174E-01	5.98517E+00	8.77812E-01	2.18232E-03	0.00000E+00	0.00000E+00
150	8.81947E-01	6.02450E+00	8.77840E-01	2.16771E-03	0.00000E+00	0.00000E+00
151	9.01951E-01	6.06383E+00	8.78002E-01	2.15918E-03	0.00000E+00	0.00000E+00
152	9.16983E-01	6.10417E+00	8.78262E-01	2.16043E-03	0.00000E+00	0.00000E+00
153	8.64412E-01	6.14433E+00	8.78170E-01	2.14803E-03	0.00000E+00	0.00000E+00
154	8.93949E-01	6.18383E+00	8.78274E-01	2.13638E-03	0.00000E+00	0.00000E+00
155	9.01515E-01	6.22317E+00	8.78426E-01	2.12780E-03	0.00000E+00	0.00000E+00
156	8.95357E-01	6.26250E+00	8.78536E-01	2.11679E-03	0.00000E+00	0.00000E+00
157	9.15528E-01	6.30367E+00	8.78774E-01	2.11659E-03	0.00000E+00	0.00000E+00
158	8.58517E-01	6.34400E+00	8.78645E-01	2.10698E-03	0.00000E+00	0.00000E+00
159	9.21723E-01	6.38333E+00	8.78919E-01	2.11142E-03	0.00000E+00	0.00000E+00
160	8.86235E-01	6.42183E+00	8.78965E-01	2.09853E-03	0.00000E+00	0.00000E+00
161	8.56564E-01	6.46200E+00	8.78824E-01	2.09004E-03	0.00000E+00	0.00000E+00
162	9.09129E-01	6.50150E+00	8.79014E-01	2.08556E-03	0.00000E+00	0.00000E+00
163	9.03646E-01	6.54083E+00	8.79167E-01	2.07820E-03	0.00000E+00	0.00000E+00
164	8.81791E-01	6.57917E+00	8.79183E-01	2.06540E-03	0.00000E+00	0.00000E+00
165	8.92339E-01	6.61867E+00	8.79264E-01	2.05427E-03	0.00000E+00	0.00000E+00
166	8.53030E-01	6.65700E+00	8.79104E-01	2.04797E-03	0.00000E+00	0.00000E+00
167	8.79323E-01	6.69633E+00	8.79105E-01	2.03552E-03	0.00000E+00	0.00000E+00
168	8.67184E-01	6.73667E+00	8.79033E-01	2.02449E-03	0.00000E+00	0.00000E+00
169	8.69610E-01	6.77700E+00	8.78977E-01	2.01312E-03	0.00000E+00	0.00000E+00
170	8.55339E-01	6.81733E+00	8.78836E-01	2.00604E-03	0.00000E+00	0.00000E+00
171	8.95872E-01	6.85667E+00	8.78937E-01	1.99669E-03	0.00000E+00	0.00000E+00
172	8.57411E-01	6.89500E+00	8.78810E-01	1.98894E-03	0.00000E+00	0.00000E+00
173	9.01362E-01	6.93533E+00	8.78942E-01	1.98167E-03	0.00000E+00	0.00000E+00
174	8.89882E-01	6.97467E+00	8.79006E-01	1.97114E-03	0.00000E+00	0.00000E+00
175	8.82664E-01	7.01583E+00	8.79027E-01	1.95983E-03	0.00000E+00	0.00000E+00

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

176	8.97747E-01	7.05617E+00	8.79134E-01	1.95150E-03	0.00000E+00	0.00000E+00
177	8.40187E-01	7.09550E+00	8.78912E-01	1.95304E-03	0.00000E+00	0.00000E+00
178	8.70747E-01	7.13483E+00	8.78866E-01	1.94246E-03	0.00000E+00	0.00000E+00
179	8.71556E-01	7.17433E+00	8.78824E-01	1.93190E-03	0.00000E+00	0.00000E+00
180	9.36237E-01	7.21450E+00	8.79147E-01	1.94790E-03	0.00000E+00	0.00000E+00
181	9.06304E-01	7.25483E+00	8.79299E-01	1.94292E-03	0.00000E+00	0.00000E+00
182	9.06124E-01	7.29517E+00	8.79448E-01	1.93784E-03	0.00000E+00	0.00000E+00
183	8.84520E-01	7.33450E+00	8.79476E-01	1.92731E-03	0.00000E+00	0.00000E+00
184	9.03656E-01	7.37383E+00	8.79608E-01	1.92129E-03	0.00000E+00	0.00000E+00
185	8.52782E-01	7.41317E+00	8.79462E-01	1.91638E-03	0.00000E+00	0.00000E+00
186	8.90962E-01	7.45250E+00	8.79524E-01	1.90696E-03	0.00000E+00	0.00000E+00
187	8.75557E-01	7.49283E+00	8.79503E-01	1.89674E-03	0.00000E+00	0.00000E+00
188	8.63271E-01	7.53217E+00	8.79416E-01	1.88853E-03	0.00000E+00	0.00000E+00
189	8.61642E-01	7.57250E+00	8.79321E-01	1.88081E-03	0.00000E+00	0.00000E+00
190	8.69610E-01	7.61183E+00	8.79269E-01	1.87149E-03	0.00000E+00	0.00000E+00
191	8.73927E-01	7.65217E+00	8.79241E-01	1.86178E-03	0.00000E+00	0.00000E+00
192	8.84263E-01	7.69233E+00	8.79267E-01	1.85214E-03	0.00000E+00	0.00000E+00
193	8.76541E-01	7.73183E+00	8.79253E-01	1.84248E-03	0.00000E+00	0.00000E+00
194	8.97996E-01	7.77117E+00	8.79350E-01	1.83545E-03	0.00000E+00	0.00000E+00
195	8.88123E-01	7.81133E+00	8.79396E-01	1.82648E-03	0.00000E+00	0.00000E+00
196	8.93078E-01	7.85167E+00	8.79466E-01	1.81841E-03	0.00000E+00	0.00000E+00
197	8.51225E-01	7.89200E+00	8.79322E-01	1.81485E-03	0.00000E+00	0.00000E+00
198	9.15090E-01	7.93217E+00	8.79504E-01	1.81477E-03	0.00000E+00	0.00000E+00
199	9.08755E-01	7.97167E+00	8.79653E-01	1.81163E-03	0.00000E+00	0.00000E+00
200	9.10498E-01	8.01100E+00	8.79808E-01	1.80917E-03	0.00000E+00	0.00000E+00
.						
.						
950	8.75947E-01	3.94778E+01	8.83104E-01	7.71055E-04	0.00000E+00	0.00000E+00
951	8.75460E-01	3.95190E+01	8.83096E-01	7.70285E-04	0.00000E+00	0.00000E+00
952	8.95944E-01	3.95575E+01	8.83110E-01	7.69592E-04	0.00000E+00	0.00000E+00
953	8.96185E-01	3.95968E+01	8.83123E-01	7.68905E-04	0.00000E+00	0.00000E+00
954	8.74146E-01	3.96352E+01	8.83114E-01	7.68155E-04	0.00000E+00	0.00000E+00
955	9.05963E-01	3.96755E+01	8.83138E-01	7.67723E-04	0.00000E+00	0.00000E+00
956	9.06859E-01	3.97140E+01	8.83163E-01	7.67321E-04	0.00000E+00	0.00000E+00
957	8.83999E-01	3.97542E+01	8.83164E-01	7.66518E-04	0.00000E+00	0.00000E+00
958	9.09150E-01	3.97937E+01	8.83191E-01	7.66198E-04	0.00000E+00	0.00000E+00
959	8.57473E-01	3.98338E+01	8.83164E-01	7.65868E-04	0.00000E+00	0.00000E+00
960	8.94787E-01	3.98732E+01	8.83176E-01	7.65165E-04	0.00000E+00	0.00000E+00
961	8.97012E-01	3.99135E+01	8.83190E-01	7.64502E-04	0.00000E+00	0.00000E+00
962	9.30624E-01	3.99538E+01	8.83240E-01	7.65302E-04	0.00000E+00	0.00000E+00
963	8.89713E-01	3.99940E+01	8.83247E-01	7.64535E-04	0.00000E+00	0.00000E+00
964	8.49902E-01	4.00335E+01	8.83212E-01	7.64526E-04	0.00000E+00	0.00000E+00
965	8.76986E-01	4.00728E+01	8.83205E-01	7.63759E-04	0.00000E+00	0.00000E+00
966	8.78277E-01	4.01122E+01	8.83200E-01	7.62984E-04	0.00000E+00	0.00000E+00
967	8.85869E-01	4.01507E+01	8.83203E-01	7.62198E-04	0.00000E+00	0.00000E+00
968	8.87499E-01	4.01900E+01	8.83208E-01	7.61421E-04	0.00000E+00	0.00000E+00
969	8.49915E-01	4.02293E+01	8.83173E-01	7.61412E-04	0.00000E+00	0.00000E+00
970	8.78878E-01	4.02687E+01	8.83169E-01	7.60638E-04	0.00000E+00	0.00000E+00
971	8.67161E-01	4.03072E+01	8.83152E-01	7.60032E-04	0.00000E+00	0.00000E+00
972	8.86124E-01	4.03483E+01	8.83155E-01	7.59255E-04	0.00000E+00	0.00000E+00
973	8.91461E-01	4.03877E+01	8.83164E-01	7.58521E-04	0.00000E+00	0.00000E+00
974	9.03433E-01	4.04262E+01	8.83185E-01	7.58027E-04	0.00000E+00	0.00000E+00
975	8.74918E-01	4.04665E+01	8.83176E-01	7.57295E-04	0.00000E+00	0.00000E+00
976	8.61610E-01	4.05067E+01	8.83154E-01	7.56841E-04	0.00000E+00	0.00000E+00
977	9.49750E-01	4.05470E+01	8.83222E-01	7.59143E-04	0.00000E+00	0.00000E+00
978	8.64457E-01	4.05873E+01	8.83203E-01	7.58609E-04	0.00000E+00	0.00000E+00
979	8.95833E-01	4.06275E+01	8.83216E-01	7.57942E-04	0.00000E+00	0.00000E+00
980	9.00901E-01	4.06678E+01	8.83234E-01	7.57383E-04	0.00000E+00	0.00000E+00
981	9.08891E-01	4.07063E+01	8.83260E-01	7.57062E-04	0.00000E+00	0.00000E+00
982	8.83295E-01	4.07457E+01	8.83260E-01	7.56290E-04	0.00000E+00	0.00000E+00
983	8.70552E-01	4.07860E+01	8.83247E-01	7.55629E-04	0.00000E+00	0.00000E+00
984	9.07649E-01	4.08262E+01	8.83272E-01	7.55268E-04	0.00000E+00	0.00000E+00
985	9.11443E-01	4.08655E+01	8.83301E-01	7.55044E-04	0.00000E+00	0.00000E+00
986	8.71276E-01	4.09050E+01	8.83289E-01	7.54375E-04	0.00000E+00	0.00000E+00
987	8.49950E-01	4.09443E+01	8.83255E-01	7.54368E-04	0.00000E+00	0.00000E+00
988	8.96020E-01	4.09837E+01	8.83268E-01	7.53714E-04	0.00000E+00	0.00000E+00
989	8.92620E-01	4.10248E+01	8.83277E-01	7.53010E-04	0.00000E+00	0.00000E+00
990	9.06883E-01	4.10660E+01	8.83301E-01	7.52626E-04	0.00000E+00	0.00000E+00
991	8.86281E-01	4.11063E+01	8.83304E-01	7.51871E-04	0.00000E+00	0.00000E+00
992	8.75118E-01	4.11467E+01	8.83296E-01	7.51157E-04	0.00000E+00	0.00000E+00
993	8.92430E-01	4.11860E+01	8.83305E-01	7.50455E-04	0.00000E+00	0.00000E+00
994	9.04477E-01	4.12262E+01	8.83326E-01	7.50002E-04	0.00000E+00	0.00000E+00
995	8.64342E-01	4.12665E+01	8.83307E-01	7.49490E-04	0.00000E+00	0.00000E+00
996	8.91975E-01	4.13068E+01	8.83316E-01	7.48786E-04	0.00000E+00	0.00000E+00
997	9.12615E-01	4.13462E+01	8.83345E-01	7.48613E-04	0.00000E+00	0.00000E+00
998	8.50638E-01	4.13855E+01	8.83313E-01	7.48581E-04	0.00000E+00	0.00000E+00
999	9.06102E-01	4.14258E+01	8.83336E-01	7.48180E-04	0.00000E+00	0.00000E+00
1000	8.96657E-01	4.14652E+01	8.83349E-01	7.47549E-04	0.00000E+00	0.00000E+00
1001	8.77960E-01	4.15055E+01	8.83343E-01	7.46819E-04	0.00000E+00	0.00000E+00
1002	9.06259E-01	4.15457E+01	8.83366E-01	7.46424E-04	0.00000E+00	0.00000E+00
1003	8.59517E-01	4.15852E+01	8.83343E-01	7.46059E-04	0.00000E+00	0.00000E+00

KENO MESSAGE NUMBER K5-123   EXECUTION TERMINATED DUE TO COMPLETION OF THE SPECIFIED NUMBER OF GENERATIONS.

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

TRANSPORT CRITICALITY: ACCIDENT CONDITIONS (PITCH = 300 CM) (IVF = 1.0) (EVF = 1.0

```
LIFETIME =  3.48455E-05 + OR -  6.93436E-08          GENERATION TIME =  2.47240E-05 + OR -  3.63759E-08
NU BAR   =  2.44275E+00 + OR -  6.92320E-05    AVERAGE FISSION GROUP =  2.16236E+01 + OR -  3.91568E-03
            ENERGY(EV) OF THE AVERAGE LETHARGY CAUSING FISSION =  3.01215E-01 + OR -  9.58153E-04
```

NO. OF INITIAL GENERATIONS SKIPPED	AVERAGE K-EFFECTIVE	DEVIATION	67 PER CENT CONFIDENCE INTERVAL	95 PER CENT CONFIDENCE INTERVAL	99 PER CENT CONFIDENCE INTERVAL	NUMBER OF HISTORIES
3	0.88338	+ OR - 0.00075	0.88264 TO 0.88413	0.88189 TO 0.88487	0.88114 TO 0.88562	1000000
4	0.88336	+ OR - 0.00075	0.88261 TO 0.88411	0.88187 TO 0.88485	0.88112 TO 0.88560	999000
5	0.88332	+ OR - 0.00075	0.88257 TO 0.88406	0.88183 TO 0.88481	0.88108 TO 0.88556	998000
6	0.88335	+ OR - 0.00075	0.88260 TO 0.88410	0.88186 TO 0.88484	0.88111 TO 0.88559	997000
7	0.88331	+ OR - 0.00075	0.88257 TO 0.88406	0.88182 TO 0.88480	0.88107 TO 0.88555	996000
8	0.88332	+ OR - 0.00075	0.88257 TO 0.88407	0.88183 TO 0.88481	0.88108 TO 0.88556	995000
9	0.88329	+ OR - 0.00075	0.88255 TO 0.88404	0.88180 TO 0.88479	0.88105 TO 0.88553	994000
10	0.88333	+ OR - 0.00075	0.88258 TO 0.88408	0.88184 TO 0.88482	0.88109 TO 0.88557	993000
11	0.88331	+ OR - 0.00075	0.88256 TO 0.88406	0.88182 TO 0.88480	0.88107 TO 0.88555	992000
12	0.88330	+ OR - 0.00075	0.88255 TO 0.88405	0.88181 TO 0.88480	0.88106 TO 0.88555	991000
17	0.88338	+ OR - 0.00075	0.88264 TO 0.88413	0.88189 TO 0.88488	0.88114 TO 0.88563	986000
22	0.88338	+ OR - 0.00075	0.88263 TO 0.88413	0.88188 TO 0.88489	0.88112 TO 0.88564	981000
27	0.88350	+ OR - 0.00075	0.88275 TO 0.88426	0.88200 TO 0.88501	0.88124 TO 0.88576	976000
32	0.88358	+ OR - 0.00076	0.88283 TO 0.88434	0.88207 TO 0.88510	0.88132 TO 0.88585	971000
37	0.88367	+ OR - 0.00076	0.88291 TO 0.88442	0.88215 TO 0.88518	0.88139 TO 0.88594	966000
42	0.88366	+ OR - 0.00076	0.88290 TO 0.88442	0.88214 TO 0.88518	0.88138 TO 0.88594	961000
47	0.88377	+ OR - 0.00076	0.88301 TO 0.88453	0.88225 TO 0.88529	0.88149 TO 0.88605	956000
52	0.88387	+ OR - 0.00076	0.88311 TO 0.88463	0.88234 TO 0.88539	0.88158 TO 0.88616	951000

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

TRANSPORT CRITICALITY: ACCIDENT CONDITIONS (PITCH = 300 CM) (IVF = 1.0) (EVF = 1.0

NO. OF INITIAL GENERATIONS SKIPPED	AVERAGE K-EFFECTIVE	DEVIATION	67 PER CENT CONFIDENCE INTERVAL	95 PER CENT CONFIDENCE INTERVAL	99 PER CENT CONFIDENCE INTERVAL	NUMBER OF HISTORIES
907	0.88715	+ OR - 0.00219	0.88496 TO 0.88934	0.88277 TO 0.89152	0.88058 TO 0.89371	96000
912	0.88806	+ OR - 0.00224	0.88582 TO 0.89030	0.88358 TO 0.89254	0.88134 TO 0.89478	91000
917	0.88840	+ OR - 0.00235	0.88605 TO 0.89075	0.88370 TO 0.89311	0.88135 TO 0.89546	86000
922	0.88737	+ OR - 0.00241	0.88496 TO 0.88978	0.88255 TO 0.89218	0.88014 TO 0.89459	81000
927	0.88714	+ OR - 0.00247	0.88467 TO 0.88961	0.88220 TO 0.89208	0.87973 TO 0.89455	76000
932	0.88723	+ OR - 0.00258	0.88465 TO 0.88981	0.88207 TO 0.89239	0.87949 TO 0.89497	71000
937	0.88755	+ OR - 0.00266	0.88489 TO 0.89021	0.88223 TO 0.89286	0.87957 TO 0.89552	66000
942	0.88802	+ OR - 0.00257	0.88545 TO 0.89059	0.88287 TO 0.89316	0.88030 TO 0.89573	61000
947	0.88793	+ OR - 0.00273	0.88520 TO 0.89066	0.88247 TO 0.89339	0.87974 TO 0.89612	56000
952	0.88768	+ OR - 0.00295	0.88473 TO 0.89063	0.88178 TO 0.89358	0.87883 TO 0.89653	51000
957	0.88706	+ OR - 0.00320	0.88386 TO 0.89026	0.88066 TO 0.89346	0.87746 TO 0.89666	46000
962	0.88575	+ OR - 0.00329	0.88246 TO 0.88903	0.87918 TO 0.89232	0.87589 TO 0.89560	41000
967	0.88708	+ OR - 0.00359	0.88349 TO 0.89067	0.87991 TO 0.89425	0.87632 TO 0.89784	36000
972	0.88920	+ OR - 0.00391	0.88529 TO 0.89311	0.88138 TO 0.89702	0.87747 TO 0.90094	31000
977	0.88785	+ OR - 0.00379	0.88406 TO 0.89164	0.88027 TO 0.89543	0.87648 TO 0.89922	26000
982	0.88718	+ OR - 0.00439	0.88279 TO 0.89157	0.87841 TO 0.89595	0.87402 TO 0.90034	21000
987	0.88874	+ OR - 0.00462	0.88413 TO 0.89336	0.87951 TO 0.89798	0.87489 TO 0.90260	16000
992	0.88754	+ OR - 0.00641	0.88114 TO 0.89395	0.87473 TO 0.90036	0.86832 TO 0.90676	11000
997	0.88286	+ OR - 0.00981	0.87305 TO 0.89266	0.86324 TO 0.90247	0.85344 TO 0.91228	6000

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
RANDOM NUMBER-          4BC7185F6126
TRANSPORT CRITICALITY: ACCIDENT CONDITIONS (PITCH = 300 CM) (IVF = 1.0) (EVF = 1.0
                               FREQUENCY FOR GENERATIONS    4 TO 1003
0.7895 TO 0.7925     *
0.7925 TO 0.7954
0.7954 TO 0.7984
0.7984 TO 0.8014
0.8014 TO 0.8043
0.8043 TO 0.8073
0.8073 TO 0.8103
0.8103 TO 0.8132     *
0.8132 TO 0.8162
0.8162 TO 0.8192     *
0.8192 TO 0.8221
0.8221 TO 0.8251     **
0.8251 TO 0.8281     ***
0.8281 TO 0.8310     **
0.8310 TO 0.8340     ********
0.8340 TO 0.8369     *******
0.8369 TO 0.8399     **********
0.8399 TO 0.8429     **********
0.8429 TO 0.8458     ************
0.8458 TO 0.8488     ***************
0.8488 TO 0.8518     *******************
0.8518 TO 0.8547     ********************
0.8547 TO 0.8577     ***********************
0.8577 TO 0.8607     **************************
0.8607 TO 0.8636     *******************************
0.8636 TO 0.8666     ******************************************
0.8666 TO 0.8695     ******************************************
0.8695 TO 0.8725     *****************************************
0.8725 TO 0.8755     ***********************************************
0.8755 TO 0.8784     ************************************************
0.8784 TO 0.8814     ****************************************************
0.8814 TO 0.8844     ********************************************
0.8844 TO 0.8873     *********************************************************
0.8873 TO 0.8903     *********************************************************
0.8903 TO 0.8933     ****************************************************
0.8933 TO 0.8962     **********************************************
0.8962 TO 0.8992     **************************************
0.8992 TO 0.9022     ***************************************************
0.9022 TO 0.9051     ******************************
0.9051 TO 0.9081     ****************************
0.9081 TO 0.9110     ************************
0.9110 TO 0.9140     *******************
0.9140 TO 0.9170     ********************
0.9170 TO 0.9199     *********
0.9199 TO 0.9229     ***********
0.9229 TO 0.9259     ************
0.9259 TO 0.9288     ******
0.9288 TO 0.9318     **********
0.9318 TO 0.9348     ****
0.9348 TO 0.9377     ***
0.9377 TO 0.9407     ****
0.9407 TO 0.9437     ****
0.9437 TO 0.9466
0.9466 TO 0.9496     ***
0.9496 TO 0.9525     *
0.9525 TO 0.9555
0.9555 TO 0.9585     **
0.9585 TO 0.9614
0.9614 TO 0.9644     **
```

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
TRANSPORT CRITICALITY: ACCIDENT CONDITIONS (PITCH = 300 CM) (IVF = 1.0) (EVF = 1.0
                              FREQUENCY FOR GENERATIONS  254 TO 1003
0.7895 TO 0.7925
0.7925 TO 0.7954
0.7954 TO 0.7984
0.7984 TO 0.8014
0.8014 TO 0.8043
0.8043 TO 0.8073
0.8073 TO 0.8103
0.8103 TO 0.8132     *
0.8132 TO 0.8162
0.8162 TO 0.8192     *
0.8192 TO 0.8221
0.8221 TO 0.8251     **
0.8251 TO 0.8281     **
0.8281 TO 0.8310     *
0.8310 TO 0.8340     ***
0.8340 TO 0.8369     ***
0.8369 TO 0.8399     ********
0.8399 TO 0.8429     *******
0.8429 TO 0.8458     **********
0.8458 TO 0.8488     *********
0.8488 TO 0.8518     **************
0.8518 TO 0.8547     ************
0.8547 TO 0.8577     ***************
0.8577 TO 0.8607     *****************
0.8607 TO 0.8636     **************************
0.8636 TO 0.8666     ************************************
0.8666 TO 0.8695     *******************************
0.8695 TO 0.8725     ****************************
0.8725 TO 0.8755     ***********************************
0.8755 TO 0.8784     *************************************
0.8784 TO 0.8814     ******************************************
0.8814 TO 0.8844     *****************************
0.8844 TO 0.8873     *********************************************
0.8873 TO 0.8903     *******************************************
0.8903 TO 0.8933     ****************************************
0.8933 TO 0.8962     ********************************
0.8962 TO 0.8992     *********************************
0.8992 TO 0.9022     ***************************************
0.9022 TO 0.9051     ***********************
0.9051 TO 0.9081     ************************
0.9081 TO 0.9110     ******************
0.9110 TO 0.9140     *****************
0.9140 TO 0.9170     ***************
0.9170 TO 0.9199     *******
0.9199 TO 0.9229     ********
0.9229 TO 0.9259     *********
0.9259 TO 0.9288     ***
0.9288 TO 0.9318     *********
0.9318 TO 0.9348     ***
0.9348 TO 0.9377     *
0.9377 TO 0.9407     ***
0.9407 TO 0.9437     ***
0.9437 TO 0.9466
0.9466 TO 0.9496     ***
0.9496 TO 0.9525     *
0.9525 TO 0.9555
0.9555 TO 0.9585
0.9585 TO 0.9614
0.9614 TO 0.9644     **
```

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
TRANSPORT CRITICALITY: ACCIDENT CONDITIONS (PITCH = 300 CM) (IVF = 1.0) (EVF = 1.0
                                 FREQUENCY FOR GENERATIONS  504 TO 1003
0.7895 TO 0.7925
0.7925 TO 0.7954
0.7954 TO 0.7984
0.7984 TO 0.8014
0.8014 TO 0.8043
0.8043 TO 0.8073
0.8073 TO 0.8103
0.8103 TO 0.8132     *
0.8132 TO 0.8162
0.8162 TO 0.8192     *
0.8192 TO 0.8221
0.8221 TO 0.8251     *
0.8251 TO 0.8281     *
0.8281 TO 0.8310
0.8310 TO 0.8340
0.8340 TO 0.8369     ***
0.8369 TO 0.8399     *****
0.8399 TO 0.8429     ****
0.8429 TO 0.8458     ********
0.8458 TO 0.8488     ******
0.8488 TO 0.8518     **********
0.8518 TO 0.8547     *****
0.8547 TO 0.8577     ******
0.8577 TO 0.8607     *************
0.8607 TO 0.8636     *******************
0.8636 TO 0.8666     *************************
0.8666 TO 0.8695     ********************
0.8695 TO 0.8725     ****************
0.8725 TO 0.8755     ************************
0.8755 TO 0.8784     ********************
0.8784 TO 0.8814     ***********************************
0.8814 TO 0.8844     ******************
0.8844 TO 0.8873     *******************************
0.8873 TO 0.8903     ****************************
0.8903 TO 0.8933     ***************************
0.8933 TO 0.8962     **************************
0.8962 TO 0.8992     *******************
0.8992 TO 0.9022     ************************
0.9022 TO 0.9051     ******************
0.9051 TO 0.9081     *****************
0.9081 TO 0.9110     **********
0.9110 TO 0.9140     *************
0.9140 TO 0.9170     ***********
0.9170 TO 0.9199     ***
0.9199 TO 0.9229     *******
0.9229 TO 0.9259     *******
0.9259 TO 0.9288     **
0.9288 TO 0.9318     *******
0.9318 TO 0.9348     ***
0.9348 TO 0.9377
0.9377 TO 0.9407     *
0.9407 TO 0.9437     **
0.9437 TO 0.9466
0.9466 TO 0.9496     *
0.9496 TO 0.9525     *
0.9525 TO 0.9555
0.9555 TO 0.9585
0.9585 TO 0.9614
0.9614 TO 0.9644     *
```

Figure 6.6-8 CSAS25 Output for Canistered Fuel Accident Conditions Criticality Analysis (continued)

```
TRANSPORT CRITICALITY: ACCIDENT CONDITIONS (PITCH = 300 CM) (IVF = 1.0) (EVF = 1.0
                                    FREQUENCY FOR GENERATIONS  754 TO 1003
0.7895 TO 0.7925
0.7925 TO 0.7954
0.7954 TO 0.7984
0.7984 TO 0.8014
0.8014 TO 0.8043
0.8043 TO 0.8073
0.8073 TO 0.8103
0.8103 TO 0.8132
0.8132 TO 0.8162
0.8162 TO 0.8192
0.8192 TO 0.8221
0.8221 TO 0.8251
0.8251 TO 0.8281
0.8281 TO 0.8310
0.8310 TO 0.8340
0.8340 TO 0.8369     ***
0.8369 TO 0.8399     **
0.8399 TO 0.8429     **
0.8429 TO 0.8458     **
0.8458 TO 0.8488     **
0.8488 TO 0.8518     *********
0.8518 TO 0.8547     *
0.8547 TO 0.8577     ****
0.8577 TO 0.8607     ******
0.8607 TO 0.8636     ******
0.8636 TO 0.8666     ***************
0.8666 TO 0.8695     ******
0.8695 TO 0.8725     **********
0.8725 TO 0.8755     **********
0.8755 TO 0.8784     *************
0.8784 TO 0.8814     ***************
0.8814 TO 0.8844     *********
0.8844 TO 0.8873     ***************
0.8873 TO 0.8903     ************
0.8903 TO 0.8933     ***************
0.8933 TO 0.8962     ****************
0.8962 TO 0.8992     **********
0.8992 TO 0.9022     ***********
0.9022 TO 0.9051     ********
0.9051 TO 0.9081     ***********
0.9081 TO 0.9110     ******
0.9110 TO 0.9140     *******
0.9140 TO 0.9170     *******
0.9170 TO 0.9199     *
0.9199 TO 0.9229     **
0.9229 TO 0.9259     ****
0.9259 TO 0.9288
0.9288 TO 0.9318     *****
0.9318 TO 0.9348     **
0.9348 TO 0.9377
0.9377 TO 0.9407
0.9407 TO 0.9437     *
0.9437 TO 0.9466
0.9466 TO 0.9496
0.9496 TO 0.9525     *
0.9525 TO 0.9555
0.9555 TO 0.9585
0.9585 TO 0.9614
0.9614 TO 0.9644     *
```

List of Figures

List of Tables

This Page Intentionally Left Blank

Table 7.0-1 Torque Table

Component	No. Used	Fastener	Torque Value*
Outer Lid Bolt**	36	1-8 UNC - Socket Head Cap Screw	270 ± 20 ft.-lb (366 ± 27 N-m)
Inner Lid Bolt**	42	1 1/2 - 8 UN - Socket Head cap Screw	2540 ± 10 ft-lb (3444 ± 14 N-m)
Port Cover Bolt**	9	3/8 - 16 UNC - Socket Head Cap Screw	140 ± 10 in-lb (16 ± 1 N-m)
Coverplate Bolt**	8	1/2 - 13 UNC - Socket Head Cap Screw	300 ± 20 in-lb (34 ± 2 N-m)
Test Plug	1	Part No. 423-803-13	30 ± 3 ft-lb (41 ± 4 N-m)
Test Plug	2	Part No. 423-806-3	70 ± 5 in-lb (8 ± 0.6 N-m)
Test Plug	2	Part No. 423-807-8	70 ± 5 in-lb (8 ± 0.6 N-m)
Impact Limiter Retaining Rods**	32	Part No. 423-811-7	75 ± 5 ft-lb (100 ± 8 N-m)
Impact Limiter Nut**	32	1 - 8 UNC - 2A Retaining Rods	35 ± 2 ft-lb (47 ± 3 N-m)
Impact Limiter Jam Nut**	32	1 - 8 UN - 2B	75 ± 5 ft-lb (100 ± 8 N-m)
Adapter Plate Bolts***	4	1-8 UNC - Socket Head Cap Screw	270 ± 20 ft.-lb (366 ± 27 N-m)

* Torque values not shown in this table are provided on the appropriate license drawings in Section 1.3.2

** All bolts shall be lightly lubricated using Nuclear Grade Pure Nicket NEVER-SEEZ or equivalent.

*** Outer lid bolts may be used for this application.

This Page Intentionally Left Blank

33. Perform final external decontamination and perform survey to verify acceptable level of removable contamination (220 dpm/100 cm^2 β,γ and 22 dpm/100 cm^2 α). Perform final radiation survey. Record the survey results in the cask loading report.
34. Perform final visual inspection to verify assembly of the NAC-STC in accordance with the COC. Verify that the loading procedure and checklist have been appropriately completed and signed off.

7.1.3.2 Canistered Fuel or GTCC Waste Loading

Canistered fuel or canistered GTCC waste is loaded into the NAC-STC using a transfer cask. This procedure assumes that the canister has been previously loaded, drained, vacuum dried, backfilled with helium and welded closed. The canister may have been retrieved from a dry storage overpack, or it may have been loaded and sealed immediately prior to loading in the NAC-STC. This procedure assumes the sealed canister conforms to the design basis of the NAC-STC, that the canister is already in the transfer cask, and that any necessary canister bottom spacer is installed in the cask cavity. The NAC-STC is assumed to be positioned in the area designated for dry canister loading.

1. Install the adapter plate on the top of the cask.
2. Bolt the adapter plate to the cask using four (4) socket head cap screws (1-8 UNC).
3. Attach the transfer cask yoke to the cask handling crane hook.
4. Engage the transfer cask yoke to the trunnion of the transfer cask.
5. Raise the transfer cask over the NAC-STC cask and lower it until it rests on the transfer cask adapter plate. Remove and store the transfer cask lifting yoke.
6. Attach the hydraulic system to the transfer cask doors.
7. Remove the transfer cask canister retaining ring.
8. Attach the two (2) canister lifting slings to the lifting rings in the canister lid. Attach the opposite end of the slings to the crane hook and raise the canister just enough to take the canister weight off of the transfer cask bottom doors.
9. Remove the transfer cask door locking pins and open the doors.

10. Lower the canister into the NAC-STC cask. Exercise caution to avoid contact with the interior cavity wall.
11. Disconnect and remove the canister lifting sling.
12. Close the transfer cask bottom doors and install the door locking pins.
13. Retrieve the transfer cask lifting yoke and engage the transfer cask trunnions. Lift the transfer cask from the adapter plate. Store the transfer cask and transfer cask lifting yoke in the designated locations.
14. Install the top canister spacer, if one is required.
15. Retrieve the adapter plate lifting sling and attach it to the adapter plate.
16. Remove the four (4) bolts attaching the adapter plate to the NAC-STC. Remove the adapter plate and store it in the designated location.
17. Remove the inner lid o-rings and clean inner lid o-ring groove surfaces. Replace the metallic o-rings on the inner lid, carefully inspecting the new o-rings for damage prior to installation. Secure the o-rings in the groove by the use of the o-ring clips and screws.
18. Attach the inner lid lifting slings to an auxiliary crane hook, lift the inner lid and place it on the cask using the inner lid alignment pins to assist in proper lid seating and orientation. Visually verify proper lid position.
19. Disconnect the lid lifting device from the auxiliary crane hook and remove it from the inner lid.
20. Install at least 10 inner lid bolts equally spaced on the bolt circle to hand tight. Remove the inner lid alignment pins.
21. Install the remaining inner lid bolts and torque all of the bolts to the torque value specified in Table 7.0-1. The bolt torquing sequence will be specified in the detailed operating procedure.
22. Connect the vacuum pump to the cask vent port and evacuate the cask cavity to a stable vacuum pressure of 4 mbar (3 mm of Hg) for 30 minutes. Without allowing air to re-enter the cask, backfill the cavity with 99.9% pure helium to 1 atmosphere (absolute) pressure. Disconnect the helium supply.
23. Remove the metallic o-rings in the coverplates and clean and inspect the o-ring groove. Install new metallic o-rings in the vent and drain port coverplates and install the coverplates onto the inner lid. Torque the coverplate bolts to the value specified in Table 7.0-1.
24. Connect the leak detector vacuum pump to drain port coverplate test port and evacuate the air between the metallic o-rings. ithout allowing air to re-enter the interseal

14. Purge the water from the cask by pressurizing to 60 to 75 psig and hold until all water is removed (observed when no water is coming from the drain line).
15. Remove the lines from the drain and the vent port quick disconnect.
16. Install the port coverplates over the vent and drain ports in the inner lid. Torque the coverplate bolts to the value specified in Table 7.0-1.
17. Decontaminate the surfaces of the inner lid and the inner surfaces of the top forging.
18. Install the outer lid alignment pins. Using the outer lid lifting device, install the outer lid using the alignment pins to assist in proper seating. Remove the lid lifting device, lid lifting eyebolts, and the outer lid alignment pins.
19. Install the outer lid bolts and torque them to the value specified in Table 7.0-1.
20. Install the interlid port cover and torque the bolts to the value specified in Table 7.0-1.

7.3.3.2 Unloading Canistered Fuel or Canistered GTCC Waste

Canistered fuel or GTCC waste is unloaded from the NAC-STC using a transfer cask. The transfer cask could be used to transfer the loaded canister to a work station where the canister could be opened, or to transfer it to another storage or disposal overpack.

1. Install the lift rings in the canister lid.

   Note: The canister lid may be thermally hot.
2. Attach the canister lifting sling to the lifting rings in the canister lid. Position the sling so that the free end of the sling can be engaged by the cask handling crane hook.
3. Install the transfer cask adapter plate.
4. Attach the transfer cask lifting yoke to the cask handling crane hook. Engage the yoke to the lifting trunnions of the transfer cask.
5. Lift the transfer cask and move it over the NAC-STC cask. Lower the transfer cask to engage the transfer cask adapter plate. Once the transfer cask is fully seated, remove the transfer cask lifting yoke and store it in the designated location.
6. Install the transfer cask bottom door hydraulic operating system and open the transfer cask bottom doors.
7. Lower the cask handling crane hook through the transfer cask and engage the canister lifting sling.

8. Raise the canister into the transfer cask just far enough to allow the transfer cask bottom doors to close. Use caution to ensure that the cavity walls of the NAC-STC and the transfer cask are not contacted.
9. Close the bottom doors and install the door locking pins.
10. Carefully lower the canister until it rests on the transfer cask bottom doors. Disengage the canister lifting sling from the crane hook.
11. Retrieve the transfer cask lifting yoke and attach it to the transfer cask trunnions. Lift the transfer cask from the NAC-STC cask and move it to its intended destination.
12. Attach the adapter plate lifting fixture.
13. Remove the four (4) bolts securing the adapter plate to the NAC-STC and using the auxiliary crane, lift the adapter plate from the top of the cask. Move the adapter plate to the designated storage location.
14. Install the inner lid alignment pins.
15. Attach the inner lid lifting fixture to the inner lid and engage the lifting fixture to the auxiliary crane. Install the inner lid in the NAC-STC using the alignment pins to assist in proper seating.
16. Disconnect the lifting fixture and remove the guide pins.
17. Install and torque the inner lid bolts.
18. Install the port coverplates over the vent and drain ports in the inner lid. Torque the coverplate bolts to the values specified in Table 7.0-1.
19. Decontaminate the surfaces of the inner lid and the inner surfaces of the top forging.
20. Install the outer lid alignment pins. Using the outer lid lifting device, install the outer lid using the alignment pins to assist in proper seating. Remove the lid lifting device, lid lifting eyebolts, and the outer lid alignment pins.
21. Install the outer lid bolts and torque them to the value specified in Table 7.0-1.
22. Install the interlid port cover and torque the bolts to the value specified in Table 7.0-1.

7.3.4 Preparation of Empty Cask for Transport

1. Decontaminate all surfaces of the cask to acceptable release limits as defined in 49 CFR 173.
2. Attach the lifting yoke to a crane hook and engage the yoke arms with the lifting trunnions. Lift the cask onto the transport vehicle and lower to the horizontal position.

7.7 Procedure for Loading the NAC-MPC Canister

This section describes the loading and closing of the NAC-MPC canister. The canister is designed to contain up to 36 Yankee Class spent fuel assemblies or up to 24 GTCC waste canisters. As described in this SAR, the canister is designed to be transported in the NAC-STC.

The principal handling operations are the draining, drying, and helium backfilling of the canister, and sealing it by welding the shield lid, penetration port covers, and structural lid in place.

This procedure assumes that the canister with an empty basket is installed in the transfer cask, that the transfer cask is positioned in the decontamination area or other suitable work station, and that the vertical concrete cask is positioned on a heavy-haul transporter in the cask receiving area or other suitable staging area. The staging area should be within the handling "footprint" of the cask handling crane.

The transfer cask is primarily a lifting device used to move the canister assembly, and to provide biological shielding when it contains a loaded canister. The transfer cask is used for the vertical transfer of the canister between work stations and the storage or transport casks.

The canister vent and drain port locations are shown in Figure 7.7-1.

7.7.1 Loading and Closing the Canister

1. Visually inspect the basket fuel tubes or waste container positions to ensure that they are unobstructed and free of debris.
2. Flood the canister with clean water until the water is about 4 inches from the top of the canister.

   Note: Do not fill the canister completely in order to avoid spilling water during the transfer to the spent fuel pool.
3. Attach a clean water line to the transfer cask.
4. If it is not already attached, attach the transfer cask lifting yoke to the cask handling crane, and engage the transfer cask lifting trunnions.
5. Raise the transfer cask and move it over the pool, following the prescribed travel path.
6. Lower the transfer cask to the pool surface and turn on the clean water line to flood the annulus between the transfer cask and canister.

7. Lower the transfer cask as the annulus fills with clean water until the trunnions are at the surface, and hold that position until clean water fills the remainder of the canister and overflows the sides of the transfer cask. Then lower the transfer cask to the bottom of the pool cask loading area.

    Note: If an intermediate shelf is used to avoid wetting the cask handling crane hook, follow the plant procedure for use of the extension piece.

8. Disengage the transfer cask lifting yoke to provide clear access to the canister.
9. Load the previously designated fuel assemblies or waste containers into the canister.
10. Attach a three-legged sling to the shield lid using the swivel hoist rings.
11. Using the cask handling crane, or auxiliary hook, lower the shield lid until it rests in the top of the canister.

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

12. Raise the transfer cask until its top just clears the pool surface. Hold at that position, and using a suction pump, drain the pool water from above the shield lid. After the water is removed, continue to raise the cask.
13. As the cask is raised, spray the transfer cask outer surface with clean water to wash off any gross contamination.
14. When the cask is clear of the pool surface, but still over the pool, turn off the clean water flow to the annulus and allow the annulus water to drain to the pool. Detach the water supply lines. Move the cask to the decontamination area or other suitable work station.

    Note: Access to the top of the transfer cask is required. A suitable work platform may need to be erected.

15. Decontaminate the top of the transfer cask and shield lid as required.

    Note: Supplemental shielding may be used for activities around the shield lid.

16. Install the drain tube in the drain port of the shield lid. Install a mating quick-disconnect fitting in the vent line to open the vent. Remove the hoist rings from the shield lid.
17. Attach the suction pump to the drain port. Verify that the vent port is open. Remove approximately 50 gallons of water from the canister. Disconnect and remove the pump.
18. Install the automated weld equipment.
19. Attach the vacuum drying equipment to the vent port. Operate the vacuum drying equipment for 3 to 5 minutes to clear any gases.

    Note: At the end of the gas clearing period, a small vacuum may exist on the under side of the shield lid. This will result in an in-rush of air when the vent port is opened.

20. Operate the welding equipment to complete the root weld joining the shield lid to the canister shell.

21. Prepare the weld and perform a liquid penetrant weld examination of the root pass.
22. Complete welding of the shield lid to the canister wall and remove the weld equipment.
23. Prepare the weld and perform a liquid penetrant weld examination of the final pass.
24. Remove any lines attached to the drain port. Attach an air pressure line to the vent port. Pressurize the canister to 22 psia and hold the pressure. There must be no loss of pressure for 10 minutes.
25. Release the pressure and visually inspect the shield lid to canister shell weld for indications of defects.
26. Attach the suction pump to the drain line. Ensure that the vent line is open. Using the pump remove the remaining free water from the canister cavity.
27. Remove the mating quick-disconnect fitting from the vent line. Remove any free water in the vent port cavity. Install the vent port cover.
28. Weld the vent port cover to the shield lid.
29. Prepare the weld and perform a liquid penetrant examination of the vent port cover weld.
30. Attach the vacuum equipment to the drain port line.
31. Operate the vacuum equipment until a vacuum of 3 to 5 mm of mercury exists.
32. Verify that no water remains in the canister by holding the vacuum for 20 minutes. If water exists in the cavity, the pressure will rise as the water vaporizes. Continue the vacuum/hold cycle until there is no indicated rise in pressure after 20 minutes.
33. Backfill the canister cavity with helium.*
34. Restart the vacuum equipment and evacuate the canister to 3 to 5 mm of mercury.
35. Backfill the canister cavity with helium, pressurizing it to 22 psia.*
36. Using a helium leak detector, check for leaks at the shield lid welds.
37. Vent the canister helium pressure to one (1) atmosphere (absolute).
38. Remove the attachment to the drain port fitting. Dry any residual water that may be present in the drain port cavity.
39. Install the drain port cover.
40. Weld the drain port cover to the shield lid.
41. Prepare the weld and perform a liquid penetrant examination of the drain port cover weld.
42. Remove any supplemental shielding used during shield lid closure activities.

* Helium must be of hospital, laboratory or industrial grade with a certificate of analysis for the specific batch used.

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

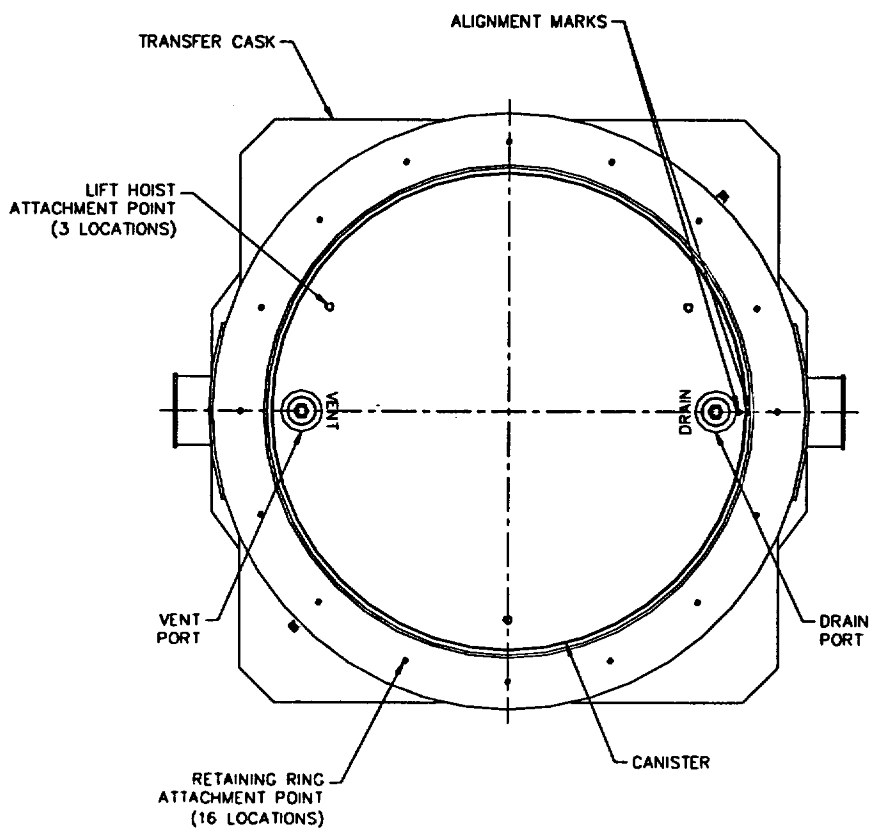
    Note: Verify that the structural lid is stamped, or otherwise marked, to provide traceability of the canister contents. Verify that the structural lid weld backing ring is in place on the structural lid.

44. Using the cask handling crane or the auxiliary hook, install the structural lid in the top of the canister. Verify that the structural lid does not protrude above the canister shell and remove the hoist rings. Verify that the gap in the backing ring is not aligned with the shield lid alignment key.
45. Install the automated welding equipment on the structural lid.
46. Complete the root weld joining the structural lid to the canister shell.
47. Prepare the weld and perform a liquid penetrant examination of the root weld.
48. Complete the remainder of the weld.
49. Remove the welding equipment.
50. Prepare the weld and perform a liquid penetrant examination of the final weld surface.
51. Decontaminate the external surface of the transfer cask.
52. Install the transfer cask retaining ring.

At this point, the loaded canister may be loaded into the NAC-STC, in accordance with Section 7.1.2.2, but will more likely be installed in the vertical concrete storage cask.

The NAC-MPC storage system is described in the NAC-MPC SAR, docket no. 72-1025.

Figure 7.7-1 Canister Vent and Drain Port Locations



This Page Intentionally Left Blank

recorded for identification. A reference BORAL standard for the appropriate B-10 aerial density shall be used as the test acceptance standard.

8.1.7.3 Radiographic Test Performance

An approved facility with a neutron beam capability shall be selected to perform the described tests. For system calibration, a camera shall be placed in the neutron beam path and the reference BORAL standard plate is placed in a stationary, fixed location between the camera and beamport. A luminance level is then determined at a location near the center of the specimen. The BORAL standard is then replaced by the BORAL test specimen and a luminance level is determined at a location near the center of the specimen.

8.1.7.4 Acceptance Criteria

The test shall be considered acceptable if the luminance level determined for each test specimen is equal to or less than that of the BORAL standard. The minimum aerial density for BORAL B-10 loading shall be ≥ 0.01g/cm^2 B-10.

Any specimen not meeting the acceptance criteria of 0.01g/cm^2 B-10 shall be rejected and the sheets from that pour shall be similarly rejected.

8.1.8 Transportable Storage Canister

The transportable storage canister is constructed of 304L stainless steel. The canister shell is fabricated in two sections. Each section has a seam weld, and the sections are joined by a circumferential weld. In joining the two sections, the seam welds must not align within 45°. The completed cylinder is closed at the bottom by a circular plate welded to the shell wall. The top of the cylinder is closed by a field-installed circular plate welded to the top of the canister at the time it is loaded with fuel.

The transportable storage canister is not considered to be a containment boundary when transported in the NAC-STC. However, all of the structural seam welds of the canister shall be radiographically examined in accordance with ASME Code, Section V, Article 2. These welds shall have the same acceptance criteria as the NAC-STC primary containment boundary welds as described in Section 8.1.1 above. The canister bottom weld shall be ultrasonically examined, per

ASME Code Section V, Article 5. Acceptance criteria shall be in accordance with ASME Code Section III, Subsection NB, Article NB-5330.

The structural welds made in the field to attach the closure lid to the canister shall be dye penetrant tested on the root and final passes in accordance with the requirements of the ASME Code, Section IV, Article 6. The liquid penetrant test acceptance criteria shall be as described in Article NC-5350. The dye penetrant test shall be applied to the root and final weld passes. A leak test shall be performed as described in the operating procedures following installation of the shielding lid.

The finished surfaces of all welds on the canister will be visually examined in accordance with ASME Code, Section V, Article 9, to verify that the components are assembled in accordance with the License Drawings (Section 1.3.2) and that the components are free of nicks, gouges, or other damage. The acceptance criteria for the visually examined welds will be in accordance with ASME Code, Section VIII, Division 1, UW-35 and UW-36.

Each selected fabricator for the canister will establish a detailed written weld inspection plan in accordance with an approved Quality Assurance program, of visual (VT), dye penetrant (PT), ultrasonic (UT) and radiographic (RT) weld examinations to be performed during fabrication and prior to acceptance of the canister. The weld inspection plan will identify the welds to be examined, the sequence of the examinations, the type of examination method to be used, and the criteria for acceptance of the weld in accordance with the applicable sections of the ASME Boiler and Pressure Vessel Code (ASME Code).

The closure system of the canister is to be welded. The closure welds (structural and shield lids) will be PT inspected and the canister will be pressurized with helium. The weld integrity is then subsequently leak tested.

Letter from Nuclear Assurance Corporation to Nuclear Regulatory Commission dated May 18, 1987, Control No. 28239 with attachment letter from Larry J. Dietrick, BISCO Products, Inc., to Todd H. Lesser, Nuclear Assurance Corporation, "Weight Loss of NS4FR Under Extreme Temperature Conditions," April 1987.

Luksic, A., "Spent Fuel Assembly Hardware: Characterization and 10 CFR 61 Classification for Waste Disposal," Pacific Northwest Laboratory Report PNL-6906, Vol. 1, June 1989.

Manufacture's Data, AAR Advanced Structures, Standard Specification for BORAL Composite Sheet, BORAL Performance Report 624.

Merritt, F.S., Standard Handbook for Civil Engineers, New York, McGraw-Hill Book Company, 1968.

The Metals Handbook, 9th Edition, American Society of Metals, Metals Park, Ohio, 1978.

MIL-HDBK-5E, "Metallic Materials and Elements for Aerospace Vehicle Structures," U.S. Department of Defense, May 1989.

Muraca, R.F. and J.S. Whittick, "Materials Data Handbook," Aluminum Alloy 2219 (2nd Edition), Western Applied Research & Development, Inc., San Carlos, CA, March 1972.

NEDO-10048-2, "IF-300 Consolidated Safety Analysis Report," General Electric Company, Nuclear Fuel and Special Projects Division, San Jose, CA, 1983.

Nelms, H.A., "Effects of Jacket Physical Properties and Curvature on Puncture Resistance," Structural Analysis of Shipping Casks, Volume 3, ORNL/TM-1312, Oak Ridge National Laboratory, June 1968.

"Nuclear Systems Materials Handbook," Volume 1, Revision 1, Hanford Engineering Development Laboratories, Richland, WA, March 10, 1976.

NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants," U.S. Nuclear Regulatory Commission, July 1980.

NUREG/CR-0497, "A Handbook of Materials Properties for Use in the Analysis of Light Water Reactor Fuel Rod Behavior, MATPRO Version 11 (Revision 2)," EG&G Idaho, Inc., TREE-1280, August 1981

NUREG/CR-0481, "An Assessment of Stress-Strain Data Suitable for Finite-Element Elastic-Plastic Analysis of Shipping Containers," H.J. Rack and G.A. Knorovsky, Sandia Laboratories, SAND77-1872, September 1978.

NUREG/CR-0796, PNL-2827, "Criticality Experiments with Sub-Critical Clusters of 2.35 and 4.29 w/o U^{235} Enriched UO_2 Rods in Water with Uranium or Lead Reflecting Walls," S.R. Bierman, B.M. Durst, E.D. Clayton, Battelle Pacific Northwest Laboratories, April 1979.

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

NUREG/CR-1815, "Recommendations for Protecting Against Failure by Brittle Fracture in Ferritic Steel Shipping Containers Up to Four Inches Thick," U.S. Nuclear Regulatory Commission, June 1981.

NUREG/CR-3285 HEDL-TME 83-9, "Pre-Test Visual Examination and Crud Characterization of LWR Rods Used in the Long-Term, Low-Temperature Whole Rod Test," R.E. Einziger, J.A. Cook, Hanford Engineering Development Laboratory, March 1984.

NUREG/CR-3854 UCRL-53544, "Fabrication Criteria for Shipping Containers," L.E. Fischer, W. Lai, April 1984.

NUREG/CR-4554, "SCANS (Shipping Cask Analysis System) A Microcomputer Based Analysis System for Shipping Cask Design Review," R.C. Chun, D.J. Trummer, and T.A. Nelson, Lawrence Livermore National Laboratory, UCID-20674, January 1989.

Olander, Donald R., Fundamental Aspects of Nuclear Reactor Fuel Elements, Technical Information Center (U. S. Department of Energy), 1995

Petrie, L.M. and N.F. Landers, "KENO V.a: An Improved Monte Carlo Criticality Program with Supergrouping," Oak Ridge National Laboratory, August 1990.

Petrie, L.M. and N.F. Landers, "KENO-Va: An Improved Monte Carlo Criticality Program with Supergrouping," Volume 2, Part 2, Section F11, ORNL/NUREG/CSD-2/V2/R2, September 1995.

PNL-2438, "Critical Separation Between Sub-Critical Clusters of 2.35 w/o U^{235} Enriched UO_2 Rods in Water with Fixed Neutron Poisons," S.R. Bierman, E.D. Clayton, B.M. Durst, Battelle Pacific Northwest Laboratories, October 1977.

PNL-4835/UC-85, "Technical Basis for Storage of Zircalloy-Clad Spent Fuel in Inert Gases," A.B. Johnson, Jr. and E.R. Gilbert, Pacific Northwest Laboratories, September 1983.

PNL-6273/UC-85, "Characteristics of Fuel Crud and its Impact on Storage, Handling and Shipment of Spent Fuel," R.F. Hazelton, Pacific Northwest Laboratory, September 1987.

PNL-4555, "Results of Simulated Abnormal Heating Events for Full-Length Nuclear Fuel Rods," R.J. Gwenther, Pacific Northwest Laboratory, 1983.

Product Data, NS4FR Fire Resistant Neutron and/or Gamma Shielding Material, GESC Shield, Material, Techniques Report No. NS-4-025 and No. NS-4-030.

"QAD-CGGP: A Combinatorial Geometry Version of QAD-P5A, A Point Kernel Code System for Neutron and Gamma-Ray Shielding Calculations using the GP Buildup Factor," CCC-493/QAD-CGGP, Radiation Shielding Information Center, December 1988.

Regulatory Guide 1.13, "Spent Fuel Storage Facility Design Basis," Division 1, U.S. Nuclear Regulatory Commission, December 1981. (Proposed Revision 2)

Regulatory Guide 1.25, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurizing Water Reactions," U.S. Atomic Energy Commission, March 1972. (Safety Guide 25)

Regulatory Guide 1.109, "Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," U.S. Nuclear Regulatory Commission, October 1977.

Regulatory Guide 1.145, "Atmospheric Dispersement Models for Potential Accident Consequence Assessments at Nuclear Power Plants," U.S. Nuclear Regulatory Commission, November 1982.

Regulatory Guide 7.6, "Design Criteria for the Structural Analysis of Shipping Cask Containment Vessels," U.S. Nuclear Regulatory Commission, March 1978.

Regulatory Guide 7.8, "Load Combinations for the Structural Analysis of Shipping Casks," U.S. Nuclear Regulatory Commission, May 1977.

Regulatory Guide 7.11, "Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Maximum Wall Thickness of 4 Inches (0.1 m)," U.S. Nuclear Regulatory Commission, June 1991.

Regulatory Guide 7.12, "Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Wall Thickness Greater than 4 Inches (0.1 m) but Not Exceeding 12 Inches (0.3 m), "U.S. Nuclear Regulatory Commission, June 1991.

Resnick, R. and D. Halliday, Physics, 3rd Edition, Part 1, New York, John Wiley & Sons, 1977.

Rimshaw, S.J. and E.E. Ketchen, "Curium Data Sheets," ORNL-4187, Oak Ridge National Laboratory, December 1967.

Roark, R.J., Formulas for Stress and Strain, 4th Edition, New York, McGraw-Hill, Inc., 1965.

Roark, R.J., and W.C. Young, Formulas for Stress and Strain, 5th Edition, New York, McGraw-Hill, Inc., 1975.

Roddy, J.W., H.C. Claiborne, R.C. Ashline, P.J. Johnson, B.T. Rhyne, "Physical and Decay Characteristics of Commercial LWR Spent Fuel," ORNL/TM-9591/V1-R1, Oak Ridge National Laboratory, January 1986.

Roehrich, R.L., "Torquing Stresses in Lubricated Bolts," Machine Design, Penton Publishing Co., Cleveland, OH, June 1967.

Wix, S. D. and Hohnstreiter, G. F., "Convective Effects in a Regulatory and Proposed Fire Model," Proceedings (Volume II) of the 11th International Conference on the Packaging and Transportation of Radioactive Materials (PATRAM '95), 1995.

This Page Intentionally Left Blank

FIGURE WITHHELD UNDER 10 CFR 2.390

9705050287-01

97 ASSY	98 ASSY	99 ASSY	ITEM	NAME	MATERIAL	SPEC	DRAWING No.	DESCRIPTION
		4	3	LOCATION LUG	304 ST.STL.	ASTM A240/A276		PLATE/BAR
		1	2	BOTTOM	304L ST.STL.	ASME SA240		1 PLATE
		1	1	SHELL	304L ST.STL.	ASME SA240		5/8 PLATE

QUANTITY

NAC INTERNATIONAL

CANISTER SHELL, MPC-YANKEE

SYM	GEOMETRY
	FLATNESS
	STRAIGHTNESS
	ANGULARITY
	PERPENDICULARITY
//	PARALLELISM
	CONCENTRICITY
	TRUE POSITION

TOLERANCES UNLESS OTHERWISE SPECIFIED

3 PLACE DEC.	TOL.	2 PLACE DEC.	TOL.
UNDER 3		UNDER 6	±.04
3-12		6-16	±.06
OVER 12		OVER 16	±.06
1 PLACE DEC.	±.1	FILLETS .03	

NEXT ASSEMBLY: 455-872

DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARED	[illegible]	[illegible]
CHECKED	[illegible]	[illegible]
PROJECT MANAGER	[illegible]	[illegible]
DIRECTOR OF PROJECTS	[illegible]	[illegible]
LICENSING MANAGER	[illegible]	[illegible]
QUALITY	[illegible]	[illegible]

PROJECT	DESIGN PACKAGE	DRAWING	REV
455		870	1
SCALE 1/8	EST.WT.	SH 1 OF 1	

FIGURE WITHHELD UNDER 10 CFR 2.390

9705050287-02

-97	-98	-99	ITEM	NAME	MATERIAL	SPEC	DRAWING No.	DESCRIPTION
			8	KEY	304 ST.STL.	ASTM A240/A276		1/2 PLATE/BAR
			7	PORT COVER	304 ST.STL.	ASTM A276		6 DIA BAR
		1	6	VALVED NIPPLE	ST.STL.	COML		SNAP-TITE #VHN16EM
			5	STRUCTURAL LID	304L ST.STL.	ASME SA240		3 PLATE
			4	(REMOVED)				
		1	3	SHIELD LID	304 ST.STL.	ASTM A240		5 PLATE
			2	BACKING RING	304 ST.STL.	ASTM A479		1/2 X 1/2 SQ. BAR
			1	LID SUPPORT RING	304 ST.STL.	ASTM A479		1/2 X 1/2 SQ. BAR
ASSY	ASSY	ASSY						
QUANTITY								

NAC INTERNATIONAL

DETAILS, CANISTER, MPC–YANKEE

SYM	GEOMETRY
▱	FLATNESS
—	STRAIGHTNESS
∠	ANGULARITY
⊥	PERPENDICULARITY
//	PARALLELISM
○	CONCENTRICITY
⊕	TRUE POSITION

TOLERANCES UNLESS OTHERWISE SPECIFIED

3 PLACE DEC.	TOL.	2 PLACE DEC.	TOL.
UNDER 3		UNDER 6	±.04
3–12		6–18	±.06
OVER 12		OVER 18	±.04
1 PLACE DEC.	±.1	FILLETS .03	
FINISH [illegible]		ANGLES ±.5°	
THREADS-UNIFIED CLSA-2B		CORNERS ±.03	

NEXT ASSEMBLY: 455–872

DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARER	[signature]	[illegible]
CHECKER	[signature]	[illegible]
PROJECT MANAGER	[signature]	[illegible]
QA/CHIEF ENGINEER	[signature]	[illegible]
DIRECTOR OF PROJECTS	[signature]	[illegible]
LICENSING MANAGER	[signature]	[illegible]
QUALITY	[signature]	[illegible]
SIGN OFF	[signature]	[illegible]

PROJECT 455 | DESIGN PACKAGE | DRAWING 871 | REV 1

SCALE 1/8 | EST.WT. | SH 1 OF 2

FIGURE WITHHELD UNDER 10 CFR 2.390

DETAIL D—D

SCALE: 1/2

ANSTEC APERTURE CARD

Also Available on Aperture Card

NAC INTERNATIONAL

DETAILS,
CANISTER,
MPC–YANKEE

PROJECT 455	DESIGN PACKAGE	DRAWING 871	REV 1
SCALE 1/8	EST.WT.	SH 2 OF 2	[illegible]

FIGURE WITHHELD UNDER 10 CFR 2.390

9705050287-04

97 ASSY	98 ASSY	99 ASSY	ITEM	NAME	MATERIAL	SPEC	DRAWING No.	DESCRIPTION
		1	9	KEY			455-871-8	
		1	8	BACKING RING			455-871-2	
		2	7	PORT COVER			455-871-7	
		1	6	STRUCTURAL LID			455-871-5	
		1	5	SHIELD LID ASSY			455-871-99	
		1	4	LID SUPPORT RING			455-871-1	
		1	3	DRAIN TUBE ASSY			455-873-99	
		1	2	FUEL BASKET ASSY			455-895-99	
		1	1	SHELL WELDMENT			455-870-99	

QUANTITY

NAC INTERNATIONAL

ASSEMBLY, TRANSPORTABLE STORAGE CANISTER (TSC), MPC-YANKEE

SYM	GEOMETRY
▱	FLATNESS
—	STRAIGHTNESS
∠	ANGULARITY
⊥	PERPENDICULARITY
//	PARALLELISM
◎	CONCENTRICITY
⊕	TRUE POSITION

TOLERANCES UNLESS OTHERWISE SPECIFIED

3 PLACE DEC.	TOL.	2 PLACE DEC.	TOL.
UNDER 3		UNDER 6	±.04
3-12		6-18	±.06
OVER 12		OVER 18	±.09
1 PLACE DEC.	±.1	FILLETS .03	
FINISH (√)-AA-125 MICRO IN		ANGLES ±.5°	
THREADS-UNIFIED CL2A-2B		CORNERS R.03	

NEXT ASSEMBLY: 455-800/862

DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARER	[illegible]	[illegible]
CHECKER	[illegible]	[illegible]
PROJECT MANAGER	[illegible]	[illegible]
LICENSING ENGINEER	[illegible]	[illegible]
DIRECTOR OF PROJECTS	[illegible]	[illegible]
LICENSING MANAGER	[illegible]	[illegible]
QUALITY	[illegible]	[illegible]
SR. VP	[illegible]	[illegible]

PROJECT 455 | DESIGN PACKAGE | DRAWING 872 | REV 1

SCALE 1/8 | EST. WT. | SH 1 OF 1

FIGURE WITHHELD UNDER 10 CFR 2.390

9705050287 -05

ASSY	ASSY	ASSY	ITEM	NAME	MATERIAL	SPEC	DRAWING No.	DESCRIPTION
		1	3	METAL BOSS SEAL	ST. STL.	COML		FURON #10061-16-1-0
		1	2	TUBE	304 ST. STL.	ASTM A249		1 OD X .035 WALL TUBE
		1	1	VALVED NIPPLE	ST. STL.	COML		SNAP-TITE #VHN16EM

QUANTITY

NAC INTERNATIONAL

ASSEMBLY,
DRAIN TUBE,
CANISTER
MPC-YANKEE

TOLERANCES UNLESS OTHERWISE SPECIFIED

3 PLACE DEC.	TOL.	2 PLACE DEC.	TOL.
UNDER 3		UNDER 6	±.04
3-12		6-18	±.06
OVER 12		OVER 18	±.08
1 PLACE DEC.	±.1	FILLETS .03	
		ANGLES ±.5°	
		CORNERS R.03	

FLATNESS · STRAIGHTNESS · ANGULARITY · PERPENDICULARITY · PARALLELISM · CONCENTRICITY · TRUE POSITION

NEXT ASSEMBLY: 455-872

DRAWING TYPE: LICENSE

PROJECT 455 | DESIGN PACKAGE | DRAWING 873 | REV 1

SCALE FULL | EST.WT. | SH 1 OF 1

FIGURE WITHHELD UNDER 10 CFR 2.390

9705050287-06

97 ASSY	98 ASSY	99 ASSY	ITEM	NAME	MATERIAL	SPEC	DRAWING No.	DESCRIPTION
		1	8	DRAIN SLEEVE	304 ST. STL.	ASTM A269		2 DIA X .035 WALL
		4	7	ANTI-ROTATIONAL BAR	304 ST. STL.	ASTM A240		PLATE/BAR
		4	6	BOTTOM PAD	304 ST. STL.	ASTM A240		1 1/2 PLATE
		24	5	TUBE	304 ST. STL.	ASTM A240		1/4 PLATE
		8	4	SUPPORT DISK	304 ST. STL.	ASTM A240		1 PLATE
		4	3	SUPPORT WALL	304 ST. STL.	ASTM A240		2 1/2 PLATE
		12	2	SUPPORT WALL	304 ST. STL.	ASTM A240		2 1/2 PLATE
		4	1	SUPPORT WALL	304 ST. STL.	ASTM A240		2 1/2 PLATE

QUANTITY

NAC INTERNATIONAL

BASKET ASSEMBLY,
24 GTCC CONTAINER
MPC-YANKEE

TOLERANCES UNLESS OTHERWISE SPECIFIED

NEXT ASSEMBLY: 455-888

DRAWING TYPE: LICENSE

PROJECT 455 | DESIGN PACKAGE | DRAWING 887 | REV 1

SCALE 1/8 | SH 1 OF 2

FIGURE WITHHELD UNDER 10 CFR 2.390

9705050287 -07

NAC INTERNATIONAL

BASKET ASSEMBLY,
24 GTCC CONTAINER,
MPC-YANKEE

PROJECT 455	DESIGN PACKAGE	DRAWING 887	REV 1
SCALE 1/8	EST.WT.	SH 2 OF 2	

FIGURE WITHHELD UNDER 10 CFR 2.390

9705050287-08

1	9	KEY			455-871-8
1	8	BACKING RING			455-871-2
2	7	PORT COVER			455-871-7
1	6	STRUCTURAL LID			455-871-5
1	5	SHIELD LID ASSY			455-871-99
1	4	LID SUPPORT RING			455-871-1
1	3	DRAIN TUBE ASSY			455-873-99
1	2	GTCC BASKET ASSY			455-887-99
1	1	SHELL WELDMENT			455-870-99

NAC INTERNATIONAL

ASSEMBLY, TRANSPORTABLE STORAGE CANISTER (TSC), 24 GTCC CONTAINER, MPC-YANKEE

NEXT ASSEMBLY 455-800/-862

LICENSE

PROJECT 455

DRAWING 888

REV 1

SCALE 1/8

SH 1 OF 1

FIGURE WITHHELD UNDER 10 CFR 2.390

VIEW B–B
SCALE: FULL
VIEW ROTATED

9705050287 -09

		4	4	BAFFLE	304 ST STL	ASME SA240		3/8 PLATE
		8	3	SUPPORT	304 ST STL	ASME SA240		3/8 PLATE
		1	2	SUPPORT RING	304 ST STL	ASME SA240		1/2 PLATE
		1	1	PLATE	304 ST STL	ASME SA240		1/2 PLATE

NAC INTERNATIONAL

TOP WELDMENT,
FUEL BASKET,
MPC–YANKEE

NEXT ASSEMBLY: 455–895
DRAWING TYPE: LICENSE

PROJECT 455
DRAWING 892
REV 1
SCALE 1/5
SH 1 OF 1

FIGURE WITHHELD UNDER 10 CFR 2.390

9705050287 -10

-97	-98	-99	ITEM	NAME	MATERIAL	SPEC	DRAWING No.	DESCRIPTION
			7	TOP SPACER	304 ST.STL.	ASTM A511		2 1/2 DIA TUBE WITH 5/8 WALL
			6	SPLIT SPACER	304 ST.STL.	ASTM A511		2 1/2 DIA TUBE WITH 5/8 WALL
			5	TIE ROD	304 ST.STL.	ASME SA479		1 1/8 DIA BAR
			4	TOP NUT, LARGE	304 ST.STL.	ASME SA479		2 3/4 DIA BAR
			3	BOTTOM SPACER	304 ST.STL.	ASTM A511		2 1/2 DIA TUBE WITH 5/8 WALL
			2	SPACER	304 ST.STL.	ASTM A511		2 1/2 DIA TUBE WITH 5/8 WALL
			1	PLATE	17-4PH ST.STL.	ASME SA564, TYPE 630		1/2 PLATE
ASSY	ASSY	ASSY						
QUANTITY								

NAC INTERNATIONAL

SUPPORT DISK AND MISC. BASKET DETAILS, MPC-YANKEE

NEXT ASSEMBLY: 455-895

DRAWING TYPE: LICENSE

PROJECT 455

DRAWING 893

REV 1

SCALE 1/5

EXCEPT NOTED

SH 1 OF 1

FIGURE WITHHELD UNDER 10 CFR 2.390

FUEL BASKET ASSEMBLY 9705050287 -11

		QTY	ITEM	NAME	MATERIAL	SPEC	DRAWING NO.	DESCRIPTION
		8	15	TOP SPACER			455-893-7	
		14	14	HEAT TRANSFER DISK			455-894-1	
		224	13	FLAT WASHER	ST. STL.	COML, ANSI B18.22.1		2 TYPE A PLAIN WASHER
		224	12	SPLIT SPACER			455-893-6	
		8	11	TIE ROD			455-893-5	
		8	10	TOP NUT			455-893-4	
		8	9	BOTTOM SPACER			455-893-3	
		56	8	SPACER			455-893-2	
			7	(REMOVED)				
			6	(REMOVED)				
		36	5	TUBE (4-SIDED)			455-881-99	
		1	4	DRAIN TUBE SLEEVE	304 ST.STL.	ASTM A269		2 DIA TUBE WITH .035 WALL
		22	3	SUPPORT DISK			455-893-1	
		1	2	TOP WELDMENT			455-892-99	
		1	1	BOTTOM WELDMENT			455-891-99	

NAC INTERNATIONAL

FUEL BASKET ASSEMBLY, MPC-YANKEE

NEXT ASSEMBLY 455-872

DRAWING TYPE: LICENSE

PROJECT 455 | DRAWING 895 | REV 1

SCALE 1/6 | SH 1 OF 1