CHAPTER 6
TABLE OF CONTENTS

6 CRITICALITY EVALUATION 6.1-1
6.1 Discussion and Results 6.1-1
6.2 Package Fuel Loading 6.2-1
6.3 Model Specification 6.3-1
6.3.1 Description of Calculational Model 6.3-1
6.3.2 Package Regional Densities 6.3-1
6.4 Criticality Calculations 6.4-1
6.4.1 Calculational Method 6.4-1
6.4.1.1 Computer Codes 6.4-1
6.4.1.2 Physical and Nuclear Data 6.4-1
6.4.1.3 Bases and Assumptions 6.4-1
6.4.1.4 Determination of K_{eff} 6.4-3
6.4.2 Fuel Loading Optimization 6.4-3
6.4.3 Criticality Results 6.4-10
6.5 Critical Benchmark Experiments 6.5-1
6.5.1 Benchmark Experiments and Applicability 6.5-1
6.5.2 Details of Benchmark Calculations 6.5-1
6.5.3 Results of Benchmark Calculations 6.5-10
6.6 Appendix A 6.6-1
6.6.1 CSAS25 Input Data for Design Calculations 6.6-1
6.6.2 CSAS25 Input Data for Benchmark Calculations 6.6-177
6.6.3 References for Sections 6.1 through 6.5 ..... 6.6-206

FIGURES

6.1-1 GA-4 legal weight truck cask cross section 6.1-2
6.1-2 GA-4 fuel support structure 6.1-3
6.3-1 KENO V.a model of GA-4 cask 6.3-2
6.3-2 Cross-section map of Westinghouse 15 x 15 OFA fuel assembly as modeled with KENO V.a 6.3-3
6.3-3 KENO V.a Unit Geometry 6.3-9
6.4-1 Cross-section map of fuel assembly type as modeled with KENO V.a 6.4-4
6.5-1 The 4.31 wt% U-235-enriched UO_2 rods and 2.35 wt% U-235-enriched UO_2 rods 6.5-8
6.5-2 Graphical arrangements of cases 1 to 12 ..... 6.5-9

TABLES

6.1-1	SUMMARY OF GA-4 CRITICALITY EVALUATION	6.1-5
6.2-1	PARAMETERS FOR PWR ASSEMBLIES FOR SHIPMENT IN GA-4 CASK	6.2-2
6.3-1	MATERIAL PROPERTY DATA	6.3-18
6.4-1	KEY PARAMETERS FOR CRITICALITY ANALYSIS	6.4-2
6.4-2	MOST REACTIVE FUEL ANALYSIS (3.15 WT% INITIAL ENRICHMENT)	6.4-8
6.4-3	MOST REACTIVE CONFIGURATION CALCULATIONS (3.15 WT% INITIAL ENRICHMENT)	6.4.9
6.4-4	FINAL CRITICALITY RESULTS	6.4.10
6.5-1	COMPARISON OF SELECTED CRITICAL EXPERIMENTS WITH GA-4 CASK CONDITIONS	6.5-2
6.5-2	CASK CONDITIONS MODELED N BENCHMARK CALCULATIONS	6.5-3
6.5-3	CSAS25-CALCULATED K_{EFF} FOR EXPERIMENTALLY CRITICAL LOW-ENRICHED UO_2 SYSTEMS	6.5-4
6.5-4	CASK CONDITIONS COMPARED TO BENCHMARK	6.5-11

6. CRITICALITY EVALUATION

The GA-4 cask design provides criticality control to meet the criticality performance requirements specified in Sections 71.55 and 71.59 of 10 CFR Part 71. The criticality control design ensures that the effective multiplication factor (k_{eff}) of the contained fuel is no greater than 0.95 for the most reactive configuration, including 2σ uncertainties and analytical bias. The design has a nuclear criticality control Transport Index of 0 because "N" is infinite. The number "N" is based on all of the following conditions being satisfied, assuming packages are stacked together in any arrangement and with close full reflection on all sides of the stack by water:

1. Five times "N" undamaged packages with nothing between the packages would be subcritical.

2. Two times "N" damaged packages, if each package were subjected to the test specified in 10 CFR Part 71.73 ("Hypothetical accident conditions') would be subcritical with optimum interspersed hydrogenous moderation; and.

3. The value of "N" cannot be less than 0.5.

6.1 Discussion and Results

Figure 6.1-1 shows the cross section of the GA-4 cask. The cask uses fixed B_4C pellets for criticality control. The cask fuel cavity structure consists of a steel cavity liner with a fuel support structure (FSS) in the center to provide the fixed poison absorber (B_4C) and to provide separation between the fuel assemblies loaded into the cask. As demonstrated by analysis in Chapter 2, the fuel support structure provides structural integrity to maintain the geometry for criticality control under hypothetical accident conditions.

The interactions between fuel assemblies are partially decoupled by the fuel support structure, which consists of solid enriched boron carbide (B_4C) pellets enclosed in a stainless steel cruciform structure as shown in Figs. 6.1-1 and 6.1-2. Encasing the B_4C pellets in the stainless steel structure prevents the B_4C from coming into contact with water. The steel structure also serves as a mild neutron absorber and physically separates the fuel assemblies, providing further reduction in reactivity.

The steel fuel cavity liner is a structural component and partially decouples the fuel assemblies neutronically from the depleted uranium (DU) shielding material and the other cask materials. The cavity liner partially decouples the interactions by reducing the number of thermal neutrons entering the DU shield and returning from the cask body due to reflection.

Table 6.1-1 summarizes the criticality evaluation for normal and hypothetical accident conditions for the cask, showing that it meets criticality safety requirements for "N" equal to infinity. The containment criterion for both normal transport and hypothetical accident conditions as described in Chapter 4, "Containment," is that the cask must be leaktight. The structural analysis in Chapter 2 shows that all structural criteria are met and there are no deformations that would affect the leaktightness of the seals. Therefore, the criticality analysis is based on the cask being watertight, allowing no water inleakage for either normal transport or hypothetical accident conditions. It is necessary to consider water inleakage only for a single undamaged

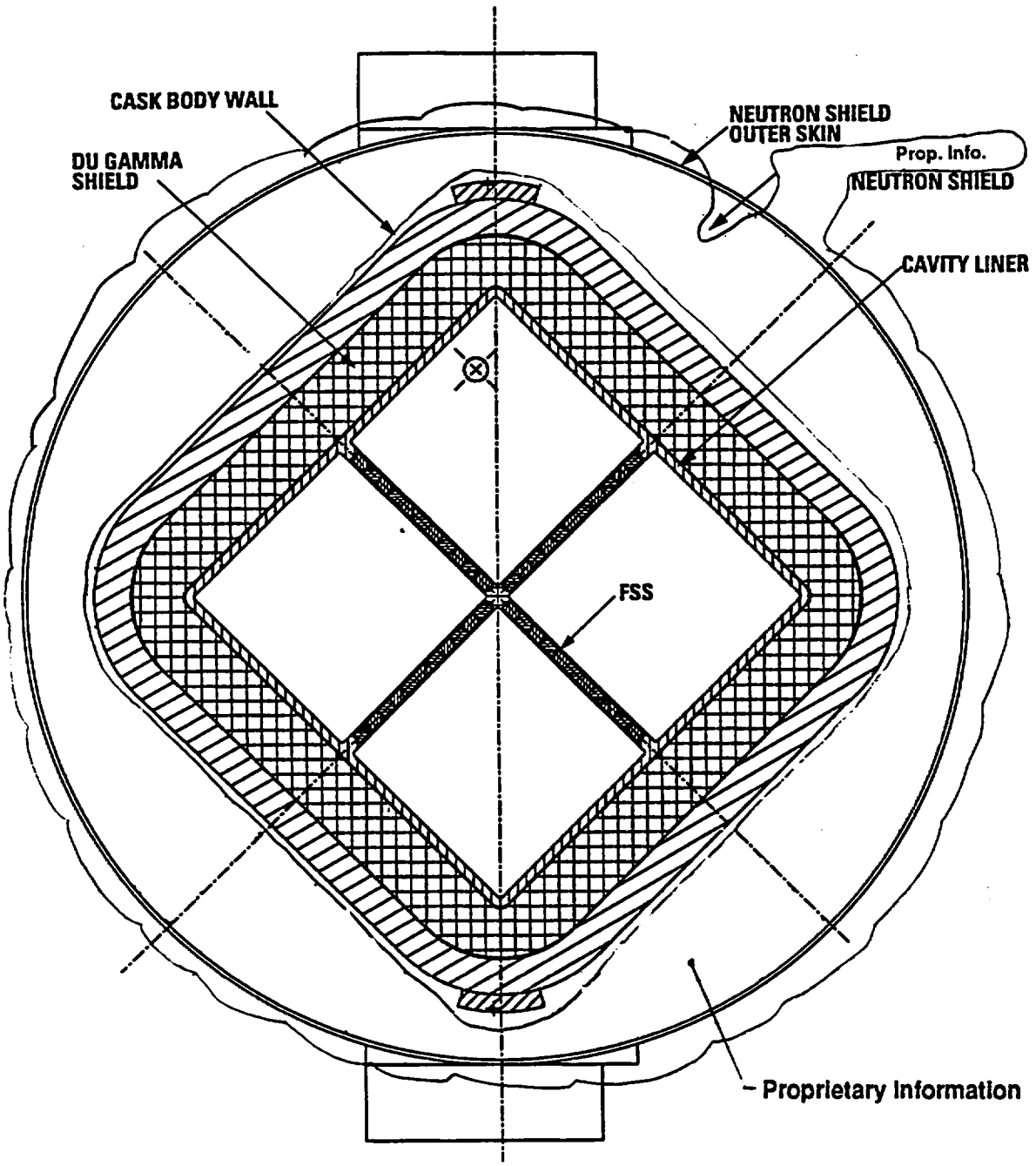
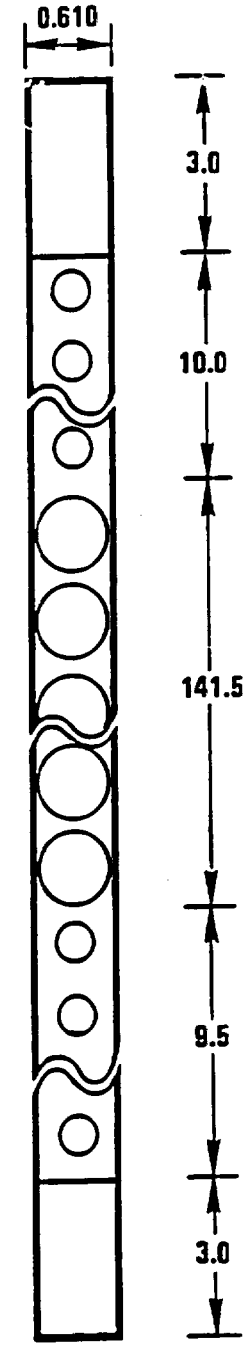
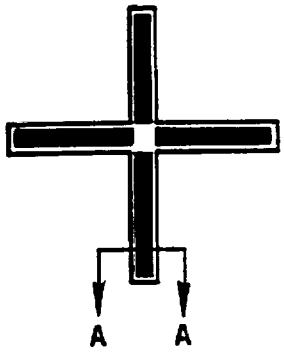


Fig. 6.1-1. GA-4 legal weight truck cask cross section



END VIEW OF FSS



SMALL HOLES
HOLE DIA. = 0.292 in. max.
B_4C DIA. = 0.278 in. min.

LARGE HOLES
HOLE DIA. = 0.440 in. max.
B_4C DIA. = 0.426 in. min.

HOLE PITCH = 0.5 in.

K-238 (4)
9-17-91

SECTION A-A

Fig. 6.1-2. GA-4 fuel support structure

package, in accordance with 10 CFR Part 71.55(b). The reactivity for the hypothetical accident conditions and the infinite array of casks under normal conditions of transport is much lower than for a single package with water in the cavity for normal transport. For this reason, the criticality analysis was performed for a single flooded package with close water reflection.

The criticality calculations assume the Westinghouse (W) 15x15 OFA fuel assembly because it is the most reactive fuel assembly allowed by the authorized contents. The calculations determine k_{eff} with the CSAS25 control module of SCALE-4.3 (Ref. 6.1-1) for various configurations and initial enrichments, including all uncertainties to assure criticality safety under all credible conditions.

The results of the evaluation demonstrate that the maximum k_{eff}—including statistical uncertainty and analytical bias—is < 0.95 for the single undamaged package with water ingress.

TABLE 6.1-1
SUMMARY OF GA-4 CRITICALITY EVALUATION

Normal Conditions	
Number of undamaged packages calculated to be subcritical	Infinite[a]
Optimum interspersed hydrogenous moderation[b]	Water
Closely reflected by water	Yes
Package size, cm^3	3.82×10^6
Accident Conditions	
Number of damaged packages calculated to be subcritical	Infinite
Optimum interspersed hydrogenous moderation, full water reflection [a]	Water
Package size, cm^3	2.18×10^6
Nuclear Criticality Control Transport Index	0

[a] or single flooded package (most reactive configuration for GA-4 cask).
[b] No water ingress assumed because cask is designed to be watertight.

THIS PAGE LEFT BLANK INTENTIONALLY

6.2 Package Fuel Loading

The GA-4 cask is capable of transporting standard PWR fuel assemblies as intact assemblies. The fuel assemblies considered as design basis include the following:

GA-4 Cask (PWR Spent Fuels)

Westinghouse Electric, Standard ZC	15x15
Westinghouse Electric, OFA	15x15
Westinghouse Electric, Standard ZCA	14x14
Westinghouse Electric, Standard ZCB	14x14
Westinghouse Electric, Mod	14x14
Westinghouse Electric, OFA	14x14
Babcock & Wilcox, Mark B, BZ, BGD	15x15
Combustion Engineering, Palisades	15x15
Combustion Engineering, Standard	14x14
Combustion Engineering, Fort Calhoun	14x14
Exxon Nuclear/ANF	15x15
Exxon Nuclear/ANF, CE	14x14
Exxon Nuclear/ANF, W	14x14

Table 6.2-1 lists the fuel parameters for the standard PWR fuel assemblies. The reference fuel chosen for the GA-4 cask criticality analysis is the W 15x15 OFA fuel assembly. The W 15x15 OFA assembly is used because, as demonstrated in Section 6.4, it is the most reactive assembly of those authorized to be shipped in the GA-4 cask.

TABLE 6.2-1
PARAMETERS FOR PWR ASSEMBLIES FOR SHIPMENT IN GA-4 CASK

Mfr.	Array	Version	Active Fuel Length (in)	Fuel Content (MTU)	Fuel Rods/H_2O Holes per Assembly	Pitch (in)	Solid UO_2 Fuel o.d. (in)	Zircalloy Thickness (in)
W	15x15	Std/ZC	144	0.469	204/21	0.563	0.3659	0.0242
W	15x15	OFA	144	0.463	204/21	0.563	0.3659	0.0242
W	14x14	Std/ZCA, ZCB	145.5	0.407	179/17	0.556	0.3674	0.0225
W	14x14	Model C	137	0.397	176/20	0.580	0.3805	0.02595
W	14x14	OFA	144	0.358	179/17	0.556	0.3444	0.0243
B & W	15x15	Mark B, BZ, BGD	142	0.464	208/17	0.568	0.3686	0.0265
CE	15x15	Palis.	144	0.413	204/21	0.550	0.358	0.026
CE	14x14	Std/Gen.	137	0.386	176/20	0.580	0.3765	0.028
CE	14x14	Ft. Cal.	128	0.376	176/20	0.580	0. 3765	0.028
Exx/A	15x15	WE	144	0.432	204/21	0.563	0.3565	0.030
Exx/A	14x14	CE	137	0.381	176/20	0.580	0.370	0.031
Exx/A	14x14	WE	142	0.379	179/17	0.556	0.3505	0.030

6.3 Model Specification

The following subsections describe the physical models and materials of the GA-4 cask used for input to the CSAS25 module of SCALE-4.3 (Ref. 6.1-1) to perform the criticality evaluation.

6.3.1 Description of Calculational Model

We modeled the cask with a square cross section because geometry limitations in KENO V.a of the CSAS25 module in SCALE-4.3 prevented modeling the exact cross section. This assumption is conservative because the slight increase of DU in the corners introduces additional fission reactions in the DU and also reflects more neutrons back into the system.

One general cask model was developed. The cask model is a full-height and 1/4-radial cross section of the cask. The W 15x15 OFA fuel assembly is modeled as a 15x15 array comprising (1) 204 fuel rods, including fuel, gap and cladding, and (2) 21 water holes. Figure 6.3-1 is a dimensioned sketch showing the axial position of the assembled KENO V.a geometry units and the axial position of the fuel assemblies in the cask relative to the B_4C pellets as modeled. Figure 6.3-2 is a series of dimensional cross sectional maps showing the assembled geometry units in the radial direction. Figure 6.3-3 is a sketch of each KENO V.a unit showing all materials and dimensions. The assembly-to-assembly pitch is minimized (i.e., the assemblies are pushed to the center of the cask), to represent the most reactive configuration in the cask. Inclusion of the water holes is conservative as compared to modeling the entire 15x15 array filled with fuel. The B_4C is modeled with minimum pellet stack length and diameter in the center of the maximum diameter holes.

6.3.2 Package Regional Densities

The Oak Ridge National Laboratory (ORNL) SCALE code package (Ref. 6.1-1) contains a standard material data library for common elements, compounds, and mixtures. All the materials used for the cask analysis are available in this data library. The neutron shield material is modeled as water and the cask skin is not modeled. The material data for the fuel assemblies were obtained from the DOE computerized database (Ref. 6.3-1).

Table 6.3-1 provides a complete list of all the relevant materials used for the criticality evaluation. The material densities for the B_4C represents 90% of the minimum B_4C (96% enriched, 96% theoretical density pellets) poison content in the basket. [

Proprietary Information

]

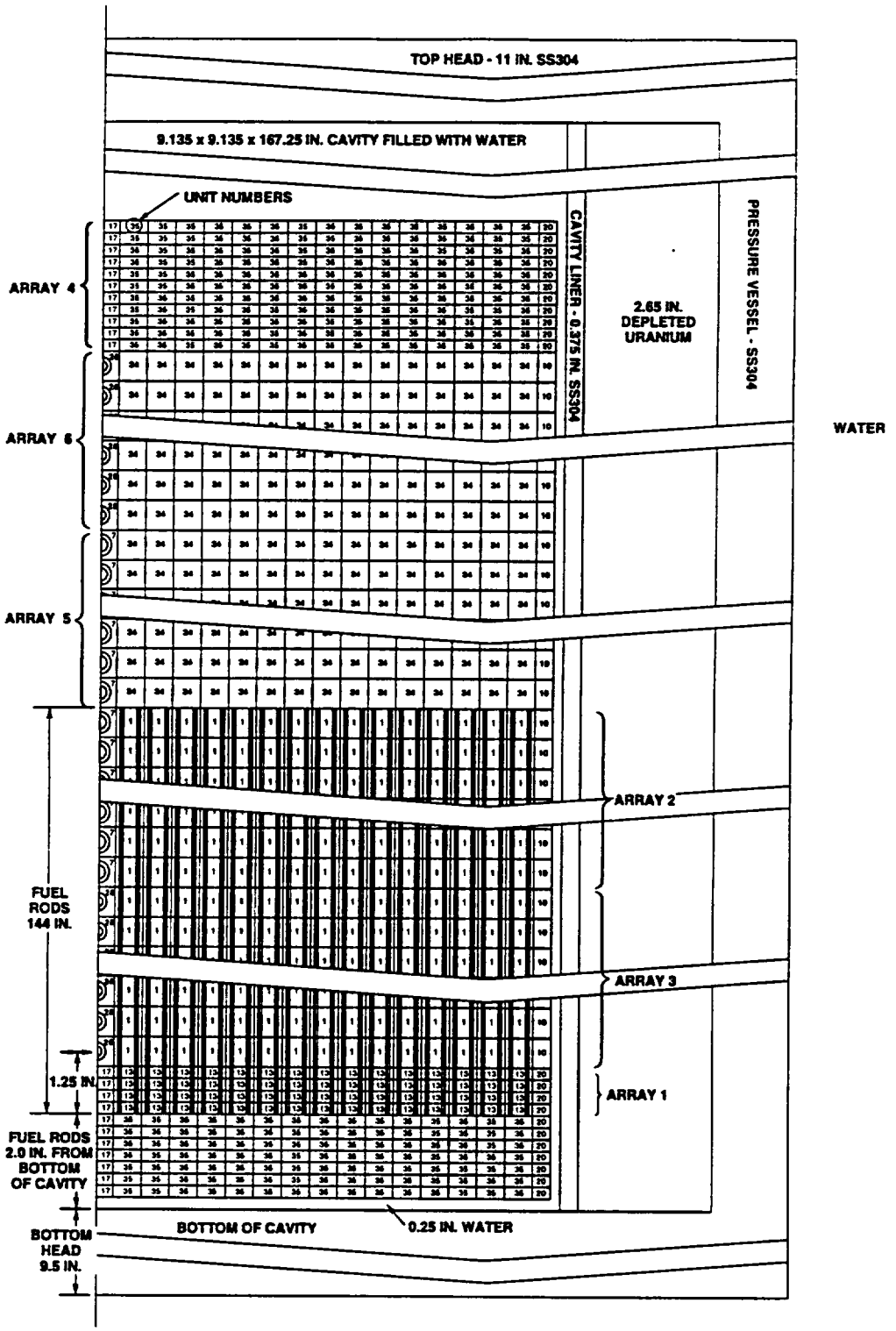


Fig. 6.3-1. KENO V.a model of GA-4 cask

ARRAY 1

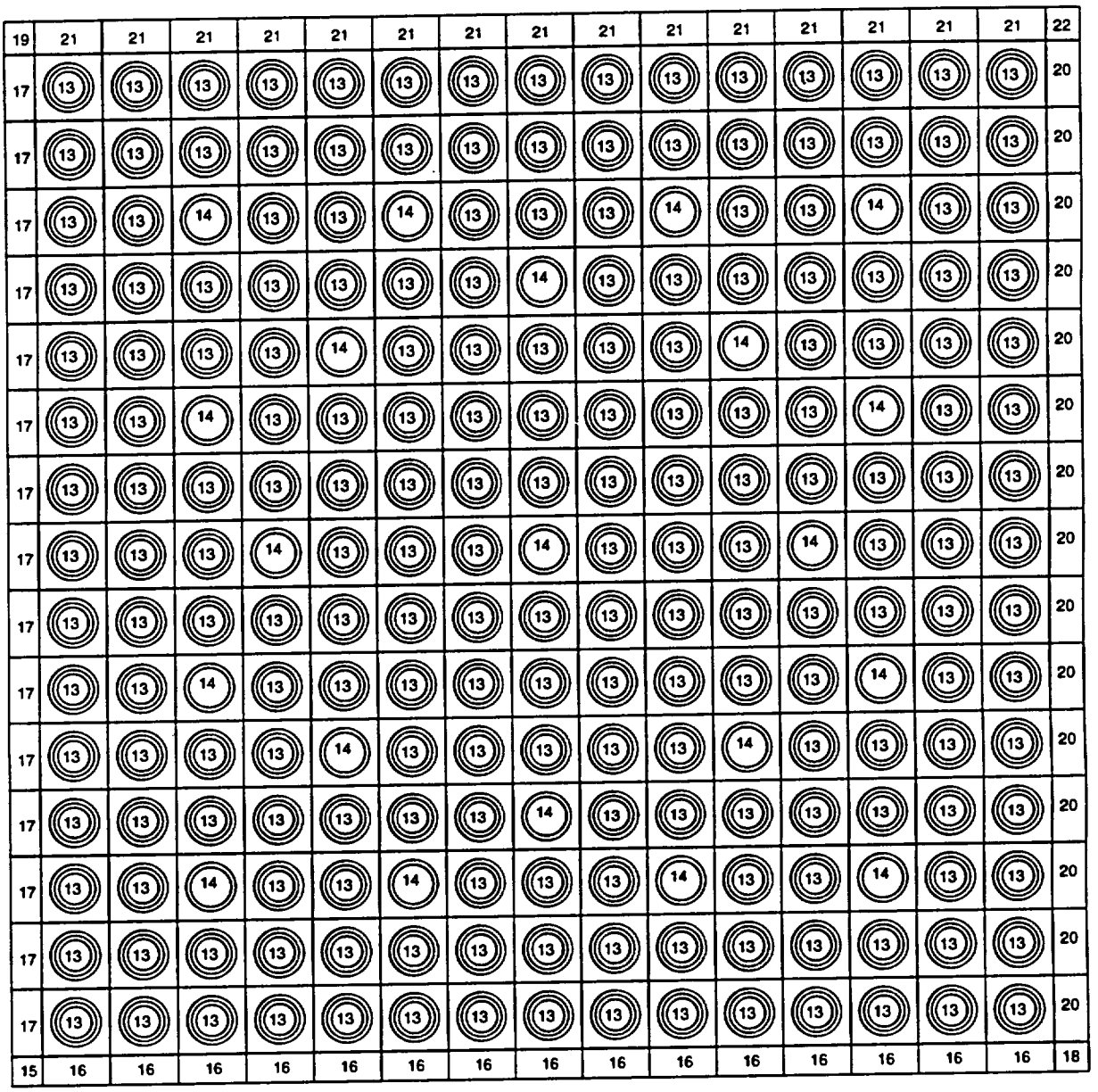


Fig. 6.3-2. Cross-section map of Westinghouse 15x15 OFA fuel assembly as modeled with KENO V.a (sheet 1 of 6)

ARRAY 2

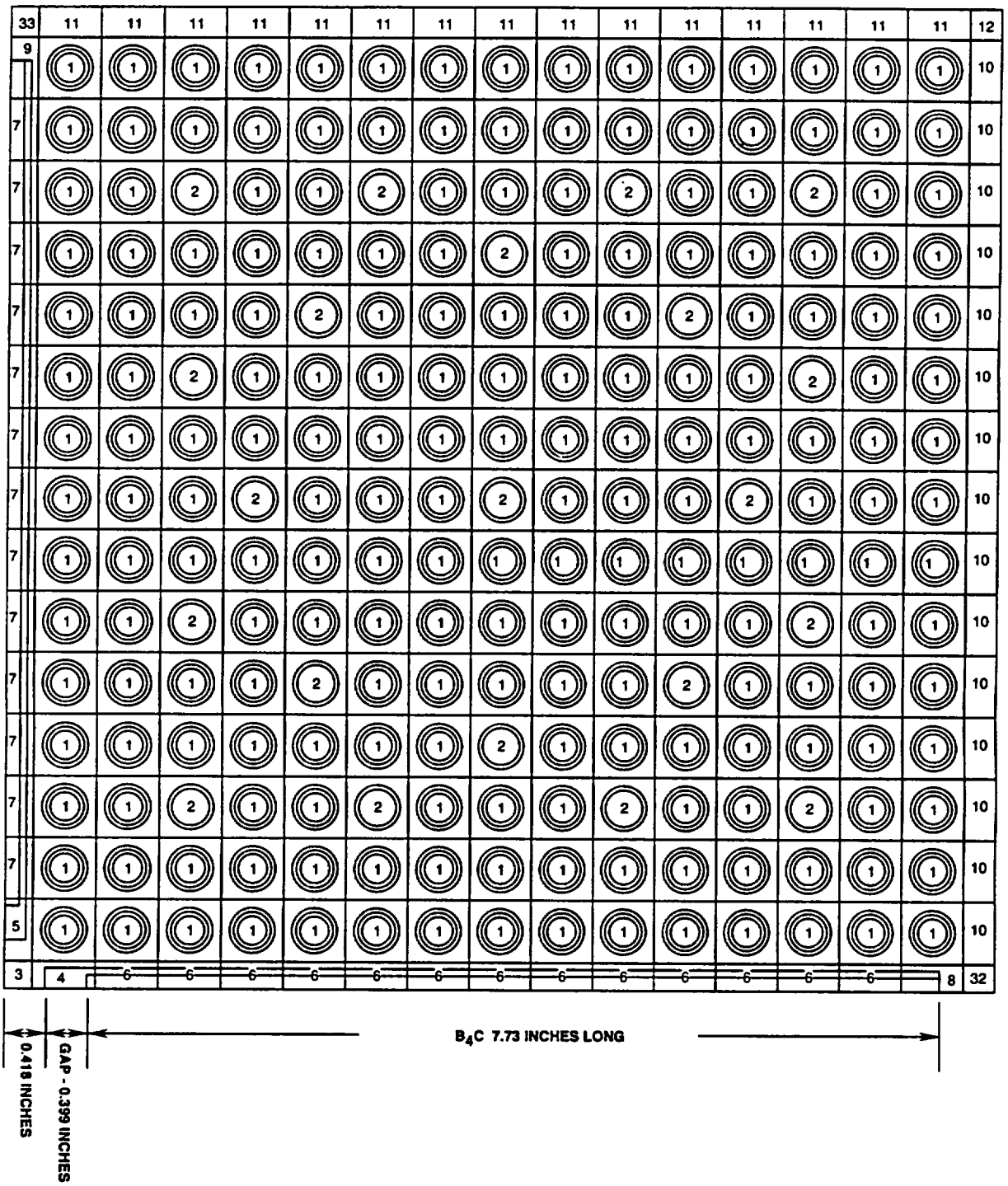


Fig. 6.3-2. Cross-section map of Westinghouse 15x15 OFA fuel assembly as modeled with KENO V.a (sheet 2 of 6)

ARRAY 3

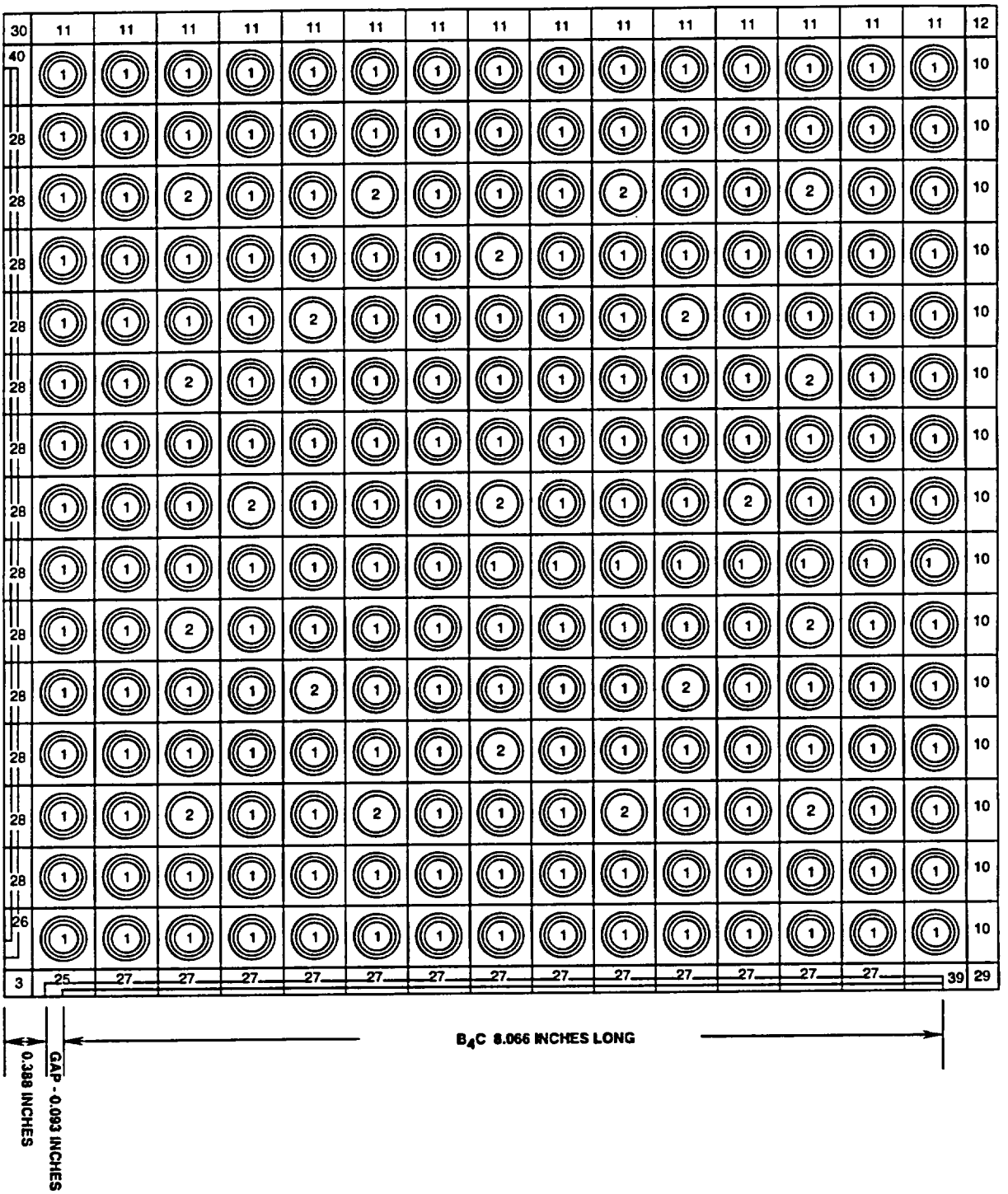


Fig. 6.3-2. Cross-section map of Westinghouse 15x15 OFA fuel assembly as modeled with KENO V.a (sheet 3 of 6)

ARRAY 4

19	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	22
17	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	20
17	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	20
17	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	20
17	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	20
17	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	20
17	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	20
17	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	20
17	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	20
17	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	20
17	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	20
17	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	20
17	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	20
17	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	20
17	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	20
17	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	20
15	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	18

Fig. 6.3-2. Cross-section map of Westinghouse 15x15 OFA fuel assembly as modeled with KENO V.a (sheet 4 of 6)

ARRAY 5

33	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	12
9	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
7	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
7	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
7	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
7	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
7	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
7	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
7	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
7	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
7	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
7	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
7	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
7	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
7	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
5	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
3	4	6	6	6	6	6	6	6	6	6	6	6	6	6	8	32

Fig. 6.3-2. Cross-section map of Westinghouse 15x15 OFA fuel assembly as modeled with KENO V.a (sheet 5 of 6)

ARRAY 6

30	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	12
40	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
28	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
28	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
28	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
28	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
28	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
28	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
28	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
28	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
28	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
28	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
28	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
28	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
28	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
26	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	10
3	25	27	27	27	27	27	27	27	27	27	27	27	27	27	39	29

Fig. 6.3-2. Cross-section map of Westinghouse 15x15 OFA fuel assembly as modeled with KENO V.a (sheet 6 of 6)

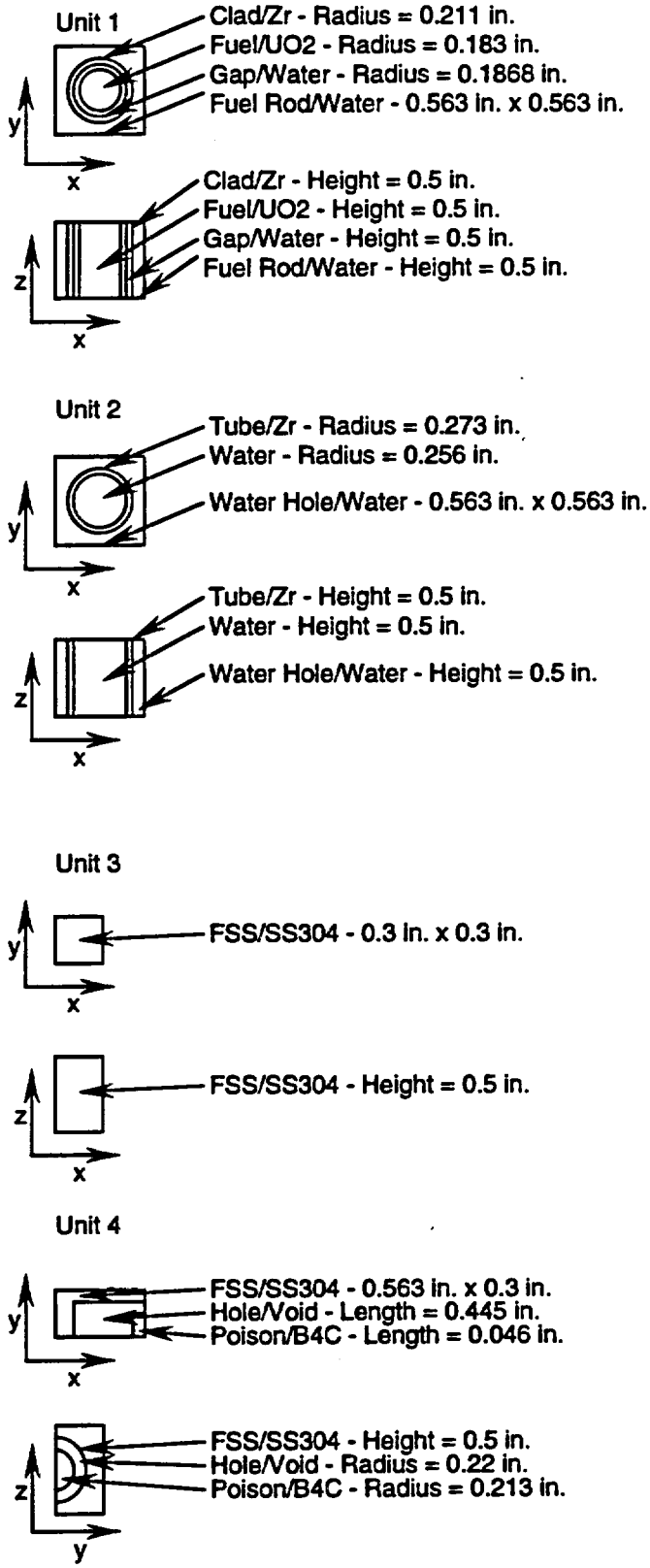


Fig. 6.3-3. KENO V.a Unit Geometry (sheet 1 of 9)

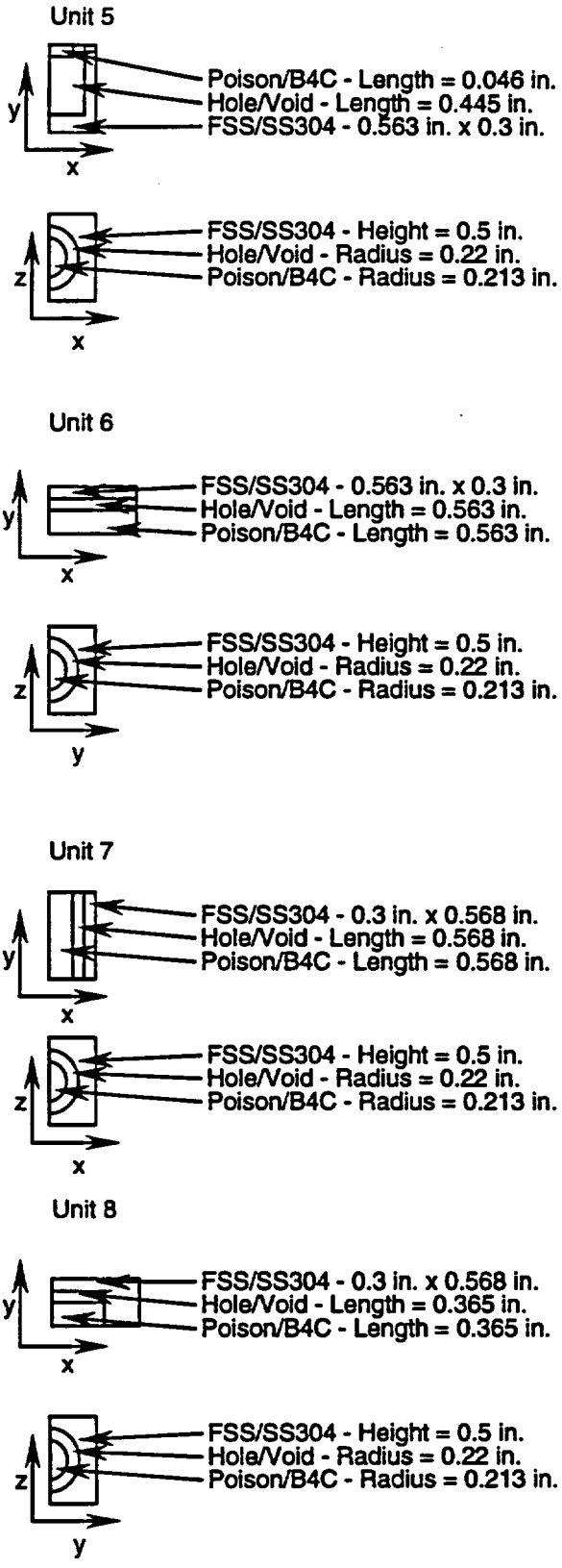


Fig. 6.3-3. KENO V.a Unit Geometry (sheet 2 of 9)

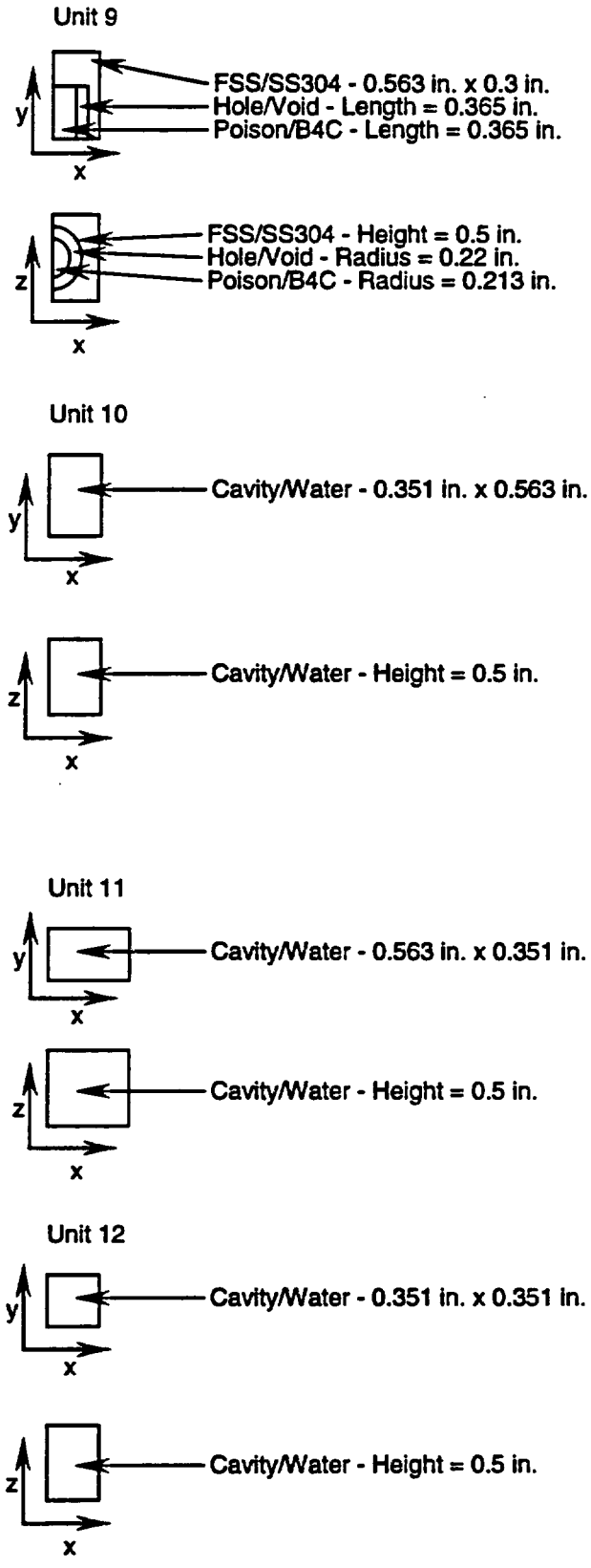


Fig. 6.3-3. KENO V.a Unit Geometry (sheet 3 of 9)

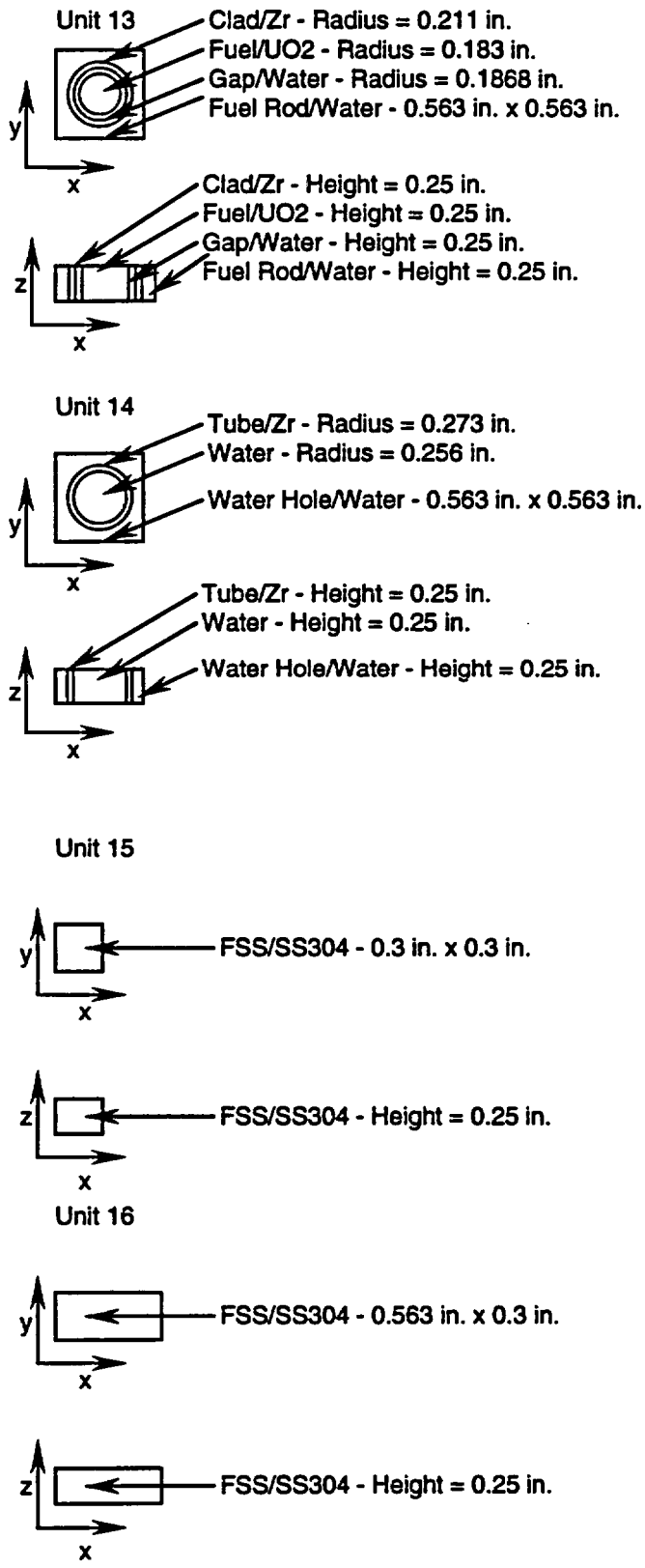


Fig. 6.3-3. KENO V.a Unit Geometry (sheet 4 of 9)

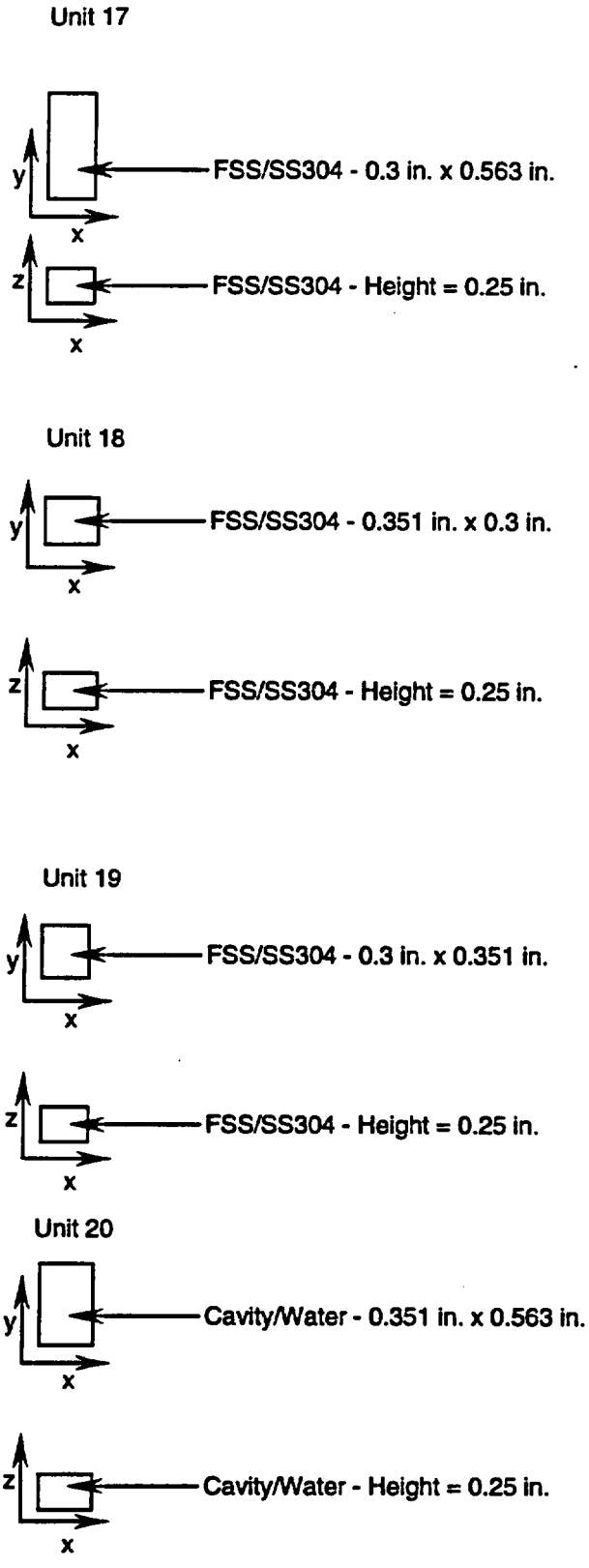


Fig. 6.3-3. KENO V.a Unit Geometry (sheet 5 of 9)

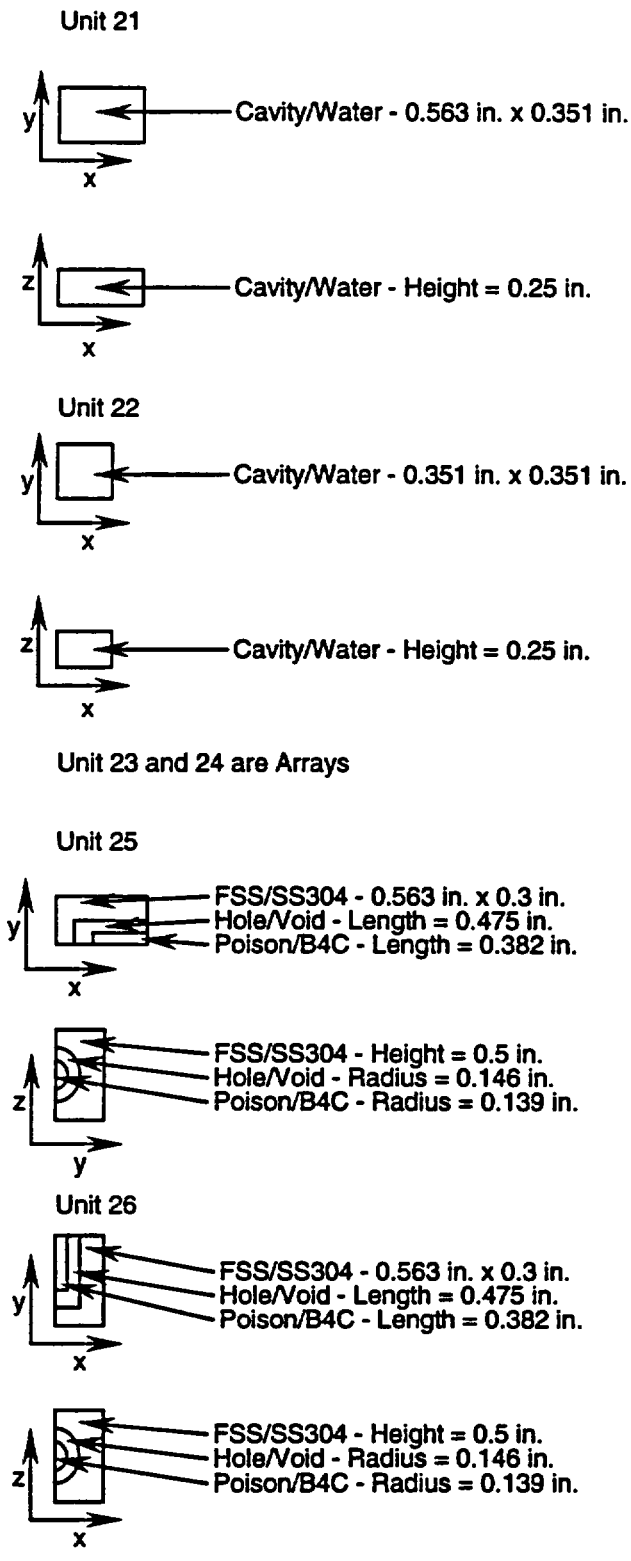


Fig. 6.3-3. KENO V.a Unit Geometry (sheet 6 of 9)

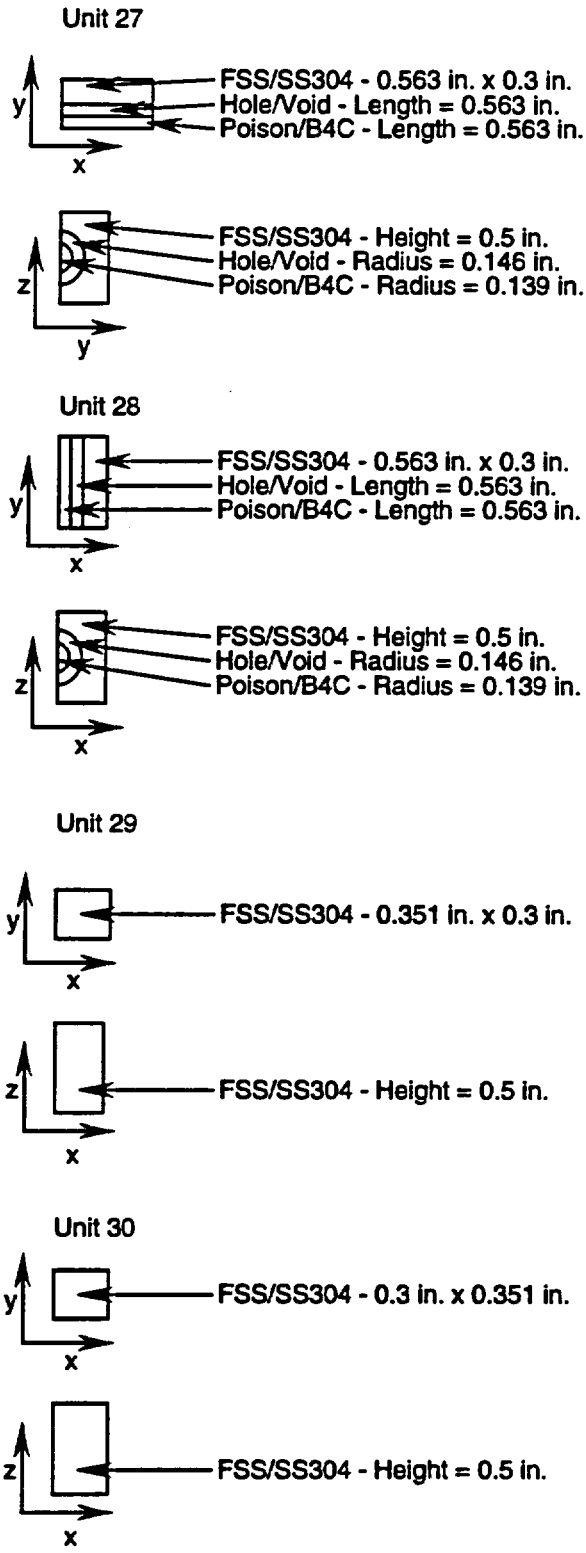


Fig. 6.3-3. KENO V.a Unit Geometry (sheet 7 of 9)

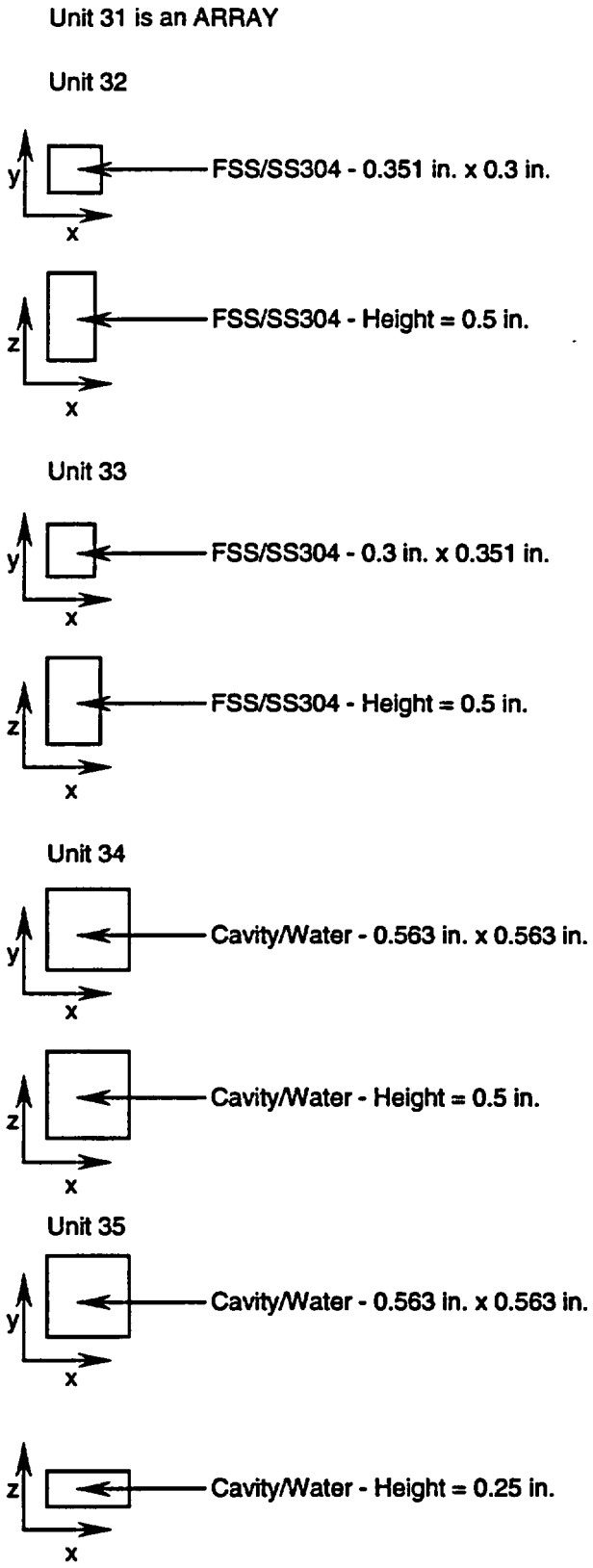


Fig. 6.3-3. KENO V.a Unit Geometry (sheet 8 of 9)

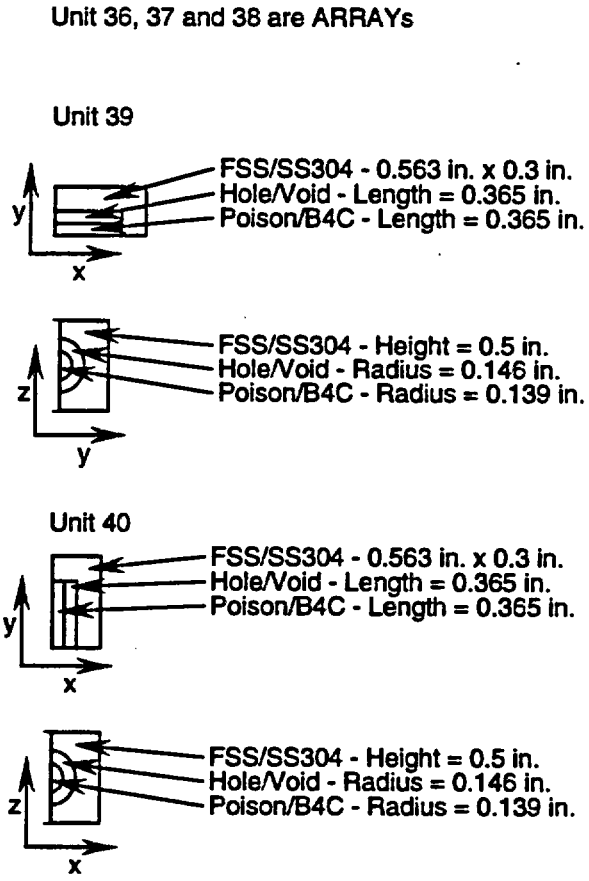


Fig. 6.3-3. KENO V.a Unit Geometry (sheet 9 of 9)

TABLE 6.3-1
MATERIAL PROPERTY DATA

Material	Density g/cm^3 ($lb/in.^3$)	Element	Physical wt %	Modeled Atom Density (atoms/b-cm)
B_4C	2.19 (0.0791)	B-10	73.91	9.760E–2
		B-11	3.08	3.698E–2
		C	23.01	2.532E–2
XM-19 (SS-304)	7.92 (0.286)	Cr	19.0	1.743E–2
		Mn	2.0	1.736E–3
		Fe	69.5	5.936E–2
		Ni	9.5	7.721E–3
Water	1.0 (0.0361)	H	11.1	6.677E–2
		O	88.9	3.338E–2
Depleted uranium	19.05 (0.688)	U-235	0.3	1.464E–4
		U-238	99.7	4.805E–2
Fuel W 15x15 UO_2 3.15% enriched	10.41 (0.3760)	U-235	2.78	7.408E–4
		U-238	85.37	2.249E–2
		O	11.85	4.646E–2
Zircaloy	6.56 (0.2369)	Zr	100.0	4.331E–2

6.4 Criticality Calculations

This section describes the models used for the criticality analysis. The analyses were performed with the CSAS25 module of the SCALE system. A series of calculations were performed to determine the most reactive fuel and configuration. The most reactive fuel, as demonstrated by the analyses, is the Westinghouse 15x15 OFA assembly. The most reactive credible configuration is a single flooded undamaged cask with minimum assembly-to-assembly pitch.

6.4.1 Calculational Method

6.4.1.1 Computer Codes. The CSAS25 control module of SCALE-4.3 (Ref. 6.1-1) was used to calculate the effective multiplication factor (k_{eff}) of the fuel in the cask. The CSAS25 control module allows simplified data input to the functional modules BONAMI-S, NITAWL-S, and KENO V.a. These modules process the required cross sections and calculate the k_{eff} of the system. BONAMI-S performs resonance self-shielding calculations for nuclides that have Bondarenko data associated with their cross sections. NITAWL-S applies a Nordheim resonance self-shielding correction to nuclides having resonance parameters. Finally, KENO V.a calculates the k_{eff} of a three-dimensional system.

6.4.1.2 Physical and Nuclear Data. The physical and nuclear data required for the criticality analysis include the fuel assembly data and cross-section data as described below.

The physical data for the fuel assemblies are available in Report DOE/RW-0184 (Ref. 6.3-1). Table 6.4-1 reproduces the pertinent data for criticality analysis with the W 15x15 OFA fuel assembly.

The criticality analysis used the 27-group cross-section library (27BURNUPLIB) built into the SCALE system. ORNL used ENDF/B-IV data to develop this broad-group library specifically for criticality analysis of a wide variety of thermal systems.

6.4.1.3 Bases and Assumptions. The analytical results reported in Section 2.7 demonstrate that the cask containment boundary, fuel support structure, and cavity liner do not experience any distortion under hypothetical accident conditions. Therefore, for both normal and hypothetical accident conditions the cask geometries are identical except for the neutron shield and skin.

We modeled the cask with KENO V.a using the available geometry input. This option allows a model to be constructed that uses regular geometric shapes to define the material boundaries. The following conservative assumptions were also incorporated into the criticality calculations:

1. Omission of grid plates, spacers, and hardware in the fuel assembly.
2. No burnable poisons accounted for in the fuel.
3. Water density at 1.0 g/cm^3.

TABLE 6.4-1
KEY PARAMETERS FOR CRITICALITY ANALYSIS

Description	Parameter
Fuel support structure poison material	B_4C
Minimum B_4C pellet diameter/stack length (in.) small pellets large pellets	 0.278/8.066 0.426/7.73
B_4C hole pitch (in.)	0.5
Maximum fuel cavity width (in.)	9.135
Fuel type	W 15x15 OFA
Fuel assembly-to-assembly pitch	Minimum
Number of fuel rods Number of water holes	204 21
Fuel rod pitch (in.)	0.563
Fuel o.d. (in.)	0.366
Cladding thickness (in.)	0.0242
UO_2 smear density (% theoretical density)	95
Fuel enrichment (wt % U-235)	3.1 (used 3.15)

4. Temperature at 20°C (293K).

5. B_4C density assumed to be 86.4% theoretical density, accounting for 4% manufacturing uncertainty and 10% margin.

6. No boron modeled in the neutron shield.

7. Modeled fuel with 3.15 wt% U-235 to account for 0.05 wt% uncertainty in fuel initial enrichment

8. Used 95% theoretical density for fuel even though this assumption conservatively increases the total fuel content in the model.

6.4.1.4 Determination of k_{eff}. The criticality calculations were performed with the CSAS25 control module in SCALE-4.3.

The Monte Carlo calculations performed with CSAS25 (KENO V.a) used a flat neutron starting distribution. The total number of histories traced for each calculation was approximately 200,000. This number of histories was sufficient to converge the source and produce standard deviations of less than 0.3% in k_{eff}. The maximum k_{eff} for the calculation was determined with the following formula:

$$k_{eff} = k_{KENO} + BIAS + 2(\sigma_{BIAS}^2 + \sigma_{KENO}^2)^{1/2}.$$

6.4.2 Fuel Loading Optimization

The fuel loading configuration of the cask affects the reactivity of the package. A series of analyses was first carried out to determine the most reactive credible cask configuration. The first series of runs determined the most reactive fuel assembly type. The model used for this analysis was a full-height, quarter-radial model. Each fuel assembly was modeled as an array of clad fuel pins with gap and water holes and an initial enrichment of 3.15 wt%. Figure 6.4-1 is a cross-section map of each fuel assembly type as modeled with KENO V.a showing the water hole positions in the array.

The results of the most reactive fuel evaluation are given in Table 6.4-2 for each assembly type. The W 15x15 OFA assembly is the most reactive fuel assembly and is used in the remainder of the analysis.

The next series of analyses determined the most reactive configuration for the cask. For accident conditions, an infinite array of casks without inleakage of water, neutron shield, or outer skin was modeled to determine k_{eff} as a function of water gap between the casks. The model is identical to the model shown in Figs. 6.3-2 and 6.3-3 except the cavity is filled with air instead of water, the water outside the pressure vessel is various thicknesses and has a reflective boundary condition on its right and top faces. The results are given in Table 6.4-3. The most reactive accident configuration occurs when the array of casks is at minimum cask-to-cask pitch. This configuration however, is very subcritical as compared to a single flooded, undamaged cask.

```
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 2 1 1 1 2 1 1 1 1 1
1 1 1 2 1 1 1 1 1 1 1 2 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 1 1 2 1 1 1 2 1 1 2 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 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 2 1 1 2 1 1 1 2 1 1 2 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 2 1 1 1 1 1 1 1 2 1 1 1
1 1 1 1 1 2 1 1 1 2 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
B&W (15X15) Mark B, BZ, BGD

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 1 1 2 1 1 1 2 1 1 2 1 1
1 1 1 1 1 1 1 2 1 1 1 1 1 1 1
1 1 1 1 2 1 1 1 1 1 2 1 1 1 1
1 1 2 1 1 1 1 1 1 1 1 1 2 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 2 1 1 1 2 1 1 1 2 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 1 1 1 1 1 1 1 1 1 2 1 1
1 1 1 1 2 1 1 1 1 1 2 1 1 1 1
1 1 1 1 1 1 1 2 1 1 1 1 1 1 1
1 1 2 1 1 2 1 1 1 2 1 1 2 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
W (15X15) STD/ZC

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 1 1 2 1 1 1 2 1 1 2 1 1
1 1 1 1 1 1 1 2 1 1 1 1 1 1 1
1 1 1 1 2 1 1 1 1 1 2 1 1 1 1
1 1 2 1 1 1 1 1 1 1 1 1 2 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 2 1 1 1 2 1 1 1 2 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 1 1 1 1 1 1 1 1 1 2 1 1
1 1 1 1 2 1 1 1 1 1 2 1 1 1 1
1 1 1 1 1 1 1 2 1 1 1 1 1 1 1
1 1 2 1 1 2 1 1 1 2 1 1 2 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
W (15X15) OFA
```

1 = Fuel

2 = Waterhole

Fig. 6.4-1. Cross-section map of fuel assembly type as modeled with KENO V.a (sheet 1 of 4)

```
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 1 1 2 1 1 1 2 1 1 2 1 1
1 1 1 1 1 1 1 2 1 1 1 1 1 1 1
1 1 1 1 2 1 1 1 1 1 2 1 1 1 1
1 1 2 1 1 1 1 1 1 1 1 1 2 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 2 1 1 1 2 1 1 1 2 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 1 1 1 1 1 1 1 1 1 2 1 1
1 1 1 1 2 1 1 1 1 1 2 1 1 1 1
1 1 1 1 1 1 1 2 1 1 1 1 1 1 1
1 1 2 1 1 2 1 1 1 2 1 1 2 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
EXXON/ANF  (15X15)  (W)

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 1 1 2 1 1 1 2 1 1 2 1 1
1 1 1 1 1 1 1 2 1 1 1 1 1 1 1
1 1 1 1 2 1 1 1 1 1 2 1 1 1 1
1 1 2 1 1 1 1 1 1 1 1 1 2 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 2 1 1 1 2 1 1 1 2 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 1 1 1 1 1 1 1 1 1 2 1 1
1 1 1 1 2 1 1 1 1 1 2 1 1 1 1
1 1 1 1 1 1 1 2 1 1 1 1 1 1 1
1 1 2 1 1 2 1 1 1 2 1 1 2 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
CE  (15X15)  (PALIS)

1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 2 1 1 1 1 1 1 2 2 1 1
1 1 2 2 1 1 1 1 1 1 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 2 2 1 1 1 1 1 1
1 1 1 1 1 1 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 2 2 1 1 1 1 1 1 2 2 1 1
1 1 2 2 1 1 1 1 1 1 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
CE  (14X14)  STD
```

1 = Fuel

2 = Waterhole

Fig. 6.4-1. Cross-section map of fuel assembly type as modeled with KENO V.a (sheet 2 of 4)

```
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 2 1 1 1 1 1 1 2 2 1 1
1 1 2 2 1 1 1 1 1 1 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 2 2 1 1 1 1 1 1
1 1 1 1 1 1 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 2 2 1 1 1 1 1 1 2 2 1 1
1 1 2 2 1 1 1 1 1 1 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
EXXON/ANF (14X14) CE
```

1 = Fuel

2 = Waterhole

```
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 2 1 1 1 1 1 1 2 2 1 1
1 1 2 2 1 1 1 1 1 1 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 2 2 1 1 1 1 1 1
1 1 1 1 1 1 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 2 2 1 1 1 1 1 1 2 2 1 1
1 1 2 2 1 1 1 1 1 1 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
CE (14X14) FT CALHOUN
```

```
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 2 1 1 1 1 1 1 2 2 1 1
1 1 2 2 1 1 1 1 1 1 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 2 2 1 1 1 1 1 1
1 1 1 1 1 1 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 2 2 1 1 1 1 1 1 2 2 1 1
1 1 2 2 1 1 1 1 1 1 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
W (14X14) MODEL C
```

Fig. 6.4-1. Cross-section map of fuel assembly type as modeled with KENO V.a (sheet 3 of 4)

```
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 1 1 2 1 1 2 1 1 2 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 2 1 1 1 1 2 1 1 1 1
1 1 2 1 1 1 1 1 1 1 1 2 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 1 1 1 1 1 1 1 1 2 1 1
1 1 1 1 2 1 1 1 1 2 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 1 1 2 1 1 2 1 1 2 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
W  (14X14)  ZCA/ZCB

1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 1 1 2 1 1 2 1 1 2 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 2 1 1 1 1 2 1 1 1 1
1 1 2 1 1 1 1 1 1 1 1 2 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 1 1 1 1 1 1 1 1 2 1 1
1 1 1 1 2 1 1 1 1 2 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 1 1 2 1 1 2 1 1 2 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
W  (14X14)  OFA

1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 1 1 2 1 1 2 1 1 2 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 2 1 1 1 1 2 1 1 1 1
1 1 2 1 1 1 1 1 1 1 1 2 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 1 1 1 1 1 1 1 1 2 1 1
1 1 1 1 2 1 1 1 1 2 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 1 1 2 1 1 2 1 1 2 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
EXXON/ANF  (14X14)  WE
```

1 = Fuel

2 = Waterhole

Fig. 6.4-1. Cross-section map of fuel assembly type as modeled with KENO V.a (sheet 4 of 4)

TABLE 6.4-2
MOST REACTIVE FUEL ANALYSIS
(3.15 WT% INITIAL ENRICHMENT)

Mfr.	Array	Version	k_{KENO}	$\pm 1\ \sigma_{KENO}$	k_{eff} [a]	Input Name
B & W	15x15	Mark B, BZ, BGD	0.9192	0.0015	0.9395	mrf01
W	15x15	Std/ZC [b]	0.9228	0.0016	0.9432	mrf02
W	15x15	OFA [b]	0.9228	0.0016	0.9432	mrf03
Exx/A	15x15	WE	0.9211	0.0015	0.9414	mrf04
CE	15x15	Palisades	0.9172	0.0015	0.9375	mrf05
CE	14x14	Std/Gen.	0.9023	0.0014	0.9225	mrf06
Exx/A	14x14	CE	0.8987	0.0016	0.9191	mrf07
CE	14x14	Ft. Calhoun	0.8998	0.0015	0.9201	mrf08
W	14x14	Model C	0.9061	0.0016	0.9265	mrf09
W	14x14	Std/ZCA Std/ZCB	0.8914	0.0015	0.9117	mrf10
W	14x14	OFA	0.8944	0.0016	0.9148	mrf11
Exx/A	14x14	WE	0.8817	0.0014	0.9019	mrf12

[a] $k_{eff} = k_{KENO} + BIAS + 2(\sigma_{BIAS}^2 + \sigma_{KENO}^2)^{1/2}$ as determined in Section 6.5.3.

[b] The std/ZC and OFA have identical dimensions but different fuel loadings; however, due to conservative modeling assumptions (Assumption 8, Section 6.4.1.3), the model for both fuel assemblies is the same.

TABLE 6.4-3
MOST REACTIVE CONFIGURATION CALCULATIONS
(3.15 WT% INITIAL ENRICHMENT)

Hypothetical Accident Conditions Infinite Array with Water between Casks				
Water-filled space between casks (cm)	k_{KENO}	$\pm 1\ \sigma_{KENO}$	k_{eff} [a]	Input Name
0.0	0.3351	0.0008	0.3546	acc01
2.5	0.3134	0.0007	0.3329	acc02
5.0	0.2981	0.0007	0.3176	acc03
7.5	0.2946	0.0008	0.3141	acc04
Undamaged Package Moderator Density Variations				
Water density (g/cm^3)	k_{KENO}	$\pm 1\ \sigma_{KENO}$	k_{eff} [a]	Input Name
0.98	0.9159	0.0015	0.9362	den98
0.96	0.9104	0.0015	0.9307	den96
0.90	0.8884	0.0014	0.9086	den90
0.85	0.8677	0.0014	0.8879	den85
0.80	0.8484	0.0015	0.8687	den80
0.70	0.7965	0.0015	0. 8168	den70
0.60	0.7386	0.0014	0.7588	den60
0.50	0.6676	0.0014	0.6878	den50
0.40	0.5906	0.0013	0.6106	den40
0.30	0.5053	0.0012	0.5252	den30
Undamaged Package Assembly-to-Assembly Pitch				
Assembly position	k_{KENO}	$\pm 1\ \sigma_{KENO}$	k_{eff} [a]	Input Name
Maximum pitch	0.9228	0.0016	0.9432	pit01
Centered in cavity	0.9214	0.0015	0.9417	pit02
Minimum pitch	0.9167	0.0015	0.9370	mrf03

[a] $k_{eff} = k_{KENO} + BIAS + 2(\sigma_{BIAS}^2 + \sigma_{KENO}^2)^{1/2}$, as determined in Section 6.5.3.

6.4.3 Criticality Results

Table 6.4-4 lists the results of the three final criticality calculations performed with CSAS25 of SCALE-4.3. For each case, the result includes (1) the KENO-calculated k_{eff}; (2) the one sigma uncertainty; and (3) the final k_{eff}, which accounts for the calculational bias and the two-sigma uncertainty. The results for all cases are given in Table 6.4-4. As stated before, the GA-4 cask can transport up to four 14 x 14 or 15 x 15 PWR fuel assemblies with a maximum initial enrichment of 3.1 wt% U-235. The input data for all cases are included in Appendix 6.6.

TABLE 6.4-4
FINAL CRITICALITY RESULTS

No. of Fuel Assemblies	Initial Enrichment (wt % U-235)	k_{KENO}	$\pm 1\ \sigma_{KENO}$	k_{eff} [a]
A single package optimally flooded and reflected (input - mrf03)				
4	3.1 (used 3.15)	0.9228	0.0016	0.9432
Array of packages under normal conditions of transport (input - acc03)[b]				
4	3.1 (used 3.15)	0.2946	0.0008	0.3141
Array of packages under hypothetical accident conditions (input - acc01)				
4	3.1 (used 3.15)	0.3351	0.0008	0.3546

[a] $k_{eff} = k_{KENO} + BIAS + 2(\sigma_{BIAS}^2 + \sigma_{KENO}^2)^{1/2}$, as determined in Section 6.5.3.
[b] Case bounds normal conditions.

6.5 Critical Benchmark Experiments

The criticality safety analysis of the GA-4 shipping cask used the CSAS25 module of the SCALE system of codes. The CSAS25 control module allows simplified data input to the functional modules BONAMI-S, NITAWL-S, and KENO V.a. These modules process the required cross-section data and calculate the k_{eff} of the system. BONAMI-S performs resonance self-shielding calculations for nuclides that have Bondarenko data associated with their cross sections. NITAWL-S applies a Nordheim resonance self-shielding correction to nuclides having resonance parameters. Finally, KENO V.a calculates the effective neutron multiplication (k_{eff}) of a 3-D system.

The GA-4 cask uses the fresh fuel assumption for criticality analysis. The analysis employed the 27-group ENDF/B-IV (27BURNUPLIB) cross-section library because it has a small bias, as determined by the 15 benchmark calculations described in Section 6.5.1. The bias for the fresh fuel assumption was determined, using 15 fresh fuel criticals, as discussed in Sections 6.5.1 to 6.5.3.

6.5.1 Benchmark Experiments and Applicability

To verify the calculational techniques for fresh fuel used in the criticality safety analysis in Section 6.4.1, several critical benchmark experiments (Refs. 6.5-1 to 6.5-4) were selected and analyzed with the CSAS25 module of SCALE-4.3, using the 27BURNUPLIB cross-section library.

The selected fresh fuel critical experiments relate to the GA-4 cask conditions closely, with certain exceptions as noted in Table 6.5-1. The difference in the fuel cladding material has little effect on reactivity, since both Zircaloy and aluminum are weak neutron absorbers.

The fresh fuel benchmarks chosen were sufficiently diverse to cover the various neutron absorbers (B_4C, steel, water) between the fuel assemblies as well as close reflection from water, steel, or DU around the fuel assemblies. The experiments consisted of three enrichments: 2.35, 2.46, and 4.29 wt % U-235. These are representative of the range of fuel enrichments to be carried in the GA-4 cask. Table 6.5-2 lists, by case number, the critical experiment selected to represent the cask conditions listed. Table 6.5-3 provides a brief description of each critical experiment. Table 6.5-4 compares the benchmark to the cask and fuel system parameters showing that the benchmarks used are adequate to bracket the analysis.

6.5.2 Details of Benchmark Calculations

Figure 6.5-1 illustrates the fuel rods and dimensions. Figure 6.5-2 shows the experimental geometry for Cases 1 through 12. The poison curtains (separating material in Table 6.5-2), when present, are positioned between the center cluster of fuel rods and the two outer clusters on either side, as shown in Fig. 6.5-2. Table 6.5-3 gives a brief description and dimensions for each critical benchmark experiment.

TABLE 6.5-1
COMPARISON OF SELECTED CRITICAL EXPERIMENTS
WITH GA-4 CASK CONDITIONS

Condition	GA-4 Cask	Critical Experiments
Fuel type	Low-enriched UO_2	Same
Enrichment (%)	3.15	2.35, 2.46, 4.31
Fuel pitch/rod diameter ratio	1.54	1.59 to 2.0
Moderator	Water	Same
Fixed absorber	B_4C/steel	B_4C, Boral, borated steel
Reflector	DU	DU/water
Fuel cladding material	Zircaloy	Al

TABLE 6.5-2
CASK CONDITIONS MODELED IN BENCHMARK CALCULATIONS

Case	Enrichment U-235 wt %	Separating Material	Surrounding Material	Pitch/Rod Ratio
1	4.31	Water	Water	2.008
2	4.31	Boral (B_4C)	Water	2.008
3	4.31	Steel w/boron	Water	2.008
4	4.31	Steel w/boron	Water	2.008
5	4.31	Steel w/boron	Water	2.008
6	4.31	Steel w/boron	Water	2.008
7	4.31	Water	Water/DU	2.008
8	4.31	Water	Water/DU	2.008
9	2.35	Boral (B_4C)	Water	1.818
10	2.35	Boral (B_4C)	Water	1.818
11	2.35	Water	Water/DU	1.818
12	2.35	Water	Water/DU	1.818
13	2.46	Water	Water	1.588
14	2.46	B_4C	Water	1.588
15	2.46	B_4C	Water	1.588

TABLE 6.5-3
CSAS25-CALCULATED K_{EFF} FOR EXPERIMENTALLY CRITICAL LOW-ENRICHED UO_2 SYSTEMS

Case	Experiment Description[a]	Reference	27-Group $k_{eff} \pm 1\ \sigma$
1	Experiment 004. UO_2 rods, 4.31 wt % U-235, 1.2649 cm diameter. Al cladding, 1.3487 cm o.d., 0.066 cm thick. Fuel length 91.44 cm. Square pitch = 2.54 cm. 3 x 1 array of 15 x 8 rod bundles, 11.72 cm separation between bundles. Water-moderated and -reflected.	6.5-1	0.9991 ± 0.0022 Average Group Causing Fission 23.3
2	Experiment 031. UO_2 rods, 4.31 wt % U-235, 1.2649 cm diameter. Al cladding, 1.3487 cm o.d., 0.066 cm thick. Fuel length 91.44 cm. Square pitch = 2.54 cm. 3 x 1 array of 15 x 8 rod bundles, 6.72 cm separation between bundles. Boral curtains, 0.713 cm thick, between bundles; 3.277 cm from edge of center bundle. Water-moderated and -reflected.	6.5-1	0.9910 ± 0.0022 Average Group Causing Fission 23.3
3	Experiment 010. UO_2 rods, 4.31 wt % U-235, 1.2649 cm diameter. Al cladding, 1.3487 cm o.d., 0.066 cm thick. Fuel length 91.44 cm. Square pitch = 2.54 cm. 3 x 1 array of 15 x 8 rod bundles, 6.10 cm separation between bundles. SS304L 1.05 wt % boron curtains, 0.298 cm thick, between bundles; 0.432 cm from edge of center bundle. Water-moderated and -reflected.	6.5-1	1.0008 ± 0.0023 Average Group Causing Fission 23.3
4	Experiment 009. UO_2 rods, 4.31 wt % U-235, 1.2649 cm diameter. Al cladding, 1.3487 cm o.d., 0.066 cm thick. Fuel length 91.44 cm. Square pitch = 2.54 cm. 3 x 1 array of 15 x 8 rod bundles, 8.08 cm separation between bundles. SS304L 1.05 wt % boron curtains, 0.298 cm thick, between bundles; 3.277 cm from edge of center bundle. Water-moderated and -reflected.	6.5-1	0.9963 ± 0.0022 Average Group Causing Fission 23.3

TABLE 6.5-3 (Continued)
CSAS25-CALCULATED K_{EFF} FOR EXPERIMENTALLY CRITICAL LOW-ENRICHED UO_2 SYSTEMS

Case	Experiment Description[a]	Reference	27-Group $k_{eff} \pm 1\ \sigma$
5	Experiment 012. UO_2 rods, 4.31 wt % U-235, 1.2649 cm diameter. Al cladding, 1.3487 cm o.d., 0.066 cm thick. Fuel length 91.44 cm. Square pitch = 2.54 cm. 3 x 1 array of 15 x 8 rod bundles, 5.76 cm separation between bundles. SS304L 1.62 wt % boron curtains, 0.298 cm thick, between bundles; 0.432 cm from edge of center bundle. Water-moderated and -reflected.	6.5-1	0.9975 ± 0.0025 Average Group Causing Fission 23.3
6	Experiment 011. UO_2 rods, 4.31 wt % U-235, 1.2649 cm diameter. Al cladding, 1.3487 cm o.d., 0.066 cm thick. Fuel length 91.44 cm. Square pitch = 2.54 cm. 3 x 1 array of 15 x 8 rod bundles, 7.90 cm separation between bundles. SS304L 1.62 wt % boron curtains, 0.298 cm thick, between bundles; 3.277 cm from edge of center bundle. Water-moderated and -reflected.	6.5-1	0.9973 ±0.0021 Average Group Causing Fission 23.3
7	UO_2 rods, 4.31 wt % U-235, 1.2649 cm diameter. Al cladding, 1.3487 cm o.d., 0.066 cm thick. Fuel length 91.44 cm. Square pitch = 2.54 cm. 3 x 1 array of 13 x 8 rod bundles, 15.38 cm separation between bundles. Depleted uranium reflecting walls, 7.65 cm thick, 0.0 cm from left and right edges of bundles. Water-moderated and uranium-reflected.	6.5-4	1.0008 ± 0.0022 Average Group Causing Fission 21.8
8	UO_2 rods, 4.31 wt % U-235, 1.2649 cm diameter. Al cladding, 1.3487 cm o.d., 0.066 cm thick. Fuel length 91.44 cm. Square pitch = 2.54 cm. 3 x 1 array of 13 x 8 rod bundles, 15.32 cm separation between bundles. Depleted uranium reflecting walls, 7.65 cm thick, 1.956 cm from left and right edges of bundles. Water-moderated and uranium-reflected.	6.5-4	0.9951 ±0.0023 Average Group Causing Fission 22.1

TABLE 6.5-3 (Continued)
CSAS25-CALCULATED K_{EFF} FOR EXPERIMENTALLY CRITICAL LOW-ENRICHED UO_2 SYSTEMS

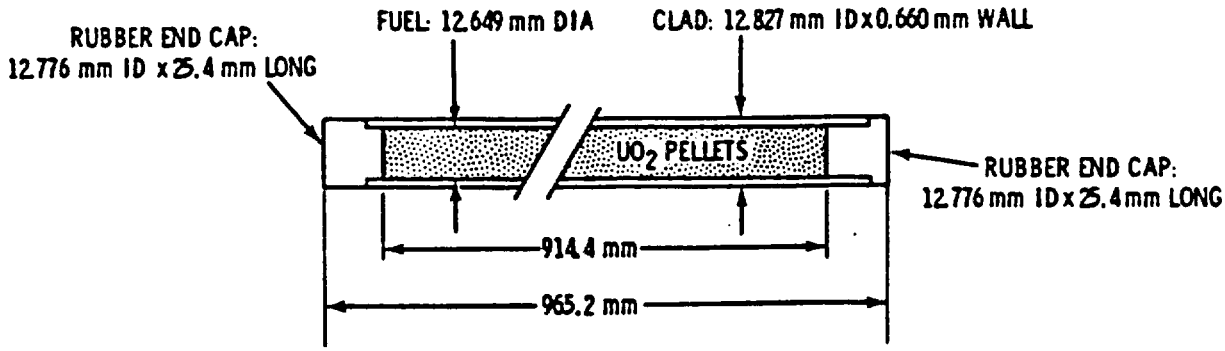
Case	Experiment Description[a]	Reference	27-Group $k_{eff} \pm 1\ \sigma$
9	UO_2 rods, 2.35 wt % U-235, 1.1176 cm diameter Al cladding, 1.270 cm o.d., 0.0762 cm thick. Fuel length = 91.44 cm. Square pitch = 2.032 cm. 3 x 1 array of 20 x 17 rod bundles, 6.34 cm separation between bundles. Boral curtains, 0.713 cm thick, between bundles; 0.645 cm from edge of center bundle. Water-moderated and -reflected.	6.5-2	0.9895 ± 0.0020 Average Group Causing Fission 23.5
10	UO_2 rods, 2.35 wt % U-235, 1.1176 cm diameter. Al cladding, 1.270 cm o.d., 0.0762 cm thick. Fuel length = 91.44 cm. Square pitch = 2.032 cm. 3 x 1 array of 20 x 17 rod bundles, 9.03 cm separation between bundles. Boral curtains, 0.713 cm thick, between bundles; 0.645 cm from edge of center bundle. Water-moderated and -reflected.	6.5-2	0.9961 ± 0.0021 Average Group Causing Fission 23.6
11	UO_2 rods, 2.35 wt % U-235, 1.1176 cm diameter. Al cladding, 1.2170 cm o.d., 90.0762 cm thick. Fuel length 91.44 cm. Square pitch = 2.032 cm. 3 x 1 array of 19 x 18 rod bundles, 11.83 cm separation between bundles. Depleted uranium reflecting walls, 10.2 cm thick, 0.10 cm from left and right edges of bundles. Water-moderated and uranium-reflected.	6.5-4	0.9948 ± 0.0022 Average Group Causing Fission 22.6
12	UO_2 rods, 2.35 wt % U-235, 1.1176 cm diameter. Al cladding, 1.270 cm o.d., 0.0762 cm thick. Fuel length 91.44 cm. Square pitch = 2.032 cm. 3 x 1 array of 19 x 18 rod bundles, 14.11 cm separation between bundles. Depleted uranium reflecting walls, 10.2 cm thick, 1.956 cm from left and right edges of bundles. Water-moderated and uranium-reflected.	6.5-4	0.9977 ±0.0018 Average Group Causing Fission 22.8

TABLE 6.5-3 (Continued)
CSAS25-CALCULATED K_{EFF} FOR EXPERIMENTALLY CRITICAL LOW-ENRICHED UO_2 SYSTEMS

Case	Experiment Description[a]	Reference	27-Group $k_{eff} \pm 1\ \sigma$
13	Core I UO_2 rods, 2.46 wt % U-235, 1.03 cm diameter. Al cladding, 1.206 cm o.d., 0.081 cm thick. Fuel length = 153.34 cm. Square pitch = 1.636 cm. 438 rods in cylindrical arrangement. Water-moderated and -reflected.	6.5-3	0.9844 ± 0.0018 Average Group Causing Fission 23.1
14	Core IV UO_2 Rods, 2.46 wt % U-235, 1.03 cm diameter. Al cladding, 1.206 cm o.d., 0.081 cm thick. Fuel length = 153.34 cm. Square pitch = 1.636 cm. 3 x 3 array of 14 x 14 rod bundles, 1-pitch separation with 84 B_4C pins between clusters. Water-moderated and -reflected.	6.5-3	0.9864 ± 0.0019 Average Group Causing Fission 22.6
15	Core V UO_2 rods, 2.46 wt % U-235, 1.03 cm diameter. Al cladding, 1.206 cm o.d., 0.081 cm thick. Fuel length = 153.34 cm. Square pitch = 1.636 cm. 3 x 3 array of 14 x 14 rod bundles, 2-pitch separation with 64 B_4C pins between clusters. Water-moderated and -reflected.	6.5-3	0.9875 ± 0.0017 Average Group Causing Fission 22.8

[a]See Fig. 6.5-2 for a graphical layout for cases 1 to 12.

4.31 wt% ^{235}U-ENRICHED UO_2 RODS



CLADDING: 6061 ALUMINUM TUBING

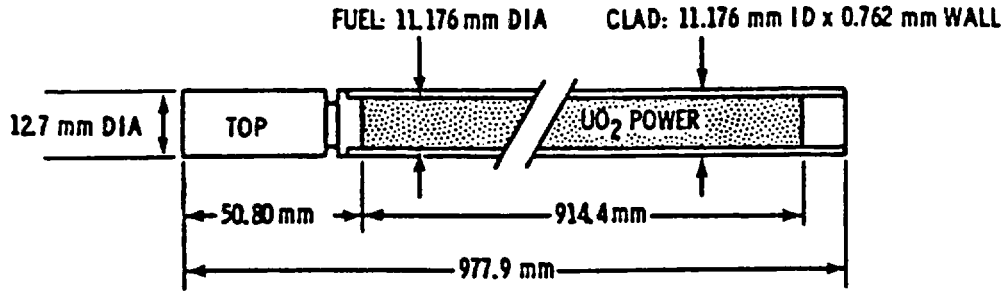
LOADING:

ENRICHMENT – 4.31 ± 0.01 wt% ^{235}U
FUEL DENSITY – 94.9 ± 0.55% OF THEORETICAL DENSITY
URANIUM ASSAY – 88.055 ± 0.261 wt% OF TOTAL FUEL COMPOSITION
UO_2 – 1203.38 ± 4.12 g/ROD

END CAP:

DENSITY – 1.321 g/cm^3
COMPOSITION – C – 58 ± 1 wt%; H – 6.5 ± 0.3 wt%; Ca – 11.4 ± 1.8 wt%; S – 1.7 ± 0.2 wt%; O – 22.1 wt% (BALANCE); Si – 0.3 ± 0.1 wt%

2.35 wt% ^{235}U-ENRICHED UO_2 RODS



CLADDING: 6061 ALUMINUM TUBING SEAL WELDED WITH A LOWER END PLUG OF 5052-H32 ALUMINUM AND A TOP PLUG OF 1100 ALUMINUM

LOADING:

ENRICHMENT – 2.35 ± 0.05 wt% ^{235}U
FUEL DENSITY – 9.20 mg/mm^3 (84% THEORETICAL DENSITY)
URANIUM ASSAY – 88.0 wt%
UO_2 – 825 g/ROD (AVERAGE)

Fig. 6.5-1. The 4.31 wt% U-235–enriched UO_2 rods and 2.35 wt% U-235–enriched UO_2 rods

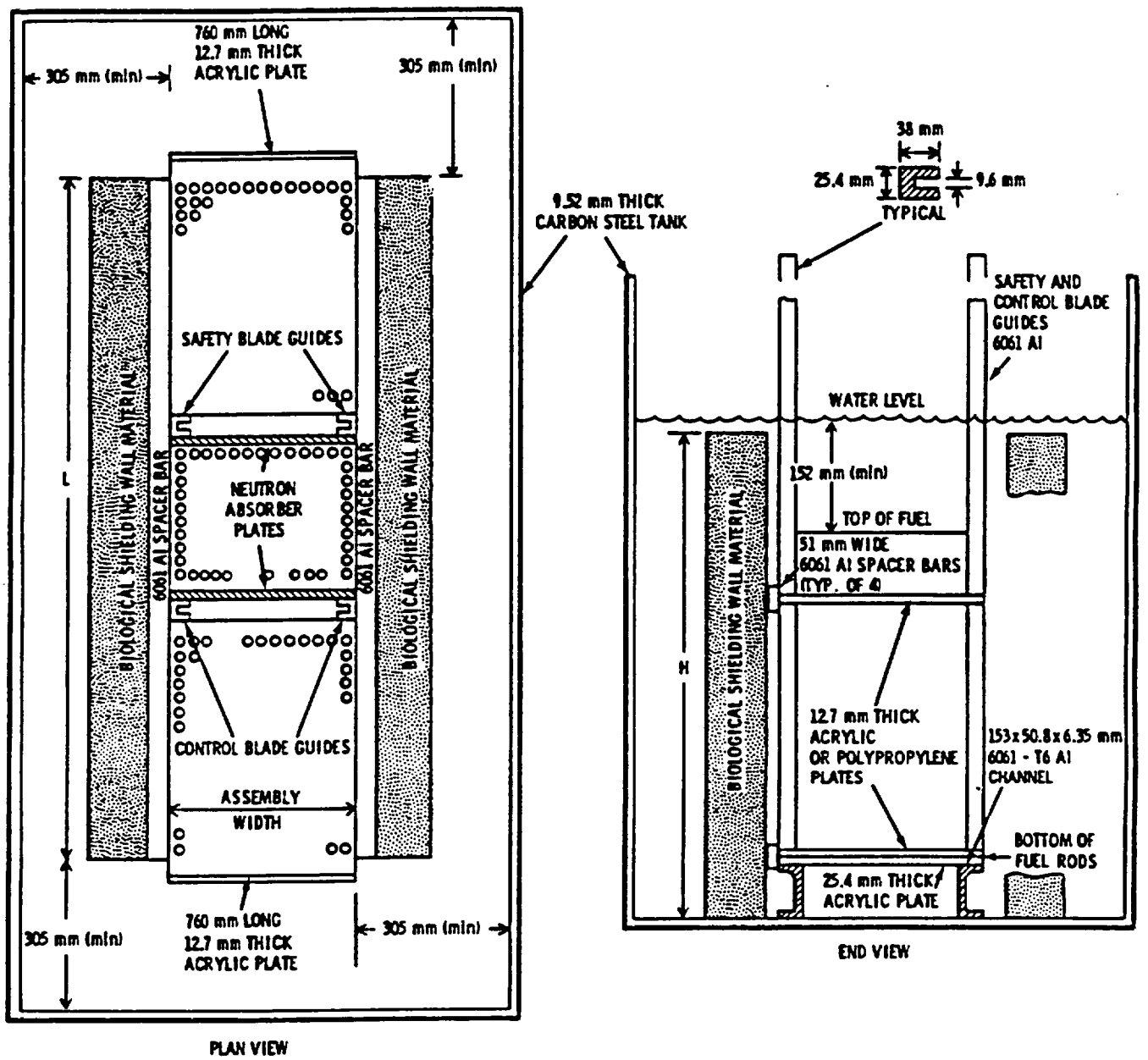


Fig. 6.5-2. Graphical arrangement of Cases 1 to 12

The KENO-V.a calculations modeled the fuel pins explicitly and the rest of the experiment as closely as possible. The models used the exact geometry and materials, with the following three exceptions:

1. The rubber end caps on the fuel rods were modeled as water.
2. The aluminum support structure was ignored.
3. The acrylic plates were treated as water.

The three assumptions are discussed in Ref. 6.5-1, p. 22, and Ref. 6.5-5, p. 238. The references conclude that the effect of the rubber end caps and aluminum support structure is negligible. The acrylic plates used in the experiments were modeled as water because the acrylic material (Plexiglas) has about the same density as water and the neutron-moderating characteristics are almost identical to those of water. These properties, combined with the small volume of acrylic used, have a negligible effect on the results, as discussed in the references cited above.

The complete list of the inputs to CSAS25 for all 15 experiments is given in Section 6.6.

6.5.3 Results of Benchmark Calculations

Table 6.5-3 shows the results for each calculation. The calculations performed by means of the 27-group ENDF/B-IV cross-section library (27BURNUPLIB) show a maximum calculational bias (BIAS) of ±0.0156 in k_{eff} (under prediction). The one-sigma uncertainty associated with the bias (σ_{BIAS}) is 0.0018. The bias is the maximum difference between any calculated benchmark k_{eff} and unity, excluding any cases where the calculated k_{eff} of the benchmark was greater than unity.

TABLE 6.5-4
CASK CONDITIONS COMPARED TO BENCHMARK

Input Name	Average Group Causing Fission	Benchmark Average Group Causing Fission	Pitch/Rod Ratio	Benchmark Pitch/Rod Ratio
MRF01	21.2	22.1 - 23.6	1.541	1.588 - 2.008
MRF02	21.3		1.539	
MRF03	21.3		1.539	
MRF04	21.4		1.579	
MRF05	21.4		1.536	
MRF06	21.4		1.541	
MRF07	21.5		1.568	
MRF08	21.4		1.541	
MRF09	21.4		1.524	
MRF10	21.4		1.513	
MRF11	21.7		1.614	
MRF12	21.5		1.586	
PIT01	21.2		1.539	
PIT02	21.3		1.539	

THIS PAGE LEFT BLANK INTENTIONALLY

6.6 Appendix A

6.6.1 CSAS25 Input Data for Design Calculations

mrf01

```
=CSAS25
4 PWR ASSEM. B&W(15X15) MARK B, BZ, BGD, E=3.1, BU=00,
27BURNUPLIB  LATTICECELL
UO2  1 0.95 293 92235 3.15 92238 96.85 END
ZIRCALLOY  2 1.0 END
H2O  3 1.0 END
B4C  4 0.864 293.0 5010 96.0 5011 4.0 END
SS304  5 1.0 END
URANIUM  6 1.0 293.0 92235 0.3 92238 99.7 END
H2O  7 1.0 END
END COMP
SQUAREPITCH 1.44272 0.936244 1 3 1.0922 2 0.95758 7 END
FLAT FULL HEIGHT GA-4, 4/96, 90% FOR NRC WITH B4C
READ PARAM  TME=200.0 GEN=200 NPG=1000 FLX=NO FDN=NO
NUB=YES END PARAM
READ ARRAY
ARA=1 NUX=17 NUY=17 NUZ=1
FILL
     15 15R16 18
     17 15R13 20
     17 15R13 20
     17 5R13 14 3R13 14 5R13 20
     17 3R13 14 7R13 14 3R13 20
     17 15R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 15R13 20
     17 7R13 14 7R13 20
     17 15R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 15R13 20
     17 3R13 14 7R13 14 3R13 20
     17 5R13 14 3R13 14 5R13 20
     17 15R13 20
     17 15R13 20
     19 15R21 22
     END FILL
ARA=2 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R1 10
     7 15R1 10
     7 5R1 2 3R1 2 5R1 10
     7 3R1 2 7R1 2 3R1 10
     7 15R1 10
     7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
```

```
      7 15R1 10
      7 7R1 2 7R1 10
      7 15R1 10
      7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      7 15R1 10
      7 3R1 2 7R1 2 3R1 10
      7 5R1 2 3R1 2 5R1 10
      7 15R1 10
      9 15R1 10
      33 15R11 12
      END FILL
ARA=3 NUX=17 NUY=17 NUZ=1
FILL
      3 25 13R27 39 29
      26 15R1 10
      28 15R1 10
      28 5R1 2 3R1 2 5R1 10
      28 3R1 2 7R1 2 3R1 10
      28 15R1 10
      28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      28 15R1 10
      28 7R1 2 7R1 10
      28 15R1 10
      28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      28 15R1 10
      28 3R1 2 7R1 2 3R1 10
      28 5R1 2 3R1 2 5R1 10
      28 15R1 10
      40 15R1 10
      30 15R11 12
      END FILL
ARA=4 NUX=17 NUY=17 NUZ=1
FILL
      15 15R16 18
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
```

```
     17 15R35 20
     19 15R21 22
     END FILL
ARA=5 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     9 15R34 10
     33 15R11 12
     END FILL
ARA=6 NUX=17 NUY=17 NUZ=1
FILL
     3 25 13R27 39 29
     26 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     40 15R34 10
     30 15R11 12
     END FILL
ARA=7 NUX=1 NUY=1 NUZ=344
FILL
     7R36
     4R23
     19R31
```

```
     263R24
     20R37
     20R38
     11R36
     END FILL
END ARRAY
READ BNDS -XY=MIRROR   END BNDS
READ GEOM
UNIT 1
CYLINDER 1 1 0.468122 2P0.635
CYLINDER 7 1 0.47879 2P0.635
CYLINDER 2 1 0.5461 2P0.635
CUBOID   3 1 4P0.72136 2P0.635
UNIT 2
CYLINDER 3 1 0.63245 2P0.635
CYLINDER 2 1 0.6731 2P0.635
CUBOID   3 1 4P0.72136 2P0.635
UNIT 3
CUBOID 5 1 4P0.381 2P0.635
UNIT 4
XHEMICYL+Y 4 1 0.5410 1.44272 1.31318
XHEMICYL+Y 0 1 0.5588 1.44272 0.29972
CUBOID     5 1 1.44272 0.0 0.762 0.0 2P0.635
UNIT 5
YHEMICYL+X 4 1 0.5410 1.44272 1.31318
YHEMICYL+X 0 1 0.5588 1.44272 0.29972
CUBOID     5 1 0.762 0.0 1.44272 0.0 2P0.635
UNIT 6
XHEMICYL+Y 4 1 0.5410 2P0.72136
XHEMICYL+Y 0 1 0.5588 2P0.72136
CUBOID     5 1 2P0.72136 0.762 0.0 2P0.635
UNIT 7
YHEMICYL+X 4 1 0.5410 2P0.72136
YHEMICYL+X 0 1 0.5588 2P0.72136
CUBOID     5 1 0.762 0.0 2P0.72136 2P0.635
UNIT 8
XHEMICYL+Y 4 1 0.5410 0.7493 0.0
XHEMICYL+Y 0 1 0.5588 0.7493 0.0
CUBOID     5 1 1.44272 0.0 0.762 0.0 2P0.635
UNIT 9
YHEMICYL+X 4 1 0.5410 0.7493 0.0
YHEMICYL+X 0 1 0.5588 0.7493 0.0
CUBOID     5 1 0.762 0.0 1.44272 0.0 2P0.635
UNIT 10
CUBOID 3 1 2P0.35052 2P0.72136 2P0.635
UNIT 11
CUBOID 3 1 2P0.72136 2P0.35052 2P0.635
UNIT 12
```

```
CUBOID 3 1 4P0.35052 2P0.635
UNIT 13
CYLINDER 1 1 0.468122 2P0.3175
CYLINDER 7 1 0.478789 2P0.3175
CYLINDER 2 1 0.5461 2P0.3175
CUBOID   3 1 4P0.72136 2P0.3175
UNIT 14
CYLINDER 3 1 0.63245 2P0.3175
CYLINDER 2 1 0.6731 2P0.3175
CUBOID   3 1 4P0.72136 2P0.3175
UNIT 15
CUBOID 5 1 4P0.381 2P0.3175
UNIT 16
CUBOID 5 1 2P0.72136 2P0.381 2P0.3175
UNIT 17
CUBOID 5 1 2P0.381 2P0.72136 2P0.3175
UNIT 18
CUBOID 5 1 2P0.35052 2P0.381 2P0.3175
UNIT 19
CUBOID 5 1 2P0.381 2P0.35052 2P0.3175
UNIT 20
CUBOID 3 1 2P0.35052 2P0.72136 2P0.3175
UNIT 21
CUBOID 3 1 2P0.72136 2P0.35052 2P0.3175
UNIT 22
CUBOID 3 1 4P0.35052 2P0.3175
UNIT 23
ARRAY 1 0.0 0.0 -0.3175
UNIT 24
ARRAY 2 0.0 0.0 -0.635
UNIT 25
XHEMICYL+Y 4 1 0.35306 1.44272 0.45974
XHEMICYL+Y 0 1 0.37084 1.44272 0.22352
CUBOID     5 1 1.44272 0.0 0.762 0.0 2P0.635
UNIT 26
YHEMICYL+X 4 1 0.35306 1.44272 0.45974
YHEMICYL+X 0 1 0.37084 1.44272 0.22352
CUBOID     5 1 0.762 0.0 1.44272 0.0 2P0.635
UNIT 27
XHEMICYL+Y 4 1 0.35306 2P0.72136
XHEMICYL+Y 0 1 0.37084 2P0.72136
CUBOID     5 1 2P0.72136 0.762 0.0 2P0.635
UNIT 28
YHEMICYL+X 4 1 0.35306 2P0.72136
YHEMICYL+X 0 1 0.37084 2P0.72136
CUBOID     5 1 0.762 0.0 2P0.72136 2P0.635
UNIT 29
CUBOID     5 1 0.70104 0.0 0.762 0.0 2P0.635
```

```
UNIT 30
CUBOID     5 1 0.762 0.0 0.70104 0.0 2P0.635
UNIT 31
ARRAY 3 0.0 0.0 -0.635
UNIT 32
CUBOID     5 1 0.70104 0.0 0.762 0.0 2P0.635
UNIT 33
CUBOID     5 1 0.762 0.0 0.70104 0.0 2P0.635
UNIT 34
CUBOID     3 1 4P0.72136 2P0.635
UNIT 35
CUBOID     3 1 4P0.72136 2P0.3175
UNIT 36
ARRAY 4  0.0 0.0 -0.3175
UNIT 37
ARRAY 5  0.0 0.0 -0.635
UNIT 38
ARRAY 6  0.0 0.0 -0.635
UNIT 39
XHEMICYL+Y 4 1 0.35306 0.7493 0.0
XHEMICYL+Y 0 1 0.37084 0.7493 0.0
CUBOID     5 1 1.44272 0.0 0.762 0.0 2P0.635
UNIT 40
YHEMICYL+X 4 1 0.35306 0.7493 0.0
YHEMICYL+X 0 1 0.37084 0.7493 0.0
CUBOID     5 1 0.762 0.0 1.44272 0.0 2P0.635
CORE 7 1 0.0 0.0 0.635
CUBOID 3 1 23.2029 0.0 23.2029 0.0 424.815 0.0
CUBOID 5 1 24.1554 0.0 24.1554 0.0 424.815 0.0
CUBOID 6 1 30.8864 0.0 30.8864 0.0 424.815 0.0
CUBOID 5 1 34.6964 0.0 34.6964 0.0 452.755 -24.13
CUBOID 3 1 100.0 0.0 100.0 0.0 510.0 -75.0
END GEOM
END DATA
END
```

mrf02

```
=CSAS25
4 PWR ASSEM. W(15X15) STD/ZC, E=3.1, BU=00,
27BURNUPLIB  LATTICECELL
UO2  1 0.95 293 92235 3.15 92238 96.85 END
ZIRCALLOY  2 1.0 END
H2O  3 1.0 END
B4C  4 0.864 293.0 5010 96.0 5011 4.0 END
SS304  5 1.0 END
URANIUM  6 1.0 293.0 92235 0.3 92238 99.7 END
H2O  7 1.0 END
END COMP
SQUAREPITCH 1.43002 0.92964 1 3 1.07188 2 0.948944 7 END
FLAT FULL HEIGHT GA-4, 4/96, 90% FOR NRC WITH B4C
READ PARAM  TME=200.0 GEN=200 NPG=1000 FLX=NO FDN=NO
NUB=YES END PARAM
READ ARRAY
ARA=1 NUX=17 NUY=17 NUZ=1
FILL
     15 15R16 18
     17 15R13 20
     17 15R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 7R13 14 7R13 20
     17 4R13 14 5R13 14 4R13 20
     17 2R13 14 9R13 14 2R13 20
     17 15R13 20
     17 3R13 14 3R13 14 3R13 14 3R13 20
     17 15R13 20
     17 2R13 14 9R13 14 2R13 20
     17 4R13 14 5R13 14 4R13 20
     17 7R13 14 7R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 15R13 20
     17 15R13 20
     19 15R21 22
     END FILL
ARA=2 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R1 10
     7 15R1 10
     7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
     7 7R1 2 7R1 10
     7 4R1 2 5R1 2 4R1 10
     7 2R1 2 9R1 2 2R1 10
```

```
      7 15R1 10
      7 3R1 2 3R1 2 3R1 2 3R1 10
      7 15R1 10
      7 2R1 2 9R1 2 2R1 10
      7 4R1 2 5R1 2 4R1 10
      7 7R1 2 7R1 10
      7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      7 15R1 10
      9 15R1 10
      33 15R11 12
      END FILL
ARA=3 NUX=17 NUY=17 NUZ=1
FILL
      3 25 13R27 39 29
      26 15R1 10
      28 15R1 10
      28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      28 7R1 2 7R1 10
      28 4R1 2 5R1 2 4R1 10
      28 2R1 2 9R1 2 2R1 10
      28 15R1 10
      28 3R1 2 3R1 2 3R1 2 3R1 10
      28 15R1 10
      28 2R1 2 9R1 2 2R1 10
      28 4R1 2 5R1 2 4R1 10
      28 7R1 2 7R1 10
      28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      28 15R1 10
      40 15R1 10
      30 15R11 12
      END FILL
ARA=4 NUX=17 NUY=17 NUZ=1
FILL
      15 15R16 18
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
```

```
     17 15R35 20
     19 15R21 22
     END FILL
ARA=5 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     9 15R34 10
     33 15R11 12
     END FILL
ARA=6 NUX=17 NUY=17 NUZ=1
FILL
     3 25 13R27 39 29
     26 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     40 15R34 10
     30 15R11 12
     END FILL
ARA=7 NUX=1 NUY=1 NUZ=344
FILL
     7R36
     4R23
     19R31
```

```
     267R24
     16R37
     20R38
     11R36
     END FILL
END ARRAY
READ BNDS -XY=MIRROR   END BNDS
READ GEOM
UNIT 1
CYLINDER 1 1 0.46482 2P0.635
CYLINDER 7 1 0.474472 2P0.635
CYLINDER 2 1 0.53594 2P0.635
CUBOID   3 1 4P0.71501 2P0.635
UNIT 2
CYLINDER 3 1 0.6502 2P0.635
CYLINDER 2 1 0.6934 2P0.635
CUBOID   3 1 4P0.71501 2P0.635
UNIT 3
CUBOID 5 1 4P0.381 2P0.635
UNIT 4
XHEMICYL+Y 4 1 0.5410 1.43002 1.31318
XHEMICYL+Y 0 1 0.5588 1.43002 0.29972
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 5
YHEMICYL+X 4 1 0.5410 1.43002 1.31318
YHEMICYL+X 0 1 0.5588 1.43002 0.29972
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 6
XHEMICYL+Y 4 1 0.5410 2P0.71501
XHEMICYL+Y 0 1 0.5588 2P0.71501
CUBOID     5 1 2P0.71501 0.762 0.0 2P0.635
UNIT 7
YHEMICYL+X 4 1 0.5410 2P0.71501
YHEMICYL+X 0 1 0.5588 2P0.71501
CUBOID     5 1 0.762 0.0 2P0.71501 2P0.635
UNIT 8
XHEMICYL+Y 4 1 0.5410 0.9271 0.0
XHEMICYL+Y 0 1 0.5588 0.9271 0.0
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 9
YHEMICYL+X 4 1 0.5410 0.9271 0.0
YHEMICYL+X 0 1 0.5588 0.9271 0.0
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 10
CUBOID 3 1 2P0.44577 2P0.71501 2P0.635
UNIT 11
CUBOID 3 1 2P0.71501 2P0.44577 2P0.635
UNIT 12
```

```
CUBOID 3 1 4P0.44577 2P0.635
UNIT 13
CYLINDER 1 1 0.46482 2P0.3175
CYLINDER 7 1 0.474472 2P0.3175
CYLINDER 2 1 0.53594 2P0.3175
CUBOID   3 1 4P0.71501 2P0.3175
UNIT 14
CYLINDER 3 1 0.6502 2P0.3175
CYLINDER 2 1 0.6934 2P0.3175
CUBOID   3 1 4P0.71501 2P0.3175
UNIT 15
CUBOID 5 1 4P0.381 2P0.3175
UNIT 16
CUBOID 5 1 2P0.71501 2P0.381 2P0.3175
UNIT 17
CUBOID 5 1 2P0.381 2P0.71501 2P0.3175
UNIT 18
CUBOID 5 1 2P0.44577 2P0.381 2P0.3175
UNIT 19
CUBOID 5 1 2P0.381 2P0.44577 2P0.3175
UNIT 20
CUBOID 3 1 2P0.44577 2P0.71501 2P0.3175
UNIT 21
CUBOID 3 1 2P0.71501 2P0.44577 2P0.3175
UNIT 22
CUBOID 3 1 4P0.44577 2P0.3175
UNIT 23
ARRAY 1 0.0 0.0 -0.3175
UNIT 24
ARRAY 2 0.0 0.0 -0.635
UNIT 25
XHEMICYL+Y 4 1 0.35306 1.43002 0.45974
XHEMICYL+Y 0 1 0.37084 1.43002 0.22352
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 26
YHEMICYL+X 4 1 0.35306 1.43002 0.45974
YHEMICYL+X 0 1 0.37084 1.43002 0.22352
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 27
XHEMICYL+Y 4 1 0.35306 2P0.71501
XHEMICYL+Y 0 1 0.37084 2P0.71501
CUBOID     5 1 2P0.71501 0.762 0.0 2P0.635
UNIT 28
YHEMICYL+X 4 1 0.35306 2P0.71501
YHEMICYL+X 0 1 0.37084 2P0.71501
CUBOID     5 1 0.762 0.0 2P0.71501 2P0.635
UNIT 29
CUBOID     5 1 0.89154 0.0 0.762 0.0 2P0.635
```

```
UNIT 30
CUBOID     5 1 0.762 0.0 0.89154 0.0 2P0.635
UNIT 31
ARRAY 3 0.0 0.0 -0.635
UNIT 32
CUBOID     5 1 0.89154 0.0 0.762 0.0 2P0.635
UNIT 33
CUBOID     5 1 0.762 0.0 0.89154 0.0 2P0.635
UNIT 34
CUBOID     3 1 4P0.71501 2P0.635
UNIT 35
CUBOID     3 1 4P0.71501 2P0.3175
UNIT 36
ARRAY 4  0.0 0.0 -0.3175
UNIT 37
ARRAY 5  0.0 0.0 -0.635
UNIT 38
ARRAY 6  0.0 0.0 -0.635
UNIT 39
XHEMICYL+Y 4 1 0.35306 0.9271 0.0
XHEMICYL+Y 0 1 0.37084 0.9271 0.0
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 40
YHEMICYL+X 4 1 0.35306 0.9271 0.0
YHEMICYL+X 0 1 0.37084 0.9271 0.0
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
CORE 7 1 0.0 0.0 0.635
CUBOID 3 1 23.2029 0.0 23.2029 0.0 424.815 0.0
CUBOID 5 1 24.1554 0.0 24.1554 0.0 424.815 0.0
CUBOID 6 1 30.8864 0.0 30.8864 0.0 424.815 0.0
CUBOID 5 1 34.6964 0.0 34.6964 0.0 452.755 -24.13
CUBOID 3 1 100.0 0.0 100.0 0.0 510.0 -75.0
END GEOM
END DATA
END
```

mrf03

```
=CSAS25
4 PWR ASSEM. W(15X15) OFA, E=3.1, BU=00,
27BURNUPLIB  LATTICECELL
UO2  1 0.95 293 92235 3.15 92238 96.85 END
ZIRCALLOY  2 1.0 END
H2O  3 1.0 END
B4C  4 0.864 293.0 5010 96.0 5011 4.0 END
SS304  5 1.0 END
URANIUM  6 1.0 293.0 92235 0.3 92238 99.7 END
H2O  7 1.0 END
END COMP
SQUAREPITCH 1.43002 0.92964 1 3 1.07188 2 0.948944 7 END
FLAT FULL HEIGHT GA-4, 4/96, 90% FOR NRC WITH B4C
READ PARAM  TME=200.0 GEN=200 NPG=1000 FLX=NO FDN=NO
NUB=YES END PARAM
READ ARRAY
ARA=1 NUX=17 NUY=17 NUZ=1
FILL
     15 15R16 18
     17 15R13 20
     17 15R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 7R13 14 7R13 20
     17 4R13 14 5R13 14 4R13 20
     17 2R13 14 9R13 14 2R13 20
     17 15R13 20
     17 3R13 14 3R13 14 3R13 14 3R13 20
     17 15R13 20
     17 2R13 14 9R13 14 2R13 20
     17 4R13 14 5R13 14 4R13 20
     17 7R13 14 7R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 15R13 20
     17 15R13 20
     19 15R21 22
     END FILL
ARA=2 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R1 10
     7 15R1 10
     7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
     7 7R1 2 7R1 10
     7 4R1 2 5R1 2 4R1 10
     7 2R1 2 9R1 2 2R1 10
```

```
     7 15R1 10
     7 3R1 2 3R1 2 3R1 2 3R1 10
     7 15R1 10
     7 2R1 2 9R1 2 2R1 10
     7 4R1 2 5R1 2 4R1 10
     7 7R1 2 7R1 10
     7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
     7 15R1 10
     9 15R1 10
     33 15R11 12
     END FILL
ARA=3 NUX=17 NUY=17 NUZ=1
FILL
     3 25 13R27 39 29
     26 15R1 10
     28 15R1 10
     28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
     28 7R1 2 7R1 10
     28 4R1 2 5R1 2 4R1 10
     28 2R1 2 9R1 2 2R1 10
     28 15R1 10
     28 3R1 2 3R1 2 3R1 2 3R1 10
     28 15R1 10
     28 2R1 2 9R1 2 2R1 10
     28 4R1 2 5R1 2 4R1 10
     28 7R1 2 7R1 10
     28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
     28 15R1 10
     40 15R1 10
     30 15R11 12
     END FILL
ARA=4 NUX=17 NUY=17 NUZ=1
FILL
     15 15R16 18
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
```

```
     17 15R35 20
     19 15R21 22
     END FILL
ARA=5 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     9 15R34 10
     33 15R11 12
     END FILL
ARA=6 NUX=17 NUY=17 NUZ=1
FILL
     3 25 13R27 39 29
     26 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     40 15R34 10
     30 15R11 12
     END FILL
ARA=7 NUX=1 NUY=1 NUZ=344
FILL
     7R36
     4R23
     19R31
```

```
     267R24
     16R37
     20R38
     11R36
     END FILL
END ARRAY
READ BNDS -XY=MIRROR   END BNDS
READ GEOM
UNIT 1
CYLINDER 1 1 0.46482 2P0.635
CYLINDER 7 1 0.474472 2P0.635
CYLINDER 2 1 0.53594 2P0.635
CUBOID   3 1 4P0.71501 2P0.635
UNIT 2
CYLINDER 3 1 0.6502 2P0.635
CYLINDER 2 1 0.6934 2P0.635
CUBOID   3 1 4P0.71501 2P0.635
UNIT 3
CUBOID 5 1 4P0.381 2P0.635
UNIT 4
XHEMICYL+Y 4 1 0.5410 1.43002 1.31318
XHEMICYL+Y 0 1 0.5588 1.43002 0.29972
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 5
YHEMICYL+X 4 1 0.5410 1.43002 1.31318
YHEMICYL+X 0 1 0.5588 1.43002 0.29972
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 6
XHEMICYL+Y 4 1 0.5410 2P0.71501
XHEMICYL+Y 0 1 0.5588 2P0.71501
CUBOID     5 1 2P0.71501 0.762 0.0 2P0.635
UNIT 7
YHEMICYL+X 4 1 0.5410 2P0.71501
YHEMICYL+X 0 1 0.5588 2P0.71501
CUBOID     5 1 0.762 0.0 2P0.71501 2P0.635
UNIT 8
XHEMICYL+Y 4 1 0.5410 0.9271 0.0
XHEMICYL+Y 0 1 0.5588 0.9271 0.0
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 9
YHEMICYL+X 4 1 0.5410 0.9271 0.0
YHEMICYL+X 0 1 0.5588 0.9271 0.0
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 10
CUBOID 3 1 2P0.44577 2P0.71501 2P0.635
UNIT 11
CUBOID 3 1 2P0.71501 2P0.44577 2P0.635
UNIT 12
```

```
CUBOID 3 1 4P0.44577 2P0.635
UNIT 13
CYLINDER 1 1 0.46482 2P0.3175
CYLINDER 7 1 0.474472 2P0.3175
CYLINDER 2 1 0.53594 2P0.3175
CUBOID   3 1 4P0.71501 2P0.3175
UNIT 14
CYLINDER 3 1 0.6502 2P0.3175
CYLINDER 2 1 0.6934 2P0.3175
CUBOID   3 1 4P0.71501 2P0.3175
UNIT 15
CUBOID 5 1 4P0.381 2P0.3175
UNIT 16
CUBOID 5 1 2P0.71501 2P0.381 2P0.3175
UNIT 17
CUBOID 5 1 2P0.381 2P0.71501 2P0.3175
UNIT 18
CUBOID 5 1 2P0.44577 2P0.381 2P0.3175
UNIT 19
CUBOID 5 1 2P0.381 2P0.44577 2P0.3175
UNIT 20
CUBOID 3 1 2P0.44577 2P0.71501 2P0.3175
UNIT 21
CUBOID 3 1 2P0.71501 2P0.44577 2P0.3175
UNIT 22
CUBOID 3 1 4P0.44577 2P0.3175
UNIT 23
ARRAY 1 0.0 0.0 -0.3175
UNIT 24
ARRAY 2 0.0 0.0 -0.635
UNIT 25
XHEMICYL+Y 4 1 0.35306 1.43002 0.45974
XHEMICYL+Y 0 1 0.37084 1.43002 0.22352
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 26
YHEMICYL+X 4 1 0.35306 1.43002 0.45974
YHEMICYL+X 0 1 0.37084 1.43002 0.22352
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 27
XHEMICYL+Y 4 1 0.35306 2P0.71501
XHEMICYL+Y 0 1 0.37084 2P0.71501
CUBOID     5 1 2P0.71501 0.762 0.0 2P0.635
UNIT 28
YHEMICYL+X 4 1 0.35306 2P0.71501
YHEMICYL+X 0 1 0.37084 2P0.71501
CUBOID     5 1 0.762 0.0 2P0.71501 2P0.635
UNIT 29
CUBOID     5 1 0.89154 0.0 0.762 0.0 2P0.635
```

```
UNIT 30
CUBOID     5 1 0.762 0.0 0.89154 0.0 2P0.635
UNIT 31
ARRAY 3 0.0 0.0 -0.635
UNIT 32
CUBOID     5 1 0.89154 0.0 0.762 0.0 2P0.635
UNIT 33
CUBOID     5 1 0.762 0.0 0.89154 0.0 2P0.635
UNIT 34
CUBOID     3 1 4P0.71501 2P0.635
UNIT 35
CUBOID     3 1 4P0.71501 2P0.3175
UNIT 36
ARRAY 4  0.0 0.0 -0.3175
UNIT 37
ARRAY 5  0.0 0.0 -0.635
UNIT 38
ARRAY 6  0.0 0.0 -0.635
UNIT 39
XHEMICYL+Y 4 1 0.35306 0.9271 0.0
XHEMICYL+Y 0 1 0.37084 0.9271 0.0
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 40
YHEMICYL+X 4 1 0.35306 0.9271 0.0
YHEMICYL+X 0 1 0.37084 0.9271 0.0
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
CORE 7 1 0.0 0.0 0.635
CUBOID 3 1 23.2029 0.0 23.2029 0.0 424.815 0.0
CUBOID 5 1 24.1554 0.0 24.1554 0.0 424.815 0.0
CUBOID 6 1 30.8864 0.0 30.8864 0.0 424.815 0.0
CUBOID 5 1 34.6964 0.0 34.6964 0.0 452.755 -24.13
CUBOID 3 1 100.0 0.0 100.0 0.0 510.0 -75.0
END GEOM
END DATA
END
```

mrf04

```
=CSAS25
4 PWR ASSEM. EXXON/ANF(15X15) WE, E=3.1, BU=00,
27BURNUPLIB  LATTICECELL
UO2  1 0.95 293 92235 3.15 92238 96.85 END
ZIRCALLOY  2 1.0 END
H2O  3 1.0 END
B4C  4 0.864 293.0 5010 96.0 5011 4.0 END
SS304  5 1.0 END
URANIUM  6 1.0 293.0 92235 0.3 92238 99.7 END
H2O  7 1.0 END
END COMP
SQUAREPITCH 1.43002 0.90551 1 3 1.07696 2 0.92456 7 END
FLAT FULL HEIGHT GA-4, 4/96, 90% FOR NRC WITH B4C
READ PARAM  TME=200.0 GEN=200 NPG=1000 FLX=NO FDN=NO
NUB=YES END PARAM
READ ARRAY
ARA=1 NUX=17 NUY=17 NUZ=1
FILL
     15 15R16 18
     17 15R13 20
     17 15R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 7R13 14 7R13 20
     17 4R13 14 5R13 14 4R13 20
     17 2R13 14 9R13 14 2R13 20
     17 15R13 20
     17 3R13 14 3R13 14 3R13 14 3R13 20
     17 15R13 20
     17 2R13 14 9R13 14 2R13 20
     17 4R13 14 5R13 14 4R13 20
     17 7R13 14 7R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 15R13 20
     17 15R13 20
     19 15R21 22
     END FILL
ARA=2 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R1 10
     7 15R1 10
     7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
     7 7R1 2 7R1 10
     7 4R1 2 5R1 2 4R1 10
     7 2R1 2 9R1 2 2R1 10
```

```
      7 15R1 10
      7 3R1 2 3R1 2 3R1 2 3R1 10
      7 15R1 10
      7 2R1 2 9R1 2 2R1 10
      7 4R1 2 5R1 2 4R1 10
      7 7R1 2 7R1 10
      7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      7 15R1 10
      9 15R1 10
      33 15R11 12
      END FILL
ARA=3 NUX=17 NUY=17 NUZ=1
FILL
      3 25 13R27 39 29
      26 15R1 10
      28 15R1 10
      28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      28 7R1 2 7R1 10
      28 4R1 2 5R1 2 4R1 10
      28 2R1 2 9R1 2 2R1 10
      28 15R1 10
      28 3R1 2 3R1 2 3R1 2 3R1 10
      28 15R1 10
      28 2R1 2 9R1 2 2R1 10
      28 4R1 2 5R1 2 4R1 10
      28 7R1 2 7R1 10
      28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      28 15R1 10
      40 15R1 10
      30 15R11 12
      END FILL
ARA=4 NUX=17 NUY=17 NUZ=1
FILL
      15 15R16 18
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
```

```
     17 15R35 20
     19 15R21 22
     END FILL
ARA=5 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     9 15R34 10
     33 15R11 12
     END FILL
ARA=6 NUX=17 NUY=17 NUZ=1
FILL
     3 25 13R27 39 29
     26 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     40 15R34 10
     30 15R11 12
     END FILL
ARA=7 NUX=1 NUY=1 NUZ=344
FILL
     7R36
     4R23
     19R31
```

```
     267R24
     16R37
     20R38
     11R36
     END FILL
END ARRAY
READ BNDS -XY=MIRROR   END BNDS
READ GEOM
UNIT 1
CYLINDER 1 1 0.452755 2P0.635
CYLINDER 7 1 0.46228 2P0.635
CYLINDER 2 1 0.53848 2P0.635
CUBOID   3 1 4P0.71501 2P0.635
UNIT 2
CYLINDER 3 1 0.6502 2P0.635
CYLINDER 2 1 0.6934 2P0.635
CUBOID   3 1 4P0.71501 2P0.635
UNIT 3
CUBOID 5 1 4P0.381 2P0.635
UNIT 4
XHEMICYL+Y 4 1 0.5410 1.43002 1.31318
XHEMICYL+Y 0 1 0.5588 1.43002 0.29972
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 5
YHEMICYL+X 4 1 0.5410 1.43002 1.31318
YHEMICYL+X 0 1 0.5588 1.43002 0.29972
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 6
XHEMICYL+Y 4 1 0.5410 2P0.71501
XHEMICYL+Y 0 1 0.5588 2P0.71501
CUBOID     5 1 2P0.71501 0.762 0.0 2P0.635
UNIT 7
YHEMICYL+X 4 1 0.5410 2P0.71501
YHEMICYL+X 0 1 0.5588 2P0.71501
CUBOID     5 1 0.762 0.0 2P0.71501 2P0.635
UNIT 8
XHEMICYL+Y 4 1 0.5410 0.9271 0.0
XHEMICYL+Y 0 1 0.5588 0.9271 0.0
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 9
YHEMICYL+X 4 1 0.5410 0.9271 0.0
YHEMICYL+X 0 1 0.5588 0.9271 0.0
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 10
CUBOID 3 1 2P0.44577 2P0.71501 2P0.635
UNIT 11
CUBOID 3 1 2P0.71501 2P0.44577 2P0.635
UNIT 12
```

```
CUBOID 3 1 4P0.44577 2P0.635
UNIT 13
CYLINDER 1 1 0.452755 2P0.3175
CYLINDER 7 1 0.46228 2P0.3175
CYLINDER 2 1 0.53848 2P0.3175
CUBOID   3 1 4P0.71501 2P0.3175
UNIT 14
CYLINDER 3 1 0.6502 2P0.3175
CYLINDER 2 1 0.6934 2P0.3175
CUBOID   3 1 4P0.71501 2P0.3175
UNIT 15
CUBOID 5 1 4P0.381 2P0.3175
UNIT 16
CUBOID 5 1 2P0.71501 2P0.381 2P0.3175
UNIT 17
CUBOID 5 1 2P0.381 2P0.71501 2P0.3175
UNIT 18
CUBOID 5 1 2P0.44577 2P0.381 2P0.3175
UNIT 19
CUBOID 5 1 2P0.381 2P0.44577 2P0.3175
UNIT 20
CUBOID 3 1 2P0.44577 2P0.71501 2P0.3175
UNIT 21
CUBOID 3 1 2P0.71501 2P0.44577 2P0.3175
UNIT 22
CUBOID 3 1 4P0.44577 2P0.3175
UNIT 23
ARRAY 1 0.0 0.0 -0.3175
UNIT 24
ARRAY 2 0.0 0.0 -0.635
UNIT 25
XHEMICYL+Y 4 1 0.35306 1.43002 0.45974
XHEMICYL+Y 0 1 0.37084 1.43002 0.22352
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 26
YHEMICYL+X 4 1 0.35306 1.43002 0.45974
YHEMICYL+X 0 1 0.37084 1.43002 0.22352
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 27
XHEMICYL+Y 4 1 0.35306 2P0.71501
XHEMICYL+Y 0 1 0.37084 2P0.71501
CUBOID     5 1 2P0.71501 0.762 0.0 2P0.635
UNIT 28
YHEMICYL+X 4 1 0.35306 2P0.71501
YHEMICYL+X 0 1 0.37084 2P0.71501
CUBOID     5 1 0.762 0.0 2P0.71501 2P0.635
UNIT 29
CUBOID     5 1 0.89154 0.0 0.762 0.0 2P0.635
```

```
UNIT 30
CUBOID     5 1 0.762 0.0 0.89154 0.0 2P0.635
UNIT 31
ARRAY 3 0.0 0.0 -0.635
UNIT 32
CUBOID     5 1 0.89154 0.0 0.762 0.0 2P0.635
UNIT 33
CUBOID     5 1 0.762 0.0 0.89154 0.0 2P0.635
UNIT 34
CUBOID     3 1 4P0.71501 2P0.635
UNIT 35
CUBOID     3 1 4P0.71501 2P0.3175
UNIT 36
ARRAY 4  0.0 0.0 -0.3175
UNIT 37
ARRAY 5  0.0 0.0 -0.635
UNIT 38
ARRAY 6  0.0 0.0 -0.635
UNIT 39
XHEMICYL+Y 4 1 0.35306 0.9271 0.0
XHEMICYL+Y 0 1 0.37084 0.9271 0.0
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 40
YHEMICYL+X 4 1 0.35306 0.9271 0.0
YHEMICYL+X 0 1 0.37084 0.9271 0.0
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
CORE 7 1 0.0 0.0 0.635
CUBOID 3 1 23.2029 0.0 23.2029 0.0 424.815 0.0
CUBOID 5 1 24.1554 0.0 24.1554 0.0 424.815 0.0
CUBOID 6 1 30.8864 0.0 30.8864 0.0 424.815 0.0
CUBOID 5 1 34.6964 0.0 34.6964 0.0 452.755 -24.13
CUBOID 3 1 100.0 0.0 100.0 0.0 510.0 -75.0
END GEOM
END DATA
END
```

mrf05

```
=CSAS25
4 PWR ASSEM. CE(15X15) PALIS., E=3.1, BU=00,
27BURNUPLIB  LATTICECELL
UO2  1 0.95 293 92235 3.15 92238 96.85 END
ZIRCALLOY  2 1.0 END
H2O  3 1.0 END
B4C  4 0.864 293.0 5010 96.0 5011 4.0 END
SS304  5 1.0 END
URANIUM  6 1.0 293.0 92235 0.3 92238 99.7 END
H2O  7 1.0 END
END COMP
SQUAREPITCH 1.397 0.90932 1 3 1.06172 2 0.92964 7 END
FLAT FULL HEIGHT GA-4, 4/96, 90% FOR NRC WITH B4C
READ PARAM  TME=200.0 GEN=200 NPG=1000 FLX=NO FDN=NO
NUB=YES END PARAM
READ ARRAY
ARA=1 NUX=17 NUY=17 NUZ=1
FILL
     15 15R16 18
     17 15R13 20
     17 15R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 7R13 14 7R13 20
     17 4R13 14 5R13 14 4R13 20
     17 2R13 14 9R13 14 2R13 20
     17 15R13 20
     17 3R13 14 3R13 14 3R13 14 3R13 20
     17 15R13 20
     17 2R13 14 9R13 14 2R13 20
     17 4R13 14 5R13 14 4R13 20
     17 7R13 14 7R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 15R13 20
     17 15R13 20
     19 15R21 22
     END FILL
ARA=2 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R1 10
     7 15R1 10
     7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
     7 7R1 2 7R1 10
     7 4R1 2 5R1 2 4R1 10
     7 2R1 2 9R1 2 2R1 10
```

```
     7 15R1 10
     7 3R1 2 3R1 2 3R1 2 3R1 10
     7 15R1 10
     7 2R1 2 9R1 2 2R1 10
     7 4R1 2 5R1 2 4R1 10
     7 7R1 2 7R1 10
     7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
     7 15R1 10
     9 15R1 10
     33 15R11 12
     END FILL
ARA=3 NUX=17 NUY=17 NUZ=1
FILL
     3 25 13R27 39 29
     26 15R1 10
     28 15R1 10
     28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
     28 7R1 2 7R1 10
     28 4R1 2 5R1 2 4R1 10
     28 2R1 2 9R1 2 2R1 10
     28 15R1 10
     28 3R1 2 3R1 2 3R1 2 3R1 10
     28 15R1 10
     28 2R1 2 9R1 2 2R1 10
     28 4R1 2 5R1 2 4R1 10
     28 7R1 2 7R1 10
     28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
     28 15R1 10
     40 15R1 10
     30 15R11 12
     END FILL
ARA=4 NUX=17 NUY=17 NUZ=1
FILL
     15 15R16 18
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
     17 15R35 20
```

```
     17 15R35 20
     19 15R21 22
     END FILL
ARA=5 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     9 15R34 10
     33 15R11 12
     END FILL
ARA=6 NUX=17 NUY=17 NUZ=1
FILL
     3 25 13R27 39 29
     26 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     40 15R34 10
     30 15R11 12
     END FILL
ARA=7 NUX=1 NUY=1 NUZ=344
FILL
     7R36
     4R23
     19R31
```

```
     267R24
     16R37
     20R38
     11R36
     END FILL
END ARRAY
READ BNDS -XY=MIRROR   END BNDS
READ GEOM
UNIT 1
CYLINDER 1 1 0.45466 2P0.635
CYLINDER 7 1 0.46482 2P0.635
CYLINDER 2 1 0.53086 2P0.635
CUBOID   3 1 4P0.6985 2P0.635
UNIT 2
CYLINDER 3 1 0.6502 2P0.635
CYLINDER 2 1 0.6934 2P0.635
CUBOID   3 1 4P0.6985 2P0.635
UNIT 3
CUBOID 5 1 4P0.381 2P0.635
UNIT 4
XHEMICYL+Y 4 1 0.5410 1.397 1.31318
XHEMICYL+Y 0 1 0.5588 1.397 0.29972
CUBOID     5 1 1.397 0.0 0.762 0.0 2P0.635
UNIT 5
YHEMICYL+X 4 1 0.5410 1.397 1.31318
YHEMICYL+X 0 1 0.5588 1.397 0.29972
CUBOID     5 1 0.762 0.0 1.397 0.0 2P0.635
UNIT 6
XHEMICYL+Y 4 1 0.5410 2P0.6985
XHEMICYL+Y 0 1 0.5588 2P0.6985
CUBOID     5 1 2P0.6985 0.762 0.0 2P0.635
UNIT 7
YHEMICYL+X 4 1 0.5410 2P0.6985
YHEMICYL+X 0 1 0.5588 2P0.6985
CUBOID     5 1 0.762 0.0 2P0.6985 2P0.635
UNIT 8
XHEMICYL+Y 4 1 0.5410 1.38938 0.0
XHEMICYL+Y 0 1 0.5588 1.38938 0.0
CUBOID     5 1 1.397 0.0 0.762 0.0 2P0.635
UNIT 9
YHEMICYL+X 4 1 0.5410 1.38938 0.0
YHEMICYL+X 0 1 0.5588 1.38938 0.0
CUBOID     5 1 0.762 0.0 1.397 0.0 2P0.635
UNIT 10
CUBOID 3 1 2P0.69342 2P0.6985 2P0.635
UNIT 11
CUBOID 3 1 2P0.6985 2P0.69342 2P0.635
UNIT 12
```

```
CUBOID 3 1 4P0.69342 2P0.635
UNIT 13
CYLINDER 1 1 0.45466 2P0.3175
CYLINDER 7 1 0.46482 2P0.3175
CYLINDER 2 1 0.53086 2P0.3175
CUBOID   3 1 4P0.6985 2P0.3175
UNIT 14
CYLINDER 3 1 0.6502 2P0.3175
CYLINDER 2 1 0.6934 2P0.3175
CUBOID   3 1 4P0.6985 2P0.3175
UNIT 15
CUBOID 5 1 4P0.381 2P0.3175
UNIT 16
CUBOID 5 1 2P0.6985 2P0.381 2P0.3175
UNIT 17
CUBOID 5 1 2P0.381 2P0.6985 2P0.3175
UNIT 18
CUBOID 5 1 2P0.69342 2P0.381 2P0.3175
UNIT 19
CUBOID 5 1 2P0.381 2P0.69342 2P0.3175
UNIT 20
CUBOID 3 1 2P0.69342 2P0.6985 2P0.3175
UNIT 21
CUBOID 3 1 2P0.6985 2P0.69342 2P0.3175
UNIT 22
CUBOID 3 1 4P0.69342 2P0.3175
UNIT 23
ARRAY 1 0.0 0.0 -0.3175
UNIT 24
ARRAY 2 0.0 0.0 -0.635
UNIT 25
XHEMICYL+Y 4 1 0.35306 1.397 0.45974
XHEMICYL+Y 0 1 0.37084 1.397 0.22352
CUBOID     5 1 1.397 0.0 0.762 0.0 2P0.635
UNIT 26
YHEMICYL+X 4 1 0.35306 1.397 0.45974
YHEMICYL+X 0 1 0.37084 1.397 0.22352
CUBOID     5 1 0.762 0.0 1.397 0.0 2P0.635
UNIT 27
XHEMICYL+Y 4 1 0.35306 2P0.6985
XHEMICYL+Y 0 1 0.37084 2P0.6985
CUBOID     5 1 2P0.6985 0.762 0.0 2P0.635
UNIT 28
YHEMICYL+X 4 1 0.35306 2P0.6985
YHEMICYL+X 0 1 0.37084 2P0.6985
CUBOID     5 1 0.762 0.0 2P0.6985 2P0.635
UNIT 29
CUBOID     5 1 1.38684 0.0 0.762 0.0 2P0.635
```

```
UNIT 30
CUBOID     5 1 0.762 0.0 1.38684 0.0 2P0.635
UNIT 31
ARRAY 3 0.0 0.0 -0.635
UNIT 32
CUBOID     5 1 1.38684 0.0 0.762 0.0 2P0.635
UNIT 33
CUBOID     5 1 0.762 0.0 1.38684 0.0 2P0.635
UNIT 34
CUBOID     3 1 4P0.6985 2P0.635
UNIT 35
CUBOID     3 1 4P0.6985 2P0.3175
UNIT 36
ARRAY 4  0.0 0.0 -0.3175
UNIT 37
ARRAY 5  0.0 0.0 -0.635
UNIT 38
ARRAY 6  0.0 0.0 -0.635
UNIT 39
XHEMICYL+Y 4 1 0.35306 1.38938 0.0
XHEMICYL+Y 0 1 0.37084 1.38938 0.0
CUBOID     5 1 1.397 0.0 0.762 0.0 2P0.635
UNIT 40
YHEMICYL+X 4 1 0.35306 1.38938 0.0
YHEMICYL+X 0 1 0.37084 1.38938 0.0
CUBOID     5 1 0.762 0.0 1.397 0.0 2P0.635
CORE 7 1 0.0 0.0 0.635
CUBOID 3 1 23.2029 0.0 23.2029 0.0 424.815 0.0
CUBOID 5 1 24.1554 0.0 24.1554 0.0 424.815 0.0
CUBOID 6 1 30.8864 0.0 30.8864 0.0 424.815 0.0
CUBOID 5 1 34.6964 0.0 34.6964 0.0 452.755 -24.13
CUBOID 3 1 100.0 0.0 100.0 0.0 510.0 -75.0
END GEOM
END DATA
END
```

mrf06

```
=CSAS25
4 PWR ASSEM. CE(14X14) STD, E=3.1, BU=00,
27BURNUPLIB  LATTICECELL
UO2  1 0.95 293 92235 3.15 92238 96.85 END
ZIRCALLOY  2 1.0 END
H2O  3 1.0 END
B4C  4 0.864 293.0 5010 96.0 5011 4.0 END
SS304  5 1.0 END
URANIUM  6 1.0 293.0 92235 0.3 92238 99.7 END
H2O  7 1.0 END
END COMP
SQUAREPITCH 1.4732 0.95631 1 3 1.1176 2 0.97536 7 END
FLAT FULL HEIGHT GA-4, 4/96, 90% FOR NRC WITH B4C
READ PARAM  TME=200.0 GEN=200 NPG=1000 FLX=NO FDN=NO
NUB=YES END PARAM
READ ARRAY
ARA=1 NUX=16 NUY=16 NUZ=1
FILL
     15 14R16 18
     17 14R13 20
     17 14R13 20
     17 2R13 2R14 6R13 2R14 2R13 20
     17 2R13 2R14 6R13 2R14 2R13 20
     17 14R13 20
     17 14R13 20
     17 6R13 2R14 6R13 20
     17 6R13 2R14 6R13 20
     17 14R13 20
     17 14R13 20
     17 2R13 2R14 6R13 2R14 2R13 20
     17 2R13 2R14 6R13 2R14 2R13 20
     17 14R13 20
     17 14R13 20
     19 14R21 22
     END FILL
ARA=2 NUX=16 NUY=16 NUZ=1
FILL
     3 4 13R6 32
     5 14R1 10
     7 14R1 10
     7 2R1 2R2 6R1 2R2 2R1 10
     7 2R1 2R2 6R1 2R2 2R1 10
     7 14R1 10
     7 14R1 10
     7 6R1 2R2 6R1 10
```

```
      7 6R1 2R2 6R1 10
      7 14R1 10
      7 14R1 10
      7 2R1 2R2 6R1 2R2 2R1 10
      7 2R1 2R2 6R1 2R2 2R1 10
      7 14R1 10
      7 14R1 10
      33 14R11 12
      END FILL
ARA=3 NUX=16 NUY=16 NUZ=1
FILL
      3 25 13R27 29
      26 14R1 10
      28 14R1 10
      28 2R1 2R2 6R1 2R2 2R1 10
      28 2R1 2R2 6R1 2R2 2R1 10
      28 14R1 10
      28 14R1 10
      28 6R1 2R2 6R1 10
      28 6R1 2R2 6R1 10
      28 14R1 10
      28 14R1 10
      28 2R1 2R2 6R1 2R2 2R1 10
      28 2R1 2R2 6R1 2R2 2R1 10
      28 14R1 10
      28 14R1 10
      30 14R11 12
      END FILL
ARA=4 NUX=16 NUY=16 NUZ=1
FILL
      15 14R16 18
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      19 14R21 22
      END FILL
ARA=5 NUX=16 NUY=16 NUZ=1
```

```
FILL
     3 4 13R6 32
     5 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     33 14R11 12
     END FILL
ARA=6 NUX=16 NUY=16 NUZ=1
FILL
     3 25 13R27 29
     26 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     30 14R11 12
     END FILL
ARA=7 NUX=1 NUY=1 NUZ=344
FILL
     7R36
     4R23
     19R31
     253R24
     30R37
     20R38
     11R36
     END FILL
END ARRAY
```

```
READ BNDS -XY=MIRROR   END BNDS
READ GEOM
UNIT 1
CYLINDER 1 1 0.478155 2P0.635
CYLINDER 7 1 0.48768 2P0.635
CYLINDER 2 1 0.5588 2P0.635
CUBOID   3 1 4P0.7366 2P0.635
UNIT 2
CUBOID   3 1 4P0.7366 2P0.635
UNIT 3
CUBOID 5 1 4P0.381 2P0.635
UNIT 4
XHEMICYL+Y 4 1 0.5410 1.4732 1.31318
XHEMICYL+Y 0 1 0.5588 1.4732 0.29972
CUBOID     5 1 1.4732 0.0 0.762 0.0 2P0.635
UNIT 5
YHEMICYL+X 4 1 0.5410 1.4732 1.31318
YHEMICYL+X 0 1 0.5588 1.4732 0.29972
CUBOID     5 1 0.762 0.0 1.4732 0.0 2P0.635
UNIT 6
XHEMICYL+Y 4 1 0.5410 2P0.7366
XHEMICYL+Y 0 1 0.5588 2P0.7366
CUBOID     5 1 2P0.7366 0.762 0.0 2P0.635
UNIT 7
YHEMICYL+X 4 1 0.5410 2P0.7366
YHEMICYL+X 0 1 0.5588 2P0.7366
CUBOID     5 1 0.762 0.0 2P0.7366 2P0.635
UNIT 8
XHEMICYL+Y 4 1 0.5410 0.78994 0.0
XHEMICYL+Y 0 1 0.5588 0.78994 0.0
CUBOID     5 1 1.25984 0.0 0.762 0.0 2P0.635
UNIT 9
YHEMICYL+X 4 1 0.5410 0.78994 0.0
YHEMICYL+X 0 1 0.5588 0.78994 0.0
CUBOID     5 1 0.762 0.0 1.25984 0.0 2P0.635
UNIT 10
CUBOID 3 1 2P0.85852 2P0.7366 2P0.635
UNIT 11
CUBOID 3 1 2P0.7366 2P0.85852 2P0.635
UNIT 12
CUBOID 3 1 4P0.85852 2P0.635
UNIT 13
CYLINDER 1 1 0.478155 2P0.3175
CYLINDER 7 1 0.48768 2P0.3175
CYLINDER 2 1 0.5588 2P0.3175
CUBOID   3 1 4P0.7366 2P0.3175
UNIT 14
CUBOID   3 1 4P0.7366 2P0.3175
```

```
UNIT 15
CUBOID 5 1 4P0.381 2P0.3175
UNIT 16
CUBOID 5 1 2P0.7366 2P0.381 2P0.3175
UNIT 17
CUBOID 5 1 2P0.381 2P0.7366 2P0.3175
UNIT 18
CUBOID 5 1 2P0.85852 2P0.381 2P0.3175
UNIT 19
CUBOID 5 1 2P0.381 2P0.85852 2P0.3175
UNIT 20
CUBOID 3 1 2P0.85852 2P0.7366 2P0.3175
UNIT 21
CUBOID 3 1 2P0.7366 2P0.85852 2P0.3175
UNIT 22
CUBOID 3 1 4P0.85852 2P0.3175
UNIT 23
ARRAY 1 0.0 0.0 -0.3175
UNIT 24
ARRAY 2 0.0 0.0 -0.635
UNIT 25
XHEMICYL+Y 4 1 0.35306 1.4732 0.45974
XHEMICYL+Y 0 1 0.37084 1.4732 0.22352
CUBOID     5 1 1.4732 0.0 0.762 0.0 2P0.635
UNIT 26
YHEMICYL+X 4 1 0.35306 1.4732 0.45974
YHEMICYL+X 0 1 0.37084 1.4732 0.22352
CUBOID     5 1 0.762 0.0 1.4732 0.0 2P0.635
UNIT 27
XHEMICYL+Y 4 1 0.35306 2P0.7366
XHEMICYL+Y 0 1 0.37084 2P0.7366
CUBOID     5 1 2P0.7366 0.762 0.0 2P0.635
UNIT 28
YHEMICYL+X 4 1 0.35306 2P0.7366
YHEMICYL+X 0 1 0.37084 2P0.7366
CUBOID     5 1 0.762 0.0 2P0.7366 2P0.635
UNIT 29
XHEMICYL+Y 4 1 0.35306 0.32258 0.0
XHEMICYL+Y 0 1 0.37084 0.32258 0.0
CUBOID     5 1 1.71704 0.0 0.762 0.0 2P0.635
UNIT 30
YHEMICYL+X 4 1 0.35306 0.32258 0.0
YHEMICYL+X 0 1 0.37084 0.32258 0.0
CUBOID     5 1 0.762 0.0 1.71704 0.0 2P0.635
UNIT 31
ARRAY 3 0.0 0.0 -0.635
UNIT 32
XHEMICYL+Y 4 1 0.5410 0.32258 0.0
```

```
XHEMICYL+Y 0 1 0.5588 0.32258 0.0
CUBOID     5 1 1.71704 0.0 0.762 0.0 2P0.635
UNIT 33
YHEMICYL+X 4 1 0.5410 0.32258 0.0
YHEMICYL+X 0 1 0.5588 0.32258 0.0
CUBOID     5 1 0.762 0.0 1.71704 0.0 2P0.635
UNIT 34
CUBOID     3 1 4P0.7366 2P0.635
UNIT 35
CUBOID     3 1 4P0.7366 2P0.3175
UNIT 36
ARRAY 4  0.0 0.0 -0.3175
UNIT 37
ARRAY 5  0.0 0.0 -0.635
UNIT 38
ARRAY 6  0.0 0.0 -0.635
CORE 7 1 0.0 0.0 0.635
CUBOID 3 1 23.2029 0.0 23.2029 0.0 424.815 0.0
CUBOID 5 1 24.1554 0.0 24.1554 0.0 424.815 0.0
CUBOID 6 1 30.8864 0.0 30.8864 0.0 424.815 0.0
CUBOID 5 1 34.6964 0.0 34.6964 0.0 452.755 -24.13
CUBOID 3 1 100.0 0.0 100.0 0.0 510.0 -75.0
END GEOM
END DATA
END
```

mrf07

```
=CSAS25
4 PWR ASSEM. EXXON/ANF (14X14) CE, E=3.1, BU=00,
27BURNUPLIB  LATTICECELL
UO2  1 0.95 293 92235 3.15 92238 96.85 END
ZIRCALLOY  2 1.0 END
H2O  3 1.0 END
B4C  4 0.864 293.0 5010 96.0 5011 4.0 END
SS304  5 1.0 END
URANIUM  6 1.0 293.0 92235 0.3 92238 99.7 END
H2O  7 1.0 END
END COMP
SQUAREPITCH 1.4732 0.9398 1 3 1.1176 2 0.96012 7 END
FLAT FULL HEIGHT GA-4, 4/96, 90% FOR NRC WITH B4C
READ PARAM  TME=200.0 GEN=200 NPG=1000 FLX=NO FDN=NO
NUB=YES END PARAM
READ ARRAY
ARA=1 NUX=16 NUY=16 NUZ=1
FILL
     15 14R16 18
     17 14R13 20
     17 14R13 20
     17 2R13 2R14 6R13 2R14 2R13 20
     17 2R13 2R14 6R13 2R14 2R13 20
     17 14R13 20
     17 14R13 20
     17 6R13 2R14 6R13 20
     17 6R13 2R14 6R13 20
     17 14R13 20
     17 14R13 20
     17 2R13 2R14 6R13 2R14 2R13 20
     17 2R13 2R14 6R13 2R14 2R13 20
     17 14R13 20
     17 14R13 20
     19 14R21 22
     END FILL
ARA=2 NUX=16 NUY=16 NUZ=1
FILL
     3 4 13R6 32
     5 14R1 10
     7 14R1 10
     7 2R1 2R2 6R1 2R2 2R1 10
     7 2R1 2R2 6R1 2R2 2R1 10
     7 14R1 10
     7 14R1 10
     7 6R1 2R2 6R1 10
```

```
      7 6R1 2R2 6R1 10
      7 14R1 10
      7 14R1 10
      7 2R1 2R2 6R1 2R2 2R1 10
      7 2R1 2R2 6R1 2R2 2R1 10
      7 14R1 10
      7 14R1 10
      33 14R11 12
      END FILL
ARA=3 NUX=16 NUY=16 NUZ=1
FILL
      3 25 13R27 29
      26 14R1 10
      28 14R1 10
      28 2R1 2R2 6R1 2R2 2R1 10
      28 2R1 2R2 6R1 2R2 2R1 10
      28 14R1 10
      28 14R1 10
      28 6R1 2R2 6R1 10
      28 6R1 2R2 6R1 10
      28 14R1 10
      28 14R1 10
      28 2R1 2R2 6R1 2R2 2R1 10
      28 2R1 2R2 6R1 2R2 2R1 10
      28 14R1 10
      28 14R1 10
      30 14R11 12
      END FILL
ARA=4 NUX=16 NUY=16 NUZ=1
FILL
      15 14R16 18
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      19 14R21 22
      END FILL
ARA=5 NUX=16 NUY=16 NUZ=1
```

```
FILL
     3 4 13R6 32
     5 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     33 14R11 12
     END FILL
ARA=6 NUX=16 NUY=16 NUZ=1
FILL
     3 25 13R27 29
     26 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     30 14R11 12
     END FILL
ARA=7 NUX=1 NUY=1 NUZ=344
FILL
     7R36
     4R23
     19R31
     247R24
     36R37
     20R38
     11R36
     END FILL
END ARRAY
```

```
READ BNDS -XY=MIRROR   END BNDS
READ GEOM
UNIT 1
CYLINDER 1 1 0.4699 2P0.635
CYLINDER 7 1 0.48006 2P0.635
CYLINDER 2 1 0.5588 2P0.635
CUBOID   3 1 4P0.7366 2P0.635
UNIT 2
CUBOID   3 1 4P0.7366 2P0.635
UNIT 3
CUBOID 5 1 4P0.381 2P0.635
UNIT 4
XHEMICYL+Y 4 1 0.5410 1.4732 1.31318
XHEMICYL+Y 0 1 0.5588 1.4732 0.29972
CUBOID     5 1 1.4732 0.0 0.762 0.0 2P0.635
UNIT 5
YHEMICYL+X 4 1 0.5410 1.4732 1.31318
YHEMICYL+X 0 1 0.5588 1.4732 0.29972
CUBOID     5 1 0.762 0.0 1.4732 0.0 2P0.635
UNIT 6
XHEMICYL+Y 4 1 0.5410 2P0.7366
XHEMICYL+Y 0 1 0.5588 2P0.7366
CUBOID     5 1 2P0.7366 0.762 0.0 2P0.635
UNIT 7
YHEMICYL+X 4 1 0.5410 2P0.7366
YHEMICYL+X 0 1 0.5588 2P0.7366
CUBOID     5 1 0.762 0.0 2P0.7366 2P0.635
UNIT 8
XHEMICYL+Y 4 1 0.5410 0.78994 0.0
XHEMICYL+Y 0 1 0.5588 0.78994 0.0
CUBOID     5 1 1.25984 0.0 0.762 0.0 2P0.635
UNIT 9
YHEMICYL+X 4 1 0.5410 0.78994 0.0
YHEMICYL+X 0 1 0.5588 0.78994 0.0
CUBOID     5 1 0.762 0.0 1.25984 0.0 2P0.635
UNIT 10
CUBOID 3 1 2P0.85852 2P0.7366 2P0.635
UNIT 11
CUBOID 3 1 2P0.7366 2P0.85852 2P0.635
UNIT 12
CUBOID 3 1 4P0.85852 2P0.635
UNIT 13
CYLINDER 1 1 0.4699 2P0.3175
CYLINDER 7 1 0.48006 2P0.3175
CYLINDER 2 1 0.5588 2P0.3175
CUBOID   3 1 4P0.7366 2P0.3175
UNIT 14
CUBOID   3 1 4P0.7366 2P0.3175
```

```
UNIT 15
CUBOID 5 1 4P0.381 2P0.3175
UNIT 16
CUBOID 5 1 2P0.7366 2P0.381 2P0.3175
UNIT 17
CUBOID 5 1 2P0.381 2P0.7366 2P0.3175
UNIT 18
CUBOID 5 1 2P0.85852 2P0.381 2P0.3175
UNIT 19
CUBOID 5 1 2P0.381 2P0.85852 2P0.3175
UNIT 20
CUBOID 3 1 2P0.85852 2P0.7366 2P0.3175
UNIT 21
CUBOID 3 1 2P0.7366 2P0.85852 2P0.3175
UNIT 22
CUBOID 3 1 4P0.85852 2P0.3175
UNIT 23
ARRAY 1 0.0 0.0 -0.3175
UNIT 24
ARRAY 2 0.0 0.0 -0.635
UNIT 25
XHEMICYL+Y 4 1 0.35306 1.4732 0.45974
XHEMICYL+Y 0 1 0.37084 1.4732 0.22352
CUBOID     5 1 1.4732 0.0 0.762 0.0 2P0.635
UNIT 26
YHEMICYL+X 4 1 0.35306 1.4732 0.45974
YHEMICYL+X 0 1 0.37084 1.4732 0.22352
CUBOID     5 1 0.762 0.0 1.4732 0.0 2P0.635
UNIT 27
XHEMICYL+Y 4 1 0.35306 2P0.7366
XHEMICYL+Y 0 1 0.37084 2P0.7366
CUBOID     5 1 2P0.7366 0.762 0.0 2P0.635
UNIT 28
YHEMICYL+X 4 1 0.35306 2P0.7366
YHEMICYL+X 0 1 0.37084 2P0.7366
CUBOID     5 1 0.762 0.0 2P0.7366 2P0.635
UNIT 29
XHEMICYL+Y 4 1 0.35306 0.32258 0.0
XHEMICYL+Y 0 1 0.37084 0.32258 0.0
CUBOID     5 1 1.71704 0.0 0.762 0.0 2P0.635
UNIT 30
YHEMICYL+X 4 1 0.35306 0.32258 0.0
YHEMICYL+X 0 1 0.37084 0.32258 0.0
CUBOID     5 1 0.762 0.0 1.71704 0.0 2P0.635
UNIT 31
ARRAY 3 0.0 0.0 -0.635
UNIT 32
XHEMICYL+Y 4 1 0.5410 0.32258 0.0
```

```
XHEMICYL+Y 0 1 0.5588 0.32258 0.0
CUBOID     5 1 1.71704 0.0 0.762 0.0 2P0.635
UNIT 33
YHEMICYL+X 4 1 0.5410 0.32258 0.0
YHEMICYL+X 0 1 0.5588 0.32258 0.0
CUBOID     5 1 0.762 0.0 1.71704 0.0 2P0.635
UNIT 34
CUBOID     3 1 4P0.7366 2P0.635
UNIT 35
CUBOID     3 1 4P0.7366 2P0.3175
UNIT 36
ARRAY 4  0.0 0.0 -0.3175
UNIT 37
ARRAY 5  0.0 0.0 -0.635
UNIT 38
ARRAY 6  0.0 0.0 -0.635
CORE 7 1 0.0 0.0 0.635
CUBOID 3 1 23.2029 0.0 23.2029 0.0 424.815 0.0
CUBOID 5 1 24.1554 0.0 24.1554 0.0 424.815 0.0
CUBOID 6 1 30.8864 0.0 30.8864 0.0 424.815 0.0
CUBOID 5 1 34.6964 0.0 34.6964 0.0 452.755 -24.13
CUBOID 3 1 100.0 0.0 100.0 0.0 510.0 -75.0
END GEOM
END DATA
END
```

mrf08

```
=CSAS25
4 PWR ASSEM. CE(14X14) FT CALHOUN, E=3.1, BU=00,
27BURNUPLIB  LATTICECELL
UO2  1 0.95 293 92235 3.15 92238 96.85 END
ZIRCALLOY  2 1.0 END
H2O  3 1.0 END
B4C  4 0.864 293.0 5010 96.0 5011 4.0 END
SS304  5 1.0 END
URANIUM  6 1.0 293.0 92235 0.3 92238 99.7 END
H2O  7 1.0 END
END COMP
SQUAREPITCH 1.4732 0.95631 1 3 1.1176 2 0.97536 7 END
FLAT FULL HEIGHT GA-4, 4/96, 90% FOR NRC WITH B4C
READ PARAM  TME=200.0 GEN=200 NPG=1000 FLX=NO FDN=NO
NUB=YES END PARAM
READ ARRAY
ARA=1 NUX=16 NUY=16 NUZ=1
FILL
     15 14R16 18
     17 14R13 20
     17 14R13 20
     17 2R13 2R14 6R13 2R14 2R13 20
     17 2R13 2R14 6R13 2R14 2R13 20
     17 14R13 20
     17 14R13 20
     17 6R13 2R14 6R13 20
     17 6R13 2R14 6R13 20
     17 14R13 20
     17 14R13 20
     17 2R13 2R14 6R13 2R14 2R13 20
     17 2R13 2R14 6R13 2R14 2R13 20
     17 14R13 20
     17 14R13 20
     19 14R21 22
     END FILL
ARA=2 NUX=16 NUY=16 NUZ=1
FILL
     3 4 13R6 32
     5 14R1 10
     7 14R1 10
     7 2R1 2R2 6R1 2R2 2R1 10
     7 2R1 2R2 6R1 2R2 2R1 10
     7 14R1 10
     7 14R1 10
     7 6R1 2R2 6R1 10
```

```
      7 6R1 2R2 6R1 10
      7 14R1 10
      7 14R1 10
      7 2R1 2R2 6R1 2R2 2R1 10
      7 2R1 2R2 6R1 2R2 2R1 10
      7 14R1 10
      7 14R1 10
      33 14R11 12
      END FILL
ARA=3 NUX=16 NUY=16 NUZ=1
FILL
      3 25 13R27 29
      26 14R1 10
      28 14R1 10
      28 2R1 2R2 6R1 2R2 2R1 10
      28 2R1 2R2 6R1 2R2 2R1 10
      28 14R1 10
      28 14R1 10
      28 6R1 2R2 6R1 10
      28 6R1 2R2 6R1 10
      28 14R1 10
      28 14R1 10
      28 2R1 2R2 6R1 2R2 2R1 10
      28 2R1 2R2 6R1 2R2 2R1 10
      28 14R1 10
      28 14R1 10
      30 14R11 12
      END FILL
ARA=4 NUX=16 NUY=16 NUZ=1
FILL
      15 14R16 18
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      19 14R21 22
      END FILL
ARA=5 NUX=16 NUY=16 NUZ=1
```

```
FILL
     3 4 13R6 32
     5 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     33 14R11 12
     END FILL
ARA=6 NUX=16 NUY=16 NUZ=1
FILL
     3 25 13R27 29
     26 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     30 14R11 12
     END FILL
ARA=7 NUX=1 NUY=1 NUZ=344
FILL
     7R36
     4R23
     19R31
     235R24
     48R37
     20R38
     11R36
     END FILL
END ARRAY
```

```
READ BNDS -XY=MIRROR   END BNDS
READ GEOM
UNIT 1
CYLINDER 1 1 0.478155 2P0.635
CYLINDER 7 1 0.48768 2P0.635
CYLINDER 2 1 0.5588 2P0.635
CUBOID   3 1 4P0.7366 2P0.635
UNIT 2
CUBOID   3 1 4P0.7366 2P0.635
UNIT 3
CUBOID 5 1 4P0.381 2P0.635
UNIT 4
XHEMICYL+Y 4 1 0.5410 1.4732 1.31318
XHEMICYL+Y 0 1 0.5588 1.4732 0.29972
CUBOID     5 1 1.4732 0.0 0.762 0.0 2P0.635
UNIT 5
YHEMICYL+X 4 1 0.5410 1.4732 1.31318
YHEMICYL+X 0 1 0.5588 1.4732 0.29972
CUBOID     5 1 0.762 0.0 1.4732 0.0 2P0.635
UNIT 6
XHEMICYL+Y 4 1 0.5410 2P0.7366
XHEMICYL+Y 0 1 0.5588 2P0.7366
CUBOID     5 1 2P0.7366 0.762 0.0 2P0.635
UNIT 7
YHEMICYL+X 4 1 0.5410 2P0.7366
YHEMICYL+X 0 1 0.5588 2P0.7366
CUBOID     5 1 0.762 0.0 2P0.7366 2P0.635
UNIT 8
XHEMICYL+Y 4 1 0.5410 0.78994 0.0
XHEMICYL+Y 0 1 0.5588 0.78994 0.0
CUBOID     5 1 1.25984 0.0 0.762 0.0 2P0.635
UNIT 9
YHEMICYL+X 4 1 0.5410 0.78994 0.0
YHEMICYL+X 0 1 0.5588 0.78994 0.0
CUBOID     5 1 0.762 0.0 1.25984 0.0 2P0.635
UNIT 10
CUBOID 3 1 2P0.85852 2P0.7366 2P0.635
UNIT 11
CUBOID 3 1 2P0.7366 2P0.85852 2P0.635
UNIT 12
CUBOID 3 1 4P0.85852 2P0.635
UNIT 13
CYLINDER 1 1 0.478155 2P0.3175
CYLINDER 7 1 0.48768 2P0.3175
CYLINDER 2 1 0.5588 2P0.3175
CUBOID   3 1 4P0.7366 2P0.3175
UNIT 14
CUBOID   3 1 4P0.7366 2P0.3175
```

```
UNIT 15
CUBOID 5 1 4P0.381 2P0.3175
UNIT 16
CUBOID 5 1 2P0.7366 2P0.381 2P0.3175
UNIT 17
CUBOID 5 1 2P0.381 2P0.7366 2P0.3175
UNIT 18
CUBOID 5 1 2P0.85852 2P0.381 2P0.3175
UNIT 19
CUBOID 5 1 2P0.381 2P0.85852 2P0.3175
UNIT 20
CUBOID 3 1 2P0.85852 2P0.7366 2P0.3175
UNIT 21
CUBOID 3 1 2P0.7366 2P0.85852 2P0.3175
UNIT 22
CUBOID 3 1 4P0.85852 2P0.3175
UNIT 23
ARRAY 1 0.0 0.0 -0.3175
UNIT 24
ARRAY 2 0.0 0.0 -0.635
UNIT 25
XHEMICYL+Y 4 1 0.35306 1.4732 0.45974
XHEMICYL+Y 0 1 0.37084 1.4732 0.22352
CUBOID     5 1 1.4732 0.0 0.762 0.0 2P0.635
UNIT 26
YHEMICYL+X 4 1 0.35306 1.4732 0.45974
YHEMICYL+X 0 1 0.37084 1.4732 0.22352
CUBOID     5 1 0.762 0.0 1.4732 0.0 2P0.635
UNIT 27
XHEMICYL+Y 4 1 0.35306 2P0.7366
XHEMICYL+Y 0 1 0.37084 2P0.7366
CUBOID     5 1 2P0.7366 0.762 0.0 2P0.635
UNIT 28
YHEMICYL+X 4 1 0.35306 2P0.7366
YHEMICYL+X 0 1 0.37084 2P0.7366
CUBOID     5 1 0.762 0.0 2P0.7366 2P0.635
UNIT 29
XHEMICYL+Y 4 1 0.35306 0.32258 0.0
XHEMICYL+Y 0 1 0.37084 0.32258 0.0
CUBOID     5 1 1.71704 0.0 0.762 0.0 2P0.635
UNIT 30
YHEMICYL+X 4 1 0.35306 0.32258 0.0
YHEMICYL+X 0 1 0.37084 0.32258 0.0
CUBOID     5 1 0.762 0.0 1.71704 0.0 2P0.635
UNIT 31
ARRAY 3 0.0 0.0 -0.635
UNIT 32
XHEMICYL+Y 4 1 0.5410 0.32258 0.0
```

```
XHEMICYL+Y 0 1 0.5588 0.32258 0.0
CUBOID     5 1 1.71704 0.0 0.762 0.0 2P0.635
UNIT 33
YHEMICYL+X 4 1 0.5410 0.32258 0.0
YHEMICYL+X 0 1 0.5588 0.32258 0.0
CUBOID     5 1 0.762 0.0 1.71704 0.0 2P0.635
UNIT 34
CUBOID     3 1 4P0.7366 2P0.635
UNIT 35
CUBOID     3 1 4P0.7366 2P0.3175
UNIT 36
ARRAY 4  0.0 0.0 -0.3175
UNIT 37
ARRAY 5  0.0 0.0 -0.635
UNIT 38
ARRAY 6  0.0 0.0 -0.635
CORE 7 1 0.0 0.0 0.635
CUBOID 3 1 23.2029 0.0 23.2029 0.0 424.815 0.0
CUBOID 5 1 24.1554 0.0 24.1554 0.0 424.815 0.0
CUBOID 6 1 30.8864 0.0 30.8864 0.0 424.815 0.0
CUBOID 5 1 34.6964 0.0 34.6964 0.0 452.755 -24.13
CUBOID 3 1 100.0 0.0 100.0 0.0 510.0 -75.0
END GEOM
END DATA
END
```

mrf09

```
=CSAS25
4 PWR ASSEM. W(15X15) OFA, E=3.1, BU=00,
27BURNUPLIB  LATTICECELL
UO2  1 0.95 293 92235 3.15 92238 96.85 END
ZIRCALLOY  2 1.0 END
H2O  3 1.0 END
B4C  4 0.864 293.0 5010 96.0 5011 4.0 END
SS304  5 1.0 END
URANIUM  6 1.0 293.0 92235 0.3 92238 99.7 END
END COMP
SQUAREPITCH 1.43002 0.92964 1 0 1.07188 2 0.948944 0 END
FLAT FULL HEIGHT GA-4 ACCIDENT, 4/96, 90% FOR NRC WITH B4C
READ PARAM  TME=200.0 GEN=200 NPG=1000 FLX=NO FDN=NO
NUB=YES END PARAM
READ ARRAY
ARA=1 NUX=17 NUY=17 NUZ=1
FILL
     15 15R16 18
     17 15R13 20
     17 15R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 7R13 14 7R13 20
     17 4R13 14 5R13 14 4R13 20
     17 2R13 14 9R13 14 2R13 20
     17 15R13 20
     17 3R13 14 3R13 14 3R13 14 3R13 20
     17 15R13 20
     17 2R13 14 9R13 14 2R13 20
     17 4R13 14 5R13 14 4R13 20
     17 7R13 14 7R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 15R13 20
     17 15R13 20
     19 15R21 22
     END FILL
ARA=2 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R1 10
     7 15R1 10
     7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
     7 7R1 2 7R1 10
     7 4R1 2 5R1 2 4R1 10
     7 2R1 2 9R1 2 2R1 10
     7 15R1 10
```

```
      7 3R1 2 3R1 2 3R1 2 3R1 10
      7 15R1 10
      7 2R1 2 9R1 2 2R1 10
      7 4R1 2 5R1 2 4R1 10
      7 7R1 2 7R1 10
      7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      7 15R1 10
      9 15R1 10
      33 15R11 12
      END FILL
ARA=3 NUX=17 NUY=17 NUZ=1
FILL
      3 25 13R27 39 29
      26 15R1 10
      28 15R1 10
      28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      28 7R1 2 7R1 10
      28 4R1 2 5R1 2 4R1 10
      28 2R1 2 9R1 2 2R1 10
      28 15R1 10
      28 3R1 2 3R1 2 3R1 2 3R1 10
      28 15R1 10
      28 2R1 2 9R1 2 2R1 10
      28 4R1 2 5R1 2 4R1 10
      28 7R1 2 7R1 10
      28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      28 15R1 10
      40 15R1 10
      30 15R11 12
      END FILL
ARA=4 NUX=17 NUY=17 NUZ=1
FILL
      15 15R16 18
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
```

```
     19 15R21 22
     END FILL
ARA=5 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     9 15R34 10
     33 15R11 12
     END FILL
ARA=6 NUX=17 NUY=17 NUZ=1
FILL
     3 25 13R27 39 29
     26 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     40 15R34 10
     30 15R11 12
     END FILL
ARA=7 NUX=1 NUY=1 NUZ=344
FILL
     7R36
     4R23
     19R31
     267R24
```

```
     16R37
     20R38
     11R36
     END FILL
END ARRAY
READ BNDS ALL=MIRROR   END BNDS
READ GEOM
UNIT 1
CYLINDER 1 1 0.46482 2P0.635
CYLINDER 0 1 0.474472 2P0.635
CYLINDER 2 1 0.53594 2P0.635
CUBOID   0 1 4P0.71501 2P0.635
UNIT 2
CYLINDER 0 1 0.6502 2P0.635
CYLINDER 2 1 0.6934 2P0.635
CUBOID   0 1 4P0.71501 2P0.635
UNIT 3
CUBOID 5 1 4P0.381 2P0.635
UNIT 4
XHEMICYL+Y 4 1 0.5410 1.43002 1.31318
XHEMICYL+Y 0 1 0.5588 1.43002 0.29972
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 5
YHEMICYL+X 4 1 0.5410 1.43002 1.31318
YHEMICYL+X 0 1 0.5588 1.43002 0.29972
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 6
XHEMICYL+Y 4 1 0.5410 2P0.71501
XHEMICYL+Y 0 1 0.5588 2P0.71501
CUBOID     5 1 2P0.71501 0.762 0.0 2P0.635
UNIT 7
YHEMICYL+X 4 1 0.5410 2P0.71501
YHEMICYL+X 0 1 0.5588 2P0.71501
CUBOID     5 1 0.762 0.0 2P0.71501 2P0.635
UNIT 8
XHEMICYL+Y 4 1 0.5410 0.9271 0.0
XHEMICYL+Y 0 1 0.5588 0.9271 0.0
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 9
YHEMICYL+X 4 1 0.5410 0.9271 0.0
YHEMICYL+X 0 1 0.5588 0.9271 0.0
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 10
CUBOID 0 1 2P0.44577 2P0.71501 2P0.635
UNIT 11
CUBOID 0 1 2P0.71501 2P0.44577 2P0.635
UNIT 12
CUBOID 0 1 4P0.44577 2P0.635
```

```
UNIT 13
CYLINDER 1 1 0.46482 2P0.3175
CYLINDER 0 1 0.474472 2P0.3175
CYLINDER 2 1 0.53594 2P0.3175
CUBOID   0 1 4P0.71501 2P0.3175
UNIT 14
CYLINDER 0 1 0.6502 2P0.3175
CYLINDER 2 1 0.6934 2P0.3175
CUBOID   0 1 4P0.71501 2P0.3175
UNIT 15
CUBOID 5 1 4P0.381 2P0.3175
UNIT 16
CUBOID 5 1 2P0.71501 2P0.381 2P0.3175
UNIT 17
CUBOID 5 1 2P0.381 2P0.71501 2P0.3175
UNIT 18
CUBOID 5 1 2P0.44577 2P0.381 2P0.3175
UNIT 19
CUBOID 5 1 2P0.381 2P0.44577 2P0.3175
UNIT 20
CUBOID 0 1 2P0.44577 2P0.71501 2P0.3175
UNIT 21
CUBOID 0 1 2P0.71501 2P0.44577 2P0.3175
UNIT 22
CUBOID 0 1 4P0.44577 2P0.3175
UNIT 23
ARRAY 1 0.0 0.0 -0.3175
UNIT 24
ARRAY 2 0.0 0.0 -0.635
UNIT 25
XHEMICYL+Y 4 1 0.35306 1.43002 0.45974
XHEMICYL+Y 0 1 0.37084 1.43002 0.22352
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 26
YHEMICYL+X 4 1 0.35306 1.43002 0.45974
YHEMICYL+X 0 1 0.37084 1.43002 0.22352
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 27
XHEMICYL+Y 4 1 0.35306 2P0.71501
XHEMICYL+Y 0 1 0.37084 2P0.71501
CUBOID     5 1 2P0.71501 0.762 0.0 2P0.635
UNIT 28
YHEMICYL+X 4 1 0.35306 2P0.71501
YHEMICYL+X 0 1 0.37084 2P0.71501
CUBOID     5 1 0.762 0.0 2P0.71501 2P0.635
UNIT 29
CUBOID     5 1 0.89154 0.0 0.762 0.0 2P0.635
UNIT 30
```

```
CUBOID      5 1 0.762 0.0 0.89154 0.0 2P0.635
UNIT 31
ARRAY 3 0.0 0.0 -0.635
UNIT 32
CUBOID      5 1 0.89154 0.0 0.762 0.0 2P0.635
UNIT 33
CUBOID      5 1 0.762 0.0 0.89154 0.0 2P0.635
UNIT 34
CUBOID      0 1 4P0.71501 2P0.635
UNIT 35
CUBOID      0 1 4P0.71501 2P0.3175
UNIT 36
ARRAY 4  0.0 0.0 -0.3175
UNIT 37
ARRAY 5  0.0 0.0 -0.635
UNIT 38
ARRAY 6  0.0 0.0 -0.635
UNIT 39
XHEMICYL+Y 4 1 0.35306 0.9271 0.0
XHEMICYL+Y 0 1 0.37084 0.9271 0.0
CUBOID      5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 40
YHEMICYL+X 4 1 0.35306 0.9271 0.0
YHEMICYL+X 0 1 0.37084 0.9271 0.0
CUBOID      5 1 0.762 0.0 1.43002 0.0 2P0.635
CORE 7 1 0.0 0.0 0.635
CUBOID 0 1 23.2029 0.0 23.2029 0.0 424.815 0.0
CUBOID 5 1 24.1554 0.0 24.1554 0.0 424.815 0.0
CUBOID 6 1 30.8864 0.0 30.8864 0.0 424.815 0.0
CUBOID 5 1 34.6964 0.0 34.6964 0.0 452.755 -24.13
END GEOM
END DATA
END
```

mrf10

```
=CSAS25
4 PWR ASSEM. W(14X14) ZCA/ZCB, E=3.1, BU=00,
27BURNUPLIB  LATTICECELL
UO2  1 0.95 293 92235 3.15 92238 96.85 END
ZIRCALLOY  2 1.0 END
H2O  3 1.0 END
B4C  4 0.864 293.0 5010 96.0 5011 4.0 END
SS304  5 1.0 END
URANIUM  6 1.0 293.0 92235 0.3 92238 99.7 END
H2O  7 1.0 END
END COMP
SQUAREPITCH 1.41224 0.933196 1 3 1.07188 2 0.95758 7 END
FLAT FULL HEIGHT GA-4, 4/96, 90% FOR NRC WITH B4C
READ PARAM  TME=200.0 GEN=200 NPG=1000 FLX=NO FDN=NO
NUB=YES END PARAM
READ ARRAY
ARA=1 NUX=16 NUY=16 NUZ=1
FILL
     15 14R16 18
     17 14R13 20
     17 14R13 20
     17 2R13 14 2R13 14 2R13 14 2R13 14 2R13 20
     17 14R13 20
     17 4R13 14 4R13 14 4R13 20
     17 2R13 14 8R13 14 2R13 20
     17 14R13 20
     17 14R13 20
     17 2R13 14 8R13 14 2R13 20
     17 4R13 14 4R13 14 4R13 20
     17 14R13 20
     17 2R13 14 2R13 14 2R13 14 2R13 14 2R13 20
     17 14R13 20
     17 14R13 20
     19 14R21 22
     END FILL
ARA=2 NUX=16 NUY=16 NUZ=1
FILL
     3 4 13R6 32
     5 14R1 10
     7 14R1 10
     7 2R1 2 2R1 2 2R1 2 2R1 2 2R1 10
     7 14R1 10
     7 4R1 2 4R1 2 4R1 10
     7 2R1 2 8R1 2 2R1 10
     7 14R1 10
```

```
      7 14R1 10
      7 2R1 2 8R1 2 2R1 10
      7 4R1 2 4R1 2 4R1 10
      7 14R1 10
      7 2R1 2 2R1 2 2R1 2 2R1 2 2R1 10
      7 14R1 10
      7 14R1 10
      33 14R11 12
      END FILL
ARA=3 NUX=16 NUY=16 NUZ=1
FILL
      3 25 13R27 29
      26 14R1 10
      28 14R1 10
      28 2R1 2 2R1 2 2R1 2 2R1 2 2R1 10
      28 14R1 10
      28 4R1 2 4R1 2 4R1 10
      28 2R1 2 8R1 2 2R1 10
      28 14R1 10
      28 14R1 10
      28 2R1 2 8R1 2 2R1 10
      28 4R1 2 4R1 2 4R1 10
      28 14R1 10
      28 2R1 2 2R1 2 2R1 2 2R1 2 2R1 10
      28 14R1 10
      28 14R1 10
      30 14R11 12
      END FILL
ARA=4 NUX=16 NUY=16 NUZ=1
FILL
      15 14R16 18
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      19 14R21 22
      END FILL
ARA=5 NUX=16 NUY=16 NUZ=1
```

```
FILL
     3 4 13R6 32
     5 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     33 14R11 12
     END FILL
ARA=6 NUX=16 NUY=16 NUZ=1
FILL
     3 25 13R27 29
     26 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     30 14R11 12
     END FILL
ARA=7 NUX=1 NUY=1 NUZ=344
FILL
     7R36
     4R23
     19R31
     270R24
     13R37
     20R38
     11R36
     END FILL
END ARRAY
```

```
READ BNDS -XY=MIRROR   END BNDS
READ GEOM
UNIT 1
CYLINDER 1 1 0.466598 2P0.635
CYLINDER 7 1 0.47879 2P0.635
CYLINDER 2 1 0.53594 2P0.635
CUBOID   3 1 4P0.70612 2P0.635
UNIT 2
CYLINDER 3 1 0.64895 2P0.635
CYLINDER 2 1 0.67945 2P0.635
CUBOID   3 1 4P0.70612 2P0.635
UNIT 3
CUBOID 5 1 4P0.381 2P0.635
UNIT 4
XHEMICYL+Y 4 1 0.5410 1.41224 1.31318
XHEMICYL+Y 0 1 0.5588 1.41224 0.29972
CUBOID     5 1 1.41224 0.0 0.762 0.0 2P0.635
UNIT 5
YHEMICYL+X 4 1 0.5410 1.41224 1.31318
YHEMICYL+X 0 1 0.5588 1.41224 0.29972
CUBOID     5 1 0.762 0.0 1.41224 0.0 2P0.635
UNIT 6
XHEMICYL+Y 4 1 0.5410 2P0.70612
XHEMICYL+Y 0 1 0.5588 2P0.70612
CUBOID     5 1 2P0.70612 0.762 0.0 2P0.635
UNIT 7
YHEMICYL+X 4 1 0.5410 2P0.70612
YHEMICYL+X 0 1 0.5588 2P0.70612
CUBOID     5 1 0.762 0.0 2P0.70612 2P0.635
UNIT 8
XHEMICYL+Y 4 1 0.5410 0.78994 0.0
XHEMICYL+Y 0 1 0.5588 0.78994 0.0
CUBOID     5 1 1.25984 0.0 0.762 0.0 2P0.635
UNIT 9
YHEMICYL+X 4 1 0.5410 0.78994 0.0
YHEMICYL+X 0 1 0.5588 0.78994 0.0
CUBOID     5 1 0.762 0.0 1.25984 0.0 2P0.635
UNIT 10
CUBOID 3 1 2P1.28524 2P0.70612 2P0.635
UNIT 11
CUBOID 3 1 2P0.70612 2P1.28524 2P0.635
UNIT 12
CUBOID 3 1 4P1.28524 2P0.635
UNIT 13
CYLINDER 1 1 0.466598 2P0.3175
CYLINDER 7 1 0.47879 2P0.3175
CYLINDER 2 1 0.53594 2P0.3175
CUBOID   3 1 4P0.70612 2P0.3175
```

```
UNIT 14
CYLINDER 3 1 0.64895 2P0.3175
CYLINDER 2 1 0.67945 2P0.3175
CUBOID   3 1 4P0.70612 2P0.3175
UNIT 15
CUBOID 5 1 4P0.381 2P0.3175
UNIT 16
CUBOID 5 1 2P0.70612 2P0.381 2P0.3175
UNIT 17
CUBOID 5 1 2P0.381 2P0.70612 2P0.3175
UNIT 18
CUBOID 5 1 2P1.28524 2P0.381 2P0.3175
UNIT 19
CUBOID 5 1 2P0.381 2P1.28524 2P0.3175
UNIT 20
CUBOID 3 1 2P1.28524 2P0.70612 2P0.3175
UNIT 21
CUBOID 3 1 2P0.70612 2P1.28524 2P0.3175
UNIT 22
CUBOID 3 1 4P1.28524 2P0.3175
UNIT 23
ARRAY 1 0.0 0.0 -0.3175
UNIT 24
ARRAY 2 0.0 0.0 -0.635
UNIT 25
XHEMICYL+Y 4 1 0.35306 1.41224 0.45974
XHEMICYL+Y 0 1 0.37084 1.41224 0.22352
CUBOID     5 1 1.41224 0.0 0.762 0.0 2P0.635
UNIT 26
YHEMICYL+X 4 1 0.35306 1.41224 0.45974
YHEMICYL+X 0 1 0.37084 1.41224 0.22352
CUBOID     5 1 0.762 0.0 1.41224 0.0 2P0.635
UNIT 27
XHEMICYL+Y 4 1 0.35306 2P0.70612
XHEMICYL+Y 0 1 0.37084 2P0.70612
CUBOID     5 1 2P0.70612 0.762 0.0 2P0.635
UNIT 28
YHEMICYL+X 4 1 0.35306 2P0.70612
YHEMICYL+X 0 1 0.37084 2P0.70612
CUBOID     5 1 0.762 0.0 2P0.70612 2P0.635
UNIT 29
XHEMICYL+Y 4 1 0.35306 1.17602 0.0
XHEMICYL+Y 0 1 0.37084 1.17602 0.0
CUBOID     5 1 2.57048 0.0 0.762 0.0 2P0.635
UNIT 30
YHEMICYL+X 4 1 0.35306 1.17602 0.0
YHEMICYL+X 0 1 0.37084 1.17602 0.0
CUBOID     5 1 0.762 0.0 2.57048 0.0 2P0.635
```

```
UNIT 31
ARRAY 3 0.0 0.0 -0.635
UNIT 32
XHEMICYL+Y 4 1 0.5410 1.17602 0.0
XHEMICYL+Y 0 1 0.5588 1.17602 0.0
CUBOID     5 1 2.57048 0.0 0.762 0.0 2P0.635
UNIT 33
YHEMICYL+X 4 1 0.5410 1.17602 0.0
YHEMICYL+X 0 1 0.5588 1.17602 0.0
CUBOID     5 1 0.762 0.0 2.57048 0.0 2P0.635
UNIT 34
CUBOID     3 1 4P0.70612 2P0.635
UNIT 35
CUBOID     3 1 4P0.70612 2P0.3175
UNIT 36
ARRAY 4  0.0 0.0 -0.3175
UNIT 37
ARRAY 5  0.0 0.0 -0.635
UNIT 38
ARRAY 6  0.0 0.0 -0.635
CORE 7 1 0.0 0.0 0.635
CUBOID 3 1 23.2029 0.0 23.2029 0.0 424.815 0.0
CUBOID 5 1 24.1554 0.0 24.1554 0.0 424.815 0.0
CUBOID 6 1 30.8864 0.0 30.8864 0.0 424.815 0.0
CUBOID 5 1 34.6964 0.0 34.6964 0.0 452.755 -24.13
CUBOID 3 1 100.0 0.0 100.0 0.0 510.0 -75.0
END GEOM
END DATA
END
```

mrf11

```
=CSAS25
4 PWR ASSEM. W(14X14) OFA, E=3.1, BU=00,
27BURNUPLIB  LATTICECELL
UO2  1 0.95 293 92235 3.15 92238 96.85 END
ZIRCALLOY  2 1.0 END
H2O  3 1.0 END
B4C  4 0.864 293.0 5010 96.0 5011 4.0 END
SS304  5 1.0 END
URANIUM  6 1.0 293.0 92235 0.3 92238 99.7 END
H2O  7 1.0 END
END COMP
SQUAREPITCH 1.41224 0.874776 1 3 1.016 2 0.892556 7 END
FLAT FULL HEIGHT GA-4, 4/96, 90% FOR NRC WITH B4C
READ PARAM  TME=200.0 GEN=200 NPG=1000 FLX=NO FDN=NO
NUB=YES END PARAM
READ ARRAY
ARA=1 NUX=16 NUY=16 NUZ=1
FILL
     15 14R16 18
     17 14R13 20
     17 14R13 20
     17 2R13 14 2R13 14 2R13 14 2R13 14 2R13 20
     17 14R13 20
     17 4R13 14 4R13 14 4R13 20
     17 2R13 14 8R13 14 2R13 20
     17 14R13 20
     17 14R13 20
     17 2R13 14 8R13 14 2R13 20
     17 4R13 14 4R13 14 4R13 20
     17 14R13 20
     17 2R13 14 2R13 14 2R13 14 2R13 14 2R13 20
     17 14R13 20
     17 14R13 20
     19 14R21 22
     END FILL
ARA=2 NUX=16 NUY=16 NUZ=1
FILL
     3 4 13R6 32
     5 14R1 10
     7 14R1 10
     7 2R1 2 2R1 2 2R1 2 2R1 2 2R1 10
     7 14R1 10
     7 4R1 2 4R1 2 4R1 10
     7 2R1 2 8R1 2 2R1 10
     7 14R1 10
```

```
      7 14R1 10
      7 2R1 2 8R1 2 2R1 10
      7 4R1 2 4R1 2 4R1 10
      7 14R1 10
      7 2R1 2 2R1 2 2R1 2 2R1 2 2R1 10
      7 14R1 10
      7 14R1 10
      33 14R11 12
      END FILL
ARA=3 NUX=16 NUY=16 NUZ=1
FILL
      3 25 13R27 29
      26 14R1 10
      28 14R1 10
      28 2R1 2 2R1 2 2R1 2 2R1 2 2R1 10
      28 14R1 10
      28 4R1 2 4R1 2 4R1 10
      28 2R1 2 8R1 2 2R1 10
      28 14R1 10
      28 14R1 10
      28 2R1 2 8R1 2 2R1 10
      28 4R1 2 4R1 2 4R1 10
      28 14R1 10
      28 2R1 2 2R1 2 2R1 2 2R1 2 2R1 10
      28 14R1 10
      28 14R1 10
      30 14R11 12
      END FILL
ARA=4 NUX=16 NUY=16 NUZ=1
FILL
      15 14R16 18
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      19 14R21 22
      END FILL
ARA=5 NUX=16 NUY=16 NUZ=1
```

```
FILL
     3 4 13R6 32
     5 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     33 14R11 12
     END FILL
ARA=6 NUX=16 NUY=16 NUZ=1
FILL
     3 25 13R27 29
     26 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     30 14R11 12
     END FILL
ARA=7 NUX=1 NUY=1 NUZ=344
FILL
     7R36
     4R23
     19R31
     267R24
     16R37
     20R38
     11R36
     END FILL
END ARRAY
```

```
READ BNDS -XY=MIRROR   END BNDS
READ GEOM
UNIT 1
CYLINDER 1 1 0.437388 2P0.635
CYLINDER 7 1 0.446278 2P0.635
CYLINDER 2 1 0.508 2P0.635
CUBOID   3 1 4P0.70612 2P0.635
UNIT 2
CYLINDER 3 1 0.64895 2P0.635
CYLINDER 2 1 0.67945 2P0.635
CUBOID   3 1 4P0.70612 2P0.635
UNIT 3
CUBOID 5 1 4P0.381 2P0.635
UNIT 4
XHEMICYL+Y 4 1 0.5410 1.41224 1.31318
XHEMICYL+Y 0 1 0.5588 1.41224 0.29972
CUBOID     5 1 1.41224 0.0 0.762 0.0 2P0.635
UNIT 5
YHEMICYL+X 4 1 0.5410 1.41224 1.31318
YHEMICYL+X 0 1 0.5588 1.41224 0.29972
CUBOID     5 1 0.762 0.0 1.41224 0.0 2P0.635
UNIT 6
XHEMICYL+Y 4 1 0.5410 2P0.70612
XHEMICYL+Y 0 1 0.5588 2P0.70612
CUBOID     5 1 2P0.70612 0.762 0.0 2P0.635
UNIT 7
YHEMICYL+X 4 1 0.5410 2P0.70612
YHEMICYL+X 0 1 0.5588 2P0.70612
CUBOID     5 1 0.762 0.0 2P0.70612 2P0.635
UNIT 8
XHEMICYL+Y 4 1 0.5410 0.78994 0.0
XHEMICYL+Y 0 1 0.5588 0.78994 0.0
CUBOID     5 1 1.25984 0.0 0.762 0.0 2P0.635
UNIT 9
YHEMICYL+X 4 1 0.5410 0.78994 0.0
YHEMICYL+X 0 1 0.5588 0.78994 0.0
CUBOID     5 1 0.762 0.0 1.25984 0.0 2P0.635
UNIT 10
CUBOID 3 1 2P1.28524 2P0.70612 2P0.635
UNIT 11
CUBOID 3 1 2P0.70612 2P1.28524 2P0.635
UNIT 12
CUBOID 3 1 4P1.28524 2P0.635
UNIT 13
CYLINDER 1 1 0.437388 2P0.3175
CYLINDER 7 1 0.446278 2P0.3175
CYLINDER 2 1 0.508 2P0.3175
CUBOID   3 1 4P0.70612 2P0.3175
```

```
UNIT 14
CYLINDER 3 1 0.64895 2P0.3175
CYLINDER 2 1 0.67945 2P0.3175
CUBOID   3 1 4P0.70612 2P0.3175
UNIT 15
CUBOID 5 1 4P0.381 2P0.3175
UNIT 16
CUBOID 5 1 2P0.70612 2P0.381 2P0.3175
UNIT 17
CUBOID 5 1 2P0.381 2P0.70612 2P0.3175
UNIT 18
CUBOID 5 1 2P1.28524 2P0.381 2P0.3175
UNIT 19
CUBOID 5 1 2P0.381 2P1.28524 2P0.3175
UNIT 20
CUBOID 3 1 2P1.28524 2P0.70612 2P0.3175
UNIT 21
CUBOID 3 1 2P0.70612 2P1.28524 2P0.3175
UNIT 22
CUBOID 3 1 4P1.28524 2P0.3175
UNIT 23
ARRAY 1 0.0 0.0 -0.3175
UNIT 24
ARRAY 2 0.0 0.0 -0.635
UNIT 25
XHEMICYL+Y 4 1 0.35306 1.41224 0.45974
XHEMICYL+Y 0 1 0.37084 1.41224 0.22352
CUBOID     5 1 1.41224 0.0 0.762 0.0 2P0.635
UNIT 26
YHEMICYL+X 4 1 0.35306 1.41224 0.45974
YHEMICYL+X 0 1 0.37084 1.41224 0.22352
CUBOID     5 1 0.762 0.0 1.41224 0.0 2P0.635
UNIT 27
XHEMICYL+Y 4 1 0.35306 2P0.70612
XHEMICYL+Y 0 1 0.37084 2P0.70612
CUBOID     5 1 2P0.70612 0.762 0.0 2P0.635
UNIT 28
YHEMICYL+X 4 1 0.35306 2P0.70612
YHEMICYL+X 0 1 0.37084 2P0.70612
CUBOID     5 1 0.762 0.0 2P0.70612 2P0.635
UNIT 29
XHEMICYL+Y 4 1 0.35306 1.17602 0.0
XHEMICYL+Y 0 1 0.37084 1.17602 0.0
CUBOID     5 1 2.57048 0.0 0.762 0.0 2P0.635
UNIT 30
YHEMICYL+X 4 1 0.35306 1.17602 0.0
YHEMICYL+X 0 1 0.37084 1.17602 0.0
CUBOID     5 1 0.762 0.0 2.57048 0.0 2P0.635
```

```
UNIT 31
ARRAY 3 0.0 0.0 -0.635
UNIT 32
XHEMICYL+Y 4 1 0.5410 1.17602 0.0
XHEMICYL+Y 0 1 0.5588 1.17602 0.0
CUBOID     5 1 2.57048 0.0 0.762 0.0 2P0.635
UNIT 33
YHEMICYL+X 4 1 0.5410 1.17602 0.0
YHEMICYL+X 0 1 0.5588 1.17602 0.0
CUBOID     5 1 0.762 0.0 2.57048 0.0 2P0.635
UNIT 34
CUBOID     3 1 4P0.70612 2P0.635
UNIT 35
CUBOID     3 1 4P0.70612 2P0.3175
UNIT 36
ARRAY 4  0.0 0.0 -0.3175
UNIT 37
ARRAY 5  0.0 0.0 -0.635
UNIT 38
ARRAY 6  0.0 0.0 -0.635
CORE 7 1 0.0 0.0 0.635
CUBOID 3 1 23.2029 0.0 23.2029 0.0 424.815 0.0
CUBOID 5 1 24.1554 0.0 24.1554 0.0 424.815 0.0
CUBOID 6 1 30.8864 0.0 30.8864 0.0 424.815 0.0
CUBOID 5 1 34.6964 0.0 34.6964 0.0 452.755 -24.13
CUBOID 3 1 100.0 0.0 100.0 0.0 510.0 -75.0
END GEOM
END DATA
END
```

mrf12

```
=CSAS25
4 PWR ASSEM. EXXON/ANF(14X14) WE, E=3.1, BU=00,
27BURNUPLIB  LATTICECELL
UO2  1 0.95 293 92235 3.15 92238 96.85 END
ZIRCALLOY  2 1.0 END
H2O  3 1.0 END
B4C  4 0.864 293.0 5010 96.0 5011 4.0 END
SS304  5 1.0 END
URANIUM  6 1.0 293.0 92235 0.3 92238 99.7 END
H2O  7 1.0 END
END COMP
SQUAREPITCH 1.41224 0.89027 1 3 1.07696 2 0.92456 7 END
FLAT FULL HEIGHT GA-4, 4/96, 90% FOR NRC WITH B4C
READ PARAM  TME=200.0 GEN=200 NPG=1000 FLX=NO FDN=NO
NUB=YES END PARAM
READ ARRAY
ARA=1 NUX=16 NUY=16 NUZ=1
FILL
     15 14R16 18
     17 14R13 20
     17 14R13 20
     17 2R13 14 2R13 14 2R13 14 2R13 14 2R13 20
     17 14R13 20
     17 4R13 14 4R13 14 4R13 20
     17 2R13 14 8R13 14 2R13 20
     17 14R13 20
     17 14R13 20
     17 2R13 14 8R13 14 2R13 20
     17 4R13 14 4R13 14 4R13 20
     17 14R13 20
     17 2R13 14 2R13 14 2R13 14 2R13 14 2R13 20
     17 14R13 20
     17 14R13 20
     19 14R21 22
     END FILL
ARA=2 NUX=16 NUY=16 NUZ=1
FILL
     3 4 13R6 32
     5 14R1 10
     7 14R1 10
     7 2R1 2 2R1 2 2R1 2 2R1 2 2R1 10
     7 14R1 10
     7 4R1 2 4R1 2 4R1 10
     7 2R1 2 8R1 2 2R1 10
     7 14R1 10
```

```
      7 14R1 10
      7 2R1 2 8R1 2 2R1 10
      7 4R1 2 4R1 2 4R1 10
      7 14R1 10
      7 2R1 2 2R1 2 2R1 2 2R1 2 2R1 10
      7 14R1 10
      7 14R1 10
      33 14R11 12
      END FILL
ARA=3 NUX=16 NUY=16 NUZ=1
FILL
      3 25 13R27 29
      26 14R1 10
      28 14R1 10
      28 2R1 2 2R1 2 2R1 2 2R1 2 2R1 10
      28 14R1 10
      28 4R1 2 4R1 2 4R1 10
      28 2R1 2 8R1 2 2R1 10
      28 14R1 10
      28 14R1 10
      28 2R1 2 8R1 2 2R1 10
      28 4R1 2 4R1 2 4R1 10
      28 14R1 10
      28 2R1 2 2R1 2 2R1 2 2R1 2 2R1 10
      28 14R1 10
      28 14R1 10
      30 14R11 12
      END FILL
ARA=4 NUX=16 NUY=16 NUZ=1
FILL
      15 14R16 18
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      17 14R35 20
      19 14R21 22
      END FILL
ARA=5 NUX=16 NUY=16 NUZ=1
```

```
FILL
     3 4 13R6 32
     5 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     7 14R34 10
     33 14R11 12
     END FILL
ARA=6 NUX=16 NUY=16 NUZ=1
FILL
     3 25 13R27 29
     26 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     28 14R34 10
     30 14R11 12
     END FILL
ARA=7 NUX=1 NUY=1 NUZ=344
FILL
     7R36
     4R23
     19R31
     263R24
     20R37
     20R38
     11R36
     END FILL
END ARRAY
```

```
READ BNDS -XY=MIRROR   END BNDS
READ GEOM
UNIT 1
CYLINDER 1 1 0.445135 2P0.635
CYLINDER 7 1 0.46228 2P0.635
CYLINDER 2 1 0.53848 2P0.635
CUBOID   3 1 4P0.70612 2P0.635
UNIT 2
CYLINDER 3 1 0.64895 2P0.635
CYLINDER 2 1 0.67945 2P0.635
CUBOID   3 1 4P0.70612 2P0.635
UNIT 3
CUBOID 5 1 4P0.381 2P0.635
UNIT 4
XHEMICYL+Y 4 1 0.5410 1.41224 1.31318
XHEMICYL+Y 0 1 0.5588 1.41224 0.29972
CUBOID     5 1 1.41224 0.0 0.762 0.0 2P0.635
UNIT 5
YHEMICYL+X 4 1 0.5410 1.41224 1.31318
YHEMICYL+X 0 1 0.5588 1.41224 0.29972
CUBOID     5 1 0.762 0.0 1.41224 0.0 2P0.635
UNIT 6
XHEMICYL+Y 4 1 0.5410 2P0.70612
XHEMICYL+Y 0 1 0.5588 2P0.70612
CUBOID     5 1 2P0.70612 0.762 0.0 2P0.635
UNIT 7
YHEMICYL+X 4 1 0.5410 2P0.70612
YHEMICYL+X 0 1 0.5588 2P0.70612
CUBOID     5 1 0.762 0.0 2P0.70612 2P0.635
UNIT 8
XHEMICYL+Y 4 1 0.5410 0.78994 0.0
XHEMICYL+Y 0 1 0.5588 0.78994 0.0
CUBOID     5 1 1.25984 0.0 0.762 0.0 2P0.635
UNIT 9
YHEMICYL+X 4 1 0.5410 0.78994 0.0
YHEMICYL+X 0 1 0.5588 0.78994 0.0
CUBOID     5 1 0.762 0.0 1.25984 0.0 2P0.635
UNIT 10
CUBOID 3 1 2P1.28524 2P0.70612 2P0.635
UNIT 11
CUBOID 3 1 2P0.70612 2P1.28524 2P0.635
UNIT 12
CUBOID 3 1 4P1.28524 2P0.635
UNIT 13
CYLINDER 1 1 0.445135 2P0.3175
CYLINDER 7 1 0.46228 2P0.3175
CYLINDER 2 1 0.53848 2P0.3175
CUBOID   3 1 4P0.70612 2P0.3175
```

```
UNIT 14
CYLINDER 3 1 0.64895 2P0.3175
CYLINDER 2 1 0.67945 2P0.3175
CUBOID   3 1 4P0.70612 2P0.3175
UNIT 15
CUBOID 5 1 4P0.381 2P0.3175
UNIT 16
CUBOID 5 1 2P0.70612 2P0.381 2P0.3175
UNIT 17
CUBOID 5 1 2P0.381 2P0.70612 2P0.3175
UNIT 18
CUBOID 5 1 2P1.28524 2P0.381 2P0.3175
UNIT 19
CUBOID 5 1 2P0.381 2P1.28524 2P0.3175
UNIT 20
CUBOID 3 1 2P1.28524 2P0.70612 2P0.3175
UNIT 21
CUBOID 3 1 2P0.70612 2P1.28524 2P0.3175
UNIT 22
CUBOID 3 1 4P1.28524 2P0.3175
UNIT 23
ARRAY 1 0.0 0.0 -0.3175
UNIT 24
ARRAY 2 0.0 0.0 -0.635
UNIT 25
XHEMICYL+Y 4 1 0.35306 1.41224 0.45974
XHEMICYL+Y 0 1 0.37084 1.41224 0.22352
CUBOID     5 1 1.41224 0.0 0.762 0.0 2P0.635
UNIT 26
YHEMICYL+X 4 1 0.35306 1.41224 0.45974
YHEMICYL+X 0 1 0.37084 1.41224 0.22352
CUBOID     5 1 0.762 0.0 1.41224 0.0 2P0.635
UNIT 27
XHEMICYL+Y 4 1 0.35306 2P0.70612
XHEMICYL+Y 0 1 0.37084 2P0.70612
CUBOID     5 1 2P0.70612 0.762 0.0 2P0.635
UNIT 28
YHEMICYL+X 4 1 0.35306 2P0.70612
YHEMICYL+X 0 1 0.37084 2P0.70612
CUBOID     5 1 0.762 0.0 2P0.70612 2P0.635
UNIT 29
XHEMICYL+Y 4 1 0.35306 1.17602 0.0
XHEMICYL+Y 0 1 0.37084 1.17602 0.0
CUBOID     5 1 2.57048 0.0 0.762 0.0 2P0.635
UNIT 30
YHEMICYL+X 4 1 0.35306 1.17602 0.0
YHEMICYL+X 0 1 0.37084 1.17602 0.0
CUBOID     5 1 0.762 0.0 2.57048 0.0 2P0.635
```

```
UNIT 31
ARRAY 3 0.0 0.0 -0.635
UNIT 32
XHEMICYL+Y 4 1 0.5410 1.17602 0.0
XHEMICYL+Y 0 1 0.5588 1.17602 0.0
CUBOID     5 1 2.57048 0.0 0.762 0.0 2P0.635
UNIT 33
YHEMICYL+X 4 1 0.5410 1.17602 0.0
YHEMICYL+X 0 1 0.5588 1.17602 0.0
CUBOID     5 1 0.762 0.0 2.57048 0.0 2P0.635
UNIT 34
CUBOID     3 1 4P0.70612 2P0.635
UNIT 35
CUBOID     3 1 4P0.70612 2P0.3175
UNIT 36
ARRAY 4  0.0 0.0 -0.3175
UNIT 37
ARRAY 5  0.0 0.0 -0.635
UNIT 38
ARRAY 6  0.0 0.0 -0.635
CORE 7 1 0.0 0.0 0.635
CUBOID 3 1 23.2029 0.0 23.2029 0.0 424.815 0.0
CUBOID 5 1 24.1554 0.0 24.1554 0.0 424.815 0.0
CUBOID 6 1 30.8864 0.0 30.8864 0.0 424.815 0.0
CUBOID 5 1 34.6964 0.0 34.6964 0.0 452.755 -24.13
CUBOID 3 1 100.0 0.0 100.0 0.0 510.0 -75.0
END GEOM
END DATA
END
```

acc01

```
=CSAS25
4 PWR ASSEM. W(15X15) OFA, E=3.1, BU=00,
27BURNUPLIB  LATTICECELL
UO2  1 0.95 293 92235 3.15 92238 96.85 END
ZIRCALLOY  2 1.0 END
H2O  3 1.0 END
B4C  4 0.864 293.0 5010 96.0 5011 4.0 END
SS304  5 1.0 END
URANIUM  6 1.0 293.0 92235 0.3 92238 99.7 END
END COMP
SQUAREPITCH 1.43002 0.92964 1 0 1.07188 2 0.948944 0 END
FLAT FULL HEIGHT GA-4 ACCIDENT, 4/96, 90% FOR NRC WITH B4C
READ PARAM  TME=200.0 GEN=200 NPG=1000 FLX=NO FDN=NO
NUB=YES END PARAM
READ ARRAY
ARA=1 NUX=17 NUY=17 NUZ=1
FILL
     15 15R16 18
     17 15R13 20
     17 15R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 7R13 14 7R13 20
     17 4R13 14 5R13 14 4R13 20
     17 2R13 14 9R13 14 2R13 20
     17 15R13 20
     17 3R13 14 3R13 14 3R13 14 3R13 20
     17 15R13 20
     17 2R13 14 9R13 14 2R13 20
     17 4R13 14 5R13 14 4R13 20
     17 7R13 14 7R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 15R13 20
     17 15R13 20
     19 15R21 22
     END FILL
ARA=2 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R1 10
     7 15R1 10
     7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
     7 7R1 2 7R1 10
     7 4R1 2 5R1 2 4R1 10
     7 2R1 2 9R1 2 2R1 10
     7 15R1 10
```

```
      7 3R1 2 3R1 2 3R1 2 3R1 10
      7 15R1 10
      7 2R1 2 9R1 2 2R1 10
      7 4R1 2 5R1 2 4R1 10
      7 7R1 2 7R1 10
      7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      7 15R1 10
      9 15R1 10
      33 15R11 12
      END FILL
ARA=3 NUX=17 NUY=17 NUZ=1
FILL
      3 25 13R27 39 29
      26 15R1 10
      28 15R1 10
      28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      28 7R1 2 7R1 10
      28 4R1 2 5R1 2 4R1 10
      28 2R1 2 9R1 2 2R1 10
      28 15R1 10
      28 3R1 2 3R1 2 3R1 2 3R1 10
      28 15R1 10
      28 2R1 2 9R1 2 2R1 10
      28 4R1 2 5R1 2 4R1 10
      28 7R1 2 7R1 10
      28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      28 15R1 10
      40 15R1 10
      30 15R11 12
      END FILL
ARA=4 NUX=17 NUY=17 NUZ=1
FILL
      15 15R16 18
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
```

```
     19 15R21 22
     END FILL
ARA=5 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     9 15R34 10
     33 15R11 12
     END FILL
ARA=6 NUX=17 NUY=17 NUZ=1
FILL
     3 25 13R27 39 29
     26 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     40 15R34 10
     30 15R11 12
     END FILL
ARA=7 NUX=1 NUY=1 NUZ=344
FILL
     7R36
     4R23
     19R31
     267R24
```

```
     16R37
     20R38
     11R36
     END FILL
END ARRAY
READ BNDS ALL=MIRROR   END BNDS
READ GEOM
UNIT 1
CYLINDER 1 1 0.46482 2P0.635
CYLINDER 0 1 0.474472 2P0.635
CYLINDER 2 1 0.53594 2P0.635
CUBOID   O 1 4P0.71501 2P0.635
UNIT 2
CYLINDER 0 1 0.6502 2P0.635
CYLINDER 2 1 0.6934 2P0.635
CUBOID   O 1 4P0.71501 2P0.635
UNIT 3
CUBOID 5 1 4P0.381 2P0.635
UNIT 4
XHEMICYL+Y 4 1 0.5410 1.43002 1.31318
XHEMICYL+Y 0 1 0.5588 1.43002 0.29972
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 5
YHEMICYL+X 4 1 0.5410 1.43002 1.31318
YHEMICYL+X 0 1 0.5588 1.43002 0.29972
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 6
XHEMICYL+Y 4 1 0.5410 2P0.71501
XHEMICYL+Y 0 1 0.5588 2P0.71501
CUBOID     5 1 2P0.71501 0.762 0.0 2P0.635
UNIT 7
YHEMICYL+X 4 1 0.5410 2P0.71501
YHEMICYL+X 0 1 0.5588 2P0.71501
CUBOID     5 1 0.762 0.0 2P0.71501 2P0.635
UNIT 8
XHEMICYL+Y 4 1 0.5410 0.9271 0.0
XHEMICYL+Y 0 1 0.5588 0.9271 0.0
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 9
YHEMICYL+X 4 1 0.5410 0.9271 0.0
YHEMICYL+X 0 1 0.5588 0.9271 0.0
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 10
CUBOID O 1 2P0.44577 2P0.71501 2P0.635
UNIT 11
CUBOID 0 1 2P0.71501 2P0.44577 2P0.635
UNIT 12
CUBOID 0 1 4P0.44577 2P0.635
```

```
UNIT 13
CYLINDER 1 1 0.46482 2P0.3175
CYLINDER 0 1 0.474472 2P0.3175
CYLINDER 2 1 0.53594 2P0.3175
CUBOID   0 1 4P0.71501 2P0.3175
UNIT 14
CYLINDER 0 1 0.6502 2P0.3175
CYLINDER 2 1 0.6934 2P0.3175
CUBOID   0 1 4P0.71501 2P0.3175
UNIT 15
CUBOID 5 1 4P0.381 2P0.3175
UNIT 16
CUBOID 5 1 2P0.71501 2P0.381 2P0.3175
UNIT 17
CUBOID 5 1 2P0.381 2P0.71501 2P0.3175
UNIT 18
CUBOID 5 1 2P0.44577 2P0.381 2P0.3175
UNIT 19
CUBOID 5 1 2P0.381 2P0.44577 2P0.3175
UNIT 20
CUBOID 0 1 2P0.44577 2P0.71501 2P0.3175
UNIT 21
CUBOID 0 1 2P0.71501 2P0.44577 2P0.3175
UNIT 22
CUBOID 0 1 4P0.44577 2P0.3175
UNIT 23
ARRAY 1 0.0 0.0 -0.3175
UNIT 24
ARRAY 2 0.0 0.0 -0.635
UNIT 25
XHEMICYL+Y 4 1 0.35306 1.43002 0.45974
XHEMICYL+Y 0 1 0.37084 1.43002 0.22352
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 26
YHEMICYL+X 4 1 0.35306 1.43002 0.45974
YHEMICYL+X 0 1 0.37084 1.43002 0.22352
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 27
XHEMICYL+Y 4 1 0.35306 2P0.71501
XHEMICYL+Y 0 1 0.37084 2P0.71501
CUBOID     5 1 2P0.71501 0.762 0.0 2P0.635
UNIT 28
YHEMICYL+X 4 1 0.35306 2P0.71501
YHEMICYL+X 0 1 0.37084 2P0.71501
CUBOID     5 1 0.762 0.0 2P0.71501 2P0.635
UNIT 29
CUBOID     5 1 0.89154 0.0 0.762 0.0 2P0.635
UNIT 30
```

```
CUBOID      5 1 0.762 0.0 0.89154 0.0 2P0.635
UNIT 31
ARRAY 3 0.0 0.0 -0.635
UNIT 32
CUBOID      5 1 0.89154 0.0 0.762 0.0 2P0.635
UNIT 33
CUBOID      5 1 0.762 0.0 0.89154 0.0 2P0.635
UNIT 34
CUBOID      0 1 4P0.71501 2P0.635
UNIT 35
CUBOID      0 1 4P0.71501 2P0.3175
UNIT 36
ARRAY 4  0.0 0.0 -0.3175
UNIT 37
ARRAY 5  0.0 0.0 -0.635
UNIT 38
ARRAY 6  0.0 0.0 -0.635
UNIT 39
XHEMICYL+Y 4 1 0.35306 0.9271 0.0
XHEMICYL+Y 0 1 0.37084 0.9271 0.0
CUBOID      5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 40
YHEMICYL+X 4 1 0.35306 0.9271 0.0
YHEMICYL+X 0 1 0.37084 0.9271 0.0
CUBOID      5 1 0.762 0.0 1.43002 0.0 2P0.635
CORE 7 1 0.0 0.0 0.635
CUBOID 0 1 23.2029 0.0 23.2029 0.0 424.815 0.0
CUBOID 5 1 24.1554 0.0 24.1554 0.0 424.815 0.0
CUBOID 6 1 30.8864 0.0 30.8864 0.0 424.815 0.0
CUBOID 5 1 34.6964 0.0 34.6964 0.0 452.755 -24.13
END GEOM
END DATA
END
```

acc02

```
=CSAS25
4 PWR ASSEM. W(15X15) OFA, E=3.1, BU=00,
27BURNUPLIB  LATTICECELL
UO2  1 0.95 293 92235 3.15 92238 96.85 END
ZIRCALLOY  2 1.0 END
H2O  3 1.0 END
B4C  4 0.864 293.0 5010 96.0 5011 4.0 END
SS304  5 1.0 END
URANIUM  6 1.0 293.0 92235 0.3 92238 99.7 END
END COMP
SQUAREPITCH 1.43002 0.92964 1 0 1.07188 2 0.948944 0 END
FLAT FULL HEIGHT GA-4 ACCIDENT, 4/96, 90% FOR NRC WITH B4C
READ PARAM  TME=200.0 GEN=200 NPG=1000 FLX=NO FDN=NO
NUB=YES END PARAM
READ ARRAY
ARA=1 NUX=17 NUY=17 NUZ=1
FILL
     15 15R16 18
     17 15R13 20
     17 15R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 7R13 14 7R13 20
     17 4R13 14 5R13 14 4R13 20
     17 2R13 14 9R13 14 2R13 20
     17 15R13 20
     17 3R13 14 3R13 14 3R13 14 3R13 20
     17 15R13 20
     17 2R13 14 9R13 14 2R13 20
     17 4R13 14 5R13 14 4R13 20
     17 7R13 14 7R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 15R13 20
     17 15R13 20
     19 15R21 22
     END FILL
ARA=2 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R1 10
     7 15R1 10
     7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
     7 7R1 2 7R1 10
     7 4R1 2 5R1 2 4R1 10
     7 2R1 2 9R1 2 2R1 10
     7 15R1 10
```

```
      7 3R1 2 3R1 2 3R1 2 3R1 10
      7 15R1 10
      7 2R1 2 9R1 2 2R1 10
      7 4R1 2 5R1 2 4R1 10
      7 7R1 2 7R1 10
      7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      7 15R1 10
      9 15R1 10
      33 15R11 12
      END FILL
ARA=3 NUX=17 NUY=17 NUZ=1
FILL
      3 25 13R27 39 29
      26 15R1 10
      28 15R1 10
      28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      28 7R1 2 7R1 10
      28 4R1 2 5R1 2 4R1 10
      28 2R1 2 9R1 2 2R1 10
      28 15R1 10
      28 3R1 2 3R1 2 3R1 2 3R1 10
      28 15R1 10
      28 2R1 2 9R1 2 2R1 10
      28 4R1 2 5R1 2 4R1 10
      28 7R1 2 7R1 10
      28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      28 15R1 10
      40 15R1 10
      30 15R11 12
      END FILL
ARA=4 NUX=17 NUY=17 NUZ=1
FILL
      15 15R16 18
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
```

```
      19 15R21 22
      END FILL
ARA=5 NUX=17 NUY=17 NUZ=1
FILL
      3 4 13R6 8 32
      5 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      9 15R34 10
      33 15R11 12
      END FILL
ARA=6 NUX=17 NUY=17 NUZ=1
FILL
      3 25 13R27 39 29
      26 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      40 15R34 10
      30 15R11 12
      END FILL
ARA=7 NUX=1 NUY=1 NUZ=344
FILL
      7R36
      4R23
      19R31
      267R24
```

```
     16R37
     20R38
     11R36
     END FILL
END ARRAY
READ BNDS ALL=MIRROR   END BNDS
READ GEOM
UNIT 1
CYLINDER 1 1 0.46482 2P0.635
CYLINDER 0 1 0.474472 2P0.635
CYLINDER 2 1 0.53594 2P0.635
CUBOID   0 1 4P0.71501 2P0.635
UNIT 2
CYLINDER 0 1 0.6502 2P0.635
CYLINDER 2 1 0.6934 2P0.635
CUBOID   0 1 4P0.71501 2P0.635
UNIT 3
CUBOID 5 1 4P0.381 2P0.635
UNIT 4
XHEMICYL+Y 4 1 0.5410 1.43002 1.31318
XHEMICYL+Y 0 1 0.5588 1.43002 0.29972
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 5
YHEMICYL+X 4 1 0.5410 1.43002 1.31318
YHEMICYL+X 0 1 0.5588 1.43002 0.29972
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 6
XHEMICYL+Y 4 1 0.5410 2P0.71501
XHEMICYL+Y 0 1 0.5588 2P0.71501
CUBOID     5 1 2P0.71501 0.762 0.0 2P0.635
UNIT 7
YHEMICYL+X 4 1 0.5410 2P0.71501
YHEMICYL+X 0 1 0.5588 2P0.71501
CUBOID     5 1 0.762 0.0 2P0.71501 2P0.635
UNIT 8
XHEMICYL+Y 4 1 0.5410 0.9271 0.0
XHEMICYL+Y 0 1 0.5588 0.9271 0.0
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 9
YHEMICYL+X 4 1 0.5410 0.9271 0.0
YHEMICYL+X 0 1 0.5588 0.9271 0.0
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 10
CUBOID 0 1 2P0.44577 2P0.71501 2P0.635
UNIT 11
CUBOID 0 1 2P0.71501 2P0.44577 2P0.635
UNIT 12
CUBOID 0 1 4P0.44577 2P0.635
```

```
UNIT 13
CYLINDER 1 1 0.46482 2P0.3175
CYLINDER 0 1 0.474472 2P0.3175
CYLINDER 2 1 0.53594 2P0.3175
CUBOID   0 1 4P0.71501 2P0.3175
UNIT 14
CYLINDER 0 1 0.6502 2P0.3175
CYLINDER 2 1 0.6934 2P0.3175
CUBOID   0 1 4P0.71501 2P0.3175
UNIT 15
CUBOID 5 1 4P0.381 2P0.3175
UNIT 16
CUBOID 5 1 2P0.71501 2P0.381 2P0.3175
UNIT 17
CUBOID 5 1 2P0.381 2P0.71501 2P0.3175
UNIT 18
CUBOID 5 1 2P0.44577 2P0.381 2P0.3175
UNIT 19
CUBOID 5 1 2P0.381 2P0.44577 2P0.3175
UNIT 20
CUBOID 0 1 2P0.44577 2P0.71501 2P0.3175
UNIT 21
CUBOID 0 1 2P0.71501 2P0.44577 2P0.3175
UNIT 22
CUBOID 0 1 4P0.44577 2P0.3175
UNIT 23
ARRAY 1 0.0 0.0 -0.3175
UNIT 24
ARRAY 2 0.0 0.0 -0.635
UNIT 25
XHEMICYL+Y 4 1 0.35306 1.43002 0.45974
XHEMICYL+Y 0 1 0.37084 1.43002 0.22352
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 26
YHEMICYL+X 4 1 0.35306 1.43002 0.45974
YHEMICYL+X 0 1 0.37084 1.43002 0.22352
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 27
XHEMICYL+Y 4 1 0.35306 2P0.71501
XHEMICYL+Y 0 1 0.37084 2P0.71501
CUBOID     5 1 2P0.71501 0.762 0.0 2P0.635
UNIT 28
YHEMICYL+X 4 1 0.35306 2P0.71501
YHEMICYL+X 0 1 0.37084 2P0.71501
CUBOID     5 1 0.762 0.0 2P0.71501 2P0.635
UNIT 29
CUBOID     5 1 0.89154 0.0 0.762 0.0 2P0.635
UNIT 30
```

```
CUBOID      5 1 0.762 0.0 0.89154 0.0 2P0.635
UNIT 31
ARRAY 3 0.0 0.0 -0.635
UNIT 32
CUBOID      5 1 0.89154 0.0 0.762 0.0 2P0.635
UNIT 33
CUBOID      5 1 0.762 0.0 0.89154 0.0 2P0.635
UNIT 34
CUBOID      0 1 4P0.71501 2P0.635
UNIT 35
CUBOID      0 1 4P0.71501 2P0.3175
UNIT 36
ARRAY 4   0.0 0.0 -0.3175
UNIT 37
ARRAY 5   0.0 0.0 -0.635
UNIT 38
ARRAY 6   0.0 0.0 -0.635
UNIT 39
XHEMICYL+Y 4 1 0.35306 0.9271 0.0
XHEMICYL+Y 0 1 0.37084 0.9271 0.0
CUBOID      5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 40
YHEMICYL+X 4 1 0.35306 0.9271 0.0
YHEMICYL+X 0 1 0.37084 0.9271 0.0
CUBOID      5 1 0.762 0.0 1.43002 0.0 2P0.635
CORE 7 1 0.0 0.0 0.635
CUBOID 0 1 23.2029 0.0 23.2029 0.0 424.815 0.0
CUBOID 5 1 24.1554 0.0 24.1554 0.0 424.815 0.0
CUBOID 6 1 30.8864 0.0 30.8864 0.0 424.815 0.0
CUBOID 5 1 34.6964 0.0 34.6964 0.0 452.755 -24.13
CUBOID 3 1 37.1964 0.0 37.1964 0.0 452.755 -24.13
END GEOM
END DATA
END
```

acc03

```
=CSAS25
4 PWR ASSEM. W(15X15) OFA, E=3.1, BU=00,
27BURNUPLIB  LATTICECELL
UO2  1 0.95 293 92235 3.15 92238 96.85 END
ZIRCALLOY  2 1.0 END
H2O  3 1.0 END
B4C  4 0.864 293.0 5010 96.0 5011 4.0 END
SS304  5 1.0 END
URANIUM  6 1.0 293.0 92235 0.3 92238 99.7 END
END COMP
SQUAREPITCH 1.43002 0.92964 1 0 1.07188 2 0.948944 0 END
FLAT FULL HEIGHT GA-4 ACCIDENT, 4/96, 90% FOR NRC WITH B4C
READ PARAM  TME=200.0 GEN=200 NPG=1000 FLX=NO FDN=NO
NUB=YES END PARAM
READ ARRAY
ARA=1 NUX=17 NUY=17 NUZ=1
FILL
     15 15R16 18
     17 15R13 20
     17 15R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 7R13 14 7R13 20
     17 4R13 14 5R13 14 4R13 20
     17 2R13 14 9R13 14 2R13 20
     17 15R13 20
     17 3R13 14 3R13 14 3R13 14 3R13 20
     17 15R13 20
     17 2R13 14 9R13 14 2R13 20
     17 4R13 14 5R13 14 4R13 20
     17 7R13 14 7R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 15R13 20
     17 15R13 20
     19 15R21 22
     END FILL
ARA=2 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R1 10
     7 15R1 10
     7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
     7 7R1 2 7R1 10
     7 4R1 2 5R1 2 4R1 10
     7 2R1 2 9R1 2 2R1 10
     7 15R1 10
```

```
      7 3R1 2 3R1 2 3R1 2 3R1 10
      7 15R1 10
      7 2R1 2 9R1 2 2R1 10
      7 4R1 2 5R1 2 4R1 10
      7 7R1 2 7R1 10
      7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      7 15R1 10
      9 15R1 10
      33 15R11 12
      END FILL
ARA=3 NUX=17 NUY=17 NUZ=1
FILL
      3 25 13R27 39 29
      26 15R1 10
      28 15R1 10
      28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      28 7R1 2 7R1 10
      28 4R1 2 5R1 2 4R1 10
      28 2R1 2 9R1 2 2R1 10
      28 15R1 10
      28 3R1 2 3R1 2 3R1 2 3R1 10
      28 15R1 10
      28 2R1 2 9R1 2 2R1 10
      28 4R1 2 5R1 2 4R1 10
      28 7R1 2 7R1 10
      28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      28 15R1 10
      40 15R1 10
      30 15R11 12
      END FILL
ARA=4 NUX=17 NUY=17 NUZ=1
FILL
      15 15R16 18
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
```

```
     19 15R21 22
     END FILL
ARA=5 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     9 15R34 10
     33 15R11 12
     END FILL
ARA=6 NUX=17 NUY=17 NUZ=1
FILL
     3 25 13R27 39 29
     26 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     40 15R34 10
     30 15R11 12
     END FILL
ARA=7 NUX=1 NUY=1 NUZ=344
FILL
     7R36
     4R23
     19R31
     267R24
```

```
     16R37
     20R38
     11R36
     END FILL
END ARRAY
READ BNDS ALL=MIRROR   END BNDS
READ GEOM
UNIT 1
CYLINDER 1 1 0.46482 2P0.635
CYLINDER 0 1 0.474472 2P0.635
CYLINDER 2 1 0.53594 2P0.635
CUBOID   0 1 4P0.71501 2P0.635
UNIT 2
CYLINDER 0 1 0.6502 2P0.635
CYLINDER 2 1 0.6934 2P0.635
CUBOID   0 1 4P0.71501 2P0.635
UNIT 3
CUBOID 5 1 4P0.381 2P0.635
UNIT 4
XHEMICYL+Y 4 1 0.5410 1.43002 1.31318
XHEMICYL+Y 0 1 0.5588 1.43002 0.29972
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 5
YHEMICYL+X 4 1 0.5410 1.43002 1.31318
YHEMICYL+X 0 1 0.5588 1.43002 0.29972
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 6
XHEMICYL+Y 4 1 0.5410 2P0.71501
XHEMICYL+Y 0 1 0.5588 2P0.71501
CUBOID     5 1 2P0.71501 0.762 0.0 2P0.635
UNIT 7
YHEMICYL+X 4 1 0.5410 2P0.71501
YHEMICYL+X 0 1 0.5588 2P0.71501
CUBOID     5 1 0.762 0.0 2P0.71501 2P0.635
UNIT 8
XHEMICYL+Y 4 1 0.5410 0.9271 0.0
XHEMICYL+Y 0 1 0.5588 0.9271 0.0
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 9
YHEMICYL+X 4 1 0.5410 0.9271 0.0
YHEMICYL+X 0 1 0.5588 0.9271 0.0
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 10
CUBOID 0 1 2P0.44577 2P0.71501 2P0.635
UNIT 11
CUBOID 0 1 2P0.71501 2P0.44577 2P0.635
UNIT 12
CUBOID 0 1 4P0.44577 2P0.635
```

```
UNIT 13
CYLINDER 1 1 0.46482 2P0.3175
CYLINDER 0 1 0.474472 2P0.3175
CYLINDER 2 1 0.53594 2P0.3175
CUBOID   0 1 4P0.71501 2P0.3175
UNIT 14
CYLINDER 0 1 0.6502 2P0.3175
CYLINDER 2 1 0.6934 2P0.3175
CUBOID   0 1 4P0.71501 2P0.3175
UNIT 15
CUBOID 5 1 4P0.381 2P0.3175
UNIT 16
CUBOID 5 1 2P0.71501 2P0.381 2P0.3175
UNIT 17
CUBOID 5 1 2P0.381 2P0.71501 2P0.3175
UNIT 18
CUBOID 5 1 2P0.44577 2P0.381 2P0.3175
UNIT 19
CUBOID 5 1 2P0.381 2P0.44577 2P0.3175
UNIT 20
CUBOID 0 1 2P0.44577 2P0.71501 2P0.3175
UNIT 21
CUBOID 0 1 2P0.71501 2P0.44577 2P0.3175
UNIT 22
CUBOID 0 1 4P0.44577 2P0.3175
UNIT 23
ARRAY 1 0.0 0.0 -0.3175
UNIT 24
ARRAY 2 0.0 0.0 -0.635
UNIT 25
XHEMICYL+Y 4 1 0.35306 1.43002 0.45974
XHEMICYL+Y 0 1 0.37084 1.43002 0.22352
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 26
YHEMICYL+X 4 1 0.35306 1.43002 0.45974
YHEMICYL+X 0 1 0.37084 1.43002 0.22352
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 27
XHEMICYL+Y 4 1 0.35306 2P0.71501
XHEMICYL+Y 0 1 0.37084 2P0.71501
CUBOID     5 1 2P0.71501 0.762 0.0 2P0.635
UNIT 28
YHEMICYL+X 4 1 0.35306 2P0.71501
YHEMICYL+X 0 1 0.37084 2P0.71501
CUBOID     5 1 0.762 0.0 2P0.71501 2P0.635
UNIT 29
CUBOID     5 1 0.89154 0.0 0.762 0.0 2P0.635
UNIT 30
```

```
CUBOID      5 1 0.762 0.0 0.89154 0.0 2P0.635
UNIT 31
ARRAY 3 0.0 0.0 -0.635
UNIT 32
CUBOID      5 1 0.89154 0.0 0.762 0.0 2P0.635
UNIT 33
CUBOID      5 1 0.762 0.0 0.89154 0.0 2P0.635
UNIT 34
CUBOID      0 1 4P0.71501 2P0.635
UNIT 35
CUBOID      0 1 4P0.71501 2P0.3175
UNIT 36
ARRAY 4   0.0 0.0 -0.3175
UNIT 37
ARRAY 5   0.0 0.0 -0.635
UNIT 38
ARRAY 6   0.0 0.0 -0.635
UNIT 39
XHEMICYL+Y 4 1 0.35306 0.9271 0.0
XHEMICYL+Y 0 1 0.37084 0.9271 0.0
CUBOID      5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 40
YHEMICYL+X 4 1 0.35306 0.9271 0.0
YHEMICYL+X 0 1 0.37084 0.9271 0.0
CUBOID      5 1 0.762 0.0 1.43002 0.0 2P0.635
CORE 7 1 0.0 0.0 0.635
CUBOID 0 1 23.2029 0.0 23.2029 0.0 424.815 0.0
CUBOID 5 1 24.1554 0.0 24.1554 0.0 424.815 0.0
CUBOID 6 1 30.8864 0.0 30.8864 0.0 424.815 0.0
CUBOID 5 1 34.6964 0.0 34.6964 0.0 452.755 -24.13
CUBOID 3 1 39.6964 0.0 39.6964 0.0 452.755 -24.13
END GEOM
END DATA
END
```

acc04

```
=CSAS25
4 PWR ASSEM. W(15X15) OFA, E=3.1, BU=00,
27BURNUPLIB  LATTICECELL
UO2  1 0.95 293 92235 3.15 92238 96.85 END
ZIRCALLOY  2 1.0 END
H2O  3 1.0 END
B4C  4 0.864 293.0 5010 96.0 5011 4.0 END
SS304  5 1.0 END
URANIUM  6 1.0 293.0 92235 0.3 92238 99.7 END
END COMP
SQUAREPITCH 1.43002 0.92964 1 0 1.07188 2 0.948944 0 END
FLAT FULL HEIGHT GA-4 ACCIDENT, 4/96, 90% FOR NRC WITH B4C
READ PARAM  TME=200.0 GEN=200 NPG=1000 FLX=NO FDN=NO
NUB=YES END PARAM
READ ARRAY
ARA=1 NUX=17 NUY=17 NUZ=1
FILL
     15 15R16 18
     17 15R13 20
     17 15R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 7R13 14 7R13 20
     17 4R13 14 5R13 14 4R13 20
     17 2R13 14 9R13 14 2R13 20
     17 15R13 20
     17 3R13 14 3R13 14 3R13 14 3R13 20
     17 15R13 20
     17 2R13 14 9R13 14 2R13 20
     17 4R13 14 5R13 14 4R13 20
     17 7R13 14 7R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 15R13 20
     17 15R13 20
     19 15R21 22
     END FILL
ARA=2 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R1 10
     7 15R1 10
     7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
     7 7R1 2 7R1 10
     7 4R1 2 5R1 2 4R1 10
     7 2R1 2 9R1 2 2R1 10
     7 15R1 10
```

```
      7 3R1 2 3R1 2 3R1 2 3R1 10
      7 15R1 10
      7 2R1 2 9R1 2 2R1 10
      7 4R1 2 5R1 2 4R1 10
      7 7R1 2 7R1 10
      7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      7 15R1 10
      9 15R1 10
      33 15R11 12
      END FILL
ARA=3 NUX=17 NUY=17 NUZ=1
FILL
      3 25 13R27 39 29
      26 15R1 10
      28 15R1 10
      28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      28 7R1 2 7R1 10
      28 4R1 2 5R1 2 4R1 10
      28 2R1 2 9R1 2 2R1 10
      28 15R1 10
      28 3R1 2 3R1 2 3R1 2 3R1 10
      28 15R1 10
      28 2R1 2 9R1 2 2R1 10
      28 4R1 2 5R1 2 4R1 10
      28 7R1 2 7R1 10
      28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      28 15R1 10
      40 15R1 10
      30 15R11 12
      END FILL
ARA=4 NUX=17 NUY=17 NUZ=1
FILL
      15 15R16 18
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
```

```
      19 15R21 22
      END FILL
ARA=5 NUX=17 NUY=17 NUZ=1
FILL
      3 4 13R6 8 32
      5 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      7 15R34 10
      9 15R34 10
      33 15R11 12
      END FILL
ARA=6 NUX=17 NUY=17 NUZ=1
FILL
      3 25 13R27 39 29
      26 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      28 15R34 10
      40 15R34 10
      30 15R11 12
      END FILL
ARA=7 NUX=1 NUY=1 NUZ=344
FILL
      7R36
      4R23
      19R31
      267R24
```

```
     16R37
     20R38
     11R36
     END FILL
END ARRAY
READ BNDS ALL=MIRROR   END BNDS
READ GEOM
UNIT 1
CYLINDER 1 1 0.46482 2P0.635
CYLINDER 0 1 0.474472 2P0.635
CYLINDER 2 1 0.53594 2P0.635
CUBOID   0 1 4P0.71501 2P0.635
UNIT 2
CYLINDER 0 1 0.6502 2P0.635
CYLINDER 2 1 0.6934 2P0.635
CUBOID   0 1 4P0.71501 2P0.635
UNIT 3
CUBOID 5 1 4P0.381 2P0.635
UNIT 4
XHEMICYL+Y 4 1 0.5410 1.43002 1.31318
XHEMICYL+Y 0 1 0.5588 1.43002 0.29972
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 5
YHEMICYL+X 4 1 0.5410 1.43002 1.31318
YHEMICYL+X 0 1 0.5588 1.43002 0.29972
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 6
XHEMICYL+Y 4 1 0.5410 2P0.71501
XHEMICYL+Y 0 1 0.5588 2P0.71501
CUBOID     5 1 2P0.71501 0.762 0.0 2P0.635
UNIT 7
YHEMICYL+X 4 1 0.5410 2P0.71501
YHEMICYL+X 0 1 0.5588 2P0.71501
CUBOID     5 1 0.762 0.0 2P0.71501 2P0.635
UNIT 8
XHEMICYL+Y 4 1 0.5410 0.9271 0.0
XHEMICYL+Y 0 1 0.5588 0.9271 0.0
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 9
YHEMICYL+X 4 1 0.5410 0.9271 0.0
YHEMICYL+X 0 1 0.5588 0.9271 0.0
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 10
CUBOID 0 1 2P0.44577 2P0.71501 2P0.635
UNIT 11
CUBOID 0 1 2P0.71501 2P0.44577 2P0.635
UNIT 12
CUBOID 0 1 4P0.44577 2P0.635
```

```
UNIT 13
CYLINDER 1 1 0.46482 2P0.3175
CYLINDER 0 1 0.474472 2P0.3175
CYLINDER 2 1 0.53594 2P0.3175
CUBOID   0 1 4P0.71501 2P0.3175
UNIT 14
CYLINDER 0 1 0.6502 2P0.3175
CYLINDER 2 1 0.6934 2P0.3175
CUBOID   0 1 4P0.71501 2P0.3175
UNIT 15
CUBOID 5 1 4P0.381 2P0.3175
UNIT 16
CUBOID 5 1 2P0.71501 2P0.381 2P0.3175
UNIT 17
CUBOID 5 1 2P0.381 2P0.71501 2P0.3175
UNIT 18
CUBOID 5 1 2P0.44577 2P0.381 2P0.3175
UNIT 19
CUBOID 5 1 2P0.381 2P0.44577 2P0.3175
UNIT 20
CUBOID 0 1 2P0.44577 2P0.71501 2P0.3175
UNIT 21
CUBOID 0 1 2P0.71501 2P0.44577 2P0.3175
UNIT 22
CUBOID 0 1 4P0.44577 2P0.3175
UNIT 23
ARRAY 1 0.0 0.0 -0.3175
UNIT 24
ARRAY 2 0.0 0.0 -0.635
UNIT 25
XHEMICYL+Y 4 1 0.35306 1.43002 0.45974
XHEMICYL+Y 0 1 0.37084 1.43002 0.22352
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 26
YHEMICYL+X 4 1 0.35306 1.43002 0.45974
YHEMICYL+X 0 1 0.37084 1.43002 0.22352
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
UNIT 27
XHEMICYL+Y 4 1 0.35306 2P0.71501
XHEMICYL+Y 0 1 0.37084 2P0.71501
CUBOID     5 1 2P0.71501 0.762 0.0 2P0.635
UNIT 28
YHEMICYL+X 4 1 0.35306 2P0.71501
YHEMICYL+X 0 1 0.37084 2P0.71501
CUBOID     5 1 0.762 0.0 2P0.71501 2P0.635
UNIT 29
CUBOID     5 1 0.89154 0.0 0.762 0.0 2P0.635
UNIT 30
```

```
CUBOID     5 1 0.762 0.0 0.89154 0.0 2P0.635
UNIT 31
ARRAY 3 0.0 0.0 -0.635
UNIT 32
CUBOID     5 1 0.89154 0.0 0.762 0.0 2P0.635
UNIT 33
CUBOID     5 1 0.762 0.0 0.89154 0.0 2P0.635
UNIT 34
CUBOID     0 1 4P0.71501 2P0.635
UNIT 35
CUBOID     0 1 4P0.71501 2P0.3175
UNIT 36
ARRAY 4  0.0 0.0 -0.3175
UNIT 37
ARRAY 5  0.0 0.0 -0.635
UNIT 38
ARRAY 6  0.0 0.0 -0.635
UNIT 39
XHEMICYL+Y 4 1 0.35306 0.9271 0.0
XHEMICYL+Y 0 1 0.37084 0.9271 0.0
CUBOID     5 1 1.43002 0.0 0.762 0.0 2P0.635
UNIT 40
YHEMICYL+X 4 1 0.35306 0.9271 0.0
YHEMICYL+X 0 1 0.37084 0.9271 0.0
CUBOID     5 1 0.762 0.0 1.43002 0.0 2P0.635
CORE 7 1 0.0 0.0 0.635
CUBOID 0 1 23.2029 0.0 23.2029 0.0 424.815 0.0
CUBOID 5 1 24.1554 0.0 24.1554 0.0 424.815 0.0
CUBOID 6 1 30.8864 0.0 30.8864 0.0 424.815 0.0
CUBOID 5 1 34.6964 0.0 34.6964 0.0 452.755 -24.13
CUBOID 3 1 42.1964 0.0 42.1964 0.0 452.755 -24.13
END GEOM
END DATA
END
```

den98

```
=CSAS25
4 PWR ASSEM. W(15X15) OFA, E=3.1, BU=00, H2O Den = 0.98
27BURNUPLIB  LATTICECELL
UO2  1 0.95 293 92235 3.15 92238 96.85 END
ZIRCALLOY  2 1.0 END
H2O  3 0.98 END
B4C  4 0.864 293.0 5010 96.0 5011 4.0 END
SS304  5 1.0 END
URANIUM  6 1.0 293.0 92235 0.3 92238 99.7 END
H2O  7 0.98 END
H2O  8 1.0 END
END COMP
SQUAREPITCH 1.43002 0.92964 1 3 1.07188 2 0.948944 7 END
FLAT FULL HEIGHT GA-4, 4/96, 90% FOR NRC WITH B4C
READ PARAM  TME=200.0 GEN=200 NPG=1000 FLX=NO FDN=NO
NUB=YES END PARAM
READ ARRAY
ARA=1 NUX=17 NUY=17 NUZ=1
FILL
     15 15R16 18
     17 15R13 20
     17 15R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 7R13 14 7R13 20
     17 4R13 14 5R13 14 4R13 20
     17 2R13 14 9R13 14 2R13 20
     17 15R13 20
     17 3R13 14 3R13 14 3R13 14 3R13 20
     17 15R13 20
     17 2R13 14 9R13 14 2R13 20
     17 4R13 14 5R13 14 4R13 20
     17 7R13 14 7R13 20
     17 2R13 14 2R13 14 3R13 14 2R13 14 2R13 20
     17 15R13 20
     17 15R13 20
     19 15R21 22
     END FILL
ARA=2 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R1 10
     7 15R1 10
     7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
     7 7R1 2 7R1 10
     7 4R1 2 5R1 2 4R1 10
```

```
      7 2R1 2 9R1 2 2R1 10
      7 15R1 10
      7 3R1 2 3R1 2 3R1 2 3R1 10
      7 15R1 10
      7 2R1 2 9R1 2 2R1 10
      7 4R1 2 5R1 2 4R1 10
      7 7R1 2 7R1 10
      7 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      7 15R1 10
      9 15R1 10
      33 15R11 12
      END FILL
ARA=3 NUX=17 NUY=17 NUZ=1
FILL
      3 25 13R27 39 29
      26 15R1 10
      28 15R1 10
      28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      28 7R1 2 7R1 10
      28 4R1 2 5R1 2 4R1 10
      28 2R1 2 9R1 2 2R1 10
      28 15R1 10
      28 3R1 2 3R1 2 3R1 2 3R1 10
      28 15R1 10
      28 2R1 2 9R1 2 2R1 10
      28 4R1 2 5R1 2 4R1 10
      28 7R1 2 7R1 10
      28 2R1 2 2R1 2 3R1 2 2R1 2 2R1 10
      28 15R1 10
      40 15R1 10
      30 15R11 12
      END FILL
ARA=4 NUX=17 NUY=17 NUZ=1
FILL
      15 15R16 18
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
      17 15R35 20
```

```
     17 15R35 20
     17 15R35 20
     19 15R21 22
     END FILL
ARA=5 NUX=17 NUY=17 NUZ=1
FILL
     3 4 13R6 8 32
     5 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     7 15R34 10
     9 15R34 10
     33 15R11 12
     END FILL
ARA=6 NUX=17 NUY=17 NUZ=1
FILL
     3 25 13R27 39 29
     26 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     28 15R34 10
     40 15R34 10
     30 15R11 12
     END FILL
ARA=7 NUX=1 NUY=1 NUZ=344
FILL
     7R36
     4R23
```