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Design Analysis Cover Sheet

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Page: 1 Of: 41

2. DESIGN ANALYSIS TITLE	
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11. REMARKS

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Table of Contents:

1. Purpose

The purpose of this design analysis is to determine the accuracy of the SAS2H module of SCALE 4.3 in predicting isotopic concentrations of spent fuel assemblies. The objective is to develop a methodology for modeling assemblies similar to those evaluated within this analysis and to establish the consistency of SAS2H predictions. The results of this analysis may then be applied to future depletion calculations using SAS2H in which no measurements are available.

2. Quality Assurance

The Quality Assurance (QA) program applies to this analysis. The work reported in this document is part of the Waste Package Design analysis that will eventually support the License Application Design phase. This activity, when appropriately confirmed, can impact the proper functioning of the Mined Geologic Disposal System (MGDS) waste package; the waste package has been identified as an MGDS Q-List item important to safety and waste isolation (pp. 4, 15, Reference 5.1). The waste package is on the Q-List by direct inclusion by the Department of Energy (DOE), without conducting a QAP-2-3 evaluation. The Waste Package Development Department (WPDD) responsible manager has evaluated this activity in accordance with QAP-2-0, *Conduct of Activities*. The *Perform Criticality, Thermal, Structural, and Shielding Analyses* (Reference 5.2) evaluation has determined the preparation and review of this design analysis is subject to *Quality Assurance Requirements and Description* (Reference 5.3) requirements. As specified in NLP-3-18, this activity is subject to QA controls.

The analysis described in this document supports development of the disposal criticality analysis methodology. No designs were analyzed in this document. This document will not directly support any construction, fabrication, or procurement activity and therefore is not required to be procedurally controlled as TBV (to be verified). The calculation design inputs or information used in this document comes from data accepted by the Nuclear Regulatory Commission and by the scientific and engineering community as established fact. The specific references are listed in Section 5 and identified in Section 7. The information is therefore not treated as unqualified data.

3. Method

The analytical model employed for this analysis was the SAS2H module of the SCALE sequence. Based upon fuel design, power history, and operating data for specific assemblies in the Calvert Cliffs pressurized water reactor (PWR), a computational model was developed for use with the SAS2H module of SCALE. The SAS2H module is used to perform a fuel depletion analysis to predict the isotopic concentrations in localized areas of assembly pins (pellet samples) subsequent to irradiation and cooling time. The isotopic concentrations predicted by the SAS2H module are then compared with measured concentrations of the same localized areas (axial locations) of the assembly pins to determine the accuracy of the developed model. The measured isotopic concentrations used for comparisons in the analysis are obtained from a separate report (Reference 5.6).

4. Design Inputs

The sources for the design parameters are References 5.4 through 5.11. References 5.4 and 5.5 provide information on molar masses and half-lives; the assembly design, power history and operating parameters are obtained from References 5.6 through 5.9; the cladding composition from Reference 5.10; and a list of trace elements in the fuel is derived from Reference 5.11.

4.1 Design Parameters

The half-lives of selected isotopes and molar masses of selected elements are obtained from Reference 5.4, while molar masses for selected isotopes are obtained from Reference 5.5. The half-life and molar masses are provided below within three significant figures. Precision beyond three significant figures is not necessary since the calculated isotopic concentrations from SCALE are only to three significant figures. Also, the weight per mole of enriched uranium is approximated by the weight per mole of natural uranium since the weight percent of enrichment is small.

Mole of natural uranium = 238 g,
Half-Life of $^{99}Tc = 2.13 \times 10^5$ years,
Half-Life of $^{237}Np = 2.14 \times 10^6$ years,
Half-Life of $^{241}Am = 432.7$ years,
6.02×10^{23} atoms per mole. (Reference 5.4)
Mole of $^{99}Tc = 98.9$ g,
Mole of $^{237}Np = 237$ g,
Mole of $^{241}Am = 241$ g. (Reference 5.5)

General spent fuel characteristics for each pellet sample are presented in Table 4-1 and include the initial ^{235}U enrichment, final burnup and the cooling time (Table 2, Reference 5.6). The initial enrichment ranges from 2.453 to 3.038 wt% ^{235}U and the burnup ranges from 18.68 to 46.46 GWd/MTU. The cooling time for the samples from assembly D047 is 1,870 days, for assembly

D101 is 2,374 days, and for assembly BT03 is 2,447 days.

Assembly design parameters are presented in Table 4-2 (Table 3, Reference 5.6; and Table 4.0-1, Reference 5.7). The design is a Combustion Engineering 14 x 14 assembly with 5 guide tube positions. Assembly BT03 was used for testing materials and contains four non-fuel rods, one in each corner, and 12 poison rods in place of 16 fuel rods. The non-fuel rod dimensions and the burnable poison rod composition and dimensions for Assembly BT03 are included in Tables 4-3 through 4-4 (Table 5.0-1, Reference 5.8; Table 2.1-23, Reference 5.9). A cross section of the assemblies are presented in Figures 4-1 through 4-3 (Figures 5 through 6, Reference 5.6). The initial enrichment of ^{234}U, ^{235}U, ^{236}U and ^{238}U for each assembly type is given in Table 4-5 (Table 4, Reference 5.6).

The operating parameters in Table 4-7 include the cumulative burnups, average specific powers, average cycle boron concentrations and the fuel temperatures (Table 5, Reference 5.6). Assembly D047 was irradiated for cycles 2 through 5, D101 for cycles 2 through 4 and BT03 for cycles 1 through 4. Power history, in the form of linear heat generation rates (LHGRs), is only available for assembly D047, Table 4-6, which is used to determine the cycle cumulative burnup, Table 4-7, (Table 6, Reference 5.6). The LHGRs are used to sum the interval linear burnups over the entire cycle and are then normalized to the final burnup to produce the cumulative burnups. Assembly D101 resided in the reactor three cycles in which assembly D047 was present, and the axial locations of samples from D101 are approximately the same as those for samples from assembly D047. Therefore, the same methodology was applied for determining cumulative burnups for assembly D101 as that used for assembly D047, using the LHGRs of assembly D047 from cycles 2 through 4 (p. 19, Reference 5.6). For assembly BT03 the cumulative burnup for the entire rod was known and evaluated against the rod's final burnup. Then the cycle burnup fraction was applied to the sample's final burnup to determine the cumulative burnups (p. 19, Reference 5.6). The specific powers for each sample in Table 4-7 were determined from the cycle lengths and cumulative burnups. Fuel temperatures were known only for assembly D047 and are also included in Table 4-7 (Table 6, Reference 5.6).

Table 4-8 includes the moderator temperature and density (Table 7, Reference 5.6). The moderator temperatures obtained were based on a sinusoidal function of position, and inlet and outlet moderator temperatures of 543.2°F and 593.6°F, respectively. The moderator density was determined from the moderator temperature and the nominal pressure of 2247 psia (p. 23, Reference 5.6). The boron concentration for cycles 2 through 5 was determined by taking the first and last interval boron concentrations from the LHGR tables to linearly extrapolate the boron concentrations at the beginning and end of the cycle, which were used to calculate the cycle average boron concentration. It was assumed that the boron concentration for cycle 1 was the same as the concentration in cycle 2 (p. 19, Reference 5.6).

The composition of the cladding, Zircaloy-4, is presented in Table 4-9, and has a density of 6.56 g/cm^3 (Reference 5.10). A list of trace elements in the fuel used in updating cross sections during

the depletion analysis is presented in Table 4-10 and developed with consideration of elements used in (Table 1, Reference 5.11). A generic set of light element weights for PWRs that is typically used in depletion analyses is included in Table 4-11 (Table 17, Reference 5.6). Variations in light element masses per unit fuel in different PWRs are small when compared to this generic set (p. 2-2, Reference 5.9). This data is provided in units of kg/MTUO_2 or kg/MTU depending on the units required in the analysis.

Measured isotopic concentrations are presented in Tables 4-12 and 4-13 and are given in g/gUO_2 and Ci/gUO_2, respectively (Tables 19 through 24, Reference 5.6). The measurements were performed at the Materials Characterization Center at Pacific Northwest Laboratory for fuel pellets at different axial positions in rod MKP-109 of assembly D047, rod MLA-098 of assembly D101, and rod NBD-107 of assembly BT03. Measured isotopic data is more complete for assembly D047; however, isotopic concentrations for assemblies D101 and BT03 do include the major actinides. The measurement uncertainty was obtained for assembly BT03 and is as follows: atom % burnup uncertainty of ±2.5%, Pu uncertainty of ± 1.6%, U uncertainty of ± 1.6%, ^{99}Tc uncertainty of ± 3.5% and ^{237}Np uncertainty of ± 1.9% (Table 4.15, Reference 5.12).

Table 4-1. Spent Fuel Characteristic Parameters for Calvert Cliffs PWR

Assembly	Rod	Axial Location from Bottom of Assembly, cm	Enrichment, wt % ^{235}U	Burnup, GWd/MTU	Cooling Time, days
D047	MKP109	13.20	3.038	27.35	1870
		27.70	3.038	37.12	1870
		165.22	3.038	44.34	1870
D101	MLA098	8.90	2.72	18.68	2374
		24.30	2.72	26.62	2374
		161.70	2.72	33.17	2374
BT03	NBD107	11.28	2.453	31.40	2447
		19.92	2.453	37.27	2447
		161.21	2.453	46.46	2447

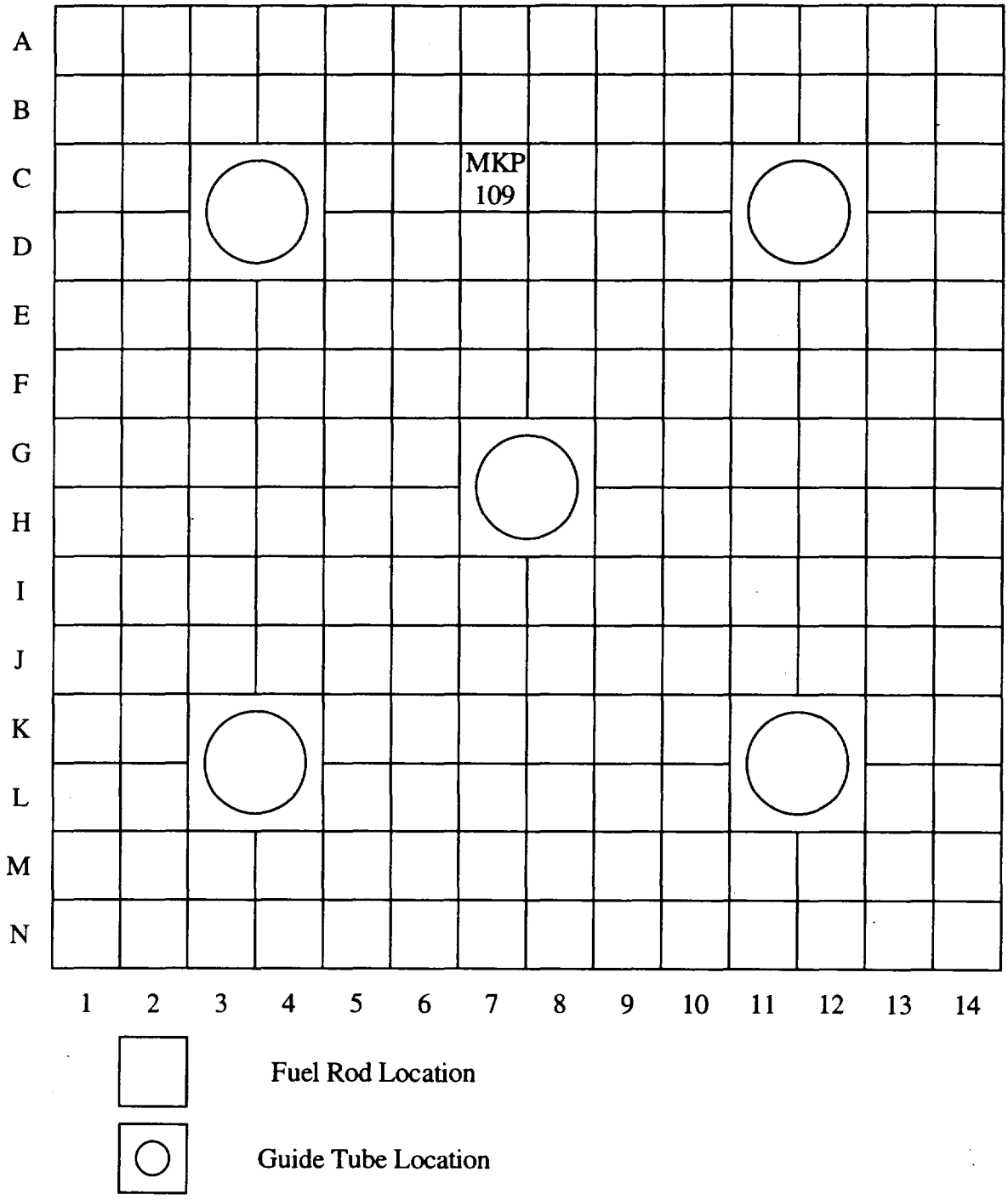
Reference 5.6

Table 4-2. Assembly Design Parameters for Calvert Cliffs PWR

Parameter		**Data**
Assembly ID	D047 and D101	BT03
Assembly general data:		
Designer	Combustion Engineering	Combustion Engineering
Lattice	14 x 14	14 x 14
Number of Fuel Rods	176	160
Number of Guide Tubes	5	5
Number of Non-Fuel Rods	0	4
Number of Poison Rods	0	12
Assembly Pitch, cm	20.78	20.78
Fuel Rod Data:		
Type of Fuel Pellet	UO_2	UO_2
UO_2 Density, % Theoretical (g/cm^3)	94.75 (10.385[a])	93.0 (10.193[a])
UO_2 Stack Height Density, g/cm^3	10.018	10.054
Rod Pitch, cm	1.4732	1.4732
Rod Outside Diameter (OD), cm	1.1176	1.1176
Rod Inside Diameter (ID), cm	0.9855	0.9754
Pellet Diameter, cm	0.9563	0.9639
Active Fuel Length, cm	347.22	347.22
Clad Material	Zircaloy-4	Zircaloy-4
Guide Tube Data:		
Inner Radius, cm	1.314	1.314
Outer Radius, cm	1.416	1.416
Tube Material	Zircaloy-4	Zircaloy-4

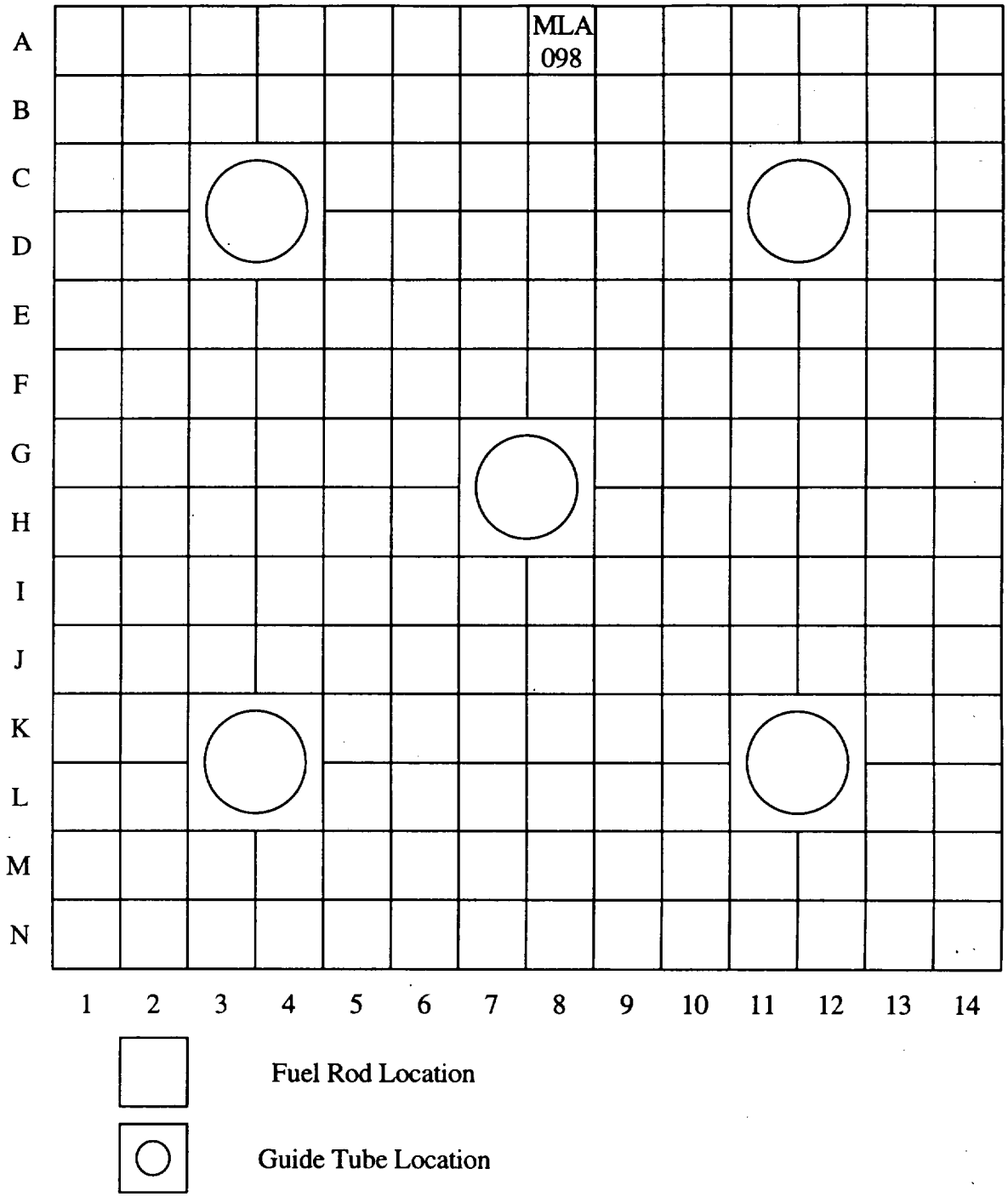
[a]UO_2 density is based on a theoretical density of 10.96 g/cm^3.
References 5.6 and 5.7

Figure 4-1. Location of Fuel Rod MKP109 in Assembly D047



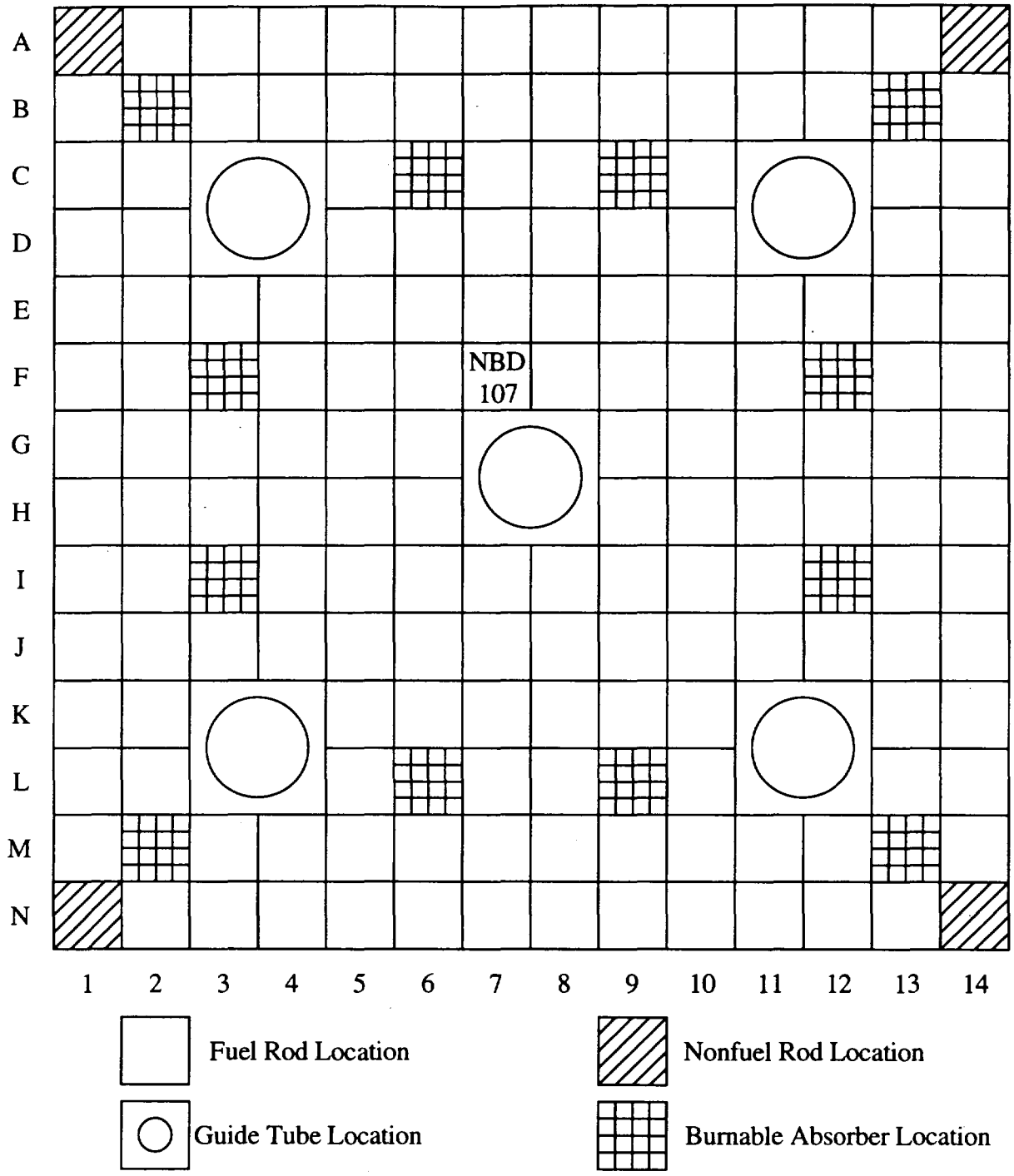
Reference 5.6

Figure 4-2. Location of Fuel Rod MLA098 in Assembly D101



Reference 5.6

Figure 4-3. Location of Fuel Rod NBD107 in Assembly BT03



Reference 5.6

Table 4-3. Burnable Absorber and Test Rod Description for Assembly BT03

Burnable Absorber Rod	
Pellet Outside Diameter, cm	0.955
Clad Inside Diameter, cm	0.9855
Clad Outside Diameter, cm	1.1176
Pellet Material	B_4C- Al_2O_3
Absorber Clad Material	Zircaloy-4
Test Rod	
(Voids are dry gas)	
Stainless Steel Tube Inner Diameter, cm	0.660
Stainless Steel Tube Outer Diameter, cm	0.945
Clad Inner Diameter, cm	0.9855
Clad Outer Diameter, cm	1.1176
Clad Material	Zircaloy-4

References 5.8 and 5.9

Table 4-4. Burnable Absorber Atom Densities

Element/Isotope	**Density, atoms/barn-cm**
Al	0.039
O	0.058
C	0.00107
B-10	0.000859
B-11	0.00344

Reference 5.9

Table 4-5. Fuel Composition by Assembly

Parameter	**D047**	**D101**	**BT03**
Enrichment,			
wt % ^{235}U	3.038	2.72	2.453
wt % ^{234}U	0.027	0.024	0.022
wt % ^{236}U	0.014	0.013	0.011
wt % ^{238}U	96.921	97.243	97.514

Reference 5.6

Table 4-6. Power History and Boron Concentrations for Assembly D047

Interval (days)	Average Soluble Boron, ppm	LHGR, kW/ft		
		Axial Height of 13.20 cm	Axial Height of 27.70 cm	Axial Height of 165.22 cm
Cycle No. 2 (3-22-77 to 1-22-78)				
7.0	654	2.0	3.04	5.42
30.8	614	2.73	4.08	6.64
16.3	563	2.80	4.18	6.60
11.4	533	2.86	4.26	6.60
12.5	507	2.94	4.34	6.56
23.7	468	3.01	4.43	6.41
22.8	418	3.16	4.61	6.44
23.2	368	3.27	4.73	6.37
8.1	333	3.30	4.75	6.34
31.4	290	3.48	4.95	6.34
34.3	218	3.59	5.05	6.53
16.4	162	3.75	5.25	6.38
19.2	122	3.75	5.21	6.26
12.8	86	3.81	5.28	6.30
34.2	36	3.63	4.98	5.95
1.9	0	3.64	4.98	5.96
71.0	0	0	0	0

Table 4-6. Power History and Boron Concentrations for Assembly D047

Interval (days)	Average Soluble Boron, ppm	LHGR, kW/ft		
		Axial Height of 13.20 cm	Axial Height of 27.70 cm	Axial Height of 165.22 cm
Cycle No. 3 (4-3-78 to 4-20-79)				
7.9	883	2.63	3.85	7.47
14.4	862	2.71	3.95	7.20
19.7	837	2.14	3.11	5.04
16.8	808	3.18	4.58	7.79
16.3	775	3.35	4.81	7.78
15.4	741	3.74	5.33	8.16
39.1	684	3.71	5.23	7.45
31.2	611	3.95	5.50	7.37
31.8	545	4.08	5.64	7.20
31.8	478	4.20	5.75	7.02
44.3	368	4.38	5.93	6.93
25.0	291	0	0	0
59.1	224	4.67	6.20	6.89
28.9	120	4.95	6.52	7.12
81.0	83	0	0	0
Cycle No. 4 (7-10-79 to 10-18-80)				
46.1	960	2.79	3.97	6.59
24.0	889	2.91	4.11	6.54
22.6	827	3.07	4.29	6.43
25.7	759	3.29	4.56	6.33
30.2	706	1.58	2.17	3.05
41.2	788	1.79	2.46	3.18
50.3	720	1.72	2.35	3.00
11.0	673	3.18	4.33	5.23

Table 4-6. Power History and Boron Concentrations for Assembly D047

Interval (days)	Average Soluble Boron, ppm	LHGR, kW/ft		
		Axial Height of 13.20 cm	Axial Height of 27.70 cm	Axial Height of 165.22 cm
32.8	527	3.93	5.31	6.17
23.5	460	4.07	5.42	6.12
29.4	370	4.05	5.35	5.95
28.1	301	4.25	5.56	6.07
65.4	191	4.42	5.67	5.98
35.7	73	4.62	5.87	6.02
85.0	31	0	0	0
Cycle No. 5 (1-11-81 to 4-17-82)				
5.5	911	2.15	2.91	4.80
6.6	896	2.20	2.98	4.80
28.6	854	2.36	3.15	4.79
31.2	784	2.54	3.36	4.72
27.0	715	2.66	3.52	4.73
22.7	655	2.77	3.63	4.71
27.1	603	2.46	3.22	4.05
55.2	521	2.81	3.64	4.34
20.9	434	3.17	4.08	4.75
41.9	356	3.32	4.24	4.79
21.6	281	3.38	4.30	4.80
27.6	226	3.21	4.04	4.49
19.0	173	3.57	4.49	4.87
61.2	79	3.05	3.79	4.00

Reference 5.6

Table 4-7. Operating Data for Calvert Cliffs PWR

	Sample	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5
Uptime, days		816.0	306.0	381.7	466.0	461.1
Downtime, days		81.0	71.0	81.3	85.0	See Table 4-1
Cumulative Burnup, GWd/MTU	D047, 13.20 cm	-	5.28	12.69	20.63	27.35
	D047, 27.70 cm	-	7.56	17.78	28.42	37.12
	D047, 165.22 cm	-	9.52	21.93	34.14	44.34
	D101, 9.10 cm	-	4.78	11.49	18.68	-
	D101, 24.50 cm	-	7.08	16.65	26.62	-
	D101, 161.90 cm	-	9.25	21.31	33.17	-
	BT03, 11.28 cm	14.59	20.31	25.29	31.40	-
	BT03, 19.92 cm	17.32	24.10	31.02	37.27	-
	BT03, 161.21 cm	21.59	30.05	37.42	46.46	-
Specific Power, MW/MTU	D047, 13.20 cm	-	17.24	19.43	17.04	14.57
	D047, 27.70 cm	-	24.72	26.76	22.84	18.87
	D047, 165.22 cm	-	31.12	32.51	26.20	22.12
	D101, 9.10 cm	-	15.61	17.59	15.43	-
	D101, 24.50 cm	-	23.15	25.06	21.39	-
	D101, 161.90 cm	-	30.24	31.58	25.46	-
	BT03, 11.28 cm	17.88	18.67	13.06	13.10	-
	BT03, 19.92 cm	21.22	22.16	15.51	15.55	-
	BT03, 161.21 cm	26.46	27.62	19.33	19.39	-
Fuel Temperature, K	D047, 13.20 cm	-	829	850	775	709
	D047, 27.70 cm	-	940	927	793	712
	D047, 165.22 cm	-	997	958	794	747
Boron Concentration, ppm		330.8	330.8	469.4	503.7	492.1

Reference 5.6

Table 4-8. Moderator Conditions for Calvert Cliffs PWR

Assembly	Axial Location, cm	Total Burnup, GWd/MTU	Moderator Temperature		Density of Moderator, g/cm³
			°F	K	
D047	13.20	27.35	543.4	557	0.7575
	27.70	37.12	544.0	558	0.7569
	165.22	44.34	566.5	570	0.7332
D101	9.10	18.68	543.3	557	0.7576
	24.50	26.62	543.8	558	0.7571
	161.90	33.17	565.7	570	0.7341
BT03	11.28	31.40	543.3	557	0.7576
	19.92	37.27	543.6	557	0.7573
	161.21	46.46	565.6	570	0.7342

Reference 5.6

Table 4-9. Composition of Zircaloy-4

Material	Weight Percent
O	0.12
Cr	0.10
Fe	0.20
Sn	1.40
Zr	98.18
Density = 6.56 g/cm³	

Reference 5.10

Table 4-10. Nuclides Updated in SAS2H

^{83}Kr	^{85}Kr	^{89}Y	^{90}Sr	^{95}Mo	^{93}Zr
^{94}Zr	^{94}Nb	^{95}Zr	^{99}Tc	^{101}Ru	^{103}Rh
^{105}Rh	^{106}Ru	^{105}Pd	^{108}Pd	^{109}Ag	^{124}Sb
^{131}Xe	^{132}Xe	^{134}Cs	^{135}Xe	^{135}Cs	^{136}Xe
^{136}Ba	^{137}Cs	^{139}La	^{141}Pr	^{143}Pr	^{143}Nd
^{144}Ce	^{145}Nd	^{147}Nd	^{147}Pm	^{147}Sm	^{148}Pm
^{149}Sm	^{150}Sm	^{151}Sm	^{152}Sm	^{153}Eu	^{154}Eu
^{155}Gd	^{155}Eu				

Reference 5.11

Table 4-11. Light Element Mass per Unit of Fuel for a Typical PWR

Element	**kg/MTUO_2**
O	119.0
Cr	5.2
Mn	0.29
Fe	11.0
Co	0.066
Ni	8.7
Zr	195.0
Nb	0.63
Sn	3.2

Reference 5.6

Table 4-12. Measured Concentrations of Actinides and Fission Products (g/gUO_2)

Assembly	D047	D047	D047	D101	D101	D101	BT03	BT03	BT03
Axial Height	13.20 cm	27.70 cm	165.22 cm	8.90 cm	24.30 cm	161.70 cm	11.28 cm	19.92 cm	161.21 cm
^{234}U	1.6E-4	1.4E-4	1.2E-4	1.400E-4	1.210E-4	1.200E-4	1.53E-4	1.27E-4	7.49E-5
^{235}U	8.47E-3	5.17E-3	3.54E-3	1.025E-2	6.940E-3	4.780E-3	3.86E-3	2.71E-3	1.406E-3
^{236}U	3.14E-3	3.53E-3	3.69E-3	2.500E-3	2.990E-3	3.260E-3	2.86E-3	3.03E-3	3.04E-3
^{238}U	8.425E-1	8.327E-1	8.2486E-1	8.551E-1	8.538E-1	8.422E-1	8.446E-1	8.438E-1	8.272E-1
^{237}Np	2.68E-4	3.56E-4	4.68E-4	-	-	-	-	-	-
^{238}Pu	1.01E-4	1.89E-4	2.69E-4	4.850E-5	9.690E-5	1.483E-4	1.426E-4	1.947E-4	2.842E-4
^{239}Pu	4.264E-3	4.357E-3	4.357E-3	3.954E-3	4.252E-3	4.187E-3	3.814E-3	3.835E-3	3.766E-3
^{240}Pu	1.719E-3	2.239E-3	2.543E-3	1.243E-3	1.766E-3	2.111E-3	2.067E-3	2.321E-3	2.599E-3
^{241}Pu	6.81E-4	9.03E-4	1.020E-3	4.543E-4	6.822E-4	8.125E-4	7.260E-4	8.130E-4	8.862E-4
^{242}Pu	2.89E-4	5.76E-4	8.40E-4	1.394E-4	3.301E-4	5.474E-4	5.463E-4	7.753E-4	1.169E-3
^{143}Nd	6.13E-4	7.16E-4	7.63E-4	-	-	-	-	-	-
^{145}Nd	5.10E-4	6.53E-4	7.44E-4	-	-	-	-	-	-
^{149}Sm	2.9E-6	3.0E-6	4.7E-6	-	-	-	-	-	-
^{150}Sm	2.07E-4	2.71E-4	3.61E-4	-	-	-	-	-	-
^{152}Sm	8.7E-5	1.04E-4	1.21E-4	-	-	-	-	-	-
^{153}Eu	7.9E-5	1.09E-4	1.48E-4	-	-	-	-	-	-

Reference 5.6

Table 4-13. Measured Concentrations of Fission Products (Ci/gUO_2)

Assembly	D047	D047	D047	D101	D101	D101	BT03	BT03	BT03
Axial Height	13.20 cm	27.70 cm	165.22 cm	8.90 cm	24.30 cm	161.70 cm	11.28 cm	19.92 cm	161.21 cm
^{99}Tc	9.59E-6	1.23E-5	1.35E-5	7.07E-6	9.37E-6	1.13E-5	7.70E-6	8.96E-6	1.09E-5
^{237}Np	-	-	-	1.23E-7	2.11E-7	2.41E-7	1.84E-7	2.26E-7	2.66E-7
^{241}Am	8.56E-4	1.18E-3	1.31E-3	6.67E-4	9.91E-4	1.20E-3	1.18E-3	1.46E-3	2.18E-3

Reference 5.6

4.2 Criteria

The design of the waste package will depend on waste package configuration criticality analyses performed using an acceptable disposal criticality analysis methodology. Criteria that relate to the development and design of repository and engineered barrier components are derived from the applicable requirements and planning documents. The Engineered Barrier Design Requirements Document (EBDRD, Reference 5.15) provides requirements for engineered barrier segment design. The Repository Design Requirements Document (RDRD, Reference 5.16) provides requirements for repository design. The Controlled Design Assumptions Document (Reference 5.17) provides guidance for requirements listed in the EBDRD and RDRD which have unqualified or unconfirmed data associated with the requirement.

This analysis supports the disposal criticality analysis methodology by providing input, in the form of fuel depletion results, to benchmark calculations which address the prediction of both spent fuel isotopic compositions and their associated reactivity. These benchmark calculations will contribute to the determination of bias values in the method of critical multiplication factor calculation that is implemented by the analytic tools to be used in the disposal criticality methodology. The requirements for utilizing the bias in the method of calculation of the critical multiplication factor for disposal configurations containing spent nuclear fuel are located in Section 3.2.2.5 of the RDRD and Section 3.2.2.6 of the EBDRD. This analysis does not satisfy these requirements, but the results from this analysis will be used as input to subsequent analyses which will satisfy these requirements.

4.3 Assumptions

4.3.1 Due to lack of data, the boron concentration in cycle 1 is assumed to be equal to the concentration in cycle 2. The basis for this assumption originates in Reference 5.6 and is used because average boron concentrations do not typically vary greatly from cycle to cycle. This assumption is used in Section 7.2.

4.3.2 The cladding temperature could not be obtained, therefore, a cladding temperature of 620 K is assumed for each sample. The basis for this assumption is that the value is consistent with the expectation that the cladding temperature is closer to the moderator temperature than it is to the fuel temperature. Furthermore, it is expected that the cladding temperature will not significantly effect the resulting isotopic concentrations, since the composition contains no nuclides that are strong neutron absorbers. This assumption is used in Section 7.2.

4.4 Codes and Standards

There are no applicable codes or standards for this design analysis.

5. References

5.1 *Yucca Mountain Site Characterization Project Q-List*, YMP/90-55Q REV 4, Yucca Mountain Site Characterization Project.

5.2 *QAP-2-0 Activity Evaluations: ID #WP-20, Perform Criticality, Thermal, Structural, and Shielding Analyses*, Civilian Radioactive Waste Management System (CRWMS) Management and Operating Contractor (M&O), August 3, 1997.

5.3 *Quality Assurance Requirements and Description*, DOE/RW-0333P REV 7, U.S. Department of Energy (DOE) Office of Civilian Radioactive Waste Management (OCRWM).

5.4 *Nuclides and Isotopes*, General Electric Company, 14ed., 1989.

5.5 G. Audi and A. H. Wapstra, *Atomic Mass Adjustments: 'The 1995 Update to the Atomic Mass Evaluation'*, Nuclear Physics A595 Vol. 4, p. 409-480.

5.6 *Validation of the Scale System for PWR Spent Fuel Isotopic Composition Analyses*, ORNL/TM-12667, Oak Ridge National Laboratory, March 1995.

5.7 *Calvert Cliffs Nuclear Power Plant, Unit 1. Licence No. DPR-53 amendment 21: TS changes re termination of interim restrictions on peak linear heat generation rate; authorization use of Cycle 2 test assemblies; incorporation of ECCs model evaluation limits*, DOCKET-50-317-848, Baltimore Gas and Electric Co., MD, 1977.

5.8 *Startup Test Report*, DOCKET-50-317-463, Baltimore Gas and Electric Co., MD, 1975.

5.9 *Isotopic and Criticality Validation for PWR Actinide-Only Burnup Credit*, DOE/RW-0497, DOE OCRWM.

5.10 *Material Compositions and Number Densities for Neutronics Calculations*, Document Identification (DI) Number: BBA000000-01717-0200-00002 REV 00, CRWMS M&O.

5.11 *SCALE-4 Analysis of Pressurized Water Reactor Critical Configurations: Volume 2-Sequoyah Unit 2 Cycle 3*, ORNL/TM-12294/V2, March 1995.

5.12 *Characterization of Spent Fuel Approved Testing Material-ATM-106*, PNL-5109-106, Pacific Northwest Laboratory, October 1988.

5.13 *SCALE 4.3, A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation for Workstations and Personal Computers*, NUREG/CR-0200 REV 5, ORNL/NUREG/CSD-2/R5, Volumes 1-3, Oak Ridge National Laboratory.

5.14 *Software Qualification Report for the SCALE Modular Code System*, DI Number: 30011-2002 REV 01, CRWMS M&O.

5.15 *Engineered Barrier Design Requirements Document*, YMP/CM-0024, REV 00, ICN 01, DOE OCRWM.

5.16 *Repository Design Requirements Document*, YMP/CM-0023, REV 00, ICN 01, DOE OCRWM.

5.17 *Controlled Design Assumptions Document*, DI#: B00000000-01717-4600-00032 REV 04, ICN 01, CRWMS M&O.

6. Use of Computer Software

A. Reference 5.13 describes the SAS2H module of SCALE 4.3 that is used with the 44GROUPNDF5 cross section library to calculate the isotopic concentrations for the specified burnup and cooling time. The computer code's spatially independent point depletion model is appropriate for comparison with pellet sample measurements, and is used within the range of validation, as described in Reference 5.14, in accordance with the QAP-SI series procedures. SCALE is obtained from the Software Configuration Management in accordance with appropriate procedures. SCALE's CSCI number is 30011 V4.3 and is installed on the WPDD HP 9000, 700 Workstation with CRWMS M&O tag number 110433.

B. *Lotus 1-2-3* Release 5 for Windows 95 is an Acquired Software spreadsheet program as defined in QAP-SI-0. User defined formulas and/or algorithms, inputs and results, are documented in the appropriate sections.

7. Design Analysis

The SAS2H module of SCALE 4.3 is used to perform one-dimensional (1-D) neutron transport and point depletion analyses on the Calvert Cliffs samples using the preferred 44GROUPNDF5 cross-section library. To properly model the neutron flux spectrum and the nuclide composition changes, it is necessary to define the compositions, temperatures, and geometry of the fuel assembly. This is accomplished with the use of data blocks in which similar parameters are grouped together.

7.1 SCALE Input Data Blocks 1, 2, and 3

Data blocks 1 through 3 define the SCALE module to be used, the title of the input file, the cross section library to be used, and the lattice type to be modeled. The module used is SAS2H and the cross sectional library is 44GROUPNDF5, abbreviated as 44GROUP. The 44GROUP cross section library is recommended by Oak Ridge National Laboratory. Since SAS2H is only to be used for isotopic depletion/generation, the 'parm=skipshipdata' option is used so that a shipping cask shielding analysis is not performed. The title is arbitrary and should contain information that is sample specific, while the lattice type is "latticecell" to reflect the array characteristic of the assembly.

7.2 SCALE Input Data Block 4

Data block 4 defines the material compositions present in the assembly. A unique mixture number is assigned to each composition, and follows the form of mixture 1 for fuel, mixture 2 for cladding and mixture 3 for moderator.

The fuel mixture is specified as UO_2 using the stack density and isotopic weight percentages from Tables 4-2 and 4-5, respectively. Fuel temperatures for the samples from assembly D047 are presented in Table 4-7; however, no fuel temperatures for samples from the other assemblies could be obtained. Therefore, these temperatures are approximated by performing a regression analysis, based on specific power, on the available temperatures. The resulting temperatures are reported in Table 7-1. The temperature used during the first cycle of irradiation is input in data block 4. The other cycle temperatures are input in data block 9. Isotopes which are selected as needing their cross sections updated during the depletion analysis are included in the fuel mixture. A standard list of trace fuel elements is given in Table 4-10 and defined in the fuel mixture to have a concentration of 10^{-20} atoms/barn·cm.

Table 7-1. Fuel Temperatures (K) for Assemblies D101 and BT03

	Regression Slope		**Regression Intercept**		
	13.79207 K/(MW/MTU)		521.6644 K		
	Cycle 1	**Cycle 2**	**Cycle 3**	**Cycle 4**	**Cycle 5**
D101, 9.10 cm	-	737	764	734	-
D101, 24.50 cm	-	841	867	817	-
D101, 161.90 cm	-	939	957	873	-
BT03, 11.28 cm	768	779	702	702	-
BT03, 19.92 cm	814	827	736	736	-
BT03, 161.21 cm	887	903	788	789	-

The cladding material of Zircaloy-4 is not contained within the Standard Composition Library in SCALE 4.3 and must be defined as an arbitrary material. The cladding is defined with a density and isotopic weight percentages from Table 4-9. The cladding temperature could not be obtained, therefore, a cladding temperature of 620 K is assumed for each sample. This value is consistent with the expectation that the cladding temperature is closer to the moderator temperature than the fuel temperature. Furthermore, it is expected that the cladding temperature will not significantly effect the resulting isotopic concentrations.

The moderator temperature, density and boron concentration are given in Tables 4-7 and 4-8, and is composed of H_2O and boron. The boron is defined as an arbitrary material with the moderator density and temperature, a volume fraction equal to the average boron concentration of the first cycle irradiated, and a standard boron composition of from the Standard Composition Library designated as 5000.

Three additional mixtures must be specified. These are the Zircaloy-4 cladding of the poison rod, the composition of the poison rod and the air in between the poison rod and cladding. The air between the poison rod and the cladding is given the mixture number of 4, and is defined as nitrogen with an atom density of 5×10^{-5} atoms/barn·cm, and a temperature equal to the moderator temperature. The poison rod cladding of Zircaloy-4 is given the mixture number of 5 with a temperature also equal to the moderator temperature. Finally, the poison rod composition is given a mixture number of 6 with atom densities from Table 4-4 and a temperature equal to the moderator temperature.

7.3 SCALE Input Data Blocks 5 Through 7

The unit fuel rod cell geometry is defined in data block 5. The 'squarepitch' designation for the type of lattice is appropriate since the fuel assembly consists of a square array of fuel rods. Fuel rod, cladding and pitch dimensions are given in Table 4-2 with the mixture number for each composition defined in Section 7.2. The gap mixture is defined as 0.

Data block 6 allows the user to specify such parameters as the spatial mesh, angular quadrature and the convergence criteria. It is determined that the default values are sufficient and such options are not used in this design model.

In data block 7 the user defines general assembly data and determines the level of detail in which the assembly is to be modeled. The number of fuel rods per assembly is given in Table 4-2 and the length is calculated so that an assembly contains 1 Metric Ton of Uranium Dioxide ($MTUO_2$), using the following equation:

$$Length = \frac{1}{\frac{\pi}{4}(POD)^2(PDen)(NFR)} * \frac{10^6 gUO_2}{1 MTUO_2} \qquad \text{Equation 7-1}$$

Where:

Length = Length Required for an Assembly to Contain 1 $MTUO_2$ (cm)
POD = Fuel Pellet Diameter (cm)
PDen = Fuel Pellet Density (gUO_2/cm^3)
NFR = Number of Fuel Rods

Since measured isotopic concentrations are presented in grams of isotope per gram UO_2 and SCALE presents concentrations in grams of isotope per assembly, it is possible to alter the length so that the assembly contains 1 $MTUO_2$. This is possible since the 1-D transport calculation is axially independent. Consequently, the length of the assembly does not impact the neutron flux spectrum nor the nuclide cross sections. The resulting calculated lengths for the Calvert Cliffs assemblies are 789.64 cm for assemblies D047 and D101, and 851.90 cm for assembly BT03.

Assembly D047 was irradiated for 4 cycles, D101 for 3 cycles and BT03 for 4 cycles. It is determined that approximately 80 days per cross section library is sufficient to accurately model the change in nuclide cross sections with increasing burnup, without over-burdening the SAS2H code. Therefore, the number of libraries per cycle are specified as five. To obtain the concentrations of all interested nuclides, a print level of 5 is chosen, while an input level of 2 is defined so that a Path B model may be utilized. The number of light elements are nine and are determined from Table 4-11, while the number of zones are five for assemblies D047 and D101, and six for assembly BT03, which are determined by the Path B model described in Section 7.4.

7.4 SCALE Input Data Block 8

Two different Path B models are required for Calvert Cliffs assemblies. For assemblies D047 and D101, the Path B model centralizes the guide tube with a surrounding homogenized fuel and moderator mixture which is further surrounded by the moderator between assemblies. Assembly BT03 with burnable poison and test rods, uses a Path B model with a central poison rod, a surrounding homogenized fuel and moderator mixture and further surrounded by the moderator between assemblies. The neutron flux in the samples is assumed to not be effected by the test rods because samples are taken from a rod next to the guide tube in the center of the assembly and the test rods are at the corners of the assembly. Therefore, the test rod material is not included in the Path B model.

For assemblies D047 and D101, the equations below are used to determine the number of fuel unit cells that surround the guide tube for the Path B model, by conserving the fuel to moderator volume ratio. All of the following equations used to calculate the Path B model dimensions are derived. The results of the fuel-unit-cell calculations are presented in Table 7-2, and the resulting Path B model dimensions are presented in Table 7-3.

$$x = \frac{(\frac{F}{M})(CUCMV)}{(FV)-(\frac{F}{M})(MV)} \qquad \text{Equation 7-2}$$

$$\frac{F}{M} = \frac{(NFR)(\frac{\pi}{4})(POD)^2}{(NFR)[RP^2-(\frac{\pi}{4})(COD)^2]+(NGT)[(2*RP)^2-(\frac{\pi}{4})(GTOD)^2+(\frac{\pi}{4})(GTID)^2]} \qquad \text{Equation 7-3}$$

$$CUCMV=(2*RP)^2-(\frac{\pi}{4})(GTOD)^2+(\frac{\pi}{4})(GTID)^2 \qquad \text{Equation 7-4}$$

$$FV=(\frac{\pi}{4})(POD)^2 \qquad \text{Equation 7-5}$$

$$MV=RP^2-(\frac{\pi}{4})(COD)^2 \qquad \text{Equation 7-6}$$

Where:

x = Number of Unit Fuel Cells per Centralized Guide Tube
F/M = Fuel to Moderator Volume Ratio
NFR = Number of Fuel Rods
POD = Fuel Pellet Outer Diameter
RP = Rod Pitch
COD = Cladding Outer Diameter
NGT = Number of Guide Tubes
GTOD = Guide Tube Outer Diameter
GTID = Guide Tube Inner Diameter
CUCMV = Central Unit Cell Moderator Volume
FV = Fuel Volume of One Fuel Unit Cell
MV = Moderator Volume of One Fuel Unit Cell

Once the number of fuel cells per guide tube is determined the geometry of the Path B model is calculated. Since the guide tube is centralized, the dimensions of the guide tube are the same as those presented in Table 4-2.

The radius for the moderator surrounding the guide tube but still within the guide tube's 2 x 2 cell, is calculated with the following equation:

$$R_3 = \sqrt{(\frac{1}{\pi})(2*RP)^2}$$ Equation 7-7

Where:
R_3 = Radius of Moderator Surrounding Guide Tube

The area of an annular region is calculated by the difference between the outer circular area and the inner circular area. Equation 7-8 is the basis for the Equations 7-9 and 7-10 which determine the radii of the homogenized fuel zone and the outer moderator zone.

$$ARA = \pi(ORAR^2 - IRAR^2)$$ Equation 7-8

Where:
ARA = Annular Region Area
ORAR = Outer Radius of Annular Region
IRAR = Inner Radius of Annular Region

The area of the homogenized fuel zone surrounding the guide tube's 2 x 2 cell is equal to the number of fuel unit cells surrounding the guide tube multiplied by the area of a fuel unit cell. Consequently, the radius of the homogenized fuel zone is computed with the following equation:

$$R_4 = \sqrt{(\frac{x}{\pi})RP^2 + R_3^2}$$ Equation 7-9

Where:
R_4 = Radius of Homogenized Fuel and Moderator Zone

The mixture number of the homogenized fuel and moderator mixture must be specified as 500. The code then determines the composition of the region using cell averages or homogenized densities of the fuel-pin-cell.

The moderator in the channel between assemblies is determined by calculating the total moderator volume and multiplying by the fraction of unit cells in the larger unit cell of the Path B model. The total moderator volume between assemblies is determined by the assembly pitch and the fuel cell pitch multiplied by the number of unit cells. The radius of the moderator between assemblies is calculated from the following equation:

$$R_5=\sqrt{\frac{(x+4)}{\pi*NCell}[AP^2-(NCell)(RP^2)]+R_4^2} \qquad \text{Equation 7-10}$$

Where:
R_5 = Radius of Moderator Surrounding Assembly Zone
NCell = Number of Cells in Assembly
AP = Assembly Pitch

For assembly BT03, the poison rod is centralized and the Path B model dimension for zones 1 through 3 are the poison rod pellet radius, poison rod inner cladding radius and poison rod outer cladding radius, with compositions of poison rod, air and cladding, respectively. These dimensions and compositions are obtained from Tables 4-3 and 4-4.

The number of fuel unit cells needed for each centralized burnable absorber unit cell is calculated by Equation 7-2 with an exception to Equations 7-3 and 7-4. Since the centralized unit cell is different, Equations 7-3, 7-4, 7-7 and 7-10 are modified to reflect such conditions and are shown below:

$$\frac{F}{M}=\frac{(NFR)(\frac{\pi}{4})(POD)^2}{(NFR)[RP^2-(\frac{\pi}{4})(COD)^2]+(NGT)[(2*RP)^2-(\frac{\pi}{4})(GTOD)^2+(\frac{\pi}{4})(GTID)^2]+}$$

$$(NBPR)[RP^2-(\frac{\pi}{4})(COD)^2]+(NNFR)[RP^2-(\frac{\pi}{4})(COD)^2] \qquad \text{Equation 7-11}$$

$$CUCMV=(RP)^2-(\frac{\pi}{4})(COD)^2 \qquad \text{Equation 7-12}$$

$$R_3=\sqrt{(\frac{1}{\pi})RP^2} \qquad \text{Equation 7-13}$$

$$R_6=\sqrt{\frac{(x+1)}{\pi*NCell}[AP^2-(NCell)(RP^2)]+R_5^2} \qquad \text{Equation 7-14}$$

Where:
NNFR = Number of Non-Fuel Rods
NBPR = Number of Burnable Poison Rods

Equations 7-5, 7-6, and 7-8 are used without modification and Equation 7-9 is used to determine the radius of zone 5 of the Path B model.

Table 7-2. Calculation of Fuel Unit Cell per Guide Tube Unit Cell

Assembly	F/M	CUCMV, cm^2	FV, cm^2	MV, cm^2	x
D047 and D101	0.5090	7.8065	0.7183	1.1893	35.2000
BT03	0.4701	1.1893	0.7297	1.1893	3.2774

Table 7-3. Path B Model Dimensions

	D047 and D101		BT03	
	Radius, cm	**Composition**	**Radius, cm**	**Composition**
R_1	1.3140	Moderator	0.4775	Poison Rod
R_2	1.4160	Cladding	0.4928	Air
R_3	1.6623	Moderator	0.5588	Cladding
R_4	5.2039	Fuel	0.8312	Moderator
R_5	5.2431	Moderator	1.7190	Fuel
R_6	NA	NA	1.7319	Moderator

7.5 SCALE Input Data Blocks 9 Through 16

Data block 9 is used to describe the power history of the reactor. The specific power, fuel irradiation period, the length of downtime, the fraction of boron and moderator density, and the temperature during the cycle may all be defined. The specific power is specified in units of $MW/MTUO_2$ and must be converted from the average specific powers given in Table 4-7 with the relation of 238 g U is equal to 270 g UO_2, Table 7-4. The irradiation period and length of downtime are both defined in days with values presented in Table 4-7. The moderator density is constant over all cycles and the boron fraction is determined by dividing the cycle average boron concentration by the boron concentration specified in data block 4, Section 7.2. The individual cycle temperatures are calculated as described in Section 7.2 with values given in Table 7-1. The boron fraction is specified with the command 'bfrac=' and the temperature with 'temkcyc='. Values for the specific power and boron fraction are presented in Table 7-4.

Table 7-4. Specific Power and Boron Fractions

	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5
Boron Fraction	1	1	1.419	1.523	1.488
Specific Power, $MW/MTUO_2$					
D047 MKP109, 13.20 cm	-	15.197	17.127	15.020	12.843
D047 MKP109, 27.70 cm	-	21.790	23.588	20.133	16.634
D047 MKP109, 165.22 cm	-	27.432	28.657	23.095	19.498
D101 MLA098, 9.10 cm	-	13.760	15.505	13.601	-
D101 MLA098, 24.50 cm	-	20.406	22.090	18.855	-
D101 MLA098, 161.90 cm	-	26.656	27.837	22.443	-
BT03 NBD107, 11.28 cm	15.761	16.457	11.512	11.547	-
BT03 NBD107, 19.92 cm	18.705	19.534	13.672	13.707	-
BT03 NBD107, 161.21 cm	23.324	24.347	17.039	17.092	-

Light elements and their effective weight, in kg per assembly, are entered in data block 10. Table 4-11 provides a generic set of light elements and their weights, in kg per $MTUO_2$. Since the fuel length is altered so that there is 1 $MTUO_2$ per assembly the use of light elements with weights of kg per $MTUO_2$ is appropriate.

Data blocks 11 through 15 describe parameters used in the radial shielding analysis of a shipping cask and are not necessary in performing the depletion analysis. Data block 16 denotes the end of the SCALE input.

7.6 Comparison of Calculated and Measured Concentrations

Comparisons of corresponding calculated and measured concentrations are performed on a percent difference basis. The difference between the measured and the calculated value is divided by the measured value to determine the accuracy of the SAS2H calculation. A positive percent difference represents an over-prediction by the code, while a negative percent difference represents an under-prediction by the code.

Measured concentrations presented in Table 4-12 have units of g of isotope per g of UO_2, while calculated concentrations presented in Table 7-5 have units of g of isotope per Metric Ton of UO_2. Therefore, the measured concentrations must be multiplied by 10^6 $gUO_2/MTUO_2$ to obtain similar units. Included in Table 7-6 are the total Uranium and total Plutonium concentrations, which are determined by summing the concentrations for all reported isotopes of the particular element.

Measured concentrations are presented in Table 4-13 with units of Curies per g UO_2. The activity of a particular isotope per gram UO_2 is converted to grams of that isotope per gram UO_2 using the half-life and molar mass presented in Section 4.1 and the following equation:

$$\left(\frac{Yg}{gUO_2}\right)=\left(\frac{XCi}{gUO_2}\right)\left(\frac{3.7x10^{10}Bq}{Ci}\right)\left(\frac{1}{\lambda}\right)\left(\frac{3.16x10^{7}s}{1yr}\right)\left(\frac{1mole}{6.02x10^{23}atoms}\right)\left(\frac{Mass}{1mole}\right) \qquad \text{Equation 7-15}$$

Where:

Y = Measured Value Used in Comparison (g isotope/g UO_2)
X = Measured Value from SAS2H (Ci isotope/g UO_2)

$$\lambda=\frac{\ln(2)}{T_{½}} \ (yr^{-1})$$

$T_{½}$ = Half-life of Isotope (yr)
Mass = Molar Mass of Isotope

Percent differences for the actinides and fission products are presented in Table 7-7.

7.7 Results

SAS2H predicted isotopic concentrations are presented in Table 7-5. The calculated concentrations are obtained through the methodology described in Sections 7.1 through 7.5, and with the input parameters defined in Section 4.1. Included in Table 7-6 are the total Plutonium and total Uranium measured concentrations. Calculated concentrations are compared with measured concentrations as described in Section 7.6 to determine the accuracy of the SAS2H code. Results of the comparison, in the form of percent differences, are presented in Table 7-7.

Table 7-5. Calculated Concentrations ($g/MTUO_2$)

Assembly	D047	D047	D047	D101	D101	D101	BT03	BT03	BT03
Axial Height	13.20 cm	27.70 cm	165.22 cm	8.90 cm	24.30 cm	161.70 cm	11.28 cm	19.92 cm	161.21 cm
^{99}Tc	5.96E2	7.74E2	8.93E2	4.20E2	5.78E2	6.98E2	6.56E2	7.59E2	9.05E2
^{234}U	1.59E2	1.38E2	1.22E2	1.58E2	1.40E2	1.28E2	1.18E2	1.09E2	9.76E1
^{235}U	8.33E3	5.06E3	3.30E3	1.03E4	7.05E3	5.16E3	4.66E3	3.29E3	1.95E3
^{236}U	3.23E3	3.65E3	3.75E3	2.44E3	2.93E3	3.18E3	2.91E3	3.05E3	3.13E3
^{238}U	8.37E5	8.30E5	8.24E5	8.46E5	8.40E5	8.35E5	8.37E5	8.33E5	8.25E5
^{237}Np	2.78E2	4.00E2	5.01E2	1.67E2	2.64E2	3.46E2	3.10E2	3.67E2	4.48E2
^{238}Pu	9.56E1	1.83E2	2.48E2	3.81E1	8.88E1	1.48E2	1.48E2	2.00E2	2.90E2
^{239}Pu	3.67E3	3.71E3	4.52E3	3.38E3	3.42E3	3.46E3	3.52E3	3.38E3	3.32E3
^{240}Pu	1.80E3	2.28E3	2.53E3	1.32E3	1.89E3	2.25E3	2.26E3	2.49E3	2.75E3
^{241}Pu	6.66E2	8.51E2	9.95E2	4.25E2	6.48E2	7.99E2	7.23E2	7.95E2	8.82E2
^{242}Pu	3.37E2	6.67E2	8.44E2	1.50E2	3.74E2	6.16E2	5.73E2	8.13E2	1.21E3
^{241}Am	2.37E2	2.95E2	3.42E2	1.80E2	2.71E2	3.30E2	3.47E2	3.71E2	3.96E2
^{143}Nd	6.24E2	7.29E2	7.75E2	-	-	-	-	-	-
^{145}Nd	5.09E2	6.48E2	7.38E2	-	-	-	-	-	-
^{149}Sm	1.87E0	2.03E0	2.23E0	-	-	-	-	-	-
^{150}Sm	2.07E2	2.98E2	3.67E2	-	-	-	-	-	-
^{152}Sm	1.00E2	1.30E2	1.51E2	-	-	-	-	-	-

Table 7-5. Calculated Concentrations ($g/MTUO_2$)

Assembly	D047	D047	D047	D101	D101	D101	BT03	BT03	BT03
Axial Height	13.20 cm	27.70 cm	165.22 cm	8.90 cm	24.30 cm	161.70 cm	11.28 cm	19.92 cm	161.21 cm
^{153}Eu	7.96E1	1.21E2	1.51E2	-	-	-	-	-	-
Total U	8.49E+05	8.39E+05	8.31E+05	8.59E+05	8.50E+05	8.43E+05	8.45E+05	8.39E+05	8.30E+05
Total Pu	6.57E+03	7.69E+03	9.14E+03	5.31E+03	6.42E+03	7.27E+03	7.55E+03	7.68E+03	8.45E+03

Table 7-6. Measured Concentrations of Total Pu and U (g/gUO_2)

Assembly	D047	D047	D047	D101	D101	D101	BT03	BT03	BT03
Axial Height	13.20 cm	27.70 cm	165.22 cm	8.90 cm	24.30 cm	161.70 cm	11.28 cm	19.92 cm	161.21 cm
Total U	8.54E-01	8.42E-01	8.32E-01	8.68E-01	8.64E-01	8.50E-01	8.51E-01	8.50E-01	8.32E-01
Total Pu	7.05E-03	8.26E-03	9.03E-03	5.84E-03	7.13E-03	7.81E-03	7.30E-03	7.94E-03	8.70E-03

Table 7-7. Percent Difference Between Measured and Calculated [(C/M-1)*100]

Assembly	D047	D047	D047	D101	D101	D101	BT03	BT03	BT03
Axial Height	13.20 cm	27.70 cm	165.22 cm	8.90 cm	24.30 cm	161.70 cm	11.28 cm	19.92 cm	161.21 cm
^{99}Tc	5.27	6.59	12.04	0.62	4.48	4.63	44.30	43.48	40.63
^{234}U	-0.63	-1.43	1.67	12.86	15.70	6.67	-22.88	-14.17	30.31
^{235}U	-1.65	-2.13	-6.78	0.49	1.59	7.95	20.73	21.40	38.69
^{236}U	2.87	3.40	1.63	-2.40	-2.01	-2.45	1.75	0.66	2.96
^{238}U	-0.65	-0.32	-0.10	-1.06	-1.62	-0.85	-0.90	-1.28	-0.27

Table 7-7. Percent Difference Between Measured and Calculated [(C/M-1)*100]

Assembly	D047	D047	D047	D101	D101	D101	BT03	BT03	BT03
Axial Height	13.20 cm	27.70 cm	165.22 cm	8.90 cm	24.30 cm	161.70 cm	11.28 cm	19.92 cm	161.21 cm
^{237}Np	3.73	12.36	7.05	-4.48	-11.98	1.00	18.53	14.24	18.49
^{238}Pu	-5.35	-3.17	-7.81	-21.44	-8.36	-0.20	3.79	2.72	2.04
^{239}Pu	-13.93	-14.85	3.74	-14.52	-19.57	-17.36	-7.71	-11.86	-11.84
^{240}Pu	4.71	1.83	-0.51	6.19	7.02	6.58	9.34	7.28	5.81
^{241}Pu	-2.20	-5.76	-2.45	-6.45	-5.01	-1.66	-0.41	-2.21	-0.47
^{242}Pu	16.61	15.80	0.48	7.60	13.30	12.53	4.89	4.86	3.51
^{241}Am	-5.26	-14.46	-10.67	-7.66	-6.43	-5.90	0.62	-13.05	-37.85
^{143}Nd	1.79	1.82	1.57	-	-	-	-	-	-
^{145}Nd	-0.20	-0.77	-0.81	-	-	-	-	-	-
^{149}Sm	-35.52	-32.33	-52.55	-	-	-	-	-	-
^{150}Sm	0.00	9.96	1.66	-	-	-	-	-	-
^{152}Sm	14.94	25.00	24.79	-	-	-	-	-	-
^{153}Eu	0.76	11.01	2.03	-	-	-	-	-	-
Total U	-0.65	-0.32	-0.12	-1.05	-1.59	-0.81	-0.80	-1.20	-0.19
Total Pu	-6.88	-6.93	1.20	-9.01	-9.91	-6.83	-0.99	-3.29	-2.90

8. Conclusions

The accuracy in which the SAS2H module is able to predict isotopic concentrations is indicated by the percent differences presented in Table 7-7. Inspection of such results reveals that the code has a tendency to over-predict ^{99}Tc, ^{240}Pu, and ^{242}Pu, while it tends to under-predict ^{239}Pu, ^{241}Am, and ^{149}Sm. Furthermore, some calculated concentrations vary widely from the measured concentration, for example, ^{234}U ranges from -22.88% to 30.31%. Percent differences from this analysis are compared with results from Reference 5.6, in which similar calculations were performed with a previous version of SCALE and the 27burnuplib cross section library. The concentrations calculated in Reference 5.6 for the most part agree with the concentrations calculated in this analysis; however, significant differences are seen for the plutonium isotopes. Since there are few differences between the models of assemblies D047 and D101 in Reference 5.6 and the models for those assemblies contained within, it is believed that the discrepancy between calculated concentrations for plutonium isotopes is caused by a change in the cross section library. However, since there is a significant difference in the Path B model for assembly BT03 from Reference 5.6 and the model for that assembly contained within, it cannot be determined what is responsible for the differences between calculated concentrations.

Uncertainty in the measured concentration of each isotope helps to explain the deviation of the calculated concentrations from the measured concentrations. For example, the calculated concentration of total U is always within the ±1.6% measurement uncertainty. However, such is not always the case for the total Pu, ^{99}Tc or ^{237}Np, which generally deviate only slightly more than the measurement uncertainty. For these, the deviation (not accounted for by the measurement uncertainty) may be explained by the lack of detailed operating data. For instance, calculated concentrations for samples from assembly BT03 deviate much more than the calculated concentrations for samples from the other assemblies for the isotopes of ^{99}Tc, ^{234}U, and ^{241}Am. This may be a result of the Path B model containing an effective infinite array of BT03 assemblies, while in reality there were few BT03 assemblies in the core. Therefore, the neutron spectrum calculated by SAS2H would be slightly different than the actual spectrum effecting the calculated concentrations.

The SAS2H code normally predicts isotopic concentrations as a radial assembly average; however, measurements are performed on individual pellet samples. Therefore, local pellet conditions are modeled as closely as possible in this analysis so that a more realistic pellet composition can be determined. However, approximations made to obtain local pellet conditions will influence the calculated isotopic concentrations.

In general, the SAS2H module of SCALE is adequate in predicting isotopic concentrations for samples from Calvert Cliffs, using the methodology presented. While over-prediction or under-prediction is significant for a few isotopes, the majority of calculated concentrations are very close to the measured concentrations. The measurement uncertainty does account for some deviation between measured and calculated concentrations. More detailed operating data would be expected to improve the accuracy of the calculated concentrations in relation to the corresponding measurements. It is recommended that future analyses use more detailed data if possible.

9. Attachments

Attachment I includes nine pages and contains the input files used in the modeling of the Calvert Cliffs samples. A description of the parameters contained within the input files is found in Sections 7.1 through 7.5.

Included in Attachment II is an extraction from each of the output files, containing the following information:

- echo of the SAS2H input deck,
- time/date stamp for when the SAS2H depletion calculation was performed,
- the output extraction of information pertinent to the Radiochemical Assay evaluations from the final ORIGEN calculation of the SAS2H depletion calculation.

ccd047g27.input

```
=sas2h    parm=skipshipdata
calvert cliffs 1 pwr, d047, rod mkp109, 13.200 cm, 27.35/mtu  June 97
'
'  mixtures of fuel-pin-unit-cell:
'
44group       latticecell
uo2  1 den=10.018  1  829
  92234 0.027 92235 3.038 92236 0.014 92238 96.921   end
kr-83  1 0 1-20 829  end
kr-85  1 0 1-20 829  end
y-89   1 0 1-20 829  end
sr-90  1 0 1-20 829  end
zr-93  1 0 1-20 829  end
zr-94  1 0 1-20 829  end
zr-95  1 0 1-20 829  end
nb-94  1 0 1-20 829  end
mo-95  1 0 1-20 829  end
tc-99  1 0 1-20 829  end
ru-101 1 0 1-20 829  end
ru-106 1 0 1-20 829  end
rh-103 1 0 1-20 829  end
rh-105 1 0 1-20 829  end
pd-105 1 0 1-20 829  end
pd-108 1 0 1-20 829  end
ag-109 1 0 1-20 829  end
sb-124 1 0 1-20 829  end
xe-131 1 0 1-20 829  end
xe-132 1 0 1-20 829  end
xe-135 1 0 1-20 829  end
xe-136 1 0 1-20 829  end
cs-134 1 0 1-20 829  end
cs-135 1 0 1-20 829  end
cs-137 1 0 1-20 829  end
ba-136 1 0 1-20 829  end
la-139 1 0 1-20 829  end
pr-141 1 0 1-20 829  end
pr-143 1 0 1-20 829  end
ce-144 1 0 1-20 829  end
nd-143 1 0 1-20 829  end
nd-145 1 0 1-20 829  end
nd-147 1 0 1-20 829  end
pm-147 1 0 1-20 829  end
pm-148 1 0 1-20 829  end
sm-147 1 0 1-20 829  end
sm-149 1 0 1-20 829  end
sm-150 1 0 1-20 829  end
sm-151 1 0 1-20 829  end
sm-152 1 0 1-20 829  end
eu-153 1 0 1-20 829  end
eu-154 1 0 1-20 829  end
eu-155 1 0 1-20 829  end
gd-155 1 0 1-20 829  end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
        40000 98.18 2 1.0 620   end
h2o  3 den=0.7575  1  557 end
arbm-bormod  0.7575 1 1 0 0 5000 100 3 330.8e-6  557  end
'
'  331 ppm boron (wt) in moderator
'------------------------------
end comp
'
'------------------------------
'
'    fuel-pin-cell geometry:
'
squarepitch   1.4732  0.9563 1  3  1.1176  2  0.9855   0  end
'
'------------------------------
'
'   assembly and cycle parameters:
'
npin/assm=176 fuelnght=789.64 ncycles=4  nlib/cyc=5
printlevel=5 lightel=9  inplevel=2 numztotal=5 end
3  1.3140  2  1.4160  3  1.6623  500  5.2039  3  5.2431
power=15.197 burn=306.0  down=71   end
power=17.127  burn=381.7    down=81.3    bfrac=1.419
temkcyc=850 end
power=15.020  burn=466.0    down=85     bfrac=1.523
temkcyc=775 end
power=12.843  burn=461.1    down=1870    bfrac=1.488
temkcyc=709 end
 o 119  cr  5.2  mn  0.29
 fe 11.0 co 0.066 ni  8.7
 zr 195  nb  0.63 sn  3.2
'
'------------------------------
'
end
```

ccd047g37.input

```
=sas2h    parm=skipshipdata
calvert cliffs 1 pwr, d047, rod mkp109, 27.700 cm, 37.12/mtu  June 97
'
'  mixtures of fuel-pin-unit-cell:
'
44group      latticecell
uo2  1 den=10.018  1  940
  92234 0.027 92235 3.038 92236 0.014 92238 96.921   end
kr-83  1 0 1-20 940  end
kr-85  1 0 1-20 940  end
y-89   1 0 1-20 940  end
sr-90  1 0 1-20 940  end
zr-93  1 0 1-20 940  end
zr-94  1 0 1-20 940  end
zr-95  1 0 1-20 940  end
nb-94  1 0 1-20 940  end
mo-95  1 0 1-20 940  end
tc-99  1 0 1-20 940  end
ru-101 1 0 1-20 940  end
ru-106 1 0 1-20 940  end
rh-103 1 0 1-20 940  end
rh-105 1 0 1-20 940  end
pd-105 1 0 1-20 940  end
pd-108 1 0 1-20 940  end
ag-109 1 0 1-20 940  end
sb-124 1 0 1-20 940  end
xe-131 1 0 1-20 940  end
xe-132 1 0 1-20 940  end
xe-135 1 0 1-20 940  end
xe-136 1 0 1-20 940  end
cs-134 1 0 1-20 940  end
cs-135 1 0 1-20 940  end
cs-137 1 0 1-20 940  end
ba-136 1 0 1-20 940  end
la-139 1 0 1-20 940  end
pr-141 1 0 1-20 940  end
pr-143 1 0 1-20 940  end
ce-144 1 0 1-20 940  end
nd-143 1 0 1-20 940  end
nd-145 1 0 1-20 940  end
nd-147 1 0 1-20 940  end
pm-147 1 0 1-20 940  end
pm-148 1 0 1-20 940  end
sm-147 1 0 1-20 940  end
sm-149 1 0 1-20 940  end
sm-150 1 0 1-20 940  end
sm-151 1 0 1-20 940  end
sm-152 1 0 1-20 940  end
eu-153 1 0 1-20 940  end
eu-154 1 0 1-20 940  end
eu-155 1 0 1-20 940  end
gd-155 1 0 1-20 940  end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
        40000 98.18 2 1.0 620   end
h2o  3 den=0.7569  1  558 end
arbm-bormod  0.7569 1 1 0 0 5000 100 3 330.8e-6  558  end
'
'  331 ppm boron (wt) in moderator
'------------------------------
end comp
'
'------------------------------
'
'    fuel-pin-cell geometry:
'
squarepitch   1.4732  0.9563 1  3  1.1176  2  0.9855   0  end
'
'------------------------------
'
'   assembly and cycle parameters:
'
npin/assm=176 fuelnght=789.64 ncycles=4  nlib/cyc=5
printlevel=5 lightel=9  inplevel=2 numztotal=5  end
3  1.3140  2  1.4160  3  1.6623  500  5.2039  3  5.2431
power=21.790 burn=306.0  down=71    end
power=23.588   burn=381.7     down=81.3     bfrac=1.419
temkcyc=927 end
power=20.133   burn=466.0     down=85       bfrac=1.523
temkcyc=793   end
power=16.634   burn=461.1     down=1870     bfrac=1.488
temkcyc=712  end
 o 119   cr  5.2  mn  0.29
 fe 11.0 co 0.066 ni  8.7
 zr 195  nb  0.63 sn  3.2
'
'------------------------------
'
end
```

ccd047g44.input

```
=sas2h    parm=skipshipdata
calvert cliffs 1 pwr, d047, rod mkp109, 165.22 cm, 44.34/mtu  June 97
'
'  mixtures of fuel-pin-unit-cell:
'
44group      latticecell
uo2  1 den=10.018  1  997
  92234 0.027 92235 3.038 92236 0.014 92238 96.921   end
kr-83  1 0 1-20 997  end
kr-85  1 0 1-20 997  end
y-89   1 0 1-20 997  end
sr-90  1 0 1-20 997  end
zr-93  1 0 1-20 997  end
zr-94  1 0 1-20 997  end
zr-95  1 0 1-20 997  end
nb-94  1 0 1-20 997  end
mo-95  1 0 1-20 997  end
tc-99  1 0 1-20 997  end
ru-101 1 0 1-20 997  end
ru-106 1 0 1-20 997  end
rh-103 1 0 1-20 997  end
rh-105 1 0 1-20 997  end
pd-105 1 0 1-20 997  end
pd-108 1 0 1-20 997  end
ag-109 1 0 1-20 997  end
sb-124 1 0 1-20 997  end
xe-131 1 0 1-20 997  end
xe-132 1 0 1-20 997  end
xe-135 1 0 1-20 997  end
xe-136 1 0 1-20 997  end
cs-134 1 0 1-20 997  end
cs-135 1 0 1-20 997  end
cs-137 1 0 1-20 997  end
ba-136 1 0 1-20 997  end
la-139 1 0 1-20 997  end
pr-141 1 0 1-20 997  end
pr-143 1 0 1-20 997  end
ce-144 1 0 1-20 997  end
nd-143 1 0 1-20 997  end
nd-145 1 0 1-20 997  end
nd-147 1 0 1-20 997  end
pm-147 1 0 1-20 997  end
pm-148 1 0 1-20 997  end
sm-147 1 0 1-20 997  end
sm-149 1 0 1-20 997  end
sm-150 1 0 1-20 997  end
sm-151 1 0 1-20 997  end
sm-152 1 0 1-20 997  end
eu-153 1 0 1-20 997  end
eu-154 1 0 1-20 997  end
eu-155 1 0 1-20 997  end
gd-155 1 0 1-20 997  end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
        40000 98.18 2 1.0 620   end
h2o  3 den=0.7332  1  570 end
arbm-bormod  0.7332 1 1 0 0 5000 100 3 330.8e-6  570  end
'
'  331 ppm boron (wt) in moderator
'------------------------------
end comp
'
'------------------------------
'
'    fuel-pin-cell geometry:
'
squarepitch   1.4732  0.9563 1  3  1.1176  2  0.9855   0  end
'
'------------------------------
'
'   assembly and cycle parameters:
'
npin/assm=176 fuelnght=789.64 ncycles=4  nlib/cyc=5
printlevel=5 lightel=9  inplevel=2 numztotal=5 end
3  1.3140  2  1.4160  3  1.6623  500  5.2039  3  5.2431
power=27.432 burn=306.0  down=71    end
power=28.657 burn=381.7  down=81.3  bfrac=1.419    end
power=23.095 burn=466.0  down=85    bfrac=1.523   end
power=19.498 burn=461.1  down=1870  bfrac=1.488   end
  o 119   cr  5.2  mn  0.29
  fe 11.0 co 0.066 ni  8.7
  zr 195  nb  0.63 sn  3.2
'
'------------------------------
'
end
```

ccd101g18.input

```
=sas2h    parm=skipshipdata
calvert cliffs 1 pwr, d101, rod mla098, 8.9 cm 18.68gwd/mtu June 97
'
'  mixtures of fuel-pin-unit-cell:
'
'    This model uses the temperature that was derived by ORNL.
'
'
44group      latticecell
uo2  1 den=10.018  1  816
  92234 0.024 92235 2.72  92236 0.013 92238 97.243   end
kr-83  1 0 1-20 816  end
kr-85  1 0 1-20 816  end
y-89   1 0 1-20 816  end
sr-90  1 0 1-20 816  end
zr-93  1 0 1-20 816  end
zr-94  1 0 1-20 816  end
zr-95  1 0 1-20 816  end
nb-94  1 0 1-20 816  end
mo-95  1 0 1-20 816  end
tc-99  1 0 1-20 816  end
ru-101 1 0 1-20 816  end
ru-106 1 0 1-20 816  end
rh-103 1 0 1-20 816  end
rh-105 1 0 1-20 816  end
pd-105 1 0 1-20 816  end
pd-108 1 0 1-20 816  end
ag-109 1 0 1-20 816  end
sb-124 1 0 1-20 816  end
xe-131 1 0 1-20 816  end
xe-132 1 0 1-20 816  end
xe-135 1 0 1-20 816  end
xe-136 1 0 1-20 816  end
cs-134 1 0 1-20 816  end
cs-135 1 0 1-20 816  end
cs-137 1 0 1-20 816  end
ba-136 1 0 1-20 816  end
la-139 1 0 1-20 816  end
pr-141 1 0 1-20 816  end
pr-143 1 0 1-20 816  end
ce-144 1 0 1-20 816  end
nd-143 1 0 1-20 816  end
nd-145 1 0 1-20 816  end
nd-147 1 0 1-20 816  end
pm-147 1 0 1-20 816  end
pm-148 1 0 1-20 816  end
sm-147 1 0 1-20 816  end
sm-149 1 0 1-20 816  end
sm-150 1 0 1-20 816  end
sm-151 1 0 1-20 816  end
sm-152 1 0 1-20 816  end
eu-153 1 0 1-20 816  end
eu-154 1 0 1-20 816  end
eu-155 1 0 1-20 816  end
gd-155 1 0 1-20 816  end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
        40000 98.18 2 1.0 620   end
h2o  3 den=0.7576  1  557 end
arbm-bormod  0.7576 1 1 0 0 5000 100 3 330.8e-6  557  end
'
'  331 ppm boron (wt) in moderator
'-------------------------------
end comp
'
'-------------------------------
'
'    fuel-pin-cell geometry:
'
squarepitch   1.4732  0.9563 1  3  1.1176  2  0.9855   0  end
'
'-------------------------------
'
'   assembly and cycle parameters:
'
npin/assm=176 fuelnght=789.64 ncycles=3  nlib/cyc=5
printlevel=5 lightel=9  inplevel=2 numztotal=5  end
3  1.3140  2  1.4160  3  1.6623  500  5.2039  3  5.2431
power=13.760 burn=306.0  down=71    end
power=15.505 burn=381.7  down=81.3  bfrac=1.419   end
power=13.601 burn=466.0  down=2374  bfrac=1.523   end
 o 119   cr  5.2  mn  0.29
 fe 11.0 co 0.066 ni  8.7
 zr 195  nb  0.63 sn  3.2
'
'-------------------------------
'
end
```

ccd101g26.input

```
=sas2h    parm=skipshipdata
calvert cliffs 1 pwr, d101, rod mla098, 24.5 cm 26.62gwd/mtu June 97
'
'  mixtures of fuel-pin-unit-cell:
'
44group      latticecell
uo2  1 den=10.018  1  841
  92234 0.024 92235 2.72  92236 0.013 92238 97.243    end
kr-83  1 0 1-20 841  end
kr-85  1 0 1-20 841  end
y-89   1 0 1-20 841  end
sr-90  1 0 1-20 841  end
zr-93  1 0 1-20 841  end
zr-94  1 0 1-20 841  end
zr-95  1 0 1-20 841  end
nb-94  1 0 1-20 841  end
mo-95  1 0 1-20 841  end
tc-99  1 0 1-20 841  end
ru-101 1 0 1-20 841  end
ru-106 1 0 1-20 841  end
rh-103 1 0 1-20 841  end
rh-105 1 0 1-20 841  end
pd-105 1 0 1-20 841  end
pd-108 1 0 1-20 841  end
ag-109 1 0 1-20 841  end
sb-124 1 0 1-20 841  end
xe-131 1 0 1-20 841  end
xe-132 1 0 1-20 841  end
xe-135 1 0 1-20 841  end
xe-136 1 0 1-20 841  end
cs-134 1 0 1-20 841  end
cs-135 1 0 1-20 841  end
cs-137 1 0 1-20 841  end
ba-136 1 0 1-20 841  end
la-139 1 0 1-20 841  end
pr-141 1 0 1-20 841  end
pr-143 1 0 1-20 841  end
ce-144 1 0 1-20 841  end
nd-143 1 0 1-20 841  end
nd-145 1 0 1-20 841  end
nd-147 1 0 1-20 841  end
pm-147 1 0 1-20 841  end
pm-148 1 0 1-20 841  end
sm-147 1 0 1-20 841  end
sm-149 1 0 1-20 841  end
sm-150 1 0 1-20 841  end
sm-151 1 0 1-20 841  end
sm-152 1 0 1-20 841  end
eu-153 1 0 1-20 841  end
eu-154 1 0 1-20 841  end
eu-155 1 0 1-20 841  end
gd-155 1 0 1-20 841  end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
        40000 98.18 2 1.0 620   end
h2o  3 den=0.7571  1  558 end
arbm-bormod  0.7571 1 1 0 0 5000 100 3 330.8e-6  558  end
'
'  331 ppm boron (wt) in moderator
'-------------------------------
end comp
'
'-------------------------------
'
'    fuel-pin-cell geometry:
'
squarepitch   1.4732  0.9563 1  3  1.1176  2  0.9855   0  end
'
'-------------------------------
'
'   assembly and cycle parameters:
'
npin/assm=176 fuelnght=789.64 ncycles=3  nlib/cyc=5
printlevel=5 lightel=9  inplevel=2 numztotal=5 end
3  1.3140  2  1.4160  3  1.6623  500  5.2039  3  5.2431
power=20.406 burn=306.0  down=71    end
power=22.090   burn=381.7     down=81.3     bfrac=1.419
temkcyc=867 end
power=18.855   burn=466.0     down=2374     bfrac=1.523
temkcyc=817 end
 o 119   cr  5.2  mn  0.29
 fe 11.0 co 0.066 ni  8.7
 zr 195  nb  0.63 sn  3.2
'
'-------------------------------
'
end
```

ccd101g33.input

```
=sas2h     parm=skipshipdata
calvert cliffs 1 pwr, d101, rod mla098, 161.7 cm 33.17gwd/mtu June 97
'
'  mixtures of fuel-pin-unit-cell:
'
44group       latticecell
uo2  1 den=10.018  1  939
  92234 0.024 92235 2.72  92236 0.013 92238 97.243    end
kr-83  1 0 1-20 939  end
kr-85  1 0 1-20 939  end
y-89   1 0 1-20 939  end
sr-90  1 0 1-20 939  end
zr-93  1 0 1-20 939  end
zr-94  1 0 1-20 939  end
zr-95  1 0 1-20 939  end
nb-94  1 0 1-20 939  end
mo-95  1 0 1-20 939  end
tc-99  1 0 1-20 939  end
ru-101 1 0 1-20 939  end
ru-106 1 0 1-20 939  end
rh-103 1 0 1-20 939  end
rh-105 1 0 1-20 939  end
pd-105 1 0 1-20 939  end
pd-108 1 0 1-20 939  end
ag-109 1 0 1-20 939  end
sb-124 1 0 1-20 939  end
xe-131 1 0 1-20 939  end
xe-132 1 0 1-20 939  end
xe-135 1 0 1-20 939  end
xe-136 1 0 1-20 939  end
cs-134 1 0 1-20 939  end
cs-135 1 0 1-20 939  end
cs-137 1 0 1-20 939  end
ba-136 1 0 1-20 939  end
la-139 1 0 1-20 939  end
pr-141 1 0 1-20 939  end
pr-143 1 0 1-20 939  end
ce-144 1 0 1-20 939  end
nd-143 1 0 1-20 939  end
nd-145 1 0 1-20 939  end
nd-147 1 0 1-20 939  end
pm-147 1 0 1-20 939  end
pm-148 1 0 1-20 939  end
sm-147 1 0 1-20 939  end
sm-149 1 0 1-20 939  end
sm-150 1 0 1-20 939  end
sm-151 1 0 1-20 939  end
sm-152 1 0 1-20 939  end
eu-153 1 0 1-20 939  end
eu-154 1 0 1-20 939  end
eu-155 1 0 1-20 939  end
gd-155 1 0 1-20 939  end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
        40000 98.18 2 1.0 620   end
h2o  3 den=0.7341  1  570 end
arbm-bormod  0.7341 1 1 0 0 5000 100 3 330.8e-6  570  end
'
'  331 ppm boron (wt) in moderator
'------------------------------
end comp
'
'------------------------------
'
'    fuel-pin-cell geometry:
'
squarepitch   1.4732  0.9563 1  3  1.1176  2  0.9855   0  end
'
'------------------------------
'
'   assembly and cycle parameters:
'
npin/assm=176 fuelnght=789.64 ncycles=3  nlib/cyc=5
printlevel=5 lightel=9  inplevel=2 numztotal=5 end
3  1.3140  2  1.4160  3  1.6623  500  5.2039  3  5.2431
power=26.656 burn=306.0  down=71    end
power=27.837  burn=381.7     down=81.3     bfrac=1.419
temkcyc=957 end
power=22.443  burn=466.0     down=2374     bfrac=1.523
temkcyc=873 end
 o 119   cr  5.2  mn  0.29
 fe 11.0 co 0.066 ni  8.7
 zr 195  nb  0.63 sn  3.2
'
'------------------------------
'
end
```

ccbt03g31.input

```
=sas2h    parm=skipshipdata
calvert cliffs 1 pwr, bt03, rod nbd107, 11.28 cm 31.40gwd June 97
'
'  mixtures of fuel-pin-unit-cell:
'
44group      latticecell
uo2  1 den=10.054  1  768
  92234 0.022 92235 2.453 92236 0.011 92238 97.514   end
kr-83  1 0 1-20 768  end
kr-85  1 0 1-20 768  end
y-89   1 0 1-20 768  end
sr-90  1 0 1-20 768  end
zr-93  1 0 1-20 768  end
zr-94  1 0 1-20 768  end
zr-95  1 0 1-20 768  end
nb-94  1 0 1-20 768  end
mo-95  1 0 1-20 768  end
tc-99  1 0 1-20 768  end
ru-101 1 0 1-20 768  end
ru-106 1 0 1-20 768  end
rh-103 1 0 1-20 768  end
rh-105 1 0 1-20 768  end
pd-105 1 0 1-20 768  end
pd-108 1 0 1-20 768  end
ag-109 1 0 1-20 768  end
sb-124 1 0 1-20 768  end
xe-131 1 0 1-20 768  end
xe-132 1 0 1-20 768  end
xe-135 1 0 1-20 768  end
xe-136 1 0 1-20 768  end
cs-134 1 0 1-20 768  end
cs-135 1 0 1-20 768  end
cs-137 1 0 1-20 768  end
ba-136 1 0 1-20 768  end
la-139 1 0 1-20 768  end
pr-141 1 0 1-20 768  end
pr-143 1 0 1-20 768  end
ce-144 1 0 1-20 768  end
nd-143 1 0 1-20 768  end
nd-145 1 0 1-20 768  end
nd-147 1 0 1-20 768  end
pm-147 1 0 1-20 768  end
pm-148 1 0 1-20 768  end
sm-147 1 0 1-20 768  end
sm-149 1 0 1-20 768  end
sm-150 1 0 1-20 768  end
sm-151 1 0 1-20 768  end
sm-152 1 0 1-20 768  end
eu-153 1 0 1-20 768  end
eu-154 1 0 1-20 768  end
eu-155 1 0 1-20 768  end
gd-155 1 0 1-20 768  end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
        40000 98.18 2 1.0 620   end
h2o  3 den=0.7576  1  557 end
arbm-bormod  0.7576 1 1 0 0 5000 100 3 330.8e-6  557  end
'
n    4 0 5-5 557  end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
        40000 98.18 5 1.0 557   end
o    6 0 0.058 557  end
al   6 0 0.039 557  end
c    6 0 0.00107 557  end
b-10  6 0 0.000859 557  end
b-11  6 0 0.0034 557  end
'
'  331 ppm boron (wt) in moderator
'------------------------------
end comp
'
'------------------------------
'
'    fuel-pin-cell geometry:
'
squarepitch  1.4732  0.9639 1  3  1.1176  2  0.9754   0  end
'
'------------------------------
'
'   assembly and cycle parameters:
'
npin/assm=160 fuelngth=851.90 ncycles=4  nlib/cyc=5
printlevel=5 lightel=9  inplevel=2 numztotal=6 end
6 0.4775 4 0.4928 5 0.5588 3 0.8312 500 1.7190 3 1.7319
power=15.761 burn=816.0  down=81    end
power=16.457 burn=306.0  down=71   temkcyc=779  end
power=11.512  burn=381.7     down=81.3     bfrac=1.419
temkcyc=702  end
power=11.547  burn=466.0     down=2447     bfrac=1.523
temkcyc=702  end
 o 119   cr  5.2  mn  0.29
 fe 11.0 co 0.066 ni  8.7
 zr 195  nb  0.63 sn  3.2
'
'------------------------------
'
end
```

ccbt03g37.input

```
=sas2h    parm=skipshipdata
calvert cliffs 1 pwr, bt03, rod nbd107, 19.92 cm 37.27gwd June 97
'------------------------------
'
'  mixtures of fuel-pin-unit-cell:
'
44group      latticecell
uo2  1 den=10.054  1  814
  92234 0.022 92235 2.453 92236 0.011 92238 97.514   end
kr-83  1 0 1-20 814  end
kr-85  1 0 1-20 814  end
y-89   1 0 1-20 814  end
sr-90  1 0 1-20 814  end
zr-93  1 0 1-20 814  end
zr-94  1 0 1-20 814  end
zr-95  1 0 1-20 814  end
nb-94  1 0 1-20 814  end
mo-95  1 0 1-20 814  end
tc-99  1 0 1-20 814  end
ru-101 1 0 1-20 814  end
ru-106 1 0 1-20 814  end
rh-103 1 0 1-20 814  end
rh-105 1 0 1-20 814  end
pd-105 1 0 1-20 814  end
pd-108 1 0 1-20 814  end
ag-109 1 0 1-20 814  end
sb-124 1 0 1-20 814  end
xe-131 1 0 1-20 814  end
xe-132 1 0 1-20 814  end
xe-135 1 0 1-20 814  end
xe-136 1 0 1-20 814  end
cs-134 1 0 1-20 814  end
cs-135 1 0 1-20 814  end
cs-137 1 0 1-20 814  end
ba-136 1 0 1-20 814  end
la-139 1 0 1-20 814  end
pr-141 1 0 1-20 814  end
pr-143 1 0 1-20 814  end
ce-144 1 0 1-20 814  end
nd-143 1 0 1-20 814  end
nd-145 1 0 1-20 814  end
nd-147 1 0 1-20 814  end
pm-147 1 0 1-20 814  end
pm-148 1 0 1-20 814  end
sm-147 1 0 1-20 814  end
sm-149 1 0 1-20 814  end
sm-150 1 0 1-20 814  end
sm-151 1 0 1-20 814  end
sm-152 1 0 1-20 814  end
eu-153 1 0 1-20 814  end
eu-154 1 0 1-20 814  end
eu-155 1 0 1-20 814  end
gd-155 1 0 1-20 814  end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
        40000 98.18 2 1.0 620   end
h2o  3 den=0.7573  1  557 end
arbm-bormod  0.7573 1 1 0 0 5000 100 3 330.8e-6  557  end
'
n    4 0 5-5 557  end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
        40000 98.18 5 1.0 557   end
o    6 0 0.058 557  end
al   6 0 0.039 557  end
c    6 0 0.00107 557  end
b-10  6 0 0.000859 557  end
b-11  6 0 0.0034 557  end
'
'
'  331 ppm boron (wt) in moderator
'------------------------------
end comp
'
'------------------------------
'
'    fuel-pin-cell geometry:
'
squarepitch  1.4732  0.9639 1  3  1.1176  2  0.9754   0  end
'
'------------------------------
'
'   assembly and cycle parameters:
'
npin/assm=160 fuelngth=851.90 ncycles=4  nlib/cyc=5
printlevel=5 lightel=9  inplevel=2 numztotal=6 end
6 0.4775 4 0.4928 5 0.5588 3 0.8312 500 1.7190 3 1.7319
power=18.705 burn=816.0  down=81    end
power=19.534 burn=306.0  down=71  temkcyc=827   end
power=13.672  burn=381.7     down=81.3     bfrac=1.419
temkcyc=736  end
power=13.707  burn=466.0     down=2447     bfrac=1.523
temkcyc=736  end
  o 119   cr  5.2  mn  0.29
  fe 11.0 co 0.066 ni  8.7
  zr 195  nb  0.63 sn  3.2
'
'------------------------------
'
end
```

ccbt03g46.input

```
sas2h    parm=skipshipdata
calvert cliffs 1 pwr, bt03, rod nbd107, 161.21 cm 46.46gwd June 97
'------------------------------
'
'  mixtures of fuel-pin-unit-cell:
'
44group      latticecell
uo2  1 den=10.054  1  887
  92234 0.022 92235 2.453 92236 0.011 92238 97.514   end
kr-83  1 0 1-20 887  end
kr-85  1 0 1-20 887  end
y-89   1 0 1-20 887  end
sr-90  1 0 1-20 887  end
zr-93  1 0 1-20 887  end
zr-94  1 0 1-20 887  end
zr-95  1 0 1-20 887  end
nb-94  1 0 1-20 887  end
mo-95  1 0 1-20 887  end
tc-99  1 0 1-20 887  end
ru-101 1 0 1-20 887  end
ru-106 1 0 1-20 887  end
rh-103 1 0 1-20 887  end
rh-105 1 0 1-20 887  end
pd-105 1 0 1-20 887  end
pd-108 1 0 1-20 887  end
ag-109 1 0 1-20 887  end
sb-124 1 0 1-20 887  end
xe-131 1 0 1-20 887  end
xe-132 1 0 1-20 887  end
xe-135 1 0 1-20 887  end
xe-136 1 0 1-20 887  end
cs-134 1 0 1-20 887  end
cs-135 1 0 1-20 887  end
cs-137 1 0 1-20 887  end
ba-136 1 0 1-20 887  end
la-139 1 0 1-20 887  end
pr-141 1 0 1-20 887  end
pr-143 1 0 1-20 887  end
ce-144 1 0 1-20 887  end
nd-143 1 0 1-20 887  end
nd-145 1 0 1-20 887  end
nd-147 1 0 1-20 887  end
pm-147 1 0 1-20 887  end
pm-148 1 0 1-20 887  end
sm-147 1 0 1-20 887  end
sm-149 1 0 1-20 887  end
sm-150 1 0 1-20 887  end
sm-151 1 0 1-20 887  end
sm-152 1 0 1-20 887  end
eu-153 1 0 1-20 887  end
eu-154 1 0 1-20 887  end
eu-155 1 0 1-20 887  end
gd-155 1 0 1-20 887  end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
        40000 98.18 2 1.0 620   end
h2o  3 den=0.7342  1  570 end
arbm-bormod  0.7342 1 1 0 0 5000 100 3 330.8e-6  570  end
'
'
n    4 0 5-5 570  end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
        40000 98.18 5 1.0 570   end
o    6 0 0.058 570  end
al   6 0 0.039 570  end
c    6 0 0.00107 570  end
b-10  6 0 0.000859 570  end
b-11  6 0 0.0034 570  end
'
'  331 ppm boron (wt) in moderator
'------------------------------
end comp
'
'------------------------------
'
'    fuel-pin-cell geometry:
'
squarepitch  1.4732  0.9639 1  3  1.1176  2  0.9754   0  end
'
'------------------------------
'
'   assembly and cycle parameters:
'
npin/assm=160 fuelngth=851.90 ncycles=4  nlib/cyc=5
printlevel=5 lightel=9  inplevel=2 numztotal=6 end
6 0.4775 4 0.4928 5 0.5588 3 0.8312 500 1.7190 3 1.7319
power=23.324 burn=816.0  down=81    end
power=24.347 burn=306.0  down=71  temkcyc=903   end
power=17.039   burn=381.7     down=81.3     bfrac=1.419
temkcyc=788  end
power=17.092   burn=466.0     down=2447     bfrac=1.523
temkcyc=789  end
  o 119   cr  5.2  mn  0.29
  fe 11.0 co 0.066 ni  8.7
  zr 195  nb  0.63 sn  3.2
'
'------------------------------
'
end
```

d047g27.sum

```
0*************************************************************************
 *                                                                       *
 *                    SCALE4.3  Bulletin  Board                          *
 *                    --------  --------  -----                          *
 *                                                                       *
 *                      Welcome to SCALE-4.3.                            *
 *                                                                       *
 *                                                                       *
 *************************************************************************
1          primary module access and input record ( scale driver - 95/03/29 - 09:06:37 )
-   module sas2h    will be called
      calvert cliffs 1 pwr, d047, rod mkp109, 13.200 cm, 27.35/mtu  June 97
      '
      '   mixtures of fuel-pin-unit-cell:
      '
      44group        latticecell
      uo2  1 den=10.018  1  829
         92234 0.027 92235 3.038 92236 0.014 92238 96.921   end
      kr-83  1 0 1-20 829  end
      kr-85  1 0 1-20 829  end
      y-89   1 0 1-20 829  end
      sr-90  1 0 1-20 829  end
      zr-93  1 0 1-20 829  end
      zr-94  1 0 1-20 829  end
      zr-95  1 0 1-20 829  end
      nb-94  1 0 1-20 829  end
      mo-95  1 0 1-20 829  end
      tc-99  1 0 1-20 829  end
      ru-101 1 0 1-20 829  end
      ru-106 1 0 1-20 829  end
      rh-103 1 0 1-20 829  end
      rh-105 1 0 1-20 829  end
      pd-105 1 0 1-20 829  end
      pd-108 1 0 1-20 829  end
      ag-109 1 0 1-20 829  end
      sb-124 1 0 1-20 829  end
      xe-131 1 0 1-20 829  end
      xe-132 1 0 1-20 829  end
      xe-135 1 0 1-20 829  end
      xe-136 1 0 1-20 829  end
      cs-134 1 0 1-20 829  end
      cs-135 1 0 1-20 829  end
      cs-137 1 0 1-20 829  end
      ba-136 1 0 1-20 829  end
      la-139 1 0 1-20 829  end
      pr-141 1 0 1-20 829  end
      pr-143 1 0 1-20 829  end
      ce-144 1 0 1-20 829  end
      nd-143 1 0 1-20 829  end
      nd-145 1 0 1-20 829  end
      nd-147 1 0 1-20 829  end
      pm-147 1 0 1-20 829  end
      pm-148 1 0 1-20 829  end
      sm-147 1 0 1-20 829  end
      sm-149 1 0 1-20 829  end
      sm-150 1 0 1-20 829  end
      sm-151 1 0 1-20 829  end
      sm-152 1 0 1-20 829  end
      eu-153 1 0 1-20 829  end
      eu-154 1 0 1-20 829  end
      eu-155 1 0 1-20 829  end
      gd-155 1 0 1-20 829  end
      arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
                 40000 98.18 2 1.0 620   end
      h2o  3 den=0.7575  1  557 end
      arbm-bormod  0.7575 1 1 0 0 5000 100 3 330.8e-6  557  end
      '
      '  331 ppm boron (wt) in moderator
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '      fuel-pin-cell geometry:
      '
      squarepitch   1.4732  0.9563 1  3  1.1176  2  0.9855   0  end
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '    assembly and cycle parameters:
      '
      npin/assm=176 fuelnght=789.64 ncycles=4  nlib/cyc=5
      printlevel=5 lightel=9  inplevel=2 numztotal=5 end
      3  1.3140  2  1.4160  3  1.6623  500  5.2039  3  5.2431
      power=15.197 burn=306.0  down=71    end
      power=17.127 burn=381.7  down=81.3  bfrac=1.419 temkcyc=850 end
      power=15.020 burn=466.0  down=85  bfrac=1.523 temkcyc=775 end
      power=12.843 burn=461.1  down=1870  bfrac=1.488 temkcyc=709 end
        o 119   cr  5.2  mn  0.29
        fe 11.0 co 0.066 ni  8.7
        zr 195  nb  0.63 sn  3.2
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
1   sssssssssss      aaaaaaaaa      ssssssssss     22222222222    hh          hh
   sssssssssssss    aaaaaaaaaaa    sssssssssssss   2222222222222  hh          hh
   ss          ss   aa         aa  ss          ss  22          22  hh          hh
   ss               aa         aa  ss              22          22  hh          hh
   ss               aa         aa  ss              22          22  hh          hh
   sssssssssss      aaaaaaaaaaaaa  sssssssssss            22     hhhhhhhhhhhhh
    sssssssssss     aaaaaaaaaaaaa   sssssssssss         22       hhhhhhhhhhhhh
              ss    aa         aa              ss        22       hh          hh
              ss    aa         aa              ss      22         hh          hh
   ss         ss    aa         aa  ss          ss    22           hh          hh
   sssssssssssss    aa         aa  sssssssssssss   2222222222222  hh          hh
    sssssssssss     aa         aa   sssssssssss    2222222222222  hh          hh
0

   nn          nn  iiiiiiiiiii     ccccccccccc    hh          hh    ooooooooooo    11
```

```
   nnn         nn  iiiiiiiiiii   cccccccccccc  hh         hh  ooooooooooooo   ll
   nnnn        nn      ii        cc         cc hh         hh  oo         oo   ll
   nn nn       nn      ii        cc            hh         hh  oo         oo   ll
   nn  nn      nn      ii        cc            hh         hh  oo         oo   ll
   nn   nn     nn      ii        cc            hhhhhhhhhhhhh  oo         oo   ll
   nn    nn    nn      ii        cc            hhhhhhhhhhhhh  oo         oo   ll
   nn     nn   nn      ii        cc            hh         hh  oo         oo   ll
   nn      nn  nn      ii        cc            hh         hh  oo         oo   ll
   nn       nnnn       ii        cc         cc hh         hh  oo         oo   ll
   nn        nnn   iiiiiiiiiii   cccccccccccc  hh         hh  ooooooooooooo   llllllllllll
   nn         nn   iiiiiiiiiii    cccccccccc   hh         hh   ooooooooooo    llllllllllll
0
     0000000     88888888888          //    0000000     88888888888          //  99999999999    777777777777
    000000000    8888888888888       //    000000000    8888888888888       //   9999999999999  777777777777
   00      00    88         88      //    00      00    88         88      //    99         99  77        77
  00        00   88         88     //    00        00   88         88     //     99         99            77
  00        00   88         88    //     00        00   88         88    //      99         99           77
  00        00    88888888888    //      00        00    88888888888    //       9999999999999          77
  00        00    88888888888   //       00        00    88888888888   //         999999999999         77
  00        00   88         88 //        00        00   88         88 //                    99        77
  00        00   88         88//         00        00   88         88//                     99       77
   00      00    88         88/           00      00    88         88/                      99      77
    000000000    8888888888888//           000000000    8888888888888//          9999999999999     77
     0000000     88888888888 //             0000000     88888888888 //            999999999999     77
0
        11           11                   11            44                       44   5555555555555
       111          111                  111           444                      444   5555555555555
      1111         1111        :::      1111          4444         :::         4444   55
        11           11        :::        11         44 44         :::        44 44   55
        11           11        :::        11        44  44         :::       44  44   55
        11           11                   11       44   44                  44   44   555555555555
        11           11                   11      44    44                 44    44   5555555555555
        11           11        :::        11     4444444444444     :::    4444444444444           55
        11           11        :::        11     4444444444444     :::    4444444444444           55
        11           11        :::        11            44         :::               44   55        55
     11111111     11111111             11111111         44                           44   5555555555555
     11111111     11111111             11111111         44                           44    55555555555
1
0
                                 sssssssssss     cccccccccc      aaaaaaaaa     ll            eeeeeeeeeeeee
                                ssssssssssss    cccccccccccc    aaaaaaaaaaa    ll            eeeeeeeeeeeee
                                ss         ss   cc         cc  aa         aa   ll            ee
                                ss              cc             aa         aa   ll            ee
                                ss              cc             aa         aa   ll            ee
                                sssssssssss     cc             aaaaaaaaaaaaa   ll            eeeeeeeee
                                 sssssssssss    cc             aaaaaaaaaaaaa   ll            eeeeeeeee
                                          ss    cc             aa         aa   ll            ee
                                          ss    cc             aa         aa   ll            ee
                                ss        ss    cc         cc  aa         aa   ll            ee
                                ssssssssssss    cccccccccccc   aa         aa   llllllllllll  eeeeeeeeeeeee
                                 sssssssssss     cccccccccc    aa         aa   llllllllllll  eeeeeeeeeeeee


                  ***********************************************************************
                  ***********************************************************************
                  ***********************************************************************
                  *****                                                             *****
                  *****               program verification information              *****
                  *****                                                             *****
                  *****            code system:    scale  version:    4.3           *****
                  *****                                                             *****
                  ***********************************************************************
                  ***********************************************************************
                  *****                                                             *****
                  *****                                                             *****
                  *****            program:  sas2                                   *****
                  *****                                                             *****
                  *****      creation date:  03/07/97                               *****
                  *****                                                             *****
                  *****            library:  /opt/neut/Scale4.3/bin                 *****
                  *****                                                             *****
                  *****                                                             *****
                  *****   this is not a   scale  configuration controlled code      *****
                  *****                                                             *****
                  *****            jobname:  nichol                                 *****
                  *****                                                             *****
                  *****  date of execution:  08/08/97                               *****
                  *****                                                             *****
                  *****  time of execution:  11:14:45                               *****
                  *****                                                             *****
                  *****                                                             *****
                  ***********************************************************************
                  ***********************************************************************
                  ***********************************************************************
1
0'
0                                      nuclide concentrations, grams
                                       basis =single reactor assembly
            initial   1E-18 d
    o 16    1.19E+05  1.19E+05
 total      3.43E+05  3.43E+05
0                                      nuclide concentrations, grams
                                       basis =single reactor assembly
            initial   1E-18 d
   u234     2.38E+02  2.38E+02
   u235     2.68E+04  2.68E+04
   u236     1.23E+02  1.23E+02
   u238     8.54E+05  8.54E+05
 total      8.81E+05  8.81E+05
0                                     basis =
0                  initial          15.3 d         30.6 d         45.9 d         61.2 d         61.2 d
0                  initial          15.3 d         30.6 d         45.9 d         61.2 d         61.2 d
0                                      nuclide concentrations, grams
                                       basis =single reactor assembly
            initial   311.7 d   623.3 d   935.0 d  1246.7 d  1558.3 d  1870.0 d
    o 16    1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05
0                                      nuclide concentrations, grams
                                       basis =single reactor assembly
```

	initial	311.7 d	623.3 d	935.0 d	1246.7 d	1558.3 d	1870.0 d
mo 95	1.14E+01	1.24E+01	1.24E+01	1.24E+01	1.24E+01	1.24E+01	1.24E+01
tc 99	2.33E-05	2.35E-05	2.35E-05	2.35E-05	2.35E-05	2.35E-05	2.35E-05
total	3.43E+05	3.43E+05	3.43E+05	3.43E+05	3.43E+05	3.43E+05	3.43E+05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	311.7 d	623.3 d	935.0 d	1246.7 d	1558.3 d	1870.0 d
u233	1.47E-03	1.55E-03	1.64E-03	1.72E-03	1.81E-03	1.89E-03	1.98E-03
u234	1.55E+02	1.56E+02	1.56E+02	1.57E+02	1.58E+02	1.58E+02	1.59E+02
u235	8.33E+03	8.33E+03	8.33E+03	8.33E+03	8.33E+03	8.33E+03	8.33E+03
u236	3.23E+03	3.23E+03	3.23E+03	3.23E+03	3.23E+03	3.23E+03	3.23E+03
u238	8.37E+05	8.37E+05	8.37E+05	8.37E+05	8.37E+05	8.37E+05	8.37E+05
np237	2.74E+02	2.77E+02	2.77E+02	2.77E+02	2.77E+02	2.78E+02	2.78E+02
pu236	2.87E-04	2.34E-04	1.91E-04	1.56E-04	1.27E-04	1.04E-04	8.46E-05
pu238	8.97E+01	9.63E+01	9.75E+01	9.74E+01	9.69E+01	9.62E+01	9.56E+01
pu238	8.97E+01	9.63E+01	9.75E+01	9.74E+01	9.69E+01	9.62E+01	9.56E+01
pu239	3.64E+03	3.67E+03	3.67E+03	3.67E+03	3.67E+03	3.67E+03	3.67E+03
pu240	1.80E+03	1.80E+03	1.80E+03	1.80E+03	1.80E+03	1.80E+03	1.80E+03
pu241	8.53E+02	8.18E+02	7.85E+02	7.54E+02	7.23E+02	6.94E+02	6.66E+02
pu242	3.37E+02	3.37E+02	3.37E+02	3.37E+02	3.37E+02	3.37E+02	3.37E+02
am241	5.10E+01	8.53E+01	1.18E+02	1.50E+02	1.80E+02	2.09E+02	2.37E+02
am242m	1.02E+00	1.01E+00	1.01E+00	1.00E+00	9.99E-01	9.95E-01	9.90E-01
am243	5.60E+01	5.60E+01	5.60E+01	5.60E+01	5.60E+01	5.60E+01	5.60E+01
total	8.56E+05	8.56E+05	8.56E+05	8.56E+05	8.56E+05	8.56E+05	8.56E+05

0 element concentrations, grams
0 nuclide concentrations, grams
basis =single reactor assembly

	initial	311.7 d	623.3 d	935.0 d	1246.7 d	1558.3 d	1870.0 d
mo 95	5.26E+02	5.65E+02	5.67E+02	5.67E+02	5.67E+02	5.67E+02	5.67E+02

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	311.7 d	623.3 d	935.0 d	1246.7 d	1558.3 d	1870.0 d
tc 99	5.95E+02	5.96E+02	5.96E+02	5.96E+02	5.96E+02	5.96E+02	5.96E+02
ru101	5.64E+02	5.64E+02	5.64E+02	5.64E+02	5.64E+02	5.64E+02	5.64E+02
rh103	3.40E+02	3.57E+02	3.57E+02	3.57E+02	3.57E+02	3.57E+02	3.57E+02
ag109	6.23E+01	6.23E+01	6.23E+01	6.23E+01	6.23E+01	6.23E+01	6.23E+01

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	311.7 d	623.3 d	935.0 d	1246.7 d	1558.3 d	1870.0 d
nd143	6.15E+02	6.24E+02	6.24E+02	6.24E+02	6.24E+02	6.24E+02	6.24E+02
nd145	5.09E+02	5.09E+02	5.09E+02	5.09E+02	5.09E+02	5.09E+02	5.09E+02
sm147	9.75E+01	1.22E+02	1.42E+02	1.57E+02	1.70E+02	1.80E+02	1.88E+02
sm149	1.41E+00	1.87E+00	1.87E+00	1.87E+00	1.87E+00	1.87E+00	1.87E+00
sm150	2.07E+02	2.07E+02	2.07E+02	2.07E+02	2.07E+02	2.07E+02	2.07E+02
sm151	1.14E+01	1.14E+01	1.14E+01	1.13E+01	1.12E+01	1.11E+01	1.11E+01
eu151	2.78E-02	1.03E-01	1.78E-01	2.53E-01	3.27E-01	4.00E-01	4.73E-01
sm152	1.00E+02	1.00E+02	1.00E+02	1.00E+02	1.00E+02	1.00E+02	1.00E+02

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	311.7 d	623.3 d	935.0 d	1246.7 d	1558.3 d	1870.0 d
eu153	7.93E+01	7.96E+01	7.96E+01	7.96E+01	7.96E+01	7.96E+01	7.96E+01
gd155	5.12E-02	4.40E-01	7.82E-01	1.08E+00	1.35E+00	1.58E+00	1.79E+00
total	2.48E+04	2.48E+04	2.48E+04	2.48E+04	2.48E+04	2.48E+04	2.48E+04

d047g37.sum

```
0*******************************************************************************
 *                                                                             *
 *                    SCALE4.3  Bulletin  Board                                *
 *                    --------  --------  -----                                *
 *                                                                             *
 *                      Welcome to SCALE-4.3.                                  *
 *                                                                             *
 *                                                                             *
 *******************************************************************************
1          primary module access and input record ( scale driver - 95/03/29 - 09:06:37 )
-   module sas2h    will be called
      calvert cliffs 1 pwr, d047, rod mkp109, 27.700 cm, 37.12/mtu  June 97
      '
      '   mixtures of fuel-pin-unit-cell:
      '
      44group        latticecell
      uo2  1 den=10.018  1  940
         92234 0.027 92235 3.038 92236 0.014 92238 96.921   end
      kr-83  1 0 1-20 940  end
      kr-85  1 0 1-20 940  end
      y-89   1 0 1-20 940  end
      sr-90  1 0 1-20 940  end
      zr-93  1 0 1-20 940  end
      zr-94  1 0 1-20 940  end
      zr-95  1 0 1-20 940  end
      nb-94  1 0 1-20 940  end
      mo-95  1 0 1-20 940  end
      tc-99  1 0 1-20 940  end
      ru-101 1 0 1-20 940  end
      ru-106 1 0 1-20 940  end
      rh-103 1 0 1-20 940  end
      rh-105 1 0 1-20 940  end
      pd-105 1 0 1-20 940  end
      pd-108 1 0 1-20 940  end
      ag-109 1 0 1-20 940  end
      sb-124 1 0 1-20 940  end
      xe-131 1 0 1-20 940  end
      xe-132 1 0 1-20 940  end
      xe-135 1 0 1-20 940  end
      xe-136 1 0 1-20 940  end
      cs-134 1 0 1-20 940  end
      cs-135 1 0 1-20 940  end
      cs-137 1 0 1-20 940  end
      ba-136 1 0 1-20 940  end
      la-139 1 0 1-20 940  end
      pr-141 1 0 1-20 940  end
      pr-143 1 0 1-20 940  end
      ce-144 1 0 1-20 940  end
      nd-143 1 0 1-20 940  end
      nd-145 1 0 1-20 940  end
      nd-147 1 0 1-20 940  end
      pm-147 1 0 1-20 940  end
      pm-148 1 0 1-20 940  end
      sm-147 1 0 1-20 940  end
      sm-149 1 0 1-20 940  end
      sm-150 1 0 1-20 940  end
      sm-151 1 0 1-20 940  end
      sm-152 1 0 1-20 940  end
      eu-153 1 0 1-20 940  end
      eu-154 1 0 1-20 940  end
      eu-155 1 0 1-20 940  end
      gd-155 1 0 1-20 940  end
      arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
                 40000 98.18 2 1.0 620   end
      h2o  3 den=0.7569  1  558 end
      arbm-bormod  0.7569 1 1 0 0 5000 100 3 330.8e-6  558  end
      '
      '  331 ppm boron (wt) in moderator
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '      fuel-pin-cell geometry:
      '
      squarepitch   1.4732  0.9563 1  3  1.1176  2  0.9855   0  end
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '    assembly and cycle parameters:
      '
      npin/assm=176 fuelnght=789.64 ncycles=4  nlib/cyc=5
      printlevel=5 lightel=9  inplevel=2 numztotal=5  end
      3  1.3140  2  1.4160  3  1.6623  500  5.2039  3  5.2431
      power=21.790 burn=306.0  down=71    end
      power=23.588 burn=381.7  down=81.3  bfrac=1.419 temkcyc=927 end
      power=20.133 burn=466.0  down=85    bfrac=1.523 temkcyc=793   end
      power=16.634 burn=461.1  down=1870  bfrac=1.488 temkcyc=712  end
        o 119   cr  5.2  mn  0.29
        fe 11.0 co 0.066 ni  8.7
        zr 195  nb  0.63 sn  3.2
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
1   ssssssssss      aaaaaaaaa      ssssssssss     22222222222    hh          hh
   sssssssssssss    aaaaaaaaaaa    sssssssssssss  2222222222222  hh          hh
   ss          ss   aa          aa  ss          ss  22          22  hh          hh
   ss               aa          aa  ss              22          hh          hh
   ss               aa          aa  ss              22          hh          hh
   sssssssssss      aaaaaaaaaaaaa   sssssssssss            22    hhhhhhhhhhhhh
    sssssssssss     aaaaaaaaaaaaa    sssssssssss         22      hhhhhhhhhhhhh
              ss    aa          aa              ss       22          hh          hh
              ss    aa          aa              ss     22            hh          hh
   ss         ss    aa          aa  ss          ss   22              hh          hh
   sssssssssssss    aa          aa  sssssssssssss  2222222222222    hh          hh
    sssssssssss     aa          aa   sssssssssss   2222222222222    hh          hh
0

   nn          nn  iiiiiiiiiii     ccccccccccc    hh          hh    ooooooooooo    ll
```

```
   nnn         nn  iiiiiiiiiii    cccccccccccc  hh          hh  ooooooooooooo   ll
   nnnn        nn      ii         cc        cc  hh          hh  oo         oo   ll
   nn nn       nn      ii         cc            hh          hh  oo         oo   ll
   nn  nn      nn      ii         cc            hh          hh  oo         oo   ll
   nn   nn     nn      ii         cc            hhhhhhhhhhhhhh  oo         oo   ll
   nn    nn    nn      ii         cc            hhhhhhhhhhhhhh  oo         oo   ll
   nn     nn   nn      ii         cc            hh          hh  oo         oo   ll
   nn      nn  nn      ii         cc            hh          hh  oo         oo   ll
   nn       nnnn       ii         cc        cc  hh          hh  oo         oo   ll
   nn        nnn   iiiiiiiiiii    cccccccccccc  hh          hh  ooooooooooooo   llllllllllll
   nn         nn   iiiiiiiiiii     cccccccccc   hh          hh   ooooooooooo    llllllllllll
0
     0000000    7777777777777           //  33333333333     0000000            //  99999999999   7777777777777
    000000000   777777777777           //  3333333333333   000000000          //  9999999999999  777777777777
   00       00  77         77         //   33         33  00       00        //   99         99  77         77
   00       00            77         //               33  00       00       //    99         99            77
   00       00           77         //                33  00       00      //     99         99           77
   00       00          77         //               333   00       00     //      9999999999999          77
   00       00          77        //                333   00       00    //        999999999999          77
   00       00         77        //                   33  00       00   //                   99         77
   00       00         77       //                    33  00       00  //                    99         77
   00       00        77       //      33         33  00       00 //                     99        77
    000000000         77      //       3333333333333   000000000 //        9999999999999          77
     0000000          77     //         33333333333     0000000 //          999999999999          77
0
       11       22222222222               44            44               33333333333          44
      111       2222222222222            444           444               3333333333333       444
     1111       22         22    :::    4444          4444        :::    33         33      4444
       11                  22    :::   44 44         44 44        :::               33     44 44
       11                  22    :::  44  44        44  44        :::               33    44  44
       11                22          44   44       44   44                        333    44   44
       11              22           44    44      44    44                        333   44    44
       11            22          :::  444444444444  444444444444  :::               33  444444444444
       11          22            :::  444444444444  444444444444  :::               33  444444444444
       11        22              :::          44            44    :::    33         33          44
    11111111    2222222222222                 44            44           3333333333333          44
    11111111    2222222222222                 44            44            33333333333           44
1
0                                   sssssssssss    cccccccccc    aaaaaaaaa     ll          eeeeeeeeeeeee
                                   ssssssssssss   cccccccccccc   aaaaaaaaaaa   ll          eeeeeeeeeeeee
                                   ss        ss   cc        cc  aa        aa   ll          ee
                                   ss             cc            aa        aa   ll          ee
                                   ss             cc            aa        aa   ll          ee
                                   sssssssssss    cc            aaaaaaaaaaaa   ll          eeeeeeeee
                                    sssssssssss   cc            aaaaaaaaaaaa   ll          eeeeeeeee
                                             ss   cc            aa        aa   ll          ee
                                             ss   cc            aa        aa   ll          ee
                                   ss        ss   cc        cc  aa        aa   ll          ee
                                   ssssssssssss   cccccccccccc  aa        aa   llllllllllll  eeeeeeeeeeeee
                                    sssssssssss    cccccccccc   aa        aa   llllllllllll  eeeeeeeeeeeee


                        ************************************************************************
                        ************************************************************************
                        ************************************************************************
                        *****                                                              *****
                        *****                 program verification information                 *****
                        *****                                                              *****
                        *****                code system:    scale  version:    4.3          *****
                        *****                                                              *****
                        ************************************************************************
                        ************************************************************************
                        *****                                                              *****
                        *****                                                              *****
                        *****             program:  sas2                                   *****
                        *****                                                              *****
                        *****       creation date:  03/07/97                               *****
                        *****                                                              *****
                        *****             library:  /opt/neut/Scale4.3/bin                 *****
                        *****                                                              *****
                        *****                                                              *****
                        *****    this is not a   scale  configuration controlled code     *****
                        *****                                                              *****
                        *****             jobname:  nichol                                 *****
                        *****                                                              *****
                        *****    date of execution:  07/30/97                              *****
                        *****                                                              *****
                        *****    time of execution:  12:44:35                              *****
                        *****                                                              *****
                        *****                                                              *****
                        ************************************************************************
                        ************************************************************************
                        ************************************************************************
1
0
0                                        nuclide concentrations, grams
                                         basis =single reactor assembly
              initial  1E-18 d
      o 16    1.19E+05  1.19E+05
   total      3.43E+05  3.43E+05
0                                        nuclide concentrations, grams
                                         basis =single reactor assembly
              initial  1E-18 d
     u234     2.38E+02  2.38E+02
     u235     2.68E+04  2.68E+04
     u236     1.23E+02  1.23E+02
     u238     8.54E+05  8.54E+05
   total      8.81E+05  8.81E+05
0                                       basis =
0                   initial         15.3 d          30.6 d          45.9 d          61.2 d          61.2 d
0                   initial         15.3 d          30.6 d          45.9 d          61.2 d          61.2 d
0                                        nuclide concentrations, grams
                                         basis =single reactor assembly
              initial  311.7 d   623.3 d   935.0 d  1246.7 d  1558.3 d  1870.0 d
      o 16    1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05
0                                        nuclide concentrations, grams
                                         basis =single reactor assembly
```

	initial	311.7 d	623.3 d	935.0 d	1246.7 d	1558.3 d	1870.0 d
mo 95	1.62E+01	1.77E+01	1.77E+01	1.77E+01	1.77E+01	1.77E+01	1.77E+01
tc 99	6.77E-05	6.82E-05	6.82E-05	6.82E-05	6.82E-05	6.82E-05	6.82E-05
total	3.43E+05	3.43E+05	3.43E+05	3.43E+05	3.43E+05	3.43E+05	3.43E+05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	311.7 d	623.3 d	935.0 d	1246.7 d	1558.3 d	1870.0 d
u233	1.54E-03	1.66E-03	1.78E-03	1.90E-03	2.02E-03	2.15E-03	2.27E-03
u234	1.30E+02	1.31E+02	1.33E+02	1.34E+02	1.35E+02	1.36E+02	1.38E+02
u235	5.06E+03	5.06E+03	5.06E+03	5.06E+03	5.06E+03	5.06E+03	5.06E+03
u236	3.64E+03	3.64E+03	3.64E+03	3.64E+03	3.64E+03	3.65E+03	3.65E+03
u238	8.30E+05	8.30E+05	8.30E+05	8.30E+05	8.30E+05	8.30E+05	8.30E+05
np237	3.94E+02	3.98E+02	3.99E+02	3.99E+02	3.99E+02	3.99E+02	4.00E+02
pu236	6.20E-04	5.07E-04	4.14E-04	3.37E-04	2.75E-04	2.24E-04	1.83E-04
pu238	1.74E+02	1.85E+02	1.87E+02	1.87E+02	1.86E+02	1.84E+02	1.83E+02
pu238	1.74E+02	1.85E+02	1.87E+02	1.87E+02	1.86E+02	1.84E+02	1.83E+02
pu239	3.67E+03	3.71E+03	3.71E+03	3.71E+03	3.71E+03	3.71E+03	3.71E+03
pu240	2.27E+03	2.27E+03	2.27E+03	2.27E+03	2.27E+03	2.27E+03	2.28E+03
pu241	1.09E+03	1.05E+03	1.00E+03	9.63E+02	9.24E+02	8.87E+02	8.51E+02
pu242	6.67E+02	6.67E+02	6.67E+02	6.67E+02	6.67E+02	6.67E+02	6.67E+02
am241	5.75E+01	1.01E+02	1.43E+02	1.84E+02	2.22E+02	2.59E+02	2.95E+02
am242m	1.17E+00	1.17E+00	1.16E+00	1.16E+00	1.15E+00	1.15E+00	1.14E+00
am243	1.49E+02	1.49E+02	1.49E+02	1.49E+02	1.49E+02	1.49E+02	1.49E+02
total	8.48E+05	8.48E+05	8.48E+05	8.48E+05	8.48E+05	8.48E+05	8.48E+05

0 element concentrations, grams

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	311.7 d	623.3 d	935.0 d	1246.7 d	1558.3 d	1870.0 d
mo 95	6.82E+02	7.30E+02	7.33E+02	7.33E+02	7.33E+02	7.33E+02	7.33E+02

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	311.7 d	623.3 d	935.0 d	1246.7 d	1558.3 d	1870.0 d
tc 99	7.72E+02	7.74E+02	7.74E+02	7.74E+02	7.74E+02	7.74E+02	7.74E+02
ru101	7.59E+02	7.59E+02	7.59E+02	7.59E+02	7.59E+02	7.59E+02	7.59E+02
rh103	4.29E+02	4.53E+02	4.53E+02	4.53E+02	4.53E+02	4.53E+02	4.53E+02
ag109	9.42E+01	9.43E+01	9.43E+01	9.43E+01	9.43E+01	9.43E+01	9.43E+01

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	311.7 d	623.3 d	935.0 d	1246.7 d	1558.3 d	1870.0 d
nd143	7.18E+02	7.29E+02	7.29E+02	7.29E+02	7.29E+02	7.29E+02	7.29E+02
nd145	6.48E+02	6.48E+02	6.48E+02	6.48E+02	6.48E+02	6.48E+02	6.48E+02
sm147	1.09E+02	1.37E+02	1.59E+02	1.77E+02	1.91E+02	2.03E+02	2.12E+02
sm149	1.38E+00	2.03E+00	2.03E+00	2.03E+00	2.03E+00	2.03E+00	2.03E+00
sm150	2.98E+02	2.98E+02	2.98E+02	2.98E+02	2.98E+02	2.98E+02	2.98E+02
sm151	1.30E+01	1.30E+01	1.29E+01	1.29E+01	1.28E+01	1.27E+01	1.26E+01
eu151	2.15E-02	1.07E-01	1.93E-01	2.77E-01	3.62E-01	4.45E-01	5.28E-01

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	311.7 d	623.3 d	935.0 d	1246.7 d	1558.3 d	1870.0 d
sm152	1.30E+02	1.30E+02	1.30E+02	1.30E+02	1.30E+02	1.30E+02	1.30E+02
eu153	1.21E+02	1.21E+02	1.21E+02	1.21E+02	1.21E+02	1.21E+02	1.21E+02
gd155	6.23E-02	6.93E-01	1.25E+00	1.74E+00	2.17E+00	2.55E+00	2.89E+00
total	3.35E+04	3.35E+04	3.35E+04	3.35E+04	3.35E+04	3.35E+04	3.35E+04

d047g44.sum

```
0*************************************************************************
 *                                                                       *
 *                    SCALE4.3  Bulletin  Board                          *
 *                    --------  --------  -----                          *
 *                                                                       *
 *                      Welcome to SCALE-4.3.                            *
 *                                                                       *
 *                                                                       *
 *************************************************************************
1          primary module access and input record ( scale driver - 95/03/29 - 09:06:37 )
-   module sas2h    will be called
      calvert cliffs 1 pwr, d047, rod mkp109, 165.22 cm, 44.34/mtu  June 97
      '
      '    mixtures of fuel-pin-unit-cell:
      '
      44group        latticecell
      uo2  1 den=10.018  1  997
         92234 0.027 92235 3.038 92236 0.014 92238 96.921   end
      kr-83  1 0 1-20 997  end
      kr-85  1 0 1-20 997  end
      y-89   1 0 1-20 997  end
      sr-90  1 0 1-20 997  end
      zr-93  1 0 1-20 997  end
      zr-94  1 0 1-20 997  end
      zr-95  1 0 1-20 997  end
      nb-94  1 0 1-20 997  end
      mo-95  1 0 1-20 997  end
      tc-99  1 0 1-20 997  end
      ru-101 1 0 1-20 997  end
      ru-106 1 0 1-20 997  end
      rh-103 1 0 1-20 997  end
      rh-105 1 0 1-20 997  end
      pd-105 1 0 1-20 997  end
      pd-108 1 0 1-20 997  end
      ag-109 1 0 1-20 997  end
      sb-124 1 0 1-20 997  end
      xe-131 1 0 1-20 997  end
      xe-132 1 0 1-20 997  end
      xe-135 1 0 1-20 997  end
      xe-136 1 0 1-20 997  end
      cs-134 1 0 1-20 997  end
      cs-135 1 0 1-20 997  end
      cs-137 1 0 1-20 997  end
      ba-136 1 0 1-20 997  end
      la-139 1 0 1-20 997  end
      pr-141 1 0 1-20 997  end
      pr-143 1 0 1-20 997  end
      ce-144 1 0 1-20 997  end
      nd-143 1 0 1-20 997  end
      nd-145 1 0 1-20 997  end
      nd-147 1 0 1-20 997  end
      pm-147 1 0 1-20 997  end
      pm-148 1 0 1-20 997  end
      sm-147 1 0 1-20 997  end
      sm-149 1 0 1-20 997  end
      sm-150 1 0 1-20 997  end
      sm-151 1 0 1-20 997  end
      sm-152 1 0 1-20 997  end
      eu-153 1 0 1-20 997  end
      eu-154 1 0 1-20 997  end
      eu-155 1 0 1-20 997  end
      gd-155 1 0 1-20 997  end
      arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
                 40000 98.18 2 1.0 620   end
      h2o  3 den=0.7332  1  570 end
      arbm-bormod  0.7332 1 1 0 0 5000 100 3 330.8e-6  570  end
      '
      '  331 ppm boron (wt) in moderator
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '      fuel-pin-cell geometry:
      '
      squarepitch   1.4732  0.9563 1  3  1.1176  2  0.9855   0  end
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '    assembly and cycle parameters:
      '
      npin/assm=176 fuelnght=789.64 ncycles=4  nlib/cyc=5
      printlevel=5 lightel=9  inplevel=2 numztotal=5 end
      3  1.3140  2  1.4160  3  1.6623  500  5.2039  3  5.2431
      power=27.432 burn=306.0  down=71     end
      power=28.657 burn=381.7  down=81.3  bfrac=1.419     end
      power=23.095 burn=466.0  down=85    bfrac=1.523   end
      power=19.498 burn=461.1  down=1870  bfrac=1.488   end
        o 119   cr  5.2  mn  0.29
        fe 11.0 co 0.066 ni  8.7
        zr 195  nb  0.63 sn  3.2
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
1   sssssssssss      aaaaaaaaa      sssssssssss     22222222222    hh          hh
   sssssssssssss    aaaaaaaaaaa    sssssssssssss   2222222222222   hh          hh
   ss          ss   aa         aa   ss          ss   22          22   hh          hh
   ss               aa         aa   ss               22          22   hh          hh
   ss               aa         aa   ss               22          22   hh          hh
   sssssssssss      aaaaaaaaaaaaa   sssssssssss             22      hhhhhhhhhhhhh
    sssssssssss     aaaaaaaaaaaaa    sssssssssss         22         hhhhhhhhhhhhh
              ss    aa         aa              ss      22           hh          hh
              ss    aa         aa              ss    22             hh          hh
   ss         ss    aa         aa   ss         ss   22              hh          hh
   sssssssssssss    aa         aa   sssssssssssss   2222222222222   hh          hh
    sssssssssss     aa         aa    sssssssssss    2222222222222   hh          hh
0

   nn          nn  iiiiiiiiiii     ccccccccccc    hh          hh    ooooooooooo    ll
```

```
 nnn          nn  iiiiiiiiiii    cccccccccccc   hh         hh   ooooooooooooo   11
 nnnn         nn      ii         cc         cc  hh         hh   oo         oo   11
 nn nn        nn      ii         cc             hh         hh   oo         oo   11
 nn  nn       nn      ii         cc             hh         hh   oo         oo   11
 nn   nn      nn      ii         cc             hhhhhhhhhhhhh   oo         oo   11
 nn    nn     nn      ii         cc             hhhhhhhhhhhhh   oo         oo   11
 nn     nn    nn      ii         cc             hh         hh   oo         oo   11
 nn      nn   nn      ii         cc             hh         hh   oo         oo   11
 nn       nnnn        ii         cc         cc  hh         hh   oo         oo   11
 nn        nnn    iiiiiiiiiii    cccccccccccc   hh         hh   ooooooooooooo   1111111111111
 nn         nn    iiiiiiiiiii     cccccccccc    hh         hh    ooooooooooo    1111111111111
0
     0000000      7777777777777           //   33333333333     0000000            //   99999999999    7777777777777
   000000000      777777777777           //   3333333333333   000000000          //   9999999999999   777777777777
  00       00     77         77         //    33         33  00       00        //    99         99   77        77
 00         00              77         //                33  00       00       //     99         99            77
 00         00             77         //                 33  00       00      //      99         99           77
 00         00            77         //                333   00       00     //       9999999999999           77
 00         00           77         //                 333   00       00    //         999999999999          77
 00         00          77         //                   33   00       00   //                    99          77
 00         00          77        //                    33   00       00  //                     99         77
  00       00          77        //       33         33      00       00  //                     99         77
   000000000           77       //        3333333333333   000000000     //       9999999999999         77
     0000000           77      //          33333333333      0000000    //         999999999999         77
0
        11        33333333333                 22222222222   33333333333                5555555555555   7777777777777
       111       3333333333333               2222222222222 3333333333333               5555555555555   777777777777
      1111       33         33      :::      22         22 33         33      :::      55              77        77
        11                  33      :::                 22            33      :::      55                        77
        11                  33      :::                 22            33      :::      55                       77
        11                 333                         22            333               555555555555            77
        11                 333                       22              333               5555555555555           77
        11                  33      :::            22                 33      :::                 55          77
        11                  33      :::          22                   33      :::                 55          77
        11       33         33      :::      22              33         33    :::      55         55         77
    11111111     3333333333333               2222222222222   3333333333333             5555555555555         77
    11111111      33333333333                2222222222222    33333333333               55555555555          77
1
0                                sssssssssss    ccccccccccc     aaaaaaaaa    11             eeeeeeeeeeeee
                                sssssssssssss  ccccccccccccc   aaaaaaaaaaa   11             eeeeeeeeeeeee
                                ss         ss  cc         cc  aa         aa  11             ee
                                ss             cc             aa         aa  11             ee
                                ss             cc             aa         aa  11             ee
                                sssssssssss    cc             aaaaaaaaaaaaa  11             eeeeeeeee
                                 sssssssssss   cc             aaaaaaaaaaaaa  11             eeeeeeeee
                                          ss   cc             aa         aa  11             ee
                                          ss   cc             aa         aa  11             ee
                                ss         ss  cc         cc  aa         aa  11             ee
                                sssssssssssss  ccccccccccccc  aa         aa  1111111111111  eeeeeeeeeeeee
                                 sssssssssss    ccccccccccc   aa         aa  1111111111111  eeeeeeeeeeeee
```

```
*********************************************************************************
*********************************************************************************
*********************************************************************************
*****                                                                       *****
*****                     program verification information                  *****
*****                                                                       *****
*****                 code system:    scale  version:    4.3                *****
*****                                                                       *****
*********************************************************************************
*********************************************************************************
*****                                                                       *****
*****                                                                       *****
*****                 program:  sas2                                        *****
*****                                                                       *****
*****           creation date:  03/07/97                                    *****
*****                                                                       *****
*****                 library:  /opt/neut/Scale4.3/bin                      *****
*****                                                                       *****
*****                                                                       *****
*****        this is not a   scale  configuration controlled code           *****
*****                                                                       *****
*****                 jobname:  nichol                                      *****
*****                                                                       *****
*****       date of execution:  07/30/97                                    *****
*****                                                                       *****
*****       time of execution:  13:23:58                                    *****
*****                                                                       *****
*********************************************************************************
*********************************************************************************
*********************************************************************************
```

```
1
0
0                                            nuclide concentrations, grams
                                             basis =single reactor assembly
               initial   1E-18 d
    o 16      1.19E+05  1.19E+05
 total        3.43E+05  3.43E+05
0                                            nuclide concentrations, grams
                                             basis =single reactor assembly
               initial   1E-18 d
    u234      2.38E+02  2.38E+02
    u235      2.68E+04  2.68E+04
    u236      1.23E+02  1.23E+02
    u238      8.54E+05  8.54E+05
 total        8.81E+05  8.81E+05
0                                           basis =
0                     initial         15.3 d          30.6 d          45.9 d          61.2 d          61.2 d
0                     initial         15.3 d          30.6 d          45.9 d          61.2 d          61.2 d
0                                            nuclide concentrations, grams
                                             basis =single reactor assembly
               initial   311.7 d   623.3 d   935.0 d  1246.7 d  1558.3 d  1870.0 d
    o 16      1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05
0                                            nuclide concentrations, grams
                                             basis =single reactor assembly
```

	initial	311.7 d	623.3 d	935.0 d	1246.7 d	1558.3 d	1870.0 d
mo 95	2.03E+01	2.22E+01	2.23E+01	2.23E+01	2.23E+01	2.23E+01	2.23E+01
tc 99	1.34E-04	1.35E-04	1.35E-04	1.35E-04	1.35E-04	1.35E-04	1.35E-04
total	3.43E+05	3.43E+05	3.43E+05	3.43E+05	3.43E+05	3.43E+05	3.43E+05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	311.7 d	623.3 d	935.0 d	1246.7 d	1558.3 d	1870.0 d
u233	1.50E-03	1.66E-03	1.81E-03	1.96E-03	2.12E-03	2.27E-03	2.42E-03
u234	1.12E+02	1.14E+02	1.16E+02	1.17E+02	1.19E+02	1.21E+02	1.22E+02
u235	3.30E+03	3.30E+03	3.30E+03	3.30E+03	3.30E+03	3.30E+03	3.30E+03
u236	3.75E+03	3.75E+03	3.75E+03	3.75E+03	3.75E+03	3.75E+03	3.75E+03
u238	8.24E+05	8.24E+05	8.24E+05	8.24E+05	8.24E+05	8.24E+05	8.24E+05
np237	4.93E+02	4.99E+02	5.00E+02	5.00E+02	5.00E+02	5.01E+02	5.01E+02
pu236	1.00E-03	8.19E-04	6.68E-04	5.45E-04	4.44E-04	3.62E-04	2.96E-04
pu238	2.37E+02	2.51E+02	2.53E+02	2.53E+02	2.51E+02	2.50E+02	2.48E+02
pu238	2.37E+02	2.51E+02	2.53E+02	2.53E+02	2.51E+02	2.50E+02	2.48E+02
pu239	4.46E+03	4.52E+03	4.52E+03	4.52E+03	4.52E+03	4.52E+03	4.52E+03
pu240	2.51E+03	2.51E+03	2.52E+03	2.52E+03	2.52E+03	2.52E+03	2.53E+03
pu241	1.27E+03	1.22E+03	1.17E+03	1.13E+03	1.08E+03	1.04E+03	9.95E+02
pu242	8.44E+02	8.44E+02	8.44E+02	8.44E+02	8.44E+02	8.44E+02	8.44E+02
am241	6.46E+01	1.16E+02	1.65E+02	2.12E+02	2.57E+02	3.01E+02	3.42E+02
am242m	1.23E+00	1.22E+00	1.22E+00	1.21E+00	1.21E+00	1.20E+00	1.20E+00
am243	2.19E+02	2.19E+02	2.19E+02	2.19E+02	2.19E+02	2.19E+02	2.19E+02
total	8.41E+05	8.41E+05	8.41E+05	8.41E+05	8.41E+05	8.41E+05	8.41E+05

0 element concentrations, grams
0 nuclide concentrations, grams
basis =single reactor assembly

	initial	311.7 d	623.3 d	935.0 d	1246.7 d	1558.3 d	1870.0 d
mo 95	7.89E+02	8.43E+02	8.46E+02	8.46E+02	8.46E+02	8.46E+02	8.46E+02

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	311.7 d	623.3 d	935.0 d	1246.7 d	1558.3 d	1870.0 d
tc 99	8.91E+02	8.93E+02	8.93E+02	8.93E+02	8.93E+02	8.93E+02	8.93E+02
ru101	8.99E+02	8.99E+02	8.99E+02	8.99E+02	8.99E+02	8.99E+02	8.99E+02
rh103	4.89E+02	5.18E+02	5.18E+02	5.18E+02	5.18E+02	5.18E+02	5.18E+02
ag109	1.17E+02	1.17E+02	1.17E+02	1.17E+02	1.17E+02	1.17E+02	1.17E+02

0 nuclide concentrations, grams
basis =single reactor assembly

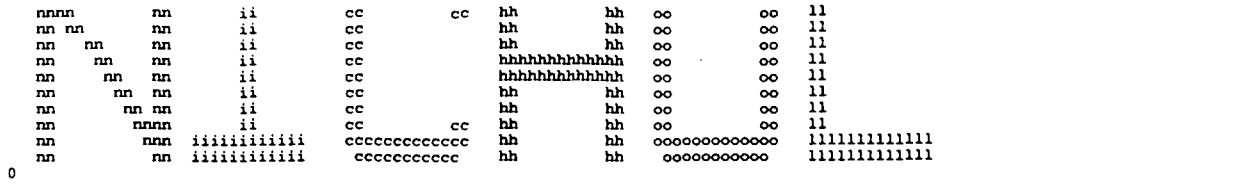
	initial	311.7 d	623.3 d	935.0 d	1246.7 d	1558.3 d	1870.0 d
nd143	7.63E+02	7.75E+02	7.75E+02	7.75E+02	7.75E+02	7.75E+02	7.75E+02
nd145	7.38E+02	7.38E+02	7.38E+02	7.38E+02	7.38E+02	7.38E+02	7.38E+02
sm147	1.12E+02	1.41E+02	1.64E+02	1.83E+02	1.97E+02	2.09E+02	2.19E+02
sm149	1.41E+00	2.23E+00	2.23E+00	2.23E+00	2.23E+00	2.23E+00	2.23E+00
sm150	3.67E+02	3.67E+02	3.67E+02	3.67E+02	3.67E+02	3.67E+02	3.67E+02
sm151	1.33E+01	1.34E+01	1.33E+01	1.32E+01	1.31E+01	1.30E+01	1.29E+01
eu151	1.78E-02	1.06E-01	1.93E-01	2.80E-01	3.67E-01	4.53E-01	5.38E-01

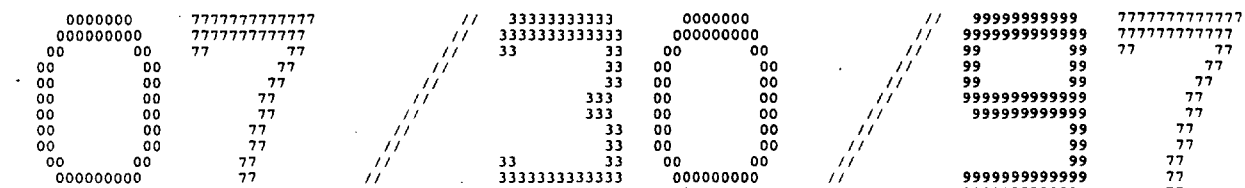
0 nuclide concentrations, grams
basis =single reactor assembly

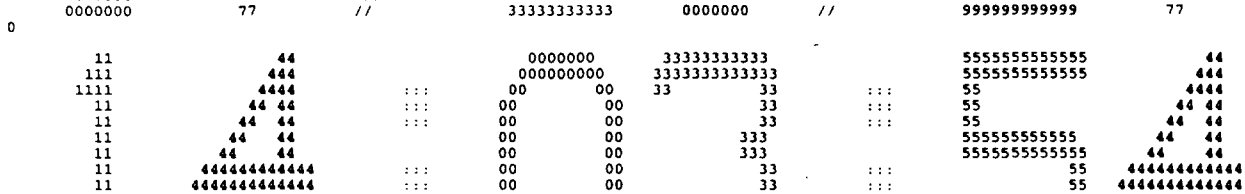
	initial	311.7 d	623.3 d	935.0 d	1246.7 d	1558.3 d	1870.0 d
sm152	1.51E+02	1.51E+02	1.51E+02	1.51E+02	1.51E+02	1.51E+02	1.51E+02
eu153	1.50E+02	1.51E+02	1.51E+02	1.51E+02	1.51E+02	1.51E+02	1.51E+02
gd155	7.05E-02	9.64E-01	1.75E+00	2.45E+00	3.06E+00	3.60E+00	4.07E+00
total	3.99E+04	3.99E+04	3.99E+04	3.99E+04	3.99E+04	3.99E+04	3.99E+04

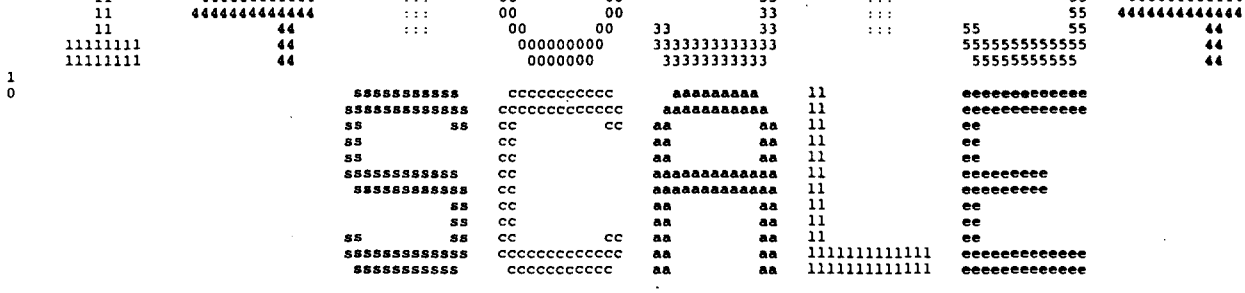
d101g18.sum

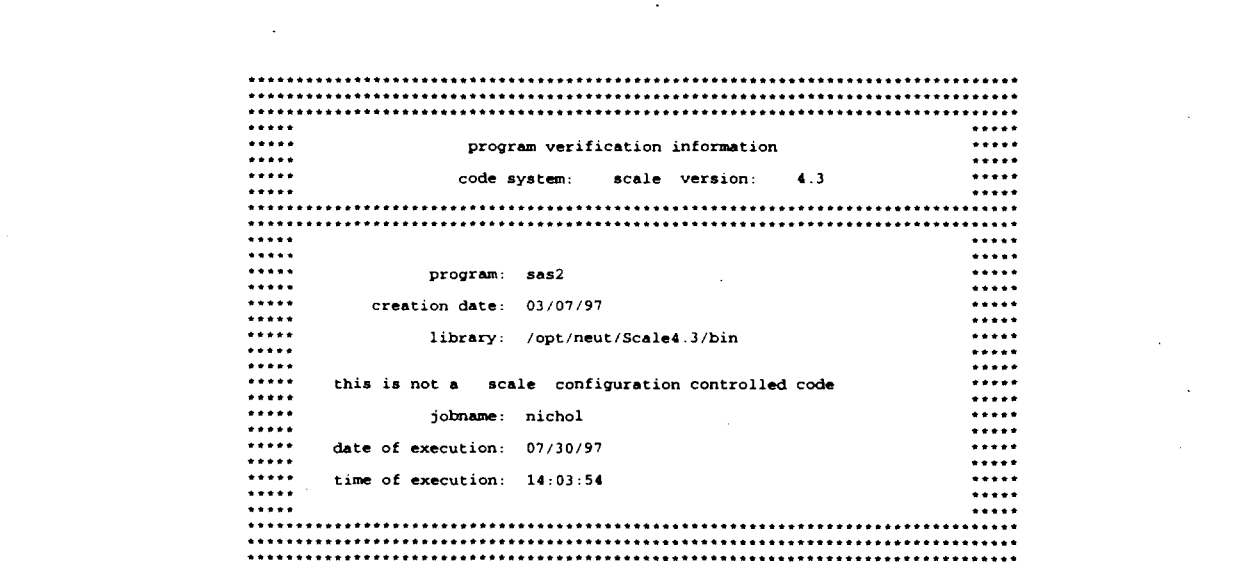
```
0*****************************************************************************
 *                                                                           *
 *                    SCALE4.3  Bulletin  Board                              *
 *                    --------  --------  -----                              *
 *                                                                           *
 *                      Welcome to SCALE-4.3.                                *
 *                                                                           *
 *                                                                           *
 *****************************************************************************
1          primary module access and input record ( scale driver - 95/03/29 - 09:06:37 )
-   module sas2h    will be called
      calvert cliffs 1 pwr, d101, rod mla098, 8.9 cm 18.68gwd/mtu June 97
      '
      '    mixtures of fuel-pin-unit-cell:
      '
      44group        latticecell
      uo2  1 den=10.018  1  737
         92234 0.024 92235 2.72  92236 0.013 92238 97.243    end
      kr-83  1 0 1-20 737  end
      kr-85  1 0 1-20 737  end
      y-89   1 0 1-20 737  end
      sr-90  1 0 1-20 737  end
      zr-93  1 0 1-20 737  end
      zr-94  1 0 1-20 737  end
      zr-95  1 0 1-20 737  end
      nb-94  1 0 1-20 737  end
      mo-95  1 0 1-20 737  end
      tc-99  1 0 1-20 737  end
      ru-101 1 0 1-20 737  end
      ru-106 1 0 1-20 737  end
      rh-103 1 0 1-20 737  end
      rh-105 1 0 1-20 737  end
      pd-105 1 0 1-20 737  end
      pd-108 1 0 1-20 737  end
      ag-109 1 0 1-20 737  end
      sb-124 1 0 1-20 737  end
      xe-131 1 0 1-20 737  end
      xe-132 1 0 1-20 737  end
      xe-135 1 0 1-20 737  end
      xe-136 1 0 1-20 737  end
      cs-134 1 0 1-20 737  end
      cs-135 1 0 1-20 737  end
      cs-137 1 0 1-20 737  end
      ba-136 1 0 1-20 737  end
      la-139 1 0 1-20 737  end
      pr-141 1 0 1-20 737  end
      pr-143 1 0 1-20 737  end
      ce-144 1 0 1-20 737  end
      nd-143 1 0 1-20 737  end
      nd-145 1 0 1-20 737  end
      nd-147 1 0 1-20 737  end
      pm-147 1 0 1-20 737  end
      pm-148 1 0 1-20 737  end
      sm-147 1 0 1-20 737  end
      sm-149 1 0 1-20 737  end
      sm-150 1 0 1-20 737  end
      sm-151 1 0 1-20 737  end
      sm-152 1 0 1-20 737  end
      eu-153 1 0 1-20 737  end
      eu-154 1 0 1-20 737  end
      eu-155 1 0 1-20 737  end
      gd-155 1 0 1-20 737  end
      arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
                 40000 98.18 2 1.0 620   end
      h2o  3 den=0.7576  1  557 end
      arbm-bormod  0.7576 1 1 0 0 5000 100 3 330.8e-6  557  end
      '
      '  331 ppm boron (wt) in moderator
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '      fuel-pin-cell geometry:
      '
      squarepitch   1.4732  0.9563 1  3  1.1176  2  0.9855   0  end
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '    assembly and cycle parameters:
      '
      npin/assm=176 fuelnght=789.64 ncycles=3  nlib/cyc=5
      printlevel=5 lightel=9  inplevel=2 numztotal=5  end
      3  1.3140  2  1.4160  3  1.6623  500  5.2039  3  5.2431
      power=13.760 burn=306.0  down=71     end
      power=15.505 burn=381.7  down=81.3  bfrac=1.419 temkcyc=764  end
      power=13.601 burn=466.0  down=2374  bfrac=1.523  temkcyc=734 end
        o 119   cr  5.2  mn  0.29
        fe 11.0 co 0.066 ni  8.7
        zr 195  nb  0.63 sn  3.2
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
1   sssssssssss      aaaaaaaaa      sssssssssss     22222222222    hh          hh
   ssssssssssss     aaaaaaaaaaa    ssssssssssss   2222222222222   hh          hh
   ss          ss   aa          aa   ss          ss   22          22   hh          hh
   ss               aa          aa   ss                       22   hh          hh
   ss               aa          aa   ss                       22   hh          hh
   sssssssssss      aaaaaaaaaaaaa    sssssssssss             22     hhhhhhhhhhhhh
    sssssssssss     aaaaaaaaaaaaa     sssssssssss          22       hhhhhhhhhhhhh
             ss     aa          aa               ss        22          hh          hh
             ss     aa          aa               ss      22            hh          hh
   ss        ss     aa          aa   ss          ss    22              hh          hh
   ssssssssssss     aa          aa   ssssssssssss    2222222222222    hh          hh
    sssssssssss     aa          aa    sssssssssss    2222222222222    hh          hh
0

   nn          nn  iiiiiiiiiiii     ccccccccccc    hh          hh    ooooooooooo    11
   nnn         nn  iiiiiiiiiiii    ccccccccccccc   hh          hh   oooooooooooo   11
```











```
1
0
0                                   nuclide concentrations, grams
                                    basis =single reactor assembly
             initial  1E-18 d
    o 16   1.19E+05  1.19E+05
   total   3.43E+05  3.43E+05
0                                   nuclide concentrations, grams
                                    basis =single reactor assembly
             initial  1E-18 d
     u234  2.12E+02  2.12E+02
     u235  2.40E+04  2.40E+04
     u236  1.15E+02  1.15E+02
     u238  8.57E+05  8.57E+05
   total   8.81E+05  8.81E+05
0                                  basis =
0                  initial         15.3 d         30.6 d         45.9 d         61.2 d         61.2 d
0                  initial         15.3 d         30.6 d         45.9 d         61.2 d         61.2 d
0                                   nuclide concentrations, grams
                                    basis =single reactor assembly
             initial  395.7 d   791.3 d  1187.0 d  1582.7 d  1978.3 d  2374.0 d
    o 16   1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05
0                                   nuclide concentrations, grams
                                    basis =single reactor assembly
             initial  395.7 d   791.3 d  1187.0 d  1582.7 d  1978.3 d  2374.0 d
```

mo 95	7.43E+00	8.51E+00	8.53E+00	8.53E+00	8.53E+00	8.53E+00	8.53E+00
tc 99	7.21E-06	7.29E-06	7.29E-06	7.29E-06	7.29E-06	7.29E-06	7.29E-06
total	3.43E+05	3.43E+05	3.43E+05	3.43E+05	3.43E+05	3.43E+05	3.43E+05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	395.7 d	791.3 d	1187.0 d	1582.7 d	1978.3 d	2374.0 d
u233	1.07E-03	1.13E-03	1.20E-03	1.26E-03	1.32E-03	1.39E-03	1.45E-03
u234	1.56E+02	1.57E+02	1.57E+02	1.57E+02	1.58E+02	1.58E+02	1.58E+02
u235	1.03E+04	1.03E+04	1.03E+04	1.03E+04	1.03E+04	1.03E+04	1.03E+04
u236	2.44E+03	2.44E+03	2.44E+03	2.44E+03	2.44E+03	2.44E+03	2.44E+03
u238	8.46E+05	8.46E+05	8.46E+05	8.46E+05	8.46E+05	8.46E+05	8.46E+05
np237	1.63E+02	1.66E+02	1.66E+02	1.66E+02	1.66E+02	1.66E+02	1.67E+02
pu236	1.22E-04	9.42E-05	7.27E-05	5.61E-05	4.33E-05	3.34E-05	2.58E-05
pu238	3.58E+01	3.90E+01	3.92E+01	3.90E+01	3.87E+01	3.84E+01	3.81E+01
pu238	3.58E+01	3.90E+01	3.92E+01	3.90E+01	3.87E+01	3.84E+01	3.81E+01
pu239	3.35E+03	3.38E+03	3.38E+03	3.38E+03	3.38E+03	3.38E+03	3.38E+03
pu240	1.32E+03	1.32E+03	1.32E+03	1.32E+03	1.32E+03	1.32E+03	1.32E+03
pu241	5.82E+02	5.52E+02	5.24E+02	4.97E+02	4.72E+02	4.48E+02	4.25E+02
pu242	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02
am241	2.43E+01	5.39E+01	8.19E+01	1.08E+02	1.34E+02	1.57E+02	1.80E+02
am242m	4.59E-01	4.57E-01	4.54E-01	4.52E-01	4.50E-01	4.47E-01	4.45E-01
am243	1.69E+01	1.69E+01	1.69E+01	1.69E+01	1.69E+01	1.69E+01	1.69E+01
total	8.64E+05	8.64E+05	8.64E+05	8.64E+05	8.64E+05	8.64E+05	8.64E+05

0 element concentrations, grams
0 nuclide concentrations, grams
basis =single reactor assembly

	initial	395.7 d	791.3 d	1187.0 d	1582.7 d	1978.3 d	2374.0 d
mo 95	3.55E+02	4.00E+02	4.00E+02	4.00E+02	4.00E+02	4.00E+02	4.00E+02
tc 99	4.19E+02	4.20E+02	4.20E+02	4.20E+02	4.20E+02	4.20E+02	4.20E+02

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	395.7 d	791.3 d	1187.0 d	1582.7 d	1978.3 d	2374.0 d
ru101	3.87E+02	3.87E+02	3.87E+02	3.87E+02	3.87E+02	3.87E+02	3.87E+02
rh103	2.42E+02	2.60E+02	2.60E+02	2.60E+02	2.60E+02	2.60E+02	2.60E+02
ag109	3.90E+01	3.91E+01	3.91E+01	3.91E+01	3.91E+01	3.91E+01	3.91E+01

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	395.7 d	791.3 d	1187.0 d	1582.7 d	1978.3 d	2374.0 d
nd143	4.61E+02	4.70E+02	4.70E+02	4.70E+02	4.70E+02	4.70E+02	4.70E+02
nd145	3.62E+02	3.63E+02	3.63E+02	3.63E+02	3.63E+02	3.63E+02	3.63E+02
sm147	5.80E+01	8.59E+01	1.07E+02	1.23E+02	1.34E+02	1.43E+02	1.50E+02
sm149	1.38E+00	1.84E+00	1.84E+00	1.84E+00	1.84E+00	1.84E+00	1.84E+00
sm150	1.39E+02	1.39E+02	1.39E+02	1.39E+02	1.39E+02	1.39E+02	1.39E+02
sm151	9.73E+00	9.75E+00	9.67E+00	9.59E+00	9.51E+00	9.43E+00	9.35E+00
eu151	2.26E-02	1.04E-01	1.85E-01	2.66E-01	3.45E-01	4.24E-01	5.03E-01
sm152	7.11E+01	7.11E+01	7.11E+01	7.11E+01	7.11E+01	7.11E+01	7.11E+01
eu153	4.72E+01	4.75E+01	4.75E+01	4.75E+01	4.75E+01	4.75E+01	4.75E+01

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	395.7 d	791.3 d	1187.0 d	1582.7 d	1978.3 d	2374.0 d
gd155	2.70E-02	3.09E-01	5.49E-01	7.53E-01	9.27E-01	1.08E+00	1.20E+00
total	1.70E+04	1.70E+04	1.70E+04	1.70E+04	1.70E+04	1.70E+04	1.70E+04

d101g26.sum

```
0*************************************************************************
 *                                                                       *
 *                    SCALE4.3  Bulletin  Board                          *
 *                    --------  --------  -----                          *
 *                                                                       *
 *                      Welcome to SCALE-4.3.                            *
 *                                                                       *
 *                                                                       *
 *************************************************************************
1          primary module access and input record ( scale driver - 95/03/29 - 09:06:37 )
-   module sas2h    will be called
      calvert cliffs 1 pwr, d101, rod mla098, 24.5 cm 26.62gwd/mtu June 97
      '
      '   mixtures of fuel-pin-unit-cell:
      '
      44group        latticecell
      uo2  1 den=10.018  1  841
         92234 0.024 92235 2.72  92236 0.013 92238 97.243    end
      kr-83  1 0 1-20 841  end
      kr-85  1 0 1-20 841  end
      y-89   1 0 1-20 841  end
      sr-90  1 0 1-20 841  end
      zr-93  1 0 1-20 841  end
      zr-94  1 0 1-20 841  end
      zr-95  1 0 1-20 841  end
      nb-94  1 0 1-20 841  end
      mo-95  1 0 1-20 841  end
      tc-99  1 0 1-20 841  end
      ru-101 1 0 1-20 841  end
      ru-106 1 0 1-20 841  end
      rh-103 1 0 1-20 841  end
      rh-105 1 0 1-20 841  end
      pd-105 1 0 1-20 841  end
      pd-108 1 0 1-20 841  end
      ag-109 1 0 1-20 841  end
      sb-124 1 0 1-20 841  end
      xe-131 1 0 1-20 841  end
      xe-132 1 0 1-20 841  end
      xe-135 1 0 1-20 841  end
      xe-136 1 0 1-20 841  end
      cs-134 1 0 1-20 841  end
      cs-135 1 0 1-20 841  end
      cs-137 1 0 1-20 841  end
      ba-136 1 0 1-20 841  end
      la-139 1 0 1-20 841  end
      pr-141 1 0 1-20 841  end
      pr-143 1 0 1-20 841  end
      ce-144 1 0 1-20 841  end
      nd-143 1 0 1-20 841  end
      nd-145 1 0 1-20 841  end
      nd-147 1 0 1-20 841  end
      pm-147 1 0 1-20 841  end
      pm-148 1 0 1-20 841  end
      sm-147 1 0 1-20 841  end
      sm-149 1 0 1-20 841  end
      sm-150 1 0 1-20 841  end
      sm-151 1 0 1-20 841  end
      sm-152 1 0 1-20 841  end
      eu-153 1 0 1-20 841  end
      eu-154 1 0 1-20 841  end
      eu-155 1 0 1-20 841  end
      gd-155 1 0 1-20 841  end
      arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
                 40000 98.18 2 1.0 620   end
      h2o  3 den=0.7571  1  558 end
      arbm-bormod  0.7571 1 1 0 0 5000 100 3 330.8e-6  558  end
      '
      '  331 ppm boron (wt) in moderator
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '      fuel-pin-cell geometry:
      '
      squarepitch   1.4732  0.9563 1  3  1.1176  2  0.9855   0  end
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '    assembly and cycle parameters:
      '
      npin/assm=176 fuelnght=789.64 ncycles=3  nlib/cyc=5
      printlevel=5 lightel=9  inplevel=2 numztotal=5 end
      3  1.3140  2  1.4160  3  1.6623  500  5.2039  3  5.2431
      power=20.406 burn=306.0  down=71     end
      power=22.090 burn=381.7  down=81.3  bfrac=1.419 temkcyc=867 end
      power=18.855 burn=466.0  down=2374  bfrac=1.523 temkcyc=817 end
        o 119   cr  5.2  mn  0.29
        fe 11.0 co 0.066 ni  8.7
        zr 195  nb  0.63 sn  3.2
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
1   sssssssssss      aaaaaaaaa      sssssssssss     22222222222    hh          hh
   sssssssssssss    aaaaaaaaaaa    sssssssssssss   2222222222222   hh          hh
   ss           ss   aa         aa   ss           ss   22          22   hh          hh
   ss                aa         aa   ss                           22   hh          hh
   ss                aa         aa   ss                           22   hh          hh
   sssssssssss       aaaaaaaaaaaaa    sssssssssss                 22   hhhhhhhhhhhhh
    sssssssssss      aaaaaaaaaaaaa     sssssssssss              22      hhhhhhhhhhhhh
              ss   aa         aa              ss          22           hh          hh
              ss   aa         aa              ss       22              hh          hh
   ss         ss   aa         aa   ss         ss    22                 hh          hh
   sssssssssssss   aa         aa   sssssssssssss   2222222222222      hh          hh
    sssssssssss    aa         aa    sssssssssss    2222222222222      hh          hh
0

   nn          nn  iiiiiiiiiiii     ccccccccccc    hh          hh    oooooooooo    ll
   nnn         nn  iiiiiiiiiiii    ccccccccccccc   hh          hh   oooooooooooo   ll
```

```
 nnnn         nn      ii       cc          cc  hh          hh  oo          oo  11
 nn nn        nn      ii       cc              hh          hh  oo          oo  11
 nn   nn      nn      ii       cc              hh          hh  oo          oo  11
 nn    nn     nn      ii       cc              hhhhhhhhhhhhh   oo          oo  11
 nn     nn    nn      ii       cc              hhhhhhhhhhhhh   oo          oo  11
 nn      nn   nn      ii       cc              hh          hh  oo          oo  11
 nn       nn  nn      ii       cc              hh          hh  oo          oo  11
 nn        nnnn       ii       cc          cc  hh          hh  oo          oo  11
 nn         nnn  iiiiiiiiiiii  ccccccccccccc   hh          hh  oooooooooooooo  1111111111111
 nn          nn  iiiiiiiiiiii   ccccccccccc    hh          hh   oooooooooooo   1111111111111
0
   0000000     7777777777777          //  33333333333     0000000          //  99999999999   7777777777777
  000000000    777777777777          //  3333333333333   000000000        //  9999999999999  777777777777
 00       00   77         77        //   33          33  00       00     //   99         99  77         77
00         00            77        //                33 00         00   //    99         99            77
00         00           77        //                 33 00         00  //     99         99           77
00         00          77        //               333   00         00 //      9999999999999          77
00         00         77        //                333   00         00//        999999999999         77
00         00        77        //                   33  00         00 //                 99        77
00         00        77       //                    33  00         00//                  99        77
 00       00        77       //      33          33   00       00   //                   99       77
  000000000         77      //       3333333333333    000000000    //     9999999999999          77
   0000000          77     //         33333333333      0000000     //      999999999999           77
0
     11              44                  33333333333    22222222222            33333333333   33333333333
    111             444                 3333333333333  2222222222222          3333333333333 3333333333333
   1111            4444        :::      33          33 22          22   :::   33          33 33          33
     11           44 44        :::                  33             22   :::               33             33
     11          44  44        :::                  33             22   :::               33             33
     11         44   44                          333             22                    333             333
     11        44    44                          333           22                      333             333
     11       444444444444     :::                33         22         :::               33             33
     11       444444444444     :::                33       22           :::               33             33
     11              44        :::      33          33   22             :::   33          33 33          33
   11111111          44                 3333333333333  2222222222222          3333333333333 3333333333333
   11111111          44                  33333333333   2222222222222           33333333333   33333333333
1
0                      sssssssssss    ccccccccccc      aaaaaaaaa    11             eeeeeeeeeeeee
                      ssssssssssss   ccccccccccccc   aaaaaaaaaaa    11             eeeeeeeeeeeee
                      ss        ss   cc          cc  aa         aa  11             ee
                      ss             cc              aa         aa  11             ee
                      ss             cc              aa         aa  11             ee
                      ssssssssssss   cc              aaaaaaaaaaaaa  11             eeeeeeeee
                       sssssssssss   cc              aaaaaaaaaaaaa  11             eeeeeeeee
                                ss   cc              aa         aa  11             ee
                                ss   cc              aa         aa  11             ee
                      ss        ss   cc          cc  aa         aa  11             ee
                      ssssssssssss   ccccccccccccc   aa         aa  1111111111111  eeeeeeeeeeeee
                       ssssssssss     ccccccccccc    aa         aa  1111111111111  eeeeeeeeeeeee


          *******************************************************************************
          *******************************************************************************
          *******************************************************************************
          *****                                                                    *****
          *****                   program verification information                 *****
          *****                                                                    *****
          *****                code system:    scale  version:    4.3              *****
          *****                                                                    *****
          *******************************************************************************
          *******************************************************************************
          *****                                                                    *****
          *****                                                                    *****
          *****                program:  sas2                                      *****
          *****                                                                    *****
          *****          creation date:  03/07/97                                  *****
          *****                                                                    *****
          *****                library:  /opt/neut/Scale4.3/bin                    *****
          *****                                                                    *****
          *****                                                                    *****
          *****       this is not a   scale  configuration controlled code         *****
          *****                                                                    *****
          *****                jobname:  nichol                                    *****
          *****                                                                    *****
          *****      date of execution:  07/30/97                                  *****
          *****                                                                    *****
          *****      time of execution:  14:32:33                                  *****
          *****                                                                    *****
          *****                                                                    *****
          *******************************************************************************
          *******************************************************************************
          *******************************************************************************
1
0
0                                        nuclide concentrations, grams
                                         basis =single reactor assembly
              initial  1E-18 d
   o 16      1.19E+05  1.19E+05
 total       3.43E+05  3.43E+05
0                                        nuclide concentrations, grams
                                         basis =single reactor assembly
              initial  1E-18 d
   u234      2.12E+02  2.12E+02
   u235      2.40E+04  2.40E+04
   u236      1.15E+02  1.15E+02
   u238      8.57E+05  8.57E+05
 total       8.81E+05  8.81E+05
0                                       basis =
0                    initial        15.3 d        30.6 d        45.9 d        61.2 d        61.2 d
0                    initial        15.3 d        30.6 d        45.9 d        61.2 d        61.2 d
0                                        nuclide concentrations, grams
                                         basis =single reactor assembly
              initial  395.7 d   791.3 d  1187.0 d  1582.7 d  1978.3 d  2374.0 d
   o 16      1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05
0                                        nuclide concentrations, grams
                                         basis =single reactor assembly
              initial  395.7 d   791.3 d  1187.0 d  1582.7 d  1978.3 d  2374.0 d
```

mo 95	1.10E+01	1.26E+01	1.26E+01	1.26E+01	1.26E+01	1.26E+01	1.26E+01
tc 99	2.38E-05	2.41E-05	2.41E-05	2.41E-05	2.41E-05	2.41E-05	2.41E-05
total	3.43E+05	3.43E+05	3.43E+05	3.43E+05	3.43E+05	3.43E+05	3.43E+05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	395.7 d	791.3 d	1187.0 d	1582.7 d	1978.3 d	2374.0 d
u233	1.24E-03	1.34E-03	1.44E-03	1.54E-03	1.64E-03	1.74E-03	1.84E-03
u234	1.36E+02	1.37E+02	1.37E+02	1.38E+02	1.39E+02	1.40E+02	1.40E+02
u235	7.05E+03	7.05E+03	7.05E+03	7.05E+03	7.05E+03	7.05E+03	7.05E+03
u236	2.93E+03	2.93E+03	2.93E+03	2.93E+03	2.93E+03	2.93E+03	2.93E+03
u238	8.40E+05	8.40E+05	8.40E+05	8.40E+05	8.40E+05	8.40E+05	8.40E+05
np237	2.59E+02	2.63E+02	2.63E+02	2.63E+02	2.64E+02	2.64E+02	2.64E+02
pu236	3.03E-04	2.35E-04	1.81E-04	1.40E-04	1.08E-04	8.33E-05	6.43E-05
pu238	8.35E+01	9.09E+01	9.15E+01	9.10E+01	9.03E+01	8.95E+01	8.88E+01
pu238	8.35E+01	9.09E+01	9.15E+01	9.10E+01	9.03E+01	8.95E+01	8.88E+01
pu239	3.37E+03	3.42E+03	3.42E+03	3.42E+03	3.42E+03	3.42E+03	3.42E+03
pu240	1.89E+03	1.89E+03	1.89E+03	1.89E+03	1.89E+03	1.89E+03	1.89E+03
pu241	8.88E+02	8.42E+02	7.99E+02	7.59E+02	7.20E+02	6.83E+02	6.48E+02
pu242	3.74E+02	3.74E+02	3.74E+02	3.74E+02	3.74E+02	3.74E+02	3.74E+02
am241	3.34E+01	7.85E+01	1.21E+02	1.62E+02	2.00E+02	2.37E+02	2.71E+02
am242m	7.15E-01	7.11E-01	7.07E-01	7.04E-01	7.00E-01	6.96E-01	6.93E-01
am243	6.20E+01	6.20E+01	6.20E+01	6.20E+01	6.20E+01	6.20E+01	6.20E+01
total	8.57E+05	8.57E+05	8.57E+05	8.57E+05	8.57E+05	8.57E+05	8.57E+05

0 element concentrations, grams
0 nuclide concentrations, grams
basis =single reactor assembly

	initial	395.7 d	791.3 d	1187.0 d	1582.7 d	1978.3 d	2374.0 d
mo 95	4.86E+02	5.44E+02	5.46E+02	5.46E+02	5.46E+02	5.46E+02	5.46E+02
tc 99	5.76E+02	5.78E+02	5.78E+02	5.78E+02	5.78E+02	5.78E+02	5.78E+02

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	395.7 d	791.3 d	1187.0 d	1582.7 d	1978.3 d	2374.0 d
ru101	5.50E+02	5.50E+02	5.50E+02	5.50E+02	5.50E+02	5.50E+02	5.50E+02
rh103	3.31E+02	3.57E+02	3.57E+02	3.57E+02	3.57E+02	3.57E+02	3.57E+02
ag109	6.55E+01	6.55E+01	6.55E+01	6.55E+01	6.55E+01	6.55E+01	6.55E+01

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	395.7 d	791.3 d	1187.0 d	1582.7 d	1978.3 d	2374.0 d
nd143	5.83E+02	5.95E+02	5.95E+02	5.95E+02	5.95E+02	5.95E+02	5.95E+02
nd145	4.89E+02	4.89E+02	4.89E+02	4.89E+02	4.89E+02	4.89E+02	4.89E+02
sm147	7.06E+01	1.05E+02	1.30E+02	1.49E+02	1.64E+02	1.74E+02	1.82E+02
sm149	1.46E+00	2.18E+00	2.18E+00	2.18E+00	2.18E+00	2.18E+00	2.18E+00
sm150	2.12E+02	2.12E+02	2.12E+02	2.12E+02	2.12E+02	2.12E+02	2.12E+02
sm151	1.20E+01	1.20E+01	1.19E+01	1.18E+01	1.17E+01	1.16E+01	1.15E+01
eu151	1.87E-02	1.19E-01	2.19E-01	3.18E-01	4.16E-01	5.14E-01	6.10E-01
sm152	9.89E+01	9.89E+01	9.89E+01	9.89E+01	9.89E+01	9.89E+01	9.89E+01
eu153	7.91E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	395.7 d	791.3 d	1187.0 d	1582.7 d	1978.3 d	2374.0 d
gd155	3.48E-02	5.02E-01	9.00E-01	1.24E+00	1.53E+00	1.77E+00	1.98E+00
total	2.41E+04	2.41E+04	2.41E+04	2.41E+04	2.41E+04	2.41E+04	2.41E+04

d101g33.sum

```
0*****************************************************************************
 *                                                                           *
 *                    SCALE4.3  Bulletin  Board                              *
 *                    --------  --------  -----                              *
 *                                                                           *
 *                      Welcome to SCALE-4.3.                                *
 *                                                                           *
 *                                                                           *
 *****************************************************************************
1          primary module access and input record ( scale driver - 95/03/29 - 09:06:37 )
-   module sas2h    will be called
      calvert cliffs 1 pwr, d101, rod mla098, 161.7 cm 33.17gwd/mtu June 97
      '
      '   mixtures of fuel-pin-unit-cell:
      '
      44group        latticecell
      uo2  1 den=10.018  1  939
         92234 0.024 92235 2.72  92236 0.013 92238 97.243    end
      kr-83  1 0 1-20 939  end
      kr-85  1 0 1-20 939  end
      y-89   1 0 1-20 939  end
      sr-90  1 0 1-20 939  end
      zr-93  1 0 1-20 939  end
      zr-94  1 0 1-20 939  end
      zr-95  1 0 1-20 939  end
      nb-94  1 0 1-20 939  end
      mo-95  1 0 1-20 939  end
      tc-99  1 0 1-20 939  end
      ru-101 1 0 1-20 939  end
      ru-106 1 0 1-20 939  end
      rh-103 1 0 1-20 939  end
      rh-105 1 0 1-20 939  end
      pd-105 1 0 1-20 939  end
      pd-108 1 0 1-20 939  end
      ag-109 1 0 1-20 939  end
      sb-124 1 0 1-20 939  end
      xe-131 1 0 1-20 939  end
      xe-132 1 0 1-20 939  end
      xe-135 1 0 1-20 939  end
      xe-136 1 0 1-20 939  end
      cs-134 1 0 1-20 939  end
      cs-135 1 0 1-20 939  end
      cs-137 1 0 1-20 939  end
      ba-136 1 0 1-20 939  end
      la-139 1 0 1-20 939  end
      pr-141 1 0 1-20 939  end
      pr-143 1 0 1-20 939  end
      ce-144 1 0 1-20 939  end
      nd-143 1 0 1-20 939  end
      nd-145 1 0 1-20 939  end
      nd-147 1 0 1-20 939  end
      pm-147 1 0 1-20 939  end
      pm-148 1 0 1-20 939  end
      sm-147 1 0 1-20 939  end
      sm-149 1 0 1-20 939  end
      sm-150 1 0 1-20 939  end
      sm-151 1 0 1-20 939  end
      sm-152 1 0 1-20 939  end
      eu-153 1 0 1-20 939  end
      eu-154 1 0 1-20 939  end
      eu-155 1 0 1-20 939  end
      gd-155 1 0 1-20 939  end
      arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
                 40000 98.18 2 1.0 620    end
      h2o  3 den=0.7341  1  570 end
      arbm-bormod  0.7341 1 1 0 0 5000 100 3 330.8e-6  570  end
      '
      '  331 ppm boron (wt) in moderator
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '      fuel-pin-cell geometry:
      '
      squarepitch   1.4732  0.9563 1  3  1.1176  2  0.9855   0  end
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '    assembly and cycle parameters:
      '
      npin/assm=176 fuelnght=789.64 ncycles=3  nlib/cyc=5
      printlevel=5 lightel=9  inplevel=2 numztotal=5 end
      3  1.3140  2  1.4160  3  1.6623  500  5.2039  3  5.2431
      power=26.656 burn=306.0  down=71     end
      power=27.837 burn=381.7  down=81.3  bfrac=1.419  temkcyc=957 end
      power=22.443 burn=466.0  down=2374  bfrac=1.523  temkcyc=873 end
        o 119   cr  5.2  mn  0.29
        fe 11.0 co 0.066 ni  8.7
        zr 195  nb  0.63 sn  3.2
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
1   sssssssssss      aaaaaaaaa      sssssssssss     22222222222    hh          hh
   sssssssssssss    aaaaaaaaaaa    sssssssssssss   2222222222222   hh          hh
   ss          ss   aa          aa   ss          ss   22          22   hh          hh
   ss               aa          aa   ss                           22   hh          hh
   ss               aa          aa   ss                           22   hh          hh
   sssssssssss      aaaaaaaaaaaaa    sssssssssss              22      hhhhhhhhhhhhh
    sssssssssss     aaaaaaaaaaaaa     sssssssssss          22         hhhhhhhhhhhhh
              ss   aa          aa              ss       22           hh          hh
              ss   aa          aa              ss     22             hh          hh
   ss         ss   aa          aa   ss         ss    22              hh          hh
   sssssssssssss   aa          aa   sssssssssssss   2222222222222   hh          hh
    sssssssssss    aa          aa    sssssssssss    2222222222222   hh          hh
0
   nn          nn  iiiiiiiiiiii     ccccccccccc    hh          hh    oooooooooo    11
   nnn         nn  iiiiiiiiiiii    ccccccccccccc   hh          hh   oooooooooooo   11
```

```
     nnnn          nn        ii          cc          cc    hh          hh    oo          oo    11
     nn nn         nn        ii          cc                hh          hh    oo          oo    11
     nn   nn       nn        ii          cc                hh          hh    oo          oo    11
     nn     nn     nn        ii          cc                hhhhhhhhhhhhh    oo          oo    11
     nn       nn   nn        ii          cc                hhhhhhhhhhhhh    oo          oo    11
     nn         nn nn        ii          cc                hh          hh    oo          oo    11
     nn          nn nn       ii          cc                hh          hh    oo          oo    11
     nn           nnnn       ii          cc          cc    hh          hh    oo          oo    11
     nn            nnn  iiiiiiiiiiii  cccccccccccccc    hh          hh    oooooooooooooo    1111111111111
     nn             nn  iiiiiiiiiii    ccccccccccc      hh          hh     ooooooooooo      1111111111111
0
      0000000      7777777777777           //  33333333333      0000000           //  99999999999    7777777777777
     000000000     777777777777           //   3333333333333   000000000         //   9999999999999  777777777777
    00       00    77        77          //    33          33  00       00      //    99          99  77        77
   00         00            77          //                 33 00         00    //     99          99           77
   00         00           77          //                  33 00         00   //      99          99          77
   00         00          77          //                  333 00         00  //       9999999999999         77
   00         00         77          //                   333 00         00 //         999999999999        77
   00         00        77          //                     33 00         00//                   99        77
   00         00        77         //                      33 00         0//                    99        77
    00       00        77         //       33          33  00       00  //                     99       77
     000000000         77        //        3333333333333   000000000  //          9999999999999      77
      0000000          77       //          33333333333     0000000  //           999999999999       77
0
        11       5555555555555              0000000          44                 33333333333    99999999999
       111       5555555555555             000000000        444                 3333333333333  9999999999999
      1111       55               :::     00       00      4444         :::     33          33 99          99
        11       55               :::    00         00    44 44         :::                 33 99          99
        11       55               :::    00         00   44  44         :::                 33 99          99
        11       555555555555            00         00  44   44                            333 9999999999999
        11       5555555555555           00         00 44    44                            333  999999999999
        11                  55    :::    00         00 44444444444      :::                 33             99
        11                  55    :::    00         00 444444444444     :::                 33             99
        11       55         55    :::     00       00         44        :::     33          33             99
     11111111    5555555555555             000000000          44                3333333333333  9999999999999
     11111111     55555555555               0000000           44                 33333333333   999999999999
1
0                                  sssssssssss    ccccccccccc     aaaaaaaaa     11            eeeeeeeeeeeee
                                  ssssssssssss   ccccccccccccc   aaaaaaaaaaa    11            eeeeeeeeeeeee
                                  ss         ss  cc          cc  aa         aa  11            ee
                                  ss             cc              aa         aa  11            ee
                                  ss             cc              aa         aa  11            ee
                                  sssssssssss    cc              aaaaaaaaaaaaa  11            eeeeeeeee
                                   sssssssssss   cc              aaaaaaaaaaaaa  11            eeeeeeeee
                                            ss   cc              aa         aa  11            ee
                                            ss   cc              aa         aa  11            ee
                                  ss        ss   cc          cc  aa         aa  11            ee
                                  sssssssssssss  ccccccccccccc   aa         aa  1111111111111 eeeeeeeeeeeee
                                   sssssssssss    ccccccccccc    aa         aa  1111111111111 eeeeeeeeeeeee


                    ***********************************************************************
                    ***********************************************************************
                    ***********************************************************************
                    *****                                                             *****
                    *****                program verification information             *****
                    *****                                                             *****
                    *****               code system:    scale  version:    4.3        *****
                    *****                                                             *****
                    ***********************************************************************
                    ***********************************************************************
                    *****                                                             *****
                    *****                                                             *****
                    *****                                                             *****
                    *****            program:  sas2                                   *****
                    *****                                                             *****
                    *****      creation date:  03/07/97                               *****
                    *****                                                             *****
                    *****            library:  /opt/neut/Scale4.3/bin                 *****
                    *****                                                             *****
                    *****                                                             *****
                    *****  this is not a   scale  configuration controlled code      *****
                    *****                                                             *****
                    *****            jobname:  nichol                                 *****
                    *****                                                             *****
                    *****  date of execution:  07/30/97                               *****
                    *****                                                             *****
                    *****  time of execution:  15:04:39                               *****
                    *****                                                             *****
                    *****                                                             *****
                    ***********************************************************************
                    ***********************************************************************
                    ***********************************************************************
1
0'
0                                         nuclide concentrations, grams
                                          basis =single reactor assembly
            initial  1E-18 d
     o 16  1.19E+05  1.19E+05
   total   3.43E+05  3.43E+05
0                                         nuclide concentrations, grams
                                          basis =single reactor assembly
            initial  1E-18 d
     u234  2.12E+02  2.12E+02
     u235  2.40E+04  2.40E+04
     u236  1.15E+02  1.15E+02
     u238  8.57E+05  8.57E+05
   total   8.81E+05  8.81E+05
0                                        basis =
0                  initial         15.3 d         30.6 d         45.9 d         61.2 d         61.2 d
0                  initial         15.3 d         30.6 d         45.9 d         61.2 d         61.2 d
0                                         nuclide concentrations, grams
                                          basis =single reactor assembly
            initial  395.7 d   791.3 d  1187.0 d  1582.7 d  1978.3 d  2374.0 d
     o 16  1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05
0                                         nuclide concentrations, grams
                                          basis =single reactor assembly
            initial  395.7 d   791.3 d  1187.0 d  1582.7 d  1978.3 d  2374.0 d
```

mo 95	1.44E+01	1.64E+01	1.65E+01	1.65E+01	1.65E+01	1.65E+01	1.65E+01
tc 99	5.41E-05	5.47E-05	5.47E-05	5.47E-05	5.47E-05	5.47E-05	5.47E-05
total	3.43E+05	3.43E+05	3.43E+05	3.43E+05	3.43E+05	3.43E+05	3.43E+05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	395.7 d	791.3 d	1187.0 d	1582.7 d	1978.3 d	2374.0 d
u233	1.32E-03	1.45E-03	1.58E-03	1.71E-03	1.85E-03	1.98E-03	2.11E-03
u234	1.20E+02	1.22E+02	1.23E+02	1.24E+02	1.25E+02	1.27E+02	1.28E+02
u235	5.16E+03	5.16E+03	5.16E+03	5.16E+03	5.16E+03	5.16E+03	5.16E+03
u236	3.18E+03	3.18E+03	3.18E+03	3.18E+03	3.18E+03	3.18E+03	3.18E+03
u238	8.35E+05	8.35E+05	8.35E+05	8.35E+05	8.35E+05	8.35E+05	8.35E+05
np237	3.39E+02	3.44E+02	3.45E+02	3.45E+02	3.45E+02	3.46E+02	3.46E+02
pu236	5.41E-04	4.19E-04	3.24E-04	2.50E-04	1.93E-04	1.49E-04	1.15E-04
pu238	1.40E+02	1.52E+02	1.53E+02	1.52E+02	1.51E+02	1.49E+02	1.48E+02
pu238	1.40E+02	1.52E+02	1.53E+02	1.52E+02	1.51E+02	1.49E+02	1.48E+02
pu239	3.40E+03	3.46E+03	3.46E+03	3.46E+03	3.46E+03	3.46E+03	3.46E+03
pu240	2.25E+03	2.25E+03	2.25E+03	2.25E+03	2.25E+03	2.25E+03	2.25E+03
pu241	1.09E+03	1.04E+03	9.85E+02	9.35E+02	8.87E+02	8.42E+02	7.99E+02
pu242	6.16E+02	6.16E+02	6.16E+02	6.16E+02	6.16E+02	6.16E+02	6.16E+02
am241	3.76E+01	9.33E+01	1.46E+02	1.96E+02	2.43E+02	2.88E+02	3.30E+02
am242m	8.73E-01	8.68E-01	8.64E-01	8.59E-01	8.54E-01	8.50E-01	8.45E-01
am243	1.28E+02	1.29E+02	1.29E+02	1.29E+02	1.29E+02	1.29E+02	1.29E+02
total	8.51E+05	8.51E+05	8.51E+05	8.51E+05	8.51E+05	8.51E+05	8.51E+05

0 element concentrations, grams
0 nuclide concentrations, grams
basis =single reactor assembly

	initial	395.7 d	791.3 d	1187.0 d	1582.7 d	1978.3 d	2374.0 d
mo 95	5.87E+02	6.54E+02	6.56E+02	6.56E+02	6.56E+02	6.56E+02	6.56E+02
tc 99	6.96E+02	6.98E+02	6.98E+02	6.98E+02	6.98E+02	6.98E+02	6.98E+02

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	395.7 d	791.3 d	1187.0 d	1582.7 d	1978.3 d	2374.0 d
ru101	6.81E+02	6.81E+02	6.81E+02	6.81E+02	6.81E+02	6.81E+02	6.81E+02
rh103	3.94E+02	4.26E+02	4.26E+02	4.26E+02	4.26E+02	4.26E+02	4.26E+02
ag109	8.85E+01	8.86E+01	8.86E+01	8.86E+01	8.86E+01	8.86E+01	8.86E+01

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	395.7 d	791.3 d	1187.0 d	1582.7 d	1978.3 d	2374.0 d
nd143	6.63E+02	6.77E+02	6.77E+02	6.77E+02	6.77E+02	6.77E+02	6.77E+02
nd145	5.82E+02	5.82E+02	5.82E+02	5.82E+02	5.82E+02	5.82E+02	5.82E+02
sm147	7.70E+01	1.14E+02	1.42E+02	1.63E+02	1.78E+02	1.90E+02	1.99E+02
sm149	1.57E+00	2.50E+00	2.50E+00	2.50E+00	2.50E+00	2.50E+00	2.50E+00
sm150	2.78E+02	2.78E+02	2.78E+02	2.78E+02	2.78E+02	2.78E+02	2.78E+02
sm151	1.42E+01	1.43E+01	1.41E+01	1.40E+01	1.39E+01	1.38E+01	1.37E+01
eu151	1.79E-02	1.37E-01	2.56E-01	3.73E-01	4.90E-01	6.05E-01	7.20E-01
sm152	1.19E+02	1.19E+02	1.19E+02	1.19E+02	1.19E+02	1.19E+02	1.19E+02
eu153	1.07E+02	1.08E+02	1.08E+02	1.08E+02	1.08E+02	1.08E+02	1.08E+02

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	395.7 d	791.3 d	1187.0 d	1582.7 d	1978.3 d	2374.0 d
gd155	4.33E-02	6.73E-01	1.21E+00	1.67E+00	2.05E+00	2.39E+00	2.67E+00
total	2.99E+04	2.99E+04	2.99E+04	2.99E+04	2.99E+04	2.99E+04	2.99E+04

bt03g31.sum

```
0*****************************************************************************
 *                                                                           *
 *                    SCALE4.3  Bulletin  Board                              *
 *                    --------  --------  -----                              *
 *                                                                           *
 *                      Welcome to SCALE-4.3.                                *
 *                                                                           *
 *                                                                           *
 *****************************************************************************
1         primary module access and input record ( scale driver - 95/03/29 - 09:06:37 )
-   module sas2h    will be called
      calvert cliffs 1 pwr, bt03, rod nbd107, 11.28 cm 31.40gwd June 97
      '
      '   mixtures of fuel-pin-unit-cell:
      '
      44group        latticecell
      uo2  1 den=10.054  1  768
         92234 0.022 92235 2.453 92236 0.011 92238 97.514   end
      kr-83  1 0 1-20 768  end
      kr-85  1 0 1-20 768  end
      y-89   1 0 1-20 768  end
      sr-90  1 0 1-20 768  end
      zr-93  1 0 1-20 768  end
      zr-94  1 0 1-20 768  end
      zr-95  1 0 1-20 768  end
      nb-94  1 0 1-20 768  end
      mo-95  1 0 1-20 768  end
      tc-99  1 0 1-20 768  end
      ru-101 1 0 1-20 768  end
      ru-106 1 0 1-20 768  end
      rh-103 1 0 1-20 768  end
      rh-105 1 0 1-20 768  end
      pd-105 1 0 1-20 768  end
      pd-108 1 0 1-20 768  end
      ag-109 1 0 1-20 768  end
      sb-124 1 0 1-20 768  end
      xe-131 1 0 1-20 768  end
      xe-132 1 0 1-20 768  end
      xe-135 1 0 1-20 768  end
      xe-136 1 0 1-20 768  end
      cs-134 1 0 1-20 768  end
      cs-135 1 0 1-20 768  end
      cs-137 1 0 1-20 768  end
      ba-136 1 0 1-20 768  end
      la-139 1 0 1-20 768  end
      pr-141 1 0 1-20 768  end
      pr-143 1 0 1-20 768  end
      ce-144 1 0 1-20 768  end
      nd-143 1 0 1-20 768  end
      nd-145 1 0 1-20 768  end
      nd-147 1 0 1-20 768  end
      pm-147 1 0 1-20 768  end
      pm-148 1 0 1-20 768  end
      sm-147 1 0 1-20 768  end
      sm-149 1 0 1-20 768  end
      sm-150 1 0 1-20 768  end
      sm-151 1 0 1-20 768  end
      sm-152 1 0 1-20 768  end
      eu-153 1 0 1-20 768  end
      eu-154 1 0 1-20 768  end
      eu-155 1 0 1-20 768  end
      gd-155 1 0 1-20 768  end
      arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
                 40000 98.18 2 1.0 620   end
      h2o  3 den=0.7576  1  557 end
      arbm-bormod  0.7576 1 1 0 0 5000 100 3 330.8e-6  557  end
      '
      n     4 0 5-5 557  end
      arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
                 40000 98.18 5 1.0 557   end
      o     6 0 0.058 557  end
      al    6 0 0.039 557  end
      c     6 0 0.00107 557  end
      b-10  6 0 0.000859 557  end
      b-11  6 0 0.0034 557  end
      '
      '  331 ppm boron (wt) in moderator
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '      fuel-pin-cell geometry:
      '
      squarepitch   1.4732  0.9639 1  3  1.1176  2  0.9754   0  end
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '    assembly and cycle parameters:
      '
      npin/assm=160 fuelngth=851.90 ncycles=4  nlib/cyc=5
      printlevel=5 lightel=9  inplevel=2 numztotal=6 end
      6 0.4775 4 0.4928 5 0.5588 3 0.8312 500 1.7190 3 1.7319
      power=15.761 burn=816.0  down=81     end
      power=16.457 burn=306.0  down=71   temkcyc=779  end
      power=11.512 burn=381.7  down=81.3  bfrac=1.419 temkcyc=702  end
      power=11.547 burn=466.0  down=2447  bfrac=1.523 temkcyc=702  end
        o 119   cr  5.2  mn  0.29
        fe 11.0 co 0.066 ni  8.7
        zr 195  nb  0.63 sn  3.2
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
1   sssssssssss       aaaaaaaaa       sssssssssss     22222222222    hh          hh
   sssssssssssss     aaaaaaaaaaa     sssssssssssss   2222222222222   hh          hh
   ss          ss   aa         aa   ss          ss   22          22   hh          hh
   ss               aa         aa   ss               22          22   hh          hh
   ss               aa         aa   ss               22          22   hh          hh
   sssssssssss      aaaaaaaaaaaaa   sssssssssss              22      hhhhhhhhhhhhh
```

```
  sssssssssss   aaaaaaaaaaaa   sssssssssss         22        hhhhhhhhhhhhh
           ss   aa        aa            ss       22          hh         hh
           ss   aa        aa            ss     22            hh         hh
ss         ss   aa        aa   ss       ss   22              hh         hh
sssssssssssss   aa        aa   sssssssssssss 2222222222222   hh         hh
 sssssssssss    aa        aa    sssssssssss  2222222222222   hh         hh
0
nn         nn iiiiiiiiiii   cccccccccc   hh         hh   ooooooooooo   11
nnn        nn iiiiiiiiiii  cccccccccccc  hh         hh  ooooooooooooo  11
nnnn       nn      ii      cc        cc  hh         hh  oo         oo  11
nn nn      nn      ii      cc            hh         hh  oo         oo  11
nn  nn     nn      ii      cc            hh         hh  oo         oo  11
nn   nn    nn      ii      cc            hhhhhhhhhhhhh  oo         oo  11
nn    nn   nn      ii      cc            hhhhhhhhhhhhh  oo         oo  11
nn     nn  nn      ii      cc            hh         hh  oo         oo  11
nn      nn nn      ii      cc            hh         hh  oo         oo  11
nn       nnnn      ii      cc        cc  hh         hh  oo         oo  11
nn        nnn iiiiiiiiiii  cccccccccccc  hh         hh  ooooooooooooo  1111111111111
nn         nn iiiiiiiiiii   cccccccccc   hh         hh   ooooooooooo   1111111111111
0
   0000000     88888888888           //    0000000          44          //  99999999999   7777777777777
  000000000   8888888888888         //    000000000        444         //  9999999999999  777777777777
 00       00  88         88        //    00       00      4444        //   99         99  77         77
00         00 88         88       //    00         00    44 44       //    99         99            77
00         00 88         88      //     00         00   44  44      //     99         99           77
00         00  88888888888      //      00         00  44   44     //      9999999999999          77
00         00  88888888888     //       00         00 44    44    //        999999999999         77
00         00 88         88   //        00         00 4444444444444//                 99        77
00         00 88         88  //         00         00 4444444444444/                  99       77
 00       00  88         88 //           00       00        44  //                    99      77
  000000000   8888888888888//             000000000         44 //       9999999999999        77
   0000000     88888888888 //              0000000          44//        999999999999         77
0
     11          0000000                        44   7777777777777           22222222222       11
    111         000000000                      444   777777777777           2222222222222     111
   1111        00       00       :::          4444   77         77   :::    22         22    1111
     11       00         00      :::         44 44             77    :::               22      11
     11       00         00      :::        44  44            77     :::               22      11
     11       00         00                44   44           77                      22        11
     11       00         00               44    44          77                     22          11
     11       00         00      :::     444444444444      77        :::         22            11
     11       00         00      :::     444444444444     77         :::       22              11
     11        00       00       :::              44     77          :::     22                11
  11111111      000000000                         44    77                  2222222222222   11111111
  11111111       0000000                          44    77                  2222222222222   11111111
1
0                                 sssssssssss    cccccccccc     aaaaaaaaa    11           eeeeeeeeeeeee
                                 sssssssssssss  cccccccccccc   aaaaaaaaaaa   11           eeeeeeeeeeeee
                                 ss         ss  cc        cc  aa         aa  11           ee
                                 ss             cc            aa         aa  11           ee
                                 ss             cc            aa         aa  11           ee
                                 sssssssssssss  cc            aaaaaaaaaaaaa  11           eeeeeeeee
                                  ssssssssssss  cc            aaaaaaaaaaaaa  11           eeeeeeeee
                                            ss  cc            aa         aa  11           ee
                                            ss  cc            aa         aa  11           ee
                                 ss         ss  cc        cc  aa         aa  11           ee
                                 sssssssssssss  cccccccccccc  aa         aa  1111111111111 eeeeeeeeeeeee
                                  sssssssssss    cccccccccc   aa         aa  1111111111111 eeeeeeeeeeeee
```

```
***************************************************************************
***************************************************************************
***************************************************************************
*****                                                                 *****
*****                  program verification information               *****
*****                                                                 *****
*****                 code system:    scale  version:    4.3          *****
*****                                                                 *****
***************************************************************************
***************************************************************************
*****                                                                 *****
*****                                                                 *****
*****                                                                 *****
*****              program:  sas2                                     *****
*****                                                                 *****
*****        creation date:  03/07/97                                 *****
*****                                                                 *****
*****              library:  /opt/neut/Scale4.3/bin                   *****
*****                                                                 *****
*****                                                                 *****
*****  this is not a   scale  configuration controlled code           *****
*****                                                                 *****
*****              jobname:  nichol                                   *****
*****                                                                 *****
*****    date of execution:  08/04/97                                 *****
*****                                                                 *****
*****    time of execution:  10:47:21                                 *****
*****                                                                 *****
*****                                                                 *****
***************************************************************************
***************************************************************************
***************************************************************************
1
0
0
```

nuclide concentrations, grams
basis =single reactor assembly

	initial	1E-18 d
o 16	1.19E+05	1.19E+05
total	3.98E+05	3.98E+05

0

nuclide concentrations, grams
basis =single reactor assembly

	initial	1E-18 d
u234	1.94E+02	1.94E+02
u235	2.16E+04	2.16E+04
u236	9.69E+01	9.69E+01
u238	8.59E+05	8.59E+05
total	8.81E+05	8.81E+05

0 basis =
0 initial 40.8 d 81.6 d 122.4 d 163.2 d 163.2 d
0 initial 40.8 d 81.6 d 122.4 d 163.2 d 163.2 d
0 nuclide concentrations, grams
basis =single reactor assembly

	initial	407.8 d	815.7 d	1223.5 d	1631.3 d	2039.2 d	2447.0 d
o 16	1.19E+05	1.19E+05	1.19E+05	1.19E+05	1.19E+05	1.19E+05	1.19E+05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	407.8 d	815.7 d	1223.5 d	1631.3 d	2039.2 d	2447.0 d
mo 95	1.51E+01	1.61E+01	1.61E+01	1.61E+01	1.61E+01	1.61E+01	1.61E+01
tc 99	5.22E-05	5.25E-05	5.25E-05	5.25E-05	5.25E-05	5.25E-05	5.25E-05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	407.8 d	815.7 d	1223.5 d	1631.3 d	2039.2 d	2447.0 d
total	3.98E+05	3.98E+05	3.98E+05	3.98E+05	3.98E+05	3.98E+05	3.98E+05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	407.8 d	815.7 d	1223.5 d	1631.3 d	2039.2 d	2447.0 d
u233	1.18E-03	1.30E-03	1.42E-03	1.54E-03	1.66E-03	1.78E-03	1.91E-03
u234	1.10E+02	1.11E+02	1.12E+02	1.14E+02	1.15E+02	1.16E+02	1.18E+02
u235	4.66E+03	4.66E+03	4.66E+03	4.66E+03	4.66E+03	4.66E+03	4.66E+03
u236	2.91E+03	2.91E+03	2.91E+03	2.91E+03	2.91E+03	2.91E+03	2.91E+03
u238	8.37E+05	8.37E+05	8.37E+05	8.37E+05	8.37E+05	8.37E+05	8.37E+05
np237	3.06E+02	3.08E+02	3.09E+02	3.09E+02	3.09E+02	3.10E+02	3.10E+02
pu236	3.51E-04	2.69E-04	2.06E-04	1.58E-04	1.21E-04	9.25E-05	7.08E-05
pu238	1.40E+02	1.51E+02	1.52E+02	1.51E+02	1.50E+02	1.49E+02	1.48E+02
pu238	1.40E+02	1.51E+02	1.52E+02	1.51E+02	1.50E+02	1.49E+02	1.48E+02
pu239	3.49E+03	3.52E+03	3.52E+03	3.52E+03	3.52E+03	3.52E+03	3.52E+03
pu240	2.26E+03	2.26E+03	2.26E+03	2.26E+03	2.26E+03	2.26E+03	2.26E+03
pu241	1.00E+03	9.47E+02	8.97E+02	8.50E+02	8.06E+02	7.63E+02	7.23E+02
pu242	5.73E+02	5.73E+02	5.73E+02	5.73E+02	5.73E+02	5.73E+02	5.73E+02
am241	7.26E+01	1.25E+02	1.74E+02	2.21E+02	2.65E+02	3.07E+02	3.47E+02
am242m	1.43E+00	1.42E+00	1.41E+00	1.41E+00	1.40E+00	1.39E+00	1.38E+00
am243	1.12E+02	1.12E+02	1.12E+02	1.12E+02	1.12E+02	1.12E+02	1.12E+02
total	8.53E+05	8.53E+05	8.53E+05	8.53E+05	8.53E+05	8.53E+05	8.53E+05

0 element concentrations, grams
0 nuclide concentrations, grams
basis =single reactor assembly

	initial	407.8 d	815.7 d	1223.5 d	1631.3 d	2039.2 d	2447.0 d
mo 95	5.78E+02	6.13E+02	6.13E+02	6.13E+02	6.13E+02	6.13E+02	6.13E+02
tc 99	6.55E+02	6.56E+02	6.56E+02	6.56E+02	6.56E+02	6.56E+02	6.56E+02

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	407.8 d	815.7 d	1223.5 d	1631.3 d	2039.2 d	2447.0 d
ru101	6.45E+02	6.45E+02	6.45E+02	6.45E+02	6.45E+02	6.45E+02	6.45E+02
rh103	3.93E+02	4.09E+02	4.09E+02	4.09E+02	4.09E+02	4.09E+02	4.09E+02
ag109	8.71E+01	8.71E+01	8.71E+01	8.71E+01	8.71E+01	8.71E+01	8.71E+01

0 nuclide concentrations, grams
basis =single reactor assembly

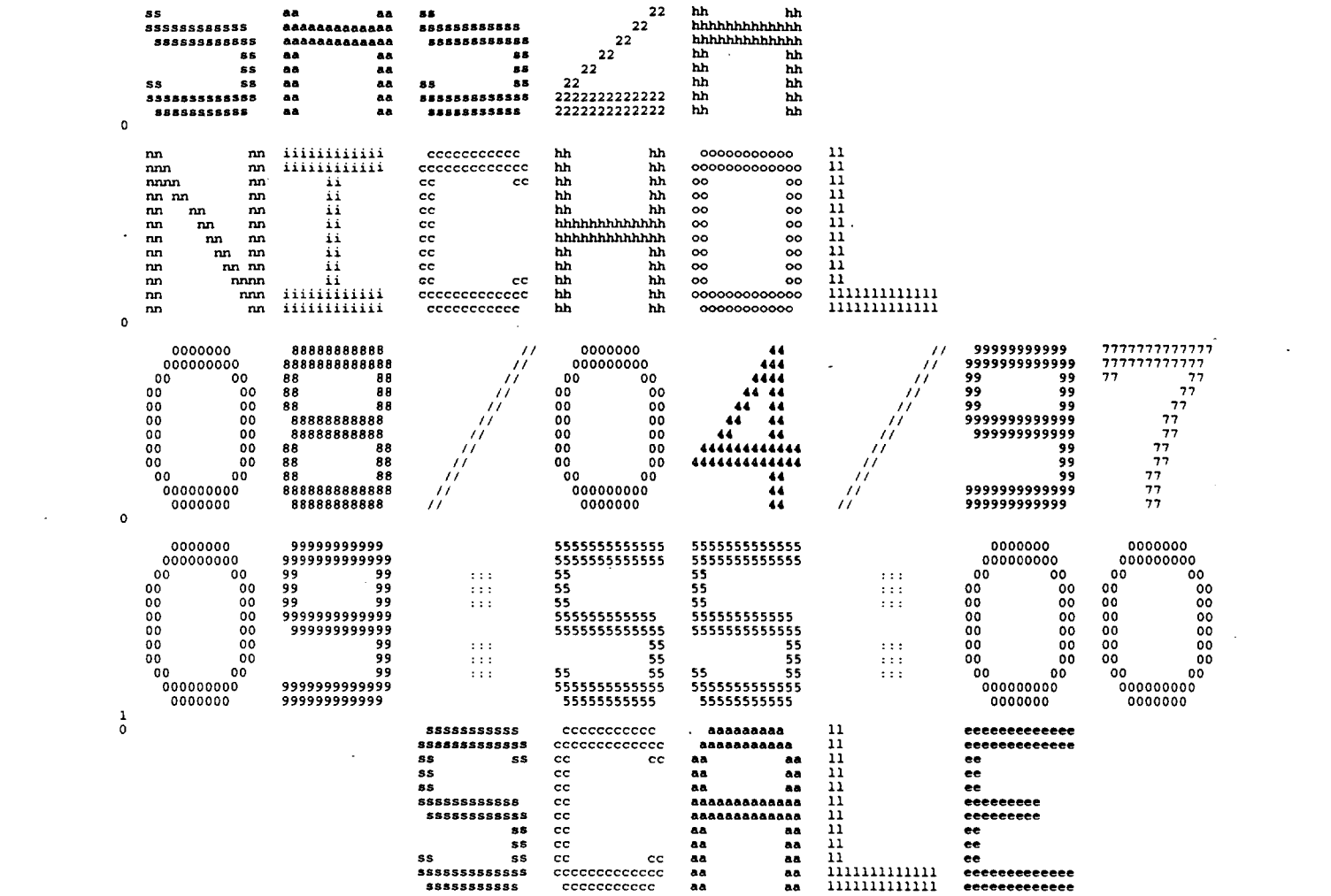
	initial	407.8 d	815.7 d	1223.5 d	1631.3 d	2039.2 d	2447.0 d
nd143	6.17E+02	6.24E+02	6.24E+02	6.24E+02	6.24E+02	6.24E+02	6.24E+02
nd145	5.48E+02	5.48E+02	5.48E+02	5.48E+02	5.48E+02	5.48E+02	5.48E+02
sm147	1.13E+02	1.42E+02	1.63E+02	1.79E+02	1.91E+02	1.99E+02	2.06E+02
sm149	1.15E+00	1.56E+00	1.56E+00	1.56E+00	1.56E+00	1.56E+00	1.56E+00
sm150	2.34E+02	2.34E+02	2.34E+02	2.34E+02	2.34E+02	2.34E+02	2.34E+02
sm151	1.07E+01	1.07E+01	1.06E+01	1.05E+01	1.04E+01	1.03E+01	1.02E+01
eu151	2.42E-02	1.16E-01	2.07E-01	2.98E-01	3.87E-01	4.76E-01	5.64E-01
sm152	1.15E+02	1.15E+02	1.15E+02	1.15E+02	1.15E+02	1.15E+02	1.15E+02
eu153	1.02E+02	1.03E+02	1.03E+02	1.03E+02	1.03E+02	1.03E+02	1.03E+02

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	407.8 d	815.7 d	1223.5 d	1631.3 d	2039.2 d	2447.0 d
gd155	6.40E-02	7.33E-01	1.30E+00	1.78E+00	2.19E+00	2.53E+00	2.83E+00
total	2.81E+04	2.81E+04	2.81E+04	2.81E+04	2.81E+04	2.81E+04	2.81E+04

bt03g37.sum

```
0*****************************************************************************
 *                                                                           *
 *                    SCALE4.3  Bulletin  Board                              *
 *                    --------  --------  -----                              *
 *                                                                           *
 *                      Welcome to SCALE-4.3.                                *
 *                                                                           *
 *                                                                           *
 *****************************************************************************
1         primary module access and input record ( scale driver - 95/03/29 - 09:06:37 )
-   module sas2h     will be called
      calvert cliffs 1 pwr, bt03, rod nbd107, 19.92 cm 37.27gwd June 97
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '   mixtures of fuel-pin-unit-cell:
      '
      44group         latticecell
      uo2  1 den=10.054  1  814
         92234 0.022 92235 2.453 92236 0.011 92238 97.514   end
      kr-83   1 0 1-20 814  end
      kr-85   1 0 1-20 814  end
      y-89    1 0 1-20 814  end
      sr-90   1 0 1-20 814  end
      zr-93   1 0 1-20 814  end
      zr-94   1 0 1-20 814  end
      zr-95   1 0 1-20 814  end
      nb-94   1 0 1-20 814  end
      mo-95   1 0 1-20 814  end
      tc-99   1 0 1-20 814  end
      ru-101  1 0 1-20 814  end
      ru-106  1 0 1-20 814  end
      rh-103  1 0 1-20 814  end
      rh-105  1 0 1-20 814  end
      pd-105  1 0 1-20 814  end
      pd-108  1 0 1-20 814  end
      ag-109  1 0 1-20 814  end
      sb-124  1 0 1-20 814  end
      xe-131  1 0 1-20 814  end
      xe-132  1 0 1-20 814  end
      xe-135  1 0 1-20 814  end
      xe-136  1 0 1-20 814  end
      cs-134  1 0 1-20 814  end
      cs-135  1 0 1-20 814  end
      cs-137  1 0 1-20 814  end
      ba-136  1 0 1-20 814  end
      la-139  1 0 1-20 814  end
      pr-141  1 0 1-20 814  end
      pr-143  1 0 1-20 814  end
      ce-144  1 0 1-20 814  end
      nd-143  1 0 1-20 814  end
      nd-145  1 0 1-20 814  end
      nd-147  1 0 1-20 814  end
      pm-147  1 0 1-20 814  end
      pm-148  1 0 1-20 814  end
      sm-147  1 0 1-20 814  end
      sm-149  1 0 1-20 814  end
      sm-150  1 0 1-20 814  end
      sm-151  1 0 1-20 814  end
      sm-152  1 0 1-20 814  end
      eu-153  1 0 1-20 814  end
      eu-154  1 0 1-20 814  end
      eu-155  1 0 1-20 814  end
      gd-155  1 0 1-20 814  end
      arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
                 40000 98.18 2 1.0 620   end
      h2o  3 den=0.7573  1  557 end
      arbm-bormod  0.7573 1 1 0 0 5000 100 3 330.8e-6  557  end
      '
      n     4 0 5-5 557  end
      arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
                 40000 98.18 5 1.0 557   end
      o     6 0 0.058 557  end
      al    6 0 0.039 557  end
      c     6 0 0.00107 557  end
      b-10  6 0 0.000859 557  end
      b-11  6 0 0.0034 557  end
      '
      '
      '  331 ppm boron (wt) in moderator
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '      fuel-pin-cell geometry:
      '
      squarepitch   1.4732  0.9639 1  3  1.1176  2  0.9754   0  end
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '    assembly and cycle parameters:
      '
      npin/assm=160 fuelngth=851.90 ncycles=4  nlib/cyc=5
      printlevel=5 lightel=9  inplevel=2 numztotal=6 end
      6 0.4775 4 0.4928 5 0.5588 3 0.8312 500 1.7190 3 1.7319
      power=18.705 burn=816.0  down=81     end
      power=19.534 burn=306.0  down=71  temkcyc=827   end
      power=13.672 burn=381.7  down=81.3  bfrac=1.419 temkcyc=736  end
      power=13.707 burn=466.0  down=2447  bfrac=1.523 temkcyc=736  end
        o 119   cr  5.2  mn  0.29
        fe 11.0 co 0.066 ni  8.7
        zr 195  nb  0.63 sn  3.2
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
1   sssssssssss       aaaaaaaaa       sssssssssss     22222222222    hh          hh
   sssssssssssss     aaaaaaaaaaa     sssssssssssss   2222222222222   hh          hh
   ss          ss   aa          aa   ss          ss  22          22   hh          hh
   ss               aa          aa   ss                          22   hh          hh
```



```
                                  ********************************************************************************
                                  ********************************************************************************
                                  ********************************************************************************
                                  *****                                                                        *****
                                  *****                  program verification information                     *****
                                  *****                                                                        *****
                                  *****                 code system:    scale  version:    4.3               *****
                                  *****                                                                        *****
                                  ********************************************************************************
                                  ********************************************************************************
                                  *****                                                                        *****
                                  *****                                                                        *****
                                  *****              program:  sas2                                            *****
                                  *****                                                                        *****
                                  *****        creation date:  03/07/97                                        *****
                                  *****                                                                        *****
                                  *****              library:  /opt/neut/Scale4.3/bin                          *****
                                  *****                                                                        *****
                                  *****                                                                        *****
                                  *****    this is not a   scale  configuration controlled code               *****
                                  *****                                                                        *****
                                  *****              jobname:  nichol                                          *****
                                  *****                                                                        *****
                                  *****    date of execution:  08/04/97                                        *****
                                  *****                                                                        *****
                                  *****    time of execution:  09:55:00                                        *****
                                  *****                                                                        *****
                                  *****                                                                        *****
                                  ********************************************************************************
                                  ********************************************************************************
                                  ********************************************************************************
1
0 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
0
0                                 nuclide concentrations, grams
                                  basis =single reactor assembly

             initial  1E-18 d
      o 16  1.19E+05  1.19E+05
   total    3.98E+05  3.98E+05
0                                 nuclide concentrations, grams
                                  basis =single reactor assembly

             initial  1E-18 d
      u234  1.94E+02  1.94E+02
      u235  2.16E+04  2.16E+04
```

u236	9.69E+01	9.69E+01
u238	8.59E+05	8.59E+05
total	8.81E+05	8.81E+05

0 basis =

0	initial	40.8 d	81.6 d	122.4 d	163.2 d	163.2 d
0	initial	40.8 d	81.6 d	122.4 d	163.2 d	163.2 d

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	407.8 d	815.7 d	1223.5 d	1631.3 d	2039.2 d	2447.0 d
o 16	1.19E+05	1.19E+05	1.19E+05	1.19E+05	1.19E+05	1.19E+05	1.19E+05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	407.8 d	815.7 d	1223.5 d	1631.3 d	2039.2 d	2447.0 d
mo 95	1.81E+01	1.93E+01	1.94E+01	1.94E+01	1.94E+01	1.94E+01	1.94E+01
tc 99	9.01E-05	9.07E-05	9.07E-05	9.07E-05	9.07E-05	9.07E-05	9.07E-05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	407.8 d	815.7 d	1223.5 d	1631.3 d	2039.2 d	2447.0 d
total	3.98E+05	3.98E+05	3.98E+05	3.98E+05	3.98E+05	3.98E+05	3.98E+05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	407.8 d	815.7 d	1223.5 d	1631.3 d	2039.2 d	2447.0 d
u233	1.16E-03	1.30E-03	1.44E-03	1.58E-03	1.73E-03	1.87E-03	2.01E-03
u234	9.83E+01	1.00E+02	1.02E+02	1.04E+02	1.05E+02	1.07E+02	1.09E+02
u235	3.29E+03	3.29E+03	3.29E+03	3.29E+03	3.29E+03	3.29E+03	3.29E+03
u236	3.05E+03	3.05E+03	3.05E+03	3.05E+03	3.05E+03	3.05E+03	3.05E+03
u238	8.33E+05	8.33E+05	8.33E+05	8.33E+05	8.33E+05	8.33E+05	8.33E+05
np237	3.62E+02	3.65E+02	3.65E+02	3.66E+02	3.66E+02	3.67E+02	3.67E+02
pu236	5.19E-04	3.98E-04	3.05E-04	2.33E-04	1.79E-04	1.37E-04	1.05E-04
pu238	1.91E+02	2.06E+02	2.07E+02	2.06E+02	2.04E+02	2.02E+02	2.00E+02
pu238	1.91E+02	2.06E+02	2.07E+02	2.06E+02	2.04E+02	2.02E+02	2.00E+02
pu239	3.35E+03	3.38E+03	3.38E+03	3.38E+03	3.38E+03	3.38E+03	3.38E+03
pu240	2.48E+03	2.48E+03	2.48E+03	2.48E+03	2.49E+03	2.49E+03	2.49E+03
pu241	1.10E+03	1.04E+03	9.86E+02	9.34E+02	8.85E+02	8.39E+02	7.95E+02
pu242	8.13E+02	8.13E+02	8.13E+02	8.13E+02	8.13E+02	8.13E+02	8.13E+02
am241	6.92E+01	1.27E+02	1.81E+02	2.33E+02	2.81E+02	3.27E+02	3.71E+02
am242m	1.41E+00	1.40E+00	1.39E+00	1.38E+00	1.37E+00	1.37E+00	1.36E+00
am243	1.83E+02	1.83E+02	1.83E+02	1.83E+02	1.83E+02	1.83E+02	1.83E+02
total	8.48E+05	8.48E+05	8.48E+05	8.48E+05	8.48E+05	8.48E+05	8.48E+05

0 element concentrations, grams
0 nuclide concentrations, grams
basis =single reactor assembly

	initial	407.8 d	815.7 d	1223.5 d	1631.3 d	2039.2 d	2447.0 d
mo 95	6.67E+02	7.07E+02	7.07E+02	7.07E+02	7.07E+02	7.07E+02	7.07E+02
tc 99	7.57E+02	7.59E+02	7.59E+02	7.59E+02	7.59E+02	7.59E+02	7.59E+02

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	407.8 d	815.7 d	1223.5 d	1631.3 d	2039.2 d	2447.0 d
ru101	7.63E+02	7.63E+02	7.63E+02	7.63E+02	7.63E+02	7.63E+02	7.63E+02
rh103	4.40E+02	4.61E+02	4.61E+02	4.61E+02	4.61E+02	4.61E+02	4.61E+02
ag109	1.07E+02	1.07E+02	1.07E+02	1.07E+02	1.07E+02	1.07E+02	1.07E+02

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	407.8 d	815.7 d	1223.5 d	1631.3 d	2039.2 d	2447.0 d
nd143	6.62E+02	6.70E+02	6.70E+02	6.70E+02	6.70E+02	6.70E+02	6.70E+02
nd145	6.27E+02	6.27E+02	6.27E+02	6.27E+02	6.27E+02	6.27E+02	6.27E+02
sm147	1.19E+02	1.50E+02	1.73E+02	1.90E+02	2.02E+02	2.12E+02	2.19E+02
sm149	1.14E+00	1.67E+00	1.67E+00	1.67E+00	1.67E+00	1.67E+00	1.67E+00
sm150	2.85E+02	2.85E+02	2.85E+02	2.85E+02	2.85E+02	2.85E+02	2.85E+02
sm151	1.17E+01	1.17E+01	1.16E+01	1.15E+01	1.14E+01	1.13E+01	1.12E+01
eu151	2.09E-02	1.22E-01	2.22E-01	3.22E-01	4.20E-01	5.18E-01	6.15E-01
sm152	1.32E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02	1.33E+02
eu153	1.28E+02	1.28E+02	1.28E+02	1.28E+02	1.28E+02	1.28E+02	1.28E+02

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	407.8 d	815.7 d	1223.5 d	1631.3 d	2039.2 d	2447.0 d
gd155	6.96E-02	9.14E-01	1.63E+00	2.24E+00	2.75E+00	3.19E+00	3.56E+00
total	3.33E+04	3.33E+04	3.33E+04	3.33E+04	3.33E+04	3.33E+04	3.33E+04

bt03g46.sum

```
0*****************************************************************************
 *                                                                           *
 *                    SCALE4.3  Bulletin  Board                              *
 *                    --------  --------  -----                              *
 *                                                                           *
 *                      Welcome to SCALE-4.3.                                *
 *                                                                           *
 *                                                                           *
 *****************************************************************************
1          primary module access and input record ( scale driver - 95/03/29 - 09:06:37 )
-   module sas2h    will be called
      calvert cliffs 1 pwr, bt03, rod nbd107, 161.21 cm 46.46gwd June 97
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '    mixtures of fuel-pin-unit-cell:
      '
      44group        latticecell
      uo2  1 den=10.054  1  887
         92234 0.022 92235 2.453 92236 0.011 92238 97.514   end
      kr-83  1 0 1-20 887  end
      kr-85  1 0 1-20 887  end
      y-89   1 0 1-20 887  end
      sr-90  1 0 1-20 887  end
      zr-93  1 0 1-20 887  end
      zr-94  1 0 1-20 887  end
      zr-95  1 0 1-20 887  end
      nb-94  1 0 1-20 887  end
      mo-95  1 0 1-20 887  end
      tc-99  1 0 1-20 887  end
      ru-101 1 0 1-20 887  end
      ru-106 1 0 1-20 887  end
      rh-103 1 0 1-20 887  end
      rh-105 1 0 1-20 887  end
      pd-105 1 0 1-20 887  end
      pd-108 1 0 1-20 887  end
      ag-109 1 0 1-20 887  end
      sb-124 1 0 1-20 887  end
      xe-131 1 0 1-20 887  end
      xe-132 1 0 1-20 887  end
      xe-135 1 0 1-20 887  end
      xe-136 1 0 1-20 887  end
      cs-134 1 0 1-20 887  end
      cs-135 1 0 1-20 887  end
      cs-137 1 0 1-20 887  end
      ba-136 1 0 1-20 887  end
      la-139 1 0 1-20 887  end
      pr-141 1 0 1-20 887  end
      pr-143 1 0 1-20 887  end
      ce-144 1 0 1-20 887  end
      nd-143 1 0 1-20 887  end
      nd-145 1 0 1-20 887  end
      nd-147 1 0 1-20 887  end
      pm-147 1 0 1-20 887  end
      pm-148 1 0 1-20 887  end
      sm-147 1 0 1-20 887  end
      sm-149 1 0 1-20 887  end
      sm-150 1 0 1-20 887  end
      sm-151 1 0 1-20 887  end
      sm-152 1 0 1-20 887  end
      eu-153 1 0 1-20 887  end
      eu-154 1 0 1-20 887  end
      eu-155 1 0 1-20 887  end
      gd-155 1 0 1-20 887  end
      arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
                 40000 98.18 2 1.0 620   end
      h2o  3 den=0.7342  1  570 end
      arbm-bormod  0.7342 1 1 0 0 5000 100 3 330.8e-6  570  end
      '
      '
      n     4 0 5-5 570  end
      arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
                 40000 98.18 5 1.0 570   end
      o     6 0 0.058 570  end
      al    6 0 0.039 570  end
      c     6 0 0.00107 570  end
      b-10  6 0 0.000859 570  end
      b-11  6 0 0.0034 570  end
      '
      '  331 ppm boron (wt) in moderator
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '      fuel-pin-cell geometry:
      '
      squarepitch   1.4732  0.9639 1  3  1.1176  2  0.9754   0  end
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '    assembly and cycle parameters:
      '
      npin/assm=160 fuelngth=851.90 ncycles=4  nlib/cyc=5
      printlevel=5 lightel=9  inplevel=2 numztotal=6 end
      6 0.4775 4 0.4928 5 0.5588 3 0.8312 500 1.7190 3 1.7319
      power=23.324 burn=816.0  down=81     end
      power=24.347 burn=306.0  down=71  temkcyc=903   end
      power=17.039 burn=381.7  down=81.3  bfrac=1.419 temkcyc=788  end
      power=17.092 burn=466.0  down=2447  bfrac=1.523 temkcyc=789  end
        o 119   cr  5.2  mn  0.29
        fe 11.0 co 0.066 ni  8.7
        zr 195  nb  0.63 sn  3.2
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
1   ssssssssss      aaaaaaaaa      sssssssssss     22222222222    hh         hh
   sssssssssssss    aaaaaaaaaaa    sssssssssssss   2222222222222  hh         hh
   ss         ss   aa         aa   ss         ss   22         22  hh         hh
   ss              aa         aa   ss                        22  hh         hh
```

```
   ss            aa          aa   ss                     22   hh          hh
   sssssssssss   aaaaaaaaaaaa     sssssssssss           22    hhhhhhhhhhhhh
    sssssssssss  aaaaaaaaaaaa      sssssssssss         22     hhhhhhhhhhhhh
             ss  aa          aa             ss        22      hh          hh
             ss  aa          aa             ss       22       hh          hh
   ss        ss  aa          aa   ss        ss      22        hh          hh
   sssssssssssss aa          aa   sssssssssssss     2222222222222  hh     hh
    sssssssssss  aa          aa    sssssssssss      2222222222222  hh     hh
0
   nn         nn iiiiiiiiiii    ccccccccccc   hh          hh   ooooooooooo   ll
   nnn        nn iiiiiiiiiii   cccccccccccc   hh          hh  ooooooooooooo  ll
   nnnn       nn      ii       cc        cc   hh          hh  oo         oo  ll
   nn nn      nn      ii       cc             hh          hh  oo         oo  ll
   nn  nn     nn      ii       cc             hh          hh  oo         oo  ll
   nn   nn    nn      ii       cc             hhhhhhhhhhhhh   oo         oo  ll
   nn    nn   nn      ii       cc             hhhhhhhhhhhhh   oo         oo  ll
   nn     nn  nn      ii       cc             hh          hh  oo         oo  ll
   nn      nn nn      ii       cc             hh          hh  oo         oo  ll
   nn       nnnn      ii       cc        cc   hh          hh  oo         oo  ll
   nn        nnn iiiiiiiiiii   cccccccccccc   hh          hh  ooooooooooooo  lllllllllllll
   nn         nn iiiiiiiiiii    ccccccccccc   hh          hh   ooooooooooo   lllllllllllll
0
     0000000      88888888888           //    0000000          44          //   99999999999   7777777777777
    000000000    8888888888888         //    000000000        444         //   9999999999999  777777777777
   00       00   88          88       //    00       00      4444        //    99         99  77        77
  00         00  88          88      //    00         00    44 44       //     99         99            77
  00         00  88          88     //     00         00   44  44      //      99         99           77
  00         00   88888888888      //      00         00  44   44     //       9999999999999          77
  00         00   88888888888     //       00         00 44    44    //         999999999999         77
  00         00  88          88  //        00         00 444444444444//                   99        77
  00         00  88          88 //         00         00 444444444444                     99       77
   00       00   88          88//           00       00        44  //                     99      77
    000000000    8888888888888 //            000000000         44 //        9999999999999        77
     0000000      88888888888 //              0000000          44//         999999999999         77
0
        11         0000000                    11       88888888888                  11            44
       111        000000000                  111      8888888888888                111           444
      1111       00       00     :::        1111      88         88     :::       1111          4444
        11       00       00     :::          11      88         88     :::         11         44 44
        11       00       00     :::          11      88         88     :::         11        44  44
        11       00       00                  11       88888888888                  11       44   44
        11       00       00                  11       88888888888                  11      44    44
        11       00       00     :::          11      88         88     :::         11     444444444444
        11       00       00     :::          11      88         88     :::         11     444444444444
        11       00       00     :::          11      88         88     :::         11              44
     11111111     000000000                11111111   8888888888888              11111111           44
     11111111      0000000                 11111111    88888888888               11111111           44
1
0                                 sssssssssss    ccccccccccc    aaaaaaaaa    ll            eeeeeeeeeeeee
                                 sssssssssssss  cccccccccccc   aaaaaaaaaaa   ll            eeeeeeeeeeeee
                                 ss         ss  cc        cc  aa         aa  ll            ee
                                 ss             cc            aa         aa  ll            ee
                                 ss             cc            aa         aa  ll            ee
                                 ssssssssssss   cc            aaaaaaaaaaaaa  ll            eeeeeeeeee
                                  ssssssssssss  cc            aaaaaaaaaaaaa  ll            eeeeeeeeee
                                            ss  cc            aa         aa  ll            ee
                                            ss  cc            aa         aa  ll            ee
                                 ss         ss  cc        cc  aa         aa  ll            ee
                                 sssssssssssss  cccccccccccc  aa         aa  lllllllllllll eeeeeeeeeeeee
                                  sssssssssss    ccccccccccc  aa         aa  lllllllllllll eeeeeeeeeeeee


                          *************************************************************************
                          *************************************************************************
                          *************************************************************************
                          *****                                                               *****
                          *****                 program verification information              *****
                          *****                                                               *****
                          *****                code system:    scale  version:    4.3         *****
                          *****                                                               *****
                          *************************************************************************
                          *************************************************************************
                          *****                                                               *****
                          *****                                                               *****
                          *****                    program:  sas2                             *****
                          *****                                                               *****
                          *****              creation date:  03/07/97                         *****
                          *****                                                               *****
                          *****                    library:  /opt/neut/Scale4.3/bin           *****
                          *****                                                               *****
                          *****                                                               *****
                          *****       this is not a   scale  configuration controlled code    *****
                          *****                                                               *****
                          *****                    jobname:  nichol                           *****
                          *****                                                               *****
                          *****          date of execution:  08/04/97                         *****
                          *****                                                               *****
                          *****          time of execution:  10:18:14                         *****
                          *****                                                               *****
                          *****                                                               *****
                          *************************************************************************
                          *************************************************************************
                          *************************************************************************
1
0 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
0
0                                            nuclide concentrations, grams
                                             basis =single reactor assembly
            initial   1E-18 d
   o 16    1.19E+05  1.19E+05
 total     3.98E+05  3.98E+05
0                                            nuclide concentrations, grams
                                             basis =single reactor assembly
            initial   1E-18 d
   u234    1.94E+02  1.94E+02
   u235    2.16E+04  2.16E+04
```

```
      u236    9.69E+01  9.69E+01
      u238    8.59E+05  8.59E+05
   total      8.81E+05  8.81E+05
0                                            basis =
0                    initial         40.8 d         81.6 d        122.4 d        163.2 d        163.2 d
0                    initial         40.8 d         81.6 d        122.4 d        163.2 d        163.2 d
0                                             nuclide concentrations, grams
                                              basis =single reactor assembly
            initial  407.8 d   815.7 d  1223.5 d  1631.3 d  2039.2 d  2447.0 d
      o 16    1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05  1.19E+05
0                                             nuclide concentrations, grams
                                              basis =single reactor assembly
            initial  407.8 d   815.7 d  1223.5 d  1631.3 d  2039.2 d  2447.0 d
     mo 95    2.32E+01  2.50E+01  2.50E+01  2.50E+01  2.50E+01  2.50E+01  2.50E+01
     tc 99    1.96E-04  1.98E-04  1.98E-04  1.98E-04  1.98E-04  1.98E-04  1.98E-04
0                                             nuclide concentrations, grams
                                              basis =single reactor assembly
            initial  407.8 d   815.7 d  1223.5 d  1631.3 d  2039.2 d  2447.0 d
   total      3.98E+05  3.98E+05  3.98E+05  3.98E+05  3.98E+05  3.98E+05  3.98E+05
0                                             nuclide concentrations, grams
                                              basis =single reactor assembly
            initial  407.8 d   815.7 d  1223.5 d  1631.3 d  2039.2 d  2447.0 d
      u233    1.11E-03  1.29E-03  1.46E-03  1.64E-03  1.81E-03  1.98E-03  2.16E-03
      u234    8.22E+01  8.47E+01  8.73E+01  8.99E+01  9.25E+01  9.51E+01  9.76E+01
      u235    1.95E+03  1.95E+03  1.95E+03  1.95E+03  1.95E+03  1.95E+03  1.95E+03
      u236    3.13E+03  3.13E+03  3.13E+03  3.13E+03  3.13E+03  3.13E+03  3.13E+03
      u238    8.25E+05  8.25E+05  8.25E+05  8.25E+05  8.25E+05  8.25E+05  8.25E+05
     np237    4.41E+02  4.46E+02  4.46E+02  4.46E+02  4.47E+02  4.47E+02  4.48E+02
     pu236    8.68E-04  6.66E-04  5.10E-04  3.90E-04  2.99E-04  2.29E-04  1.75E-04
     pu238    2.80E+02  2.99E+02  3.00E+02  2.98E+02  2.95E+02  2.93E+02  2.90E+02
     pu238    2.80E+02  2.99E+02  3.00E+02  2.98E+02  2.95E+02  2.93E+02  2.90E+02
     pu239    3.27E+03  3.32E+03  3.32E+03  3.32E+03  3.32E+03  3.32E+03  3.32E+03
     pu240    2.72E+03  2.72E+03  2.73E+03  2.73E+03  2.74E+03  2.74E+03  2.75E+03
     pu241    1.22E+03  1.15E+03  1.09E+03  1.04E+03  9.82E+02  9.30E+02  8.82E+02
     pu242    1.21E+03  1.21E+03  1.21E+03  1.21E+03  1.21E+03  1.21E+03  1.21E+03
     am241    6.17E+01  1.26E+02  1.86E+02  2.43E+02  2.97E+02  3.48E+02  3.96E+02
     am242m   1.32E+00  1.32E+00  1.31E+00  1.30E+00  1.29E+00  1.29E+00  1.28E+00
     am243    3.26E+02  3.26E+02  3.26E+02  3.26E+02  3.26E+02  3.26E+02  3.26E+02
   total      8.40E+05  8.40E+05  8.40E+05  8.40E+05  8.40E+05  8.40E+05  8.40E+05
0                                             element concentrations, grams
0                                             nuclide concentrations, grams
                                              basis =single reactor assembly
            initial  407.8 d   815.7 d  1223.5 d  1631.3 d  2039.2 d  2447.0 d
     mo 95    7.95E+02  8.42E+02  8.43E+02  8.43E+02  8.43E+02  8.43E+02  8.43E+02
     tc 99    9.03E+02  9.05E+02  9.05E+02  9.05E+02  9.05E+02  9.05E+02  9.05E+02
0                                             nuclide concentrations, grams
                                              basis =single reactor assembly
            initial  407.8 d   815.7 d  1223.5 d  1631.3 d  2039.2 d  2447.0 d
     ru101    9.42E+02  9.42E+02  9.42E+02  9.42E+02  9.42E+02  9.42E+02  9.42E+02
     rh103    4.99E+02  5.25E+02  5.25E+02  5.25E+02  5.25E+02  5.25E+02  5.25E+02
     ag109    1.38E+02  1.38E+02  1.38E+02  1.38E+02  1.38E+02  1.38E+02  1.38E+02
0                                             nuclide concentrations, grams
                                              basis =single reactor assembly
            initial  407.8 d   815.7 d  1223.5 d  1631.3 d  2039.2 d  2447.0 d
     nd143    7.14E+02  7.24E+02  7.24E+02  7.24E+02  7.24E+02  7.24E+02  7.24E+02
     nd145    7.36E+02  7.36E+02  7.36E+02  7.36E+02  7.36E+02  7.36E+02  7.36E+02
     sm147    1.21E+02  1.54E+02  1.79E+02  1.97E+02  2.11E+02  2.21E+02  2.28E+02
     sm149    1.20E+00  1.91E+00  1.91E+00  1.91E+00  1.91E+00  1.91E+00  1.91E+00
     sm150    3.67E+02  3.67E+02  3.67E+02  3.67E+02  3.67E+02  3.67E+02  3.67E+02
     sm151    1.40E+01  1.40E+01  1.39E+01  1.38E+01  1.37E+01  1.35E+01  1.34E+01
     eu151    1.90E-02  1.40E-01  2.60E-01  3.79E-01  4.97E-01  6.14E-01  7.30E-01
     sm152    1.56E+02  1.56E+02  1.56E+02  1.56E+02  1.56E+02  1.56E+02  1.56E+02
0                                             nuclide concentrations, grams
                                              basis =single reactor assembly
            initial  407.8 d   815.7 d  1223.5 d  1631.3 d  2039.2 d  2447.0 d
     eu153    1.66E+02  1.67E+02  1.67E+02  1.67E+02  1.67E+02  1.67E+02  1.67E+02
     gd155    8.14E-02  1.19E+00  2.12E+00  2.92E+00  3.59E+00  4.16E+00  4.64E+00
   total      4.14E+04  4.14E+04  4.14E+04  4.14E+04  4.14E+04  4.14E+04  4.14E+04
```