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Design Analysis Cover Sheet

Complete only applicable items.

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9. Lead Design Engineer	Dan Thomas	D. Thomas	09/02/97
10. Department Manager	Hugh Benton	Hugh A. Benton	9/2/97

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 come 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 Obrigheim 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 5.5).

4. Design Inputs

The sources for the design parameters are References 5.4 through 5.9. Reference 5.4 provides information on the molar masses; the assembly design, power history and operating parameters are obtained from References 5.5 through 5.7; cladding composition from Reference 5.8; and a list of trace elements in the fuel is derived from Reference 5.9.

4.1 Design Parameters

The molar masses of selected elements are obtained from Reference 5.4 and 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, (Reference 5.4)

General spent fuel characteristics for each test assembly are presented in Table 4-1 and include the initial ^{235}U enrichment, final burnup and the cooling time (Table 2, Reference 5.5). The initial enrichment of all assemblies is 3.13 wt% ^{235}U and the burnup ranges from 25.93 to 29.52 GWd/MTU. Reference 5.5 is unclear as to whether the measurements are corrected to the time of shutdown or discharge. However, since Table 32 in Reference 5.5 contains the measured data and states that concentrations are relative to the time of unloading, a cooling time consistent with the time of discharge is used. Unfortunately, the time between shutdown and discharge is unknown, therefore, a cooling time of 10 days is assumed. This is assumed since a longer decay period would not significantly effect the isotopic composition; however, a shorter decay period would effect isotopes that come in part from the decay of short lived parent isotopes (pp. 7 and 10, Reference 5.6). Most notable is the decay of ^{239}U ($T_{1/2}$ = 23.5 m) and ^{239}Np ($T_{1/2}$ = 2.35 d) to form ^{239}Pu, which increases by roughly 1% during the first 10 days (pp. 7 and 10, Reference 5.6). Therefore, the predicted concentration of ^{239}Pu relative to that which is measured, may be used as an indication as to whether the use of a 10 day cooling time is appropriate.

Assembly design parameters are presented in Table 4-2 (Table 13, Reference 5.5; Table 1, Reference 5.7). The assembly is a Siemens 14 x 14 with 16 guide tube positions that were empty throughout each of the three cycles of irradiation. A cross section of a Siemens 14 x 14 assembly is presented in Figure 4-1 (Section 2.1.7, Reference 5.8). The guide tube dimensions were unknown and therefore the dimensions for a guide tube from a Westinghouse 14 x 14 assembly were assumed (p. 13, Reference 5.5). Values for fuel pellet stack density, pellet diameter, and cladding inside and outside diameters are presented in Reference 5.5 while hot (i.e., in operating reactor.) However, the dimensions prior to irradiation are obtained from Reference 5.7 and used to maintain consistency in modeling from one reactor to the next. The initial enrichment of ^{234}U and ^{236}U are not known and

are approximated by: wt % ^{234}U = 0.0089 x ^{235}U %, and wt % ^{236}U = 0.0046 x ^{235}U wt % (p. 13, Reference 5.5).

Power histories for the core during the pertinent cycles of irradiation are presented in Table 4-3 (Table 2, Reference 5.7). The assemblies were irradiated for a total of 3 cycles during cycles 3, 4 and 6 and were not loaded during cycle 5. The zero load days from each of the three operating cycles are summed for each cycle and modeled as a total shutdown period subsequent to the cycle of irradiation. Consequently the sum of the full load days for a particular cycle is used as that cycle's burn time. It is expected that approximating the cycle length by summing the full load days will not significantly alter the isotopic concentrations because the relative number of zero load days to full load days is small.

The operating parameters in Table 4-4 include the cumulative burnups, specific powers and fuel temperatures for each assembly over the operating cycles (Table 15, Reference 5.5). Moderator temperature, density and boron concentration, as well as the fuel cladding temperature are also included in Table 4-4 (Table 13, Reference 5.7). The cumulative burnups and specific powers were based upon data reported by the reactor operating utility (p. 29, Reference 5.5). Fuel temperatures were derived from the fuel temperature versus rod power diagram, Figure 4-1, and the boron concentration was assumed to be 450 ppm (p. 5 and Figure 2, Reference 5.7).

The composition of the cladding, Zircaloy-4, is presented in Table 4-5, and has a density of 6.56 g/cm^3 (Reference 5.9). A list of trace elements in the fuel used in updating cross sections during the depletion analysis is presented in Table 4-6 and is developed with consideration of elements used in (Table 1, Reference 5.10). A generic set of light element weights for PWRs that is typically used in depletion analyses is included in Table 4-7 (Table 17, Reference 5.5). 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 Table 4-8 and are given in g/MTU (Table 32, Reference 5.5). The measurements were performed at the Karlsruhe Reprocessing Plant in Germany by cutting each assembly lengthwise and dissolving each half separately. The radiochemical analyses were performed independently by laboratories of the European Institute for Transuranic Elements, the Institute for Radiochemistry, the Karlsruhe Reprocessing Plant and the International Atomic Energy Agency, and are averaged to obtain the values in Table 4-8. Included in Table 4-9 is a listing of the measurement uncertainty for each of the isotopes examined (Table 8, Reference 5.7).

Table 4-1. Spent Fuel Characteristic Parameters for Obrigheim PWR

Test Assembly	Enrichment, wt % ^{235}U	Burnup, GWd/MTU	Cooling Time, days
168	3.13	28.40	10
170	3.13	25.93	10
171	3.13	29.04	10
172	3.13	26.54	10
176, batch 90	3.13	29.52	10
176, batch 91	3.13	27.99	10

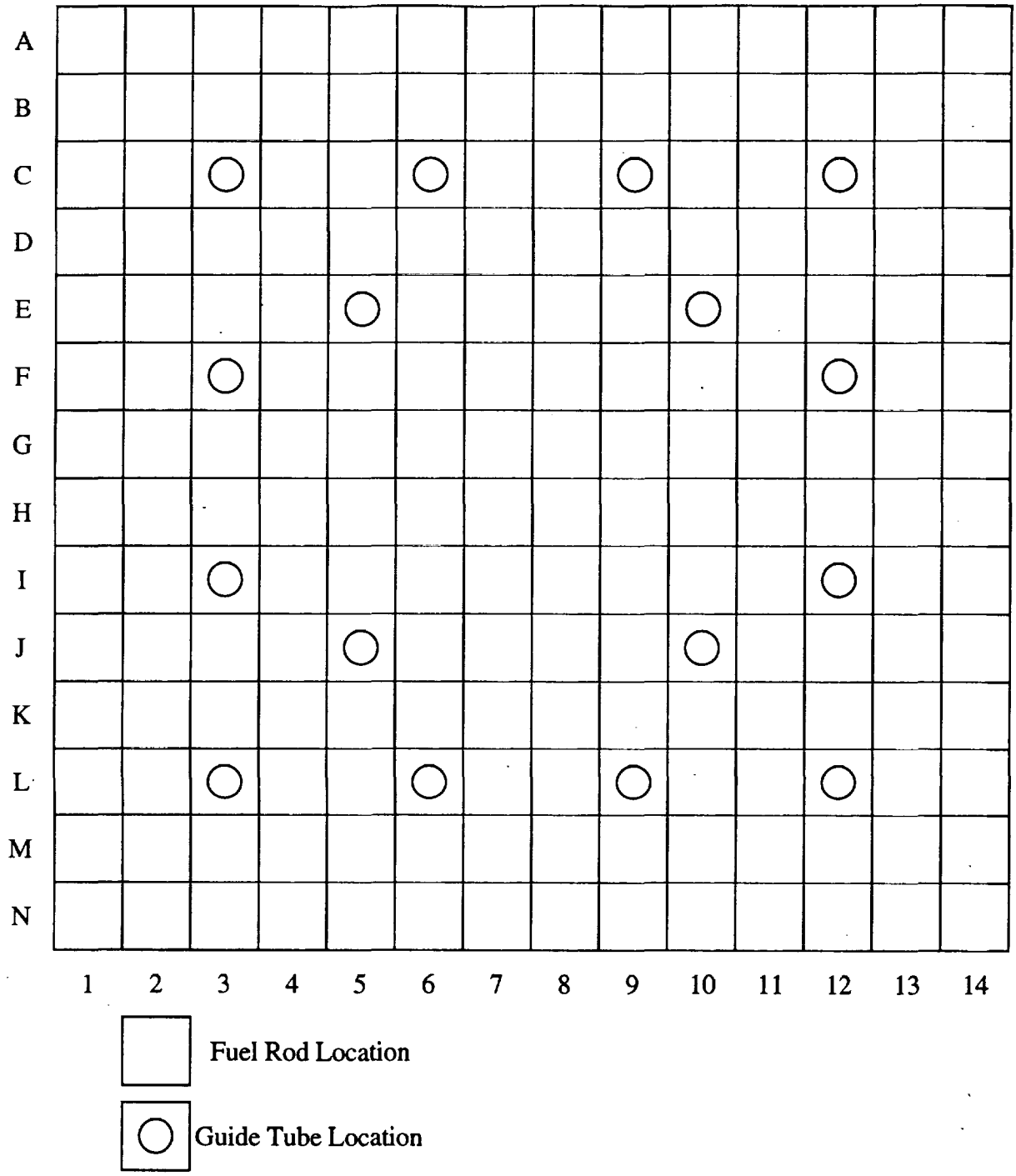
Reference 5.5

Table 4-2. Assembly Design Parameters for Obrigheim PWR

Parameter	Data
Assembly general data:	
Designer	Siemens
Lattice	14 x 14
Number of Fuel Rods	180
Number of Guide Tubes	16
Assembly Pitch, cm	20.12
Fuel Rod Data:	
Type of Fuel Pellet	UO_2
Enrichment,	
wt % ^{235}U	3.13
wt % ^{234}U	0.028
wt % ^{236}U	0.014
Pellet Stack Density, g/cm^3	10.05
Rod Pitch, cm	1.430
Rod Outside Diameter (OD), cm	1.074
Rod Inside Diameter (ID), cm	0.930
Pellet Diameter, cm	0.913
Active Fuel Length, cm	295.6
Clad Material	Zircaloy-4
Guide Tube Data:	
Inner Radius, cm	0.6413
Outer Radius, cm	0.6845
Tube Material	Zircaloy-4

References 5.5 and 5.7

Figure 4-1. Cross Section of Obrigheim Assembly



Reference 5.8

Table 4-3. Power History of Obrigheim PWR

Cycle 3, days	Operating Condition	Cycle 4, days	Operating Condition	Cycle 5, days	Operating Condition	Cycle 6, days	Operating Condition
4.9	FL[a]	124.2	FL	377	ZL	127.8	FL
2.4	ZL[b]	8.5	ZL			2.4	ZL
79.1	FL	90.1	FL			54.8	FL
3.7	ZL	2.4	ZL			1.2	ZL
18.3	FL	9.7	FL			65.7	FL
1.2	ZL	1.2	ZL				
12.2	FL	13.4	FL				
37.7	ZL	4.9	ZL				
136.5	FL	1.2	FL				
6.8	ZL	2.4	ZL				
37.0	FL	70.6	FL				
29.2	ZL						
Cycle Length, days							
369		328		377		252	
Uptime, days							
288		309		0		248	
Downtime, days							
81		19		377		4	

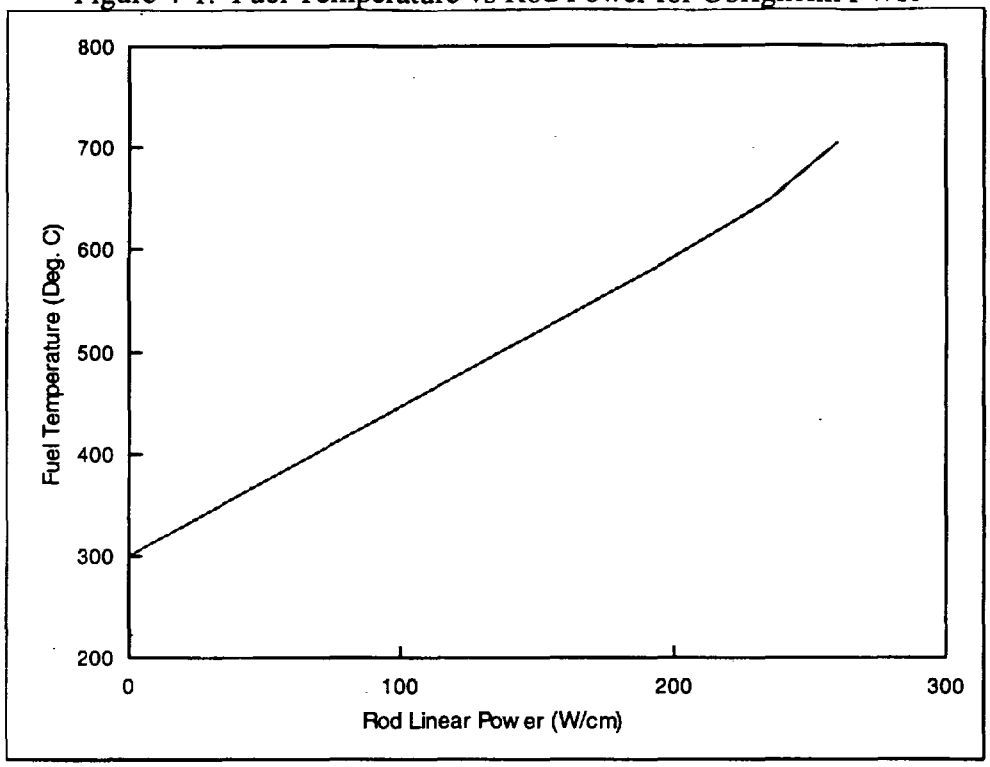
[a]Full Load
[b]Zero Load
Reference 5.7

Table 4-4. Operating Data for Obrigheim PWR

	Test Assembly	Batch	Cycle 3	Cycle 4	Cycle 5	Cycle 6
Cumulative Burnup, GWd/MTU	168	86	8.16	19.90	-	28.40
	170	94	6.03	17.61	-	25.93
	171	89	8.39	20.42	-	29.04
	172	92	10.03	17.77	-	26.54
	176	90	9.25	20.62	-	29.52
	176	91	8.77	19.55	-	27.99
Specific Power, MW/MTU	168	86	28.336	38.005	-	34.249
	170	94	20.929	37.468	-	33.564
	171	89	29.124	38.952	-	34.748
	172	92	34.883	25.035	-	35.374
	176	90	32.121	36.801	-	35.875
	176	91	30.457	34.894	-	34.016
Effective Fuel Temperature, K	168	86	807	895	-	860
	170	94	743	896	-	851
	171	89	813	905	-	865
	172	92	865	778	-	870
	176	90	840	883	-	875
	176	91	825	865	-	855
Water Temperature, K	all	all	572			
Water Density, g/cm^3	all	all	0.7283			
Soluble Boron, ppm	all	all	450			
Clad Temperature, K	all	all	605			

Reference 5.5

Figure 4-1. Fuel Temperature vs Rod Power for Obrigheim PWR



Reference 5.7

Table 4-5. 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/cm^3	

Reference 5.9

Table 4-6. 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 5.10

Table 4-7. Light Element Mass per Unit of Fuel for Typical PWR

Element	kg/MTU
O	135.0
Cr	5.9
Mn	0.33
Fe	13.0
Co	0.075
Ni	9.9
Zr	221.0
Nb	0.71
Sn	3.6

Reference 5.5

Table 4-8. Average Measured Isotopic Concentrations (g/MTU)

Batch	86	94	89	92	90	91
Assembly	168	170	171	172	176	176
Burnup, GWd/MTU	28.40	25.93	29.04	26.54	29.52	27.99
^{235}U	9680	10950	9580	10580	9180	9850
^{236}U	3730	3590	3750	3620	3810	3700
^{238}Pu	105.4	80.1	101.3	88.9	107.1	94.8
^{239}Pu	5013	4805	4957	4713	4943	4925
^{240}Pu	2020	1800	2000	1830	2040	1920
^{241}Pu	1103	978	1107	978	1128	1058
^{242}Pu	407	312	405	328	438	372

Reference 5.5

Table 4-9. Measurement Uncertainty

^{235}U	± 2 %
^{236}U	± 1 %
^{238}Pu	± 15 %
^{239}Pu	± 3 %
^{240}Pu	± 3 %
^{241}Pu	± 4 %
^{242}Pu	± 4 %

Reference 5.7

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 5.13) provides requirements for engineered barrier segment design. The Repository Design Requirements Document (RDRD, Reference 5.14) provides requirements

for repository design. The Controlled Design Assumptions Document (Reference 5.15) 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 Measured isotopic concentrations from Reference 5.5 are calculated and corrected to the time of discharge; however, the time between shutdown and discharge is not specified. Therefore, a cooling time of 10 days is assumed. The basis for this assumption is that a longer decay period does not significantly effect isotopic concentrations, but a shorter decay period effects concentrations of those isotopes with short lived parents. This assumption is used in Section 7.5.

4.3.2 The cycle average boron concentrations are assumed to be 450 ppm. The basis for this assumption is that the value is an average of typical cycle average boron concentrations, and was obtained from Reference 5.7. 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 *Validation of the Scale System for PWR Spent Fuel Isotopic Composition Analyses.* ORNL/TM-12667, Oak Ridge National Laboratory, March 1995.

5.6 *An Extension of the Validation of SCALE (SAS2H) Isotopic Predictions for PWR Spent Fuel*, ORNL/TM-13317, Oak Ridge National Laboratory, September 1996.

5.7 U. Hesse, *Verification of the OREST (HAMMER-ORIGEN) Depletion Program System Using Post-Irradiation Analyses of Fuel Assemblies 168, 170, 171, and 176 from the Obrigheim Reactor*, (ORNL-TR-88/20), GRS-A-962, Gesellschaft fur Reaktorscherheit (GRS) mbH, 1984.

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

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

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

5.11 *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.

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

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

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

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

6. Use of Computer Programs

A. Reference 5.11 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 assembly average measurements, and is used within the range of validation, as described in Reference 5.12, 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 Obrigheim assemblies 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 materials, geometry, and operating parameters 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 sectional 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 option 'parm=skipshipdata' is used so that a shipping cask shielding analysis is not performed. The title is arbitrary and should contain information that is assembly 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 with a density and isotopic weight percentages from Table 4-2. Fuel temperatures for the assemblies during each cycle are presented in Table 4-4 and the temperature during cycle 3 is input for the fuel temperature specification in data block 4. The other cycle fuel 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 4-6 and defined in the fuel mixture to have a concentration of 10^{-20} atoms/barn·cm.

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 4-5 and temperature given in Table 4-4.

The moderator temperature, density and boron concentration are given in Table 4-4 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 cycle average boron concentration, and a standard boron composition from the Standard Composition Library designated as 5000.

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 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 assemble contains 1 MTU, using the following equation:

$$Length = \frac{1}{\frac{\pi}{4}(POD)^2(PDen)(NFR)} * \frac{270 g UO_2}{238 g U} * \frac{10^6 g U}{1 MTU} \qquad \text{Equation 7-1}$$

Where:

Length = Length Required for an Assembly to Contain 1 MTU (cm)
POD = Fuel Pellet Diameter (cm)
PDen = Fuel Pellet Density (g UO_2/cm^3)
NFR = Number of Fuel Rods

Since measured isotopic concentrations are presented in grams of isotope per Metric Ton Uranium (MTU) and SCALE presents concentrations in grams of isotope per assembly, it is convenient to alter the length so that the assembly contains 1 MTU. 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 length for Obrigheim assemblies is 957.89 cm.

Each assembly was irradiated for three 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 4-5, while the number of zones are five which is determined by the Path B model described in Section 7.4.

7.4 SCALE Input Data Block 8

The Path B model for Obrigheim is a centralized guide tube unit cell surrounded by an homogenized fuel and moderator mixture that conserves the fuel to moderator volume ratio, and is further surrounded by moderator between assemblies. The equation below is used to determine the number of fuel unit cells that surround the central guide tube. 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 7-1, and the resulting Path B model dimensions are presented in Table 7-2.

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

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

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

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

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

Where:

x = Number of Unit Fuel Cells per Central 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 central guide tube is determined the geometry of the Path B model is calculated. Since the guide tube cell is centralized, the dimensions of the first two zones are the same as the guide tube inner and outer radii, these are presented in Table 7-2. The mixtures are moderator for zone 1 and zircaloy for zone 2.

The radius for the moderator surrounding the guide tube, but still within the guide tube cell, conserves volume and is calculated with the following equation:

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

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, respectively.

$$ARA=\pi(ORAR^2-IRAR^2) \qquad \text{Equation 7-8}$$

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 unit 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:

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

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:

$$R_5 = \sqrt{\frac{(x+1)}{\pi * NCell}[AP^2 - (NCell)(RP^2)] + R_4^2} \qquad \text{Equation 7-10}$$

Where:

R_5 = Radius of Moderator Surrounding Assembly Zone
Ncell = Number of Cells in Assembly
AP = Assembly Pitch

Table 7-1. Calculation of Fuel Unit Cell per Guide Tube Unit Cell

F/M	CUCMV, cm²	FV, cm²	MV, cm²	x
0.5018	1.8650	0.6547	1.1390	11.2500

Table 7-2. Path B Model Dimensions

	R_1	R_2	R_3	R_4	R_5
Radius, cm	0.6413	0.6845	0.8068	2.8238	2.8379
Composition	Moderator	Cladding	Moderator	Fuel/Moderator	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, length of downtime, fraction of boron and moderator density, and the temperature during the cycle may all be defined. The specific power is in units of MW/MTU while the irradiation period and length of downtime are both defined in days. Table 4-4 contains values for the specific powers and the resulting uptime and downtime for each cycle are presented in Table 7-3. The power used for the intervals is the same and equal to the power for cycle 1 from Table 4-4. The boron and moderator density fractions are not used in modeling the Obrigheim assemblies because data provided are not in sufficient detail to determine cycle specific values. The individual cycle temperatures are provided in Table 4-4, and are specified with the command 'temkcyc='.

Table 7-3. Cycle Irradiation Lengths and Downtime Between Cycles

	Cycle 3	Cycle 4	Cycle 5
Uptime, days	288	309	248
Downtime, days	81	396	10

Light elements and their effective weight, in kg per assembly, are entered in data block 10. Table 4-7 provides a generic set of light elements and their weights, in kg per MTU. Since the fuel length is altered so that there is 1 MTU per assembly the use of light elements with weights of kg per MTU 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 analyses. 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. The measured concentrations are given in Table 4-8, calculated concentrations in Table 7-4 and the percent differences are presented in Table 7-5.

In an attempt to determine the impact of the assumption of a cycle average boron concentration of 450 ppm for each cycle, a sensitivity analysis is performed. Two assemblies representing low and high burnups, 170 Batch 94 and 176 Batch 90, are used to observe the changes in isotopic concentrations with both a 100 ppm increase in boron concentration. The results are reported in Tables 7-5 and 7-6.

7.7 Results

SAS2H predicted isotopic concentrations are presented in Table 7-3. The calculated concentrations are obtained through the methodology described in Sections 7.1 through 7.5, with the input parameters defined in Section 4.1. Calculated concentrations are then compared with measured concentrations as described in Section 7.6 to determine the accuracy of the SAS2H module. Results of the comparison, in the form of measured percent differences, are presented in Table 7-4. Also the results of the sensitivity analysis are reported in Tables 7-5 and 7-6.

Table 7-3. Calculated Isotopic Concentrations (g/MTU)

Batch	86	94	89	92	90	91
Assembly	168	170	171	172	176	176
^{235}U	9.98E3	1.11E4	9.70E3	1.08E4	9.48E3	1.01E4
^{236}U	3.76E3	3.60E3	3.80E3	3.64E3	3.83E3	3.74E3
^{238}Pu	1.08E2	8.72E1	1.14E2	9.22E1	1.19E2	1.05E2
^{239}Pu	4.21E3	4.17E3	4.21E3	4.24E3	4.21E3	4.23E3
^{240}Pu	2.17E3	1.99E3	2.21E3	2.06E3	2.25E3	2.14E3
^{241}Pu	1.10E3	1.01E3	1.13E3	1.03E3	1.15E3	1.08E3
^{242}Pu	4.24E2	3.46E2	4.48E2	3.47E2	4.61E2	4.05E2

Table 7-4. Percent Difference Between Measured and Calculated [(C/M-1)*100]

Batch	86	94	89	92	90	91
Assembly	168	170	171	172	176	176
^{235}U	3.10	1.37	1.25	2.08	3.27	2.54
^{236}U	0.80	0.28	1.33	0.55	0.52	1.08
^{238}Pu	2.47	8.86	12.54	3.71	11.11	10.76
^{239}Pu	-16.02	-13.22	-15.07	-10.04	-14.83	-14.11
^{240}Pu	7.43	10.56	10.50	12.57	10.29	11.46
^{241}Pu	-0.27	3.27	2.08	5.32	1.95	2.08
^{242}Pu	4.18	10.90	10.62	5.79	5.25	8.87

Table 7-5. Sensitivity Analysis for Assembly 170 Batch 94

	Calculated Concentration, g/MTU		% Change in Calculated Concentrations
	Modeled Conditions	Boron Concentration Increase of 100 ppm	
^{235}U	1.11E4	1.12E4	0.90
^{236}U	3.60E3	3.60E3	0.00
^{238}Pu	8.72E1	8.80E1	0.92
^{239}Pu	4.17E3	4.21E3	0.96
^{240}Pu	1.99E3	2.00E3	0.50
^{241}Pu	1.01E3	1.01E3	0.00
^{242}Pu	3.46E2	3.47E2	0.29

Table 7-6. Sensitivity Analysis for Assembly 176 Batch 90

	Calculated Concentration, g/MTU		% Change in Calculated Concentrations
	Modeled Conditions	Boron Concentration Increase of 100 ppm	
^{235}U	9.48E3	9.54E3	0.63
^{236}U	3.83E3	3.83E3	0.00
^{238}Pu	1.19E2	1.20E2	0.84
^{239}Pu	4.21E3	4.26E3	1.19
^{240}Pu	2.25E3	2.25E3	0.00
^{241}Pu	1.15E3	1.16E3	0.87
^{242}Pu	4.61E2	4.61E2	0.00

8. Conclusions

The accuracy in which the SAS2H module is able to predict isotopic concentrations is indicated by the percent differences presented in Table 7-4. Inspection of such results reveals that the code consistently under- predicts the concentration of ^{239}Pu, while it consistently over-predicts the isotopes of ^{236}U, ^{238}Pu, ^{240}Pu, and ^{242}Pu. Percent differences from this analysis are compared with results from Reference 5.5, in which similar calculations were performed with a previous version of SCALE and the 27burnuplib cross section library. The concentrations calculated in Reference 5.5 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 model in Reference 5.5 and the model contained within, it is believed that the discrepancy between calculated concentrations for plutonium isotopes is caused by a change in the cross section library.

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 ^{235}U, ^{236}U, ^{238}Pu, and ^{241}Pu are either within or very close to the measurement uncertainties of ±2%, ±1%, ±15% and ±3%, respectively. However, such is not the case for the isotopes of ^{238}Pu, ^{240}Pu and ^{242}Pu, which deviate by more than the respective measurement uncertainties.

Results from the sensitivity analysis of the isotopic concentrations with boron concentration reveal that calculated isotopic concentrations increase by around 1% or less with a 100 ppm increase in boron concentration. Although, a slightly lower average boron concentration would improve calculated concentrations for most isotopes, it would also create a larger deviation for ^{239}Pu which already has some of the largest deviation. However, since the average boron concentration is not expected to deviate more than 250 ppm from the assumed value, it is expected that the assumption of an average boron concentration of 450 ppm does not significantly effect the calculated isotopic concentrations.

It is believed that the 10 day cooling time assumed does not adversely effect any isotopic concentrations since the concentration of ^{239}Pu is under-predicted and any longer cooling time would not significantly increase the concentration. However, if the concentration of ^{239}Pu were over-predicted then a shorter cooling time would seem to be more appropriate.

In general the SAS2H module of SCALE does well in predicting isotopic concentrations for Obrigheim assemblies, 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. Although the assumptions for the average boron concentration does effect the resulting isotopic concentrations, the effect is not significant enough to account for all variation between the 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 eight pages and contains the input files used in the modeling of the Obrigheim assemblies. 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.

ob168g28.input

```
=sas2h    parm=skipshipdata
obrighiem (kwo) pwr, assm 168, batch 86, 28.40 gwd/mtu 3-cyc  June 97
'    ....used 180 fuel rode, 16 guide tubes....,
'-------------------------------
'
'  mixtures of fuel-pin-unit-cell:
'
44group      latticecell
uo2  1 den=10.05  1  807
  92234 0.028 92235 3.13 92236 0.014 92238 96.828   end
kr-83  1 0 1-20 807  end
kr-85  1 0 1-20 807  end
y-89   1 0 1-20 807  end
sr-90  1 0 1-20 807  end
zr-93  1 0 1-20 807  end
zr-94  1 0 1-20 807  end
zr-95  1 0 1-20 807  end
nb-94  1 0 1-20 807  end
mo-95  1 0 1-20 807  end
tc-99  1 0 1-20 807  end
ru-101 1 0 1-20 807  end
ru-106 1 0 1-20 807  end
rh-103 1 0 1-20 807  end
rh-105 1 0 1-20 807  end
pd-105 1 0 1-20 807  end
pd-108 1 0 1-20 807  end
ag-109 1 0 1-20 807  end
sb-124 1 0 1-20 807  end
xe-131 1 0 1-20 807  end
xe-132 1 0 1-20 807  end
xe-135 1 0 1-20 807  end
xe-136 1 0 1-20 807  end
cs-134 1 0 1-20 807  end
cs-135 1 0 1-20 807  end
cs-137 1 0 1-20 807  end
ba-136 1 0 1-20 807  end
la-139 1 0 1-20 807  end
pr-141 1 0 1-20 807  end
pr-143 1 0 1-20 807  end
ce-144 1 0 1-20 807  end
nd-143 1 0 1-20 807  end
nd-145 1 0 1-20 807  end
nd-147 1 0 1-20 807  end
pm-147 1 0 1-20 807  end
pm-148 1 0 1-20 807  end
sm-147 1 0 1-20 807  end
sm-149 1 0 1-20 807  end
sm-150 1 0 1-20 807  end
sm-151 1 0 1-20 807  end
sm-152 1 0 1-20 807  end
eu-153 1 0 1-20 807  end
eu-154 1 0 1-20 807  end
eu-155 1 0 1-20 807  end
gd-155 1 0 1-20 807  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 1.0 605   end
h2o  3 den=0.7283 1  572  end
arbm-bormod  0.7283 1 1 0 0 5000 100 3 450.0e-6  572  end
'
'  450 ppm boron (wt) in moderator
'-------------------------------
end comp
'
'-------------------------------
'
'    fuel-pin-cell geometry:
'
squarepitch   1.43  0.913  1  3  1.074  2  0.930   0 end
'
'-------------------------------
'
'  assembly and cycle parameters:
'
npin/assm=180 fuelnght=957.89 ncycles=3  nlib/cyc=5

printlevel=5 lightel=9  inplevel=2  numztotal=5  end
3 0.6413 2 0.6845 3 0.8068 500 2.8238 3 2.8379

power=28.336 burn=288  down=81    end
power=38.005 burn=309  down=396  temkcyc=895  end

power=34.249 burn=248  down=10 temkcyc=860  end

 o 135  cr  5.9  mn  0.33
 fe 13  co 0.075 ni  9.9
 zr 221 nb  0.71 sn  3.6
'
'-------------------------------
'
end
```

ob170g25.input

```
=sas2h    parm=skipshipdata
obrighiem (kwo) pwr, assm 170, batch 94, 25.93 gwd/mtu 3-cyc June97
'   ....used 180 fuel rode, 16 guide tubes....
'------------------------------
'
'  mixtures of fuel-pin-unit-cell:
'
44group      latticecell
uo2  1 den=10.05  1  743
  92234 0.028 92235 3.13 92236 0.014 92238 96.828   end
kr-83  1 0 1-20 743  end
kr-85  1 0 1-20 743  end
y-89   1 0 1-20 743  end
sr-90  1 0 1-20 743  end
zr-93  1 0 1-20 743  end
zr-94  1 0 1-20 743  end
zr-95  1 0 1-20 743  end
nb-94  1 0 1-20 743  end
mo-95  1 0 1-20 743  end
tc-99  1 0 1-20 743  end
ru-101 1 0 1-20 743  end
ru-106 1 0 1-20 743  end
rh-103 1 0 1-20 743  end
rh-105 1 0 1-20 743  end
pd-105 1 0 1-20 743  end
pd-108 1 0 1-20 743  end
ag-109 1 0 1-20 743  end
sb-124 1 0 1-20 743  end
xe-131 1 0 1-20 743  end
xe-132 1 0 1-20 743  end
xe-135 1 0 1-20 743  end
xe-136 1 0 1-20 743  end
cs-134 1 0 1-20 743  end
cs-135 1 0 1-20 743  end
cs-137 1 0 1-20 743  end
ba-136 1 0 1-20 743  end
la-139 1 0 1-20 743  end
pr-141 1 0 1-20 743  end
pr-143 1 0 1-20 743  end
ce-144 1 0 1-20 743  end
nd-143 1 0 1-20 743  end
nd-145 1 0 1-20 743  end
nd-147 1 0 1-20 743  end
pm-147 1 0 1-20 743  end
pm-148 1 0 1-20 743  end
sm-147 1 0 1-20 743  end
sm-149 1 0 1-20 743  end
sm-150 1 0 1-20 743  end
sm-151 1 0 1-20 743  end
sm-152 1 0 1-20 743  end
eu-153 1 0 1-20 743  end
eu-154 1 0 1-20 743  end
eu-155 1 0 1-20 743  end
gd-155 1 0 1-20 743  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 1.0 605   end
h2o  3 den=0.7283 1  572  end
arbm-bormod  0.7283 1 1 0 0 5000 100 3 450.0e-6  572  end
'
'  450 ppm boron (wt) in moderator
'------------------------------
end comp
'
'------------------------------
'
'    fuel-pin-cell geometry:
'
squarepitch   1.43  0.913  1  3  1.074  2  0.930   0  end
'
'------------------------------
'
'   assembly and cycle parameters:
'
'
npin/assm=180 fuelnght=957.89 ncycles=3  nlib/cyc=5

printlevel=5 lightel=9  inplevel=2  numztotal=5  end
3 0.6413 2 0.6845 3 0.8068 500 2.8238 3 2.8379

power=20.929 burn=288  down=81    end

power=37.468 burn=309.0  down=396  temkcyc=896  end

power=33.564 burn=248.0  down=10  temkcyc=851  end

  o 135  cr  5.9  mn  0.33
  fe 13  co 0.075 ni  9.9
  zr 221 nb  0.71 sn  3.6
'
'------------------------------
'
end
```

ob171g29.input

```
=sas2h    parm=skipshipdata
obrighiem (kwo) pwr, assm 171, batch 89, 29.04 gwd/mtu 3-cyc June 97
'   ....used 180 fuel rode, 16 guide tubes....
'-------------------------------
'
'  mixtures of fuel-pin-unit-cell:
'
44group      latticecell
uo2  1 den=10.05  1  813
  92234 0.028 92235 3.13 92236 0.014 92238 96.828   end
kr-83  1 0 1-20 813  end
kr-85  1 0 1-20 813  end
y-89   1 0 1-20 813  end
sr-90  1 0 1-20 813  end
zr-93  1 0 1-20 813  end
zr-94  1 0 1-20 813  end
zr-95  1 0 1-20 813  end
nb-94  1 0 1-20 813  end
mo-95  1 0 1-20 813  end
tc-99  1 0 1-20 813  end
ru-101 1 0 1-20 813  end
ru-106 1 0 1-20 813  end
rh-103 1 0 1-20 813  end
rh-105 1 0 1-20 813  end
pd-105 1 0 1-20 813  end
pd-108 1 0 1-20 813  end
ag-109 1 0 1-20 813  end
sb-124 1 0 1-20 813  end
xe-131 1 0 1-20 813  end
xe-132 1 0 1-20 813  end
xe-135 1 0 1-20 813  end
xe-136 1 0 1-20 813  end
cs-134 1 0 1-20 813  end
cs-135 1 0 1-20 813  end
cs-137 1 0 1-20 813  end
ba-136 1 0 1-20 813  end
la-139 1 0 1-20 813  end
pr-141 1 0 1-20 813  end
pr-143 1 0 1-20 813  end
ce-144 1 0 1-20 813  end
nd-143 1 0 1-20 813  end
nd-145 1 0 1-20 813  end
nd-147 1 0 1-20 813  end
pm-147 1 0 1-20 813  end
pm-148 1 0 1-20 813  end
sm-147 1 0 1-20 813  end
sm-149 1 0 1-20 813  end
sm-150 1 0 1-20 813  end
sm-151 1 0 1-20 813  end
sm-152 1 0 1-20 813  end
eu-153 1 0 1-20 813  end
eu-154 1 0 1-20 813  end
eu-155 1 0 1-20 813  end
gd-155 1 0 1-20 813  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 1.0 605   end
h2o  3 den=0.7283 1  572  end
arbm-bormod  0.7283 1 1 0 0 5000 100 3 450.0e-6  572  end
'
'  450 ppm boron (wt) in moderator
'-------------------------------
end comp
'
'-------------------------------
'
'    fuel-pin-cell geometry:
'
squarepitch   1.43  0.913  1  3  1.074  2  0.930   0  end
'
'-------------------------------
'
'   assembly and cycle parameters:
'
npin/assm=180 fuelnght=957.89 ncycles=3  nlib/cyc=5

printlevel=5 lightel=9  inplevel=2  numztotal=5  end
3 0.6413 2 0.6845 3 0.8068 500 2.8238 3 2.8379
power=29.124 burn=288  down=81    end

power=38.952 burn=309.0  down=396  temkcyc=905  end

power=34.748 burn=248.0  down=10  temkcyc=865  end

 o 135  cr  5.9  mn  0.33
 fe 13  co 0.075 ni  9.9
 zr 221 nb  0.71 sn  3.6
'
'-------------------------------
'
end
```

ob172g26.input

```
=sas2h    parm=skipshipdata
obrighiem (kwo) pwr, assm 172, batch 92, 26.54 gwd/mtu 3-cyc June 97
'
'------------------------------
'
'  mixtures of fuel-pin-unit-cell:
'
44group      latticecell
uo2  1 den=10.05  1  865
  92234 0.028 92235 3.13 92236 0.014 92238 96.828   end
kr-83  1 0 1-20 865  end
kr-85  1 0 1-20 865  end
y-89   1 0 1-20 865  end
sr-90  1 0 1-20 865  end
zr-93  1 0 1-20 865  end
zr-94  1 0 1-20 865  end
zr-95  1 0 1-20 865  end
nb-94  1 0 1-20 865  end
mo-95  1 0 1-20 865  end
tc-99  1 0 1-20 865  end
ru-101 1 0 1-20 865  end
ru-106 1 0 1-20 865  end
rh-103 1 0 1-20 865  end
rh-105 1 0 1-20 865  end
pd-105 1 0 1-20 865  end
pd-108 1 0 1-20 865  end
ag-109 1 0 1-20 865  end
sb-124 1 0 1-20 865  end
xe-131 1 0 1-20 865  end
xe-132 1 0 1-20 865  end
xe-135 1 0 1-20 865  end
xe-136 1 0 1-20 865  end
cs-134 1 0 1-20 865  end
cs-135 1 0 1-20 865  end
cs-137 1 0 1-20 865  end
ba-136 1 0 1-20 865  end
la-139 1 0 1-20 865  end
pr-141 1 0 1-20 865  end
pr-143 1 0 1-20 865  end
ce-144 1 0 1-20 865  end
nd-143 1 0 1-20 865  end
nd-145 1 0 1-20 865  end
nd-147 1 0 1-20 865  end
pm-147 1 0 1-20 865  end
pm-148 1 0 1-20 865  end
sm-147 1 0 1-20 865  end
sm-149 1 0 1-20 865  end
sm-150 1 0 1-20 865  end
sm-151 1 0 1-20 865  end
sm-152 1 0 1-20 865  end
eu-153 1 0 1-20 865  end
eu-154 1 0 1-20 865  end
eu-155 1 0 1-20 865  end
gd-155 1 0 1-20 865  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 1.0 605   end
h2o  3 den=0.7283 1  572  end
arbm-bormod  0.7283 1 1 0 0 5000 100 3 450.0e-6  572  end
'
'  450 ppm boron (wt) in moderator
'------------------------------
end comp
'
'------------------------------
'
'    fuel-pin-cell geometry:
'
squarepitch   1.43  0.913  1  3  1.074  2  0.930   0  end
'
'------------------------------
'
'
'   assembly and cycle parameters:
'
npin/assm=180 fuelnght=957.89 ncycles=3  nlib/cyc=5

printlevel=5 lightel=9  inplevel=2  numztotal=5  end
3 0.6413 2 0.6845 3 0.8068 500 2.8238 3 2.8379
power=34.833 burn=288  down=81     end

power=25.035 burn=309.0  down=396  temkcyc=778  end

power=35.374 burn=248.0  down=10  temkcyc=870  end

  o 135  cr  5.9  mn  0.33
  fe 13  co 0.075 ni  9.9
  zr 221 nb  0.71 sn  3.6
'
'------------------------------
'
end
```

ob176g29.input

```
=sas2h    parm=skipshipdata
obrighiem (kwo) pwr, assm 176, batch 90, 29.52 gwd/mtu 3-cyc June 97
'
'------------------------------
'
'  mixtures of fuel-pin-unit-cell:
'
44group      latticecell
uo2  1 den=10.05  1  840
  92234 0.028 92235 3.13 92236 0.014 92238 96.828   end
kr-83  1 0 1-20 840  end
kr-85  1 0 1-20 840  end
y-89   1 0 1-20 840  end
sr-90  1 0 1-20 840  end
zr-93  1 0 1-20 840  end
zr-94  1 0 1-20 840  end
zr-95  1 0 1-20 840  end
nb-94  1 0 1-20 840  end
mo-95  1 0 1-20 840  end
tc-99  1 0 1-20 840  end
ru-101 1 0 1-20 840  end
ru-106 1 0 1-20 840  end
rh-103 1 0 1-20 840  end
rh-105 1 0 1-20 840  end
pd-105 1 0 1-20 840  end
pd-108 1 0 1-20 840  end
ag-109 1 0 1-20 840  end
sb-124 1 0 1-20 840  end
xe-131 1 0 1-20 840  end
xe-132 1 0 1-20 840  end
xe-135 1 0 1-20 840  end
xe-136 1 0 1-20 840  end
cs-134 1 0 1-20 840  end
cs-135 1 0 1-20 840  end
cs-137 1 0 1-20 840  end
ba-136 1 0 1-20 840  end
la-139 1 0 1-20 840  end
pr-141 1 0 1-20 840  end
pr-143 1 0 1-20 840  end
ce-144 1 0 1-20 840  end
nd-143 1 0 1-20 840  end
nd-145 1 0 1-20 840  end
nd-147 1 0 1-20 840  end
pm-147 1 0 1-20 840  end
pm-148 1 0 1-20 840  end
sm-147 1 0 1-20 840  end
sm-149 1 0 1-20 840  end
sm-150 1 0 1-20 840  end
sm-151 1 0 1-20 840  end
sm-152 1 0 1-20 840  end
eu-153 1 0 1-20 840  end
eu-154 1 0 1-20 840  end
eu-155 1 0 1-20 840  end
gd-155 1 0 1-20 840  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 1.0 605   end
h2o  3 den=0.7283 1  572  end
arbm-bormod  0.7283 1 1 0 0 5000 100 3 450.0e-6  572  end
'
'  450 ppm boron (wt) in moderator
'------------------------------
end comp
'
'------------------------------
'
'    fuel-pin-cell geometry:
'
squarepitch   1.43  0.913  1  3  1.074  2  0.930   0  end
'
'------------------------------
'
'
'    assembly and cycle parameters:
'
npin/assm=180 fuelnght=957.89 ncycles=3  nlib/cyc=5

printlevel=5 lightel=9  inplevel=2  numztotal=5  end
3 0.6413 2 0.6845 3 0.8068 500 2.8238 3 2.8379
power=32.121 burn=288  down=81    end

power=36.801 burn=309.0  down=396  temkcyc=883  end

power=35.875 burn=248.0  down=10  temkcyc=875  end

 o 135  cr  5.9  mn  0.33
 fe 13  co 0.075 ni  9.9
 zr 221 nb  0.71 sn  3.6
'
'------------------------------
'
end
```

ob176g27.input

```
=sas2h    parm=skipshipdata
obrighiem (kwo) pwr, assm 176, batch 91, 27.99 gwd/mtu 3-cyc June 97
'   ....used 180 fuel rode, 16 guide tubes....
'
'------------------------------
'
'  mixtures of fuel-pin-unit-cell:
'
44group      latticecell
uo2  1 den=10.05  1  825
  92234 0.028 92235 3.13 92236 0.014 92238 96.828   end
kr-83  1 0 1-20 825  end
kr-85  1 0 1-20 825  end
y-89   1 0 1-20 825  end
sr-90  1 0 1-20 825  end
zr-93  1 0 1-20 825  end
zr-94  1 0 1-20 825  end
zr-95  1 0 1-20 825  end
nb-94  1 0 1-20 825  end
mo-95  1 0 1-20 825  end
tc-99  1 0 1-20 825  end
ru-101 1 0 1-20 825  end
ru-106 1 0 1-20 825  end
rh-103 1 0 1-20 825  end
rh-105 1 0 1-20 825  end
pd-105 1 0 1-20 825  end
pd-108 1 0 1-20 825  end
ag-109 1 0 1-20 825  end
sb-124 1 0 1-20 825  end
xe-131 1 0 1-20 825  end
xe-132 1 0 1-20 825  end
xe-135 1 0 1-20 825  end
xe-136 1 0 1-20 825  end
cs-134 1 0 1-20 825  end
cs-135 1 0 1-20 825  end
cs-137 1 0 1-20 825  end
ba-136 1 0 1-20 825  end
la-139 1 0 1-20 825  end
pr-141 1 0 1-20 825  end
pr-143 1 0 1-20 825  end
ce-144 1 0 1-20 825  end
nd-143 1 0 1-20 825  end
nd-145 1 0 1-20 825  end
nd-147 1 0 1-20 825  end
pm-147 1 0 1-20 825  end
pm-148 1 0 1-20 825  end
sm-147 1 0 1-20 825  end
sm-149 1 0 1-20 825  end
sm-150 1 0 1-20 825  end
sm-151 1 0 1-20 825  end
sm-152 1 0 1-20 825  end
eu-153 1 0 1-20 825  end
eu-154 1 0 1-20 825  end
eu-155 1 0 1-20 825  end
gd-155 1 0 1-20 825  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 1.0 605   end
h2o  3 den=0.7283 1  572  end
arbm-bormod  0.7283 1 1 0 0 5000 100 3 450.0e-6  572  end
'
'  450 ppm boron (wt) in moderator
'------------------------------
end comp
'
'------------------------------
'
'    fuel-pin-cell geometry:
'
squarepitch   1.43  0.913  1  3  1.074  2  0.930   0  end
'
'------------------------------
'
'   assembly and cycle parameters:
'
npin/assm=180 fuelnght=957.89 ncycles=3  nlib/cyc=5

printlevel=5 lightel=9  inplevel=2  numztotal=5  end
3 0.6413 2 0.6845 3 0.8068 500 2.8238 3 2.8379
power=30.457 burn=288  down=81     end

power=34.894 burn=309.0  down=396  temkcyc=865  end

power=34.016 burn=248.0  down=10 temkcyc=855  end

  o 135  cr  5.9  mn  0.33
  fe 13  co 0.075 ni  9.9
  zr 221 nb  0.71 sn  3.6
'
'------------------------------
'
end
```

ob170g25plus100boron.input

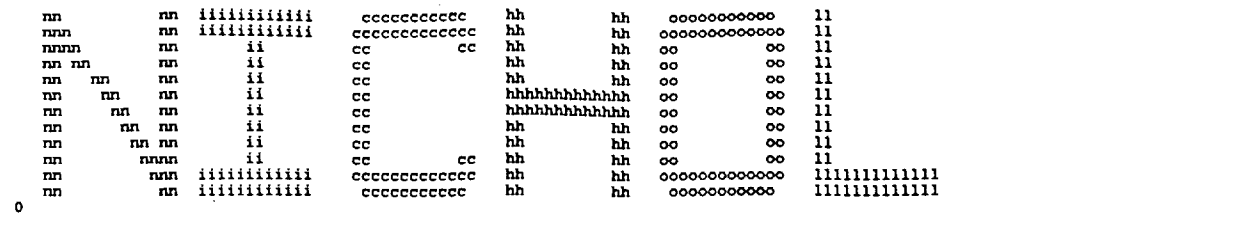
```
=sas2h    parm=skipshipdata
obrighiem (kwo) pwr, assm 170, batch 94, 25.93 gwd/mtu 3-cyc June97
'   ....used 180 fuel rode, 16 guide tubes....
'------------------------------
'
'  mixtures of fuel-pin-unit-cell:
'
44group      latticecell
uo2  1 den=10.05  1  743
  92234 0.028 92235 3.13 92236 0.014 92238 96.828   end
kr-83  1 0 1-20 743  end
kr-85  1 0 1-20 743  end
y-89   1 0 1-20 743  end
sr-90  1 0 1-20 743  end
zr-93  1 0 1-20 743  end
zr-94  1 0 1-20 743  end
zr-95  1 0 1-20 743  end
nb-94  1 0 1-20 743  end
mo-95  1 0 1-20 743  end
tc-99  1 0 1-20 743  end
ru-101 1 0 1-20 743  end
ru-106 1 0 1-20 743  end
rh-103 1 0 1-20 743  end
rh-105 1 0 1-20 743  end
pd-105 1 0 1-20 743  end
pd-108 1 0 1-20 743  end
ag-109 1 0 1-20 743  end
sb-124 1 0 1-20 743  end
xe-131 1 0 1-20 743  end
xe-132 1 0 1-20 743  end
xe-135 1 0 1-20 743  end
xe-136 1 0 1-20 743  end
cs-134 1 0 1-20 743  end
cs-135 1 0 1-20 743  end
cs-137 1 0 1-20 743  end
ba-136 1 0 1-20 743  end
la-139 1 0 1-20 743  end
pr-141 1 0 1-20 743  end
pr-143 1 0 1-20 743  end
ce-144 1 0 1-20 743  end
nd-143 1 0 1-20 743  end
nd-145 1 0 1-20 743  end
nd-147 1 0 1-20 743  end
pm-147 1 0 1-20 743  end
pm-148 1 0 1-20 743  end
sm-147 1 0 1-20 743  end
sm-149 1 0 1-20 743  end
sm-150 1 0 1-20 743  end
sm-151 1 0 1-20 743  end
sm-152 1 0 1-20 743  end
eu-153 1 0 1-20 743  end
eu-154 1 0 1-20 743  end
eu-155 1 0 1-20 743  end
gd-155 1 0 1-20 743  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 1.0 605   end
h2o  3 den=0.7283 1  572  end
arbm-bormod  0.7283 1 1 0 0 5000 100 3 550.0e-6  572  end
'
'  550 ppm boron (wt) in moderator
'------------------------------
end comp
'
'------------------------------
'
'    fuel-pin-cell geometry:
'
squarepitch   1.43  0.913  1  3  1.074  2  0.930   0 end
'
'------------------------------
'
'   assembly and cycle parameters:
'
npin/assm=180 fuelnght=957.89 ncycles=3  nlib/cyc=5

printlevel=5 lightel=9  inplevel=2  numztotal=5  end
3 0.6413 2 0.6845 3 0.8068 500 2.8238 3 2.8379

power=20.929 burn=288  down=81    end

power=37.468 burn=309.0  down=396  temkcyc=896  end

power=33.564 burn=248.0  down=10  temkcyc=851  end

  o 135  cr  5.9  mn  0.33
  fe 13  co 0.075 ni  9.9
  zr 221 nb  0.71 sn  3.6
'
'------------------------------
'
end
```

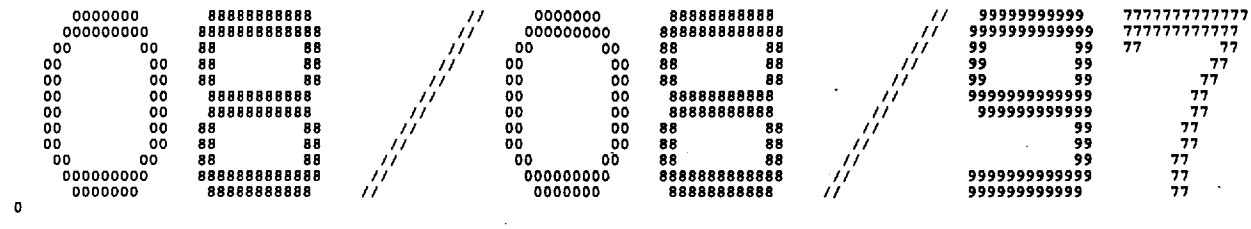
ob176g29plus100boron.input

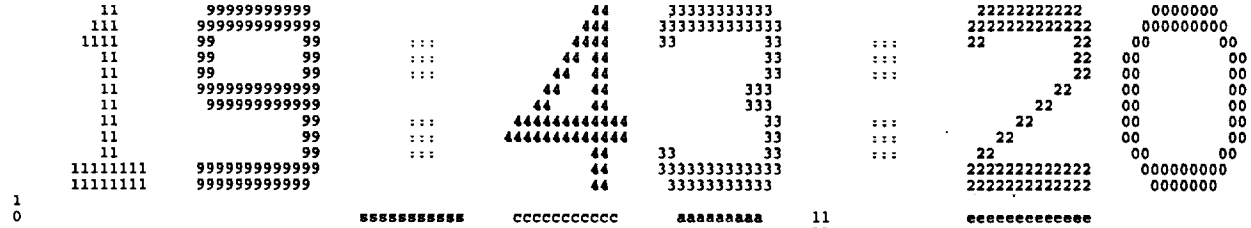
```
=sas2h    parm=skipshipdata
obrighiem (kwo) pwr, assm 176, batch 90, 29.52 gwd/mtu 3-cyc June 97
'
'------------------------------
'
'  mixtures of fuel-pin-unit-cell:
'
44group      latticecell
uo2  1 den=10.05  1  840
  92234 0.028 92235 3.13 92236 0.014 92238 96.828   end
kr-83  1 0 1-20 840  end
kr-85  1 0 1-20 840  end
y-89   1 0 1-20 840  end
sr-90  1 0 1-20 840  end
zr-93  1 0 1-20 840  end
zr-94  1 0 1-20 840  end
zr-95  1 0 1-20 840  end
nb-94  1 0 1-20 840  end
mo-95  1 0 1-20 840  end
tc-99  1 0 1-20 840  end
ru-101 1 0 1-20 840  end
ru-106 1 0 1-20 840  end
rh-103 1 0 1-20 840  end
rh-105 1 0 1-20 840  end
pd-105 1 0 1-20 840  end
pd-108 1 0 1-20 840  end
ag-109 1 0 1-20 840  end
sb-124 1 0 1-20 840  end
xe-131 1 0 1-20 840  end
xe-132 1 0 1-20 840  end
xe-135 1 0 1-20 840  end
xe-136 1 0 1-20 840  end
cs-134 1 0 1-20 840  end
cs-135 1 0 1-20 840  end
cs-137 1 0 1-20 840  end
ba-136 1 0 1-20 840  end
la-139 1 0 1-20 840  end
pr-141 1 0 1-20 840  end
pr-143 1 0 1-20 840  end
ce-144 1 0 1-20 840  end
nd-143 1 0 1-20 840  end
nd-145 1 0 1-20 840  end
nd-147 1 0 1-20 840  end
pm-147 1 0 1-20 840  end
pm-148 1 0 1-20 840  end
sm-147 1 0 1-20 840  end
sm-149 1 0 1-20 840  end
sm-150 1 0 1-20 840  end
sm-151 1 0 1-20 840  end
sm-152 1 0 1-20 840  end
eu-153 1 0 1-20 840  end
eu-154 1 0 1-20 840  end
eu-155 1 0 1-20 840  end
gd-155 1 0 1-20 840  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 1.0 605   end
h2o  3 den=0.7283 1  572  end
arbm-bormod  0.7283 1 1 0 0 5000 100 3 550.0e-6  572  end
'
'  550 ppm boron (wt) in moderator
'------------------------------
end comp
'
'------------------------------
'
'    fuel-pin-cell geometry:
'
squarepitch   1.43  0.913  1  3  1.074  2  0.930   0 end
'
'------------------------------
'
'   assembly and cycle parameters:
'
npin/assm=180 fuelnght=957.89 ncycles=3  nlib/cyc=5

printlevel=5 lightel=9  inplevel=2  numztotal=5  end
3 0.6413 2 0.6845 3 0.8068 500 2.8238 3 2.8379
power=32.121 burn=288 down=81     end

power=36.801 burn=309.0  down=396  temkcyc=883  end

power=35.875 burn=248.0  down=10  temkcyc=875  end

  o 135  cr  5.9  mn  0.33
  fe 13  co 0.075 ni  9.9
  zr 221 nb  0.71 sn  3.6
'
'------------------------------
'
end
```

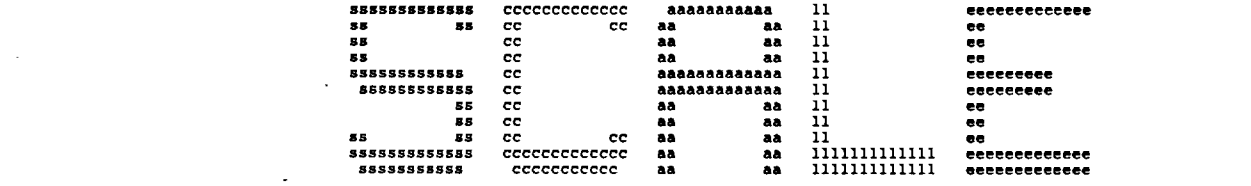
ob168g28.sum

```
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
      obrighiem (kwo) pwr, assm 168, batch 86, 28.40 gwd/mtu 3-cyc  June 97
      '     ....used 180 fuel rode, 16 guide tubes....,
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '   mixtures of fuel-pin-unit-cell:
      '
      44group        latticecell
      uo2  1 den=10.05  1  807
         92234 0.028 92235 3.13 92236 0.014 92238 96.828   end
      kr-83  1 0 1-20 807  end
      kr-85  1 0 1-20 807  end
      y-89   1 0 1-20 807  end
      sr-90  1 0 1-20 807  end
      zr-93  1 0 1-20 807  end
      zr-94  1 0 1-20 807  end
      zr-95  1 0 1-20 807  end
      nb-94  1 0 1-20 807  end
      mo-95  1 0 1-20 807  end
      tc-99  1 0 1-20 807  end
      ru-101 1 0 1-20 807  end
      ru-106 1 0 1-20 807  end
      rh-103 1 0 1-20 807  end
      rh-105 1 0 1-20 807  end
      pd-105 1 0 1-20 807  end
      pd-108 1 0 1-20 807  end
      ag-109 1 0 1-20 807  end
      sb-124 1 0 1-20 807  end
      xe-131 1 0 1-20 807  end
      xe-132 1 0 1-20 807  end
      xe-135 1 0 1-20 807  end
      xe-136 1 0 1-20 807  end
      cs-134 1 0 1-20 807  end
      cs-135 1 0 1-20 807  end
      cs-137 1 0 1-20 807  end
      ba-136 1 0 1-20 807  end
      la-139 1 0 1-20 807  end
      pr-141 1 0 1-20 807  end
      pr-143 1 0 1-20 807  end
      ce-144 1 0 1-20 807  end
      nd-143 1 0 1-20 807  end
      nd-145 1 0 1-20 807  end
      nd-147 1 0 1-20 807  end
      pm-147 1 0 1-20 807  end
      pm-148 1 0 1-20 807  end
      sm-147 1 0 1-20 807  end
      sm-149 1 0 1-20 807  end
      sm-150 1 0 1-20 807  end
      sm-151 1 0 1-20 807  end
      sm-152 1 0 1-20 807  end
      eu-153 1 0 1-20 807  end
      eu-154 1 0 1-20 807  end
      eu-155 1 0 1-20 807  end
      gd-155 1 0 1-20 807  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 1.0 605   end
      h2o  3 den=0.7283 1  572  end
      arbm-bormod  0.7283 1 1 0 0 5000 100 3.450.0e-6  572  end
      '
      '  450 ppm boron (wt) in moderator
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '      fuel-pin-cell geometry:
      '
      squarepitch   1.43  0.913  1  3  1.074  2  0.930   0  end
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '    assembly and cycle parameters:
      '
      npin/assm=180 fuelnght=957.89 ncycles=3  nlib/cyc=5
      printlevel=5 lightel=9  inplevel=2  numztotal=5  end
      3 0.6413 2 0.6845 3 0.8068 500 2.8238 3 2.8379 ,
      power=28.336 burn=288  down=81     end
      power=38.005 burn=309  down=396  temkcyc=895  end
      power=34.249 burn=248  down=10 temkcyc=860  end
        o 135  cr  5.9  mn  0.33
        fe 13  co 0.075 ni  9.9
        zr 221 nb  0.71 sn  3.6
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
1   sssssssssss      aaaaaaaaa      ssssssssssss     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
```









```
1
0
                                        ******************************************************************************
                                        ******************************************************************************
                                        ******************************************************************************
                                        *****                                                                      *****
                                        *****                  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:  19:43:20                                      *****
                                        *****                                                                      *****
                                        *****                                                                      *****
                                        ******************************************************************************
                                        ******************************************************************************
                                        ******************************************************************************
1
0'    ....used 180 fuel rode, 16 guide tubes....,
0' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
0'
0                                       nuclide concentrations, grams
                                        basis =single reactor assembly
             initial  1E-18 d
     o 16   1.35E+05  1.35E+05
   total    3.90E+05  3.90E+05
0                                       nuclide concentrations, grams
                                        basis =single reactor assembly
             initial  1E-18 d
     u234   2.80E+02  2.80E+02
     u235   3.13E+04  3.13E+04
     u236   1.40E+02  1.40E+02
     u238   9.68E+05  9.68E+05
   total    1.00E+06  1.00E+06
0                                      basis =
0                  initial        14.4 d        28.8 d        43.2 d        57.6 d        57.6 d
0                  initial        14.4 d        28.8 d        43.2 d        57.6 d        57.6 d
0                                       nuclide concentrations, grams
                                        basis =single reactor assembly
             initial    1.7 d     3.3 d     5.0 d     6.7 d     8.3 d    10.0 d
```

o 16	1.35E+05	1.35E+05	1.35E+05	1.35E+05	1.35E+05	1.35E+05	1.35E+05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
mo 95	1.22E+01	1.22E+01	1.22E+01	1.23E+01	1.23E+01	1.23E+01	1.24E+01
tc 99	3.13E-05	3.15E-05	3.16E-05	3.17E-05	3.18E-05	3.18E-05	3.18E-05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
total	3.90E+05	3.90E+05	3.90E+05	3.90E+05	3.90E+05	3.90E+05	3.90E+05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
u233	1.77E-03	1.77E-03	1.77E-03	1.77E-03	1.77E-03	1.77E-03	1.77E-03
u234	1.80E+02	1.80E+02	1.80E+02	1.80E+02	1.80E+02	1.80E+02	1.80E+02
u235	9.98E+03	9.98E+03	9.98E+03	9.98E+03	9.98E+03	9.98E+03	9.98E+03
u236	3.76E+03	3.76E+03	3.76E+03	3.76E+03	3.76E+03	3.76E+03	3.76E+03
u238	9.48E+05	9.48E+05	9.48E+05	9.48E+05	9.48E+05	9.48E+05	9.48E+05
np237	3.32E+02	3.33E+02	3.34E+02	3.35E+02	3.36E+02	3.37E+02	3.37E+02
pu236	4.03E-04	4.04E-04	4.04E-04	4.03E-04	4.03E-04	4.03E-04	4.02E-04
pu238	1.07E+02	1.07E+02	1.08E+02	1.08E+02	1.08E+02	1.08E+02	1.08E+02
pu238	1.07E+02	1.07E+02	1.08E+02	1.08E+02	1.08E+02	1.08E+02	1.08E+02
pu239	4.13E+03	4.16E+03	4.18E+03	4.19E+03	4.20E+03	4.21E+03	4.21E+03
pu240	2.17E+03	2.17E+03	2.17E+03	2.17E+03	2.17E+03	2.17E+03	2.17E+03
pu241	1.10E+03	1.10E+03	1.10E+03	1.10E+03	1.10E+03	1.10E+03	1.10E+03
pu242	4.24E+02	4.24E+02	4.24E+02	4.24E+02	4.24E+02	4.24E+02	4.24E+02
am241	4.17E+01	4.19E+01	4.22E+01	4.24E+01	4.27E+01	4.29E+01	4.31E+01
am242m	1.04E+00	1.04E+00	1.04E+00	1.04E+00	1.04E+00	1.04E+00	1.04E+00
am243	7.33E+01	7.34E+01	7.34E+01	7.34E+01	7.34E+01	7.34E+01	7.34E+01
total	9.70E+05	9.70E+05	9.70E+05	9.70E+05	9.70E+05	9.70E+05	9.70E+05

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

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
mo 95	5.66E+02	5.67E+02	5.68E+02	5.69E+02	5.70E+02	5.71E+02	5.73E+02
tc 99	6.98E+02	6.99E+02	7.00E+02	7.01E+02	7.01E+02	7.02E+02	7.02E+02
tc 99m	2.89E-01	2.07E-01	1.36E-01	8.92E-02	5.86E-02	3.85E-02	2.53E-02
ru101	6.63E+02	6.63E+02	6.63E+02	6.63E+02	6.63E+02	6.63E+02	6.63E+02
rh103	3.84E+02	3.85E+02	3.86E+02	3.87E+02	3.89E+02	3.90E+02	3.91E+02
rh103m	4.46E-02	4.33E-02	4.20E-02	4.08E-02	3.96E-02	3.85E-02	3.74E-02
ag109	7.53E+01	7.55E+01	7.55E+01	7.55E+01	7.55E+01	7.55E+01	7.55E+01

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
nd143	7.18E+02	7.20E+02	7.22E+02	7.23E+02	7.25E+02	7.26E+02	7.27E+02
nd145	5.95E+02	5.95E+02	5.95E+02	5.95E+02	5.95E+02	5.95E+02	5.95E+02
sm147	8.84E+01	8.86E+01	8.88E+01	8.90E+01	8.92E+01	8.94E+01	8.96E+01

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
sm149	2.22E+00	2.76E+00	3.08E+00	3.27E+00	3.38E+00	3.45E+00	3.49E+00
sm150	2.49E+02	2.49E+02	2.49E+02	2.49E+02	2.49E+02	2.49E+02	2.49E+02
sm151	1.58E+01	1.60E+01	1.60E+01	1.61E+01	1.61E+01	1.61E+01	1.61E+01
eu151	1.88E-02	1.94E-02	1.99E-02	2.05E-02	2.10E-02	2.16E-02	2.22E-02
sm152	1.16E+02	1.16E+02	1.16E+02	1.16E+02	1.16E+02	1.16E+02	1.16E+02
eu153	9.42E+01	9.46E+01	9.48E+01	9.49E+01	9.50E+01	9.50E+01	9.50E+01
gd155	3.49E-02	3.74E-02	3.99E-02	4.23E-02	4.48E-02	4.73E-02	4.97E-02
total	2.91E+04	2.91E+04	2.91E+04	2.91E+04	2.91E+04	2.91E+04	2.91E+04

ob170g25.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
      obrighiem (kwo) pwr, assm 170, batch 94, 25.93 gwd/mtu 3-cyc June97
      '     ....used 180 fuel rode, 16 guide tubes....
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '   mixtures of fuel-pin-unit-cell:
      '
      44group       latticecell
      uo2  1 den=10.05  1  743
         92234 0.028 92235 3.13 92236 0.014 92238 96.828   end
      kr-83  1 0 1-20 743  end
      kr-85  1 0 1-20 743  end
      y-89   1 0 1-20 743  end
      sr-90  1 0 1-20 743  end
      zr-93  1 0 1-20 743  end
      zr-94  1 0 1-20 743  end
      zr-95  1 0 1-20 743  end
      nb-94  1 0 1-20 743  end
      mo-95  1 0 1-20 743  end
      tc-99  1 0 1-20 743  end
      ru-101 1 0 1-20 743  end
      ru-106 1 0 1-20 743  end
      rh-103 1 0 1-20 743  end
      rh-105 1 0 1-20 743  end
      pd-105 1 0 1-20 743  end
      pd-108 1 0 1-20 743  end
      ag-109 1 0 1-20 743  end
      sb-124 1 0 1-20 743  end
      xe-131 1 0 1-20 743  end
      xe-132 1 0 1-20 743  end
      xe-135 1 0 1-20 743  end
      xe-136 1 0 1-20 743  end
      cs-134 1 0 1-20 743  end
      cs-135 1 0 1-20 743  end
      cs-137 1 0 1-20 743  end
      ba-136 1 0 1-20 743  end
      la-139 1 0 1-20 743  end
      pr-141 1 0 1-20 743  end
      pr-143 1 0 1-20 743  end
      ce-144 1 0 1-20 743  end
      nd-143 1 0 1-20 743  end
      nd-145 1 0 1-20 743  end
      nd-147 1 0 1-20 743  end
      pm-147 1 0 1-20 743  end
      pm-148 1 0 1-20 743  end
      sm-147 1 0 1-20 743  end
      sm-149 1 0 1-20 743  end
      sm-150 1 0 1-20 743  end
      sm-151 1 0 1-20 743  end
      sm-152 1 0 1-20 743  end
      eu-153 1 0 1-20 743  end
      eu-154 1 0 1-20 743  end
      eu-155 1 0 1-20 743  end
      gd-155 1 0 1-20 743  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 1.0 605   end
      h2o  3 den=0.7283 1  572  end
      arbm-bormod  0.7283 1 1 0 0 5000 100 3 450.0e-6  572  end
      '
      '  450 ppm boron (wt) in moderator
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '      fuel-pin-cell geometry:
      '
      squarepitch   1.43  0.913  1  3  1.074  2  0.930   0  end
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '    assembly and cycle parameters:
      '
      npin/assm=180 fuelnght=957.89 ncycles=3  nlib/cyc=5
      printlevel=5 lightel=9  inplevel=2  numztotal=5  end
      3 0.6413 2 0.6845 3 0.8068 500 2.8238 3 2.8379
      power=20.929 burn=288  down=81     end
      power=37.468 burn=309.0  down=396  temkcyc=896  end
      power=33.564 burn=248.0  down=10  temkcyc=851  end
        o 135  cr  5.9  mn  0.33
        fe 13  co 0.075 ni  9.9
        zr 221 nb  0.71 sn  3.6
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
1   ssssssssss      aaaaaaaaa      ssssssssss     22222222222    hh          hh
   ssssssssssss    aaaaaaaaaa    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
   ssssssssssss    aaaaaaaaaaaaa  ssssssssssss                22  hhhhhhhhhhhhh
    ssssssssssss   aaaaaaaaaaaaa   ssssssssssss            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
    ssssssssss     aa         aa    ssssssssss    2222222222222    hh          hh
0
```

```
 nn          nn  iiiiiiiiiiii    ccccccccccc   hh          hh   ooooooooooo   ll
 nnn         nn  iiiiiiiiiiii   ccccccccccccc  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   iiiiiiiiiiii   ccccccccccccc  hh          hh  ooooooooooooo  lllllllllllll
 nn         nn   iiiiiiiiiiii    ccccccccccc   hh          hh   ooooooooooo   lllllllllllll
0
   0000000      88888888888              //     0000000      88888888888              //   99999999999   7777777777777
  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
 22222222222     0000000                        0000000     5555555555555                            44    33333333333
2222222222222   000000000                      000000000    5555555555555                           444   3333333333333
22         22  00       00       :::          00       00   55                         :::         4444   33         33
           22  00         00     :::         00         00  55                         :::        44 44              33
           22  00         00     :::         00         00  55                         :::       44  44              33
         22    00         00                 00         00  555555555555                        44   44             333
       22      00         00                 00         00  5555555555555                      44    44             333
     22        00         00     :::         00         00             55              :::    444444444444           33
   22          00         00     :::         00         00             55              :::    444444444444           33
 22             00       00      :::          00       00   55         55              :::             44    33         33
2222222222222   000000000                      000000000    5555555555555                              44    3333333333333
2222222222222    0000000                        0000000      55555555555                               44     33333333333
1
0
                               sssssssssss    ccccccccccc     aaaaaaaaa    ll             eeeeeeeeeeeee
                              sssssssssssss  ccccccccccccc   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             eeeeeeeee
                               ssssssssssss  cc             aaaaaaaaaaaaa  ll             eeeeeeeee
                                         ss  cc             aa         aa  ll             ee
                                         ss  cc             aa         aa  ll             ee
                              ss         ss  cc         cc  aa         aa  ll             ee
                              sssssssssssss  ccccccccccccc  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:  08/08/97                              *****
*****                                                               *****
*****     time of execution:  20:05:43                              *****
*****                                                               *****
*****                                                               *****
*************************************************************************
*************************************************************************
*************************************************************************
```

```
1
0'    ....used 180 fuel rode, 16 guide tubes....
0' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
0'
0                                         nuclide concentrations, grams
                                          basis =single reactor assembly
               initial  1E-18 d
     o 16     1.35E+05  1.35E+05
   total      3.90E+05  3.90E+05
0                                         nuclide concentrations, grams
                                          basis =single reactor assembly
               initial  1E-18 d
     u234     2.80E+02  2.80E+02
     u235     3.13E+04  3.13E+04
     u236     1.40E+02  1.40E+02
     u238     9.68E+05  9.68E+05
   total      1.00E+06  1.00E+06
0                                        basis =
0                    initial         14.4 d          28.8 d          43.2 d          57.6 d          57.6 d
0                    initial         14.4 d          28.8 d          43.2 d          57.6 d          57.6 d
0                                         nuclide concentrations, grams
                                          basis =single reactor assembly
               initial     1.7 d     3.3 d     5.0 d     6.7 d     8.3 d    10.0 d
```

o 16	1.35E+05	1.35E+05	1.35E+05	1.35E+05	1.35E+05	1.35E+05	1.35E+05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
mo 95	1.09E+01	1.09E+01	1.09E+01	1.09E+01	1.10E+01	1.10E+01	1.10E+01
tc 99	2.30E-05	2.32E-05	2.33E-05	2.33E-05	2.34E-05	2.34E-05	2.34E-05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
total	3.90E+05	3.90E+05	3.90E+05	3.90E+05	3.90E+05	3.90E+05	3.90E+05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
u233	1.71E-03	1.71E-03	1.71E-03	1.71E-03	1.71E-03	1.71E-03	1.71E-03
u234	1.87E+02	1.87E+02	1.87E+02	1.87E+02	1.87E+02	1.87E+02	1.87E+02
u235	1.11E+04	1.11E+04	1.11E+04	1.11E+04	1.11E+04	1.11E+04	1.11E+04
u236	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03
u238	9.50E+05	9.50E+05	9.50E+05	9.50E+05	9.50E+05	9.50E+05	9.50E+05
np237	2.95E+02	2.96E+02	2.97E+02	2.98E+02	2.99E+02	3.00E+02	3.00E+02
pu236	3.22E-04	3.23E-04	3.23E-04	3.23E-04	3.23E-04	3.23E-04	3.22E-04
pu238	8.58E+01	8.63E+01	8.66E+01	8.68E+01	8.69E+01	8.71E+01	8.72E+01
pu238	8.58E+01	8.63E+01	8.66E+01	8.68E+01	8.69E+01	8.71E+01	8.72E+01
pu239	4.10E+03	4.13E+03	4.15E+03	4.16E+03	4.16E+03	4.17E+03	4.17E+03
pu240	1.99E+03	1.99E+03	1.99E+03	1.99E+03	1.99E+03	1.99E+03	1.99E+03
pu241	1.01E+03	1.01E+03	1.01E+03	1.01E+03	1.01E+03	1.01E+03	1.01E+03
pu242	3.46E+02	3.46E+02	3.46E+02	3.46E+02	3.46E+02	3.46E+02	3.46E+02
am241	3.68E+01	3.71E+01	3.73E+01	3.75E+01	3.77E+01	3.80E+01	3.82E+01
am242m	9.08E-01	9.08E-01	9.08E-01	9.07E-01	9.07E-01	9.07E-01	9.07E-01
am243	5.50E+01	5.51E+01	5.51E+01	5.51E+01	5.51E+01	5.51E+01	5.51E+01
total	9.73E+05	9.73E+05	9.73E+05	9.73E+05	9.73E+05	9.73E+05	9.73E+05

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

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
mo 95	5.16E+02	5.17E+02	5.18E+02	5.19E+02	5.20E+02	5.21E+02	5.22E+02
tc 99	6.44E+02	6.45E+02	6.46E+02	6.47E+02	6.47E+02	6.47E+02	6.47E+02
tc 99m	2.84E-01	2.03E-01	1.33E-01	8.76E-02	5.76E-02	3.78E-02	2.48E-02
ru101	6.06E+02	6.07E+02	6.07E+02	6.07E+02	6.07E+02	6.07E+02	6.07E+02
rh103	3.54E+02	3.55E+02	3.56E+02	3.57E+02	3.58E+02	3.60E+02	3.61E+02
rh103m	4.29E-02	4.16E-02	4.04E-02	3.92E-02	3.81E-02	3.70E-02	3.59E-02
ag109	6.64E+01	6.65E+01	6.65E+01	6.66E+01	6.66E+01	6.66E+01	6.66E+01

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d

0 nuclide concentrations, grams
basis =single reactor assembly

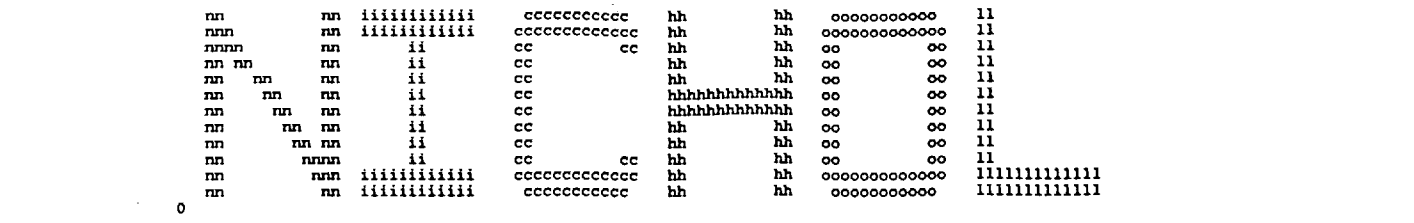
	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
nd143	6.76E+02	6.78E+02	6.80E+02	6.81E+02	6.83E+02	6.84E+02	6.85E+02
nd145	5.51E+02	5.52E+02	5.52E+02	5.52E+02	5.52E+02	5.52E+02	5.52E+02
sm147	8.14E+01	8.16E+01	8.18E+01	8.19E+01	8.21E+01	8.23E+01	8.25E+01

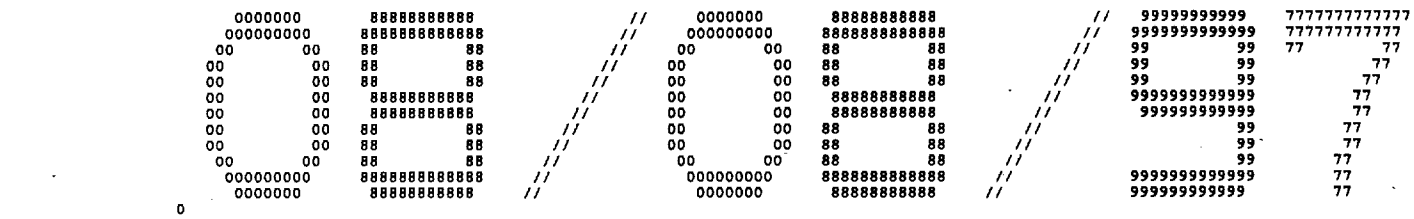
0 nuclide concentrations, grams
basis =single reactor assembly

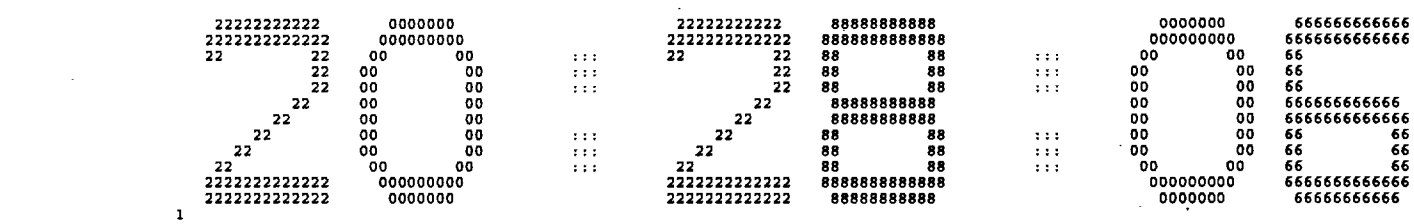
	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
sm149	2.21E+00	2.73E+00	3.04E+00	3.22E+00	3.33E+00	3.39E+00	3.43E+00
sm150	2.25E+02	2.25E+02	2.25E+02	2.25E+02	2.25E+02	2.25E+02	2.25E+02
sm151	1.52E+01	1.53E+01	1.54E+01	1.54E+01	1.54E+01	1.54E+01	1.54E+01
eu151	1.90E-02	1.95E-02	2.00E-02	2.06E-02	2.11E-02	2.17E-02	2.22E-02
sm152	1.07E+02	1.07E+02	1.07E+02	1.07E+02	1.07E+02	1.07E+02	1.07E+02
eu153	8.27E+01	8.31E+01	8.33E+01	8.34E+01	8.34E+01	8.35E+01	8.35E+01
gd155	3.04E-02	3.26E-02	3.48E-02	3.69E-02	3.91E-02	4.12E-02	4.34E-02
total	2.66E+04	2.66E+04	2.66E+04	2.66E+04	2.66E+04	2.66E+04	2.66E+04

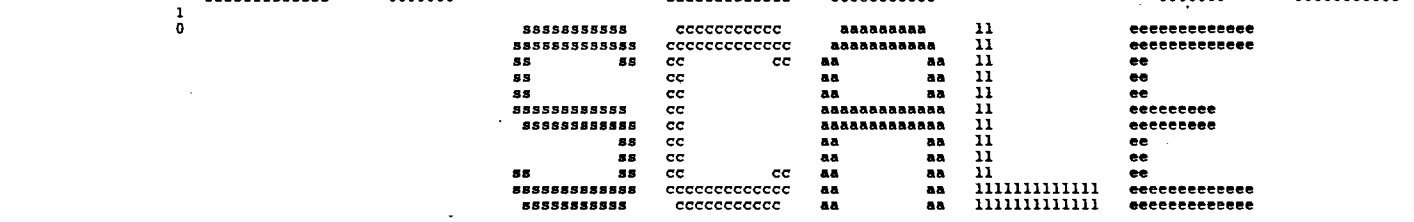
ob171g29.sum

```
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
      obrighiem (kwo) pwr, assm 171, batch 89, 29.04 gwd/mtu 3-cyc June 97
      '     ....used 180 fuel rode, 16 guide tubes....
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '    mixtures of fuel-pin-unit-cell:
      '
      44group        latticecell
      uo2  1 den=10.05  1  813
         92234 0.028 92235 3.13 92236 0.014 92238 96.828   end
      kr-83   1 0 1-20 813  end
      kr-85   1 0 1-20 813  end
      y-89    1 0 1-20 813  end
      sr-90   1 0 1-20 813  end
      zr-93   1 0 1-20 813  end
      zr-94   1 0 1-20 813  end
      zr-95   1 0 1-20 813  end
      nb-94   1 0 1-20 813  end
      mo-95   1 0 1-20 813  end
      tc-99   1 0 1-20 813  end
      ru-101  1 0 1-20 813  end
      ru-106  1 0 1-20 813  end
      rh-103  1 0 1-20 813  end
      rh-105  1 0 1-20 813  end
      pd-105  1 0 1-20 813  end
      pd-108  1 0 1-20 813  end
      ag-109  1 0 1-20 813  end
      sb-124  1 0 1-20 813  end
      xe-131  1 0 1-20 813  end
      xe-132  1 0 1-20 813  end
      xe-135  1 0 1-20 813  end
      xe-136  1 0 1-20 813  end
      cs-134  1 0 1-20 813  end
      cs-135  1 0 1-20 813  end
      cs-137  1 0 1-20 813  end
      ba-136  1 0 1-20 813  end
      la-139  1 0 1-20 813  end
      pr-141  1 0 1-20 813  end
      pr-143  1 0 1-20 813  end
      ce-144  1 0 1-20 813  end
      nd-143  1 0 1-20 813  end
      nd-145  1 0 1-20 813  end
      nd-147  1 0 1-20 813  end
      pm-147  1 0 1-20 813  end
      pm-148  1 0 1-20 813  end
      sm-147  1 0 1-20 813  end
      sm-149  1 0 1-20 813  end
      sm-150  1 0 1-20 813  end
      sm-151  1 0 1-20 813  end
      sm-152  1 0 1-20 813  end
      eu-153  1 0 1-20 813  end
      eu-154  1 0 1-20 813  end
      eu-155  1 0 1-20 813  end
      gd-155  1 0 1-20 813  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 1.0 605   end
      h2o  3 den=0.7283 1  572  end
      arbm-bormod  0.7283 1 1 0 0 5000 100 3 450.0e-6  572  end
      '
      '  450 ppm boron (wt) in moderator
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '      fuel-pin-cell geometry:
      '
      squarepitch   1.43  0.913  1  3  1.074  2  0.930   0  end
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '     assembly and cycle parameters:
      '
      npin/assm=180 fuelnght=957.89 ncycles=3  nlib/cyc=5
      printlevel=5 lightel=9  inplevel=2  numztotal=5  end
      3 0.6413 2 0.6845 3 0.8068 500 2.8238 3 2.8379 .
      power=29.124 burn=288  down=81      end
      power=38.952 burn=309.0  down=396  temkcyc=905  end
      power=34.748 burn=248.0  down=10  temkcyc=865  end
        o 135  cr  5.9  mn  0.33
        fe 13  co 0.075 ni  9.9
        zr 221 nb  0.71 sn  3.6
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
1   sssssssssss       aaaaaaaaa       ssssssssss     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
   ssssssssssss     aaaaaaaaaaaaa    ssssssssssss              22     hhhhhhhhhhhhh
    ssssssssssss    aaaaaaaaaaaaa     ssssssssssss           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
```









```
1
0                                                                              *******************************************************************************
                                                                               *******************************************************************************
                                                                               *******************************************************************************
                                                                               *****                                                                     *****
                                                                               *****                  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:  20:28:06                                    *****
                                                                               *****                                                                     *****
                                                                               *****                                                                     *****
                                                                               *******************************************************************************
                                                                               *******************************************************************************
                                                                               *******************************************************************************
1
0'    ....used 180 fuel rode, 16 guide tubes....
0' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
0'
0                                                                                                  nuclide concentrations, grams
                                                                                                   basis =single reactor assembly
                initial  1E-18 d
     o 16    1.35E+05  1.35E+05
   total     3.90E+05  3.90E+05
0                                                                                                  nuclide concentrations, grams
                                                                                                   basis =single reactor assembly
                initial  1E-18 d
     u234    2.80E+02  2.80E+02
     u235    3.13E+04  3.13E+04
     u236    1.40E+02  1.40E+02
     u238    9.68E+05  9.68E+05
   total     1.00E+06  1.00E+06
0                                                                                                  basis =
0                    initial          14.4 d          28.8 d          43.2 d          57.6 d          57.6 d
0                    initial          14.4 d          28.8 d          43.2 d          57.6 d          57.6 d
0                                                                                                  nuclide concentrations, grams
                                                                                                   basis =single reactor assembly
                initial    1.7 d     3.3 d     5.0 d     6.7 d     8.3 d    10.0 d
```

o 16	1.35E+05	1.35E+05	1.35E+05	1.35E+05	1.35E+05	1.35E+05	1.35E+05
0				nuclide concentrations, grams			
				basis =single reactor assembly			
	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
mo 95	1.25E+01	1.25E+01	1.26E+01	1.26E+01	1.26E+01	1.27E+01	1.27E+01
tc 99	3.38E-05	3.40E-05	3.41E-05	3.42E-05	3.43E-05	3.43E-05	3.43E-05
0				nuclide concentrations, grams			
				basis =single reactor assembly			
	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
total	3.90E+05	3.90E+05	3.90E+05	3.90E+05	3.90E+05	3.90E+05	3.90E+05
0				nuclide concentrations, grams			
				basis =single reactor assembly			
	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
u233	1.78E-03	1.78E-03	1.78E-03	1.78E-03	1.78E-03	1.78E-03	1.78E-03
u234	1.78E+02	1.78E+02	1.78E+02	1.78E+02	1.78E+02	1.78E+02	1.78E+02
u235	9.70E+03	9.70E+03	9.70E+03	9.70E+03	9.70E+03	9.70E+03	9.70E+03
u236	3.80E+03	3.80E+03	3.80E+03	3.80E+03	3.80E+03	3.80E+03	3.80E+03
u238	9.47E+05	9.47E+05	9.47E+05	9.47E+05	9.47E+05	9.47E+05	9.47E+05
np237	3.41E+02	3.43E+02	3.44E+02	3.45E+02	3.45E+02	3.46E+02	3.47E+02
pu236	4.26E-04	4.27E-04	4.27E-04	4.27E-04	4.26E-04	4.26E-04	4.25E-04
pu238	1.12E+02	1.13E+02	1.13E+02	1.14E+02	1.14E+02	1.14E+02	1.14E+02
pu238	1.12E+02	1.13E+02	1.13E+02	1.14E+02	1.14E+02	1.14E+02	1.14E+02
pu239	4.13E+03	4.16E+03	4.18E+03	4.19E+03	4.20E+03	4.20E+03	4.21E+03
pu240	2.21E+03	2.21E+03	2.21E+03	2.21E+03	2.21E+03	2.21E+03	2.21E+03
pu241	1.13E+03	1.13E+03	1.13E+03	1.13E+03	1.13E+03	1.13E+03	1.13E+03
pu242	4.48E+02	4.48E+02	4.48E+02	4.48E+02	4.48E+02	4.48E+02	4.48E+02
am241	4.24E+01	4.27E+01	4.29E+01	4.32E+01	4.34E+01	4.37E+01	4.39E+01
am242m	1.07E+00	1.07E+00	1.07E+00	1.07E+00	1.07E+00	1.07E+00	1.07E+00
am243	7.92E+01	7.93E+01	7.93E+01	7.93E+01	7.93E+01	7.93E+01	7.93E+01
total	9.70E+05	9.70E+05	9.70E+05	9.70E+05	9.70E+05	9.70E+05	9.70E+05
0				element concentrations, grams			
0				nuclide concentrations, grams			
				basis =single reactor assembly			
	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
0				nuclide concentrations, grams			
				basis =single reactor assembly			
	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
mo 95	5.78E+02	5.79E+02	5.80E+02	5.81E+02	5.82E+02	5.83E+02	5.84E+02
tc 99	7.12E+02	7.13E+02	7.14E+02	7.15E+02	7.15E+02	7.15E+02	7.16E+02
tc 99m	2.93E-01	2.09E-01	1.38E-01	9.05E-02	5.94E-02	3.90E-02	2.56E-02
ru101	6.78E+02	6.78E+02	6.78E+02	6.78E+02	6.78E+02	6.78E+02	6.78E+02
rh103	3.91E+02	3.92E+02	3.94E+02	3.95E+02	3.96E+02	3.97E+02	3.98E+02
rh103m	4.55E-02	4.41E-02	4.28E-02	4.16E-02	4.04E-02	3.92E-02	3.81E-02
ag109	7.77E+01	7.79E+01	7.79E+01	7.79E+01	7.79E+01	7.79E+01	7.79E+01
0				nuclide concentrations, grams			
				basis =single reactor assembly			
	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
0				nuclide concentrations, grams			
				basis =single reactor assembly			
	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
nd143	7.29E+02	7.30E+02	7.32E+02	7.34E+02	7.35E+02	7.36E+02	7.38E+02
nd145	6.06E+02	6.06E+02	6.06E+02	6.06E+02	6.06E+02	6.06E+02	6.06E+02
sm147	8.95E+01	8.97E+01	8.99E+01	9.01E+01	9.02E+01	9.04E+01	9.06E+01
0				nuclide concentrations, grams			
				basis =single reactor assembly			
	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
sm149	2.23E+00	2.78E+00	3.10E+00	3.30E+00	3.41E+00	3.48E+00	3.52E+00
sm150	2.56E+02	2.56E+02	2.56E+02	2.56E+02	2.56E+02	2.56E+02	2.56E+02
sm151	1.60E+01	1.62E+01	1.62E+01	1.63E+01	1.63E+01	1.63E+01	1.63E+01
eu151	1.86E-02	1.92E-02	1.97E-02	2.03E-02	2.09E-02	2.14E-02	2.20E-02
sm152	1.18E+02	1.18E+02	1.18E+02	1.18E+02	1.18E+02	1.18E+02	1.18E+02
eu153	9.72E+01	9.76E+01	9.78E+01	9.80E+01	9.80E+01	9.81E+01	9.81E+01
gd155	3.58E-02	3.83E-02	4.09E-02	4.34E-02	4.60E-02	4.85E-02	5.11E-02
total	2.98E+04	2.98E+04	2.98E+04	2.98E+04	2.98E+04	2.98E+04	2.98E+04

ob172g26.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
      obrighiem (kwo) pwr, assm 172, batch 92, 26.54 gwd/mtu 3-cyc June 97
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '   mixtures of fuel-pin-unit-cell:
      '
      44group        latticecell
      uo2  1 den=10.05  1  865
         92234 0.028 92235 3.13 92236 0.014 92238 96.828   end
      kr-83  1 0 1-20 865  end
      kr-85  1 0 1-20 865  end
      y-89   1 0 1-20 865  end
      sr-90  1 0 1-20 865  end
      zr-93  1 0 1-20 865  end
      zr-94  1 0 1-20 865  end
      zr-95  1 0 1-20 865  end
      nb-94  1 0 1-20 865  end
      mo-95  1 0 1-20 865  end
      tc-99  1 0 1-20 865  end
      ru-101 1 0 1-20 865  end
      ru-106 1 0 1-20 865  end
      rh-103 1 0 1-20 865  end
      rh-105 1 0 1-20 865  end
      pd-105 1 0 1-20 865  end
      pd-108 1 0 1-20 865  end
      ag-109 1 0 1-20 865  end
      sb-124 1 0 1-20 865  end
      xe-131 1 0 1-20 865  end
      xe-132 1 0 1-20 865  end
      xe-135 1 0 1-20 865  end
      xe-136 1 0 1-20 865  end
      cs-134 1 0 1-20 865  end
      cs-135 1 0 1-20 865  end
      cs-137 1 0 1-20 865  end
      ba-136 1 0 1-20 865  end
      la-139 1 0 1-20 865  end
      pr-141 1 0 1-20 865  end
      pr-143 1 0 1-20 865  end
      ce-144 1 0 1-20 865  end
      nd-143 1 0 1-20 865  end
      nd-145 1 0 1-20 865  end
      nd-147 1 0 1-20 865  end
      pm-147 1 0 1-20 865  end
      pm-148 1 0 1-20 865  end
      sm-147 1 0 1-20 865  end
      sm-149 1 0 1-20 865  end
      sm-150 1 0 1-20 865  end
      sm-151 1 0 1-20 865  end
      sm-152 1 0 1-20 865  end
      eu-153 1 0 1-20 865  end
      eu-154 1 0 1-20 865  end
      eu-155 1 0 1-20 865  end
      gd-155 1 0 1-20 865  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 1.0 605   end
      h2o  3 den=0.7283 1  572  end
      arbm-bormod  0.7283 1 1 0 0 5000 100 3 450.0e-6  572  end
      '
      '  450 ppm boron (wt) in moderator
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '      fuel-pin-cell geometry:
      '
      squarepitch   1.43  0.913  1  3  1.074  2  0.930   0  end
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '    assembly and cycle parameters:
      '
      npin/assm=180 fuelnght=957.89 ncycles=3  nlib/cyc=5
      printlevel=5 lightel=9  inplevel=2  numztotal=5  end
      3 0.6413 2 0.6845 3 0.8068 500 2.8238 3 2.8379
      power=34.833 burn=288  down=81     end
      power=25.035 burn=309.0  down=396  temkcyc=778  end
      power=35.374 burn=248.0  down=10  temkcyc=870  end
        o 135  cr  5.9  mn  0.33
        fe 13  co 0.075 ni  9.9
        zr 221 nb  0.71 sn  3.6
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
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
   sssssssssss     aa         aa   sssssssssss    2222222222222   hh          hh
    sssssssssss    aa         aa    sssssssssss   2222222222222   hh          hh
0
```

```
   nn          nn  iiiiiiiiiiii    ccccccccccc    hh          hh    oooooooooo    ll
   nnn         nn  iiiiiiiiiiii   cccccccccccccc  hh          hh   oooooooooooo   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  iiiiiiiiiiii   cccccccccccccc  hh          hh   oooooooooooo   llllllllllll
   nn         nn  iiiiiiiiiiii    ccccccccccc    hh          hh    oooooooooo    llllllllllll
0

     0000000       88888888888             //     0000000       88888888888             //    99999999999    77777777777
    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 //                     99  77
     0000000       88888888888 //                0000000       88888888888 //                      99  77
0

   22222222222      0000000                     5555555555555     0000000                    33333333333   33333333333
  2222222222222    000000000                    5555555555555    000000000                  3333333333333 3333333333333
  22         22   00       00          :::     55              00       00         :::     33         33 33         33
             22   00         00        :::     55              00         00       :::               33 33         33
             22   00         00        :::     55              00         00       :::               33 33         33
           22     00         00                555555555555    00         00                      333   333         333
         22       00         00                5555555555555   00         00                      333   333         333
       22         00         00          :::             55    00         00       :::             33    33          33
     22           00         00          :::             55    00         00       :::             33    33          33
   22             00       00            :::     55      55    00       00         :::     33      33    33          33
  2222222222222    000000000              5555555555555    000000000                  3333333333333 3333333333333
  2222222222222     0000000                555555555555     0000000                    33333333333   33333333333
1
0                              sssssssssss     ccccccccccc     aaaaaaaaa     ll          eeeeeeeeeeeee
                              ssssssssssss   cccccccccccccc   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   cccccccccccccc  aa         aa llllllllllll eeeeeeeeeeeee
                               sssssssssss    ccccccccccc    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:  20:50:33                                       *****
*****                                                                       *****
*****                                                                       *****
*********************************************************************************
*********************************************************************************
*********************************************************************************
```

```
1
0'
0' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
0'
0                                  nuclide concentrations, grams
                                   basis =single reactor assembly

            initial  1E-18 d
     o 16   1.35E+05  1.35E+05
   total    3.90E+05  3.90E+05
0                                  nuclide concentrations, grams
                                   basis =single reactor assembly

            initial  1E-18 d
     u234   2.80E+02  2.80E+02
     u235   3.13E+04  3.13E+04
     u236   1.40E+02  1.40E+02
     u238   9.68E+05  9.68E+05
   total    1.00E+06  1.00E+06
0                                  basis =
0                 initial          14.4 d          28.8 d          43.2 d          57.6 d          57.6 d
0                 initial          14.4 d          28.8 d          43.2 d          57.6 d          57.6 d
                                   basis = single reactor assembly
            charge    14.4 d    28.8 d    43.2 d    57.6 d    57.6 d
     o 16   8.41E+03  8.41E+03  8.41E+03  8.41E+03  8.41E+03  8.41E+03
```

```
                                                    basis = single reactor assembly
              charge     14.4 d     28.8 d     43.2 d     57.6 d     57.6 d
                                                    basis = single reactor assembly
              charge     14.4 d     28.8 d     43.2 d     57.6 d     57.6 d
     mo 95    .00E+00  1.67E-05  1.20E-04  3.66E-04  7.84E-04  7.84E-04
                                                    basis = single reactor assembly
              charge     14.4 d     28.8 d     43.2 d     57.6 d     57.6 d
                                                    basis = single reactor assembly
              charge     14.4 d     28.8 d     43.2 d     57.6 d     57.6 d
   totals   1.14E+04  1.14E+04  1.14E+04  1.14E+04  1.14E+04  1.14E+04
                                                    basis = single reactor assembly
              charge     14.4 d     28.8 d     43.2 d     57.6 d     57.6 d
      u233    .00E+00  2.54E-07  5.01E-07  7.39E-07  9.68E-07  9.68E-07
      u234   1.20E+00  1.19E+00  1.18E+00  1.17E+00  1.16E+00  1.16E+00
      u235   1.33E+02  1.31E+02  1.28E+02  1.26E+02  1.23E+02  1.23E+02
      u236   5.93E-01  1.06E+00  1.51E+00  1.95E+00  2.38E+00  2.38E+00
      u238   4.07E+03  4.07E+03  4.06E+03  4.06E+03  4.06E+03  4.06E+03
     np237    .00E+00  3.92E-03  1.18E-02  2.15E-02  3.25E-02  3.25E-02
     pu236    .00E+00  6.40E-11  4.25E-10  1.21E-09  2.50E-09  2.50E-09
     pu238    .00E+00  1.05E-05  8.60E-05  2.64E-04  5.61E-04  5.61E-04
     pu238    .00E+00  1.05E-05  8.60E-05  2.64E-04  5.61E-04  5.61E-04
     pu239    .00E+00  8.99E-01  2.01E+00  3.05E+00  4.03E+00  4.03E+00
     pu240    .00E+00  1.00E-02  4.38E-02  9.89E-02  1.72E-01  1.72E-01
     pu241    .00E+00  2.37E-04  2.13E-03  7.28E-03  1.70E-02  1.70E-02
     pu242    .00E+00  8.82E-07  1.63E-05  8.51E-05  2.68E-04  2.68E-04
                                                    basis = single reactor assembly
              charge     14.4 d     28.8 d     43.2 d     57.6 d     57.6 d
     am241    .00E+00  1.05E-07  1.92E-06  1.00E-05  3.15E-05  3.15E-05
   am242m     .00E+00  1.25E-10  4.46E-09  3.39E-08  1.38E-07  1.38E-07
     am243    .00E+00  1.86E-09  7.01E-08  5.60E-07  2.39E-06  2.39E-06
   totals   4.20E+03  4.20E+03  4.20E+03  4.20E+03  4.19E+03  4.19E+03
          *       decay data, including gamma and total energy, are from endf/b-vi
0                  1697    total number of nuclides in library
0                                                   nuclide concentrations, grams
                                                    basis =single reactor assembly
              initial     1.7 d      3.3 d      5.0 d      6.7 d      8.3 d     10.0 d
      o 16   1.35E+05  1.35E+05  1.35E+05  1.35E+05  1.35E+05  1.35E+05  1.35E+05
0                                                   nuclide concentrations, grams
                                                    basis =single reactor assembly
              initial     1.7 d      3.3 d      5.0 d      6.7 d      8.3 d     10.0 d
     mo 95   1.11E+01  1.11E+01  1.11E+01  1.12E+01  1.12E+01  1.12E+01  1.12E+01
     tc 99   2.47E-05  2.48E-05  2.49E-05  2.50E-05  2.51E-05  2.51E-05  2.51E-05
0                                                   nuclide concentrations, grams
                                                    basis =single reactor assembly
              initial     1.7 d      3.3 d      5.0 d      6.7 d      8.3 d     10.0 d
    total   3.90E+05  3.90E+05  3.90E+05  3.90E+05  3.90E+05  3.90E+05  3.90E+05
0                                                   nuclide concentrations, grams
                                                    basis =single reactor assembly
              initial     1.7 d      3.3 d      5.0 d      6.7 d      8.3 d     10.0 d
      u233   1.72E-03  1.72E-03  1.72E-03  1.72E-03  1.72E-03  1.72E-03  1.72E-03
      u234   1.85E+02  1.85E+02  1.85E+02  1.85E+02  1.85E+02  1.85E+02  1.85E+02
      u235   1.08E+04  1.08E+04  1.08E+04  1.08E+04  1.08E+04  1.08E+04  1.08E+04
      u236   3.64E+03  3.64E+03  3.64E+03  3.64E+03  3.64E+03  3.64E+03  3.64E+03
      u238   9.49E+05  9.49E+05  9.49E+05  9.49E+05  9.49E+05  9.49E+05  9.49E+05
     np237   3.04E+02  3.05E+02  3.06E+02  3.07E+02  3.08E+02  3.09E+02  3.09E+02
     pu236   3.42E-04  3.43E-04  3.43E-04  3.42E-04  3.42E-04  3.42E-04  3.41E-04
     pu238   9.07E+01  9.12E+01  9.16E+01  9.18E+01  9.20E+01  9.21E+01  9.22E+01
     pu238   9.07E+01  9.12E+01  9.16E+01  9.18E+01  9.20E+01  9.21E+01  9.22E+01
     pu239   4.16E+03  4.19E+03  4.21E+03  4.22E+03  4.23E+03  4.24E+03  4.24E+03
     pu240   2.06E+03  2.06E+03  2.06E+03  2.06E+03  2.06E+03  2.06E+03  2.06E+03
     pu241   1.03E+03  1.03E+03  1.03E+03  1.03E+03  1.03E+03  1.03E+03  1.03E+03
     pu242   3.47E+02  3.47E+02  3.47E+02  3.47E+02  3.47E+02  3.47E+02  3.47E+02
     am241   3.68E+01  3.70E+01  3.73E+01  3.75E+01  3.77E+01  3.79E+01  3.82E+01
   am242m    9.28E-01  9.28E-01  9.28E-01  9.28E-01  9.28E-01  9.28E-01  9.28E-01
     am243   5.49E+01  5.50E+01  5.50E+01  5.50E+01  5.50E+01  5.50E+01  5.50E+01
    total    9.72E+05  9.72E+05  9.72E+05  9.72E+05  9.72E+05  9.72E+05  9.72E+05
0                                                   element concentrations, grams
0                                                   nuclide concentrations, grams
                                                    basis =single reactor assembly
              initial     1.7 d      3.3 d      5.0 d      6.7 d      8.3 d     10.0 d
0                                                   nuclide concentrations, grams
                                                    basis =single reactor assembly
              initial     1.7 d      3.3 d      5.0 d      6.7 d      8.3 d     10.0 d
     mo 95   5.24E+02  5.26E+02  5.27E+02  5.28E+02  5.29E+02  5.30E+02  5.31E+02
     tc 99   6.58E+02  6.59E+02  6.60E+02  6.61E+02  6.61E+02  6.61E+02  6.61E+02
   tc 99m    2.99E-01  2.14E-01  1.40E-01  9.23E-02  6.06E-02  3.98E-02  2.61E-02
     ru101   6.21E+02  6.21E+02  6.21E+02  6.21E+02  6.21E+02  6.21E+02  6.21E+02
     rh103   3.59E+02  3.60E+02  3.61E+02  3.62E+02  3.64E+02  3.65E+02  3.66E+02
   rh103m    4.56E-02  4.43E-02  4.30E-02  4.17E-02  4.05E-02  3.94E-02  3.82E-02
     ag109   6.82E+01  6.83E+01  6.83E+01  6.84E+01  6.84E+01  6.84E+01  6.84E+01
0                                                   nuclide concentrations, grams
                                                    basis =single reactor assembly
              initial     1.7 d      3.3 d      5.0 d      6.7 d      8.3 d     10.0 d
0                                                   nuclide concentrations, grams
                                                    basis =single reactor assembly
              initial     1.7 d      3.3 d      5.0 d      6.7 d      8.3 d     10.0 d
     nd143   6.86E+02  6.88E+02  6.90E+02  6.91E+02  6.93E+02  6.94E+02  6.95E+02
     nd145   5.63E+02  5.63E+02  5.63E+02  5.63E+02  5.63E+02  5.63E+02  5.63E+02
     sm147   8.63E+01  8.65E+01  8.67E+01  8.69E+01  8.70E+01  8.72E+01  8.74E+01
0                                                   nuclide concentrations, grams
                                                    basis =single reactor assembly
              initial     1.7 d      3.3 d      5.0 d      6.7 d      8.3 d     10.0 d
     sm149   2.25E+00  2.79E+00  3.12E+00  3.31E+00  3.42E+00  3.49E+00  3.53E+00
     sm150   2.28E+02  2.28E+02  2.28E+02  2.28E+02  2.28E+02  2.28E+02  2.28E+02
     sm151   1.55E+01  1.56E+01  1.57E+01  1.57E+01  1.57E+01  1.57E+01  1.57E+01
     eu151   1.81E-02  1.86E-02  1.92E-02  1.98E-02  2.03E-02  2.09E-02  2.14E-02
     sm152   1.08E+02  1.08E+02  1.08E+02  1.08E+02  1.08E+02  1.08E+02  1.08E+02
     eu153   8.53E+01  8.57E+01  8.59E+01  8.60E+01  8.60E+01  8.61E+01  8.61E+01
     gd155   3.13E-02  3.35E-02  3.57E-02  3.80E-02  4.02E-02  4.24E-02  4.46E-02
    total    2.73E+04  2.73E+04  2.73E+04  2.73E+04  2.73E+04  2.73E+04  2.73E+04
```

ob176g29.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
      obrighiem (kwo) pwr, assm 176, batch 90, 29.52 gwd/mtu 3-cyc June 97
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '   mixtures of fuel-pin-unit-cell:
      '
      44group        latticecell
      uo2  1 den=10.05  1  840
         92234 0.028 92235 3.13 92236 0.014 92238 96.828   end
      kr-83   1 0 1-20 840  end
      kr-85   1 0 1-20 840  end
      y-89    1 0 1-20 840  end
      sr-90   1 0 1-20 840  end
      zr-93   1 0 1-20 840  end
      zr-94   1 0 1-20 840  end
      zr-95   1 0 1-20 840  end
      nb-94   1 0 1-20 840  end
      mo-95   1 0 1-20 840  end
      tc-99   1 0 1-20 840  end
      ru-101  1 0 1-20 840  end
      ru-106  1 0 1-20 840  end
      rh-103  1 0 1-20 840  end
      rh-105  1 0 1-20 840  end
      pd-105  1 0 1-20 840  end
      pd-108  1 0 1-20 840  end
      ag-109  1 0 1-20 840  end
      sb-124  1 0 1-20 840  end
      xe-131  1 0 1-20 840  end
      xe-132  1 0 1-20 840  end
      xe-135  1 0 1-20 840  end
      xe-136  1 0 1-20 840  end
      cs-134  1 0 1-20 840  end
      cs-135  1 0 1-20 840  end
      cs-137  1 0 1-20 840  end
      ba-136  1 0 1-20 840  end
      la-139  1 0 1-20 840  end
      pr-141  1 0 1-20 840  end
      pr-143  1 0 1-20 840  end
      ce-144  1 0 1-20 840  end
      nd-143  1 0 1-20 840  end
      nd-145  1 0 1-20 840  end
      nd-147  1 0 1-20 840  end
      pm-147  1 0 1-20 840  end
      pm-148  1 0 1-20 840  end
      sm-147  1 0 1-20 840  end
      sm-149  1 0 1-20 840  end
      sm-150  1 0 1-20 840  end
      sm-151  1 0 1-20 840  end
      sm-152  1 0 1-20 840  end
      eu-153  1 0 1-20 840  end
      eu-154  1 0 1-20 840  end
      eu-155  1 0 1-20 840  end
      gd-155  1 0 1-20 840  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 1.0 605   end
      h2o  3 den=0.7283 1  572  end
      arbm-bormod  0.7283 1 1 0 0 5000 100 3 450.0e-6  572  end
      '
      '  450 ppm boron (wt) in moderator
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '      fuel-pin-cell geometry:
      '
      squarepitch   1.43  0.913  1  3  1.074  2  0.930   0  end
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '    assembly and cycle parameters:
      '
      npin/assm=180 fuelnght=957.89 ncycles=3  nlib/cyc=5
      printlevel=5 lightel=9  inplevel=2  numztotal=5  end
      3 0.6413 2 0.6845 3 0.8068 500 2.8238 3 2.8379 .
      power=32.121 burn=288  down=81      end
      power=36.801 burn=309.0  down=396  temkcyc=883  end
      power=35.875 burn=248.0  down=10  temkcyc=875  end
        o 135  cr  5.9  mn  0.33
        fe 13  co 0.075 ni  9.9
        zr 221 nb  0.71 sn  3.6
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
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          22   hh          hh
   ss               aa         aa   ss               22          22   hh          hh
   ssssssssssss     aaaaaaaaaaaaa   ssssssssssss                22   hhhhhhhhhhhhh
    ssssssssssss    aaaaaaaaaaaaa    ssssssssssss           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    ll
     nnn         nn iiiiiiiiiiii   ccccccccccccc  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       nnnnn      ii        cc         cc  hh          hh  oo         oo   ll
     nn        nnnn iiiiiiiiiiii   ccccccccccccc  hh          hh  ooooooooooooo   llllllllllll
     nn          nn iiiiiiiiiiii    ccccccccccc   hh          hh   ooooooooooo    llllllllllll
0
       0000000      88888888888          //     0000000      88888888888          //  99999999999    7777777777777
     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
     22222222222        11                   33333333333   5555555555555              11         88888888888
    2222222222222      111                  3333333333333  5555555555555             111        8888888888888
    22         22     1111        :::       33         33  55                       1111        88         88
               22       11        :::                  33  55                 :::     11        88         88
              22        11        :::                  33  55                 :::     11        88         88
             22         11                            333  555555555555       :::     11         88888888888
           22           11                            333  5555555555555              11         88888888888
          22            11        :::                  33             55              11        88         88
         22             11        :::                  33             55      :::     11        88         88
       22               11        :::       33         33  55         55      :::     11        88         88
    2222222222222    11111111                3333333333333 5555555555555      :::  11111111     8888888888888
    2222222222222    11111111                 33333333333   55555555555        11111111     88888888888
1
0
                                 sssssssssss   ccccccccccc     aaaaaaaaa    ll            eeeeeeeeeeeee
                                sssssssssssss ccccccccccccc   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            eeeeeeeee
                                 ssssssssssss cc             aaaaaaaaaaaaa  ll            eeeeeeeee
                                           ss cc             aa         aa  ll            ee
                                           ss cc             aa         aa  ll            ee
                                ss         ss cc         cc  aa         aa  ll            ee
                                sssssssssssss ccccccccccccc  aa         aa  llllllllllll  eeeeeeeeeeeee
                                 sssssssssss   ccccccccccc   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:  21:35:18                          *****
*****                                                                *****
*****                                                                *****
**************************************************************************
**************************************************************************
**************************************************************************
```

```
1
0
0 - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
0
0                                            nuclide concentrations, grams
                                             basis =single reactor assembly
               initial  1E-18 d
     o 16      1.35E+05  1.35E+05
   total       3.90E+05  3.90E+05
0                                            nuclide concentrations, grams
                                             basis =single reactor assembly
               initial  1E-18 d
     u234      2.80E+02  2.80E+02
     u235      3.13E+04  3.13E+04
     u236      1.40E+02  1.40E+02
     u238      9.68E+05  9.68E+05
   total       1.00E+06  1.00E+06
0                                           basis =
0                    initial        14.4 d        28.8 d        43.2 d        57.6 d        57.6 d
0                    initial        14.4 d        28.8 d        43.2 d        57.6 d        57.6 d
0                                            nuclide concentrations, grams
                                             basis =single reactor assembly
               initial     1.7 d     3.3 d     5.0 d     6.7 d     8.3 d    10.0 d
```

o 16	1.35E+05	1.35E+05	1.35E+05	1.35E+05	1.35E+05	1.35E+05	1.35E+05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
mo 95	1.27E+01	1.27E+01	1.28E+01	1.28E+01	1.28E+01	1.29E+01	1.29E+01
tc 99	3.57E-05	3.59E-05	3.60E-05	3.61E-05	3.62E-05	3.62E-05	3.62E-05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
total	3.90E+05	3.90E+05	3.90E+05	3.90E+05	3.90E+05	3.90E+05	3.90E+05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
u233	1.78E-03	1.78E-03	1.79E-03	1.79E-03	1.79E-03	1.79E-03	1.79E-03
u234	1.76E+02	1.76E+02	1.76E+02	1.76E+02	1.76E+02	1.76E+02	1.76E+02
u235	9.48E+03	9.48E+03	9.48E+03	9.48E+03	9.48E+03	9.48E+03	9.48E+03
u236	3.83E+03	3.83E+03	3.83E+03	3.83E+03	3.83E+03	3.83E+03	3.83E+03
u238	9.47E+05	9.47E+05	9.47E+05	9.47E+05	9.47E+05	9.47E+05	9.47E+05
np237	3.48E+02	3.49E+02	3.51E+02	3.52E+02	3.52E+02	3.53E+02	3.54E+02
pu236	4.45E-04	4.46E-04	4.46E-04	4.46E-04	4.46E-04	4.45E-04	4.45E-04
pu238	1.17E+02	1.17E+02	1.18E+02	1.18E+02	1.18E+02	1.19E+02	1.19E+02
pu238	1.17E+02	1.17E+02	1.18E+02	1.18E+02	1.18E+02	1.19E+02	1.19E+02
pu239	4.13E+03	4.16E+03	4.19E+03	4.20E+03	4.21E+03	4.21E+03	4.21E+03
pu240	2.25E+03	2.25E+03	2.25E+03	2.25E+03	2.25E+03	2.25E+03	2.25E+03
pu241	1.15E+03	1.15E+03	1.15E+03	1.15E+03	1.15E+03	1.15E+03	1.15E+03
pu242	4.61E+02	4.61E+02	4.61E+02	4.61E+02	4.61E+02	4.61E+02	4.61E+02
am241	4.21E+01	4.23E+01	4.26E+01	4.28E+01	4.31E+01	4.33E+01	4.36E+01
am242m	1.07E+00	1.07E+00	1.07E+00	1.07E+00	1.07E+00	1.07E+00	1.07E+00
am243	8.23E+01	8.25E+01	8.25E+01	8.25E+01	8.25E+01	8.25E+01	8.25E+01
total	9.69E+05	9.69E+05	9.69E+05	9.69E+05	9.69E+05	9.69E+05	9.69E+05

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

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
mo 95	5.84E+02	5.86E+02	5.87E+02	5.88E+02	5.89E+02	5.90E+02	5.91E+02
tc 99	7.22E+02	7.24E+02	7.25E+02	7.25E+02	7.26E+02	7.26E+02	7.26E+02
tc 99m	3.02E-01	2.16E-01	1.42E-01	9.33E-02	6.13E-02	4.03E-02	2.64E-02
ru101	6.89E+02	6.89E+02	6.89E+02	6.89E+02	6.89E+02	6.89E+02	6.89E+02
rh103	3.95E+02	3.97E+02	3.98E+02	3.99E+02	4.01E+02	4.02E+02	4.03E+02
rh103m	4.71E-02	4.58E-02	4.44E-02	4.31E-02	4.19E-02	4.07E-02	3.95E-02
ag109	7.94E+01	7.96E+01	7.96E+01	7.96E+01	7.96E+01	7.96E+01	7.96E+01

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
nd143	7.35E+02	7.37E+02	7.39E+02	7.41E+02	7.42E+02	7.43E+02	7.45E+02
nd145	6.14E+02	6.14E+02	6.14E+02	6.14E+02	6.14E+02	6.14E+02	6.14E+02
sm147	9.05E+01	9.07E+01	9.09E+01	9.11E+01	9.13E+01	9.15E+01	9.16E+01

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
sm149	2.24E+00	2.82E+00	3.16E+00	3.36E+00	3.48E+00	3.55E+00	3.59E+00
sm150	2.60E+02	2.60E+02	2.60E+02	2.60E+02	2.60E+02	2.60E+02	2.60E+02
sm151	1.62E+01	1.64E+01	1.65E+01	1.65E+01	1.65E+01	1.65E+01	1.65E+01
eu151	1.81E-02	1.86E-02	1.92E-02	1.98E-02	2.04E-02	2.10E-02	2.15E-02
sm152	1.20E+02	1.20E+02	1.20E+02	1.20E+02	1.20E+02	1.20E+02	1.20E+02
eu153	9.94E+01	9.98E+01	1.00E+02	1.00E+02	1.00E+02	1.00E+02	1.00E+02
gd155	3.60E-02	3.86E-02	4.12E-02	4.38E-02	4.64E-02	4.90E-02	5.16E-02
total	3.03E+04	3.03E+04	3.03E+04	3.03E+04	3.03E+04	3.03E+04	3.03E+04

ob176g27.sum

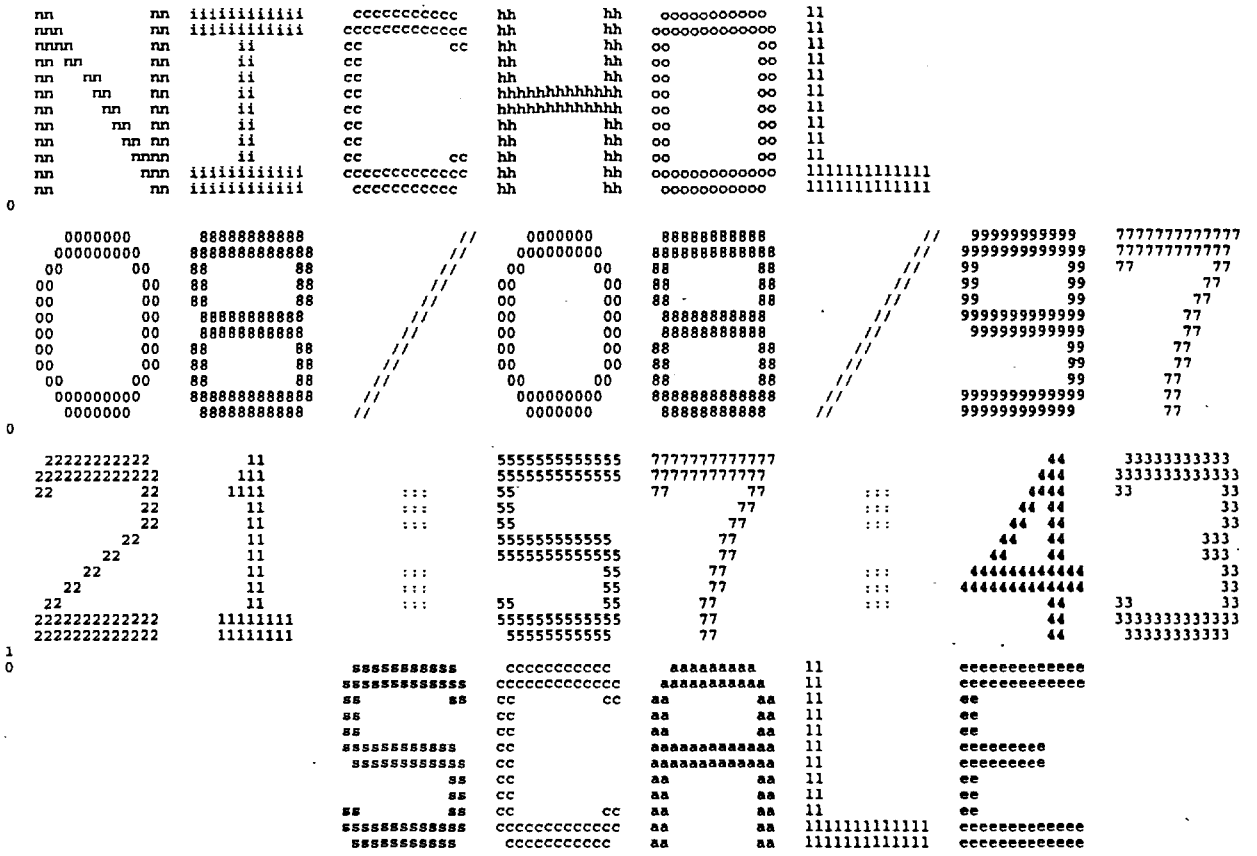
```
0*************************************************************************
 *                                                                       *
 *                    SCALE4.3  Bulletin  Board                          *
 *                    --------  --------  -----                          *
 *                                                                       *
 *                      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
      obrighiem (kwo) pwr, assm 176, batch 91, 27.99 gwd/mtu 3-cyc June 97
          ....used 180 fuel rode, 16 guide tubes....
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '   mixtures of fuel-pin-unit-cell:
      '
      44group        latticecell
      uo2  1 den=10.05  1  825
         92234 0.028 92235 3.13 92236 0.014 92238 96.828   end
      kr-83  1 0 1-20 825  end
      kr-85  1 0 1-20 825  end
      y-89   1 0 1-20 825  end
      sr-90  1 0 1-20 825  end
      zr-93  1 0 1-20 825  end
      zr-94  1 0 1-20 825  end
      zr-95  1 0 1-20 825  end
      nb-94  1 0 1-20 825  end
      mo-95  1 0 1-20 825  end
      tc-99  1 0 1-20 825  end
      ru-101 1 0 1-20 825  end
      ru-106 1 0 1-20 825  end
      rh-103 1 0 1-20 825  end
      rh-105 1 0 1-20 825  end
      pd-105 1 0 1-20 825  end
      pd-108 1 0 1-20 825  end
      ag-109 1 0 1-20 825  end
      sb-124 1 0 1-20 825  end
      xe-131 1 0 1-20 825  end
      xe-132 1 0 1-20 825  end
      xe-135 1 0 1-20 825  end
      xe-136 1 0 1-20 825  end
      cs-134 1 0 1-20 825  end
      cs-135 1 0 1-20 825  end
      cs-137 1 0 1-20 825  end
      ba-136 1 0 1-20 825  end
      la-139 1 0 1-20 825  end
      pr-141 1 0 1-20 825  end
      pr-143 1 0 1-20 825  end
      ce-144 1 0 1-20 825  end
      nd-143 1 0 1-20 825  end
      nd-145 1 0 1-20 825  end
      nd-147 1 0 1-20 825  end
      pm-147 1 0 1-20 825  end
      pm-148 1 0 1-20 825  end
      sm-147 1 0 1-20 825  end
      sm-149 1 0 1-20 825  end
      sm-150 1 0 1-20 825  end
      sm-151 1 0 1-20 825  end
      sm-152 1 0 1-20 825  end
      eu-153 1 0 1-20 825  end
      eu-154 1 0 1-20 825  end
      eu-155 1 0 1-20 825  end
      gd-155 1 0 1-20 825  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 1.0 605   end
      h2o  3 den=0.7283 1  572  end
      arbm-bormod  0.7283 1 1 0 0 5000 100 3 450.0e-6  572  end
      '
      '  450 ppm boron (wt) in moderator
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '      fuel-pin-cell geometry:
      '
      squarepitch   1.43  0.913  1  3  1.074  2  0.930   0  end
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '    assembly and cycle parameters:
      '
      npin/assm=180 fuelnght=957.89 ncycles=3  nlib/cyc=5
      printlevel=5 lightel=9  inplevel=2  numztotal=5  end
      3 0.6413 2 0.6845 3 0.8068 500 2.8238 3 2.8379
      power=30.457 burn=288  down=81      end
      power=34.894 burn=309.0  down=396  temkcyc=865  end
      power=34.016 burn=248.0  down=10 temkcyc=855  end
        o 135  cr  5.9  mn  0.33
        fe 13  co 0.075 ni  9.9
        zr 221 nb  0.71 sn  3.6
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
1   sssssssssss      aaaaaaaaa      sssssssssss     22222222222    hh          hh
   ssssssssssss     aaaaaaaaaa     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
   ssssssssssss     aaaaaaaaaaaaa  ssssssssssss            22    hhhhhhhhhhhhh
    ssssssssssss    aaaaaaaaaaaaa   ssssssssssss          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    ll
   nnn        nn  iiiiiiiiiiii   ccccccccccccc   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  iiiiiiiiiiii   ccccccccccccc   hh         hh  ooooooooooooo   lllllllllllll
   nn         nn  iiiiiiiiiiii    ccccccccccc    hh         hh   ooooooooooo    lllllllllllll
0
     0000000      88888888888            //     0000000      88888888888            //   99999999999    7777777777777
    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
    22222222222       11                          11        22222222222                   5555555555555  5555555555555
   2222222222222     111                         111       2222222222222                  5555555555555  5555555555555
   22         22    1111          :::           1111       22         22         :::      55             55
              22      11          :::             11                  22         :::      55             55
              22      11          :::             11                  22         :::      55             55
            22        11                          11                22                    555555555555   555555555555
          22          11                          11              22                      5555555555555  5555555555555
        22            11          :::             11            22               :::                 55             55
      22              11          :::             11          22                 :::                 55             55
    22                11          :::             11        22                   :::      55         55  55         55
   2222222222222   11111111                    11111111    2222222222222                  5555555555555  5555555555555
   2222222222222   11111111                    11111111    2222222222222                   55555555555    55555555555
1
0                                ssssssssss    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   lllllllllllll eeeeeeeeeeeee
                                 ssssssssss    cccccccccc   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:  08/08/97                              *****
                    *****                                                                *****
                    *****      time of execution:  21:12:55                              *****
                    *****                                                                *****
                    *****                                                                *****
                    **************************************************************************
                    **************************************************************************
                    **************************************************************************
1
0'   ....used 180 fuel rode, 16 guide tubes....
0'
0' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
0'
0                                             nuclide concentrations, grams
                                              basis =single reactor assembly
              initial  1E-18 d
      o 16   1.35E+05  1.35E+05
   total     3.90E+05  3.90E+05
0                                             nuclide concentrations, grams
                                              basis =single reactor assembly
              initial  1E-18 d
      u234   2.80E+02  2.80E+02
      u235   3.13E+04  3.13E+04
      u236   1.40E+02  1.40E+02
      u238   9.68E+05  9.68E+05
   total     1.00E+06  1.00E+06
0                                           basis =
0                   initial         14.4 d         28.8 d         43.2 d         57.6 d         57.6 d
0                   initial         14.4 d         28.8 d         43.2 d         57.6 d         57.6 d
                                            basis = single reactor assembly
              charge    14.4 d    28.8 d    43.2 d    57.6 d    57.6 d
```

```
     o 16   8.41E+03  8.41E+03  8.41E+03  8.41E+03  8.41E+03  8.41E+03
                                          basis = single reactor assembly
            charge    14.4 d    28.8 d    43.2 d    57.6 d    57.6 d
                                          basis = single reactor assembly
            charge    14.4 d    28.8 d    43.2 d    57.6 d    57.6 d
     mo 95   .00E+00  1.45E-05  1.05E-04  3.19E-04  6.84E-04  6.84E-04
                                          basis = single reactor assembly
            charge    14.4 d    28.8 d    43.2 d    57.6 d    57.6 d
                                          basis = single reactor assembly
            charge    14.4 d    28.8 d    43.2 d    57.6 d    57.6 d
   totals  1.14E+04  1.14E+04  1.14E+04  1.14E+04  1.14E+04  1.14E+04
                                          basis = single reactor assembly
            charge    14.4 d    28.8 d    43.2 d    57.6 d    57.6 d
      u233   .00E+00  2.22E-07  4.38E-07  6.47E-07  8.50E-07  8.50E-07
      u234  1.20E+00  1.19E+00  1.18E+00  1.17E+00  1.17E+00  1.17E+00
      u235  1.33E+02  1.31E+02  1.29E+02  1.27E+02  1.24E+02  1.24E+02
      u236  5.93E-01  9.98E-01  1.40E+00  1.79E+00  2.17E+00  2.17E+00
      u238  4.07E+03  4.07E+03  4.07E+03  4.06E+03  4.06E+03  4.06E+03
     np237   .00E+00  3.39E-03  1.02E-02  1.84E-02  2.76E-02  2.76E-02
     pu236   .00E+00  4.84E-11  3.20E-10  9.10E-10  1.86E-09  1.86E-09
     pu238   .00E+00  8.00E-06  6.50E-05  1.99E-04  4.21E-04  4.21E-04
     pu238   .00E+00  8.00E-06  6.50E-05  1.99E-04  4.21E-04  4.21E-04
     pu239   .00E+00  7.86E-01  1.76E+00  2.69E+00  3.56E+00  3.56E+00
     pu240   .00E+00  7.66E-03  3.38E-02  7.66E-02  1.34E-01  1.34E-01
     pu241   .00E+00  1.59E-04  1.43E-03  4.93E-03  1.16E-02  1.16E-02
     pu242   .00E+00  5.17E-07  9.57E-06  5.04E-05  1.60E-04  1.60E-04
                                          basis = single reactor assembly
            charge    14.4 d    28.8 d    43.2 d    57.6 d    57.6 d
     am241   .00E+00  7.06E-08  1.30E-06  6.80E-06  2.15E-05  2.15E-05
    am242m   .00E+00  7.38E-11  2.65E-09  2.04E-08  8.35E-08  8.35E-08
     am243   .00E+00  9.54E-10  3.60E-08  2.89E-07  1.24E-06  1.24E-06
   totals  4.20E+03  4.20E+03  4.20E+03  4.20E+03  4.19E+03  4.19E+03
          decay data, including gamma and total energy, are from endf/b-vi
0                1697    total number of nuclides in library
0                                         nuclide concentrations, grams
                                          basis =single reactor assembly
            initial     1.7 d     3.3 d     5.0 d     6.7 d     8.3 d    10.0 d
     o 16  1.35E+05  1.35E+05  1.35E+05  1.35E+05  1.35E+05  1.35E+05  1.35E+05
0                                         nuclide concentrations, grams
                                          basis =single reactor assembly
            initial     1.7 d     3.3 d     5.0 d     6.7 d     8.3 d    10.0 d
     mo 95  1.20E+01  1.20E+01  1.20E+01  1.21E+01  1.21E+01  1.21E+01  1.21E+01
     tc 99  2.97E-05  2.99E-05  3.00E-05  3.01E-05  3.02E-05  3.02E-05  3.02E-05
0                                         nuclide concentrations, grams
                                          basis =single reactor assembly
            initial     1.7 d     3.3 d     5.0 d     6.7 d     8.3 d    10.0 d
   total  3.90E+05  3.90E+05  3.90E+05  3.90E+05  3.90E+05  3.90E+05  3.90E+05
0                                         nuclide concentrations, grams
                                          basis =single reactor assembly
            initial     1.7 d     3.3 d     5.0 d     6.7 d     8.3 d    10.0 d
      u233  1.75E-03  1.76E-03  1.76E-03  1.76E-03  1.76E-03  1.76E-03  1.76E-03
      u234  1.81E+02  1.81E+02  1.81E+02  1.81E+02  1.81E+02  1.81E+02  1.81E+02
      u235  1.01E+04  1.01E+04  1.01E+04  1.01E+04  1.01E+04  1.01E+04  1.01E+04
      u236  3.74E+03  3.74E+03  3.74E+03  3.74E+03  3.74E+03  3.74E+03  3.74E+03
      u238  9.48E+05  9.48E+05  9.48E+05  9.48E+05  9.48E+05  9.48E+05  9.48E+05
     np237  3.26E+02  3.27E+02  3.28E+02  3.29E+02  3.30E+02  3.31E+02  3.31E+02
     pu236  3.88E-04  3.89E-04  3.89E-04  3.88E-04  3.88E-04  3.88E-04  3.87E-04
     pu238  1.03E+02  1.03E+02  1.04E+02  1.04E+02  1.04E+02  1.04E+02  1.05E+02
     pu238  1.03E+02  1.03E+02  1.04E+02  1.04E+02  1.04E+02  1.04E+02  1.05E+02
     pu239  4.15E+03  4.18E+03  4.20E+03  4.21E+03  4.22E+03  4.23E+03  4.23E+03
     pu240  2.14E+03  2.14E+03  2.14E+03  2.14E+03  2.14E+03  2.14E+03  2.14E+03
     pu241  1.08E+03  1.08E+03  1.08E+03  1.08E+03  1.08E+03  1.08E+03  1.08E+03
     pu242  4.05E+02  4.05E+02  4.05E+02  4.05E+02  4.05E+02  4.05E+02  4.05E+02
     am241  4.12E+01  4.15E+01  4.17E+01  4.19E+01  4.22E+01  4.24E+01  4.27E+01
    am242m  1.03E+00  1.03E+00  1.03E+00  1.03E+00  1.03E+00  1.03E+00  1.03E+00
     am243  6.86E+01  6.87E+01  6.87E+01  6.87E+01  6.87E+01  6.87E+01  6.87E+01
   total  9.71E+05  9.71E+05  9.71E+05  9.71E+05  9.71E+05  9.71E+05  9.71E+05
0                                         element concentrations, grams
0                                         nuclide concentrations, grams
                                          basis =single reactor assembly
            initial     1.7 d     3.3 d     5.0 d     6.7 d     8.3 d    10.0 d
0                                         nuclide concentrations, grams
                                          basis =single reactor assembly
            initial     1.7 d     3.3 d     5.0 d     6.7 d     8.3 d    10.0 d
     mo 95  5.58E+02  5.59E+02  5.61E+02  5.62E+02  5.63E+02  5.64E+02  5.65E+02
     tc 99  6.89E+02  6.91E+02  6.92E+02  6.92E+02  6.92E+02  6.93E+02  6.93E+02
     tc 99m 2.87E-01  2.05E-01  1.35E-01  8.86E-02  5.82E-02  3.82E-02  2.51E-02
     ru101  6.54E+02  6.54E+02  6.54E+02  6.54E+02  6.54E+02  6.54E+02  6.54E+02
     rh103  3.79E+02  3.80E+02  3.81E+02  3.82E+02  3.84E+02  3.85E+02  3.86E+02
     rh103m 4.42E-02  4.29E-02  4.17E-02  4.05E-02  3.93E-02  3.82E-02  3.70E-02
     ag109  7.36E+01  7.38E+01  7.38E+01  7.38E+01  7.38E+01  7.38E+01  7.38E+01
0                                         nuclide concentrations, grams
                                          basis =single reactor assembly
            initial     1.7 d     3.3 d     5.0 d     6.7 d     8.3 d    10.0 d
0                                         nuclide concentrations, grams
                                          basis =single reactor assembly
            initial     1.7 d     3.3 d     5.0 d     6.7 d     8.3 d    10.0 d
     nd143  7.11E+02  7.13E+02  7.15E+02  7.16E+02  7.18E+02  7.19E+02  7.20E+02
     nd145  5.88E+02  5.88E+02  5.88E+02  5.88E+02  5.88E+02  5.88E+02  5.88E+02
     sm147  8.86E+01  8.88E+01  8.90E+01  8.91E+01  8.93E+01  8.95E+01  8.97E+01
0                                         nuclide concentrations, grams
                                          basis =single reactor assembly
            initial     1.7 d     3.3 d     5.0 d     6.7 d     8.3 d    10.0 d
     sm149  2.21E+00  2.74E+00  3.06E+00  3.25E+00  3.36E+00  3.42E+00  3.46E+00
     sm150  2.44E+02  2.44E+02  2.44E+02  2.44E+02  2.44E+02  2.44E+02  2.44E+02
     sm151  1.57E+01  1.58E+01  1.59E+01  1.59E+01  1.59E+01  1.59E+01  1.59E+01
     eu151  1.88E-02  1.94E-02  1.99E-02  2.05E-02  2.10E-02  2.16E-02  2.22E-02
     sm152  1.14E+02  1.14E+02  1.14E+02  1.14E+02  1.14E+02  1.14E+02  1.14E+02
     eu153  9.22E+01  9.26E+01  9.28E+01  9.29E+01  9.30E+01  9.30E+01  9.30E+01
     gd155  3.44E-02  3.69E-02  3.93E-02  4.17E-02  4.42E-02  4.66E-02  4.90E-02
   total  2.87E+04  2.87E+04  2.87E+04  2.87E+04  2.87E+04  2.87E+04  2.87E+04
```

ob170g25plus100boron.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
      obrighiem (kwo) pwr, assm 170, batch 94, 25.93 gwd/mtu 3-cyc June97
      '     ....used 180 fuel rode, 16 guide tubes....
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '   mixtures of fuel-pin-unit-cell:
      '
      44group       latticecell
      uo2  1 den=10.05  1  743
         92234 0.028 92235 3.13 92236 0.014 92238 96.828   end
      kr-83  1 0 1-20 743  end
      kr-85  1 0 1-20 743  end
      y-89   1 0 1-20 743  end
      sr-90  1 0 1-20 743  end
      zr-93  1 0 1-20 743  end
      zr-94  1 0 1-20 743  end
      zr-95  1 0 1-20 743  end
      nb-94  1 0 1-20 743  end
      mo-95  1 0 1-20 743  end
      tc-99  1 0 1-20 743  end
      ru-101 1 0 1-20 743  end
      ru-106 1 0 1-20 743  end
      rh-103 1 0 1-20 743  end
      rh-105 1 0 1-20 743  end
      pd-105 1 0 1-20 743  end
      pd-108 1 0 1-20 743  end
      ag-109 1 0 1-20 743  end
      sb-124 1 0 1-20 743  end
      xe-131 1 0 1-20 743  end
      xe-132 1 0 1-20 743  end
      xe-135 1 0 1-20 743  end
      xe-136 1 0 1-20 743  end
      cs-134 1 0 1-20 743  end
      cs-135 1 0 1-20 743  end
      cs-137 1 0 1-20 743  end
      ba-136 1 0 1-20 743  end
      la-139 1 0 1-20 743  end
      pr-141 1 0 1-20 743  end
      pr-143 1 0 1-20 743  end
      ce-144 1 0 1-20 743  end
      nd-143 1 0 1-20 743  end
      nd-145 1 0 1-20 743  end
      nd-147 1 0 1-20 743  end
      pm-147 1 0 1-20 743  end
      pm-148 1 0 1-20 743  end
      sm-147 1 0 1-20 743  end
      sm-149 1 0 1-20 743  end
      sm-150 1 0 1-20 743  end
      sm-151 1 0 1-20 743  end
      sm-152 1 0 1-20 743  end
      eu-153 1 0 1-20 743  end
      eu-154 1 0 1-20 743  end
      eu-155 1 0 1-20 743  end
      gd-155 1 0 1-20 743  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 1.0 605   end
      h2o  3 den=0.7283 1  572  end
      arbm-bormod  0.7283 1 1 0 0 5000 100 3 550.0e-6  572  end
      '
      '  550 ppm boron (wt) in moderator
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '      fuel-pin-cell geometry:
      '
      squarepitch   1.43  0.913  1  3  1.074  2  0.930   0  end
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '    assembly and cycle parameters:
      '
      npin/assm=180 fuelnght=957.89 ncycles=3  nlib/cyc=5
      printlevel=5 lightel=9  inplevel=2  numztotal=5  end
      3 0.6413 2 0.6845 3 0.8068 500 2.8238 3 2.8379 .
      power=20.929 burn=288  down=81     end
      power=37.468 burn=309.0  down=396  temkcyc=896  end
      power=33.564 burn=248.0  down=10  temkcyc=851  end
        o 135  cr  5.9  mn  0.33
        fe 13  co 0.075 ni  9.9
        zr 221 nb  0.71 sn  3.6
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
1   sssssssssss       aaaaaaaaa       sssssssssss     22222222222    hh          hh
   ssssssssssssss    aaaaaaaaaaa    ssssssssssssss   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
   ssssssssssss     aaaaaaaaaaaaa    ssssssssssss               22     hhhhhhhhhhhhh
    ssssssssssss    aaaaaaaaaaaaa     ssssssssssss           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
```



```
                                  ****************************************************************************
                                  ****************************************************************************
                                  ****************************************************************************
                                  *****                                                                  *****
                                  *****                  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:  21:57:43                                  *****
                                  *****                                                                  *****
                                  *****                                                                  *****
                                  ****************************************************************************
                                  ****************************************************************************
                                  ****************************************************************************

1
0'    ....used 180 fuel rode, 16 guide tubes....
0' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
0'
0                                       nuclide concentrations, grams
                                        basis =single reactor assembly
              initial  1E-18 d
     o 16   1.35E+05  1.35E+05
   total    3.90E+05  3.90E+05
0                                       nuclide concentrations, grams
                                        basis =single reactor assembly
              initial  1E-18 d
     u234   2.80E+02  2.80E+02
     u235   3.13E+04  3.13E+04
     u236   1.40E+02  1.40E+02
     u238   9.68E+05  9.68E+05
   total    1.00E+06  1.00E+06
0                                      basis =
0                  initial        14.4 d        28.8 d        43.2 d        57.6 d        57.6 d
0                  initial        14.4 d        28.8 d        43.2 d        57.6 d        57.6 d
0                                       nuclide concentrations, grams
                                        basis =single reactor assembly
              initial    1.7 d     3.3 d     5.0 d     6.7 d     8.3 d    10.0 d
```

o 16	1.35E+05	1.35E+05	1.35E+05	1.35E+05	1.35E+05	1.35E+05	1.35E+05

0
nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
mo 95	1.09E+01	1.10E+01	1.10E+01	1.10E+01	1.10E+01	1.11E+01	1.11E+01
tc 99	2.35E-05	2.37E-05	2.38E-05	2.38E-05	2.39E-05	2.39E-05	2.39E-05

0
nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
total	3.90E+05	3.90E+05	3.90E+05	3.90E+05	3.90E+05	3.90E+05	3.90E+05

0
nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
u233	1.73E-03	1.73E-03	1.73E-03	1.73E-03	1.73E-03	1.73E-03	1.73E-03
u234	1.87E+02	1.87E+02	1.87E+02	1.87E+02	1.87E+02	1.87E+02	1.87E+02
u235	1.12E+04	1.12E+04	1.12E+04	1.12E+04	1.12E+04	1.12E+04	1.12E+04
u236	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03
u238	9.50E+05	9.50E+05	9.50E+05	9.50E+05	9.50E+05	9.50E+05	9.50E+05
np237	2.97E+02	2.98E+02	2.99E+02	3.00E+02	3.01E+02	3.02E+02	3.02E+02
pu236	3.28E-04	3.29E-04	3.29E-04	3.28E-04	3.28E-04	3.28E-04	3.27E-04
pu238	8.66E+01	8.70E+01	8.73E+01	8.76E+01	8.77E+01	8.79E+01	8.80E+01
pu238	8.66E+01	8.70E+01	8.73E+01	8.76E+01	8.77E+01	8.79E+01	8.80E+01
pu239	4.13E+03	4.17E+03	4.18E+03	4.20E+03	4.20E+03	4.21E+03	4.21E+03
pu240	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03
pu241	1.02E+03	1.02E+03	1.02E+03	1.02E+03	1.01E+03	1.01E+03	1.01E+03
pu242	3.47E+02	3.47E+02	3.47E+02	3.47E+02	3.47E+02	3.47E+02	3.47E+02
am241	3.73E+01	3.75E+01	3.77E+01	3.79E+01	3.82E+01	3.84E+01	3.86E+01
am242m	9.20E-01	9.20E-01	9.20E-01	9.20E-01	9.20E-01	9.20E-01	9.20E-01
am243	5.54E+01	5.55E+01	5.55E+01	5.55E+01	5.55E+01	5.55E+01	5.55E+01
total	9.73E+05	9.73E+05	9.73E+05	9.73E+05	9.73E+05	9.73E+05	9.73E+05

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

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d

0
nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
mo 95	5.15E+02	5.16E+02	5.18E+02	5.19E+02	5.20E+02	5.21E+02	5.22E+02
tc 99	6.44E+02	6.45E+02	6.46E+02	6.46E+02	6.47E+02	6.47E+02	6.47E+02
tc 99m	2.84E-01	2.03E-01	1.33E-01	8.76E-02	5.75E-02	3.78E-02	2.48E-02
ru101	6.06E+02	6.06E+02	6.06E+02	6.06E+02	6.06E+02	6.06E+02	6.06E+02
rh103	3.54E+02	3.55E+02	3.56E+02	3.58E+02	3.59E+02	3.60E+02	3.61E+02
rh103m	4.29E-02	4.17E-02	4.04E-02	3.93E-02	3.81E-02	3.70E-02	3.60E-02
ag109	6.66E+01	6.67E+01	6.67E+01	6.67E+01	6.67E+01	6.67E+01	6.67E+01

0
nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d

0
nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
nd143	6.77E+02	6.79E+02	6.80E+02	6.82E+02	6.83E+02	6.85E+02	6.86E+02
nd145	5.51E+02	5.51E+02	5.51E+02	5.51E+02	5.51E+02	5.51E+02	5.51E+02
sm147	8.12E+01	8.14E+01	8.16E+01	8.18E+01	8.20E+01	8.21E+01	8.23E+01

0
nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
sm149	2.23E+00	2.75E+00	3.05E+00	3.24E+00	3.34E+00	3.41E+00	3.45E+00
sm150	2.25E+02	2.25E+02	2.25E+02	2.25E+02	2.25E+02	2.25E+02	2.25E+02
sm151	1.53E+01	1.54E+01	1.55E+01	1.55E+01	1.55E+01	1.55E+01	1.55E+01
eu151	1.93E-02	1.98E-02	2.03E-02	2.09E-02	2.14E-02	2.20E-02	2.25E-02
sm152	1.07E+02	1.07E+02	1.07E+02	1.07E+02	1.07E+02	1.07E+02	1.07E+02
eu153	8.28E+01	8.32E+01	8.34E+01	8.35E+01	8.35E+01	8.36E+01	8.36E+01
gd155	3.09E-02	3.30E-02	3.52E-02	3.74E-02	3.95E-02	4.17E-02	4.38E-02
total	2.66E+04	2.66E+04	2.66E+04	2.66E+04	2.66E+04	2.66E+04	2.66E+04

ob176g29plus100boron.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
      obrighiem (kwo) pwr, assm 176, batch 90, 29.52 gwd/mtu 3-cyc June 97
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '    mixtures of fuel-pin-unit-cell:
      '
      44group        latticecell
      uo2  1 den=10.05  1  840
         92234 0.028 92235 3.13 92236 0.014 92238 96.828   end
      kr-83   1 0 1-20 840  end
      kr-85   1 0 1-20 840  end
      y-89    1 0 1-20 840  end
      sr-90   1 0 1-20 840  end
      zr-93   1 0 1-20 840  end
      zr-94   1 0 1-20 840  end
      zr-95   1 0 1-20 840  end
      nb-94   1 0 1-20 840  end
      mo-95   1 0 1-20 840  end
      tc-99   1 0 1-20 840  end
      ru-101  1 0 1-20 840  end
      ru-106  1 0 1-20 840  end
      rh-103  1 0 1-20 840  end
      rh-105  1 0 1-20 840  end
      pd-105  1 0 1-20 840  end
      pd-108  1 0 1-20 840  end
      ag-109  1 0 1-20 840  end
      sb-124  1 0 1-20 840  end
      xe-131  1 0 1-20 840  end
      xe-132  1 0 1-20 840  end
      xe-135  1 0 1-20 840  end
      xe-136  1 0 1-20 840  end
      cs-134  1 0 1-20 840  end
      cs-135  1 0 1-20 840  end
      cs-137  1 0 1-20 840  end
      ba-136  1 0 1-20 840  end
      la-139  1 0 1-20 840  end
      pr-141  1 0 1-20 840  end
      pr-143  1 0 1-20 840  end
      ce-144  1 0 1-20 840  end
      nd-143  1 0 1-20 840  end
      nd-145  1 0 1-20 840  end
      nd-147  1 0 1-20 840  end
      pm-147  1 0 1-20 840  end
      pm-148  1 0 1-20 840  end
      sm-147  1 0 1-20 840  end
      sm-149  1 0 1-20 840  end
      sm-150  1 0 1-20 840  end
      sm-151  1 0 1-20 840  end
      sm-152  1 0 1-20 840  end
      eu-153  1 0 1-20 840  end
      eu-154  1 0 1-20 840  end
      eu-155  1 0 1-20 840  end
      gd-155  1 0 1-20 840  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 1.0 605   end
      h2o  3 den=0.7283 1  572  end
      arbm-bormod  0.7283 1 1 0 0 5000 100 3 550.0e-6  572  end
      '
      '  550 ppm boron (wt) in moderator
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '       fuel-pin-cell geometry:
      '
      squarepitch   1.43  0.913  1  3  1.074  2  0.930   0  end
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
      '     assembly and cycle parameters:
      '
      npin/assm=180 fuelnght=957.89 ncycles=3  nlib/cyc=5
      printlevel=5 lightel=9  inplevel=2  numztotal=5  end
      3 0.6413 2 0.6845 3 0.8068 500 2.8238 3 2.8379
      power=32.121 burn=288 down=81    end
      power=36.801 burn=309.0  down=396  temkcyc=883  end
      power=35.875 burn=248.0  down=10  temkcyc=875  end
        o 135  cr  5.9  mn  0.33
        fe 13  co 0.075 ni  9.9
        zr 221 nb  0.71 sn  3.6
      '
      ' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      '
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
   ssssssssssss     aaaaaaaaaaaaa   ssssssssssss                22   hhhhhhhhhhhhh
    ssssssssssss    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    cccccccccc    hh          hh    ooooooooooo    ll
   nnn         nn  iiiiiiiiiiii   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   iiiiiiiiiiii   cccccccccccc   hh          hh  ooooooooooooo    llllllllllll
   nn         nn   iiiiiiiiiiii    cccccccccc    hh          hh   ooooooooooo     llllllllllll
0
      0000000      88888888888              //     0000000     88888888888             //   99999999999    777777777777
     000000000    8888888888888            //     000000000   8888888888888           //   9999999999999   77777777777
    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
    22222222222     22222222222                 22222222222     0000000                  0000000     33333333333
   2222222222222   2222222222222               2222222222222   000000000                000000000   3333333333333
   22         22   22         22      :::      22         22  00       00      :::     00       00  33         33
              22              22      :::                 22  00       00      :::     00       00             33
              22              22      :::                 22  00       00      :::     00       00             33
            22              22                          22    00       00              00       00            333
          22              22                          22      00       00              00       00            333
        22              22            :::           22        00       00      :::     00       00             33
      22              22              :::         22          00       00      :::     00       00             33
    22              22                :::       22             00     00       :::      00     00    33         33
   2222222222222   2222222222222               2222222222222    000000000                000000000   3333333333333
   2222222222222   2222222222222               2222222222222     0000000                  0000000     33333333333
1
0
                              sssssssssss    cccccccccc     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            eeeeeeeee
                              ssssssssssss  cc             aaaaaaaaaaaaa  ll            eeeeeeeee
                                        ss  cc             aa         aa  ll            ee
                                        ss  cc             aa         aa  ll            ee
                             ss         ss  cc          cc aa         aa  ll            ee
                             sssssssssssss  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:  22:20:03                               *****
*****                                                                     *****
*****                                                                     *****
*******************************************************************************
*******************************************************************************
*******************************************************************************
```

```
1
0'
0' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
0'
0                                           nuclide concentrations, grams
                                            basis =single reactor assembly
               initial   1E-18 d
      o 16    1.35E+05  1.35E+05
   total      3.90E+05  3.90E+05
0                                           nuclide concentrations, grams
                                            basis =single reactor assembly
               initial   1E-18 d
      u234    2.80E+02  2.80E+02
      u235    3.13E+04  3.13E+04
      u236    1.40E+02  1.40E+02
      u238    9.68E+05  9.68E+05
   total      1.00E+06  1.00E+06
0                                          basis =
0                    initial        14.4 d         28.8 d         43.2 d         57.6 d         57.6 d
0                    initial        14.4 d         28.8 d         43.2 d         57.6 d         57.6 d
0                                           nuclide concentrations, grams
                                            basis =single reactor assembly
               initial     1.7 d      3.3 d      5.0 d      6.7 d      8.3 d    10.0 d
```

o 16	1.35E+05	1.35E+05	1.35E+05	1.35E+05	1.35E+05	1.35E+05	1.35E+05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
mo 95	1.28E+01	1.28E+01	1.28E+01	1.29E+01	1.29E+01	1.29E+01	1.30E+01
tc 99	3.64E-05	3.66E-05	3.68E-05	3.69E-05	3.69E-05	3.70E-05	3.70E-05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
total	3.90E+05	3.90E+05	3.90E+05	3.90E+05	3.90E+05	3.90E+05	3.90E+05

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
u233	1.80E-03	1.80E-03	1.80E-03	1.80E-03	1.80E-03	1.80E-03	1.80E-03
u234	1.76E+02	1.76E+02	1.76E+02	1.76E+02	1.76E+02	1.76E+02	1.76E+02
u235	9.54E+03	9.54E+03	9.54E+03	9.54E+03	9.54E+03	9.54E+03	9.54E+03
u236	3.83E+03	3.83E+03	3.83E+03	3.83E+03	3.83E+03	3.83E+03	3.83E+03
u238	9.47E+05	9.47E+05	9.47E+05	9.47E+05	9.47E+05	9.47E+05	9.47E+05
np237	3.50E+02	3.52E+02	3.53E+02	3.54E+02	3.55E+02	3.55E+02	3.56E+02
pu236	4.52E-04	4.53E-04	4.53E-04	4.53E-04	4.52E-04	4.52E-04	4.51E-04
pu238	1.18E+02	1.18E+02	1.19E+02	1.19E+02	1.19E+02	1.20E+02	1.20E+02
pu238	1.18E+02	1.18E+02	1.19E+02	1.19E+02	1.19E+02	1.20E+02	1.20E+02
pu239	4.17E+03	4.21E+03	4.23E+03	4.24E+03	4.25E+03	4.25E+03	4.26E+03
pu240	2.25E+03	2.25E+03	2.25E+03	2.25E+03	2.25E+03	2.25E+03	2.25E+03
pu241	1.16E+03	1.16E+03	1.16E+03	1.16E+03	1.16E+03	1.16E+03	1.16E+03
pu242	4.61E+02	4.61E+02	4.61E+02	4.61E+02	4.61E+02	4.61E+02	4.61E+02
am241	4.26E+01	4.29E+01	4.31E+01	4.34E+01	4.36E+01	4.39E+01	4.41E+01
am242m	1.08E+00	1.08E+00	1.08E+00	1.08E+00	1.08E+00	1.08E+00	1.08E+00
am243	8.28E+01	8.30E+01	8.30E+01	8.30E+01	8.30E+01	8.30E+01	8.30E+01
total	9.69E+05	9.69E+05	9.69E+05	9.69E+05	9.69E+05	9.69E+05	9.69E+05

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

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
mo 95	5.84E+02	5.85E+02	5.86E+02	5.87E+02	5.89E+02	5.90E+02	5.91E+02
tc 99	7.22E+02	7.23E+02	7.24E+02	7.25E+02	7.25E+02	7.25E+02	7.26E+02
tc 99m	3.02E-01	2.16E-01	1.42E-01	9.33E-02	6.13E-02	4.03E-02	2.64E-02
ru101	6.89E+02	6.89E+02	6.89E+02	6.89E+02	6.89E+02	6.89E+02	6.89E+02
rh103	3.96E+02	3.97E+02	3.98E+02	4.00E+02	4.01E+02	4.02E+02	4.03E+02
rh103m	4.72E-02	4.58E-02	4.45E-02	4.32E-02	4.19E-02	4.07E-02	3.95E-02
ag109	7.96E+01	7.98E+01	7.98E+01	7.98E+01	7.98E+01	7.98E+01	7.98E+01

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
nd143	7.36E+02	7.38E+02	7.40E+02	7.42E+02	7.43E+02	7.44E+02	7.46E+02
nd145	6.14E+02	6.14E+02	6.14E+02	6.14E+02	6.14E+02	6.14E+02	6.14E+02
sm147	9.03E+01	9.05E+01	9.07E+01	9.09E+01	9.11E+01	9.12E+01	9.14E+01

0 nuclide concentrations, grams
basis =single reactor assembly

	initial	1.7 d	3.3 d	5.0 d	6.7 d	8.3 d	10.0 d
sm149	2.26E+00	2.84E+00	3.18E+00	3.38E+00	3.50E+00	3.57E+00	3.61E+00
sm150	2.60E+02	2.60E+02	2.60E+02	2.60E+02	2.60E+02	2.60E+02	2.60E+02
sm151	1.64E+01	1.65E+01	1.66E+01	1.66E+01	1.66E+01	1.66E+01	1.66E+01
eu151	1.84E-02	1.90E-02	1.95E-02	2.01E-02	2.07E-02	2.13E-02	2.19E-02
sm152	1.19E+02	1.19E+02	1.19E+02	1.19E+02	1.19E+02	1.19E+02	1.19E+02
eu153	9.95E+01	9.99E+01	1.00E+02	1.00E+02	1.00E+02	1.00E+02	1.00E+02
gd155	3.66E-02	3.92E-02	4.18E-02	4.44E-02	4.70E-02	4.96E-02	5.22E-02
total	3.03E+04	3.03E+04	3.03E+04	3.03E+04	3.03E+04	3.03E+04	3.03E+04