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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 theTurkey Point 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 5.10. Reference 5.4 provides information on molar masses; the assembly design, power history and operating parameters are obtained from References 5.5 through 5.8; the cladding composition from Reference 5.9; and a list of trace elements in the fuel is derived from Reference 5.10.

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,
6.02×10^{23} atoms per mole. (Reference 5.4)

General spent fuel characteristics for each pellet sample are presented in Table 4-1 and include the initial ^{235}U enrichment, final burnup and the cooling time (Table 1, Reference 5.5). The initial enrichment for all samples is 2.556 wt% ^{235}U and the burnup ranges from 30.510 to 31.560 GWd/MTU. The cooling time is the same for all samples and is 927 days.

Assembly design parameters are presented in Table 4-2 (Table 9, Reference 5.5; Table 8, Reference 5.6). The samples come from a Westinghouse 15 x 15 assembly with 20 guide tube positions and one instrument tube, which were empty during operation. A cross section of a Westinghouse 15 x 15 assembly is presented in Figure 4-1 (Figure 3, Reference 5.5). An assembly pitch could not be obtained for Turkey Point, therefore, the assembly pitch is obtained from the H. B. Robinson assembly, which is also a Westinghouse 15 x 15 assembly (Table 8, Reference 5.6). It is noted that the fuel loading per assembly given in Reference 5.5 indicates 456.9 kg UO_2; however, Reference 5.6 indicates that the initial loading is 456.9 kg U. Furthermore, Table 2.2 in Reference 5.7 includes assembly design information for a typical Westinghouse 15 x 15 assembly and indicates that the initial loading is 458.97 kg U, which is similar to that presented in Reference 5.6. Therefore, it is believed that the units for the fuel loading is misprinted in Reference 5.5 and a uranium loading of 456.9 kg U is used. The initial enrichments for ^{234}U, ^{235}U, ^{236}U, and ^{238}U are given in Table 4-3 (Table 10, Reference 5.5).

The operating parameters in Table 4-4 include the cycle start and stop dates, uptime and downtime, specific powers, operating temperatures, and moderator conditions (Tables 9, 11 and 12, Reference 5.5; Table 3.8, Reference 5.8). Since cycle specific data for the specific power could not be obtained, the specific power was calculated from the final burnup and the total irradiation time, and approximated as constant over the three cycles (p. 17, Reference 5.5).

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 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 5.6). Variations in light element masses per unit fuel in different PWRs are small when compared to this generic set (p. 2-2, Reference 5.9). This data is provided in units of kg/MTUO_2 or kg/MTU depending on the units required in the analysis.

Measured isotopic concentrations are presented in Tables 4-7 and are given in mg/gU (Appendix E, Reference 5.5). The measurements were performed at the BCL for the Climax Spent Fuel Test Materials for samples from rods G09, G10, and H09 from assembly D01 and rods G09 and G10 from assembly D04.

Table 4-1. Spent Fuel Characteristic Parameters for Samples from Turkey Point Unit 3 PWR

Assembly and Rod Number	Axial Location from Bottom of Assembly, cm	Enrichment, wt % ^{235}U	Burnup, GWd/MTU	Cooling Time, days
D01 (G09)	167.6	2.556	30.720	927
D01 (G10)	167.0	2.556	30.510	927
D01 (H09)	167.0	2.556	31.560	927
D04 (G09)	167.6	2.556	31.260	927
D04 (G10)	167.0	2.556	31.310	927

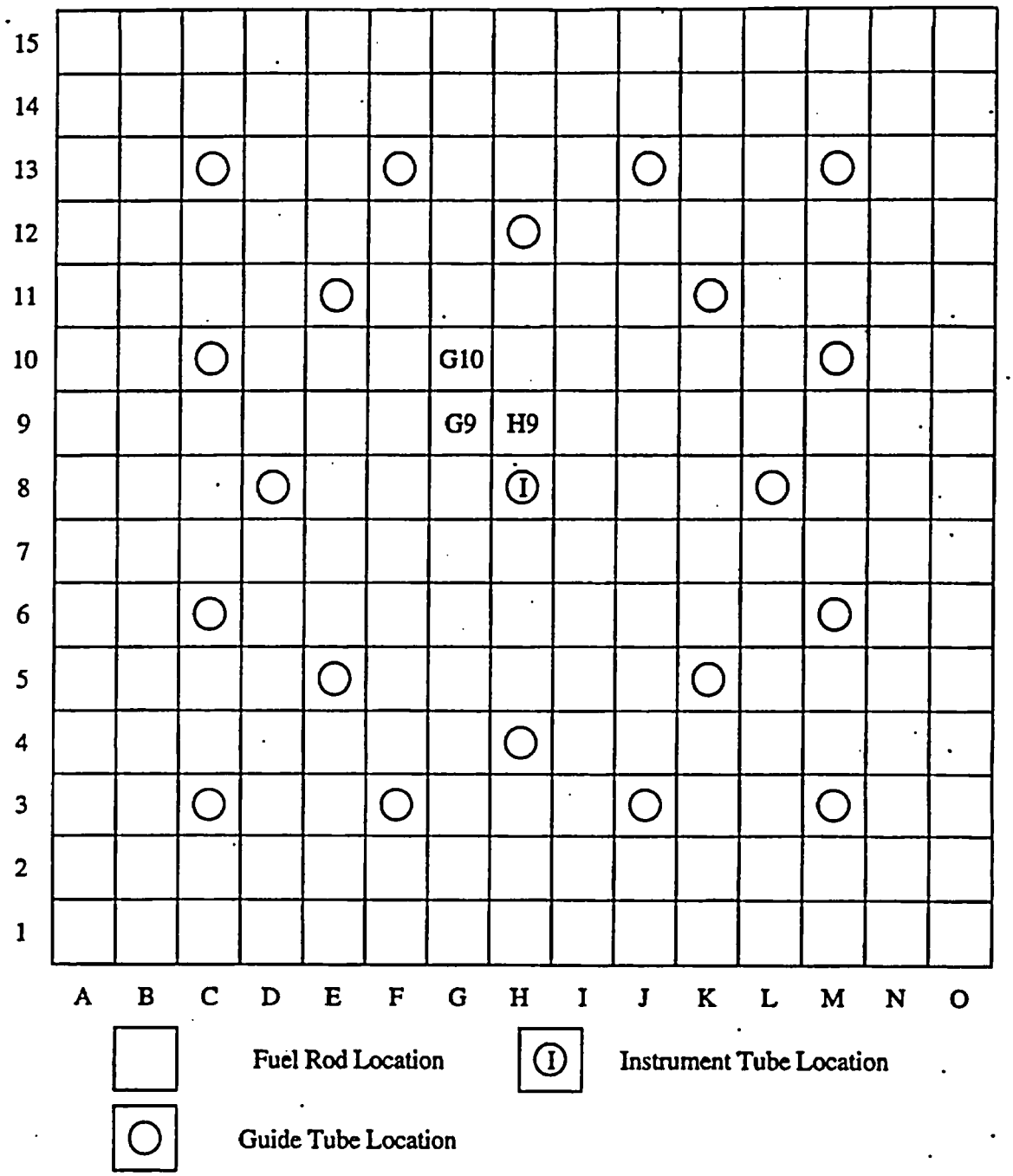
Reference 5.5

Table 4-2. Assembly Design Parameters for Turkey Point Unit 3 PWR

Parameter	Data
Assembly general data:	
Designer	Westinghouse
Lattice	15 x 15
Number of Fuel Rods	204
Number of Guide Tubes	20
Number of Instrument Tubes	1
Assembly Pitch, cm	21.50
Assembly Mass, kg U	456.9
Fuel Rod Data:	
Type of Fuel Pellet	UO_2
Pellet Stack Density, g/cm^3	10.235
Rod Pitch, cm	1.4300
Rod Outside Diameter (OD), cm	1.0719
Rod Inside Diameter (ID), cm	0.9484
Pellet Diameter, cm	0.9296
Active Fuel Length, cm	365.76
Clad Material	Zircaloy-4
Guide Tube Data:	
Inner Radius, cm	0.6502
Outer Radius, cm	0.6934
Tube Material	Zircaloy-4

References 5.5, and 5.6

Figure 4-1. Cross Section of Turkey Point Assembly



Reference 5.5

Table 4-3. Fuel Composition by Assembly for Turkey Point Unit 3 PWR

Parameter	D01	D04
Enrichment,		
wt % ^{235}U	2.556	2.556
wt % ^{234}U	0.023	0.023
wt % ^{236}U	0.012	0.012
wt % ^{238}U	97.409	97.409

Reference 5.5

Table 4-4. Operating Data for Turkey Point Unit 3 PWR

	Sample	Cycle 2	Cycle 3	Cycle 4
Cycle Start	all	12/16/74	12/23/75	1/16/77
Cycle End	all	10/26/75	11/15/76	11/24/77
Uptime, days	all	314	327	312
Downtime, days	all	58	62	927
Specific Power, MW/MTU	D01 (G09)	32.235		
	D01 (G10)	32.015		
	D01 (H09)	33.116		
	D04 (G09)	32.802		
	D04 (G10)	32.854		
Fuel Temperature, K	all	922		
Cladding Temperature, K	all	595		
Moderator Temperature, K	all	570		
Moderator Density, g/cm^3	all	0.731		
Boron concentration, ppm (wt)	all	450		

References 5.5 and 5.8

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 a 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 5.6

Table 4-8. Measured Isotopic Concentrations (mg/g U)

Axial Location, cm	167.6	167.0	167.0	167.6	167.0
Sample Identification	D01 (G09)	D01 (G10)	D01 (H09)	D04 (G09)	D04 (G10)
Burnup, GWd/MTU	30.720	30.510	31.560	31.260	31.310
^{234}U	1.321E-01	1.321E-01	1.225E-01	1.131E-01	1.320E-01
^{235}U	5.865E00	5.676E00	5.584E00	5.509E00	5.662E00
^{236}U	3.254E00	3.255E00	3.174E00	3.156E00	3.252E00
^{238}U	9.502E02	9.506E02	9.495E02	9.499E02	9.498E02
^{238}Pu	1.365E-01	1.360E-01	1.426E-01	1.382E-01	1.372E-01
^{239}Pu	4.838E00	4.840E00	4.930E00	4.941E00	4.788E00
^{240}Pu	2.266E00	2.294E00	2.295E00	2.320E00	2.278E00
^{241}Pu	1.061E00	1.068E00	1.104E00	1.124E00	1.072E00
^{242}Pu	5.020E-01	5.248E-01	5.477E-01	5.428E-01	5.235E-01

Reference 5.5

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

Not applicable.

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

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

5.7 *Physical and Decay Characteristics of Commercial LWR Spent Fuel*, ORNL/TM-9591 Vol. 1.

5.8 *Fuel Inventory and Afterheat Power Studies of Uranium-Fueled Pressurized-Water-Reactor Fuel Assemblies Using the SAS2 and ORIGEN-S Modules of SCALE with and ENDF/B-V Updated Cross Section Library*, NUREG/CR-2397, ORNL/CSD-90.

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 Software

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 pellet sample 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 Turkey Point samples using the preferred 44GROUPNDF5 cross-section library. To properly model the neutron flux spectrum and the nuclide composition changes, it is necessary to define the 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 sample specific, while the lattice type is "latticecell" to reflect the array characteristic of the assembly.

7.2 SCALE Input Data Block 4

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

The fuel mixture is specified as UO_2 with a density and isotopic weight percentages from Tables 4-2 and 4-3 and a fuel temperature from Table 4-4. 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 of cycle 2, 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 pin, cladding and pitch dimensions are given in Table 4-2 with the mixture number for each composition defined in Section 7.2. The gap mixture is defined as 0.

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

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

$$Length = \frac{1}{\frac{\pi}{4}(POD)^2(PDen)(NFR)} * \frac{270gUO_2}{238gU} * \frac{10^6gU}{1MTU} \qquad \text{Equation 7-1}$$

Where:

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

Since measured isotopic concentrations are presented in milligrams of isotope per gram of uranium 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 a Turkey Point assembly is 800.54 cm.

The samples were 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 is nine and is determined from Table 4-7, while the number of zones is 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 Turkey Point is a centralized guide tube unit cell surrounded by an homogenized fuel and moderator mixture that conserves the fuel to moderator ratio, and is further surrounded by moderator between assemblies. All of the following equations used to determine the Path B model dimensions are derived. The equation below is used to determine the number of fuel unit cells that surround the central guide tube. 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.

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

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

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

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

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

Where:

x = Number of Unit Fuel Cells per 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
ITOD = Instrument Tube Outer Diameter
ITID = Instrument Tube Inner Diameter
FV = Fuel Volume of One Fuel Unit Cell
MV = Moderator Volume of One Fuel Unit Cell

Once the number of fuel cells per guide tube is determined, the geometry of the Path B model is calculated. Since the guide tube cell is centralized, the dimensions of the first two zones are the same as the guide tube inner and outer radii. 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, 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 rod-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
0.5087	1.8626	0.6787	1.1425	9.7143

Table 7-2. Path B Model Dimensions

	R_1	R_2	R_3	R_4	R_5
Radius, cm	0.6502	0.6934	0.8068	2.6408	2.6470
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 and are found in Table 4-4. The fuel temperature, moderator density and boron concentration are constant over the three cycles, and therefore, the options to specify cycle specific values.

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.

Measured concentrations presented in Table 4-6 have units of mg of isotope per g of U, while calculated concentrations presented in Table 7-3 have units of g of isotope per Metric Ton of U. Therefore, the measured concentrations must be multiplied by 10^3 gU/MTU to obtain similar units. Percent differences are presented in Table 7-4.

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 to calculated ratios, are presented in Table 7-4.

Table 7-3. Calculated concentrations (g/MTU)

Axial Location, cm	167.6	167.0	167.0	167.6	167.0
Sample Identification	D01 (G09)	D01 (G10)	D01 (H09)	D04 (G09)	D04 (G10)
Burnup, GWd/MTU	30.720	30.510	31.560	31.260	31.310
^{234}U	1.34E2	1.35E2	1.32E2	1.33E2	1.33E2
^{235}U	5.55E3	5.61E3	5.29E3	5.38E3	5.37E3
^{236}U	3.35E3	3.34E3	3.37E3	3.36E3	3.37E3
^{238}U	9.49E5	9.49E5	9.48E5	9.49E5	9.49E5
^{238}Pu	1.35E2	1.33E2	1.42E2	1.40E2	1.40E2
^{239}Pu	5.05E3	5.05E3	5.06E3	5.06E3	5.06E3
^{240}Pu	2.34E3	2.33E3	2.39E3	2.37E3	2.38E3
^{241}Pu	1.07E3	1.06E3	1.09E3	1.08E3	1.08E3
^{242}Pu	5.45E2	5.37E2	5.77E2	5.65E2	5.67E2

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

Axial Location, cm	167.6	167.0	167.0	167.6	167.0
Sample Identification	D01 (G09)	D01 (G10)	D01 (H09)	D04 (G09)	D04 (G10)
Burnup, GWd/MTU	30.720	30.510	31.560	31.260	31.310
^{234}U	1.44	2.20	7.76	17.60	0.76
^{235}U	-5.37	-1.16	-5.27	-2.34	-5.16
^{236}U	2.95	2.61	6.18	6.46	3.63
^{238}U	-0.13	-0.17	-0.16	-0.09	-0.08
^{238}Pu	-1.10	-2.21	-0.42	1.30	2.04
^{239}Pu	4.38	4.34	2.64	2.41	5.68
^{240}Pu	3.27	1.57	4.14	2.16	4.48
^{241}Pu	0.85	-0.75	-1.27	-3.91	0.75
^{242}Pu	8.57	2.32	5.35	4.09	8.31

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 has a tendency to over-predict ^{234}U, ^{236}U, ^{239}Pu, ^{240}Pu, and ^{242}Pu, while it tends to under-predict ^{235}U. 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.

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

In general the SAS2H module of SCALE is adequate in predicting isotopic concentrations for samples from Turkey Point, 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. More detailed operating data are 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 five pages and contains the input files used in the modeling of the Turkey Point Unit 3 samples. A description of the parameters contained within the input files is found in Sections 7.1 through 7.5.

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

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

tpd01g09.input

```
=sas2h    parm=skipshipdata
Turkey Point 3, assembly D01 rod G09, 30.720 GWd/MTU, June 97
'
'
'-----------------------------
'
'    mixtures of fuel-pin-unitcell:
'
44group      latticecell
'
'
'
uo2  1 den=10.235 1 922
  92234 0.023 92235 2.556 92236 0.012 92238 97.409  end
kr-83  1 0 1-20 922  end
kr-85  1 0 1-20 922  end
y-89   1 0 1-20 922  end
sr-90  1 0 1-20 922  end
zr-93  1 0 1-20 922  end
zr-94  1 0 1-20 922  end
zr-95  1 0 1-20 922  end
nb-94  1 0 1-20 922  end
mo-95  1 0 1-20 922  end
tc-99  1 0 1-20 922  end
ru-101 1 0 1-20 922  end
ru-106 1 0 1-20 922  end
rh-103 1 0 1-20 922  end
rh-105 1 0 1-20 922  end
pd-105 1 0 1-20 922  end
pd-108 1 0 1-20 922  end
ag-109 1 0 1-20 922  end
sb-124 1 0 1-20 922  end
xe-131 1 0 1-20 922  end
xe-132 1 0 1-20 922  end
xe-135 1 0 1-20 922  end
xe-136 1 0 1-20 922  end
cs-134 1 0 1-20 922  end
cs-135 1 0 1-20 922  end
cs-137 1 0 1-20 922  end
ba-136 1 0 1-20 922  end
la-139 1 0 1-20 922  end
pr-141 1 0 1-20 922  end
pr-143 1 0 1-20 922  end
ce-144 1 0 1-20 922  end
nd-143 1 0 1-20 922  end
nd-145 1 0 1-20 922  end
nd-147 1 0 1-20 922  end
pm-147 1 0 1-20 922  end
pm-148 1 0 1-20 922  end
sm-147 1 0 1-20 922  end
sm-149 1 0 1-20 922  end
sm-150 1 0 1-20 922  end
sm-151 1 0 1-20 922  end
sm-152 1 0 1-20 922  end
eu-153 1 0 1-20 922  end
eu-154 1 0 1-20 922  end
eu-155 1 0 1-20 922  end
gd-155 1 0 1-20 922  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 1.0 595   end
h2o 3 den=0.731  1  570 end
arbm-bormod  0.731 1 1 0 0 5000 100 3 450.0e-6  570  end
'
'   450 ppm boron (wt) in moderator
'-----------------------------
end comp
'
'-----------------------------
'
'   fuel-pin-cell geometry:
'
squarepitch   1.4300  0.9296 1 3 1.0719 2 0.9484 0  end
'
'
'-----------------------------
'
'    assembly and cycle parameters:
'
npin/assm=204 fuelnght=800.54 ncycles=3 nlib/cyc=5
printlevel=5 lightel=9 inplevel=2 numztotal=5 end
3 0.6502 2 0.6934 3 0.8068 500 2.6408 3 2.6470
power=32.235 burn=314 down=58 end
power=32.235 burn=327 down=62 end
power=32.235 burn=312 down=927 end
        o 135   cr 5.9   mn 0.33
        fe 13.0 co 0.075 ni 9.9
        zr 221  nb 0.71  sn 3.6
'
'-----------------------------
'
end
```

tpd01g10.input

```
=sas2h    parm=skipshipdata
Turkey Point 3, assembly D01 rod G10, 30.51 GWd/MTU, June 97
'
'
'-----------------------------
'
'    mixtures of fuel-pin-unitcell:
'
44group      latticecell
'
'
'
uo2  1 den=10.235 1 922
  92234 0.023 92235 2.556 92236 0.012 92238 97.409  end
kr-83  1 0 1-20 922  end
kr-85  1 0 1-20 922  end
y-89   1 0 1-20 922  end
sr-90  1 0 1-20 922  end
zr-93  1 0 1-20 922  end
zr-94  1 0 1-20 922  end
zr-95  1 0 1-20 922  end
nb-94  1 0 1-20 922  end
mo-95  1 0 1-20 922  end
tc-99  1 0 1-20 922  end
ru-101 1 0 1-20 922  end
ru-106 1 0 1-20 922  end
rh-103 1 0 1-20 922  end
rh-105 1 0 1-20 922  end
pd-105 1 0 1-20 922  end
pd-108 1 0 1-20 922  end
ag-109 1 0 1-20 922  end
sb-124 1 0 1-20 922  end
xe-131 1 0 1-20 922  end
xe-132 1 0 1-20 922  end
xe-135 1 0 1-20 922  end
xe-136 1 0 1-20 922  end
cs-134 1 0 1-20 922  end
cs-135 1 0 1-20 922  end
cs-137 1 0 1-20 922  end
ba-136 1 0 1-20 922  end
la-139 1 0 1-20 922  end
pr-141 1 0 1-20 922  end
pr-143 1 0 1-20 922  end
ce-144 1 0 1-20 922  end
nd-143 1 0 1-20 922  end
nd-145 1 0 1-20 922  end
nd-147 1 0 1-20 922  end
pm-147 1 0 1-20 922  end
pm-148 1 0 1-20 922  end
sm-147 1 0 1-20 922  end
sm-149 1 0 1-20 922  end
sm-150 1 0 1-20 922  end
sm-151 1 0 1-20 922  end
sm-152 1 0 1-20 922  end
eu-153 1 0 1-20 922  end
eu-154 1 0 1-20 922  end
eu-155 1 0 1-20 922  end
gd-155 1 0 1-20 922  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 1.0 595   end
h2o 3 den=0.731  1  570 end
arbm-bormod  0.731 1 1 0 0 5000 100 3 450.0e-6  570  end
'
'   450 ppm boron (wt) in moderator
'-----------------------------
end comp
'
'-----------------------------
'
'   fuel-pin-cell geometry:
'
squarepitch   1.4300  0.9296 1 3 1.0719 2 0.9484 0  end
'
'
'-----------------------------
'
'   assembly and cycle parameters:
'
npin/assm=204 fuelnght=800.54 ncycles=3 nlib/cyc=5
printlevel=5 lightel=9 inplevel=2 numztotal=5 end
3 0.6502 2 0.6934 3 0.8068 500 2.6408 3 2.6470
power=32.015 burn=314 down=58 end
power=32.015 burn=327 down=62 end
power=32.015 burn=312 down=927 end
        o 135   cr 5.9   mn 0.33
        fe 13.0 co 0.075 ni 9.9
        zr 221  nb 0.71  sn 3.6
'
'-----------------------------
'
end
```

tpd01h09.input

```
=sas2h    parm=skipshipdata
Turkey Point 3, assembly D01 rod H09, 31.56 GWd/MTU, June 97
'
'
'-----------------------------
'
'    mixtures of fuel-pin-unitcell:
'
44group      latticecell
'
'
'
uo2  1 den=10.235 1 922
  92234 0.023 92235 2.556 92236 0.012 92238 97.409  end
kr-83  1 0 1-20 922  end
kr-85  1 0 1-20 922  end
y-89   1 0 1-20 922  end
sr-90  1 0 1-20 922  end
zr-93  1 0 1-20 922  end
zr-94  1 0 1-20 922  end
zr-95  1 0 1-20 922  end
nb-94  1 0 1-20 922  end
mo-95  1 0 1-20 922  end
tc-99  1 0 1-20 922  end
ru-101 1 0 1-20 922  end
ru-106 1 0 1-20 922  end
rh-103 1 0 1-20 922  end
rh-105 1 0 1-20 922  end
pd-105 1 0 1-20 922  end
pd-108 1 0 1-20 922  end
ag-109 1 0 1-20 922  end
sb-124 1 0 1-20 922  end
xe-131 1 0 1-20 922  end
xe-132 1 0 1-20 922  end
xe-135 1 0 1-20 922  end
xe-136 1 0 1-20 922  end
cs-134 1 0 1-20 922  end
cs-135 1 0 1-20 922  end
cs-137 1 0 1-20 922  end
ba-136 1 0 1-20 922  end
la-139 1 0 1-20 922  end
pr-141 1 0 1-20 922  end
pr-143 1 0 1-20 922  end
ce-144 1 0 1-20 922  end
nd-143 1 0 1-20 922  end
nd-145 1 0 1-20 922  end
nd-147 1 0 1-20 922  end
pm-147 1 0 1-20 922  end
pm-148 1 0 1-20 922  end
sm-147 1 0 1-20 922  end
sm-149 1 0 1-20 922  end
sm-150 1 0 1-20 922  end
sm-151 1 0 1-20 922  end
sm-152 1 0 1-20 922  end
eu-153 1 0 1-20 922  end
eu-154 1 0 1-20 922  end
eu-155 1 0 1-20 922  end
gd-155 1 0 1-20 922  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 1.0 595   end
h2o 3 den=0.731  1  570 end
arbm-bormod  0.731 1 1 0 0 5000 100 3 450.0e-6  570  end
'
'   450 ppm boron (wt) in moderator
'-----------------------------
end comp
'
'-----------------------------
'
'    fuel-pin-cell geometry:
'
squarepitch   1.4300  0.9296 1 3 1.0719 2 0.9484 0  end
'
'
'-----------------------------
'
'    assembly and cycle parameters:
'
npin/assm=204 fuelnght=800.54 ncycles=3 nlib/cyc=5
printlevel=5 lightel=9 inplevel=2 numztotal=5 end
3 0.6502 2 0.6934 3 0.8068 500 2.6408 3 2.6470
power=33.116 burn=314 down=58 end
power=33.116 burn=327 down=62 end
power=33.116 burn=312 down=927 end
        o 135   cr 5.9   mn 0.33
        fe 13.0 co 0.075 ni 9.9
        zr 221  nb 0.71  sn 3.6
'
'-----------------------------
'
end
```

tpd04g09.input

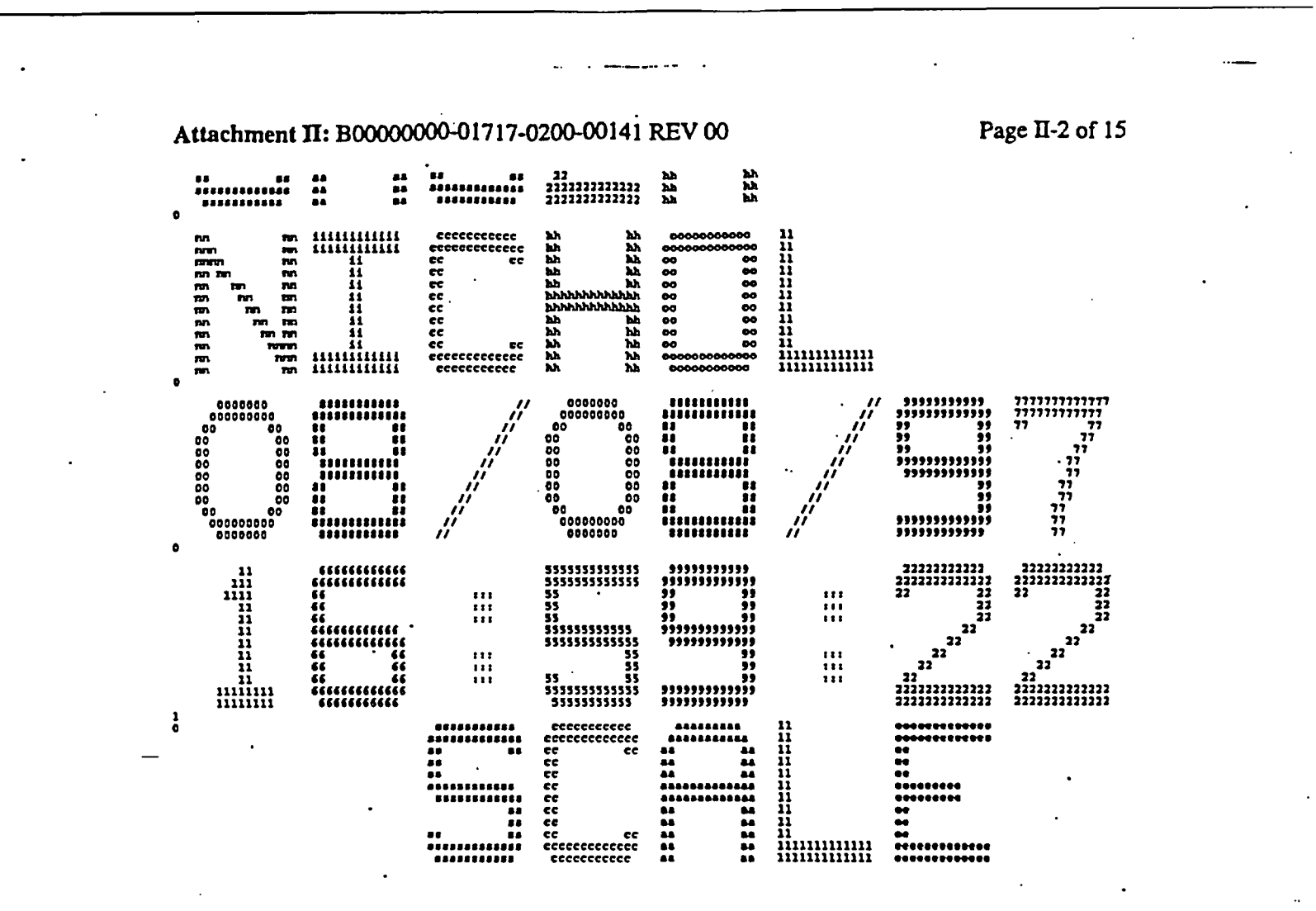
```
=sas2h    parm=skipshipdata
Turkey Point 3, assembly D04 rod G09, 31.26 GWd/MTU, June 97
'
'
'-----------------------------
'
'    mixtures of fuel-pin-unitcell:
'
44group      latticecell
'
'
'
uo2  1 den=10.235 1 922
 92234 0.023 92235 2.556 92236 0.012 92238 97.409  end
kr-83  1 0 1-20 922  end
kr-85  1 0 1-20 922  end
y-89   1 0 1-20 922  end
sr-90  1 0 1-20 922  end
zr-93  1 0 1-20 922  end
zr-94  1 0 1-20 922  end
zr-95  1 0 1-20 922  end
nb-94  1 0 1-20 922  end
mo-95  1 0 1-20 922  end
tc-99  1 0 1-20 922  end
ru-101 1 0 1-20 922  end
ru-106 1 0 1-20 922  end
rh-103 1 0 1-20 922  end
rh-105 1 0 1-20 922  end
pd-105 1 0 1-20 922  end
pd-108 1 0 1-20 922  end
ag-109 1 0 1-20 922  end
sb-124 1 0 1-20 922  end
xe-131 1 0 1-20 922  end
xe-132 1 0 1-20 922  end
xe-135 1 0 1-20 922  end
xe-136 1 0 1-20 922  end
cs-134 1 0 1-20 922  end
cs-135 1 0 1-20 922  end
cs-137 1 0 1-20 922  end
ba-136 1 0 1-20 922  end
la-139 1 0 1-20 922  end
pr-141 1 0 1-20 922  end
pr-143 1 0 1-20 922  end
ce-144 1 0 1-20 922  end
nd-143 1 0 1-20 922  end
nd-145 1 0 1-20 922  end
nd-147 1 0 1-20 922  end
pm-147 1 0 1-20 922  end
pm-148 1 0 1-20 922  end
sm-147 1 0 1-20 922  end
sm-149 1 0 1-20 922  end
sm-150 1 0 1-20 922  end
sm-151 1 0 1-20 922  end
sm-152 1 0 1-20 922  end
eu-153 1 0 1-20 922  end
eu-154 1 0 1-20 922  end
eu-155 1 0 1-20 922  end
gd-155 1 0 1-20 922  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 1.0 595   end
h2o 3 den=0.731  1  570 end
arbm-bormod  0.731 1 1 0 0 5000 100 3 450.0e-6  570  end
'
'   450 ppm boron (wt) in moderator
'-----------------------------
end comp
'
'-----------------------------
'
'    fuel-pin-cell geometry:
'
squarepitch   1.4300  0.9296 1 3 1.0719 2 0.9484 0  end
'
'
'-----------------------------
'
'    assembly and cycle parameters:
'
npin/assm=204 fuelnght=800.54 ncycles=3 nlib/cyc=5
printlevel=5 lightel=9 inplevel=2 numztotal=5 end
3 0.6502 2 0.6934 3 0.8068 500 2.6408 3 2.6470
power=32.802 burn=314 down=58 end
power=32.802 burn=327 down=62 end
power=32.802 burn=312 down=927 end
        o 135   cr 5.9   mn 0.33
        fe 13.0 co 0.075 ni 9.9
        zr 221  nb 0.71  sn 3.6
'
'-----------------------------
'
end
```

tpd04g10.input

```
=sas2h    parm=skipshipdata
Turkey Point 3, assembly D04 rod G10, 31.31 GWd/MTU, June 97
'
'
'-----------------------------
'
'    mixtures of fuel-pin-unitcell:
'
44group      latticecell
'
'
'
uo2  1 den=10.235 1 922
 92234 0.023 92235 2.556 92236 0.012 92238 97.409  end
kr-83  1 0 1-20 922  end
kr-85  1 0 1-20 922  end
y-89  1 0 1-20 922  end
sr-90  1 0 1-20 922  end
zr-93  1 0 1-20 922  end
zr-94  1 0 1-20 922  end
zr-95  1 0 1-20 922  end
nb-94  1 0 1-20 922  end
mo-95  1 0 1-20 922  end
tc-99  1 0 1-20 922  end
ru-101 1 0 1-20 922  end
ru-106 1 0 1-20 922  end
rh-103 1 0 1-20 922  end
rh-105 1 0 1-20 922  end
pd-105 1 0 1-20 922  end
pd-108 1 0 1-20 922  end
ag-109 1 0 1-20 922  end
sb-124 1 0 1-20 922  end
xe-131 1 0 1-20 922  end
xe-132 1 0 1-20 922  end
xe-135 1 0 1-20 922  end
xe-136 1 0 1-20 922  end
cs-134 1 0 1-20 922  end
cs-135 1 0 1-20 922  end
cs-137 1 0 1-20 922  end
ba-136 1 0 1-20 922  end
la-139 1 0 1-20 922  end
pr-141 1 0 1-20 922  end
pr-143 1 0 1-20 922  end
ce-144 1 0 1-20 922  end
nd-143 1 0 1-20 922  end
nd-145 1 0 1-20 922  end
nd-147 1 0 1-20 922  end
pm-147 1 0 1-20 922  end
pm-148 1 0 1-20 922  end
sm-147 1 0 1-20 922  end
sm-149 1 0 1-20 922  end
sm-150 1 0 1-20 922  end
sm-151 1 0 1-20 922  end
sm-152 1 0 1-20 922  end
eu-153 1 0 1-20 922  end
eu-154 1 0 1-20 922  end
eu-155 1 0 1-20 922  end
gd-155 1 0 1-20 922  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 1.0 595   end
h2o 3 den=0.731  1  570 end
arbm-bormod  0.731 1 1 0 0 5000 100 3 450.0e-6  570  end
'
'  450 ppm boron (wt) in moderator
'-----------------------------
end comp
'
'-----------------------------
'
'   fuel-pin-cell geometry:
'
squarepitch  1.4300  0.9296 1 3 1.0719 2 0.9484 0  end
'
'
'-----------------------------
'
'   assembly and cycle parameters:
'
npin/assm=204 fuelnght=800.54 ncycles=3 nlib/cyc=5
printlevel=5 lightel=9 inplevel=2 numztotal=5 end
3 0.6502 2 0.6934 3 0.8068 500 2.6408 3 2.6470
power=32.854 burn=314 down=58 end
power=32.854 burn=327 down=62 end
power=32.854 burn=312 down=927 end
        o 135   cr 5.9   mn 0.33
        fe 13.0 co 0.075 ni 9.9
        zr 221  nb 0.71  sn 3.6
'
'-----------------------------
'
end
```

tpd01g09.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
      Turkey Point 3, assembly D01 rod G09, 30.720 GWd/MTU, June 97
      *
      *
      *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      *
      *       mixtures of fuel-pin-unitcell:
      *
      44group        latticecell
      *
      *
      *.
      uo2  1 den=10.235 1 922
        92234 0.023 92235 2.556 92236 0.012 92238 97.409  end
      kr-83  1 0 1-20 922  end
      kr-85  1 0 1-20 922  end
      y-89   1 0 1-20 922  end
      sr-90  1 0 1-20 922  end
      sr-93  1 0 1-20 922  end
      sr-94  1 0 1-20 922  end
      sr-95  1 0 1-20 922  end
      nb-94  1 0 1-20 922  end
      mo-95  1 0 1-20 922  end
      tc-99  1 0 1-20 922  end
      ru-101 1 0 1-20 922  end
      ru-106 1 0 1-20 922  end
      rh-103 1 0 1-20 922  end
      rh-105 1 0 1-20 922  end
      pd-105 1 0 1-20 922  end
      pd-108 1 0 1-20 922  end
      ag-109 1 0 1-20 922  end
      sb-124 1 0 1-20 922  end
      xe-131 1 0 1-20 922  end
      xe-132 1 0 1-20 922  end
      xe-135 1 0 1-20 922  end
      xe-136 1 0 1-20 922  end
      cs-134 1 0 1-20 922  end
      cs-135 1 0 1-20 922  end
      cs-137 1 0 1-20 922  end
      ba-136 1 0 1-20 922  end
      la-139 1 0 1-20 922  end
      pr-141 1 0 1-20 922  end
      pr-143 1 0 1-20 922  end
      ce-144 1 0 1-20 922  end
      nd-143 1 0 1-20 922  end
      nd-145 1 0 1-20 922  end
      nd-147 1 0 1-20 922  end
      pm-147 1 0 1-20 922  end
      pm-148 1 0 1-20 922  end
      sm-147 1 0 1-20 922  end
      sm-149 1 0 1-20 922  end
      sm-150 1 0 1-20 922  end
      sm-151 1 0 1-20 922  end
      sm-152 1 0 1-20 922  end
      eu-153 1 0 1-20 922  end
      eu-154 1 0 1-20 922  end
      eu-155 1 0 1-20 922  end
      gd-155 1 0 1-20 922  end
      arbm-zirc4 6.56 5 0 0 0 8016 0.12 26000 0.10 26000 0.20 50000 1.40
                 40000 98.18 2 1.0 595   end
      h2o 3 den=0.731  1  570 end
      arbm-bormod  0.731 1 1 0 0 5000 100 3 450.0e-6  570  end
      *
      *    450 ppm boron (wt) in moderator
      *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      *
      *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      *
      *     fuel-pin-cell geometry:
      *
      squarepitch   1.4300  0.9296 1 3 1.0719 2 0.9484 0  end
      *
      *
      *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      *
      *     assembly and cycle parameters:
      *
      npin/assm=204 fuelnght=800.54 ncycles=3 nlib/cyc=5
      printlevel=5 lightel=9 inplevel=2 numxtotal=5 end
      3 0.6502 2 0.6934 3 0.8068 500 2.6408 3 2.6470
      power=32.235 burn=314 down=58 end
      power=32.235 burn=327 down=62 end
      power=32.235 burn=312 down=927 end
                o 135   cr 5.9   mn 0.33
                fe 13.0 co 0.075 ni 9.9
                zr 221  nb 0.71  sn 3.6
      *
      *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      *
1  ************      **********      ************     22222222222    hh          hh
  **************    ************    **************   2222222222222   hh          hh
  **          **    **          **  **          **   22          22  hh          hh
  **            **  **          **  **            **              22  hh          hh
  **            **  **          **  **            **              22  hh          hh
  *************     **************  *************                 22  hhhhhhhhhhhhhh
   *************    **************   *************            22     hhhhhhhhhhhhhh
            **      **          **              **        22         hh          hh
            **      **          **              **    22             hh          hh
```



```
program verification information
code system:    scale  version: . 4.3

program:  sas2
creation date:  03/07/97
library:  /opt/neut/Scale4.3/bin

this is not a  scale  configuration controlled code
jobname:  nichol
date of execution:  08/08/97
time of execution:  16:59:22
```

```
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

nuclide concentrations, grams
basis =single reactor assembly

            initial  1E-18 d
    u234   2.30E+02  2.30E+02
    u235   2.56E+04  2.56E+04
    u236   1.20E+02  1.20E+02
    u238   9.74E+05  9.74E+05
  total    1.00E+06  1.00E+06
```

```
0                                        basis =
0                 initial        15.7 d        31.4 d        47.1 d        62.8 d        62.8 d
0                 initial        15.7 d        31.4 d        47.1 d        62.8 d        62.8 d
0                                        nuclide concentrations, grams
                                         basis =single reactor assembly
            initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 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  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
    mo 95  1.50E+01 1.73E+01 1.79E+01 1.80E+01 1.81E+01 1.81E+01 1.81E+01
    tc 99  5.38E-05 5.46E-05 5.46E-05 5.46E-05 5.46E-05 5.46E-05 5.46E-05
  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  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
    u233  1.34E-03 1.39E-03 1.44E-03 1.49E-03 1.54E-03 1.59E-03 1.64E-03
    u234  1.32E+02 1.32E+02 1.33E+02 1.33E+02 1.33E+02 1.34E+02 1.34E+02
    u235  5.55E+03 5.55E+03 5.55E+03 5.55E+03 5.55E+03 5.55E+03 5.55E+03
    u236  3.34E+03 3.34E+03 3.34E+03 3.34E+03 3.34E+03 3.35E+03 3.35E+03
    u238  9.49E+05 9.49E+05 9.49E+05 9.49E+05 9.49E+05 9.49E+05 9.49E+05
   np237  3.66E+02 3.72E+02 3.72E+02 3.72E+02 3.72E+02 3.72E+02 3.72E+02
   pu236  5.66E-04 5.12E-04 4.63E-04 4.18E-04 3.78E-04 3.42E-04 3.09E-04
   pu238  1.24E+02 1.31E+02 1.33E+02 1.35E+02 1.35E+02 1.35E+02 1.35E+02
   pu239  4.96E+03 5.05E+03 5.05E+03 5.05E+03 5.05E+03 5.05E+03 5.05E+03
   pu240  2.34E+03 2.34E+03 2.34E+03 2.34E+03 2.34E+03 2.34E+03 2.34E+03
   pu241  1.20E+03 1.18E+03 1.16E+03 1.13E+03 1.11E+03 1.09E+03 1.07E+03
   pu242  5.45E+02 5.45E+02 5.45E+02 5.45E+02 5.45E+02 5.45E+02 5.45E+02
   am241  3.63E+01 6.06E+01 8.44E+01 1.08E+02 1.31E+02 1.53E+02 1.75E+02
 am242m  6.88E-01 6.87E-01 6.85E-01 6.84E-01 6.83E-01 6.81E-01 6.80E-01
   am243  1.09E+02 1.10E+02 1.10E+02 1.10E+02 1.10E+02 1.10E+02 1.10E+02
  total   9.68E+05 9.68E+05 9.68E+05 9.68E+05 9.68E+05 9.68E+05 9.68E+05
0                                        element concentrations, grams
0                                        nuclide concentrations, grams
                                         basis =single reactor assembly
            initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
    mo 95  5.97E+02 6.70E+02 6.89E+02 6.93E+02 6.94E+02 6.94E+02 6.94E+02
0                                        nuclide concentrations, grams
                                         basis =single reactor assembly
            initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
    tc 99  7.36E+02 7.39E+02 7.39E+02 7.39E+02 7.39E+02 7.39E+02 7.39E+02
   ru101  7.17E+02 7.17E+02 7.17E+02 7.17E+02 7.17E+02 7.17E+02 7.17E+02
   rh103  4.17E+02 4.60E+02 4.62E+02 4.63E+02 4.63E+02 4.63E+02 4.63E+02
   ag109  9.16E+01 9.18E+01 9.18E+01 9.18E+01 9.18E+01 9.18E+01 9.18E+01
0                                        nuclide concentrations, grams
                                         basis =single reactor assembly
            initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
   nd143  6.97E+02 7.17E+02 7.17E+02 7.17E+02 7.17E+02 7.17E+02 7.17E+02
   nd145  6.15E+02 6.15E+02 6.15E+02 6.15E+02 6.15E+02 6.15E+02 6.15E+02
   sm147  6.84E+01 8.64E+01 1.02E+02 1.17E+02 1.30E+02 1.41E+02 1.52E+02
0                                        nuclide concentrations, grams
                                         basis =single reactor assembly
            initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
   sm149  1.85E+00 3.20E+00 3.20E+00 3.20E+00 3.20E+00 3.20E+00 3.20E+00
   sm150  2.76E+02 2.76E+02 2.76E+02 2.76E+02 2.76E+02 2.76E+02 2.76E+02
   sm151  1.22E+01 1.24E+01 1.24E+01 1.24E+01 1.23E+01 1.23E+01 1.22E+01
   eu151  1.17E-02 5.23E-02 9.28E-02 1.33E-01 1.73E-01 2.13E-01 2.53E-01
   sm152  1.27E+02 1.27E+02 1.27E+02 1.27E+02 1.27E+02 1.27E+02 1.27E+02
   eu153  1.11E+02 1.12E+02 1.12E+02 1.12E+02 1.12E+02 1.12E+02 1.12E+02
   gd155  3.27E-02 3.57E-01 6.61E-01 9.47E-01 1.22E+00 1.47E+00 1.71E+00
  total   3.14E+04 3.14E+04 3.14E+04 3.14E+04 3.14E+04 3.14E+04 3.14E+04
```

tpd01g10.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
     Turkey Point 3, assembly D01 rod G10, 30.51 GWd/MTU, June 97
     '
     '
     '- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
     '
     '       mixtures of fuel-pin-unitcell:
     '
     44group        latticecell
     '
     '
     '
     uo2  1 den=10.235 1 922
       92234 0.023 92235 2.556 92236 0.012 92238 97.409  end
     kr-83  1 0 1-20 922  end
     kr-85  1 0 1-20 922  end
     y-89   1 0 1-20 922  end
     sr-90  1 0 1-20 922  end
     zr-93  1 0 1-20 922  end
     zr-94  1 0 1-20 922  end
     zr-95  1 0 1-20 922  end
     nb-94  1 0 1-20 922  end
     mo-95  1 0 1-20 922  end
     tc-99  1 0 1-20 922  end
     ru-101 1 0 1-20 922  end
     ru-106 1 0 1-20 922  end
     rh-103 1 0 1-20 922  end
     rh-105 1 0 1-20 922  end
     pd-105 1 0 1-20 922  end
     pd-108 1 0 1-20 922  end
     ag-109 1 0 1-20 922  end
     sb-124 1 0 1-20 922  end
     xe-131 1 0 1-20 922  end
     xe-132 1 0 1-20 922  end
     xe-135 1 0 1-20 922  end
     xe-136 1 0 1-20 922  end
     cs-134 1 0 1-20 922  end
     cs-135 1 0 1-20 922  end
     cs-137 1 0 1-20 922  end
     ba-136 1 0 1-20 922  end
     la-139 1 0 1-20 922  end
     pr-141 1 0 1-20 922  end
     pr-143 1 0 1-20 922  end
     ce-144 1 0 1-20 922  end
     nd-143 1 0 1-20 922  end
     nd-145 1 0 1-20 922  end
     nd-147 1 0 1-20 922  end
     pm-147 1 0 1-20 922  end
     pm-148 1 0 1-20 922  end
     sm-147 1 0 1-20 922  end
     sm-149 1 0 1-20 922  end
     sm-150 1 0 1-20 922  end
     sm-151 1 0 1-20 922  end
     sm-152 1 0 1-20 922  end
     eu-153 1 0 1-20 922  end
     eu-154 1 0 1-20 922  end
     eu-155 1 0 1-20 922  end
     gd-155 1 0 1-20 922  end
     arbm-zirc4 6.56 5 0 0 0 8016 0.32 24000 0.10 26000 0.20 50000 1.40
                40000 98.18 2 1.0 595   end
     h2o 3 den=0.731  1  570 end
     arbm-bormod  0.731 1 1 0 0 5000 100 3 450.0e-6  570  end
     '
     '    450 ppm boron (wt) in moderator
     '- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
     end comp
     '
     '- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
     '
     '     fuel-pin-cell geometry:
     '
     squarepitch   1.4300  0.9296 1 3 1.0719 2 0.9484 0  end
     '
     '
     '- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
     '
     '     assembly and cycle parameters:
     '
     npin/assm=204 fuelnght=800.54 ncycles=3 nlib/cyc=5
     printlevel=5 lightel=9 inplevel=2 numztotal=5 end
     3 0.6502 2 0.6934 3 0.8068 500 2.6408 3 2.6470
     power=32.015 burn=314 down=58 end
     power=32.015 burn=327 down=62 end
     power=32.015 burn=312 down=927 end
                o 135   cr 5.9   mn 0.33
                fe 13.0 co 0.075 ni 9.9
                zr 221  nb 0.71  sn 3.6
     '
     '- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
     '
1   ************      *********      ************     22222222222     hh          hh
   **************     ************   **************  2222222222222    hh          hh
   **          **    **          **  **          **  22          22  hh          hh
   **              **            **  **              22          22  hh          hh
   **              **            **  **              22          22  hh          hh
   *************   **************    *************             22    hhhhhhhhhhhhhh
    *************  **************     *************         22       hhhhhhhhhhhhhh
              **   **          **                **      22          hh          hh
              **   **          **                **  22              hh          hh
```

```
program verification information
code system:    scale  version:    4.3

program:  sas2
creation date:  03/07/97
library:  /opt/neut/Scale4.3/bin

this is not a   scale  configuration controlled code

jobname:  nichol
date of execution:  08/08/97
time of execution:  17:33:38
```

```
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

nuclide concentrations, grams
basis =single reactor assembly

            initial  1E-18 d
    u234   2.30E+02  2.30E+02
    u235   2.56E+04  2.56E+04
    u236   1.20E+02  1.20E+02
    u238   9.74E+05  9.74E+05
  total    1.00E+06  1.00E+06
```

```
0                                                  basis =
0                    initial          15.7 d          31.4 d          47.1 d          62.8 d          62.8 d
0                    initial          15.7 d          31.4 d          47.1 d          62.8 d          62.8 d
0                                                  nuclide concentrations, grams
                                                   basis =single reactor assembly
                 initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 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  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
        mo 95  1.49E+01  1.72E+01  1.78E+01  1.79E+01  1.79E+01  1.79E+01  1.79E+01
        tc 99  5.25E-05  5.33E-05  5.33E-05  5.33E-05  5.33E-05  5.33E-05  5.33E-05
     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  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
        u233   1.34E-03  1.39E-03  1.44E-03  1.49E-03  1.54E-03  1.59E-03  1.64E-03
        u234   1.32E+02  1.33E+02  1.33E+02  1.34E+02  1.34E+02  1.34E+02  1.35E+02
        u235   5.61E+03  5.61E+03  5.61E+03  5.61E+03  5.61E+03  5.61E+03  5.61E+03
        u236   3.34E+03  3.34E+03  3.34E+03  3.34E+03  3.34E+03  3.34E+03  3.34E+03
        u238   9.49E+05  9.49E+05  9.49E+05  9.49E+05  9.49E+05  9.49E+05  9.49E+05
       np237   3.61E+02  3.69E+02  3.69E+02  3.69E+02  3.69E+02  3.69E+02  3.69E+02
       pu236   5.55E-04  5.04E-04  4.55E-04  4.11E-04  3.72E-04  3.36E-04  3.04E-04
       pu238   1.22E+02  1.29E+02  1.31E+02  1.33E+02  1.33E+02  1.33E+02  1.33E+02
       pu239   4.96E+03  5.05E+03  5.05E+03  5.05E+03  5.05E+03  5.05E+03  5.05E+03
       pu240   2.33E+03  2.33E+03  2.33E+03  2.33E+03  2.33E+03  2.33E+03  2.33E+03
       pu241   1.20E+03  1.17E+03  1.15E+03  1.13E+03  1.10E+03  1.08E+03  1.06E+03
       pu242   5.37E+02  5.37E+02  5.37E+02  5.37E+02  5.37E+02  5.37E+02  5.37E+02
       am241   3.62E+01  6.04E+01  8.41E+01  1.07E+02  1.30E+02  1.52E+02  1.74E+02
      am242m   6.86E-01  6.85E-01  6.83E-01  6.82E-01  6.80E-01  6.79E-01  6.78E-01
       am243   1.07E+02  1.07E+02  1.07E+02  1.07E+02  1.07E+02  1.07E+02  1.07E+02
     total     9.68E+05  9.68E+05  9.68E+05  9.68E+05  9.68E+05  9.68E+05  9.68E+05
0                                                  element concentrations, grams
0                                                  nuclide concentrations, grams
                                                   basis =single reactor assembly
                 initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
        mo 95  5.94E+02  6.66E+02  6.85E+02  6.89E+02  6.90E+02  6.90E+02  6.90E+02
0                                                  nuclide concentrations, grams
                                                   basis =single reactor assembly
                 initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
        tc 99  7.31E+02  7.35E+02  7.35E+02  7.35E+02  7.35E+02  7.35E+02  7.35E+02
       ru101   7.12E+02  7.12E+02  7.12E+02  7.12E+02  7.12E+02  7.12E+02  7.12E+02
       rh103   4.15E+02  4.57E+02  4.60E+02  4.60E+02  4.60E+02  4.60E+02  4.60E+02
       ag109   9.08E+01  9.10E+01  9.10E+01  9.10E+01  9.10E+01  9.10E+01  9.10E+01
0                                                  nuclide concentrations, grams
                                                   basis =single reactor assembly
                 initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
       nd143   6.94E+02  7.14E+02  7.14E+02  7.14E+02  7.14E+02  7.14E+02  7.14E+02
       nd145   6.12E+02  6.12E+02  6.12E+02  6.12E+02  6.12E+02  6.12E+02  6.12E+02
       sm147   6.82E+01  8.62E+01  1.02E+02  1.17E+02  1.29E+02  1.41E+02  1.51E+02
0                                                  nuclide concentrations, grams
                                                   basis =single reactor assembly
                 initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
       sm149   1.85E+00  3.18E+00  3.18E+00  3.18E+00  3.18E+00  3.18E+00  3.18E+00
       sm150   2.74E+02  2.74E+02  2.74E+02  2.74E+02  2.74E+02  2.74E+02  2.74E+02
       sm151   1.22E+01  1.24E+01  1.24E+01  1.23E+01  1.23E+01  1.22E+01  1.22E+01
       eu151   1.18E-02  5.22E-02  9.26E-02  1.33E-01  1.73E-01  2.13E-01  2.53E-01
       sm152   1.26E+02  1.26E+02  1.26E+02  1.26E+02  1.26E+02  1.26E+02  1.26E+02
       eu153   1.10E+02  1.11E+02  1.11E+02  1.11E+02  1.11E+02  1.11E+02  1.11E+02
       gd155   3.25E-02  3.53E-01  6.54E-01  9.37E-01  1.20E+00  1.45E+00  1.69E+00
     total     3.12E+04  3.12E+04  3.12E+04  3.12E+04  3.12E+04  3.12E+04  3.12E+04
```

tpd01h09.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
      Turkey Point 3, assembly D01 rod H09, 31.56 GWd/MTU, June 97
      *
      *
      *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      *
      *        mixtures of fuel-pin-unitcell:
      *
      44group         latticecell
      *
      *
      *
      uo2  1 den=10.235 1 922
        92234 0.023 92235 2.356 92236 0.012 92238 97.609  end
      kr-83  1 0 1-20 922  end
      kr-85  1 0 1-20 922  end
      y-89   1 0 1-20 922  end
      sr-90  1 0 1-20 922  end
      zr-93  1 0 1-20 922  end
      zr-94  1 0 1-20 922  end
      zr-95  1 0 1-20 922  end
      nb-94  1 0 1-20 922  end
      mo-95  1 0 1-20 922  end
      tc-99  1 0 1-20 922  end
      ru-101 1 0 1-20 922  end
      ru-106 1 0 1-20 922  end
      rh-103 1 0 1-20 922  end
      rh-105 1 0 1-20 922  end
      pd-105 1 0 1-20 922  end
      pd-108 1 0 1-20 922  end
      ag-109 1 0 1-20 922  end
      sb-124 1 0 1-20 922  end
      xe-131 1 0 1-20 922  end
      xe-132 1 0 1-20 922  end
      xe-135 1 0 1-20 922  end
      xe-136 1 0 1-20 922  end
      cs-134 1 0 1-20 922  end
      cs-135 1 0 1-20 922  end
      cs-137 1 0 1-20 922  end
      ba-136 1 0 1-20 922  end
      la-139 1 0 1-20 922  end
      pr-141 1 0 1-20 922  end
      pr-143 1 0 1-20 922  end
      ce-144 1 0 1-20 922  end
      nd-143 1 0 1-20 922  end
      nd-145 1 0 1-20 922  end
      nd-147 1 0 1-20 922  end
      pm-147 1 0 1-20 922  end
      pm-148 1 0 1-20 922  end
      sm-147 1 0 1-20 922  end
      sm-149 1 0 1-20 922  end
      sm-150 1 0 1-20 922  end
      sm-151 1 0 1-20 922  end
      sm-152 1 0 1-20 922  end
      eu-153 1 0 1-20 922  end
      eu-154 1 0 1-20 922  end
      eu-155 1 0 1-20 922  end
      gd-155 1 0 1-20 922  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 1.0 595   end
      h2o 3 den=0.731  1  570 end
      arbm-bormod  0.731 1 1 0 0 5000 100 3 450.0e-6  570  end
      *
      *    450 ppm boron (wt) in moderator
      *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      *
      *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      *
      *     fuel-pin-cell geometry:
      *
      squarepitch   1.4300  0.9296 1 3 1.0719 2 0.9484 0  end
      *
      *
      *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      *
      *     assembly and cycle parameters:
      *
      npin/assm=204 fuelnght=800.54 ncycles=3 mlib/cyc=5
      printlevel=5 lightel=9 implevel=2 numxtotal=5 end
      3 0.6502 2 0.6934 3 0.8068 500 2.6408 3 2.6470
      power=33.116 burn=314 down=58 end
      power=33.116 burn=327 down=62 end
      power=33.116 burn=312 down=927 end
                o 135   cr 5.9   mn 0.33
                fe 13.0 co 0.075 ni 9.9
                zr 221  nb 0.71  sn 3.6
      *
      *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      *
1   ************      **********      ************     22222222222    hh          hh
   **************    ************    **************   2222222222222   hh          hh
   **          **   **          **   **          **   22          22  hh          hh
   **               **          **   **                          22  hh          hh
   **               **          **   **                          22  hh          hh
   **************    **************   **************             22   hhhhhhhhhhhhh
    ************     **************    ************          22      hhhhhhhhhhhhh
                **   **          **                **        22      hh          hh
                **   **          **                **      22        hh          hh
```

program verification information

code system: scale version: 4.3

program: sas2

creation date: 03/07/97

library: /opt/neut/$cale4.3/bin

this is not a scale configuration controlled code

jobname: nichol

date of execution: 08/08/97

time of execution: 18:10:11

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

nuclide concentrations, grams
basis =single reactor assembly

	initial	1E-18 d
u234	2.30E+02	2.30E+02
u235	2.56E+04	2.56E+04
u236	1.20E+02	1.20E+02
u238	9.74E+05	9.74E+05
total	1.00E+06	1.00E+06

```
0                                        basis =
0                 initial        15.7 d        31.4 d        47.1 d        62.8 d        62.8 d
0                 initial        15.7 d        31.4 d        47.1 d        62.8 d        62.8 d
0                                        nuclide concentrations, grams
                                         basis =single reactor assembly
            initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 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  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
   mo 95  1.55E+01 1.78E+01 1.85E+01 1.86E+01 1.86E+01 1.86E+01 1.86E+01
   tc 99  5.90E-05 5.98E-05 5.98E-05 5.98E-05 5.98E-05 5.98E-05 5.98E-05
 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  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
   u233  1.34E-03 1.40E-03 1.45E-03 1.50E-03 1.55E-03 1.60E-03 1.65E-03
   u234  1.29E+02 1.30E+02 1.30E+02 1.31E+02 1.31E+02 1.32E+02 1.32E+02
   u235  5.29E+03 5.29E+03 5.29E+03 5.29E+03 5.29E+03 5.29E+03 5.29E+03
   u236  3.37E+03 3.37E+03 3.37E+03 3.37E+03 3.37E+03 3.37E+03 3.37E+03
   u238  9.48E+05 9.48E+05 9.48E+05 9.48E+05 9.48E+05 9.48E+05 9.48E+05
  np237  3.75E+02 3.84E+02 3.84E+02 3.84E+02 3.84E+02 3.84E+02 3.84E+02
  pu236  6.03E-04 5.48E-04 4.95E-04 4.47E-04 4.04E-04 3.66E-04 3.30E-04
  pu238  1.31E+02 1.39E+02 1.41E+02 1.42E+02 1.43E+02 1.43E+02 1.42E+02
  pu238  1.31E+02 1.38E+02 1.41E+02 1.42E+02 1.43E+02 1.43E+02 1.42E+02
  pu239  4.97E+03 5.07E+03 5.06E+03 5.06E+03 5.06E+03 5.06E+03 5.06E+03
  pu240  2.39E+03 2.39E+03 2.39E+03 2.39E+03 2.39E+03 2.39E+03 2.39E+03
  pu241  1.23E+03 1.21E+03 1.18E+03 1.16E+03 1.13E+03 1.11E+03 1.09E+03
  pu242  5.77E+02 5.77E+02 5.77E+02 5.77E+02 5.77E+02 5.77E+02 5.77E+02
  am241  3.66E+01 6.15E+01 8.58E+01 1.10E+02 1.33E+02 1.56E+02 1.78E+02
 am242m  6.96E-01 6.94E-01 6.93E-01 6.92E-01 6.90E-01 6.89E-01 6.87E-01
  am243  1.19E+02 1.19E+02 1.19E+02 1.19E+02 1.19E+02 1.19E+02 1.19E+02
 total   9.67E+05 9.67E+05 9.67E+05 9.67E+05 9.67E+05 9.67E+05 9.67E+05
0                                        element concentrations, grams
0                                        nuclide concentrations, grams
                                         basis =single reactor assembly
            initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
   mo 95  6.11E+02 6.85E+02 7.05E+02 7.09E+02 7.10E+02 7.10E+02 7.10E+02
0                                        nuclide concentrations, grams
                                         basis =single reactor assembly
            initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
   tc 99  7.53E+02 7.56E+02 7.56E+02 7.56E+02 7.56E+02 7.56E+02 7.56E+02
  ru101  7.36E+02 7.36E+02 7.36E+02 7.36E+02 7.36E+02 7.36E+02 7.36E+02
  rh103  4.25E+02 4.70E+02 4.73E+02 4.73E+02 4.73E+02 4.73E+02 4.73E+02
  ag109  9.49E+01 9.51E+01 9.51E+01 9.51E+01 9.51E+01 9.51E+01 9.51E+01
0                                        nuclide concentrations, grams
                                         basis =single reactor assembly
            initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
  nd143  7.06E+02 7.27E+02 7.27E+02 7.27E+02 7.27E+02 7.27E+02 7.27E+02
  nd145  6.28E+02 6.29E+02 6.29E+02 6.29E+02 6.29E+02 6.29E+02 6.29E+02
  sm147  6.89E+01 8.71E+01 1.03E+02 1.18E+02 1.31E+02 1.43E+02 1.53E+02
0                                        nuclide concentrations, grams
                                         basis =single reactor assembly
            initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
  sm149  1.86E+00 3.25E+00 3.25E+00 3.25E+00 3.25E+00 3.25E+00 3.25E+00
  sm150  2.85E+02 2.85E+02 2.85E+02 2.85E+02 2.85E+02 2.85E+02 2.85E+02
  sm151  1.24E+01 1.24E+01 1.24E+01 1.25E+01 1.25E+01 1.24E+01 1.24E+01
  eu151  1.15E-02 5.26E-02 9.36E-02 1.35E-01 1.75E-01 2.16E-01 2.56E-01
  sm152  1.30E+02 1.30E+02 1.30E+02 1.30E+02 1.30E+02 1.30E+02 1.30E+02
  eu153  1.15E+02 1.16E+02 1.16E+02 1.16E+02 1.16E+02 1.16E+02 1.16E+02
  gd155  3.32E-02 3.71E-01 6.88E-01 9.86E-01 1.27E+00 1.53E+00 1.78E+00
 total   3.22E+04 3.22E+04 3.22E+04 3.22E+04 3.22E+04 3.22E+04 3.22E+04
```

tpd04g09.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
      Turkey Point 3, assembly D04 rod G09, 31.26 GWd/MTU, June 97
      *
      *
      *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      *
      *       mixtures of fuel-pin-unitcell:
      *
      44group        latticecell
      *
      *
      *
      uo2  1 den=10.235 1 922
        92234 0.023 92235 2.556 92236 0.012 92238 97.409  end
      kr-83  1 0 1-20 922  end
      kr-85  1 0 1-20 922  end
      y-89   1 0 1-20 922  end
      zr-90  1 0 1-20 922  end
      zr-93  1 0 1-20 922  end
      zr-94  1 0 1-20 922  end
      zr-95  1 0 1-20 922  end
      nb-94  1 0 1-20 922  end
      mo-95  1 0 1-20 922  end
      tc-99  1 0 1-20 922  end
      ru-101 1 0 1-20 922  end
      ru-106 1 0 1-20 922  end
      rh-103 1 0 1-20 922  end
      rh-105 1 0 1-20 922  end
      pd-105 1 0 1-20 922  end
      pd-108 1 0 1-20 922  end
      ag-109 1 0 1-20 922  end
      sb-124 1 0 1-20 922  end
      xe-131 1 0 1-20 922  end
      xe-132 1 0 1-20 922  end
      xe-135 1 0 1-20 922  end
      xe-136 1 0 1-20 922  end
      cs-134 1 0 1-20 922  end
      cs-135 1 0 1-20 922  end
      cs-137 1 0 1-20 922  end
      ba-136 1 0 1-20 922  end
      la-139 1 0 1-20 922  end
      pr-141 1 0 1-20 922  end
      pr-143 1 0 1-20 922  end
      ce-144 1 0 1-20 922  end
      nd-143 1 0 1-20 922  end
      nd-145 1 0 1-20 922  end
      nd-147 1 0 1-20 922  end
      pm-147 1 0 1-20 922  end
      pm-148 1 0 1-20 922  end
      sm-147 1 0 1-20 922  end
      sm-149 1 0 1-20 922  end
      sm-150 1 0 1-20 922  end
      sm-151 1 0 1-20 922  end
      sm-152 1 0 1-20 922  end
      eu-153 1 0 1-20 922  end
      eu-154 1 0 1-20 922  end
      eu-155 1 0 1-20 922  end
      gd-155 1 0 1-20 922  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 1.0 595   end
      h2o 3 den=0.731  1  570 end
      arbm-bormod  0.731 1 1 0 0 5000 100 3 450.0e-6  570  end
      *
      *    450 ppm boron (wt) in moderator
      *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      end comp
      *
      *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      *
      *     fuel-pin-cell geometry:
      *
      squarepitch   1.4300  0.9296 1 3 1.0719 2 0.9484 0  end
      *
      *
      *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      *
      *     assembly and cycle parameters:
      *
      npin/assm=204 fuelnght=800.54 ncycles=3 nlib/cyc=5
      printlevel=5 lightel=9 inplevel=2 numztotal=5 end
      3 0.6502 2 0.6934 3 0.8068 500 2.6408 3 2.6470
      power=32.802 burn=314 down=58 end
      power=32.802 burn=327 down=62 end
      power=32.802 burn=312 down=927 end
                o 135   cr 5.9   mn 0.33
                fe 13.0 co 0.075 ni 9.9
                zr 221  nb 0.71  sn 3.6
      *
      *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      *
1   ###########      #########      ###########     22222222222    hh         hh
   #############    ###########    #############   2222222222222   hh         hh
   ##         ##   ##         ##  ##         ##  22         22    hh         hh
   ##              ##         ##  ##                 22         hh         hh
   ##              ##         ##  ##                 22         hh         hh
   ############    ##############  ############           22     hhhhhhhhhhhhh
    ############   ##############   ############         22       hhhhhhhhhhhhh
            ##     ##         ##               ##     22          hh         hh
            ##     ##         ##               ##   22            hh         hh
```

program verification information

code system: scale version: 4.3

program: sas2

creation date: 03/07/97

library: /opt/neut/Scale4.3/bin

this is not a scale configuration controlled code

jobname: nichol

date of execution: 08/08/97

time of execution: 18:46:46

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

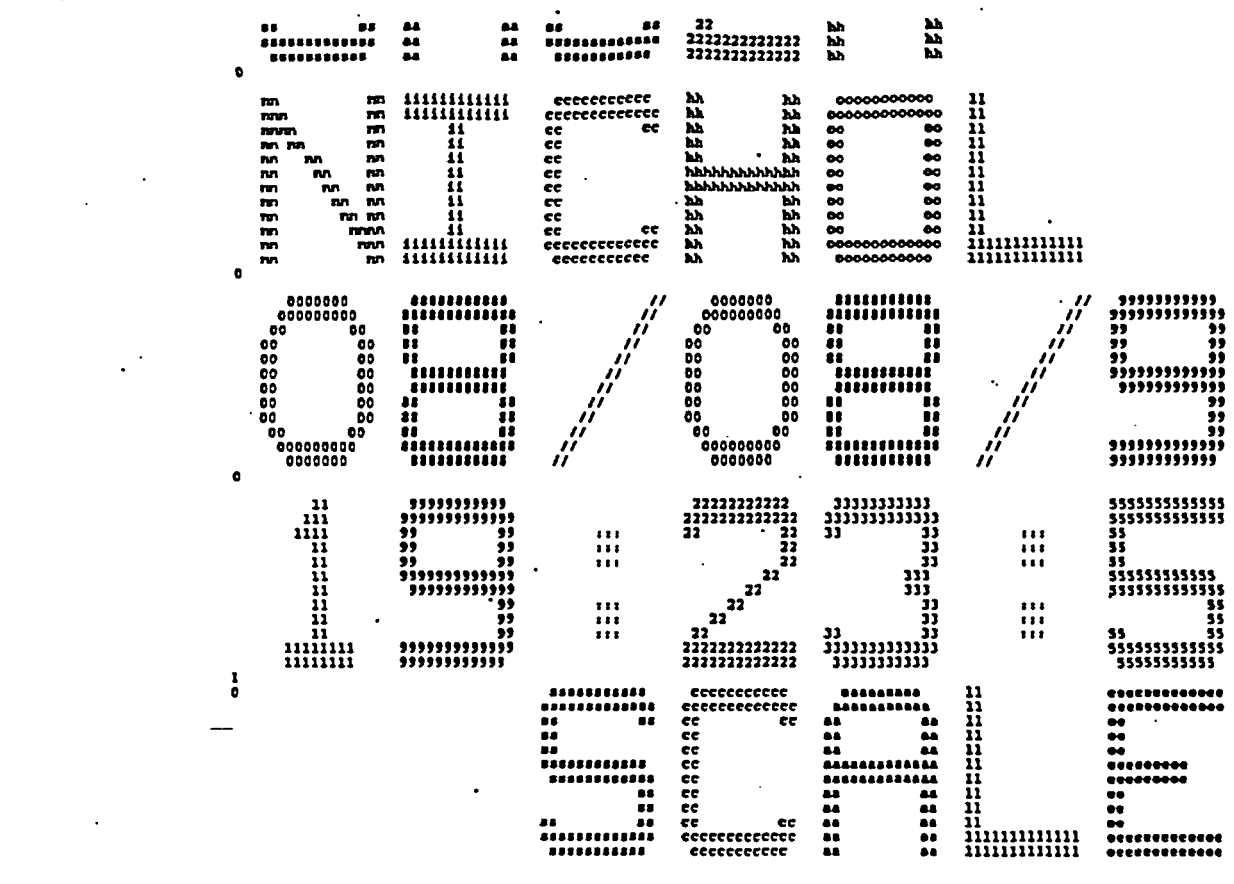
nuclide concentrations, grams
basis =single reactor assembly

	initial	1E-18 d
u234	2.30E+02	2.30E+02
u235	2.56E+04	2.56E+04
u236	1.20E+02	1.20E+02
u238	9.74E+05	9.74E+05
total	1.00E+06	1.00E+06

```
0                                   basis =
0                initial      15.7 d      31.4 d      47.1 d      62.8 d      62.8 d
0                initial      15.7 d      31.4 d      47.1 d      62.8 d      62.8 d
0                                   nuclide concentrations, grams
                                    basis =single reactor assembly
             initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 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  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
    mo 95  1.53E+01  1.77E+01  1.83E+01  1.84E+01  1.84E+01  1.84E+01  1.84E+01
    tc 99  5.71E-05  5.79E-05  5.79E-05  5.79E-05  5.79E-05  5.79E-05  5.79E-05
  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  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
    u233  1.34E-03  1.40E-03  1.45E-03  1.50E-03  1.55E-03  1.60E-03  1.65E-03
    u234  1.30E+02  1.31E+02  1.31E+02  1.32E+02  1.32E+02  1.32E+02  1.33E+02
    u235  5.38E+03  5.38E+03  5.38E+03  5.38E+03  5.38E+03  5.38E+03  5.38E+03
    u236  3.36E+03  3.36E+03  3.36E+03  3.36E+03  3.36E+03  3.36E+03  3.36E+03
    u238  9.49E+05  9.49E+05  9.49E+05  9.49E+05  9.49E+05  9.49E+05  9.49E+05
   np237  3.71E+02  3.80E+02  3.80E+02  3.80E+02  3.80E+02  3.80E+02  3.80E+02
   pu236  5.89E-04  5.35E-04  4.83E-04  4.37E-04  3.95E-04  3.57E-04  3.23E-04
   pu238  1.28E+02  1.35E+02  1.38E+02  1.39E+02  1.40E+02  1.40E+02  1.40E+02
   pu239  1.28E+02  1.35E+02  1.38E+02  1.39E+02  1.40E+02  1.40E+02  1.40E+02
   pu239  4.97E+03  5.06E+03  5.06E+03  5.06E+03  5.06E+03  5.06E+03  5.06E+03
   pu240  2.37E+03  2.37E+03  2.37E+03  2.37E+03  2.37E+03  2.37E+03  2.37E+03
   pu241  1.22E+03  1.20E+03  1.17E+03  1.15E+03  1.13E+03  1.10E+03  1.08E+03
   pu242  5.65E+02  5.65E+02  5.65E+02  5.65E+02  5.65E+02  5.65E+02  5.65E+02
   am241  3.65E+01  6.12E+01  8.54E+01  1.09E+02  1.32E+02  1.55E+02  1.77E+02
 am242m  6.93E-01  6.92E-01  6.90E-01  6.89E-01  6.88E-01  6.86E-01  6.85E-01
   am243  1.15E+02  1.16E+02  1.16E+02  1.16E+02  1.15E+02  1.15E+02  1.15E+02
  total   9.68E+05  9.68E+05  9.68E+05  9.68E+05  9.68E+05  9.68E+05  9.68E+05
0                                   element concentrations, grams
0                                   nuclide concentrations, grams
                                    basis =single reactor assembly
             initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
    mo 95  6.06E+02  6.80E+02  7.00E+02  7.03E+02  7.04E+02  7.04E+02  7.04E+02
0                                   nuclide concentrations, grams
                                    basis =single reactor assembly
             initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
    tc 99  7.46E+02  7.50E+02  7.50E+02  7.50E+02  7.50E+02  7.50E+02  7.50E+02
   ru101  7.29E+02  7.29E+02  7.29E+02  7.29E+02  7.29E+02  7.29E+02  7.29E+02
   rh103  4.22E+02  4.66E+02  4.69E+02  4.69E+02  4.69E+02  4.69E+02  4.69E+02
   ag109  9.37E+01  9.39E+01  9.39E+01  9.39E+01  9.39E+01  9.39E+01  9.39E+01
0                                   nuclide concentrations, grams
                                    basis =single reactor assembly
             initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
   nd143  7.03E+02  7.23E+02  7.23E+02  7.23E+02  7.23E+02  7.23E+02  7.23E+02
   nd145  6.24E+02  6.24E+02  6.24E+02  6.24E+02  6.24E+02  6.24E+02  6.24E+02
   sm147  6.87E+01  8.68E+01  1.03E+02  1.18E+02  1.30E+02  1.42E+02  1.52E+02
0                                   nuclide concentrations, grams
                                    basis =single reactor assembly
             initial  154.5 d  309.0 d  463.5 d  618.0 d  772.5 d  927.0 d
   sm149  1.86E+00  3.23E+00  3.23E+00  3.23E+00  3.23E+00  3.23E+00  3.23E+00
   sm150  2.82E+02  2.82E+02  2.82E+02  2.82E+02  2.82E+02  2.82E+02  2.82E+02
   sm151  1.23E+01  1.26E+01  1.25E+01  1.25E+01  1.24E+01  1.24E+01  1.23E+01
   eu151  1.15E-02  5.25E-02  9.33E-02  1.34E-01  1.75E-01  2.15E-01  2.55E-01
   sm152  1.29E+02  1.29E+02  1.29E+02  1.29E+02  1.29E+02  1.29E+02  1.29E+02
   eu153  1.14E+02  1.15E+02  1.15E+02  1.15E+02  1.15E+02  1.15E+02  1.15E+02
   gd155  3.30E-02  3.66E-01  6.79E-01  9.72E-01  1.25E+00  1.51E+00  1.75E+00
  total   3.19E+04  3.19E+04  3.19E+04  3.19E+04  3.19E+04  3.19E+04  3.19E+04
```

tpd04g10.sum

```
0*********************************************************************
 *                                                                   *
 *                    SCALE4.3  Bulletin  Board                      *
 *                    --------  --------  -----                      *
 *                                                                   *
 *                      Welcome to SCALE-4.3.                        *
 *                                                                   *
 *                                                                   *
 *********************************************************************
1          primary module access and input record ( scale driver - 95/03/29 - 08:06:37 )
-   module saa2h    will be called
     Turkey Point 3, assembly D04 rod G10, 31.31 GWd/MTU, June 97
     *
     *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
     *
     *       mixtures of fuel-pin-unitcell:
     *
     44group         latticecell
     *
     *
     *
     uo2  1 den=10.235 1 922
       92234 0.023 92235 2.556 92236 0.012 92238 97.409  end
     kr-83  1 0 1-20 922  end
     kr-85  1 0 1-20 922  end
     y-89   1 0 1-20 922  end
     sr-90  1 0 1-20 922  end
     zr-93  1 0 1-20 922  end
     zr-94  1 0 1-20 922  end
     zr-95  1 0 1-20 922  end
     nb-94  1 0 1-20 922  end
     mo-95  1 0 1-20 922  end
     tc-99  1 0 1-20 922  end
     ru-101 1 0 1-20 922  end
     ru-106 1 0 1-20 922  end
     rh-103 1 0 1-20 922  end
     rh-105 1 0 1-20 922  end
     pd-105 1 0 1-20 922  end
     pd-108 1 0 1-20 922  end
     ag-109 1 0 1-20 922  end
     sb-124 1 0 1-20 922  end
     xe-131 1 0 1-20 922  end
     xe-132 1 0 1-20 922  end
     xe-135 1 0 1-20 922  end
     xe-136 1 0 1-20 922  end
     cs-134 1 0 1-20 922  end
     cs-135 1 0 1-20 922  end
     cs-137 1 0 1-20 922  end
     ba-136 1 0 1-20 922  end
     la-139 1 0 1-20 922  end
     pr-141 1 0 1-20 922  end
     pr-143 1 0 1-20 922  end
     ce-144 1 0 1-20 922  end
     nd-143 1 0 1-20 922  end
     nd-145 1 0 1-20 922  end
     nd-147 1 0 1-20 922  end
     pm-147 1 0 1-20 922  end
     pm-148 1 0 1-20 922  end
     sm-147 1 0 1-20 922  end
     sm-149 1 0 1-20 922  end
     sm-150 1 0 1-20 922  end
     sm-151 1 0 1-20 922  end
     sm-152 1 0 1-20 922  end
     eu-153 1 0 1-20 922  end
     eu-154 1 0 1-20 922  end
     eu-155 1 0 1-20 922  end
     gd-155 1 0 1-20 922  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 1.0 595   end
     h2o 3 den=0.731  1  570 end
     arbm-bormod  0.731 1 1 0 0 5000 100 3 450.0e-6  570  end
     *
     *    450 ppm boron (wt) in moderator
     *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
     end comp
     *
     *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
     *
     *     fuel-pin-cell geometry:
     *
     squarepitch   1.4300  0.9296 1 3 1.0719 2 0.9484 0  end
     *
     *
     *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
     *
     *     assembly and cycle parameters:
     *
     npin/assm=204 fuelnght=800.54 ncycles=3 nlib/cyc=5
     printlevel=5 lightel=9 inplevel=2 numztotal=5 end
     3 0.6502 2 0.6934 3 0.8068 500 2.6408 3 2.6470
     power=32.854 burn=314 down=58 end
     power=32.854 burn=337 down=62 end
     power=32.854 burn=312 down=927 end
                o 235   cr 5.9   mn 0.33
                fe 13.0 co 0.075 ni 9.9
                zr 221  nb 0.71  sn 3.6
     *
     *- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
     *
1   ************      ***********      ************     22222222222     hh          hh
   **************    ************    **************   2222222222222    hh          hh
   **          **    **          **   **          **   22          22  hh          hh
   **              **            **   **                          22  hh          hh
   **              **            **   **                          22  hh          hh
   ************    **************    ************             22     hhhhhhhhhhhhhh
    ************   **************     ************         22         hhhhhhhhhhhhhh
              **   **          **               **     22             hh          hh
              **   **          **               **   22               hh          hh
```



program verification information

code system: scale version: .4.3

program: sas2

creation date: 03/07/97

library: /opt/neut/Scale4.3/bin

this is not a scale configuration controlled code

jobname: nichol

date of execution: 08/08/97

time of execution: 19:23:59

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

nuclide concentrations, grams
basis =single reactor assembly

	initial	1E-18 d
u234	2.30E+02	2.30E+02
u235	2.56E+04	2.56E+04
u236	1.20E+02	1.20E+02
u238	9.74E+05	9.74E+05
total	1.00E+06	1.00E+06

```
0                                                  basis =
0                  initial        15.7 d        31.4 d        47.1 d        62.8 d        62.8 d
0                  initial        15.7 d        31.4 d        47.1 d        62.8 d        62.8 d
0                                                  nuclide concentrations, grams
                                                   basis =single reactor assembly
             initial  154.5 d   309.0 d   463.5 d   618.0 d   772.5 d   927.0 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  154.5 d   309.0 d   463.5 d   618.0 d   772.5 d   927.0 d
    mo 95   1.53E+01  1.77E+01  1.83E+01  1.84E+01  1.85E+01  1.85E+01  1.85E+01
    tc 99   5.74E-05  5.82E-05  5.82E-05  5.82E-05  5.82E-05  5.82E-05  5.82E-05
   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  154.5 d   309.0 d   463.5 d   618.0 d   772.5 d   927.0 d
    u233   1.34E-03  1.40E-03  1.45E-03  1.50E-03  1.55E-03  1.60E-03  1.65E-03
    u234   1.30E+02  1.31E+02  1.31E+02  1.31E+02  1.32E+02  1.32E+02  1.33E+02
    u235   5.37E+03  5.37E+03  5.37E+03  5.37E+03  5.37E+03  5.37E+03  5.37E+03
    u236   3.36E+03  3.36E+03  3.36E+03  3.37E+03  3.37E+03  3.37E+03  3.37E+03
    u238   9.49E+05  9.49E+05  9.49E+05  9.49E+05  9.49E+05  9.49E+05  9.49E+05
   np237   3.72E+02  3.80E+02  3.80E+02  3.80E+02  3.80E+02  3.81E+02  3.81E+02
   pu236   5.92E-04  5.37E-04  4.85E-04  4.39E-04  3.97E-04  3.58E-04  3.24E-04
   pu238   1.29E+02  1.36E+02  1.39E+02  1.40E+02  1.40E+02  1.40E+02  1.40E+02
   pu239   1.29E+02  1.36E+02  1.39E+02  1.40E+02  1.40E+02  1.40E+02  1.40E+02
   pu239   4.97E+03  5.06E+03  5.06E+03  5.06E+03  5.06E+03  5.06E+03  5.06E+03
   pu240   2.37E+03  2.37E+03  2.37E+03  2.37E+03  2.37E+03  2.38E+03  2.38E+03
   pu241   1.22E+03  1.20E+03  1.17E+03  1.15E+03  1.13E+03  1.10E+03  1.08E+03
   pu242   5.67E+02  5.67E+02  5.67E+02  5.67E+02  5.67E+02  5.67E+02  5.67E+02
   am241   3.65E+01  6.12E+01  8.54E+01  1.09E+02  1.32E+02  1.55E+02  1.77E+02
  am242m   6.94E-01  6.92E-01  6.91E-01  6.89E-01  6.88E-01  6.87E-01  6.85E-01
   am243   1.16E+02  1.16E+02  1.16E+02  1.16E+02  1.16E+02  1.16E+02  1.16E+02
   total   9.68E+05  9.68E+05  9.68E+05  9.68E+05  9.68E+05  9.68E+05  9.68E+05
0                                                  element concentrations, grams
0                                                  nuclide concentrations, grams
                                                   basis =single reactor assembly
             initial  154.5 d   309.0 d   463.5 d   618.0 d   772.5 d   927.0 d
    mo 95   6.07E+02  6.81E+02  7.00E+02  7.04E+02  7.05E+02  7.05E+02  7.05E+02
0                                                  nuclide concentrations, grams
                                                   basis =single reactor assembly
             initial  154.5 d   309.0 d   463.5 d   618.0 d   772.5 d   927.0 d
    tc 99   7.48E+02  7.51E+02  7.51E+02  7.51E+02  7.51E+02  7.51E+02  7.51E+02
   ru101   7.30E+02  7.30E+02  7.30E+02  7.30E+02  7.30E+02  7.30E+02  7.30E+02
   rh103   4.23E+02  4.67E+02  4.70E+02  4.70E+02  4.70E+02  4.70E+02  4.70E+02
   ag109   9.39E+01  9.41E+01  9.41E+01  9.41E+01  9.41E+01  9.41E+01  9.41E+01
0                                                  nuclide concentrations, grams
                                                   basis =single reactor assembly
             initial  154.5 d   309.0 d   463.5 d   618.0 d   772.5 d   927.0 d
   nd143   7.03E+02  7.24E+02  7.24E+02  7.24E+02  7.24E+02  7.24E+02  7.24E+02
   nd145   6.24E+02  6.25E+02  6.25E+02  6.25E+02  6.25E+02  6.25E+02  6.25E+02
   sm147   6.87E+01  8.69E+01  1.03E+02  1.18E+02  1.31E+02  1.42E+02  1.53E+02
0                                                  nuclide concentrations, grams
                                                   basis =single reactor assembly
             initial  154.5 d   309.0 d   463.5 d   618.0 d   772.5 d   927.0 d
   sm149   1.86E+00  3.24E+00  3.24E+00  3.24E+00  3.24E+00  3.24E+00  3.24E+00
   sm150   2.82E+02  2.82E+02  2.82E+02  2.82E+02  2.82E+02  2.82E+02  2.82E+02
   sm151   1.23E+01  1.26E+01  1.25E+01  1.25E+01  1.24E+01  1.24E+01  1.24E+01
   eu151   1.15E-02  5.25E-02  9.34E-02  1.34E-01  1.75E-01  2.15E-01  2.55E-01
   sm152   1.29E+02  1.29E+02  1.29E+02  1.29E+02  1.29E+02  1.29E+02  1.29E+02
   eu153   1.14E+02  1.15E+02  1.15E+02  1.15E+02  1.15E+02  1.15E+02  1.15E+02
   gd155   3.30E-02  1.67E-01  6.80E-01  9.75E-01  1.25E+00  1.51E+00  1.76E+00
  total    3.20E+04  3.20E+04  3.20E+04  3.20E+04  3.20E+04  3.20E+04  3.20E+04
```