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**SAS2H Input for Computing
Core Activities of 4.5, 5.0, and
5.5 Weight % ^{235}U Fuel for
Sequoyah Nuclear Plant**

O. W. Hermann

**MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY**

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**SAS2H INPUT FOR COMPUTING CORE ACTIVITIES OF 4.5, 5.0, AND
5.5 WEIGHT % ²³⁵U FUEL FOR SEQUOYAH NUCLEAR PLANT**

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August 1994

NOTICE: This document contains information of a preliminary nature.
It is subject to revision or correction and therefore does not
represent a final report.

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under Contract No. ERL 94-1217

Prepared by the
OAK RIDGE NATIONAL LABORATORY
managed by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
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ABSTRACT

Sequoyah Nuclear Plant core activities at initial fuel enrichments of 4.5, 5.0, and 5.5 wt % ^{235}U , required in nuclear safety evaluations, were computed by the SAS2H analysis sequence and the ORIGEN-S code within the SCALE-4.2 code system.

OBJECTIVE

The work performed under contract number ERD-94-1217 (ref. 1) with the Tennessee Valley Authority (TVA) is described in this report. The TVA requested technical support in the computations of core activities per fuel assembly to be applied in a design basis loss-of-coolant accident (LOCA) for TVA's Sequoyah Nuclear Plant (SQN). Prior calculations of fuel assembly activities² were produced by the SCALE-4.1 code system for fuel having initial enrichments of 3.0, 3.75, and 4.5 wt % ²³⁵U. The three basic cases requested in the current project pertained to fuel assembly activities for initial enrichments of 4.5, 5.0, and 5.5 wt % ²³⁵U. Also, the effects on isotopic activities from assemblies either containing or coupled with burnable poison rods were examined as requested in three supplemental cases. The activity analyses of these six cases, applying the required reactor parameters, have been completed using the SAS2H/ORIGEN-S analysis sequence of the SCALE-4.2 code system.³ The ORIGEN-S activity tables of all the cases have been transmitted electronically, by diskette, to C. W. Burrell of TVA. Hard-copy printouts of the SAS2H 5.0 wt % case and the six ORIGEN-S cases have also been provided to Mr. Burrell.

This report gives all sources of input to the codes and includes any significant assumptions used in the input.

SOURCES OF THE CODE INPUT

This section provides references that contained the detailed problem description from which the code input data for SAS2H and ORIGEN-S were derived.

Except for initial uranium isotopic specifications, the input description data to the codes for the basic cases were identical to that of the prior SQN core activity project² referred to in the previous section. The fuel assembly loading and assumed power history were given in the statement of work of the project contract.¹ Assembly fuel pin and guide tube design dimensions for a 17 × 17 Westinghouse fuel assembly and nominal coolant pressure were taken from Chapter 4 of the SQN Final Safety Analysis Report (FSAR).⁴ The zone temperatures and boron content of the coolant were specified in a special core parameter input report⁵ for the prior core activity project. The set of light-element weights per assembly were computed from the masses per unit weight of uranium used in a project for calculating decay heat.⁶ Cross sections for 13 actinides, 181 fission products, and 5 light elements were extracted from the SCALE-4.2 burnup library³ (27BURNUPLIB), collapsed with XSDRNP-S-derived spectra and placed on the burnup-dependent ORIGEN-S libraries by the SAS2H module. The remaining nuclide cross sections in the ORIGEN-S libraries were adjusted based on spectrum changes predicted by XSDRNP-S. The initial uranium isotopes were derived, as in the prior SQN activity project,² as a function of ²³⁵U enrichment:

$$\text{wt } \% {}^{234}\text{U} = 0.007731 (\text{wt } \% {}^{235}\text{U})^{1.0837}$$

$$\text{wt } \% {}^{236}\text{U} = 0.0046 (\text{wt } \% {}^{235}\text{U})$$

$$\text{wt } \% {}^{238}\text{U} = 100 - \text{wt } \% {}^{234}\text{U} - \text{wt } \% {}^{235}\text{U} - \text{wt } \% {}^{236}\text{U}.$$

BASIC CASES COMPUTED

The descriptions of the input, output, and script files developed for the basic cases analyzed in this project are shown in Table 1. The input files to a code contained the user-specified data for the case. The output files contained the case printout. The script files contain the proper UNIX commands for the code execution and the copying or saving of required files on an IBM/RISC-6000 workstation. The lists of the two scripts for each ${}^{235}\text{U}$ enrichment case are copied to the end of the ORIGEN-S output in order to document or confirm that proper file names were applied in saving or printing files.

Table 1. Description of input, output, and script^a files for the basic cases analyzed

File name	Type	Wt % ${}^{234}\text{U}$	Code	Purpose or comment
script.sqn45s2	Script	4.5	SAS2H	Execute SAS2H, saving library
script.sqn50s2	Script	5.0	SAS2H	Execute SAS2H, saving library
script.sqn55s2	Script	5.5	SAS2H	Execute SAS2H, saving library
tva1994.sqn45	Input	4.5	SAS2H	Input file to SAS2H
tva1994.sqn50	Input	5.0	SAS2H	Input file to SAS2H
tva1994.sqn55	Input	5.5	SAS2H	Input file to SAS2H
tva1994.sqn45.o	Output	4.5	SAS2H	Output file of SAS2H
tva1994.sqn50.o	Output	5.0	SAS2H	Output file of SAS2H
tva1994.sqn55.o	Output	5.5	SAS2H	Output file of SAS2H
script.sqn45or	Script	4.5	ORIGEN-S	Execute ORIGEN-S
script.sqn50or	Script	5.0	ORIGEN-S	Execute ORIGEN-S
script.sqn55or	Script	5.5	ORIGEN-S	Execute ORIGEN-S
tva94or.sqn45	Input	4.5	ORIGEN-S	Input file to ORIGEN-S
tva94or.sqn50	Input	5.0	ORIGEN-S	Input file to ORIGEN-S
tva94or.sqn55	Input	5.5	ORIGEN-S	Input file to ORIGEN-S
tva94or.sqn45.o	Output	4.5	ORIGEN-S	Output file of ORIGEN-S
tva94or.sqn50.o	Output	5.0	ORIGEN-S	Output file of ORIGEN-S
tva94or.sqn55.o	Output	5.5	ORIGEN-S	Output file of ORIGEN-S

^aThe script files, which have commands specifying the code input and output files shown and names of files saved, are listed at the end of the corresponding ORIGEN-S output file.

SUPPLEMENTAL CASES COMPUTED

The only difference in the three basic cases from the previous work was the initial uranium isotopic composition. The activity tables produced by these basic cases provide data for a LOCA analysis as a function of initial ^{235}U enrichment. However, improvements to the fuel assembly design may become necessary for better operating characteristics when using higher initial ^{235}U enrichments. An approximate determination of the effect of a modified 5 wt % ^{235}U fuel assembly on the isotopic activities was requested by TVA as a supplement to the three basic cases. The MARK-BW17 fuel assembly description⁷ was supplied as the data for the modified or proposed new type of fuel assembly.

There are two major characteristics of the MARK-BW17 fuel assembly which may be specified only by an approximation in the SAS2H input. One of these characteristics is concerned with the number of different types of fuel rods or guide tubes within a fuel assembly. In general, a fuel assembly within a reactor may contain guide tubes, burnable poison rods containing no fuel, orifice rods, axial peaking rods, or fuel rods containing a burnable poison, in addition to the regular fuel rods. Although SAS2H maintains the feature in which one of the secondary types of rods or tubes may be explicitly described in the input model of the fuel assembly, the code has no provision for directly including more than one of these secondary rod types. The MARK-BW17 fuel assembly design includes both guide tubes and uranium/gadolinia ($\text{UO}_2/\text{Gd}_2\text{O}_3$) fuel rods.

To overcome this modeling difficulty, and at the same time determine the net activity effects of various assembly modifications, a simplified guide tube model was developed that could be represented by a single pass (path A) in SAS2H, allowing the assembly modifications to be included in the second pass (path B) of SAS2H. Thus, to perform a comparative evaluation, the MARK-BW17 assembly was analyzed first as a reference case using only the simplified guide tube model and then as a modified case with the simplified guide tube model plus the $\text{UO}_2/\text{Gd}_2\text{O}_3$ fuel rods. For the simplified guide tube model, it was assumed that the 264 fuel rods were in a full lattice and that the mass of the water in and surrounding the actual guide tubes was included in a higher density water between the fuel rods. Although the original assembly volume was reduced to the size needed for including only the fuel rods, the adjusted water density (0.8232 g/cm^3) was such that the water in the reduced assembly was equal in weight to that of the original assembly. It was assumed that the weak neutron activity of the Zircaloy guide tube was insignificant. This case containing only the single change, in water density, from the earlier 5 wt % ^{235}U basic case should be considered as the reference case to be compared with the MARK-BW17 case results. For the modification case, the SAS2H input level 2 procedure allowed for the path B model to contain a $\text{UO}_2/\text{Gd}_2\text{O}_3$ fuel rod surrounded by a fuel zone (applying path A computed data). The maximum of 8 wt % Gd_2O_3 and the largest number of 24 burnable poison fuel rods were applied, producing the maximum effect from the inclusion of gadolinium in the MARK-BW17 fuel assembly.

The second major characteristic of the MARK-BW17 fuel assembly that is not directly provided for in the SAS2H model is the natural or slightly enriched uranium axial blanket fuel rods specified in the design. The general effect of the axial blanket is to redistribute the linear axial power or burnup from the short end segments to the long central segment of the rods, where the ^{235}U enrichment is much higher. The approximation used in the SAS2H case was as follows: The total ^{235}U weight for the whole assembly was computed using the 5 wt % in the proper central segments and the natural ^{235}U abundance in the corresponding end segments. Then the active fuel length that would have produced an equal weight of ^{235}U using 5 wt % ^{235}U was applied as the length of the fuel assembly in the SAS2H case. One of the approximations of all SAS2H cases is to apply the average linear power over the complete active fuel length. Thus, the above fuel length approximation method applied in the MARK-BW17 case is probably not significantly different from that usually applied. The effect of either an axial peaking blanket or a shorter fuel assembly is to somewhat increase the neutron flux within the fuel assembly. Other small changes are noted in the MARK-BW17 fuel assembly design, which also were included in the SAS2H input data.

In addition to the $\text{UO}_2/\text{Gd}_2\text{O}_3$ modified and reference cases discussed above, a case applying a conventional burnable poison rod design using borosilicate glass was computed. Data were available from the FSAR for SQN and from data supplied for core critical calculations⁸ to provide input to the case. There were 24 burnable poison pins assumed in the case to produce the maximum effect.

The changes in total assembly isotopic activities were small in comparing the appropriate cases in the supplemental case calculations. Although these changes were small, the more significant analyses will be in the comparisons to be made by TVA in the corresponding LOCA analyses. The descriptions of the input, output, and script files used in the supplemental cases analyzed in this project are shown in Table 2.

SUMMARY

Time-dependent core activities per fuel assembly were computed by SAS2H/ORIGEN-S of the SCALE-4.2 system for SQN Units 1 and 2. The sources of the required code input are referenced, and each individual case is identified in the report. Data approximations assumed for the input are stated, in addition to the reasons for the assumptions. Hard-copy and electronic case printouts are being provided to C. W. Burrell under separate cover. The SAS2H case inputs are included in the Appendix.

Table 2. Description of input, output, and script^a files for the supplementary cases analyzed

File name	Type	Code	Purpose or comment
script.h2o50s2	Script	SAS2H	Execute reference case
script.gd50s2	Script	SAS2H	Execute Gd ₂ O ₃ /UO ₂ case
script.bp50s2	Script	SAS2H	Execute burnable boron case
tva1994.h2o50	Input	SAS2H	Input of reference case
tva1994.gd50	Input	SAS2H	Input of Gd ₂ O ₃ /UO ₂ case
tva1994.bp50	Input	SAS2H	Input of burnable boron case
tva1994.h2o50.o	Output	SAS2H	Output of reference case
tva1994.gd50.o	Output	SAS2H	Output of Gd ₂ O ₃ /UO ₂ case
tva1994.bp50.o	Output	SAS2H	Output of burnable boron case
script.h2o50or	Script	ORIGEN-S	Execute reference case
script.gd50or	Script	ORIGEN-S	Execute Gd ₂ O ₃ /UO ₂ case
script.bp50or	Script	ORIGEN-S	Execute burnable boron case
tva94or.h2o50	Input	ORIGEN-S	Input of reference case
tva94or.gd50	Input	ORIGEN-S	Input of Gd ₂ O ₃ /UO ₂ case
tva94or.bp50	Input	ORIGEN-S	Input of burnable boron case
tva94or.h2o50.o	Output	ORIGEN-S	Output of reference case
tva94or.gd50.o	Output	ORIGEN-S	Output of Gd ₂ O ₃ /UO ₂ case
tva94or.bp50.o	Output	ORIGEN-S	Output of burnable boron case

^aThe script files, which have commands specifying the code input and output files shown and names of files saved, are listed at the end of the corresponding ORIGEN-S output file.

REFERENCES

1. "Statement of Work for Calculation of Isotopic Activities for Sequoyah Nuclear Plant (SQN)," Appendix A of Contract No. ERD-94-1217 between Martin Marietta Energy Systems, Inc., and the Tennessee Valley Authority, June 22, 1994.
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APPENDIX A
SAS2H BASIC CASE INPUT

```

=sas2      parw='halt06,skipshipdata'
sas2h: tva, seq 17x17 pwr, 4.50 wt-%, 39.611 mw/mtu, 466.32 kgu/assmb.
/
/ -----
/  ** the 4.50 wt-% u235 sequoyah pwr 1 & 2 case for activities **
/
/ case uses scale-4.2; lib has endf/b5 fp yields & endf/b6 dec-data
/
/      for: c. w. burrell, at tva
/
/ - - - - - (july 6, 1994) - - - - - by o. w. hermann
/
/ -----
/ mixtures of fuel-pin-unit-cell:
/
27burnuplib  latticecell
uo2 1 0.9485 901 92234 0.039 92235 4.50 92236 0.021 92238 95.440 end
co-59 3 0 1-20 579 end
zr-94 1 0 1-20 901 end
tc-99 1 0 1-20 901 end
ge-72 1 0 1-20 901 end      sb-124 1 0 1-20 901 end
ge-73 1 0 1-20 901 end      sb-125 1 0 1-20 901 end
ge-74 1 0 1-20 901 end      sb-126 1 0 1-20 901 end
ge-76 1 0 1-20 901 end      te-122 1 0 1-20 901 end
as-75 1 0 1-20 901 end      te-123 1 0 1-20 901 end
se-76 1 0 1-20 901 end      te-124 1 0 1-20 901 end
se-77 1 0 1-20 901 end      te-125 1 0 1-20 901 end
se-78 1 0 1-20 901 end      te-126 1 0 1-20 901 end
se-80 1 0 1-20 901 end      te-127m 1 0 1-20 901 end
se-82 1 0 1-20 901 end      te-128 1 0 1-20 901 end
br-79 1 0 1-20 901 end      te-129m 1 0 1-20 901 end
br-81 1 0 1-20 901 end      te-130 1 0 1-20 901 end
kr-80 1 0 1-20 901 end      te-132 1 0 1-20 901 end
kr-82 1 0 1-20 901 end      i-127 1 0 1-20 901 end
kr-83 1 0 1-20 901 end      i-129 1 0 1-20 901 end
kr-84 1 0 1-20 901 end      i-130 1 0 1-20 901 end
kr-85 1 0 1-20 901 end      i-131 1 0 1-20 901 end
kr-86 1 0 1-20 901 end      i-135 1 0 1-20 901 end
rb-85 1 0 1-20 901 end      xe-128 1 0 1-20 901 end
rb-86 1 0 1-20 901 end      xe-129 1 0 1-20 901 end
rb-87 1 0 1-20 901 end      xe-130 1 0 1-20 901 end
sr-86 1 0 1-20 901 end      xe-131 1 0 1-20 901 end
sr-87 1 0 1-20 901 end      xe-132 1 0 1-20 901 end
sr-88 1 0 1-20 901 end      xe-133 1 0 1-20 901 end
sr-89 1 0 1-20 901 end      xe-134 1 0 1-20 901 end
sr-90 1 0 1-20 901 end      xe-136 1 0 1-20 901 end
y-89 1 0 1-20 901 end      cs-134 1 0 1-20 901 end
y-90 1 0 1-20 901 end      cs-135 1 0 1-20 901 end
y-91 1 0 1-20 901 end      cs-136 1 0 1-20 901 end
zr-90 1 0 1-20 901 end      cs-137 1 0 1-20 901 end
zr-91 1 0 1-20 901 end      ba-134 1 0 1-20 901 end
zr-92 1 0 1-20 901 end      ba-135 1 0 1-20 901 end
zr-93 1 0 1-20 901 end      ba-136 1 0 1-20 901 end
zr-94 1 0 1-20 901 end      ba-137 1 0 1-20 901 end
zr-95 1 0 1-20 901 end      ba-138 1 0 1-20 901 end
zr-96 1 0 1-20 901 end      ba-140 1 0 1-20 901 end
nb-93 1 0 1-20 901 end      la-139 1 0 1-20 901 end
nb-94 1 0 1-20 901 end      la-140 1 0 1-20 901 end
nb-95 1 0 1-20 901 end      ce-140 1 0 1-20 901 end
mo-94 1 0 1-20 901 end      ce-141 1 0 1-20 901 end
mo-95 1 0 1-20 901 end      ce-142 1 0 1-20 901 end
mo-96 1 0 1-20 901 end      ce-143 1 0 1-20 901 end
mo-97 1 0 1-20 901 end      ce-144 1 0 1-20 901 end
mo-98 1 0 1-20 901 end      pr-141 1 0 1-20 901 end
mo-99 1 0 1-20 901 end      pr-142 1 0 1-20 901 end

```

Fig. A.1. SAS2H input to 4.5 wt % ^{235}U basic case.

```

mo-100 1 0 1-20 901 end      pr-143 1 0 1-20 901 end
tc-99  1 0 1-20 901 end      nd-142 1 0 1-20 901 end
ru-99  1 0 1-20 901 end      nd-143 1 0 1-20 901 end
ru-100 1 0 1-20 901 end      nd-144 1 0 1-20 901 end
ru-101 1 0 1-20 901 end      nd-145 1 0 1-20 901 end
ru-102 1 0 1-20 901 end      nd-146 1 0 1-20 901 end
ru-103 1 0 1-20 901 end      nd-147 1 0 1-20 901 end
ru-104 1 0 1-20 901 end      nd-148 1 0 1-20 901 end
ru-105 1 0 1-20 901 end      nd-150 1 0 1-20 901 end
ru-106 1 0 1-20 901 end      pm-147 1 0 1-20 901 end
rh-103 1 0 1-20 901 end      pm-148 1 0 1-20 901 end
rh-105 1 0 1-20 901 end      pm-149 1 0 1-20 901 end
pd-104 1 0 1-20 901 end      pm-151 1 0 1-20 901 end
pd-105 1 0 1-20 901 end      sm-147 1 0 1-20 901 end
pd-106 1 0 1-20 901 end      sm-148 1 0 1-20 901 end
pd-107 1 0 1-20 901 end      sm-149 1 0 1-20 901 end
pd-108 1 0 1-20 901 end      sm-150 1 0 1-20 901 end
pd-110 1 0 1-20 901 end      sm-151 1 0 1-20 901 end
ag-107 1 0 1-20 901 end      sm-152 1 0 1-20 901 end
ag-109 1 0 1-20 901 end      sm-153 1 0 1-20 901 end
ag-111 1 0 1-20 901 end      sm-154 1 0 1-20 901 end
cd-108 1 0 1-20 901 end      eu-151 1 0 1-20 901 end
cd-110 1 0 1-20 901 end      eu-152 1 0 1-20 901 end
cd-111 1 0 1-20 901 end      eu-153 1 0 1-20 901 end
cd-112 1 0 1-20 901 end      eu-154 1 0 1-20 901 end
cd-113 1 0 1-20 901 end      eu-155 1 0 1-20 901 end
cd-114 1 0 1-20 901 end      eu-156 1 0 1-20 901 end
cd-115m 1 0 1-20 901 end     eu-157 1 0 1-20 901 end
cd-116 1 0 1-20 901 end      gd-154 1 0 1-20 901 end
in-113 1 0 1-20 901 end      gd-155 1 0 1-20 901 end
in-115 1 0 1-20 901 end      gd-156 1 0 1-20 901 end
sn-115 1 0 1-20 901 end      gd-157 1 0 1-20 901 end
sn-116 1 0 1-20 901 end      gd-158 1 0 1-20 901 end
sn-117 1 0 1-20 901 end      gd-160 1 0 1-20 901 end
sn-118 1 0 1-20 901 end      tb-159 1 0 1-20 901 end
sn-119 1 0 1-20 901 end      tb-160 1 0 1-20 901 end
sn-120 1 0 1-20 901 end      dy-160 1 0 1-20 901 end
sn-122 1 0 1-20 901 end      dy-161 1 0 1-20 901 end
sn-123 1 0 1-20 901 end      dy-162 1 0 1-20 901 end
sn-124 1 0 1-20 901 end      dy-163 1 0 1-20 901 end
sn-125 1 0 1-20 901 end      dy-164 1 0 1-20 901 end
sn-126 1 0 1-20 901 end      ho-165 1 0 1-20 901 end
sb-121 1 0 1-20 901 end      er-166 1 0 1-20 901 end
sb-123 1 0 1-20 901 end      er-167 1 0 1-20 901 end

zircalloy 2 1 628 end
h2o 3 den=0.7149 1 579 end
arbm-bormod 0.7149 1 1 0 0 5000 100 3 600.0e-6 579 end
/
600 pm(wt) boron
/
.....
end comp
/
.....
/
fuel-pin-cell geometry:
squarepitch 1.25984 0.81915 1 3 0.94966 2 0.83566 0 end
/
.....
/
more data szf=0.6 end
/
assembly and cycle parameters:
/
npin/assm=264 fuelnght=365.76 ncycles=6 nlib/cyc=1
printlevel=4 lightel=9 inplevel=1 ortube=0.61214 srtube=0.5715
numinstr=1 facmesh=0.65 end
power=18.4715 burn=200 down=0 end
power=18.4715 burn=200 down=0 end

```

Fig. A.1 (continued)

```
power=18.4715 burn=200 down=0 end  
power=18.4715 burn=200 down=0 end  
power=18.4715 burn=200 down=0 end  
power=18.4715 burn=200 down=0 end
```

```
,  
  o 63 cr 2.8 mn 0.15  
  fe 6.0 co 0.035 ni 4.6  
  zr 103 nb 0.33 sn 1.7  
,  
, .....  
,  
end
```

Fig. A.1 (continued)

```

=sas2      perm='halt06,skipshipdata'
sas2h: tva, seq 17x17 pwr, 5.00 wt-%, 39.611 mw/mtu, 466.32 kgu/assmb.
/
/ -----
/  ** the 5.00 wt-% u235 sequoyah pwr 1 & 2 case for activities **
/
/ case uses scale-4.2; lib has endf/b5 fp yields & endf/b6 dec-data
/
/      for: c. w. burrell, at tva
/
/ - - - - - (july 12, 1994) - - - - - by o. w. hermann
/
/ -----
/
/ mixtures of fuel-pin-unit-cell:
/
27burnuplib latticecell
uo2 1 0.9485 901 92234 0.044 92235 5.0 92236 0.023 92238 94.933 end
co-59 3 0 1-20 579 end
zr-94 1 0 1-20 901 end
tc-99 1 0 1-20 901 end
ge-72 1 0 1-20 901 end    sb-124 1 0 1-20 901 end
ge-73 1 0 1-20 901 end    sb-125 1 0 1-20 901 end
ge-74 1 0 1-20 901 end    sb-126 1 0 1-20 901 end
ge-76 1 0 1-20 901 end    te-122 1 0 1-20 901 end
as-75 1 0 1-20 901 end    te-123 1 0 1-20 901 end
se-76 1 0 1-20 901 end    te-124 1 0 1-20 901 end
se-77 1 0 1-20 901 end    te-125 1 0 1-20 901 end
se-78 1 0 1-20 901 end    te-126 1 0 1-20 901 end
se-80 1 0 1-20 901 end    te-127m 1 0 1-20 901 end
se-82 1 0 1-20 901 end    te-128 1 0 1-20 901 end
br-79 1 0 1-20 901 end    te-129m 1 0 1-20 901 end
br-81 1 0 1-20 901 end    te-130 1 0 1-20 901 end
kr-80 1 0 1-20 901 end    te-132 1 0 1-20 901 end
kr-82 1 0 1-20 901 end    i-127 1 0 1-20 901 end
kr-83 1 0 1-20 901 end    i-129 1 0 1-20 901 end
kr-84 1 0 1-20 901 end    i-130 1 0 1-20 901 end
kr-85 1 0 1-20 901 end    i-131 1 0 1-20 901 end
kr-86 1 0 1-20 901 end    i-135 1 0 1-20 901 end
rb-85 1 0 1-20 901 end    xe-128 1 0 1-20 901 end
rb-86 1 0 1-20 901 end    xe-129 1 0 1-20 901 end
rb-87 1 0 1-20 901 end    xe-130 1 0 1-20 901 end
sr-86 1 0 1-20 901 end    xe-131 1 0 1-20 901 end
sr-87 1 0 1-20 901 end    xe-132 1 0 1-20 901 end
sr-88 1 0 1-20 901 end    xe-133 1 0 1-20 901 end
sr-89 1 0 1-20 901 end    xe-134 1 0 1-20 901 end
sr-90 1 0 1-20 901 end    xe-136 1 0 1-20 901 end
y-89 1 0 1-20 901 end    cs-134 1 0 1-20 901 end
y-90 1 0 1-20 901 end    cs-135 1 0 1-20 901 end
y-91 1 0 1-20 901 end    cs-136 1 0 1-20 901 end
zr-90 1 0 1-20 901 end    cs-137 1 0 1-20 901 end
zr-91 1 0 1-20 901 end    ba-134 1 0 1-20 901 end
zr-92 1 0 1-20 901 end    ba-135 1 0 1-20 901 end
zr-93 1 0 1-20 901 end    ba-136 1 0 1-20 901 end
zr-94 1 0 1-20 901 end    ba-137 1 0 1-20 901 end
zr-95 1 0 1-20 901 end    ba-138 1 0 1-20 901 end
zr-96 1 0 1-20 901 end    ba-140 1 0 1-20 901 end
nb-93 1 0 1-20 901 end    la-139 1 0 1-20 901 end
nb-94 1 0 1-20 901 end    la-140 1 0 1-20 901 end
nb-95 1 0 1-20 901 end    ce-140 1 0 1-20 901 end
mo-94 1 0 1-20 901 end    ce-141 1 0 1-20 901 end
mo-95 1 0 1-20 901 end    ce-142 1 0 1-20 901 end
mo-96 1 0 1-20 901 end    ce-143 1 0 1-20 901 end
mo-97 1 0 1-20 901 end    ce-144 1 0 1-20 901 end
mo-98 1 0 1-20 901 end    pr-141 1 0 1-20 901 end

```

Fig. A.2. SAS2H input to 5.0 wt % ^{235}U basic case.

```

mo-99 1 0 1-20 901 end      pr-142 1 0 1-20 901 end
mo-100 1 0 1-20 901 end     pr-143 1 0 1-20 901 end
tc-99 1 0 1-20 901 end     nd-142 1 0 1-20 901 end
ru-99 1 0 1-20 901 end     nd-143 1 0 1-20 901 end
ru-100 1 0 1-20 901 end    rd-144 1 0 1-20 901 end
ru-101 1 0 1-20 901 end    nd-145 1 0 1-20 901 end
ru-102 1 0 1-20 901 end    nd-146 1 0 1-20 901 end
ru-103 1 0 1-20 901 end    nd-147 1 0 1-20 901 end
ru-104 1 0 1-20 901 end    nd-148 1 0 1-20 901 end
ru-105 1 0 1-20 901 end    nd-150 1 0 1-20 901 end
ru-106 1 0 1-20 901 end    pm-147 1 0 1-20 901 end
rh-103 1 0 1-20 901 end    pm-148 1 0 1-20 901 end
rh-105 1 0 1-20 901 end    pm-149 1 0 1-20 901 end
pd-104 1 0 1-20 901 end    pm-151 1 0 1-20 901 end
pd-105 1 0 1-20 901 end    sm-147 1 0 1-20 901 end
pd-106 1 0 1-20 901 end    sm-148 1 0 1-20 901 end
pd-107 1 0 1-20 901 end    sm-149 1 0 1-20 901 end
pd-108 1 0 1-20 901 end    sm-150 1 0 1-20 901 end
pd-110 1 0 1-20 901 end    sm-151 1 0 1-20 901 end
ag-107 1 0 1-20 901 end    sm-152 1 0 1-20 901 end
ag-109 1 0 1-20 901 end    sm-153 1 0 1-20 901 end
ag-111 1 0 1-20 901 end    sm-154 1 0 1-20 901 end
cd-108 1 0 1-20 901 end    eu-151 1 0 1-20 901 end
cd-110 1 0 1-20 901 end    eu-152 1 0 1-20 901 end
cd-111 1 0 1-20 901 end    eu-153 1 0 1-20 901 end
cd-112 1 0 1-20 901 end    eu-154 1 0 1-20 901 end
cd-113 1 0 1-20 901 end    eu-155 1 0 1-20 901 end
cd-114 1 0 1-20 901 end    eu-156 1 0 1-20 901 end
cd-115m 1 0 1-20 901 end   eu-157 1 0 1-20 901 end
cd-116 1 0 1-20 901 end   gd-154 1 0 1-20 901 end
in-113 1 0 1-20 901 end   gd-155 1 0 1-20 901 end
in-115 1 0 1-20 901 end   gd-156 1 0 1-20 901 end
sn-115 1 0 1-20 901 end   gd-157 1 0 1-20 901 end
sn-116 1 0 1-20 901 end   gd-158 1 0 1-20 901 end
sn-117 1 0 1-20 901 end   gd-160 1 0 1-20 901 end
sn-118 1 0 1-20 901 end   tb-159 1 0 1-20 901 end
sn-119 1 0 1-20 901 end   tb-160 1 0 1-20 901 end
sn-120 1 0 1-20 901 end   dy-160 1 0 1-20 901 end
sn-122 1 0 1-20 901 end   dy-161 1 0 1-20 901 end
sn-123 1 0 1-20 901 end   dy-162 1 0 1-20 901 end
sn-124 1 0 1-20 901 end   dy-163 1 0 1-20 901 end
sn-125 1 0 1-20 901 end   dy-164 1 0 1-20 901 end
sn-126 1 0 1-20 901 end   ho-165 1 0 1-20 901 end
sb-121 1 0 1-20 901 end   er-166 1 0 1-20 901 end
sb-123 1 0 1-20 901 end   er-167 1 0 1-20 901 end

zirccalloy 2 1 628 end
h2o 3 den=0.7149 1 579 end
arbm-bormod 0.7149 1 1 0 0 5000 100 3 600.0e-6 579 end
/
600 pm(wt) boron
/
.....
end comp
/
.....
/
fuel-pin-cell geometry:
/
squarepitch 1.25984 0.81915 1 3 0.94966 2 0.83566 0 end
/
.....
/
more data szf=0.6 end
/
assembly and cycle parameters:
/
npin/assm=264 fuelnght=365.76 ncycles=6 nlib/cyc=1
printlevel=4 lightel=9 inplevel=1 ortube=0.61214 srtube=0.5715
numinstr=1 facmesh=0.65 end

```

Fig. A.2 (continued)

```
power=18.4715 burn=200 down=0 end
power=18.4715 burn=200 down=0 end
power=18.4715 burn=200 down=0 end
power=18.4715 burn=200 down=0 end
power=18.4715 burn=200 down=0 end
power=18.4715 burn=200 down=0 end
,
o 63 cr 2.8 mn 0.15
fe 6.0 co 0.035 ni 4.6
zr 103 nb 0.33 sn 1.7
,
. . . . .
,
end
```

Fig. A.2 (continued)

```

*sas2      parm='halt06,skipshipdata'
sas2h: tva, seq 17x17 pwr, 5.50 wt-%, 39.611 mw/mtu, 466.32 kgu/assmb.
/
/-----
/  ** the 5.50 wt-% u235 sequoyah pwr 1 & 2 case for activities **
/ case uses scale-4.2; lib has endf/b5 fp yields & endf/b6 dec-data
/
/      for: c. w. burrell, at tva
/
/  - - - - - (July 12, 1994) - - - - - by o. w. hermann
/-----
/
/ mixtures of fuel-pin-unit-cell:
/
27burnuplib  latticecell
uo2  1 0.9485 901 92234 0.049 92235 5.50 92236 0.025 92238 94.426  end
co-59 3 0 1-20 579  end
zr-94 1 0 1-20 901  end
tc-99 1 0 1-20 901  end
ge-72 1 0 1-20 901  end      sb-124 1 0 1-20 901  end
ge-73 1 0 1-20 901  end      sb-125 1 0 1-20 901  end
ge-74 1 0 1-20 901  end      sb-126 1 0 1-20 901  end
ge-76 1 0 1-20 901  end      te-122 1 0 1-20 901  end
as-75 1 0 1-20 901  end      te-123 1 0 1-20 901  end
se-76 1 0 1-20 901  end      te-124 1 0 1-20 901  end
se-77 1 0 1-20 901  end      te-125 1 0 1-20 901  end
se-78 1 0 1-20 901  end      te-126 1 0 1-20 901  end
se-80 1 0 1-20 901  end      te-127m 1 0 1-20 901  end
se-82 1 0 1-20 901  end      te-128 1 0 1-20 901  end
br-79 1 0 1-20 901  end      te-129m 1 0 1-20 901  end
br-81 1 0 1-20 901  end      te-130 1 0 1-20 901  end
kr-80 1 0 1-20 901  end      te-132 1 0 1-20 901  end
kr-82 1 0 1-20 901  end      i-127 1 0 1-20 901  end
kr-83 1 0 1-20 901  end      i-129 1 0 1-20 901  end
kr-84 1 0 1-20 901  end      i-130 1 0 1-20 901  end
kr-85 1 0 1-20 901  end      i-131 1 0 1-20 901  end
kr-86 1 0 1-20 901  end      i-135 1 0 1-20 901  end
rb-85 1 0 1-20 901  end      xe-128 1 0 1-20 901  end
rb-86 1 0 1-20 901  end      xe-129 1 0 1-20 901  end
rb-87 1 0 1-20 901  end      xe-130 1 0 1-20 901  end
sr-86 1 0 1-20 901  end      xe-131 1 0 1-20 901  end
sr-87 1 0 1-20 901  end      xe-132 1 0 1-20 901  end
sr-88 1 0 1-20 901  end      xe-133 1 0 1-20 901  end
sr-89 1 0 1-20 901  end      xe-134 1 0 1-20 901  end
sr-90 1 0 1-20 901  end      xe-136 1 0 1-20 901  end
y-89 1 0 1-20 901  end      cs-134 1 0 1-20 901  end
y-90 1 0 1-20 901  end      cs-135 1 0 1-20 901  end
y-91 1 0 1-20 901  end      cs-136 1 0 1-20 901  end
zr-90 1 0 1-20 901  end      cs-137 1 0 1-20 901  end
zr-91 1 0 1-20 901  end      ba-134 1 0 1-20 901  end
zr-92 1 0 1-20 901  end      ba-135 1 0 1-20 901  end
zr-93 1 0 1-20 901  end      ba-136 1 0 1-20 901  end
zr-94 1 0 1-20 901  end      ba-137 1 0 1-20 901  end
zr-95 1 0 1-20 901  end      ba-138 1 0 1-20 901  end
zr-96 1 0 1-20 901  end      ba-140 1 0 1-20 901  end
nb-93 1 0 1-20 901  end      la-139 1 0 1-20 901  end
nb-94 1 0 1-20 901  end      la-140 1 0 1-20 901  end
nb-95 1 0 1-20 901  end      ce-140 1 0 1-20 901  end
mo-94 1 0 1-20 901  end      ce-141 1 0 1-20 901  end
mo-95 1 0 1-20 901  end      ce-142 1 0 1-20 901  end
mo-96 1 0 1-20 901  end      ce-143 1 0 1-20 901  end
mo-97 1 0 1-20 901  end      ce-144 1 0 1-20 901  end
mo-98 1 0 1-20 901  end      pr-141 1 0 1-20 901  end
mo-99 1 0 1-20 901  end      pr-142 1 0 1-20 901  end

```

Fig. A.3. SAS2H input to 5.5 wt % ^{235}U basic case.


```

mo-100 1 0 1-20 901 end      pr-143 1 0 1-20 901 end
tc-92  1 0 1-20 901 end      nd-142 1 0 1-20 901 end
ru-100 1 0 1-20 901 end      nd-143 1 0 1-20 901 end
ru-101 1 0 1-20 901 end      nd-144 1 0 1-20 901 end
ru-102 1 0 1-20 901 end      nd-145 1 0 1-20 901 end
ru-103 1 0 1-20 901 end      nd-146 1 0 1-20 901 end
ru-104 1 0 1-20 901 end      nd-147 1 0 1-20 901 end
ru-105 1 0 1-20 901 end      nd-148 1 0 1-20 901 end
ru-106 1 0 1-20 901 end      nd-150 1 0 1-20 901 end
rh-103 1 0 1-20 901 end      pm-147 1 0 1-20 901 end
rh-105 1 0 1-20 901 end      pm-148 1 0 1-20 901 end
pd-104 1 0 1-20 901 end      pm-149 1 0 1-20 901 end
pd-105 1 0 1-20 901 end      pm-151 1 0 1-20 901 end
pd-106 1 0 1-20 901 end      sm-147 1 0 1-20 901 end
pd-107 1 0 1-20 901 end      sm-148 1 0 1-20 901 end
pd-108 1 0 1-20 901 end      sm-149 1 0 1-20 901 end
pd-110 1 0 1-20 901 end      sm-150 1 0 1-20 901 end
ag-107 1 0 1-20 901 end      sm-151 1 0 1-20 901 end
ag-109 1 0 1-20 901 end      sm-152 1 0 1-20 901 end
ag-111 1 0 1-20 901 end      sm-153 1 0 1-20 901 end
cd-108 1 0 1-20 901 end      sm-154 1 0 1-20 901 end
cd-110 1 0 1-20 901 end      eu-151 1 0 1-20 901 end
cd-111 1 0 1-20 901 end      eu-152 1 0 1-20 901 end
cd-112 1 0 1-20 901 end      eu-153 1 0 1-20 901 end
cd-113 1 0 1-20 901 end      eu-154 1 0 1-20 901 end
cd-114 1 0 1-20 901 end      eu-155 1 0 1-20 901 end
cd-115m 1 0 1-20 901 end     eu-156 1 0 1-20 901 end
cd-116 1 0 1-20 901 end     eu-157 1 0 1-20 901 end
in-113 1 0 1-20 901 end     gd-154 1 0 1-20 901 end
in-115 1 0 1-20 901 end     gd-155 1 0 1-20 901 end
sn-115 1 0 1-20 901 end     gd-156 1 0 1-20 901 end
sn-116 1 0 1-20 901 end     gd-157 1 0 1-20 901 end
sn-117 1 0 1-20 901 end     gd-158 1 0 1-20 901 end
sn-118 1 0 1-20 901 end     gd-160 1 0 1-20 901 end
sn-119 1 0 1-20 901 end     tb-159 1 0 1-20 901 end
sn-120 1 0 1-20 901 end     tb-160 1 0 1-20 901 end
sn-122 1 0 1-20 901 end     dy-160 1 0 1-20 901 end
sn-123 1 0 1-20 901 end     dy-161 1 0 1-20 901 end
sn-124 1 0 1-20 901 end     dy-162 1 0 1-20 901 end
sn-125 1 0 1-20 901 end     dy-163 1 0 1-20 901 end
sn-126 1 0 1-20 901 end     dy-164 1 0 1-20 901 end
sb-121 1 0 1-20 901 end     ho-165 1 0 1-20 901 end
sb-123 1 0 1-20 901 end     er-166 1 0 1-20 901 end
                                er-167 1 0 1-20 901 end

zircalloy 2 1 628 end
h2o 3 den=0.7149 1 579 end
arbm-bormod 0.7149 1 1 0 0 5000 100 3 600.0e-6 579 end
/
600 pm(wt) boron
/
.....
end comp
/
.....
/
fuel-pin-cell geometry:
/
squarepitch 1.25984 0.81915 1 3 0.94966 2 0.83566 0 end
/
.....
/
more data szf=0.6 end
/
assembly and cycle parameters:
/
npin/assm=264 fuelnght=365.76 ncycles=6 nlib/cyc=1
printlevel=4 lightel=9 inplevel=1 ortube=0.61214 srtube=0.5715
numinstr=1 facmesh=0.65 end

```

Fig. A.3 (continued)

```
power=18.4715 burn=200 down=0      end
power=18.4715 burn=200 down=0      end
power=18.4715 burn=200 down=0      end
power=18.4715 burn=200 down=0      end
power=18.4715 burn=200 down=0      end
power=18.4715 burn=200 down=0      end
,
  o 63 cr 2.8 mn 0.15
  fe 6.0 co 0.035 ni 4.6
  zr 103 nb 0.33 sn 1.7
,
. . . . .
,
end
```

Fig. A.3 (continued)

APPENDIX B
SAS2H SUPPLEMENTAL CASE INPUT

```

=ss2      perm='halt06,skipshipdata'
mod. density increase, to equal mod in guide tubes, compare mark-bw17 with this
/
/-----
/  ** the 5.00 wt-% u235 sequoyah pwr 1 & 2 case for activities **
/
/ case uses scale-4.2; lib has endf/b5 fp yields & endf/b6 dec-data
/ ref. case for comparing with mark-bw17, for gd & shorter fuel effects.
/
/      for: c. w. burrell, at tva
/
/ - - - - - (august 2, 1994) - - - - - by o. w. hermann
/-----
/
/ mixtures of fuel-pin-unit-cell:
/
27burnuplib  latticecell
uo2  1 0.9485 901 92234 0.044 92235 5.0  92236 0.023 92238 94.933  end
co-59 3 0 1-20 579  end
zr-94 1 0 1-20 901  end
tc-99 1 0 1-20 901  end
mo-94 1 0 1-20 901  end
nb-95 1 0 1-20 901  end
mo-95 1 0 1-20 901  end
tc-99 1 0 1-20 901  end
rh-113 1 0 1-20 901  end
rh-105 1 0 1-20 901  end
ru-106 1 0 1-20 901  end
sn-126 1 0 1-20 901  end
xe-131 1 0 1-20 901  end
cs-134 1 0 1-20 901  end
cs-135 1 0 1-20 901  end
cs-137 1 0 1-20 901  end
pr-143 1 0 1-20 901  end
nd-143 1 0 1-20 901  end
ce-144 1 0 1-20 901  end
nd-144 1 0 1-20 901  end
nd-145 1 0 1-20 901  end
nd-146 1 0 1-20 901  end
nd-147 1 0 1-20 901  end
pm-147 1 0 1-20 901  end
sm-147 1 0 1-20 901  end
nd-148 1 0 1-20 901  end
pm-148 1 0 1-20 901  end
sm-148 1 0 1-20 901  end
pm-149 1 0 1-20 901  end
sm-149 1 0 1-20 901  end
nd-150 1 0 1-20 901  end
sm-150 1 0 1-20 901  end
sm-151 1 0 1-20 901  end
eu-151 1 0 1-20 901  end
sm-152 1 0 1-20 901  end
eu-153 1 0 1-20 901  end
eu-154 1 0 1-20 901  end
gd-154 1 0 1-20 901  end
eu-155 1 0 1-20 901  end
gd-155 1 0 1-20 901  end
gd-157 1 0 1-20 901  end
gd-158 1 0 1-20 901  end
gd-160 1 0 1-20 901  end
zircalloy 2 1 628  end
/  h2o 3 den=0.7149 1 579 end
h2o 3 den=0.8232 1 579 end
n 5 0 1-20 901  end
uo2  5 0.9485 901 92234 0.044 92235 5.0  92236 0.023 92238 94.933  end

```

Fig. B.1. SAS2H input to the increased water density reference case.

```

n 6 0 1-20 901 end
arbm-bormod 0.8232 1 1 0 0 5000 100 3 600.0e-6 579 end
/      use 0.8232 to keep b the same
/      600 pm(wt) boron
/      .....
end comp
/
/      .....
/      fuel-pin-cell geometry:
/
squarepitch 1.25984 0.81915 1 3 0.94966 2 0.83566 0 end
/
/      .....
more data szf=0.6 end
/
assembly and cycle parameters:
/
npin/assm=264 fuelnght=365.76 ncycles=6 nlib/cyc=1
printlevel=4 lightel=9 inplevel=2 numztotat=5 facmesh=2.2 end
5 0.40957 6 0.41783 2 0.47483 3 0.710789 500 2.35742
power=18.4715 burn=200 down=0 end
power=18.4715 burn=200 down=0 end
power=18.4715 burn=200 down=0 end
power=18.4715 burn=200 down=0 end
power=18.4715 burn=200 down=0 end
power=18.4715 burn=200 down=0 end
/
o 63 cr 2.8 mn 0.15
fe 6.0 co 0.035 ni 4.6
zr 103 nb 0.33 an 1.7
/
/      .....
end

```

Fig. B.1 (continued)

```

=sas2      perm='halt06,skipshipdata'
mark-bw17 at higher mod. dens, 8% gd2-o3, l-fuel=337.231 cm, 456 kgu, .3195 od
/
/ -----
/
/  ** the 5.00 wt-% u235 sequoyah pwr 1 & 2 case for activities **
/
/ case uses scale-4.2; lib has endf/b5 fp yields & endf/b6 dec-data
/ ref case should be compared to this case for gd & shorter fuel effects.
/
/      for: c. w. burrell, at tva
/
/ - - - - - (august 2, 1994) - - - - - by o. w. hermann
/
/ -----
/
/ mixtures of fuel-pin-unit-cell:
/
27burnuplib  latticecell
uo2  1 0.9450 901 92234 0.044 92235 5.0  92236 0.023 92238 94.933  end
co-59 3 0 1-20 579  end
zr-94 1 0 1-20 901  end
tc-99 1 0 1-20 901  end
mo-94 1 0 1-20 901  end
nb-95 1 0 1-20 901  end
mo-95 1 0 1-20 901  end
tc-99 1 0 1-20 901  end
rh-103 1 0 1-20 901  end
rh-105 1 0 1-20 901  end
ru-106 1 0 1-20 901  end
sn-126 1 0 1-20 901  end
xe-131 1 0 1-20 901  end
cs-134 1 0 1-20 901  end
cs-135 1 0 1-20 901  end
cs-137 1 0 1-20 901  end
pr-143 1 0 1-20 901  end
nd-143 1 0 1-20 901  end
ce-144 1 0 1-20 901  end
nd-144 1 0 1-20 901  end
nd-145 1 0 1-20 901  end
nd-146 1 0 1-20 901  end
nd-147 1 0 1-20 901  end
pm-147 1 0 1-20 901  end
sm-147 1 0 1-20 901  end
nd-148 1 0 1-20 901  end
pm-148 1 0 1-20 901  end
sm-148 1 0 1-20 901  end
pm-149 1 0 1-20 901  end
sm-149 1 0 1-20 901  end
nd-150 1 0 1-20 901  end
sm-150 1 0 1-20 901  end
sm-151 1 0 1-20 901  end
eu-151 1 0 1-20 901  end
sm-152 1 0 1-20 901  end
eu-153 1 0 1-20 901  end
eu-154 1 0 1-20 901  end
gd-154 1 0 1-20 901  end
eu-155 1 0 1-20 901  end
gd-155 1 0 1-20 901  end
gd-157 1 0 1-20 901  end
gd-158 1 0 1-20 901  end
gd-160 1 0 1-20 901  end
zircalloy 2 1 628  end
/ h2o 3 den=0.7149 1 579 end
h2o 3 den=0.8232 1 579 end
n 5 0 1-20 901  end
uo2  5 0.9450 901 92234 0.044 92235 5.0  92236 0.023 92238 94.933  end

```

Fig. B.2. SAS2H input to the MARK-BW17 fuel assembly Gd_2O_3/UO_2 case.

```

arbm-gdburn 10.357 7 0 1 1
        64154 2.18 64155 14.80 64156 20.47
        64157 15.65 64158 24.84 64160 21.86
        8016 150.0 5 0.08 901 end
/
        ....above is 8.0 wt % gadolinium (as gd2-ox3) in the
        burnable poison gd pins of sqn assembly....
n 6 0 1-20 901 end
arbm-bormod 0.8232 1 1 0 0 5000 100 3 600.0e-6 579 end
/
        use 0.8232 to keep b the same
/
        600 pm(wt) boron
/
        .....
end comp
/
        .....
/
        fuel-pin-cell geometry:
/
squarepitch 1.25984 0.81153 1 3 0.94966 2 0.83566 0 end
/
        .....
/
more data szf=0.6 end
/
        assembly and cycle parameters:
/
npin/assm=264 fuelnght=337.231 ncycles=6 nlib/cyc=1
printlevel=4 lightel=9 inplevel=2 numztot=5 facmesh=2.2 end
5 0.40576 6 0.41783 2 0.47483 3 0.710789 500 2.35742
power=18.4715 burn=200 down=0 end
power=18.4715 burn=200 down=0 end
power=18.4715 burn=200 down=0 end
power=18.4715 burn=200 down=0 end
power=18.4715 burn=200 down=0 end
power=18.4715 burn=200 down=0 end
/
        o 63 cr 2.8 mn 0.15
        fe 6.0 co 0.035 ni 4.6
        zr 103 nb 0.33 sn 1.7
/
        .....
/
end

```

Fig. B.2 (continued)

```

*sas2      perm='halt06,skipshipdata'
sas2h: burnable poison boron, tva sqn 17x17 pwr, 5.00 wt-%, 466.32 kgu/assmb.
/
/ -----
/  ** the 5.00 wt-% u235 sequoyah pwr 1 & 2 case for activities **
/
/ case uses scale-4.2; lib has endf/b5 fp yields & endf/b6 dec-data
/
/   burnable poison rods type case - see script:  script.bp45s2
/
/       for: c. w. burrell, at tva
/
/   - - - - - (august 2, 1994) - - - - - by o. w. hermann
/
/ -----
/
/ mixtures of fuel-pin-unit-cell:
/
27burnuplib  latticecell
uo2 1 0.9485 901 92234 0.044 92235 5.0 92236 0.023 92238 94.933 end
co-59 3 0 1-20 579 end
zr-94 1 0 1-20 901 end
tc-99 1 0 1-20 901 end
ge-72 1 0 1-20 901 end    sb-124 1 0 1-20 901 end
ge-73 1 0 1-20 901 end    sb-125 1 0 1-20 901 end
ge-74 1 0 1-20 901 end    sb-126 1 0 1-20 901 end
ge-76 1 0 1-20 901 end    te-122 1 0 1-20 901 end
as-75 1 0 1-20 901 end    te-123 1 0 1-20 901 end
se-76 1 0 1-20 901 end    te-124 1 0 1-20 901 end
se-77 1 0 1-20 901 end    te-125 1 0 1-20 901 end
se-78 1 0 1-20 901 end    te-126 1 0 1-20 901 end
se-80 1 0 1-20 901 end    te-127m 1 0 1-20 901 end
se-82 1 0 1-20 901 end    te-128 1 0 1-20 901 end
br-79 1 0 1-20 901 end    te-129m 1 0 1-20 901 end
br-81 1 0 1-20 901 end    te-130 1 0 1-20 901 end
kr-80 1 0 1-20 901 end    te-132 1 0 1-20 901 end
kr-82 1 0 1-20 901 end    i-127 1 0 1-20 901 end
kr-83 1 0 1-20 901 end    i-129 1 0 1-20 901 end
kr-84 1 0 1-20 901 end    i-130 1 0 1-20 901 end
kr-85 1 0 1-20 901 end    i-131 1 0 1-20 901 end
kr-86 1 0 1-20 901 end    i-135 1 0 1-20 901 end
rb-85 1 0 1-20 901 end    xe-128 1 0 1-20 901 end
rb-86 1 0 1-20 901 end    xe-129 1 0 1-20 901 end
rb-87 1 0 1-20 901 end    xe-130 1 0 1-20 901 end
sr-86 1 0 1-20 901 end    xe-131 1 0 1-20 901 end
sr-87 1 0 1-20 901 end    xe-132 1 0 1-20 901 end
sr-88 1 0 1-20 901 end    xe-133 1 0 1-20 901 end
sr-89 1 0 1-20 901 end    xe-134 1 0 1-20 901 end
sr-90 1 0 1-20 901 end    xe-136 1 0 1-20 901 end
y-89 1 0 1-20 901 end    cs-134 1 0 1-20 901 end
y-90 1 0 1-20 901 end    cs-135 1 0 1-20 901 end
y-91 1 0 1-20 901 end    cs-136 1 0 1-20 901 end
zr-90 1 0 1-20 901 end    cs-137 1 0 1-20 901 end
zr-91 1 0 1-20 901 end    ba-134 1 0 1-20 901 end
zr-92 1 0 1-20 901 end    ba-135 1 0 1-20 901 end
zr-93 1 0 1-20 901 end    ba-136 1 0 1-20 901 end
zr-94 1 0 1-20 901 end    ba-137 1 0 1-20 901 end
zr-95 1 0 1-20 901 end    ba-138 1 0 1-20 901 end
zr-96 1 0 1-20 901 end    ba-140 1 0 1-20 901 end
nb-93 1 0 1-20 901 end    la-139 1 0 1-20 901 end
nb-94 1 0 1-20 901 end    la-140 1 0 1-20 901 end
nb-95 1 0 1-20 901 end    ce-140 1 0 1-20 901 end
mo-94 1 0 1-20 901 end    ce-141 1 0 1-20 901 end
mo-95 1 0 1-20 901 end    ce-142 1 0 1-20 901 end
mo-96 1 0 1-20 901 end    ce-143 1 0 1-20 901 end
mo-97 1 0 1-20 901 end    ce-144 1 0 1-20 901 end

```

Fig. B.3. SAS2H input to the burnable poison rods containing boron case.


```

mo-98 1 0 1-20 901 end
mo-99 1 0 1-20 901 end
mo-100 1 0 1-20 901 end
tc-99 1 0 1-20 901 end
ru-99 1 0 1-20 901 end
ru-100 1 0 1-20 901 end
ru-101 1 0 1-20 901 end
ru-102 1 0 1-20 901 end
ru-103 1 0 1-20 901 end
ru-104 1 0 1-20 901 end
ru-105 1 0 1-20 901 end
ru-106 1 0 1-20 901 end
rh-103 1 0 1-20 901 end
rh-105 1 0 1-20 901 end
pd-104 1 0 1-20 901 end
pd-105 1 0 1-20 901 end
pd-106 1 0 1-20 901 end
pd-107 1 0 1-20 901 end
pd-108 1 0 1-20 901 end
pd-110 1 0 1-20 901 end
ag-107 1 0 1-20 901 end
ag-109 1 0 1-20 901 end
ag-111 1 0 1-20 901 end
cd-108 1 0 1-20 901 end
cd-110 1 0 1-20 901 end
cd-111 1 0 1-20 901 end
cd-112 1 0 1-20 901 end
cd-113 1 0 1-20 901 end
cd-114 1 0 1-20 901 end
cd-115m 1 0 1-20 901 end
cd-116 1 0 1-20 901 end
in-113 1 0 1-20 901 end
in-115 1 0 1-20 901 end
sn-115 1 0 1-20 901 end
sn-116 1 0 1-20 901 end
sn-117 1 0 1-20 901 end
sn-118 1 0 1-20 901 end
sn-119 1 0 1-20 901 end
sn-120 1 0 1-20 901 end
sn-122 1 0 1-20 901 end
sn-123 1 0 1-20 901 end
sn-124 1 0 1-20 901 end
sn-125 1 0 1-20 901 end
sn-126 1 0 1-20 901 end
sb-121 1 0 1-20 901 end
sb-123 1 0 1-20 901 end
pr-141 1 0 1-20 901 end
pr-142 1 0 1-20 901 end
pr-143 1 0 1-20 901 end
nd-142 1 0 1-20 901 end
nd-143 1 0 1-20 901 end
nd-144 1 0 1-20 901 end
nd-145 1 0 1-20 901 end
nd-146 1 0 1-20 901 end
nd-147 1 0 1-20 901 end
nd-148 1 0 1-20 901 end
nd-150 1 0 1-20 901 end
pm-147 1 0 1-20 901 end
pm-148 1 0 1-20 901 end
pm-149 1 0 1-20 901 end
pm-151 1 0 1-20 901 end
sm-147 1 0 1-20 901 end
sm-148 1 0 1-20 901 end
sm-149 1 0 1-20 901 end
sm-150 1 0 1-20 901 end
sm-151 1 0 1-20 901 end
sm-152 1 0 1-20 901 end
sm-153 1 0 1-20 901 end
sm-154 1 0 1-20 901 end
eu-151 1 0 1-20 901 end
eu-152 1 0 1-20 901 end
eu-153 1 0 1-20 901 end
eu-154 1 0 1-20 901 end
eu-155 1 0 1-20 901 end
eu-156 1 0 1-20 901 end
eu-157 1 0 1-20 901 end
gd-154 1 0 1-20 901 end
gd-155 1 0 1-20 901 end
gd-156 1 0 1-20 901 end
gd-157 1 0 1-20 901 end
gd-158 1 0 1-20 901 end
gd-160 1 0 1-20 901 end
tb-159 1 0 1-20 901 end
tb-160 1 0 1-20 901 end
dy-160 1 0 1-20 901 end
dy-161 1 0 1-20 901 end
dy-162 1 0 1-20 901 end
dy-163 1 0 1-20 901 end
dy-164 1 0 1-20 901 end
ho-165 1 0 1-20 901 end
er-166 1 0 1-20 901 end
er-167 1 0 1-20 901 end
zircalloy 2 1 628 end
h2o 3 den=0.7149 1 579 end
arbm-bormod 0.7149 1 1 0 0 5000 100 3 600.0e-6 579 end
/
600 pm(wt) boron
/
ss304 5 1 579 end
o 6 0 0.04497 579 end
na 6 0 0.00165 579 end
al 6 0 0.00058 579 end
si 6 0 0.01799 579 end
k 6 0 0.00011 579 end
b-10 6 0 9.595-4 579 end
b-11 6 0 3.863-3 579 end
n 7 0 5-5 579 end
end comp
/
/
fuel-pin-cell geometry:
/

```

Fig. B.3 (continued)

```

squarepitch  1.25984 0.81915 1 3 0.94966 2 0.83566 0  end
/
/ -----
/
more data  szf=0.6  end
/
assembly and cycle parameters:
/
npin/assm=264 fuelnght=365.76 ncycles=6  nlfb/cyc=1
printlevel=4 lightel=9  inplevel=2
numztotal=10  facmesh=0.65 mxrepeats=0  end
/
7 0.21400  5 0.23051  7 0.24130  6 0.42672  7 0.43688
5 0.48387  3 0.5715  2 0.61214  3 0.710789 500 2.43666
7 0.21400  5 0.23051  7 0.24130  6 0.42672  7 0.43688
5 0.48387  3 0.5715  2 0.61214  3 0.710789 500 2.43666
3 0.21400  3 0.23051  3 0.24130  3 0.42672  3 0.43688
3 0.48387  3 0.5715  2 0.61214  3 0.710789 500 2.43666
3 0.21400  3 0.23051  3 0.24130  3 0.42672  3 0.43688
3 0.48387  3 0.5715  2 0.61214  3 0.710789 500 2.43666
3 0.21400  3 0.23051  3 0.24130  3 0.42672  3 0.43688
3 0.48387  3 0.5715  2 0.61214  3 0.710789 500 2.43666
3 0.21400  3 0.23051  3 0.24130  3 0.42672  3 0.43688
3 0.48387  3 0.5715  2 0.61214  3 0.710789 500 2.43666
/
power=18.4715  burn=200  down=0  end
power=18.4715  burn=200  down=0  end
power=18.4715  burn=200  down=0  end
power=18.4715  burn=200  down=0  end
power=18.4715  burn=200  down=0  end
/
o 63 cr 2.8 mn 0.15
fe 6.0 co 0.035 ni 4.6
zr 103 nb 0.33 sn 1.7
/
/ -----
/
end

```

Fig. B.3 (continued)

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