**SAS2H INPUT AND ASSUMPTIONS FOR CASES
COMPUTING ISOTOPIC ACTIVITIES
FOR SEQUOYAH NUCLEAR PLANT**

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It is subject to revision or correction and therefore does not
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MARTIN MARIETTA ENERGY SYSTEMS, INC.
managing the
Oak Ridge National Laboratory Oak Ridge Y-12 Plant
Oak Ridge Gaseous Diffusion Plant Paducah Gaseous Diffusion Plant
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MASTER

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ABSTRACT

Sequoyah Nuclear Plant core activities, required in nuclear safety evaluations, were computed by the SAS2H analysis sequence and the ORIGEN-S code within the SCALE-4 system.

OBJECTIVE

This report describes the work performed to satisfy contract no. ERD-91-017 with the TVA. The TVA requested technical support regarding the computation of core activities to be assumed in a design basis loss-of-coolant accident (LOCA) for TVA's Sequoyah Nuclear Plant (SQN). Core activities for the required reactor parameters have been completed using the SAS2H/ORIGEN-S analysis sequence in the SCALE-4 system.¹ The ORIGEN-S activity tables have been transmitted to R. L. Sanders of TVA by floppy disks. Hard-copy printouts of all of the SAS2H and ORIGEN-S cases have also been provided to Mr. Sanders.

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

SOURCES OF THE CODE INPUT

This section provides the references used to obtain the detailed problem description from which the code input data for SAS2H and ORIGEN-S were obtained.

The core fuel loading and assumed power history were given in the statement of work in the project contract.² Assembly and pin design dimensions and nominal coolant pressure were taken from Chapter 4 of the SQN Final Safety Analysis Report (FSAR) as supplied by ref. 3. The effective or average material-zone temperatures and the boron concentration in the coolant were specified in a special core parameter input report⁴ for this project. The set of light element masses per assembly were computed from the masses per unit weight of uranium used in a recent decay heat project.⁵ The wt % ²³⁶U was computed from the ²³⁵U enrichment in a formula used in other projects.^{5,7} The wt % ²³⁴U was calculated consistent with the method used in a burnup credit project⁷ from the following formula: $\text{wt \% } ^{234}\text{U} = 0.007731 (\text{wt \% } ^{235}\text{U})^{1.0837}$. Cross sections for 13 actinides, 181 fission products, and 5 light elements on the SCALE-4 burnup library (27BURNULIB) were updated with XSDRNPM-S derived fluxes on the 18 ORIGEN-S libraries produced by SAS2H.

CASES COMPUTED

The names and purposes of the SAS2H/ORIGEN-S cases for which hard-copy printout is being provided to TVA are:

OWHSQ300 - 3.00 wt % ^{235}U SAS2H case for libraries
OWHSQ375 - 3.75 wt % ^{235}U SAS2H case for libraries
OWHSQ450 - 4.50 wt % ^{235}U SAS2H case for libraries
OWHSE300 - 3.00 wt % ^{235}U ORIGEN-S case for activities
OWHSE375 - 3.75 wt % ^{235}U ORIGEN-S case for activities
OWHSE450 - 4.50 wt % ^{235}U ORIGEN-S case for activities
OWHAB300 - 3.00 wt % ^{235}U ORIGEN-S case for neutron absorptions
OWHAB375 - 3.75 wt % ^{235}U ORIGEN-S case for neutron absorptions
OWHAB450 - 4.50 wt % ^{235}U ORIGEN-S case for neutron absorptions

On the floppy disks given TVA, the files named S300CASE.OUT, S375CASE.OUT, and S450CASE.OUT contain output corresponding to the printout of OWHSE300, OWHSE375, and OWHSE450, respectively. The ORIGEN-S cases that computed neutron absorption fractions of nuclides were added to assist in explaining differences in SAS2H/ORIGEN-S and nondepletion code results.

The initial SAS2H and ORIGEN-S cases were reviewed and approved by R. L. Sanders of TVA prior to completion of the analyses. The electronic output described and the hard-copy output for all cases have been transmitted to R. L. Sanders of TVA.

SUMMARY

Time-dependent core activities were computed by SAS2H/ORIGEN-S for Sequoyah Nuclear Plant Units 1 and 2. Hard-copy and electronic case printouts are being provided to R. L. Sanders of TVA under separate cover. The sources of essential code input are referenced, and the cases are identified in this report. The appendices include plots of time-dependent total activities, together with the activities for several important nuclides. An example of the job control language and input of one of the SAS2H cases (3.0 wt % ^{235}U) are also included in the Appendix.

REFERENCES

1. *SCALE: A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation*, Vols. 1-3, NUREG/CR-0200, U.S. Nuclear Regulatory Commission [originally issued July 1980; reissued January 1982; Rev. 1 issued July 1982; Rev. 2 issued June 1983; Rev. 3 issued December 1984; Rev. 4 (draft) issued February 1990].
2. "Statement of Work for Calculation of Isotope Activities for Sequoyah Nuclear Plant (SQN)," Appendix A of Contract No. ERD-91-1017 between the Martin Marietta Energy Systems, Inc., and the Tennessee Valley Authority, April 31, 1991.
3. Letter from P. G. Trudel, Tennessee Valley Authority, to Cecil Parks, Oak Ridge National Laboratory, "Sequoyah Nuclear Plant Units 1 and 2 - Information to Execute the ORIGEN Computer Codes" (received May 1991).
4. D. M. Brown, "Determination of Representative Core Parameters for ORNL Environmental Qualification (EQ) Calculation," File No. PFE-G97, RIMS No. L36 910515 801, Tennessee Valley Authority (May 1991).
5. O. W. Hermann, J. P. Renier, and C. V. Parks, *Technical Support for a Proposed Decay Heat Guide Using SAS2H/ORIGEN-S Data*, NUREG/CR-5625, ORNL/CSD-130, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab. (to be published).
6. S. P. Cerne, O. W. Hermann, and R. M. Westfall, *Reactivity and Isotopic Composition of Spent PWR Fuel as a Function of Initial Enrichment, Burnup, and Cooling Time*, ORNL/CSD/TM-244, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab. (October 1987).
7. O. W. Hermann, *Data Compiled in Burnup Credit Isotope Validation Study*, ORNL/M-1425, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab. (April 1991).

APPENDIX A

**PLOTS OF SEQUOYAH NUCLEAR PLANT
FUEL ASSEMBLY ACTIVITIES**

SEQUOYAH FUEL ACTIVITY - 3.0 WT % U235

ORIGEN-S

Case by: QWH

SEQUOYAH FUEL ACTIVITY - 3.75 WT % U235

ORIGEN-S

Case by: QWH

SEQUOYAH FUEL ACTIVITY - 4.50 WT % U235

ORIGEN-S

Case by: OWH

APPENDIX B

EXAMPLE OF JCL AND INPUT TO SAS2H CASE (3.0 WT % ²³⁵U)

```

//OHNSQ300 JOB (39198),'6011X10-HERMANN',TIME=(70,0)
//**HMSX300 JOB (39198),'6011X10-HERMANN',TIME=(3,00)
//**
//** *****
//** *
//** * ...FISSION PRODUCT ACTIVITIES OF SEQUOYAH PHR... *
//** *
//** * CASE FOR 3.00 WT-% U235 TVA SEQUOYAH 17X17 PHR *
//** *
//** * THIS PROJECT SPONSORED BY : R. SANDERS, TVA *
//** *
//** * REACTOR DATA PROVIDED BY: C. BURRELL, TVA *
//** * D. BROWN, TVA *
//** *
//** * COMPUTED BY: O.W. HERMANN, ORNL MAY 17, 1991 *
//** *
//** ** *****
//**
//**
//**PROCLIB DO DISP=SMR,DSN=TZA.PROCLIB.CNTL
//**
//**OUT1 OUTPUT DEFAULT=YES,JESDS=ALL,CHARS=ST15,FCB=10,FORMS=L7DL,
//** DEST=MX10A,COPIES=1
//**UT1 OUTPUT DEFAULT=YES,JESDS=ALL,
//** DEST=R1055,COPIES=1
//** >>>>>>>>> THIS IN LIST OF DECK "AS SAVED" <<<<<<<<<<
//**
//** SAVED ON OHN.TVA.SQN1
//**
//**MAIN LINES=98
//**MAIN CLASS=STANDBY
//**SPDA EXEC SPDASCR
//**SYSPRINT DD SYSOUT=*
//**SYSIN DD *
//** T.OHN39198.SQN1FT90
//** T.OHN39198.SQN1FT70
//** T.OHN39198.SQN1FT72
//** T.OHN39198.SQN1FT74
//** T.OHN39198.SQN1FT55
//** T.OHN39198.SQN1FT94
//**
//**POOL EXEC POOLSCR
//**SYSPRINT DD SYSOUT=*
//**SYSIN DD *
//** OHN.LB300WTP.PHR17F33
//** OHN.LB300WTP.PHR17F34
//** OHN.LB300WTP.PHR17F35
//** OHN.LB300WTP.PHR17F36
//** OHN.LB300WTP.PHR17F37
//** OHN.LB300WTP.PHR17F38
//** OHN.LB300WTP.PHR17F71
//**
//**S2 EXEC SCALE4,REGION=1600K,M6L7B=NULLFILE
//**
//**GO.FT01F001 DD DCB=(RECFM=VBS,LRECL=X,BLKSIZE=9440,BUFL=10232)
//**GO.FT04F001 DD DCB=(RECFM=VBS,LRECL=X,BLKSIZE=9440,BUFL=10232)
//**GO.FT13F001 DD SYSOUT=A,DCB=(RECFM=FA,BLKSIZE=133,BUFL=150)
//**GO.FT16F001 DD SPACE=(TRK,(200,80))
//**GO.FT17F001 DD DCB=(RECFM=VBS,LRECL=X,BLKSIZE=9440,BUFL=10232)
//**GO.FT18F001 DD DCB=(RECFM=VBS,LRECL=X,BLKSIZE=9440,BUFL=10232)
- //**GO.FT19F001 DD DCB=(RECFM=VBS,LRECL=X,BLKSIZE=9440,BUFL=10232)
//**GO.FT90F001 DD SPACE=(TRK,(10,8)),UNIT=SPDA,
//** DISP=(NEW,CATLG),DSN=T.OHN39198.SQN1FT90
//**GO.FT94F001 DD SPACE=(TRK,(10,8)),UNIT=SPDA,
//** DISP=(NEW,CATLG),DSN=T.OHN39198.SQN1FT94
//**GO.FT32F001 DD UNIT=SYSDA,SPACE=(TRK,(30,5)),
//** DCB=(RECFM=VBS,LRECL=X,BLKSIZE=9440,BUFL=10232)
//**GO.FT33F001 DD UNIT=DISK,SPACE=(TRK,(30,5)),
//** DISP=(NEW,CATLG),DSN=OHN.LB300WTP.PHR17F33,
//** DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136,BUFL=6136)
- //**GO.FT34F001 DD UNIT=DISK,SPACE=(TRK,(30,5)),
- //** DISP=(NEW,CATLG),DSN=OHN.LB300WTP.PHR17F34,
//** DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136,BUFL=6136)
//**GO.FT35F001 DD UNIT=DISK,SPACE=(TRK,(30,5)),
//** DISP=(NEW,CATLG),DSN=OHN.LB300WTP.PHR17F35,

```

```

// DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136,BUFL=6136)
//GO.FT36F001 DO UNIT=DISK,SPACE=(TRK,(10,5)),
// DISP=(NEW,CATLG),DSN=OMN.LB300WTP.PWR17F36,
// DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136,BUFL=6136)
//GO.FT37F001 DO UNIT=DISK,SPACE=(TRK,(10,5)),
// DISP=(NEW,CATLG),DSN=OMN.LB300W.P.PWR17F37,
// DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136,BUFL=6136)
//GO.FT38F001 DO UNIT=DISK,SPACE=(TRK,(10,5)),
// DISP=(NEW,CATLG),DSN=OMN.LB300WTP.PWR17F38,
// DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136,BUFL=6136)
//* NOTE ABOVE BLOCKSIZE/BUFL CHANGED TO SCALE DEFAULT.....
//GO.FT70F001 DO SPACE=(TRK,(10,8)),UNIT=SPDA,
// DISP=(NEW,CATLG),DSN=T.OMN39198.SQM1FT70
//GO.FT71F001 DO UNIT=DISK,SPACE=(TRK,(20,5)),
// DISP=(NEW,CATLG),DSN=OMN.LB300WTP.PWR17F71,
// DCB=(RECFM=VBS,LRECL=X,BLKSIZE=9440,BUFL=10232)
//GO.FT72F001 DO UNIT=SPDA,SPACE=(TRK,(10,5)),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=6400),
// DISP=(NEW,CATLG),DSN=T.OMN39198.SQM1FT72
//GO.FT74F001 DO UNIT=SPDA,
// SPACE=(800,(2,2),RLSE),DCB=(RECFM=FB,LRECL=80,BLKSIZE=800),
// DISP=(NEW,CATLG),DSN=T.OMN39198.SQM1FT74
//GO.FT53F001 DO UNIT=SYSDA,SPACE=(TRK,(90,5)),
// DISP=(NEW,PASS),DSN=Z&FT53,
// DCB=(RECFM=VBS,LRECL=X,BLKSIZE=3664,BUFL=4088)
//GO.FT55F001 DO UNIT=SPDA,SPACE=(TRK,(2,1)),
// DCB=(RECFM=VBS,LRECL=X,BLKSIZE=3664,BUFL=4088),
// DISP=(NEW,CATLG),DSN=T.OMN39198.SQM1FT55
//GO.FT63F001 DO UNIT=SYSDA,DSN=Z&PLTOUT,DISP=(NEW,PASS),
// SPACE=(4000,(50,50),RLSE)
//GO.SYSIN DO *
=SAS2 PARM='HALT06,SKIPSHIPDATA'
SAS2N1 TVA, SEQ PWR 17X.17 PLANT, 39.611 MM/RTU, 466.32 KGU/ASSMB.

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** THE 3.00 MT-% U235 SEQUOYAH PWR 1 & 2 CASE FOR ACTIVITIES **
MAKES CASE USING SCALE 4.1 LIB (HAS ENDF/B5 FP YIELDS)
----- (MAY 17, 1991) ----- BY O. H. HERMANN
FOR IVA, R. SANDERS, D. BROWN, C. BURRELL
-----

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MIXTURES OF FUEL-PIN-UNIT-CELL,

```

27BURNUPLIB LATTICECELL
UO2 1 0.9485 901 92234 0.025 92235 3.00 92236 0.014 92238 96.961 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
SF-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-84 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

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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
NO-96 1 0 1-20 901 END      CE-141 1 0 1-20 901 END
NO-95 1 0 1-20 901 END      CE-142 1 0 1-20 901 END
NO-96 1 0 1-20 901 END      CE-143 1 0 1-20 901 END
NO-97 1 0 1-20 901 END      CE-144 1 0 1-20 901 END
NO-98 1 0 1-20 901 END      PR-141 1 0 1-20 901 END
NO-99 1 0 1-20 901 END      PR-142 1 0 1-20 901 END
NO-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     PH-147 1 0 1-20 901 END
RH-103 1 0 1-20 901 END     PH-148 1 0 1-20 901 END
RH-105 1 0 1-20 901 END     PH-149 1 0 1-20 901 END
PD-104 1 0 1-20 901 END     PH-151 1 0 1-20 901 END
PD-105 1 0 1-20 901 END     SH-147 1 0 1-20 901 END
PD-106 1 0 1-20 901 END     SH-148 1 0 1-20 901 END
PD-107 1 0 1-20 901 END     SH-149 1 0 1-20 901 END
PD-108 1 0 1-20 901 END     SH-150 1 0 1-20 901 END
PD-110 1 0 1-20 901 END     SH-151 1 0 1-20 901 END
AG-107 1 0 1-20 901 END     SH-152 1 0 1-20 901 END
AG-109 1 0 1-20 901 END     SH-153 1 0 1-20 901 END
AG-111 1 0 1-20 901 END     SH-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
ARBH-BORHCO 0.7149 1 1 0 0 5000 100 3 600.0E-6 579 END
.
. 600 PH(NT) BORON
.
.
END COMP
.
.
. FUEL-PIN-CELL GEOMETRY,
.
SQUARE PITCH 1.25984 0.81715 1 3 0.94966 2 0.83566 0 END
.
.
.
MORE DATA SZF=0.6 END
.
. ASSEMBLY AND CYCLE PARAMETERS,
.
MPIN/ASSM=264 FUELNGHT=365.76 NCYCLES=6 NLIB/CYC=1
PRINTLEVEL=4 LIGHTEL=9 INPLEVEL=1 ORTUBE=0.61214 SRTUBE=0.5715
NUMINSTR=1 FACIESH=0.65 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
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
//