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Calculation Cover Sheet

Complete only applicable items.

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10. Remarks

Attachment III is contained on an attachment tape for this calculation file.

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1. PURPOSE

The purpose of this calculation is to develop an estimate of the isotopic content as a function of time for mixed oxide (MOX) spent nuclear fuel (SNF) assemblies in a Westinghouse pressurized water reactor (PWR). These data will be used as source data for criticality, thermal, and radiation shielding evaluations of waste package (WP) designs for MOX assemblies in the Monitored Geologic Repository (MGR).

2. METHOD

The use of MOX fuel in power reactors has been investigated through the development of conceptual designs for PWR cores fueled with Westinghouse assemblies (Ref. 1 and Ref. 2). The design documented in Reference 1 utilized the Westinghouse Vantage 5H assembly type (Ref. 2, p. 1-1). The design forming the basis for this calculation and documented in Reference 2 utilized the Westinghouse Vantage 5 assembly type (Ref. 3, p. 2A-30 and Ref. 4).

The depletion of MOX fuel assemblies was calculated with the SAS2H computer code and the isotopic content over time calculated with the ORIGEN-S computer code. A one axial node SAS2H model of the MOX fuel assembly was developed to perform the depletion steps. The isotopic content of assemblies following discharge at various exposure levels was calculated with the ORIGEN-S computer code.

3. ASSUMPTIONS

3.1 Assembly dimensions not specifically defined in the conceptual design documents (Ref. 1 and Ref. 2) are assumed to be the same as those given for Westinghouse LOPAR or Vantage 5 commercial fuel assemblies (Ref. 3, p. 2A-30). The justification for this assumption is that the MOX conceptual designs utilized commercial assembly types. Similar dimensions, where both are specified, for the LOPAR and Vantage 5H assembly designs are the same. This assumption is used in Section 5.1.

3.2 Light element weights representing assembly structural material included in the SAS2H model for the Vantage 5H assembly are assumed to be representative of the Vantage 5 assembly and no changes were made in these data. The justification for this assumption is that differences in the assemblies are in the fuel rod size and content. This assumption is used in Section 5.3.

4. USE OF COMPUTER SOFTWARE

The calculation of nuclear isotopic content of PWR MOX SNF configurations was performed with the SAS2H/ORIGEN-S computer code sequence, which is a part of the SCALE 4.3 computer code system, Computer Software Configuration Item (CSCI): 30011 V4.3. The SAS2H computer code coupled with the ORIGEN-S computer code is designed for reactivity and burnup calculations for nuclear reactor fuel assemblies to determine spent fuel isotopic content over time. Thus, SAS2H and ORIGEN-S are appropriate for the fuel geometry and materials required for these analyses. The calculations using the SCALE 4.3 software were executed on Hewlett Packard (HP) 9000 series workstations. The software qualification of the SCALE 4.3 software, including benchmark problems related to generation of isotope contents, is summarized in the Software Qualification Report for the SCALE Modular Code system (Ref. 5). The SAS2H evaluations performed for this design are fully within the range of the validation for the SAS2H software used. The associated 44GROUP cross section library was used for these calculations. The ORIGEN-S computer code is designed to be used with the SAS2H computer code as the latter code generates the cross sections for the ORIGEN-S calculation. Thus, the evaluations performed with the ORIGEN-S computer code are within the range of validation of the software. Access to and use of the SCALE 4.3 software for this analysis was granted by Software Configuration Management and performed in accordance with the QAP-SI series procedures.

5. CALCULATION

Design parameters for calculating input data for the SAS2H models of MOX SNF assemblies are given in Sections 5.1 through 5.3. The SAS2H Path B geometry is developed in Section 5.4 and exposure steps are developed in Section 5.5. The SAS2H/ORIGEN-S input data files are listed in Attachment II.

5.1 MOX Assembly Design Parameters

The MOX PWR core design parameters are given in Table 5.1-1. Parameters for the Vantage 5H and Vantage 5 assemblies are given in Table 5.1-2. Assembly dimensions are given primarily in English units and converted into metric units. The number of digits in the corresponding metric value column result from the units conversion and are not indicative of precision. Dimensional information is obtained from Westinghouse assembly dimensions and is considered qualified data.

Table 5.1-1. Core Design Parameters Using MOX Fuel

Parameter	1994 Design for Vantage 5H Assemblies	1996 Design for Vantage 5 Assemblies
Heavy Metal Mass	89.1 Metric Tons (MT)[1]	81.6 MT[3]
Number of Assemblies	193[5]	193[6]
Effective Full Power Days (EFPD)	438[1]	493[6]
Target Cycle Length	17,500 MWd/Metric Tons Heavy Metal (MTHM)[1]	21,564 MWd/MTHM[6]
Target Discharge Burnup	44,400 MWd/MTHM[1]	45,000 – 50,000 MWd/MTHM[6]
Feed Assembly Enrichment	36 @ 4.5 wt% fissile Pu 40 @ 4.1 wt% fissile Pu[1]	20 @ 4.5 wt% fissile Pu 72 @ 4.0 wt% fissile Pu[3]
Soluble Boron	750 ppm (cycle average)[2]	1301 ppm (initial)[4]

[1] Ref. 1, p. 2.1-26
[2] Ref. 6, p. 5
[3] Ref. 2, p. 2-11
[4] Ref. 2, p. 2-14
[5] Ref. 1, p. 2.1-5
[6] Ref. 2, p. 2-9

Table 5.1-2. Mechanical Parameters for Westinghouse 17x17 Fuel Assemblies

	Vantage 5H Assembly		Vantage 5 Assembly	
Parameter	Value Metric Units	Value English Units	Value Metric Units	Value English Units
Fuel Rods/Assembly	264[1]	N.A.[c]	264[3]	N.A.
Cladding Material	Zirc-4[1]	N.A.	Zirc-4[3]	N.A.
Maximum Number of WABAs[a]/Assembly	24[2]	N.A.	24[3]	N.A.
Cladding Outside Diameter (OD)	0.94996 cm	0.374 in.[1]	0.9144 cm	0.360 in.[3]
Cladding Thickness	0.05715 cm	0.0225 in.[4]	0.05715 cm	0.0225 in.[4]
Fuel Pellet OD	0.81915 cm	0.3225 in.[1]	0.784352 cm	0.3088 in.[3]
Fuel Length	365.76 cm	144 in.[1]	365.76 cm	144 in.[3]
Pitch	1.25984 cm [7]	0.496 in.	1.25984 cm [7]	0.496 in.
Guide Tube Material	Zirc-4 [10]	N.A.	Zirc-4 [11]	N.A.
Guide Tube OD	1.22428 cm [5]	0.482 in.	1.22428 cm [8]	0.482 in.
Guide Tube Inside Diameter (ID)	1.143 cm [5]	0.45 in.	1.143 cm [8]	0.45 in.

	Vantage 5H Assembly		Vantage 5 Assembly	
Parameter	Value Metric Units	Value English Units	Value Metric Units	Value English Units
Instrument Tube OD	1.22428 cm [5]	0.482 in.	1.22428 cm [8]	0.482 in.
Instrument Tube ID	1.143 cm [5]	0.45 in.	1.143 cm [8]	0.45 in.
WABA Absorber OD	0.96774 cm	0.381 in.[6]	0.96774 cm	0.381 in.[6]
Absorber ID	0.67818 cm	0.267 in.[6]	0.67818 cm	0.267 in.[6]
WABA Material	Al_2O_3-B_4C [6]	N.A.	Al_2O_3-B_4C [6]	N.A.
Density B_4C[14]	2.52 g/cm^3	N.A.	2.52 g/cm^3	N.A.
Absorber ^{10}B Content	6.03 mg/cm [6]	N.A.	6.03 mg/cm [6]	N.A.
IFBA[b] Material	ZrB_2 [12]	N.A.	N.A.	N.A.
^{10}B Content	0.61811 mg/cm	1.57 mg/in.[12]	N.A.	N.A.
Density ZrB_2 [13]	6.085 g/cm^3	N.A.	N.A.	N.A.

[a] Wet Annular Burnable Absorber
[b] Integral Fuel Burnable Absorber (fuel pellet coating)
[c] Not Applicable
[1] Ref. 1, p. 2.1-5
[2] Ref. 1, p. 2.1-11
[3] Ref. 2, p. 2-9
[4] Ref. 3, p. 2A-30 (Assumption 3.1)
[5] Ref. 7, p. 37. Upper region guide tube dimensions used for one axial node SAS2H model.
[6] Ref. 8, p. 4.3-39
[7] Ref. 7, p. 9
[8] Instrument and guide tube dimensions unchanged from Vantage 5H values.
[10] Ref. 1, p. 2.1-25
[11] Ref. 2, p. 2-27
[12] Ref. 1, p. 2.1-50
[13] Ref. 9, p. 609
[14] Ref. 10, p. M8.2.11

The heavy metal isotopic content of the Westinghouse Vantage 5H and Vantage 5 assembly fuel is given in Table 5.1-3 and the light element isotopic content in Table 5.1-4.

Table 5.1-3. Initial Heavy Metal Isotopic Content of Fuel Assemblies

Isotopes	Isotopic Mass[1] (g/mole)	1994 Design for Vantage 5H Assemblies (weight percent)[2]	1996 Design for Vantage 5 Assemblies (weight percent)[3]
^{234}U	234.040904	0.002	0.002
^{235}U	235.043915	0.200	0.200
^{236}U	236.045637	0.001	0.001
^{238}U	238.05077	99.797	99.797
^{238}Pu	238.049511	0.000	0.000

Isotopes	Isotopic Mass[1] (g/mole)	1994 Design for Vantage 5H Assemblies (weight percent)[2]	1996 Design for Vantage 5 Assemblies (weight percent)[3]
^{239}Pu	239.052146	93.600	93.600
^{240}Pu	240.053882	5.900	5.900
^{241}Pu	241.056737	0.400	0.400
^{242}Pu	242.058725	0.100	0.100

[1] Ref. 11, p. 30
[2] Ref. 1, p. 2.1-8
[3] Ref. 2, p. 2-10

Table 5.1-4. Light Element Isotopic Content of Fuel Assemblies

Isotopes	Isotopic Mass (g/mole)	Isotopic Abundance
Zirconium[2]	91.22	N.A.
Natural Boron[1]	10.811	N.A.
^{10}B	10.012939[2]	0.199[3]
^{11}B	11.009305[2]	0.801[3]
Carbon, Natural	12.01115[2]	N.A.
Oxygen, Natural[1]	15.9994	N.A.

[1] Ref. 12, p. 50
[2] Ref. 11, p. 29
[3] Ref. 12, p. 20

5.2 SAS2H Compositions for Westinghouse Vantage 5H MOX SNF Assembly

The base SAS2H model for Westinghouse MOX SNF assemblies was developed by and acquired from Oak Ridge National Laboratory (ORNL) (Ref. 6) and included as Attachment I. This model represented a Westinghouse 17x17 Vantage 5H assembly type as used in the 1994 MOX conceptual design (Ref. 1) as a set of concentric rings preserving the assembly composition areas. To use this model for the SAS2H/ORIGEN-S analyses of the 1996 MOX conceptual design (Ref. 2) incorporating the Westinghouse 17x17 Vantage 5 assembly type, material compositions and SAS2H Path A rod dimensions required revision. Certain assemblies in both the Vantage 5H and Vantage 5 designs contained Wet Annular Burnable Absorbers (WABA), shown schematically in Figure 5.2-1. The Integral Fuel Burnable Absorbers (IFBA) were not utilized in the Vantage 5 assemblies. Computational procedures were defined for deriving composition data, which were checked against the corresponding values for the Vantage 5H assembly involved in the ORNL SAS2H data files. The following calculations for the Vantage 5H assembly utilized the procedure. (Note: The ORNL SAS2H MOX SNF Path A compositions were derived using a fuel pellet OD of 0.3229 in.)

volume of heavy metal (HM) component/rod	= π [pellet OD (cm)]^2·fuel length (cm)/4 = π [0.81915]^2 365.76/4 = 192.75824 cm^3
fuel rod clad ID	= fuel rod OD (cm) – 2 clad thickness (cm) = 0.94996 – 2 0.05715 = 0.83566 cm
mass of HM/rod	= MTHM/core 1000 kg/MT/(no. rods/core) = 89.1 1000/(193 264) = 1.7487 kg/rod
mean atomic weight of uranium (at. wt.) (Table 5.1-3)	= sum (isotopic weight fraction isotopic weight) = 238.044656 g/mole
mean atomic weight of plutonium (Table 5.1-3)	= sum (isotopic weight fraction isotopic weight) = 239.122273 g/mole
weight fraction (Wt. Fr.) U in oxide	= at. wt. U/(at. wt. (U) + at. wt. (O)) = 238.044656/(238.044656 + 2 15.9994) = 0.881505
weight fraction Pu in oxide	= at. wt. Pu/(at. wt. (Pu) + at. wt. (O)) = 239.122273/(239.122273 + 2 15.9994) = 0.881976
core average Pu enrichment	=100 Σ[no. assemblies(i) Pu enrichment (Wt. Fr.(i)]/[(Wt. Fr. fissile Pu) Σno. assemblies(i)] = (40 (4.1) + 36 (4.5))/(0.94 (76)) = 4.5633 wt% Pu
Pu Wt. Fr. (4.5 % enriched fissile Pu) in HM	= Wt. Fr. fissile Pu in HM/fissile Pu Wt. Fr. in Pu = 0.045/0.94 = 0.04787 Wt. Fr. Pu in HM
uranium oxide fuel density 4.5 % enriched fissile Pu	= ((g HM/rod)/(volume/rod (cm^3)))*(1-Pu Wt. Fr.)/(Wt. Fr. U in oxide) = (1748.7/192.75824) (1.0-0.04787)/0.881505 = 9.7988 g/cm^3

plutonium oxide fuel density 4.5 % enriched fissile Pu	= ((g HM/rod)/(volume/rod (cm^3))) Pu Wt. Fr./ (Wt. Fr. Pu. in oxide) = (1748.7/192.75824) 0.04787/0.881976 = 0.4924 g/cm^3
volume of HM component/rod (0.3229 in. OD)	= π [pellet OD (cm)]^2*fuel length (cm)/4 = π [0.820166]^2 365.76/4 = 193.2367 cm^3
uranium oxide fuel density 4.563 % enrichment Pu (average) 0.3229 in. pellet OD	= ((g HM/rod)/(volume/rod (cm^3)) (1-Pu Wt. Fr.)/ (Wt. Fr. U in oxide) = (1748.7/193.2367) (1.0-0.045633)/0.881505 = 9.7975 g/cm^3
versus uranium oxide fuel density (ORNL data Attachment I, p. 1)	= 9.7982 g/cm^3
plutonium oxide fuel density 4.563 % enriched Pu (average) 0.3229 in. pellet OD	= ((g HM/rod)/(volume/rod (cm^3))) Pu Wt. Fr./ (Wt. Fr. Pu in oxide) = (1748.7/193.2367) 0.045633)/0.881976 = 0.4682 g/cm^3
versus plutonium oxide fuel density (ORNL data Attachment I, p. 1)	= 0.4681 g/cm^3
IFBA number density molecular weight (natural boron)	= 91.22 g/mole + 2 (10.811) g/mole = 112.842 g/mole
number density	= Avogadro's No.(molecules/mole) (Ref. 11, p. 31) density (cm^3) (cm^2/barn)/molecular wt (g/mole) = 6.02252e+23 (6.085) 1.0e-24/112.842 = 0.032476 (b-cm)$^{-1}$
Wt. Fr. B in ZrB_2	= 2 (at. wt. B (g/mole))/(molecular wt ZrB_2 (g/mole)) = 2·(10.811) /112.842 = 0.19161 g B/g ZrB_2
linear density B in ZrB_2 0.3229 in. pellet OD	= density (g/cm^3) area (cm^2) Wt Fr. B in ZrB_2 = 6.085 π (0.820166)^2 0.19161/4 = 0.615988 g/cm

linear density scale factor	= coating density (g/cm)/material density = (0.61811e-3 g/cm)/(0.615988 g/cm) = 1.0034e-3
reduced number density ZrB_2	= 0.032476 (1.0034e-3) = 3.2586e-5 $(b\text{-}cm)^{-1}$
reduced number density B (not used in Vantage 5 model) versus	= 2 (3.2588e-5) $(b\text{-}cm)^{-1}$ = 6.5176e-5 $(b\text{-}cm)^{-1}$
number density B_{10} (ORNL data Attachment I, p. 1)	= 6.4584e-5 $(b\text{-}cm)^{-1}$
WABA B_4C weight fraction molecular weight	= Σ(no. atoms(i) atomic fraction(i) at. wt.(i)) = 4 (0.199) 10.012939 + 4 (0.801) 11.009305 + 12.01115 = 55.255263 (g/mole)
Wt. Fr. ^{10}B in B_4C	= 4 (0.199) 10.012939 (g/mole)/55.255263 (g/mole) = 0.144245 g ^{10}B/g B_4C
linear density of B_4C	= density (cm^3) area (cm^2) Wt. Fr. = $2.52\ \pi\ ((0.96774^2 - 0.67818^2)/4)\ 0.144245$ = 0.136063 g ^{10}B/cm
density multiplier for 6.03 mg/cm	= 0.00603/0.136068 = 0.044316
versus density multiplier (ORNL data Attachment I, p. 7)	= 0.041

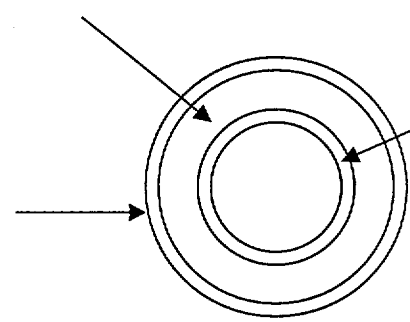

Figure 5.2-1. WABA Cross-Sectional Schematic

5.3 SAS2H Compositions for Vantage 5 Assembly with MOX Material

Composition data for the Vantage 5 assembly model with MOX fuel rods were calculated following the procedure utilized in Section 5.2 and incorporating the Vantage 5 assembly parameters. The light element definition for the Vantage 5 model was obtained from the Vantage 5H model (Assumption 3.2).

volume of HM component/rod = π [pellet OD (cm)]^2 fuel length (cm)/4
= π (0.784352)^2 365.76/4
= 176.72912 cm^3

fuel rod clad ID = fuel rod OD (cm) – 2 clad thickness (cm)
= 0.9144 – 2*0.05715
= 0.8001 cm

mass of HM/rod = MTHM/core 1000 kg/MT/(no. rods/core)
= 81.6 (1000)/(193 (264))
= 1.60151 kg/rod

mean atomic weight of uranium (Table 5.1-3) = Sum (isotopic weight fraction (isotopic weight))
= 238.044656 g/mole

mean atomic weight of plutonium (Table 5.1-3)	= Sum (isotopic weight fraction (isotopic weight)) = 239.122273 g/mole
weight fraction U in oxide	= at. wt. U/(at. wt. (U) + at. wt. (O)) = 238.044656/(238.044656 + 2 (15.9994)) = 0.881505
weight fraction Pu in oxide	= at. wt. Pu/(at. wt. (Pu) + at. wt. (O)) = 239.122273/(239.122273 + 2 (15.9994)) = 0.881976
core average Pu enrichment	= (72 (4.0) + 20 (4.5))/(0.94 (92)). = 4.37095 wt% Pu
Pu Wt. Fr. (4.5 % enriched fissile Pu) in HM	= Wt. Fr. fissile Pu in HM/fissile Pu Wt. Fr. in Pu = 0.045/0.94 = 0.04787 Wt. Fr. Pu in HM
Pu Wt. Fr. (4.0 % enriched fissile Pu) in HM	= Wt. Fr. fissile Pu in HM/fissile Pu Wt. Fr. in Pu = 0.04/0.94 = 0.04255 Wt. Fr. Pu in HM
uranium oxide fuel density 4.5 % enriched fissile Pu	= [(grams HM/rod)/(volume/rod)] (1-Pu Wt. Fr.)/ Wt. Fr. U in oxide = (1601.51/176.72912) (1.0-0.04787)/0.881505 = 9.7880 g/cm^3
plutonium oxide fuel density 4.5 % enriched fissile Pu	= ((grams HM/rod)/(volume/rod)) Pu Wt. Fr./ Wt. Fr. Pu in oxide = (1601.51/176.72912) 0.04787)/0.881976 = 0.49184 g/cm^3
uranium oxide fuel density 4.0 % enriched fissile Pu	= [(grams HM/rod)/(volume/rod)] (1-Pu Wt. Fr.)/ Wt. Fr. U in oxide = (1601.51/176.72912) (1.0-0.04255)/0.881505 = 9.8427 g/cm^3
plutonium oxide fuel density 4.0 % enriched fissile Pu	= ((grams HM/rod)/(volume/rod)) Pu Wt. Fr./ Wt. Fr. Pu in oxide = (1601.51/176.72912) 0.04255)/0.881976 = 0.43718 g/cm^3

5.4 Path B Super-Cell Geometry

The Path B super-cell geometry (Ref. 6, Attachment I, p. 7) (model 1) using burnable absorbers was constructed with an instrument tube cell at the assembly center, surrounded successively by fuel mixture, moderator, inner absorber, cladding, fuel mixture, cladding, outer absorber, moderator, and fuel mixture. The super-cell geometry without burnable absorbers (model 2) was similar, combining the absorber regions into the moderator regions. The super-cell geometry (model 1) preserves the fuel pin cell and WABA assembly areas (for the absorber model), with the remaining assembly area assigned to cladding (guide tubes and WABAs) and moderator. A schematic representation of the Path B geometry (not to scale) is shown in Figure 5.4-1. The super-cell geometry without WABAs (model 2) is the same except for moderator replacing the WABA absorber and cladding area. WABAs were utilized only in feed assemblies for the Vantage 5 MOX core design. Thus, the geometry without WABAs (model 2) was used for assemblies without WABAs present in the initial cycle.

Removing WABAs (model 1) after cycle 1 in the SAS2H analyses necessitated a composition change after the first cycle. This was accomplished by replacing the WABA absorber composition in Path B model 1 with moderator in the cycles following the initial one. The Zircaloy-4 in the guide tubes and WABA cladding was combined in the two guide tube zones resulting in a small excess of Zircaloy-4 in these zones with WABAs removed. The radii and zone areas for Path B model 1 and model 2 are given in Table 5.4-1 and Table 5.4-2, respectively.

The calculations for Path B model 1geometry are as follows:

area	$= \pi$ (outer radius (cm)^2 – inner radius^2 (cm^2))
outer radii calculated for remaining rows:	
radius	= (area (cm^2)/π + inner radius^2 (cm^2))$^{0.5}$
pin cell area	= pitch (cm)^2
	= 1.25984^2 cm^2
	= 1.58720 cm^2
guide tube cladding area	$= \pi$ [1.22428 (cm)^2 – 1.143 (cm)^2]/4
	= 0.1511 cm^2
WABA absorber area (model 1)	$= \pi$ [0.96774 (cm)^2 – 0.67818 (cm)^2]/4
	= 0.3743 cm^2
WABA cladding area	= (Clad + guide tube area) – 8 (0.1511) (cm^2)
(8 units) (derived from Path B model	= 2.6622 cm^2– 1.2088 cm^2
[Table 5.4-1, row 8] Attachment I)	= 1.4534 cm^2/8
	= 0.1817 cm^2

The second zone of 16 units results in a similar area value.

Geometry changes for Path B model 2 (guide tubes, no WABAs) replaced the WABA areas (cladding + absorber) with moderator. The calculation for the 16 unit zone is as follows:
WABA area (0.5560 cm^2/unit) added to moderator zones in model 2.

WABA absorber and cladding area $= 0.3743\ cm^2 + 0.1817\ cm^2$
$= 0.5560\ cm^2/unit$

Moderator area (16 units) $= 14.0831\ cm^2 + 16\ (0.5560)\ cm^2$
$= 22.9791\ cm^2$

(Table 5.4-2, row 10).

Table 5.4-1. Path B Geometry with WABAs for a Vantage 5H Assembly

Material	Inner Radius (cm)	Outer Radius[1] (cm)	Area (cm^2)
Moderator – Interior to Instrument Tube	0	0.5715	1.0261
Clad – Instrument Tube	0.5715	0.6121	0.1510
Moderator – Exterior to Instrument Tube	0.6121	0.7108	0.4102
Fuel Ring (40 rods)	0.7108	4.5513	63.4887
Moderator	4.5513	4.7912	7.0411
WABAs (8)	4.7912	4.8896	2.9927
Clad – Guide Tubes	4.8896	4.9755	2.6622
Fuel (84 rods)	4.9755	8.1972	133.3244
Clad – Guide Tubes	8.1972	8.2999	5.3227
WABAs (16)	8.2999	8.414	5.9912
Moderator	8.414	8.6763	14.0831
Fuel (140 rods)	8.6763	12.0834	222.2060
Total			458.6994

[1] Ref. 6, Attachment I

Table 5.4-2. Path B Geometry without WABAs for a Vantage 5H Assembly

Material	Inner Radius (cm)	Outer Radius[1] (cm)	Area (cm^2)
Moderator – Interior to Instrument Tube	0	0.5715	1.0261
Clad – Instrument Tube	0.5715	0.6121	0.1510
Moderator – Exterior to Instrument Tube	0.6121	0.7108	0.4102
Fuel Ring (40 rods)	0.7108	4.5513	63.4887
Moderator	4.5513	4.9367	11.4878
Clad – (8 Guide Tubes)	4.9367	4.9755	1.2082

Material	Inner Radius (cm)	Outer Radius[1] (cm)	Area (cm^2)
Fuel Ring (84 rods)	4.9755	8.1972	133.3244
Clad – (16 Guide Tubes)	8.1972	8.244	2.4173
Moderator	8.244	8.6763	22.9796
Fuel Ring (140 rods)	8.6763	12.0834	222.2060
Total			458.6994

[1] Ref. 6, Attachment I

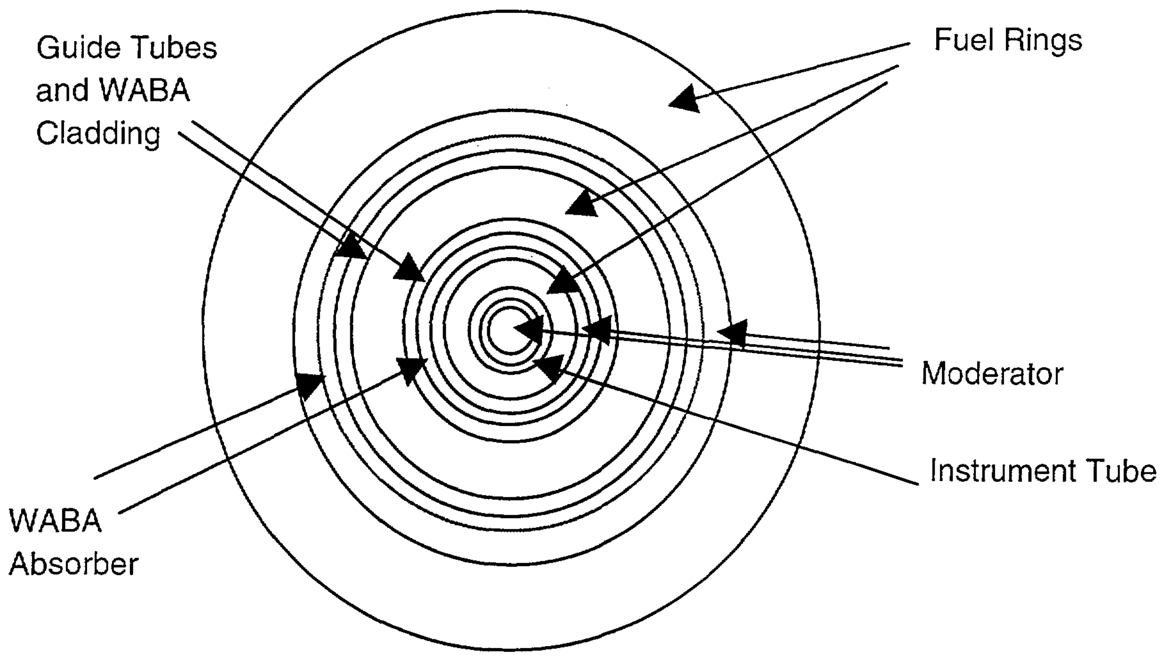

Figure 5.4-1. Schematic Diagram of the SAS2H Path B Geometry.

5.5 SAS2H Cycle Exposure Steps for Westinghouse Vantage 5 MOX Assemblies

The fuel element loading pattern for the full MOX equilibrium cycle design using Westinghouse Vantage 5 assemblies is shown in Figure 2-8 of Reference 2 (p. 2-26). Information in this figure provides, by position, the loading sequence, the assembly enrichment, and the number of WABAs. Beginning-of-cycle (BOC) assembly exposures are given in Figure 2-19 of Reference 2 (p. 2-37) and end-of-cycle (EOC) assembly exposures are given for assemblies in Figure 2-21 (p. 2-39) of the same reference. Reload locations were identified by comparing EOC assembly burnup values with similar values in the BOC map for assembly positions marked with the next cycle designator. The cycle length was given as 493 EFPD. The cycle down time of 108 days was unchanged from the value given in the Vantage 5H model (Attachment I). The assembly power level per cycle was derived from the cycle length and cycle exposures using the following equation where exposure values are given in Table 5.5-1:

assembly power (MW) = (exposure (GWd/MTHM)*1000 MW/GW *MTHM/assembly)/exposure (EFPD)

Case 1, Cycle 1 = 27.011 (GWd/MTHM) 1000.0 (MW/GW) 0.00160151 (MTHM/rod) 264 (rods/assembly)/493.0 (EFPD)
= 23.165 (MW)

Case 1, Cycle 2 = 8.569 (GWd/MTHM) 1000.0 (MW/GW) 0.00160151 (MTHM/rod) 264 (rods/assembly)/493.0 (EFPD)
= 7.35 (MW)

Case 1, Cycle 3 = 21.05 (GWd/MTHM) 1000.0 (MW/GW) 0.00160151 (MTHM/rod) 264 (rods/assembly)/493.0 (EFPD)
= 18.05 (MW)

Case 2, Cycle 1 = 26.76 (GWd/MTHM) 1000.0 (MW/GW) 0.00160151 (MTHM/rod) 264 (rods/assembly)/493.0 (EFPD)
= 22.95 (MW)

Case 2, Cycle 2 = 19.74 (GWd/MTHM) 1000.0 (MW/GW) 0.00160151 (MTHM/rod) 264 (rods/assembly)/493.0 (EFPD)
= 16.93 (MW)

Case 3, Cycle 1 = 27.0 (GWd/MTHM) 1000.0 (MW/GW) 0.00160151 (MTHM/rod) 264 (rods/assembly)/493.0 (EFPD)
= 23.155 (MW)

Case 3, Cycle 2 = 23.09 (GWd/MTHM) 1000.0 (MW/GW) 0.00160151 (MTHM/rod) 264 (rods/assembly)/493.0 (EFPD)
= 19.80 (MW)

Case 4, Cycle 1 = 27.011 (GWd/MTHM) 1000 (MW/GW)
0.00160151 (MTHM/rod)
264 (rods/assembly)/493.0 (EFPD)
= 23.165 (MW)

Case 4, Cycle 2 = 8.569 (GWd/MTHM) 1000 (MW/GW)
0.00160151 (MTHM/rod)
264 (rods/assembly)/493.0 (EFPD)
= 7.35 (MW)

Case 5, Cycle 1 = 16.32 (GWd/MTHM) 1000 (MW/GW)
0.00160151 (MTHM/rod)
264 (rods/assembly)/493.0 (EFPD)
= 14.0 (MW)

Case 5, Cycle 2 = 23.03 (GWd/MTHM) 1000 (MW/GW)
0.00160151 (MTHM/rod)
264 (rods/assembly)/493.0 (EFPD)
= 19.75 (MW)

The initial concentration of soluble boron in the MOX core was specified as 1301 ppm having a 40% ^{10}B isotopic abundance (Ref. 2, p. 2-14). Six burn steps per cycle were made to approximate the critical concentration curve of soluble boron through the cycle (Ref. 2, p. 2-45). A single library generation per exposure step was specified for each step with the average soluble boron concentration for the step specified as a fraction of the initial value. An exposure step length of about 90 EFPD was sufficient to adequately approximate the boron concentration curve.

To evaluate the repository impact of the proposed Westinghouse MOX SNF, assemblies were selected for analysis which exhibited exposure histories generating the most stressing conditions for the repository with respect to thermal output and long term criticality. The multi-cycle exposure histories were derived from the equilibrium MOX core load map (Figure 2-8, Ref. 2, p. 2-26). The particular cases selected under these criteria are given in Table 5.5-1 with the exposure steps with average soluble boron concentrations given in Table 5.5-2. Case 3 was rerun as case 6 to obtain isotopic concentrations for criticality evaluations. The only changes in the input deck were the depletion time points in the ORIGEN-S data. Cases 4 and 5 were rerun as cases 7 and 8, respectively, to obtain element compositions from ORIGEN-S in units of gram-atomic weights for geochemistry analyses. The only changes in the input decks for these cases were deleting the light elements from the SAS2H input and switching the flags in the ORIGEN-S output units array. Input decks for all cases are listed in Attachment II. Output files are provided on Colorado backup tapes (Ref. 13). Input files are echoed in the output files and included explicitly on the backup tape. The backup tape directory is listed in Attachment III.

Table 5.5-1. MOX Assembly Selection Criteria

Case ID	Enrichment (wt% fissile Pu)	Cycle Number	Cycle Power (MW)	Discharge Exposure (GWd/MTHM)	Basis
1	4.0	1	23.165[1]	27.011	Heat Generation
		2	7.35	35.58	
		3	18.05	56.63	
2	4.5	1	22.95	26.76	Heat Generation
		2	16.93	46.5	
3	4.0	1	23.155	27.0	Heat Generation
		2	19.8	50.09	
4	4.0	1	23.165	27.011	Criticality
		2	7.35	35.58	
5	4.5	1	14.0	16.32	Criticality
		2	19.75	39.35	
6	4.0	1	23.155	27.0	Criticality
		2	19.8	50.09	
7	4.0	1	23.165	27.011	Geochemistry
		2	7.35	35.58	
8	4.5	1	14.0	16.32	Geochemistry
		2	19.75	39.35	

[1] See Attachment II

Table 5.5-2. MOX Assembly Boron Concentration

Burn Step Length (EFPD)	End of Step Boron Concentration (ppm)	Average Boron Concentration (ppm)	Boron Concentration Multiplier
91.2	940	1120.5	0.861
91.8	680	810	0.623
91.1	470	575	0.442
92	385	427.5	0.329
91	80	232.5	0.179
35.9	18	49	0.038

6. RESULTS

Results from the analysis of Westinghouse MOX SNF relevant to the purpose of this calculation include the thermal power generation and isotopic content of the MOX SNF assemblies as a function of time after discharge from the reactor. Representative results from the analyses are given in Table 6-1 for the thermal power generation and in Tables 6-2 through 6-5 for isotopic content.

The total thermal power generated for each of the heat generation cases is shown in Table 6-1 for a period of 10,000 years beginning 10 years after discharge from the reactor. The power values shown are the sum of the thermal power generated by activated light elements, actinides, and fission products as calculated by the ORIGEN-S code.

Table 6-1. Total Thermal Power Generated from Westinghouse MOX SNF

Time (years)	Total Thermal Power Generation/Assembly (watts)	Total Thermal Power Generation/Assembly (watts)	Total Thermal Power Generation/Assembly (watts)
	Case 1 - 56.63 GWd/MTHM	Case 3 - 50.09 GWd/MTHM	Case 2 - 46.5 GWd/MTHM
1.00E-06	1.07E+03	8.88E+02	7.98E+02
5.00E-01	1.04E+03	8.72E+02	7.85E+02
1.00E+00	1.03E+03	8.57E+02	7.72E+02
2.00E+00	9.96E+02	8.32E+02	7.54E+02
3.00E+00	9.69E+02	8.10E+02	7.36E+02
4.00E+00	9.45E+02	7.91E+02	7.22E+02
5.00E+00	9.22E+02	7.74E+02	7.09E+02
6.00E+00	9.03E+02	7.59E+02	6.97E+02
7.00E+00	8.84E+02	7.45E+02	6.87E+02
8.00E+00	8.67E+02	7.32E+02	6.77E+02
9.00E+00	8.50E+02	7.20E+02	6.68E+02
1.00E+01	8.35E+02	7.08E+02	6.59E+02
2.00E+01	7.07E+02	6.13E+02	5.87E+02
3.00E+01	6.13E+02	5.41E+02	5.30E+02
4.00E+01	5.41E+02	4.85E+02	4.85E+02
5.00E+01	4.83E+02	4.40E+02	4.46E+02
6.00E+01	4.38E+02	4.03E+02	4.16E+02
7.00E+01	4.01E+02	3.74E+02	3.90E+02
8.00E+01	3.72E+02	3.49E+02	3.68E+02
9.00E+01	3.48E+02	3.30E+02	3.50E+02
1.00E+02	3.28E+02	3.13E+02	3.35E+02
2.50E+02	2.10E+02	2.11E+02	2.33E+02
5.00E+02	1.44E+02	1.48E+02	1.65E+02

Time (years)	Total Thermal Power Generation/Assembly (watts)	Total Thermal Power Generation/Assembly (watts)	Total Thermal Power Generation/Assembly (watts)
	Case 1 - 56.63 GWd/MTHM	Case 3 - 50.09 GWd/MTHM	Case 2 - 46.5 GWd/MTHM
7.50E+02	1.06E+02	1.09E+02	1.22E+02
1.00E+03	8.08E+01	8.36E+01	9.40E+01
5.00E+03	2.34E+01	2.46E+01	2.86E+01
1.00E+04	1.61E+01	1.70E+01	2.00E+01

The fission product isotopic concentrations from criticality Case 6 (50.1 GWd/MTHM discharge exposure) are shown in Table 6-2 for times following assembly discharge from the reactor. Actinide isotopic concentrations from this case are given in Table 6-3 for the feed assembly and for same set of time values following discharge. The isotopes listed were selected as significant from long-term reactivity considerations (Ref. 13, p. 3-26) are a subset of the total number tracked by ORIGEN-S and thus the total isotopic weights are greater than the sums of the listed values. Similar results from Case 4 (35.6 GWd/MTHM) are given in Table 6-5 and Table 6-6 and from Case 5 (39.4 GWd/MTHM) in Table 6-7 and Table 6-8.

Table 6-2. Fission Product Isotopic Concentration from Westinghouse MOX SNF (50.09 GWd/MTHM Exposure)

Nuclide	Case 6 Concentration (g/assembly)							
	Time after Discharge							
	0 (days)	365.3 (days)	3652.5 (days)	100 (years)	1000 (years)	10,000 (years)	50,000 (years)	999,999 (years)
Mo 95	3.35E+02	3.87E+02	3.88E+02	3.88E+02	3.88E+02	3.88E+02	3.88E+02	3.88E+02
Tc 99	4.71E+02	4.73E+02	4.73E+02	4.73E+02	4.72E+02	4.58E+02	4.02E+02	1.77E+01
Tc 99m	1.65E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ru101	5.09E+02	5.09E+02	5.09E+02	5.09E+02	5.09E+02	5.09E+02	5.09E+02	5.09E+02
Rh103	3.78E+02	4.10E+02	4.10E+02	4.10E+02	4.10E+02	4.10E+02	4.10E+02	4.10E+02
Rh103m	3.19E-02	5.04E-05	3.14E-30	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ag109	1.09E+02	1.09E+02	1.09E+02	1.09E+02	1.09E+02	1.09E+02	1.09E+02	1.09E+02
Ag109m	1.46E-04	7.23E-13	5.25E-15	2.13E-36	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nd143	4.46E+02	4.57E+02	4.57E+02	4.57E+02	4.57E+02	4.57E+02	4.57E+02	4.57E+02
Nd145	3.54E+02	3.54E+02	3.54E+02	3.54E+02	3.54E+02	3.54E+02	3.54E+02	3.54E+02
Sm147	3.71E+01	5.87E+01	1.24E+02	1.30E+02	1.30E+02	1.30E+02	1.30E+02	1.30E+02
Sm149	1.89E+00	2.78E+00	2.78E+00	2.78E+00	2.78E+00	2.78E+00	2.78E+00	2.78E+00
Sm150	2.24E+02	2.24E+02	2.24E+02	2.24E+02	2.24E+02	2.24E+02	2.24E+02	2.24E+02
Sm151	1.41E+01	1.42E+01	1.32E+01	6.62E+00	6.46E-03	5.05E-33	0.00E+00	0.00E+00
Eu151	1.69E-02	1.27E-01	1.08E+00	7.70E+00	1.43E+01	1.43E+01	1.43E+01	1.43E+01

Sm152	9.53E+01	9.53E+01	9.53E+01	9.54E+01	9.54E+01	9.54E+01	9.54E+01	9.54E+01
Eu153	1.01E+02	1.02E+02	1.02E+02	1.02E+02	1.02E+02	1.02E+02	1.02E+02	1.02E+02
Gd155	6.37E-02	8.39E-01	4.42E+00	5.70E+00	5.70E+00	5.70E+00	5.70E+00	5.70E+00
Total	2.13E+04	2.13E+04	2.13E+04	2.13E+04	2.13E+04	2.13E+04	2.13E+04	2.13E+04

Table 6-3. Actinide Isotopic Concentration from Westinghouse MOX SNF (50.09 GWd/MTHM Exposure)

Nuclide	Case 6 Concentration (g/Assembly)								
	Feed Assembly	Time after Discharge							
		0 (days)	365.3 (days)	3652.5 (days)	100 (years)	1000 (years)	10,000 (years)	50,000 (years)	999,999 (years)
U233		1.11E-04	1.36E-04	3.55E-04	5.89E-03	3.47E-01	6.34E+00	3.05E+01	1.22E+02
U234	8.09E+00	4.34E+00	5.02E+00	1.19E+01	5.98E+01	1.07E+02	1.05E+02	9.61E+01	2.62E+01
U235	8.09E+02	2.67E+02	2.68E+02	2.69E+02	2.81E+02	4.05E+02	1.50E+03	4.12E+03	5.35E+03
U236	4.05E+00	1.06E+02	1.07E+02	1.10E+02	1.43E+02	4.57E+02	2.39E+03	3.58E+03	3.50E+03
U238	4.04E+05	3.89E+05	3.89E+05	3.89E+05	3.89E+05	3.89E+05	3.89E+05	3.89E+05	3.90E+05
Np237		7.03E+01	7.17E+01	7.95E+01	3.24E+02	1.73E+03	2.16E+03	2.14E+03	1.57E+03
Pu238		7.12E+01	9.57E+01	9.54E+01	4.73E+01	5.92E-02	1.36E-21	0.00E+00	0.00E+00
Pu239	1.68E+04	4.89E+03	4.94E+03	4.94E+03	4.93E+03	4.82E+03	3.83E+03	1.25E+03	1.43E-05
Pu240	1.06E+03	3.46E+03	3.46E+03	3.49E+03	3.52E+03	3.20E+03	1.24E+03	1.81E+01	2.83E-06
Pu241	7.19E+01	2.04E+03	1.94E+03	1.26E+03	1.63E+01	1.02E-02	4.87E-03	1.87E-04	0.00E+00
Pu242	1.80E+01	8.73E+02	8.73E+02	8.73E+02	8.73E+02	8.72E+02	8.58E+02	7.96E+02	1.37E+02
Am241		9.24E+01	1.88E+02	8.65E+02	1.86E+03	4.44E+02	1.54E-01	5.63E-03	1.32E-36
Am242m		2.26E+00	2.25E+00	2.15E+00	1.38E+00	1.65E-02	1.01E-21	0.00E+00	0.00E+00
Am243		2.35E+02	2.36E+02	2.35E+02	2.33E+02	2.14E+02	9.20E+01	2.14E+00	4.46E-06
Total	4.23E+05	4.01E+05	4.01E+05	4.01E+05	4.01E+05	4.01E+05	4.01E+05	4.01E+05	4.01E+05

Table 6-4. Fission Product Isotopic Concentration from Westinghouse MOX SNF (35.58 GWd/MTHM Exposure)

Nuclide	Case 4 Concentration (g/assembly)							
	Time after Discharge							
	0 (days)	365.3 (days)	3652.5 (days)	100 (years)	1000 (years)	10,000 (years)	50,000 (years)	999,999 (years)
Mo 95	2.65E+02	2.85E+02	2.85E+02	2.85E+02	2.85E+02	2.85E+02	2.85E+02	2.85E+02
Tc 99	3.54E+02	3.54E+02	3.54E+02	3.54E+02	3.53E+02	3.43E+02	3.01E+02	1.33E+01

Nuclide	Case 4 Concentration (g/assembly)							
	Time after Discharge							
	0 (days)	365.3 (days)	3652.5 (days)	100 (years)	1000 (years)	10,000 (years)	50,000 (years)	999,999 (years)
Tc 99m	6.15E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ru101	3.69E+02	3.69E+02	3.69E+02	3.69E+02	3.69E+02	3.69E+02	3.69E+02	3.69E+02
Rh103	3.24E+02	3.36E+02	3.36E+02	3.36E+02	3.36E+02	3.36E+02	3.36E+02	3.36E+02
Rh103m	1.20E-02	1.90E-05	1.18E-30	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ag109	8.78E+01	8.78E+01	8.78E+01	8.78E+01	8.78E+01	8.78E+01	8.78E+01	8.78E+01
Ag109m	4.90E-05	2.40E-13	1.74E-15	7.05E-37	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nd143	3.53E+02	3.57E+02	3.57E+02	3.57E+02	3.57E+02	3.57E+02	3.57E+02	3.57E+02
Nd145	2.63E+02	2.63E+02	2.63E+02	2.63E+02	2.63E+02	2.63E+02	2.63E+02	2.63E+02
Sm147	4.13E+01	5.81E+01	1.09E+02	1.14E+02	1.14E+02	1.14E+02	1.14E+02	1.14E+02
Sm149	1.92E+00	2.19E+00	2.19E+00	2.19E+00	2.19E+00	2.19E+00	2.19E+00	2.19E+00
Sm150	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02
Sm151	1.39E+01	1.39E+01	1.29E+01	6.47E+00	6.31E-03	4.93E-33	0.00E+00	0.00E+00
Eu151	5.28E-02	1.60E-01	1.09E+00	7.56E+00	1.40E+01	1.40E+01	1.40E+01	1.40E+01
Sm152	7.49E+01	7.49E+01	7.49E+01	7.50E+01	7.50E+01	7.50E+01	7.50E+01	7.50E+01
Eu153	6.88E+01	6.90E+01	6.90E+01	6.90E+01	6.90E+01	6.90E+01	6.90E+01	6.90E+01
Gd155	1.06E-01	5.69E-01	2.71E+00	3.47E+00	3.47E+00	3.47E+00	3.47E+00	3.47E+00
Total	1.52E+04	1.52E+04	1.52E+04	1.52E+04	1.52E+04	1.52E+04	1.52E+04	1.52E+04

Table 6-5. Actinide Isotopic Concentration from Westinghouse MOX SNF (35.58 GWd/MTHM Exposure)

Nuclide	Case 4 Concentration (g/Assembly)								
	Feed Assembly	Time after Discharge							
		0 (days)	365.3 (days)	3652.5 (days)	100 (years)	1000 (years)	10,000 (years)	50,000 (years)	999,999 (years)
U233		1.12E-04	1.32E-04	3.01E-04	5.22E-03	3.26E-01	5.98E+00	2.88E+01	1.15E+02
U234	8.09E+00	5.27E+00	5.66E+00	9.51E+00	3.65E+01	6.41E+01	6.31E+01	5.86E+01	2.39E+01
U235	8.09E+02	3.97E+02	3.97E+02	3.99E+02	4.17E+02	5.91E+02	2.12E+03	5.69E+03	7.35E+03
U236	4.05E+00	8.84E+01	8.87E+01	9.21E+01	1.26E+02	4.44E+02	2.40E+03	3.61E+03	3.53E+03
U238	4.04E+05	3.94E+05	3.94E+05	3.94E+05	3.94E+05	3.94E+05	3.94E+05	3.94E+05	3.94E+05
Np237		5.41E+01	5.47E+01	6.28E+01	2.96E+02	1.63E+03	2.04E+03	2.02E+03	1.48E+03
Pu238		4.27E+01	5.40E+01	5.34E+01	2.68E+01	4.92E-02	1.80E-21	0.00E+00	0.00E+00
Pu239	1.68E+04	6.95E+03	6.97E+03	6.97E+03	6.95E+03	6.78E+03	5.28E+03	1.69E+03	1.72E-06
Pu240	1.06E+03	3.57E+03	3.57E+03	3.58E+03	3.57E+03	3.24E+03	1.25E+03	1.83E+01	7.93E-07

Nuclide	Case 4 Concentration (g/Assembly)								
	Feed Assembly	Time after Discharge							
		0 (days)	365.3 (days)	3652.5 (days)	100 (years)	1000 (years)	10,000 (years)	50,000 (years)	999,999 (years)
Pu241	7.19E+01	1.89E+03	1.80E+03	1.16E+03	1.50E+01	2.77E-03	1.33E-03	5.10E-05	0.00E+00
Pu242	1.80E+01	4.89E+02	4.89E+02	4.89E+02	4.89E+02	4.88E+02	4.80E+02	4.46E+02	7.65E+01
Am241		1.41E+02	2.29E+02	8.55E+02	1.77E+03	4.21E+02	4.21E-02	1.54E-03	3.61E-37
Am242m		2.99E+00	2.98E+00	2.85E+00	1.83E+00	2.19E-02	1.34E-21	0.00E+00	0.00E+00
Am243		1.11E+02	1.11E+02	1.11E+02	1.10E+02	1.01E+02	4.32E+01	1.00E+00	5.35E-07
Total	4.23E+05	4.07E+05	4.07E+05	4.07E+05	4.07E+05	4.07E+05	4.07E+05	4.07E+05	4.07E+05

Table 6-6. Fission Product Isotopic Concentration from Westinghouse MOX SNF (39.35 GWd/MTHM Exposure)

Nuclide	Case 5 Concentration (g/assembly)							
	Time after Discharge							
	0 (days)	365.3 (days)	3652.5 (days)	100 (years)	1000 (years)	10,000 (years)	50,000 (years)	999,999 (years)
Mo 95	2.61E+02	3.13E+02	3.14E+02	3.14E+02	3.14E+02	3.14E+02	3.14E+02	3.14E+02
Tc 99	3.88E+02	3.91E+02	3.91E+02	3.90E+02	3.89E+02	3.78E+02	3.31E+02	1.46E+01
Tc 99m	1.65E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ru101	4.08E+02	4.08E+02	4.08E+02	4.08E+02	4.08E+02	4.08E+02	4.08E+02	4.08E+02
Rh103	3.34E+02	3.66E+02	3.66E+02	3.66E+02	3.66E+02	3.66E+02	3.66E+02	3.66E+02
Rh103m	3.22E-02	5.09E-05	3.17E-30	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ag109	9.62E+01	9.63E+01	9.63E+01	9.63E+01	9.63E+01	9.63E+01	9.63E+01	9.63E+01
Ag109m	1.34E-04	3.88E-13	2.82E-15	1.14E-36	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nd143	3.81E+02	3.93E+02	3.93E+02	3.93E+02	3.93E+02	3.93E+02	3.93E+02	3.93E+02
Nd145	2.90E+02	2.90E+02	2.90E+02	2.90E+02	2.90E+02	2.90E+02	2.90E+02	2.90E+02
Sm147	3.21E+01	5.33E+01	1.17E+02	1.24E+02	1.24E+02	1.24E+02	1.24E+02	1.24E+02
Sm149	2.37E+00	3.20E+00	3.20E+00	3.20E+00	3.20E+00	3.20E+00	3.20E+00	3.20E+00
Sm150	1.67E+02	1.67E+02	1.67E+02	1.67E+02	1.67E+02	1.67E+02	1.67E+02	1.67E+02
Sm151	1.49E+01	1.50E+01	1.40E+01	6.99E+00	6.82E-03	5.33E-33	0.00E+00	0.00E+00
Eu151	2.19E-02	1.38E-01	1.14E+00	8.13E+00	1.51E+01	1.51E+01	1.51E+01	1.51E+01
Sm152	8.12E+01	8.12E+01	8.12E+01	8.12E+01	8.12E+01	8.12E+01	8.12E+01	8.12E+01
Eu153	7.63E+01	7.69E+01	7.69E+01	7.69E+01	7.69E+01	7.69E+01	7.69E+01	7.69E+01
Gd155	5.31E-02	5.99E-01	3.12E+00	4.02E+00	4.02E+00	4.02E+00	4.02E+00	4.02E+00
Total	1.68E+04	1.68E+04	1.68E+04	1.68E+04	1.68E+04	1.68E+04	1.68E+04	1.68E+04

Table 6-7. Actinide Isotopic Concentration from Westinghouse MOX SNF (39.35 GWd/MTHM Exposure).

Nuclide	Case 5 Concentration (g/assembly)								
	Feed Assembly	Time after Discharge							
		0 (days)	365.3 (days)	3652.5 (days)	100 (years)	1000 (years)	10,000 (years)	50,000 (years)	999,999 (years)
U233		1.06E-04	1.26E-04	3.03E-04	5.55E-03	3.54E-01	6.51E+00	3.13E+01	1.25E+02
U234	8.05E+00	5.04E+00	5.46E+00	9.88E+00	4.08E+01	7.18E+01	7.06E+01	6.53E+01	2.42E+01
U235	8.05E+02	3.83E+02	3.83E+02	3.85E+02	4.03E+02	5.83E+02	2.16E+03	5.84E+03	7.55E+03
U236	4.02E+00	8.92E+01	8.96E+01	9.33E+01	1.30E+02	4.82E+02	2.65E+03	3.98E+03	3.89E+03
U238	4.02E+05	3.91E+05	3.91E+05	3.91E+05	3.91E+05	3.91E+05	3.91E+05	3.91E+05	3.91E+05
Np237		5.61E+01	5.73E+01	6.54E+01	3.18E+02	1.78E+03	2.22E+03	2.20E+03	1.61E+03
Pu238		4.34E+01	6.10E+01	6.14E+01	3.06E+01	4.55E-02	1.35E-21	0.00E+00	0.00E+00
Pu239	1.89E+04	7.13E+03	7.17E+03	7.17E+03	7.15E+03	6.98E+03	5.45E+03	1.74E+03	2.28E-06
Pu240	1.19E+03	3.95E+03	3.95E+03	3.96E+03	3.94E+03	3.59E+03	1.39E+03	2.03E+01	1.14E-06
Pu241	8.09E+01	2.12E+03	2.02E+03	1.31E+03	1.69E+01	3.47E-03	1.67E-03	6.38E-05	0.00E+00
Pu242	2.02E+01	5.49E+02	5.49E+02	5.49E+02	5.49E+02	5.49E+02	5.40E+02	5.01E+02	8.60E+01
Am241	0.00E+00	9.03E+01	1.90E+02	8.93E+02	1.93E+03	4.59E+02	5.27E-02	1.92E-03	4.51E-37
Am242m		2.25E+00	2.24E+00	2.14E+00	1.37E+00	1.65E-02	1.00E-21	0.00E+00	0.00E+00
Am243		1.27E+02	1.27E+02	1.27E+02	1.26E+02	1.16E+02	4.96E+01	1.15E+00	7.08E-07
Total	4.23E+05	4.06E+05	4.06E+05	4.06E+05	4.06E+05	4.06E+05	4.06E+05	4.06E+05	4.06E+05

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8. ATTACHMENTS

Table 8-1. List of Attachments

Number	Description	Number of Pages
I	ORNL SAS2H Data Files	8
II	SAS2H/ORIGEN-S Data Files for MOX SNF	42
III	Colorado Backup Tape File Directory	1

ATTACHMENT I.

ORNL SAS2H Data Files

email mur@ca02.cad.ornl.gov on 02/16/98

```
To:    John McClure
"
cc:
"
Subject:
"

"

"

"
=sas2h    parm=skipcellwt
"
 plut. burning in Westinghouse PWR (3 cycles) (NO WABAs)
"
44groupndf5   latticecell
"
'
"
'  this is a 52,500 MWd/MT case
"
'
"
' --------------------------------------------------------

'       make sure we use the 44 group library!!!!
' --------------------------------------------------------
'       mixtures for fuel-pin unit cell
' fuel rods are mixed-oxide with uranium and plutonium.
'
uo2   1 den=9.7982 1 901 92234 0.002 92235 0.2 92236 0.001
  92238 99.797 end
puo2  1 den=0.4681 1 901 94239 93.6 94240 5.9 94241 0.4
  94242 0.1 end
b-10  1 0 6.4584-5   901 end
zr    1 0 3.2292-5   901 end
'     the boron-10 coating is assumed mixed with the fuel
'
'      --------------------
'    some extra nuclides needed from library
' ga-69  1 0 1-20     901 end
' ga-71  1 0 1-20     901 end
ga      1 0 1-20     901 end
zr-94   1 0 1-20     901 end
tc-99   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
```

```
xe-131 1 0 1-20      901 end
cs-133 1 0 1-20      901 end
cs-134 1 0 1-20      901 end
ce-144 1 0 1-20      901 end
pr-143 1 0 1-20      901 end
nd-143 1 0 1-20      901 end
nd-145 1 0 1-20      901 end
nd-147 1 0 1-20      901 end
pm-147 1 0 1-20      901 end
sm-149 1 0 1-20      901 end
sm-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
eu-155 1 0 1-20      901 end
u-232  1 0 1-20      901 end
u-233  1 0 1-20      901 end
u-237  1 0 1-20      901 end
np-238 1 0 1-20      901 end
pu-236 1 0 1-20      901 end
pu-237 1 0 1-20      901 end
pu-243 1 0 1-20      901 end
pu-244 1 0 1-20      901 end
am-242 1 0 1-20      901 end
cm-245 1 0 1-20      901 end
cm-246 1 0 1-20      901 end
cm-247 1 0 1-20      901 end
cm-248 1 0 1-20      901 end
bk-249 1 0 1-20      901 end
cf-249 1 0 1-20      901 end
cf-250 1 0 1-20      901 end
cf-251 1 0 1-20      901 end
cf-252 1 0 1-20      901 end
cf-253 1 0 1-20      901 end

' ----------------------------------------------------------------
arbmzirc 6.44 4 0 0 1 40000 97.91 26000 0.5 50116 0.86 50120
  0.73 2 1 607 end
'    above is zircalloy specified as an arbitrary material
'    because it may not be in the library
' --------------------------------------------------------
h2o     3 0.707       583 end
co-59   3 0 1-20      583 end
arbm-bormod 0.707 1 1 0 0 5000 100 3 750.0-6 583 end
'      above is 750 ppm boron in moderator (av. boron)
' --------------------------------------------------------
'       mixtures for shipping cask (just one assembly here!)
'
n       4 0 1.0-20 end
n       5 0.00122 end
' --------------------------------------------------------
'       mixtures for larger unit cell
'
arbm-alox 3.72 2 0 1 0 13027 2 8016 3 9 0.97952 end
b4c        9 0.0603 end
end comp
' --------------------------------------------------------
'       fuel-pin-cell geometry
'
```

```
squarepitch 1.25984 0.8202 1 3 0.95 2 0.8357 0 end
'
' -----------------------------------------------------------
'       assembly and cycle parameters
'
npin/assm=264 fuelngth=365.76 ncycles=3  nlib/cyc=1 lightel=22
printlevel=4 inplevel=2 numzones=10  end
'
'    no WABAs in this assembly!
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.9367 2 4.9755 500 8.1972
 2 8.244 3 8.6763 500 12.0834
'
'   discharge burnup is 52,500 MWd/MT
'
 power=18.375 burn=440 down=108   end
 power=18.375 burn=440 down=108   end
 power=18.375 burn=440 down=1825   end
' -----------------------------------------------------------
'       light elements
 c 0.06  n 0.034  o 62.14  al 0.0457  s 0.00397
 ti 0.0498  v 0.00227  cr 2.34  mn 0.109 fe 4.6 mo 0.1816
 co 0.033  ni 4.402   cu 0.011 zr 111.178 cd 0.00003
 sn 1.8168 hf 0.00886 w 0.00227 p 0.142 nb 0.328 si 0.0659
' -----------------------------------------------------------
'       shipping cask zone description
'
27n-18couple tempcask=325 numzones=2 detect=0 dryfuel=yes
4 12.0834 5 12.5
zone=1 fuelbnds=1
' -----------------------------------------------------------
szfcask=0.25 end
' -----------------------------------------------------------
```

end

email mur@ca02.cad.ornl.gov on 02/16/98

```
To:    John McClure
"
cc:
"
Subject:
"

"

"

"
=sas2h    parm=skipcellwt
 plut. burning in Westinghouse PWR (2 cycles) contains WABAs!
44groupndf5   latticecell
'
'  this is a 35,000 MWd/MT case
'
' -----------------------------------------------------------
```

```
'       make sure we use the 44 group library!!!!
' -------------------------------------------------------
'       mixtures for fuel-pin unit cell
' fuel rods are mixed-oxide with uranium and plutonium.
'
uo2   1 den=9.7982 1 901 92234 0.002 92235 0.2 92236 0.001
  92238 99.797 end
puo2  1 den=0.4681 1 901 94239 93.6 94240 5.9 94241 0.4
  94242 0.1 end
b-10  1 0 6.4584-5   901 end
zr    1 0 3.2292-5   901 end
'     the boron-10 coating is assumed mixed with the fuel
'
'      --------------------
'    some extra nuclides needed from library
zr-94  1 0 1-20     901 end
tc-99  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
xe-131 1 0 1-20     901 end
cs-133 1 0 1-20     901 end
cs-134 1 0 1-20     901 end
ce-144 1 0 1-20     901 end
pr-143 1 0 1-20     901 end
nd-143 1 0 1-20     901 end
nd-145 1 0 1-20     901 end
nd-147 1 0 1-20     901 end
pm-147 1 0 1-20     901 end
sm-149 1 0 1-20     901 end
sm-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
eu-155 1 0 1-20     901 end
u-232  1 0 1-20     901 end
u-233  1 0 1-20     901 end
u-237  1 0 1-20     901 end
np-238 1 0 1-20     901 end
pu-236 1 0 1-20     901 end
pu-237 1 0 1-20     901 end
pu-243 1 0 1-20     901 end
pu-244 1 0 1-20     901 end
am-242 1 0 1-20     901 end
cm-245 1 0 1-20     901 end
cm-246 1 0 1-20     901 end
cm-247 1 0 1-20     901 end
cm-248 1 0 1-20     901 end
bk-249 1 0 1-20     901 end
cf-249 1 0 1-20     901 end
cf-250 1 0 1-20     901 end
cf-251 1 0 1-20     901 end
cf-252 1 0 1-20     901 end
cf-253 1 0 1-20     901 end

' -----------------------------------------------------------------
arbmzirc 6.44 4 0 0 1 40000 97.91 26000 0.5 50116 0.86 50120
  0.73 2 1 607 end
'    above is zircalloy specified as an arbitrary material
```

```
'    because it may not be in the library
' ----------------------------------------------------------
h2o     3 0.707      583 end
co-59   3 0 1-20     583 end
arbm-bormod 0.707 1 1 0 0 5000 100 3 750.0-6 583 end
'       above is 750 ppm boron in moderator (av. boron)
' ----------------------------------------------------------
'        mixtures for shipping cask (just one assembly here!)
'
n       4 0 1.0-20 end
n       5 0.00122 end
' ----------------------------------------------------------
'        mixtures for larger unit cell
'
arbm-alox 3.72 2 0 1 0 13027 2 8016 3 9 0.97952 end
b4c        9 0.0603 end
end comp
' ----------------------------------------------------------
'        fuel-pin-cell geometry
'
squarepitch 1.25984 0.8202 1 3 0.95 2 0.8357 0 end
'
' ----------------------------------------------------------
'        assembly and cycle parameters
'
npin/assm=264 fuelngth=365.76 ncycles=2  nlib/cyc=1 lightel=22
printlevel=4 inplevel=2 numzones=12  end
'
'   this assembly contains WABAs!
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
  500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
'    discharge burnup is 35,000 MWd/MT
'
 power=18.375 burn=440 down=108   end
 power=18.375 burn=440 down=1825   end
' ----------------------------------------------------------
'        light elements
 c 0.06  n 0.034  o 62.14  al 0.0457  s 0.00397
 ti 0.0498  v 0.00227  cr 2.34  mn 0.109 fe 4.6 mo 0.1816
 co 0.033  ni 4.402   cu 0.011 zr 111.178 cd 0.00003
 sn 1.8168 hf 0.00886 w 0.00227 p 0.142 nb 0.328 si 0.0659
' ----------------------------------------------------------
'        shipping cask zone description
'
27n-18couple tempcask=325 numzones=2 detect=0 dryfuel=yes
4 12.0834 5 12.5
zone=1 fuelbnds=1
' ----------------------------------------------------------
szfcask=0.25 end
' ----------------------------------------------------------
end
```

email mur@ca02.cad.ornl.gov on 02/16/98

```
To:   John McClure
"
cc:
"
Subject:
"

"

"

"
=sas2h    parm=skipcellwt
"
 plut. burning in Westinghouse PWR (3 cycles) with WABAs!
"
44groupndf5   latticecell
"
'
"
'  this is a 52,500 MWd/MT case
"
'
"
' ---------------------------------------------------------
'       make sure we use the 44 group library!!!!
' ---------------------------------------------------------
'       mixtures for fuel-pin unit cell
' fuel rods are mixed-oxide with uranium and plutonium.
'
uo2   1 den=9.7982 1 901 92234 0.002 92235 0.2 92236 0.001
  92238 99.797 end
puo2  1 den=0.4681 1 901 94239 93.6 94240 5.9 94241 0.4
  94242 0.1 end
b-10  1 0 6.4584-5   901 end
zr    1 0 3.2292-5   901 end
'     the boron-10 coating is assumed mixed with the fuel
'
'      --------------------
'    some extra nuclides needed from library
zr-94  1 0 1-20     901 end
tc-99  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
xe-131 1 0 1-20     901 end
cs-133 1 0 1-20     901 end
cs-134 1 0 1-20     901 end
ce-144 1 0 1-20     901 end
pr-143 1 0 1-20     901 end
nd-143 1 0 1-20     901 end
nd-145 1 0 1-20     901 end
nd-147 1 0 1-20     901 end
pm-147 1 0 1-20     901 end
sm-149 1 0 1-20     901 end
sm-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
```

```
eu-155 1 0 1-20     901 end
u-232  1 0 1-20     901 end
u-233  1 0 1-20     901 end
u-237  1 0 1-20     901 end
np-238 1 0 1-20     901 end
pu-236 1 0 1-20     901 end
pu-237 1 0 1-20     901 end
pu-243 1 0 1-20     901 end
pu-244 1 0 1-20     901 end
am-242 1 0 1-20     901 end
cm-245 1 0 1-20     901 end
cm-246 1 0 1-20     901 end
cm-247 1 0 1-20     901 end
cm-248 1 0 1-20     901 end
bk-249 1 0 1-20     901 end
cf-249 1 0 1-20     901 end
cf-250 1 0 1-20     901 end
cf-251 1 0 1-20     901 end
cf-252 1 0 1-20     901 end
cf-253 1 0 1-20     901 end

' -----------------------------------------------------------------
arbmzirc 6.44 4 0 0 1 40000 97.91 26000 0.5 50116 0.86 50120
  0.73 2 1 607 end
'    above is zircalloy specified as an arbitrary material
'    because it may not be in the library
' ---------------------------------------------------------
h2o     3 0.707      583 end
co-59   3 0 1-20     583 end
arbm-bormod 0.707 1 1 0 0 5000 100 3 750.0-6 583 end
'      above is 750 ppm boron in moderator (av. boron)
' ----------------------------------------------------------
'       mixtures for shipping cask (just one assembly here!)
'
n       4 0 1.0-20 end
n       5 0.00122 end
' ----------------------------------------------------------
'       mixtures for larger unit cell
'
arbm-alox 3.72 2 0 1 0 13027 2 8016 3 9 0.97952 end
b4c        9 0.041 end
end comp
' ----------------------------------------------------------
'       fuel-pin-cell geometry
'
squarepitch 1.25984 0.8202 1 3 0.95 2 0.8357 0 end
'
' ----------------------------------------------------------
'       assembly and cycle parameters
'
npin/assm=264 fuelngth=365.76 ncycles=3  nlib/cyc=1 lightel=22
printlevel=4 inplevel=2 numzones=12  end
'
'   this assembly contains WABAs
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
 500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
'   discharge burnup is 52,500 MWd/MT
```

```
'
 power=18.375 burn=440 down=108   end
 power=18.375 burn=440 down=108   end
 power=18.375 burn=440 down=1825   end
' ---------------------------------------------------------
'       light elements
 c 0.06  n 0.034  o 62.14  al 0.0457  s 0.00397
 ti 0.0498  v 0.00227  cr 2.34  mn 0.109 fe 4.6 mo 0.1816
 co 0.033  ni 4.402   cu 0.011 zr 111.178 cd 0.00003
 sn 1.8168 hf 0.00886 w 0.00227 p 0.142 nb 0.328 si 0.0659
' ---------------------------------------------------------
'       shipping cask zone description
'
27n-18couple tempcask=325 numzones=2 detect=0 dryfuel=yes
4 12.0834 5 12.5
zone=1 fuelbnds=1
' ---------------------------------------------------------
szfcask=0.25 end
' ---------------------------------------------------------
end
```

ATTACHMENT II.

Data Files for Westinghouse Vantage 5 Assembly SAS2H/ORIGEN-S Analysis

Data file 'w3_56-6gwd_avgB6stps.inp' for case 1 – 56.63 GWd/MTHM

```
=sas2h   parm=skipcellwt
'
 plut. burning in Westinghouse PWR (3 cycles) cy 1 with WABAs,
'                    cy2 and 3 without WABAs!
'   run all cycles as on SAS2H case - change compositions in PATH B
44groupndf5   latticecell
'
' this is a 56.62 MWd/MTM case
' use 6 burn intervals per cycle with avg B in interval from Boron letdown curve
'    sas deck modified from from ORNL - B. Murphy
'
'-------------------------------------------------------
'     make sure we use the 44 group library!!!!
'-------------------------------------------------------
'     mixtures for fuel-pin unit cell
' fuel rods are mixed-oxide with uranium and plutonium.
'
'    use 4.0 w/o enriched Pu
'  density derived from fuel mass/volume
uo2  1 den=9.8426 1 901 92234 0.002 92235 0.2 92236 0.001
 92238 99.797 end
puo2  1 den=0.4372 1 901 94239 93.6 94240 5.9 94241 0.4
 94242 0.1 end
' NO IFBA's used for MOX core
' b-10  1 0 6.4584-5   901 end
' zr    1 0 3.2292-5   901 end
'    the boron-10 coating is assumed mixed with the fuel
'
'    --------------------
'   some extra nuclides needed from library
zr-94  1 0 1-20    901 end
tc-99  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
xe-131 1 0 1-20    901 end
cs-133 1 0 1-20    901 end
cs-134 1 0 1-20    901 end
ce-144 1 0 1-20    901 end
pr-143 1 0 1-20    901 end
nd-143 1 0 1-20    901 end
nd-145 1 0 1-20    901 end
nd-147 1 0 1-20    901 end
pm-147 1 0 1-20    901 end
sm-149 1 0 1-20    901 end
sm-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
eu-155 1 0 1-20   901 end
u-232  1 0 1-20   901 end
u-233  1 0 1-20   901 end
u-237  1 0 1-20   901 end
np-238 1 0 1-20   901 end
pu-236 1 0 1-20   901 end
pu-237 1 0 1-20   901 end
pu-243 1 0 1-20   901 end
pu-244 1 0 1-20   901 end
am-242 1 0 1-20   901 end
cm-245 1 0 1-20   901 end
cm-246 1 0 1-20   901 end
cm-247 1 0 1-20   901 end
cm-248 1 0 1-20   901 end
bk-249 1 0 1-20   901 end
cf-249 1 0 1-20   901 end
cf-250 1 0 1-20   901 end
cf-251 1 0 1-20   901 end
cf-252 1 0 1-20   901 end
cf-253 1 0 1-20   901 end

'-------------------------------------------------------------------
' nearly Zirc-2 - not a great effect although Zirc-4 has Cr & Fe
arbmzirc 6.44 4 0 0 1 40000 97.91 26000 0.5 50116 0.86 50120
 0.73 2 1 607 end
'  above is zircalloy specified as an arbitrary material
'  because it may not be in the library
'----------------------------------------------------------
h2o   3 0.707     583 end
co-59  3 0 1-20    583 end
arbm-bormod 0.707 2 0 0 0 5010 39.99 5011 60.01 3 1301.0-6 583 end
'    above is 1301 ppm boron in moderator
'    (40% isotopically enriched in B-10)
'    94 Design cases used 750 ppm av. Boron
'----------------------------------------------------------
'     mixtures for shipping cask (just one assembly here!)
'
n     4 0 1.0-20 end
n     5 0.00122 end
'----------------------------------------------------------
'     mixtures for larger unit cell
'   check WABA numbers  use ornl b4c value (redrived)
' no wabas for cy 2 or cy 3
arbm-alox 3.72 2 0 1 0 13027 2 8016 3 9 0.95568 583 end
b4c   9 den=2.52  0.04432  583 end
'
' arbm-alox 3.72 2 0 1 0 13027 2 8016 3 9 0.97952 end
' b4c      9 0.041 end
end comp
'----------------------------------------------------------
```

```
'    fuel-pin-cell geometry
'
'   pitch=1.25984 cm
'   pellet OD=0.78435 cm
'   clad OD=0.9144 cm
'   clad ID=0.8001 cm
'
'   squarepitch 1.25984 0.8202 1 3 0.95 2 0.8357 0 end (LOPAR)
squarepitch 1.25984 0.78435 1 3 0.9144 2 0.8001 0 end
'
'-----------------------------------------------------
'    assembly and cycle parameters
'
npin/assm=264 fuelngth=365.76 ncycles=18 nlib/cyc=1 lightel=22
printlevel=4 inplevel=2 numzones=12 mxrepeats=0 end
'
' this assembly contains NO WABAs - cy 2 or cy 3, (Full MOX core Cy 1 only)
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
   500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
   500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
   500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
   500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
   500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
   500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
   500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
   500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
   500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
   500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
   500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
   500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
```

```
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
  500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
  500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
  500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
  500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
  500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
  500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
'
'  discharge burnup is 27.01 GWd/MT  - cy 1
'  discharge burnup is 35.58 GWd/MT  - cy 2
'  discharge burnup is 56.63 GWd/MT  - cy 3
'
power=23.165 burn=91.2 down=0  bfrac=0.861 end
power=23.165 burn=91.8 down=0  bfrac=0.623 end
power=23.165 burn=91.1 down=0  bfrac=0.442 end
power=23.165 burn=92.0 down=0  bfrac=0.329 end
power=23.165 burn=91.0 down=0  bfrac=0.179 end
power=23.165 burn=35.9 down=108  bfrac=0.034 end
'
power=7.35 burn=91.2 down=0  bfrac=0.861 end
power=7.35 burn=91.8 down=0  bfrac=0.623 end
power=7.35 burn=91.1 down=0  bfrac=0.442 end
power=7.35 burn=92.0 down=0  bfrac=0.329 end
power=7.35 burn=91.0 down=0  bfrac=0.179 end
power=7.35 burn=35.9 down=108  bfrac=0.034 end
'
power=18.05   burn=91.2 down=0  bfrac=0.861 end
power=18.05   burn=91.8 down=0  bfrac=0.623 end
power=18.05   burn=91.1 down=0  bfrac=0.442 end
power=18.05   burn=92.0 down=0  bfrac=0.329 end
power=18.05   burn=91.0 down=0  bfrac=0.179 end
power=18.05   burn=35.9 down=1825  bfrac=0.034 end
'
'------------------------------------------------------
'
'    light elements
c 0.06  n 0.034  o 62.14  al 0.0457  s 0.00397
ti 0.0498  v 0.00227  cr 2.34  mn 0.109 fe 4.6 mo 0.1816
co 0.033  ni 4.402   cu 0.011 zr 111.178 cd 0.00003
sn 1.8168 hf 0.00886 w 0.00227 p 0.142 nb 0.328 si 0.0659
'------------------------------------------------------
```

```
'    shipping cask zone description
'
27n-18couple tempcask=325 numzones=2 detect=0 dryfuel=yes
4 12.0834 5 12.5
zone=1 fuelbnds=1
'--------------------------------------------------------
szfcask=0.25 end
'--------------------------------------------------------
end
=ORIGENS
0$$ a11 71 e
1$$ 1 1t
 decay cases for West pu burner 96 DESIGN 56.6 GWD/MTH (3 cy, WABAs cy 1)
3$$ 21 0 1 e 2t
35$$ 0 t
'  subcase 1
' 7 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a13 -1 5 3 a17 2 e
5t
 decay (101 time points) MOX Vantage 5 DESIGN (3 cy, WABAs cy 1)
 one assembly
60**  10.000001 10.01 10.02 10.03 10.04 10.05
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
' subcase 2
' 6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  10.05 e
5t
60**  10.06  10.07  10.08  10.09  10.10  10.15
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'subcase 3
' 6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  10.15 e
5t
60**  10.20  10.25  10.30  10.35  10.40  10.45
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
' 6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14  5  a17 2 e
57**  10.45 e
5t
```

```
60** 10.50 10.55 10.60 10.65 10.70 10.75
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
' 6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5 a17 2 e
57** 10.75 e
5t
60** 10.80 10.85 10.90 10.95 11.00 11.50
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
' 6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5 a17 2 e
57** 11.50 e
5t
60** 12.00 12.50 13.00 13.50 14.00 14.50
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
' 6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5 a17 2 e
57** 14.50 e
5t
60** 15.00 15.50 16.00 16.50 17.00 17.50
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
' 6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5 a17 2 e
57** 17.50 e
5t
60** 18.00 18.50 19.00 19.50 20.00 25.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
' 6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5 a17 2 e
57** 25.00 e
5t
60** 30.00 35.00 40.00 45.00 50.0 55.0
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
```

```
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
' 6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14  5  a17 2 e
57**  55.00 e
5t
60**  60.00  65.00  70.00  75.00  80.00  85.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
' 6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  85.00 e
5t
60**  90.00  95.00  100.00  105.00  110.00  160.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
' 6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  160.0 e
5t
60**  210.00  260.00  310.00  360.00  410.00  460.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
' 6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  460.0 e
5t
60**  510.00  560.00  610.00  660.00  710.00  760.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
' 6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5 a17 2 e
57**  760.0 e
5t
60**  810.00  860.00  910.00  960.00  1010.00  1510.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
```

```
' 6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  1510.0 e
5t
60**  2010.00  2510.00  3010.00  3510.00  4010.00  4510.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
' 6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  4510.0 e
5t
60**  5010.00  5510.00  6010.00  6510.00  7010.00  7510.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
' 6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 5 a6 1 a10 6 a14 5  a17 2 e
57**  7510.0 e
5t
60**  8010.00  8510.00  9010.00  9510.00  10010.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
56$$ f0 t
END
```

Data file 'w3_2cy_46-6gwd_avgB6stps.inp' for case 2 – 46.5 GWd/MTHM

```
=sas2h    parm=skipcellwt
''
 plut. burning in Westinghouse PWR (2 cycles; 1st w WABAs, 2nd w/o WABAs)!
'                           cy2 without WABAs!
'    run all cycles as one SAS2H case - change compositions in PATH B
44groupndf5   latticecell
'
'  this is a 46,500 MWd/MTM case High Enrichment
'  run first SAS2H burn step with WABA's - 2nd step w/o WABAs
'     sas deck modified from from ORNL - B. Murphy
'
' ---------------------------------------------------------
'       make sure we use the 44 group library!!!!
' ---------------------------------------------------------
'       mixtures for fuel-pin unit cell
' fuel rods are mixed-oxide with uranium and plutonium.
'
'     use 4.5 w/o enriched Pu
uo2   1 den=9.7879 1 901 92234 0.002 92235 0.2 92236 0.001
   92238 99.797 end
puo2  1 den=0.49187 1 901 94239 93.6 94240 5.9 94241 0.4
   94242 0.1 end
'  NO IFBA's used for MOX core
'  b-10  1 0 6.4584-5   901 end
'  zr    1 0 3.2292-5   901 end
'     the boron-10 coating is assumed mixed with the fuel
'
'      --------------------
'    some extra nuclides needed from library
'    included in MIX # 1
zr-94  1 0 1-20     901 end
tc-99  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
xe-131 1 0 1-20     901 end
cs-133 1 0 1-20     901 end
cs-134 1 0 1-20     901 end
ce-144 1 0 1-20     901 end
pr-143 1 0 1-20     901 end
nd-143 1 0 1-20     901 end
nd-145 1 0 1-20     901 end
nd-147 1 0 1-20     901 end
pm-147 1 0 1-20     901 end
sm-149 1 0 1-20     901 end
sm-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
eu-155 1 0 1-20     901 end
u-232  1 0 1-20     901 end
u-233  1 0 1-20     901 end
u-237  1 0 1-20     901 end
np-238 1 0 1-20     901 end
pu-236 1 0 1-20     901 end
pu-237 1 0 1-20     901 end
```

```
pu-243 1 0 1-20     901 end
pu-244 1 0 1-20     901 end
am-242 1 0 1-20     901 end
cm-245 1 0 1-20     901 end
cm-246 1 0 1-20     901 end
cm-247 1 0 1-20     901 end
cm-248 1 0 1-20     901 end
bk-249 1 0 1-20     901 end
cf-249 1 0 1-20     901 end
cf-250 1 0 1-20     901 end
cf-251 1 0 1-20     901 end
cf-252 1 0 1-20     901 end
cf-253 1 0 1-20     901 end
'
' ------------------------------------------------------------------
'  nearly Zirc-2 - not a great effect although Zirc-4 has Cr & Fe
arbmzirc 6.44 4 0 0 1 40000 97.91 26000 0.5 50116 0.86 50120
  0.73 2 1 607 end
'    above is zircalloy specified as an arbitrary material
'    because it may not be in the library
' ----------------------------------------------------------
h2o     3 0.707      583 end
co-59   3 0 1-20     583 end
arbm-bormod 0.707 2 0 0 0 5010 39.99 5011 60.01 3 1301.0-6 583 end
'      above is 1301 ppm boron in moderator
'      (40% isotopically enriched in B-10)
'      94 Design cases used 750 ppm av. Boron
' -----------------------------------------------------------
'       mixtures for shipping cask (just one assembly here!)
'
n       4 0 1.0-20 end
n       5 0.00122 end
' -----------------------------------------------------------
'       mixtures for larger unit cell
'     check WABA numbers  use ornl b4c value (redrived)
'   no wabas for cy 2 or cy 3
arbm-alox 3.72 2 0 1 0 13027 2 8016 3 9 0.95568 583 end
b4c    9 den=2.52  0.04432  583 end
'
end comp
' -----------------------------------------------------------
'       fuel-pin-cell geometry,
'       Clad ID from A00000000-01717-0200-00033 REV 00 (thickness)
'
'     pitch=1.25984 cm
'     pellet OD=0.78435 cm
'     clad OD=0.9144 cm
'     clad ID=0.8001 cm
'
'     squarepitch 1.25984 0.8202 1 3 0.95 2 0.8357 0 end
squarepitch 1.25984 0.78435 1 3 0.9144 2 0.8001 0 end
'
' -----------------------------------------------------------
'       assembly and cycle parameters
'
npin/assm=264 fuelngth=365.76 ncycles=12 nlib/cyc=1 lightel=22
printlevel=4 inplevel=2 numzones=12 mxrepeats=0 end
'
'   this assembly contains NO WABAs - cy 2, (Full MOX core Cy 1 only)
```

```
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
'   discharge burnup is 26.8 GWd/MT  - cy 1
'   discharge burnup is 46.5 GWd/MT  - cy 2
'
power=22.95 burn=91.2 down=0  bfrac=0.861 end
power=22.95 burn=91.8 down=0  bfrac=0.623 end
power=22.95 burn=91.1 down=0  bfrac=0.442 end
power=22.95 burn=92.0 down=0  bfrac=0.329 end
power=22.95 burn=91.0 down=0  bfrac=0.179 end
power=22.95 burn=35.9 down=108  bfrac=0.034 end
power=16.93   burn=91.2 down=0  bfrac=0.861 end
power=16.93   burn=91.8 down=0  bfrac=0.623 end
power=16.93   burn=91.1 down=0  bfrac=0.442 end
power=16.93   burn=92.0 down=0  bfrac=0.329 end
power=16.93   burn=91.0 down=0  bfrac=0.179 end
power=16.93   burn=35.9 down=1825  bfrac=0.034 end
'
' --------------------------------------------------------
'       light elements
c 0.06  n 0.034  o 62.14  al 0.0457  s 0.00397
ti 0.0498  v 0.00227  cr 2.34  mn 0.109 fe 4.6 mo 0.1816
co 0.033  ni 4.402   cu 0.011 zr 111.178 cd 0.00003
sn 1.8168 hf 0.00886 w 0.00227 p 0.142 nb 0.328 si 0.0659
```

```
' ----------------------------------------------------------
'       shipping cask zone description
'
27n-18couple tempcask=325 numzones=2 detect=0 dryfuel=yes
4 12.0834 5 12.5
zone=1 fuelbnds=1
' ----------------------------------------------------------
szfcask=0.25 end
' ----------------------------------------------------------
end
=ORIGENS
0$$ a11 71 e
1$$ 1 1t
 decay cases for West pu burner 96 DESIGN 46.5 GWD/MTH (2 cy, WABAs cy 1)
3$$ 21 0 1 e 2t
35$$ 0 t
'    subcase 1
'   7 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a13 -1 5 3 a17 2 e
5t
  decay (101 time points) MOX Vantage 5 DESIGN (2 cy, WABAs cy 1)
  one assembly
60**  10.000001 10.01 10.02 10.03 10.04 10.05
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  subcase 2
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  10.05 e
5t
60**  10.06  10.07  10.08  10.09  10.10  10.15
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
' subcase 3
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  10.15 e
5t
60**  10.20  10.25  10.30  10.35  10.40  10.45
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14  5  a17 2 e
57**  10.45 e
5t
60**  10.50  10.55  10.60  10.65  10.70  10.75
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
```

```
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  10.75 e
5t
60**  10.80  10.85  10.90  10.95  11.00  11.50
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14  5  a17 2 e
57**  11.50 e
5t
60**  12.00  12.50  13.00  13.50  14.00  14.50
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5 a17 2 e
57**  14.50 e
5t
60**  15.00  15.50  16.00  16.50  17.00  17.50
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  17.50 e
5t
60**  18.00  18.50  19.00  19.50  20.00  25.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  25.00 e
5t
60**  30.00  35.00  40.00  45.00  50.0   55.0
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14  5  a17 2 e
57**  55.00 e
5t
60**  60.00  65.00  70.00  75.00  80.00  85.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
```

```
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  85.00 e
5t
60**  90.00  95.00  100.00  105.00  110.00  160.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  160.0 e
5t
60**  210.00  260.00  310.00  360.00  410.00  460.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  460.0 e
5t
60**  510.00  560.00  610.00  660.00  710.00  760.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5 a17 2 e
57**  760.0 e
5t
60**  810.00  860.00  910.00  960.00  1010.00  1510.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  1510.0 e
5t
60**  2010.00  2510.00  3010.00  3510.00  4010.00  4510.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  4510.0 e
5t
60**  5010.00  5510.00  6010.00  6510.00  7010.00  7510.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
```

```
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 5 a6 1 a10 6 a14 5  a17 2 e
57**  7510.0 e
5t
60**  8010.00  8510.00  9010.00  9510.00  10010.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
56$$ f0 t
END
```

Data file 'w3_50-0gwd_2cy-90dabrn.inp' for case 3 – 50.09 GWd/MTHM

```
=sas2h    parm=skipcellwt
 plut. burning in Westinghouse PWR (2 cycles) with WABAs in cy 1!
'                            cy2 without WABAs!
'    run all cycles as one SAS2H case - change compositions in PATH B
44groupndf5   latticecell
'
'  this is a 50,087 MWd/MTM case - 2 cycle, Vantage 5 Fuel Type
'     sas deck modified from from ORNL - B. Murphy
'
' -------------------------------------------------------
'       make sure we use the 44 group library!!!!
' -------------------------------------------------------
'       mixtures for fuel-pin unit cell
' fuel rods are mixed-oxide with uranium and plutonium.
'
'     use 4.0 w/o enriched Pu
'   density derived from fuel mass/volume
uo2   1 den=9.8426 1 901 92234 0.002 92235 0.2 92236 0.001
  92238 99.797 end
puo2  1 den=0.4372 1 901 94239 93.6 94240 5.9 94241 0.4
  94242 0.1 end
'  NO IFBA's used for MOX core
'  b-10   1 0 6.4584-5   901 end
'  zr     1 0 3.2292-5   901 end
'     the boron-10 coating is assumed mixed with the fuel
'
'      --------------------
'    some extra nuclides needed from library
zr-94   1 0 1-20     901 end
tc-99   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
xe-131 1 0 1-20     901 end
cs-133 1 0 1-20     901 end
cs-134 1 0 1-20     901 end
ce-144 1 0 1-20     901 end
pr-143 1 0 1-20     901 end
nd-143 1 0 1-20     901 end
nd-145 1 0 1-20     901 end
nd-147 1 0 1-20     901 end
pm-147 1 0 1-20     901 end
sm-149 1 0 1-20     901 end
sm-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
eu-155 1 0 1-20     901 end
u-232   1 0 1-20     901 end
u-233   1 0 1-20     901 end
u-237   1 0 1-20     901 end
np-238 1 0 1-20     901 end
pu-236 1 0 1-20     901 end
pu-237 1 0 1-20     901 end
pu-243 1 0 1-20     901 end
```

```
pu-244 1 0 1-20     901 end
am-242 1 0 1-20     901 end
cm-245 1 0 1-20     901 end
cm-246 1 0 1-20     901 end
cm-247 1 0 1-20     901 end
cm-248 1 0 1-20     901 end
bk-249 1 0 1-20     901 end
cf-249 1 0 1-20     901 end
cf-250 1 0 1-20     901 end
cf-251 1 0 1-20     901 end
cf-252 1 0 1-20     901 end
cf-253 1 0 1-20     901 end.

' -------------------------------------------------------------------
'  nearly Zirc-2 - not a great effect although Zirc-4 has Cr & Fe
arbmzirc 6.44 4 0 0 1 40000 97.91 26000 0.5 50116 0.86 50120
  0.73 2 1 607 end
'    above is zircalloy specified as an arbitrary material
'    because it may not be in the library
' ----------------------------------------------------------
h2o    3 0.707      583 end
co-59  3 0 1-20     583 end
'  arbm-bormod 0.707 2 0 0 0 5010 39.99 5011 60.01 3 660.0-6 583 end
'      above is 660 ppm boron in moderator - cycle average
'      use bfrac parameter to adjust Boron content
arbm-bormod 0.707 2 0 0 0 5010 39.99 5011 60.01 3 1301.0-6 583 end
'      above is 1301 ppm boron in moderator
'      (40% isotopically enriched in B-10)
'      94 Design cases used 750 ppm av. Boron
' ----------------------------------------------------------
'       mixtures for shipping cask (just one assembly here!)
'
n      4 0 1.0-20 end
n      5 0.00122 end
' ----------------------------------------------------------
'       mixtures for larger unit cell
'     check WABA numbers  use ornl b4c value (redrived)
'   no wabas for cy 2 or cy 3
arbm-alox 3.72 2 0 1 0 13027 2 8016 3 9 0.95568 583 end
b4c   9 den=2.52  0.04432  583 end
'
'   arbm-alox 3.72 2 0 1 0 13027 2 8016 3 9 0.97952 end
'   b4c        9 0.041 end
end comp
' ----------------------------------------------------------
'       fuel-pin-cell geometry,
'       Clad ID from A00000000-01717-0200-00033 REV 00 (thickness)
'
'     pitch=1.25984 cm
'     pellet OD=0.78435 cm
'     clad OD=0.9144 cm
'     clad ID=0.8001 cm
'
'     squarepitch 1.25984 0.8202 1 3 0.95 2 0.8357 0 end
squarepitch 1.25984 0.78435 1 3 0.9144 2 0.8001 0 end
'
' ----------------------------------------------------------
'       assembly and cycle parameters
'
```

```
npin/assm=264 fuelngth=365.76 ncycles=12 nlib/cyc=1 lightel=22
printlevel=4 inplevel=2 numzones=12 mxrepeats=0 end
'
'   this assembly contains NO WABAs - cy 2, (Full MOX core Cy 1 only)
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
'   discharge burnup is 27.00 GWd/MT  - cy 1
'   discharge burnup is 50.09 GWd/MT  - cy 2
'
 power=23.155 burn=91.2 down=0   bfrac=0.861 end
 power=23.155 burn=91.8 down=0   bfrac=0.623 end
 power=23.155 burn=91.1 down=0   bfrac=0.442 end
 power=23.155 burn=92.0 down=0   bfrac=0.329 end
 power=23.155 burn=91.0 down=0   bfrac=0.179 end
 power=23.155 burn=35.9 down=108  bfrac=0.034 end
 power=19.8   burn=91.2 down=0   bfrac=0.861 end
 power=19.8   burn=91.8 down=0   bfrac=0.623 end
 power=19.8   burn=91.1 down=0   bfrac=0.442 end
 power=19.8   burn=92.0 down=0   bfrac=0.329 end
 power=19.8   burn=91.0 down=0   bfrac=0.179 end
 power=19.8   burn=35.9 down=1825  bfrac=0.034 end
' ---------------------------------------------------------
'      light elements
 c 0.06  n 0.034  o 62.14  al 0.0457  s 0.00397
```

```
 ti 0.0498  v 0.00227  cr 2.34  mn 0.109 fe 4.6 mo 0.1816
 co 0.033  ni 4.402  cu 0.011 zr 111.178 cd 0.00003
 sn 1.8168 hf 0.00886 w 0.00227 p 0.142 nb 0.328 si 0.0659
' ----------------------------------------------------------
'       shipping cask zone description
'
27n-18couple tempcask=325 numzones=2 detect=0 dryfuel=yes
4 12.0834 5 12.5
zone=1 fuelbnds=1
' ----------------------------------------------------------
szfcask=0.25 end
' ----------------------------------------------------------
end
=ORIGENS
0$$ a11 71 e
1$$ 1 1t
 decay cases for 4.0 % Pu MOX 96 DESIGN 50.1 GWD/MTH (2 cy, WABAs cy 1)
3$$ 21 0 1 e 2t
35$$ 0 t
'   subcase 1
'  7 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a13 -1 5 3 a17 2 e
5t
  decay (101 time points) MOX Vantage 5 DESIGN (2 cy, WABAs cy 1)
  one assembly
60**  10.000001 10.01 10.02 10.03 10.04 10.05
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  subcase 2
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  10.05 e
5t
60**  10.06  10.07  10.08  10.09  10.10  10.15
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
' subcase 3
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  10.15 e
5t
60**  10.20  10.25  10.30  10.35  10.40  10.45
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14  5  a17 2 e
57**  10.45 e
5t
60**  10.50  10.55  10.60  10.65  10.70  10.75
61** 0.05 0.0001 0.0001 4r0.01
```

```
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  10.75 e
5t
60**  10.80  10.85  10.90  10.95  11.00  11.50
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14  5  a17 2 e
57**  11.50 e
5t
60**  12.00  12.50  13.00  13.50  14.00  14.50
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5 a17 2 e
57**  14.50 e
5t
60**  15.00  15.50  16.00  16.50  17.00  17.50
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  17.50 e
5t
60**  18.00  18.50  19.00  19.50  20.00  25.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  25.00 e
5t
60**  30.00  35.00  40.00  45.00  50.0   55.0
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14  5  a17 2 e
57**  55.00 e
5t
60**  60.00  65.00  70.00  75.00  80.00  85.00
```

```
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  85.00 e
5t
60**  90.00  95.00  100.00  105.00  110.00  160.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  160.0 e
5t
60**  210.00  260.00  310.00  360.00  410.00  460.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  460.0 e
5t
60**  510.00  560.00  610.00  660.00  710.00  760.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5 a17 2 e
57**  760.0 e
5t
60**  810.00  860.00  910.00  960.00  1010.00  1510.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  1510.0 e
5t
60**  2010.00  2510.00  3010.00  3510.00  4010.00  4510.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 6 a6 1 a10 6 a14 5  a17 2 e
57**  4510.0 e
5t
```

```
60**  5010.00  5510.00  6010.00  6510.00  7010.00  7510.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
'  6 periods/subcase, time units in yrs - nunit = 5
56$$ 0 5 a6 1 a10 6 a14 5  a17 2 e
57**  7510.0 e
5t
60**  8010.00  8510.00  9010.00  9510.00  10010.00
61** 0.05 0.0001 0.0001 4r0.01
65$$ a4 1 2z 1 2z 1 a16 1 2z 1 a25 1 2z 1 2z 1 a37 1 2z 1
 a46 1 2z 1 2z 1 a58 1 2z 1 e
6t
'
56$$ f0 t
END
```

Data file 'w3_35-5gwd_2cy-6stps.inp' for case 4 – 35.58 GWd/MTHM

```
=sas2h    parm=skipcellwt
''
 plut. burning in Westinghouse PWR (2 cycles) cy 1 with WABAs,
''
'                            cy 2 without WABAs!
'    run all cycles as on SAS2H case - change compositions in PATH B
'    follow boron letdown curve with 6 steps per cycle
44groupndf5   latticecell
'
'  this is a 35.6 MWd/MTM case
'     sas deck modified from from ORNL - B. Murphy
'
' ---------------------------------------------------------
'       make sure we use the 44 group library!!!!
' ---------------------------------------------------------
'       mixtures for fuel-pin unit cell
' fuel rods are mixed-oxide with uranium and plutonium.
'
'     use 4.0 w/o enriched Pu
'   density derived from fuel mass/volume
uo2   1 den=9.8426 1 901 92234 0.002 92235 0.2 92236 0.001
  92238 99.797 end
puo2  1 den=0.4372 1 901 94239 93.6 94240 5.9 94241 0.4
  94242 0.1 end
'  NO IFBA's used for MOX core
'  b-10   1 0 6.4584-5   901 end
'  zr     1 0 3.2292-5   901 end
'     the boron-10 coating is assumed mixed with the fuel
'
'      --------------------
'    some extra nuclides needed from library
zr-94   1 0 1-20     901 end
tc-99   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
xe-131 1 0 1-20     901 end
cs-133 1 0 1-20     901 end
cs-134 1 0 1-20     901 end
ce-144 1 0 1-20     901 end
pr-143 1 0 1-20     901 end
nd-143 1 0 1-20     901 end
nd-145 1 0 1-20     901 end
nd-147 1 0 1-20     901 end
pm-147 1 0 1-20     901 end
sm-149 1 0 1-20     901 end
sm-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
eu-155 1 0 1-20     901 end
u-232   1 0 1-20     901 end
u-233   1 0 1-20     901 end
u-237   1 0 1-20     901 end
np-238 1 0 1-20     901 end
pu-236 1 0 1-20     901 end
```

```
pu-237 1 0 1-20     901 end
pu-243 1 0 1-20     901 end
pu-244 1 0 1-20     901 end
am-242 1 0 1-20     901 end
cm-245 1 0 1-20     901 end
cm-246 1 0 1-20     901 end
cm-247 1 0 1-20     901 end
cm-248 1 0 1-20     901 end
bk-249 1 0 1-20     901 end
cf-249 1 0 1-20     901 end
cf-250 1 0 1-20     901 end
cf-251 1 0 1-20     901 end
cf-252 1 0 1-20     901 end
cf-253 1 0 1-20     901 end

' -----------------------------------------------------------------
'  nearly Zirc-2 - not a great effect although Zirc-4 has Cr & Fe
arbmzirc 6.44 4 0 0 1 40000 97.91 26000 0.5 50116 0.86 50120
  0.73 2 1 607 end
'    above is zircalloy specified as an arbitrary material
'    because it may not be in the library
' ---------------------------------------------------------
h2o    3 0.707      583 end
co-59  3 0 1-20     583 end
arbm-bormod 0.707 2 0 0 0 5010 39.99 5011 60.01 3 1301.0-6 583 end
'      above is 1301 ppm initial boron concentration in moderator
'      (40% isotopically enriched in B-10)
'      94 Design cases used 750 ppm av. Boron
' ---------------------------------------------------------
'       mixtures for shipping cask (just one assembly here!)
'
n      4 0 1.0-20 end
n      5 0.00122 end
' ---------------------------------------------------------
'       mixtures for larger unit cell
'     check WABA numbers  use ornl b4c value (redrived)
'   no wabas for cy 2 or cy 3
arbm-alox 3.72 2 0 1 0 13027 2 8016 3 9 0.95568 583 end
b4c   9 den=2.52  0.04432  583 end
'
'   arbm-alox 3.72 2 0 1 0 13027 2 8016 3 9 0.97952 end
'   b4c       9 0.041 end
end comp
' ---------------------------------------------------------
'       fuel-pin-cell geometry
'
'     pitch=1.25984 cm
'     pellet OD=0.78435 cm
'     clad OD=0.9144 cm
'     clad ID=0.8001 cm
'
'     squarepitch 1.25984 0.8202 1 3 0.95 2 0.8357 0 end (LOPAR)
squarepitch 1.25984 0.78435 1 3 0.9144 2 0.8001 0 end
'
' ---------------------------------------------------------
'       assembly and cycle parameters
'
npin/assm=264 fuelngth=365.76 ncycles=12 nlib/cyc=1 lightel=22
printlevel=4 inplevel=2 numzones=12 mxrepeats=0 end
```

```
'
'   this assembly contains NO WABAs - cy 2, (Full MOX core Cy 1 only)
'
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
'   discharge burnup is 27.01 GWd/MT  - cy 1
'   discharge burnup is 35.58 GWd/MT  - cy 2
'
'
 power=23.165 burn=91.2 down=0   bfrac=0.861 end
 power=23.165 burn=91.8 down=0   bfrac=0.623 end
 power=23.165 burn=91.1 down=0   bfrac=0.442 end
 power=23.165 burn=92.0 down=0   bfrac=0.329 end
 power=23.165 burn=91.0 down=0   bfrac=0.179 end
 power=23.165 burn=35.9 down=108  bfrac=0.034 end
'
 power=7.35 burn=91.2 down=0  bfrac=0.861 end
 power=7.35 burn=91.8 down=0  bfrac=0.623 end
 power=7.35 burn=91.1 down=0  bfrac=0.442 end
 power=7.35 burn=92.0 down=0  bfrac=0.329 end
 power=7.35 burn=91.0 down=0  bfrac=0.179 end
 power=7.35 burn=35.9 down=108  bfrac=0.034 end
'
' --------------------------------------------------------
```

```
'       light elements
 c 0.06  n 0.034  o 62.14  al 0.0457  s 0.00397
 ti 0.0498  v 0.00227  cr 2.34  mn 0.109 fe 4.6 mo 0.1816
 co 0.033  ni 4.402   cu 0.011 zr 111.178 cd 0.00003
 sn 1.8168 hf 0.00886 w 0.00227 p 0.142 nb 0.328 si 0.0659
' ---------------------------------------------------------
'       shipping cask zone description
'
27n-18couple tempcask=325 numzones=2 detect=0 dryfuel=yes
4 12.0834 5 12.5
zone=1 fuelbnds=1
' ---------------------------------------------------------
szfcask=0.25 end
' ---------------------------------------------------------
end
=origens
0$$  a8 26 a11 71 e
1$$ 1  1t
 w 17x17 MOX
3$$ 21 0 1 e
2t
35$$ 0  t
'
56$$ 0 7 a13 -1 a15 3 0 4 e   5t
Part B W 17x17, 4.0wt%, 35.6 gwd/mtu decay
per W assembly
60**  0 1 90 365.25 730.5 1826.25  3652.5
65$$ a 5 1 a25 1 1 0 1 0 0 0 a46 1 1 0 1 0 0 0 e
6t
'
56$$ 0 10 a10 7 a14 5 a17 4 e  57** 10  e 5t
60**  15 20 30 50 100 150 200 250 300 400
65$$ a 5 1 a25 1 1 0 1 0 0 0 a46 1 1 0 1 0 0 0 e
6t
'
56$$ 0 10 a10 10 a14 5 a17 4 e  57** 400  e  5t
60**  500 1+3 2+3 4+3 6+3 8+3 1+4 1.2+4 1.4+4 1.5+4
65$$ a 5 1 a25 1 1 0 1 0 0 0 a46 1 1 0 1 0 0 0 e
6t
'
56$$ 0 10 a10 10 a14 5 a17 4 e  57** 1.5+4  e  5t
60**  1.6+4 1.7+4 1.8+4 1.9+4 2.0+4 2.1+4 2.2+4 2.3+4 2.4+4 2.5+4
65$$ a 5 1 a25 1 1 0 1 0 0 0 a46 1 1 0 1 0 0 0 e
6t
'
56$$ 0 10 a10 10 a14 5 a17 4 e  57** 2.5+4  e  5t
60**  3.5+4 4.5+4 5+4 5.5+4 6+4 6.5+4 7+4 1+5 2+5 2.5+5
65$$ a 5 1 a25 1 1 0 1 0 0 0 a46 1 1 0 1 0 0 0 e
6t
'
56$$ 0 3 a10 10 a14 5 a17 4 e  57** 2.5+5  e  5t
60**  3+5 5+5 999999
65$$ a 5 1 a25 1 1 0 1 0 0 0 a46 1 1 0 1 0 0 0 e
6t
'
56$$ f0  t
end
```

Data file 'w3_39-3gwd_2cy-6stps.inp' for case 5 – 39.35 GWd/MTHM

```
=sas2h    parm=skipcellwt
''
 plut. burning in Westinghouse PWR (2 cycles) with NOWABAs!
''
44groupndf5   latticecell
''
'
'  this is a 39,350 MWd/MTM case - 2 cycle
'     sas deck modified from from ORNL - B. Murphy
'
' --------------------------------------------------------
'        make sure we use the 44 group library!!!!
' --------------------------------------------------------
'        mixtures for fuel-pin unit cell
' fuel rods are mixed-oxide with uranium and plutonium.
'
'     use 4.5 w/o enriched Pu
'   density derived from fuel mass/volume, Spread Sheet MOX_96_39-3_PathA
uo2   1 den=9.78794 1 901 92234 0.002 92235 0.2 92236 0.001
  92238 99.797 end
puo2  1 den=0.49187 1 901 94239 93.6 94240 5.9 94241 0.4
  94242 0.1 end
'  NO IFBA's used for MOX core
'  b-10  1 0 6.4584-5   901 end
'  zr    1 0 3.2292-5   901 end
'     the boron-10 coating is assumed mixed with the fuel
'
'      --------------------
'    some extra nuclides needed from library
zr-94   1 0 1-20      901 end
tc-99   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
xe-131 1 0 1-20      901 end
cs-133 1 0 1-20      901 end
cs-134 1 0 1-20      901 end
ce-144 1 0 1-20      901 end
pr-143 1 0 1-20      901 end
nd-143 1 0 1-20      901 end
nd-145 1 0 1-20      901 end
nd-147 1 0 1-20      901 end
pm-147 1 0 1-20      901 end
sm-149 1 0 1-20      901 end
sm-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
eu-155 1 0 1-20      901 end
u-232   1 0 1-20      901 end
u-233   1 0 1-20      901 end
u-237   1 0 1-20      901 end
np-238 1 0 1-20      901 end
pu-236 1 0 1-20      901 end
pu-237 1 0 1-20      901 end
pu-243 1 0 1-20      901 end
```

```
pu-244 1 0 1-20     901 end
am-242 1 0 1-20     901 end
cm-245 1 0 1-20     901 end
cm-246 1 0 1-20     901 end
cm-247 1 0 1-20     901 end
cm-248 1 0 1-20     901 end
bk-249 1 0 1-20     901 end
cf-249 1 0 1-20     901 end
cf-250 1 0 1-20     901 end
cf-251 1 0 1-20     901 end
cf-252 1 0 1-20     901 end
cf-253 1 0 1-20     901 end

' ----------------------------------------------------------------
'  nearly Zirc-2 - not a great effect although Zirc-4 has Cr & Fe
arbmzirc 6.44 4 0 0 1 40000 97.91 26000 0.5 50116 0.86 50120
  0.73 2 1 607 end
'    above is zircalloy specified as an arbitrary material
'    because it may not be in the library
' --------------------------------------------------------
h2o    3 0.707      583 end
co-59  3 0 1-20     583 end
arbm-bormod 0.707 2 0 0 0 5010 39.99 5011 60.01 3 1301.0-6 583 end
'      above is 1301 ppm boron in moderator
'      (40% isotopically enriched in B-10)
'      94 Design cases used 750 ppm av. Boron
' ---------------------------------------------------------
'       mixtures for shipping cask (just one assembly here!)
'
n      4 0 1.0-20 end
n      5 0.00122 end
' ---------------------------------------------------------
'       mixtures for larger unit cell
'
'   arbm-alox 3.72 2 0 1 0 13027 2 8016 3 9 0.97952 end
'   b4c       9 0.041 end
end comp
' ---------------------------------------------------------
'       fuel-pin-cell geometry,
'       Clad ID from A00000000-01717-0200-00033 REV 00 (thickness)
'
'     pitch=1.25984 cm
'     pellet OD=0.78435 cm
'     clad OD=0.9144 cm
'     clad ID=0.8001 cm
'
'     squarepitch 1.25984 0.8202 1 3 0.95 2 0.8357 0 end
squarepitch 1.25984 0.78435 1 3 0.9144 2 0.8001 0 end
'
' ---------------------------------------------------------
'       assembly and cycle parameters
'
npin/assm=264 fuelngth=365.76 ncycles=12  nlib/cyc=1 lightel=22
printlevel=4 inplevel=2 numzones=10  end
'
'   this assembly contains NO WABAs, (Full MOX core Cy 1 only)
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.9367 2 4.9755
 500 8.1972 2 8.244 3 8.6763 500 12.0834
```

```
'
'   discharge burnup is 39,350 MWd/MT
'
'
 power=14.0 burn=91.2 down=0  bfrac=0.861 end
 power=14.0 burn=91.8 down=0  bfrac=0.623 end
 power=14.0 burn=91.1 down=0  bfrac=0.442 end
 power=14.0 burn=92.0 down=0  bfrac=0.329 end
 power=14.0 burn=91.0 down=0  bfrac=0.179 end
 power=14.0 burn=35.9 down=108  bfrac=0.034 end
'
 power=19.75 burn=91.2 down=0  bfrac=0.861 end
 power=19.75 burn=91.8 down=0  bfrac=0.623 end
 power=19.75 burn=91.1 down=0  bfrac=0.442 end
 power=19.75 burn=92.0 down=0  bfrac=0.329 end
 power=19.75 burn=91.0 down=0  bfrac=0.179 end
 power=19.75 burn=35.9 down=1825  bfrac=0.034 end
'
' --------------------------------------------------------
'       light elements
 c 0.06  n 0.034  o 62.14  al 0.0457  s 0.00397
 ti 0.0498  v 0.00227  cr 2.34  mn 0.109 fe 4.6 mo 0.1816
 co 0.033  ni 4.402   cu 0.011 zr 111.178 cd 0.00003
 sn 1.8168 hf 0.00886 w 0.00227 p 0.142 nb 0.328 si 0.0659
' --------------------------------------------------------
'       shipping cask zone description
'
27n-18couple tempcask=325 numzones=2 detect=0 dryfuel=yes
4 12.0834 5 12.5
zone=1 fuelbnds=1
' --------------------------------------------------------
szfcask=0.25 end
' --------------------------------------------------------
end
=origens
0$$  a8 26 a11 71 e
1$$ 1  1t
 w 17x17 MOX
3$$ 21 0 1 e
2t
35$$ 0  t
'
56$$ 0 7 a13 -1 a15 3 0 4 e   5t
Part B W 17x17, 4.5wt%, 39.4 gwd/mtu decay
per W assembly
60**  0 1 90 365.25 730.5 1826.25  3652.5
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ 0 10 a10 7 a14 5 a17 4 e  57** 10  e  5t
60**  15 20 30 50 100 150 200 250 300 400
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ 0 10 a10 10 a14 5 a17 4 e  57** 400  e  5t
60**  500 1+3 2+3 4+3 6+3 8+3 1+4 1.2+4 1.4+4 1.5+4
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
```

```
56$$ 0 10 a10 10 a14 5 a17 4 e  57** 1.5+4  e  5t
60**  1.6+4 1.7+4 1.8+4 1.9+4 2.0+4 2.1+4 2.2+4 2.3+4 2.4+4 2.5+4
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ 0 10 a10 10 a14 5 a17 4 e  57** 2.5+4  e  5t
60**  3.5+4 4.5+4 5+4 5.5+4 6+4 6.5+4 7+4 1+5 2+5 2.5+5
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ 0 3 a10 10 a14 5 a17 4 e  57** 2.5+5  e  5t
60**  3+5 5+5 999999
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ f0  t
```
end

Data file 'w3_50-0gwd_crit-6stps.inp' for case 6 – 50.09 GWd/MTHM

```
=sas2h    parm=skipcellwt
 plut. burning in Westinghouse PWR (2 cycles) with WABAs in cy 1!
'                           cy2 without WABAs!
'    run all cycles as one SAS2H case - change compositions in PATH B
44groupndf5   latticecell
'
'  this is a 50,087 MWd/MTM case - 2 cycle, Vantage 5 Fuel Type
'     sas deck modified from from ORNL - B. Murphy
'
' --------------------------------------------------------
'      make sure we use the 44 group library!!!!
' --------------------------------------------------------
'      mixtures for fuel-pin unit cell
' fuel rods are mixed-oxide with uranium and plutonium.
'
'     use 4.0 w/o enriched Pu
'   density derived from fuel mass/volume
uo2   1 den=9.8426 1 901 92234 0.002 92235 0.2 92236 0.001
  92238 99.797 end
puo2  1 den=0.4372 1 901 94239 93.6 94240 5.9 94241 0.4
  94242 0.1 end
'  NO IFBA's used for MOX core
'  b-10  1 0 6.4584-5   901 end
'  zr    1 0 3.2292-5   901 end
'     the boron-10 coating is assumed mixed with the fuel
'
'      --------------------
'    some extra nuclides needed from library
zr-94   1 0 1-20      901 end
tc-99   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
xe-131 1 0 1-20      901 end
cs-133 1 0 1-20      901 end
cs-134 1 0 1-20      901 end
ce-144 1 0 1-20      901 end
pr-143 1 0 1-20      901 end
nd-143 1 0 1-20      901 end
nd-145 1 0 1-20      901 end
nd-147 1 0 1-20      901 end
pm-147 1 0 1-20      901 end
sm-149 1 0 1-20      901 end
sm-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
eu-155 1 0 1-20      901 end
u-232   1 0 1-20      901 end
u-233   1 0 1-20      901 end
u-237   1 0 1-20      901 end
np-238 1 0 1-20      901 end
pu-236 1 0 1-20      901 end
pu-237 1 0 1-20      901 end
pu-243 1 0 1-20      901 end
pu-244 1 0 1-20      901 end
```

```
am-242 1 0 1-20     901 end
cm-245 1 0 1-20     901 end
cm-246 1 0 1-20     901 end
cm-247 1 0 1-20     901 end
cm-248 1 0 1-20     901 end
bk-249 1 0 1-20     901 end
cf-249 1 0 1-20     901 end
cf-250 1 0 1-20     901 end
cf-251 1 0 1-20     901 end
cf-252 1 0 1-20     901 end
cf-253 1 0 1-20     901 end

' -----------------------------------------------------------------
'  nearly Zirc-2 - not a great effect although Zirc-4 has Cr & Fe
arbmzirc 6.44 4 0 0 1 40000 97.91 26000 0.5 50116 0.86 50120
  0.73 2 1 607 end
'    above is zircalloy specified as an arbitrary material
'    because it may not be in the library
' ---------------------------------------------------------
h2o    3 0.707      583 end
co-59  3 0 1-20     583 end
'  arbm-bormod 0.707 2 0 0 0 5010 39.99 5011 60.01 3 660.0-6 583 end
'      above is 660 ppm boron in moderator - cycle average
'      use bfrac parameter to adjust Boron content
arbm-bormod 0.707 2 0 0 0 5010 39.99 5011 60.01 3 1301.0-6 583 end
'      above is 1301 ppm boron in moderator
'      (40% isotopically enriched in B-10)
'      94 Design cases used 750 ppm av. Boron
' ----------------------------------------------------------
'       mixtures for shipping cask (just one assembly here!)
'
n      4 0 1.0-20 end
n      5 0.00122 end
' ----------------------------------------------------------
'       mixtures for larger unit cell
'     check WABA numbers  use ornl b4c value (redrived)
'   no wabas for cy 2 or cy 3
arbm-alox 3.72 2 0 1 0 13027 2 8016 3 9 0.95568 583 end
b4c    9 den=2.52  0.04432  583 end
'
'   arbm-alox 3.72 2 0 1 0 13027 2 8016 3 9 0.97952 end
'   b4c       9 0.041 end
end comp
' ----------------------------------------------------------
'       fuel-pin-cell geometry,
'       Clad ID from A00000000-01717-0200-00033 REV 00 (thickness)
'
'     pitch=1.25984 cm
'     pellet OD=0.78435 cm
'     clad OD=0.9144 cm
'     clad ID=0.8001 cm
'
'     squarepitch 1.25984 0.8202 1 3 0.95 2 0.8357 0 end
squarepitch 1.25984 0.78435 1 3 0.9144 2 0.8001 0 end
'
' ----------------------------------------------------------
'       assembly and cycle parameters
'
npin/assm=264 fuelngth=365.76 ncycles=12 nlib/cyc=1 lightel=22
```

```
printlevel=4 inplevel=2 numzones=12 mxrepeats=0 end
'
'   this assembly contains NO WABAs - cy 2, (Full MOX core Cy 1 only)
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
    500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
    500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
'   discharge burnup is 27.00 GWd/MT  - cy 1
'   discharge burnup is 50.09 GWd/MT  - cy 2
'
 power=23.155 burn=91.2 down=0   bfrac=0.861 end
 power=23.155 burn=91.8 down=0   bfrac=0.623 end
 power=23.155 burn=91.1 down=0   bfrac=0.442 end
 power=23.155 burn=92.0 down=0   bfrac=0.329 end
 power=23.155 burn=91.0 down=0   bfrac=0.179 end
 power=23.155 burn=35.9 down=108   bfrac=0.034 end
 power=19.8   burn=91.2 down=0   bfrac=0.861 end
 power=19.8   burn=91.8 down=0   bfrac=0.623 end
 power=19.8   burn=91.1 down=0   bfrac=0.442 end
 power=19.8   burn=92.0 down=0   bfrac=0.329 end
 power=19.8   burn=91.0 down=0   bfrac=0.179 end
 power=19.8   burn=35.9 down=1825   bfrac=0.034 end
' -------------------------------------------------------
'       light elements
 c 0.06  n 0.034  o 62.14  al 0.0457  s 0.00397
 ti 0.0498  v 0.00227  cr 2.34  mn 0.109 fe 4.6 mo 0.1816
```

```
 co 0.033  ni 4.402   cu 0.011 zr 111.178 cd 0.00003
 sn 1.8168 hf 0.00886 w 0.00227 p 0.142 nb 0.328 si 0.0659
' ------------------------------------------------------
'       shipping cask zone description
'
27n-18couple tempcask=325 numzones=2 detect=0 dryfuel=yes
4 12.0834 5 12.5
zone=1 fuelbnds=1
' ------------------------------------------------------
szfcask=0.25 end
' ------------------------------------------------------
end
=origens
0$$  a8 26 a11 71 e
1$$ 1  1t
 w 17x17 MOX
3$$ 21 0 1 e
2t
35$$ 0  t
'
56$$ 0 7 a13 -1 a15 3 0 4 e   5t
Part B W 17x17, 4.5wt%, 39.3 gwd/mtu decay
per W assembly
60**  0 1 90 365.25 730.5 1826.25  3652.5
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ 0 10 a10 7 a14 5 a17 4 e  57** 10  e  5t
60**  15 20 30 50 100 150 200 250 300 400
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ 0 10 a10 10 a14 5 a17 4 e  57** 400  e  5t
60**  500 1+3 2+3 4+3 6+3 8+3 1+4 1.2+4 1.4+4 1.5+4
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ 0 10 a10 10 a14 5 a17 4 e  57** 1.5+4  e  5t
60**  1.6+4 1.7+4 1.8+4 1.9+4 2.0+4 2.1+4 2.2+4 2.3+4 2.4+4 2.5+4
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ 0 10 a10 10 a14 5 a17 4 e  57** 2.5+4  e  5t
60**  3.5+4 4.5+4 5+4 5.5+4 6+4 6.5+4 7+4 1+5 2+5 2.5+5
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ 0 3 a10 10 a14 5 a17 4 e  57** 2.5+5  e  5t
60**  3+5 5+5 999999
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ f0  t
end
```

Data file 'w3_35-5gwd_2cy-geochem.inp' for case 7 – 35.58 GWd/MTHM

```
=sas2h    parm=skipcellwt
 plut. burning in Westinghouse PWR (2 cycles) cy 1 with WABAs,
'                            cy 2 without WABAs!
'    run all cycles as on SAS2H case - change compositions in PATH B
'    follow boron letdown curve with 6 steps per cycle
44groupndf5   latticecell
'
'  this is a 35.6 MWd/MTM case
'  delete light elements for geochemical analysis
'     sas deck modified from from ORNL - B. Murphy
'
' ------------------------------------------------------------
'       make sure we use the 44 group library!!!!
' ------------------------------------------------------------
'       mixtures for fuel-pin unit cell
' fuel rods are mixed-oxide with uranium and plutonium.
'
'     use 4.0 w/o enriched Pu
'   density derived from fuel mass/volume
uo2   1 den=9.8426 1 901 92234 0.002 92235 0.2 92236 0.001
  92238 99.797 end
puo2  1 den=0.4372 1 901 94239 93.6 94240 5.9 94241 0.4
  94242 0.1 end
'  NO IFBA's used for MOX core
'  b-10  1 0 6.4584-5   901 end
'  zr    1 0 3.2292-5   901 end
'     the boron-10 coating is assumed mixed with the fuel
'
'      --------------------
'    some extra nuclides needed from library
zr-94  1 0 1-20     901 end
tc-99  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
xe-131 1 0 1-20     901 end
cs-133 1 0 1-20     901 end
cs-134 1 0 1-20     901 end
ce-144 1 0 1-20     901 end
pr-143 1 0 1-20     901 end
nd-143 1 0 1-20     901 end
nd-145 1 0 1-20     901 end
nd-147 1 0 1-20     901 end
pm-147 1 0 1-20     901 end
sm-149 1 0 1-20     901 end
sm-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
eu-155 1 0 1-20     901 end
u-232  1 0 1-20     901 end
u-233  1 0 1-20     901 end
u-237  1 0 1-20     901 end
np-238 1 0 1-20     901 end
```

```
pu-236 1 0 1-20     901 end
pu-237 1 0 1-20     901 end
pu-243 1 0 1-20     901 end
pu-244 1 0 1-20     901 end
am-242 1 0 1-20     901 end
cm-245 1 0 1-20     901 end
cm-246 1 0 1-20     901 end
cm-247 1 0 1-20     901 end
cm-248 1 0 1-20     901 end
bk-249 1 0 1-20     901 end
cf-249 1 0 1-20     901 end
cf-250 1 0 1-20     901 end
cf-251 1 0 1-20     901 end
cf-252 1 0 1-20     901 end
cf-253 1 0 1-20     901 end

' -----------------------------------------------------------
'  nearly Zirc-2 - not a great effect although Zirc-4 has Cr & Fe
arbmzirc 6.44 4 0 0 1 40000 97.91 26000 0.5 50116 0.86 50120
  0.73 2 1 607 end
'    above is zircalloy specified as an arbitrary material
'    because it may not be in the library
' -------------------------------------------------------
h2o    3 0.707      583 end
co-59  3 0 1-20     583 end
arbm-bormod 0.707 2 0 0 0 5010 39.99 5011 60.01 3 1301.0-6 583 end
'      above is 1301 ppm initial boron concentration in moderator
'      (40% isotopically enriched in B-10)
'      94 Design cases used 750 ppm av. Boron
' -------------------------------------------------------
'       mixtures for shipping cask (just one assembly here!)
'
n      4 0 1.0-20 end
n      5 0.00122 end
' -------------------------------------------------------
'       mixtures for larger unit cell
'     check WABA numbers  use ornl b4c value (redrived)
'   no wabas for cy 2 or cy 3
arbm-alox 3.72 2 0 1 0 13027 2 8016 3 9 0.95568 583 end
b4c   9 den=2.52  0.04432  583 end
'
'   arbm-alox 3.72 2 0 1 0 13027 2 8016 3 9 0.97952 end
'   b4c       9 0.041 end
end comp
' -------------------------------------------------------
'       fuel-pin-cell geometry
'
'     pitch=1.25984 cm
'     pellet OD=0.78435 cm
'     clad OD=0.9144 cm
'     clad ID=0.8001 cm
'
'     squarepitch 1.25984 0.8202 1 3 0.95 2 0.8357 0 end (LOPAR)
squarepitch 1.25984 0.78435 1 3 0.9144 2 0.8001 0 end
'
' -------------------------------------------------------
'       assembly and cycle parameters
'
'  npin/assm=264 fuelngth=365.76 ncycles=12 nlib/cyc=1 lightel=22
```

```
npin/assm=264 fuelngth=365.76 ncycles=12 nlib/cyc=1 lightel=0
printlevel=4 inplevel=2 numzones=12 mxrepeats=0 end
'
'   this assembly contains NO WABAs - cy 2, (Full MOX core Cy 1 only)
'
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
   500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
   500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
   500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
   500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
   500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 9 4.8896 2 4.9755
   500 8.1972 2 8.2999 9 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
   500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
   500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
   500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
   500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
   500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.7912 3 4.8896 2 4.9755
   500 8.1972 2 8.2999 3 8.414 3 8.6763 500 12.0834
'
'   discharge burnup is 27.01 GWd/MT  - cy 1
'   discharge burnup is 35.58 GWd/MT  - cy 2
'
'
 power=23.165 burn=91.2 down=0  bfrac=0.861 end
 power=23.165 burn=91.8 down=0  bfrac=0.623 end
 power=23.165 burn=91.1 down=0  bfrac=0.442 end
 power=23.165 burn=92.0 down=0  bfrac=0.329 end
 power=23.165 burn=91.0 down=0  bfrac=0.179 end
 power=23.165 burn=35.9 down=108  bfrac=0.034 end
'
 power=7.35 burn=91.2 down=0  bfrac=0.861 end
 power=7.35 burn=91.8 down=0  bfrac=0.623 end
 power=7.35 burn=91.1 down=0  bfrac=0.442 end
 power=7.35 burn=92.0 down=0  bfrac=0.329 end
 power=7.35 burn=91.0 down=0  bfrac=0.179 end
 power=7.35 burn=35.9 down=108  bfrac=0.034 end
```

```
'
' --------------------------------------------------------
'       light elements
'  c 0.06   n 0.034   o 62.14   al 0.0457   s 0.00397
'  ti 0.0498   v 0.00227   cr 2.34   mn 0.109 fe 4.6 mo 0.1816
'  co 0.033   ni 4.402    cu 0.011 zr 111.178 cd 0.00003
'  sn 1.8168 hf 0.00886 w 0.00227 p 0.142 nb 0.328 si 0.0659
' --------------------------------------------------------
'       shipping cask zone description
'
27n-18couple tempcask=325 numzones=2 detect=0 dryfuel=yes
4 12.0834 5 12.5
zone=1 fuelbnds=1
' --------------------------------------------------------
szfcask=0.25 end
' --------------------------------------------------------
end
=origens
0$$  a8 26 a11 71 e
1$$ 1  1t
 w 17x17 MOX
3$$ 21 0 1 e
2t
35$$ 0  t
'
56$$ 0 7 a13 -1 a15 3 0 4 e   5t
Part B W 17x17, 4.0wt%, 35.6 gwd/mtu decay
per W assembly
60**  0 1 90 365.25 730.5 1826.25  3652.5
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ 0 10 a10 7 a14 5 a17 4 e  57** 10  e  5t
60**  15 20 30 50 100 150 200 250 300 400
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ 0 10 a10 10 a14 5 a17 4 e  57** 400  e  5t
60**  500 1+3 2+3 4+3 6+3 8+3 1+4 1.2+4 1.4+4 1.5+4
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ 0 10 a10 10 a14 5 a17 4 e  57** 1.5+4  e  5t
60**  1.6+4 1.7+4 1.8+4 1.9+4 2.0+4 2.1+4 2.2+4 2.3+4 2.4+4 2.5+4
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ 0 10 a10 10 a14 5 a17 4 e  57** 2.5+4  e  5t
60**  3.5+4 4.5+4 5+4 5.5+4 6+4 6.5+4 7+4 1+5 2+5 2.5+5
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ 0 3 a10 10 a14 5 a17 4 e  57** 2.5+5  e  5t
60**  3+5 5+5 999999
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ f0  t
end
```

Data file 'w3_39-3gwd_2cy-geochem.inp' for case 8 – 39.35 GWd/MTHM

```
=sas2h    parm=skipcellwt
 plut. burning in Westinghouse PWR (2 cycles) with NOWABAs!
44groupndf5   latticecell
'
'  this is a 39,300 MWd/MTM case - 2 cycle
'     sas deck modified from from ORNL - B. Murphy
'
' -------------------------------------------------------
'       make sure we use the 44 group library!!!!
' -------------------------------------------------------
'       mixtures for fuel-pin unit cell
' fuel rods are mixed-oxide with uranium and plutonium.
'    delete light elements for geochemistry isotopics
'    structural components analyzed separately - P. Cloke
'
'     use 4.5 w/o enriched Pu
'   density derived from fuel mass/volume, Spread Sheet MOX_96_39-3_PathA
uo2   1 den=9.78794 1 901 92234 0.002 92235 0.2 92236 0.001
  92238 99.797 end
puo2  1 den=0.49187 1 901 94239 93.6 94240 5.9 94241 0.4
  94242 0.1 end
'  NO IFBA's used for MOX core
'  b-10   1 0 6.4584-5    901 end
'  zr     1 0 3.2292-5    901 end
'     the boron-10 coating is assumed mixed with the fuel
'
'       --------------------
'    some extra nuclides needed from library
zr-94   1 0 1-20     901 end
tc-99   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
xe-131  1 0 1-20     901 end
cs-133  1 0 1-20     901 end
cs-134  1 0 1-20     901 end
ce-144  1 0 1-20     901 end
pr-143  1 0 1-20     901 end
nd-143  1 0 1-20     901 end
nd-145  1 0 1-20     901 end
nd-147  1 0 1-20     901 end
pm-147  1 0 1-20     901 end
sm-149  1 0 1-20     901 end
sm-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
eu-155  1 0 1-20     901 end
u-232   1 0 1-20     901 end
u-233   1 0 1-20     901 end
u-237   1 0 1-20     901 end
np-238  1 0 1-20     901 end
pu-236  1 0 1-20     901 end
pu-237  1 0 1-20     901 end
pu-243  1 0 1-20     901 end
```

```
pu-244 1 0 1-20     901 end
am-242 1 0 1-20     901 end
cm-245 1 0 1-20     901 end
cm-246 1 0 1-20     901 end
cm-247 1 0 1-20     901 end
cm-248 1 0 1-20     901 end
bk-249 1 0 1-20     901 end
cf-249 1 0 1-20     901 end
cf-250 1 0 1-20     901 end
cf-251 1 0 1-20     901 end
cf-252 1 0 1-20     901 end
cf-253 1 0 1-20     901 end

' -----------------------------------------------------------------
'  nearly Zirc-2 - not a great effect although Zirc-4 has Cr & Fe
arbmzirc 6.44 4 0 0 1 40000 97.91 26000 0.5 50116 0.86 50120
  0.73 2 1 607 end
'    above is zircalloy specified as an arbitrary material
'    because it may not be in the library
' ---------------------------------------------------------
h2o    3 0.707      583 end
co-59  3 0 1-20     583 end
arbm-bormod 0.707 2 0 0 0 5010 39.99 5011 60.01 3 1301.0-6 583 end
'       above is 1301 ppm boron in moderator
'       (40% isotopically enriched in B-10)
'       94 Design cases used 750 ppm av. Boron
' ----------------------------------------------------------
'        mixtures for shipping cask (just one assembly here!)
'
n       4 0 1.0-20 end
n       5 0.00122 end
' ----------------------------------------------------------
'        mixtures for larger unit cell
'
'   arbm-alox 3.72 2 0 1 0 13027 2 8016 3 9 0.97952 end
'   b4c        9 0.041 end
end comp
' ----------------------------------------------------------
'        fuel-pin-cell geometry,
'        Clad ID from A00000000-01717-0200-00033 REV 00 (thickness)
'
'      pitch=1.25984 cm
'      pellet OD=0.78435 cm
'      clad OD=0.9144 cm
'      clad ID=0.8001 cm
'
'      squarepitch 1.25984 0.8202 1 3 0.95 2 0.8357 0 end
squarepitch 1.25984 0.78435 1 3 0.9144 2 0.8001 0 end
'
' ----------------------------------------------------------
'        assembly and cycle parameters
'
'   npin/assm=264 fuelngth=365.76 ncycles=12  nlib/cyc=1 lightel=22
npin/assm=264 fuelngth=365.76 ncycles=12  nlib/cyc=1 lightel=0
printlevel=4 inplevel=2 numzones=10  end
'
'   this assembly contains NO WABAs, (Full MOX core Cy 1 only)
'
3 0.5715 2 0.6121 3 0.7108 500 4.5513 3 4.9367 2 4.9755
```

```
 500 8.1972 2 8.244 3 8.6763 500 12.0834
'
'   discharge burnup is 39,300 MWd/MT
'
'
 power=14.0 burn=91.2 down=0  bfrac=0.861 end
 power=14.0 burn=91.8 down=0  bfrac=0.623 end
 power=14.0 burn=91.1 down=0  bfrac=0.442 end
 power=14.0 burn=92.0 down=0  bfrac=0.329 end
 power=14.0 burn=91.0 down=0  bfrac=0.179 end
 power=14.0 burn=35.9 down=108  bfrac=0.034 end
'
 power=19.75 burn=91.2 down=0  bfrac=0.861 end
 power=19.75 burn=91.8 down=0  bfrac=0.623 end
 power=19.75 burn=91.1 down=0  bfrac=0.442 end
 power=19.75 burn=92.0 down=0  bfrac=0.329 end
 power=19.75 burn=91.0 down=0  bfrac=0.179 end
 power=19.75 burn=35.9 down=1825  bfrac=0.034 end
'
' ----------------------------------------------------------
'       light elements
'   c 0.06  n 0.034  o 62.14  al 0.0457  s 0.00397
'   ti 0.0498  v 0.00227  cr 2.34  mn 0.109 fe 4.6 mo 0.1816
'   co 0.033  ni 4.402   cu 0.011 zr 111.178 cd 0.00003
'   sn 1.8168 hf 0.00886 w 0.00227 p 0.142 nb 0.328 si 0.0659
' ----------------------------------------------------------
'       shipping cask zone description
'
27n-18couple tempcask=325 numzones=2 detect=0 dryfuel=yes
4 12.0834 5 12.5
zone=1 fuelbnds=1
' ----------------------------------------------------------
szfcask=0.25 end
' ----------------------------------------------------------
end
=origens
0$$  a8 26 a11 71 e
1$$ 1  1t
 w 17x17 MOX
3$$ 21 0 1 e
2t
35$$ 0  t
'
56$$ 0 7 a13 -1 a15 3 0 4 e   5t
Part B W 17x17, 4.5wt%, 39.3 gwd/mtu decay
per W assembly
60**  0 1 90 365.25 730.5 1826.25  3652.5
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ 0 10 a10 7 a14 5 a17 4 e  57** 10  e  5t
60**  15 20 30 50 100 150 200 250 300 400
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ 0 10 a10 10 a14 5 a17 4 e  57** 400  e  5t
60**  500 1+3 2+3 4+3 6+3 8+3 1+4 1.2+4 1.4+4 1.5+4
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
```

```
'
56$$ 0 10 a10 10 a14 5 a17 4 e  57** 1.5+4  e  5t
60**  1.6+4 1.7+4 1.8+4 1.9+4 2.0+4 2.1+4 2.2+4 2.3+4 2.4+4 2.5+4
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ 0 10 a10 10 a14 5 a17 4 e  57** 2.5+4  e  5t
60**  3.5+4 4.5+4 5+4 5.5+4 6+4 6.5+4 7+4 1+5 2+5 2.5+5
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ 0 3 a10 10 a14 5 a17 4 e  57** 2.5+5  e  5t
60**  3+5 5+5 999999
65$$ a2 1 a4 1 a10 1 a23 1 0 1 a28 1 a31 1 a44 1 0 1 a49 1 a52 1 e
6t
'
56$$ f0  t
end
```

ATTACHMENT III.

This attachment contains the directory of output files from the SAS2H/ORIGEN-S calculations documented by this Engineering Calculation. These files were created on a HP Series 9000 workstation and transferred to a PC desktop computer. The first column lists the PC filename and the last column lists the corresponding HP workstation file name. The second column lists the HP workstation file sizes. The file sizes on the PC desktop computer differ from the HP workstation sizes due to the differences in the block sizes between the HP and personal computer. The tape containing Attachment III was written using the Colorado Model T1000e External parallel Port Backup System for personal computers. The files for this attachment are on a Colorado backup tape (Ref. 13). Input decks are echoed in the output files and not explicitly included on the backup tape.

Table III-1. PC DOS Directory of files on Colorado Backup Tape

DOS Filename	HP Workstation File size (bytes)	File Type	Case ID	HP Workstation file name
46-6G-TH.OUT	13,816,471	ASCII	2	w3_2cy_46-6gwd_avgB6stps.output
35-5G-CR.OUT	15,158,077	ASCII	4	W3_35-5gwd_2cy-6stps.output
35-5G-CH.OUT	14,584,545	ASCII	7	w3_35-5gwd_2cy-geochem.output
39-3G-CH.OUT	13,946,854	ASCII	8	w3_39-3gwd_2cy-geochem.output
39-3G-CR.OUT	14,510,210	ASCII	5	w3_39-3gwd_2cy-6stps.output
50-0G-CR.OUT	15,162,086	ASCII	6	w3_50-0gwd_crit-6stps.output
50-0G-TH.OUT	13,830,180	ASCII	3	w3_50-0gwd_2cy-90dabrn.output
56-6G-TH.OUT	19,167,514	ASCII	1	w3_56-6gwd_avgB6stps.output