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1. PURPOSE

The objective of this calculation is to establish an isotopic database to represent commercial spent nuclear fuel (CSNF) from pressurized water reactors (PWRs) in criticality analyses performed for the proposed Monitored Geologic Repository at Yucca Mountain, Nevada. Confirmation of the conservatism with respect to criticality in the isotopic concentration values represented by this isotopic database is performed as described in Section 3.5.3.1.2 of the *Disposal Criticality Analysis Methodology Topical Report* (YMP 2000). The isotopic database consists of the set of 14 actinides and 15 fission products presented in Section 3.5.2.1.1 of YMP 2000 for use in CSNF burnup credit. This set of 29 isotopes is referred to as the principal isotopes. The oxygen isotope from the UO_2 fuel is also included in the database.

The isotopic database covers enrichments of ^{235}U ranging from 1.5 to 5.5 weight percent (wt%) and burnups ranging from approximately zero to 75 GWd per metric ton of uranium (mtU). The choice of fuel assembly and operating history values used in generating the isotopic database are provided is Section 5. Tables of isotopic concentrations for the 29 principal isotopes (plus oxygen) as a function of enrichment and burnup are provided in Section 6.1. Results of the confirmation of the conservatism with respect to criticality in the isotopic concentration values are provided in Section 6.2.

This report is an engineering calculation supporting the burnup credit methodology of YMP 2000 and was performed under Administrative Procedure-3.12Q, Revision 2, Interim Change Notice 1. This calculation is subject to the Quality Assurance Requirements and Description (DOE 2003) per the activity evaluation under work package number ACRM01 in the technical work plan TWP-EBS-MD-000014 REV 01 (BSC 2003c).

2. METHOD

The burnup credit methodology for CSNF applications requires the use of isotopic concentrations that are bounding with respect to criticality. The isotopic concentrations are calculated using the SAS2H sequence of SCALE 4.4a with the 44-group, ENDF/B-V cross section library (CRWMS M&O 2000b, CRWMS M&O 2000c) and conservative input values for fuel assembly and operating history parameters. These concentrations are calculated as a function of initial fuel enrichment and fuel assembly burnup. The method to confirm the conservatism in the isotopic concentrations consists of using MCNP 4B2 (CRWMS M&O 1998b) to calculate effective neutron multiplication factor (k_{eff}) values based on measured radiochemical assay (RCA), best-estimate, and bounding isotopic concentration values. The best-estimate values are from fuel depletion calculations for the RCA samples that approximate the physical characteristics and depletion history of the sample based on the best information available.

The following two requirements are imposed in the *Disposal Criticality Analysis Methodology Topical Report* (YMP 2000, p. 3-43) to ensure that the isotopic concentrations used for burnup credit of CSNF are conservative with respect to criticality.

A. "Reactor operating histories and conditions must be selected together with burnup profiles such that the isotopic concentrations used to represent commercial SNF assemblies in waste package design shall produce values in k_{eff} that are conservative in comparison to any other expected combination of reactor history, conditions, or profiles."

B. "Bounding reactor parameters will be used to predict isotopic concentrations that, when used in criticality evaluations must produce values for k_{eff} that are conservative when compared to similar criticality evaluations using either measured radiochemical assay data or best-estimate isotopic concentrations."

For the first requirement, bounding operating histories and conditions are identified along with bounding burnup profiles from commercial reactor criticals (CRC) (Punatar 2001, CRWMS M&O 1998c, CRWMS M&O 1998d). These are the experiments used in establishing critical limit (CL) values for commercial PWR SNF (BSC 2003a, Attachment III). Each of the assemblies chosen for the confirmation of the conservatism in the isotopic database is selected to provide stringent tests for requirement A. The first test is based on previous poison rod history, which tends to maximize the concentrations of fissile isotopes. The second test is based on an unusual axial burnup profile indicative of an unusual operating history that could enhance flux redistribution, which would accentuate end effects. The axial burnup profiles are compared with the bounding axial profiles presented in NREG/CR-6801 (Wagner et al, 2003, pp. 20-26). Each of the chosen assemblies is tested individually. The confirmation consists of replacing the best-estimate isotopic concentrations for the chosen fuel assembly with values obtained from the isotopic database while keeping the best-estimate values for the remaining fuel assemblies. This process is repeated until all the chosen assemblies are tested. The k_{eff} value must always be greater when concentrations from the isotopic database are used for the chosen fuel assembly.

For requirement B, measured RCA data (isotopic concentrations) from a CSNF sample is used in an evaluation of waste package configurations to establish k_{eff} values for the waste package. A total of 74 RCA samples were analyzed and the results summarized in BSC (2002). A subset of 34 of these samples is analyzed in the calculations for this document using data from the isotopic database. The samples chosen for confirmation of the isotopic database were based on the results reported in BSC (2002) and were selected to provide a stringent test for requirement B. The 34 samples were from PWRs where waste package k_{eff} values using best-estimate isotopic concentrations were non-conservative relative to waste package k_{eff} values using measured RCA sample data (BSC 2002, pp. 89 – 91). These include the 22 samples from stainless steel clad fuel (Trino Vercelles and Yankee Rowe plants), which will produce a harder neutron spectrum and a higher fissile isotope content relative to zircaloy clad fuel (used in the database). Only 7 of the 22 samples were non-conservative, but all were analyzed to ensure that the stainless steel clad samples would be bounded by the isotopic database. In addition 9 samples from the Mihama plant, two samples from the Turkey Point plant, and one sample from the H.B. Robinson plant were chosen. The k_{eff} values for waste package calculations with concentrations from the isotopic database must always be greater than the k_{eff} values obtained when using either measured (RCA) isotopic concentration values or best-estimate values. Additional bias and uncertainty applied to CSNF CL values that are based on RCA data (i.e., Δk_I in equation 3-7 of YMP 2000) is accounted for in the confirmation of the isotopic database for requirement B. This means that k_{eff} values in waste package calculations using concentrations from the isotopic database will bound k_{eff} values based on either RCA measured data or best-estimate isotopic data. If the k_{eff} values based on the isotopic database are not bounding, a Δk_I value will be established to ensure that these concentrations will always be bounding relative to the established CL values.

3. ASSUMPTIONS

It is assumed that, for the depletion model, the Babcock & Wilcox 15x15 assembly type, Mark-B10, is conservative for all PWR spent fuel with respect to retained reactivity. The basis for this is that the Mark-B10 fuel assembly has a large initial fuel loading (DOE 1996, Table B5, pp.130 and 131; Wimmer 2001, Table 3-1, p. 3-2 and Table 4-1, p. 4-1 and 4-2). The largest fuel loading value in DOE (1996, Table B5) is 542 kgU/assembly. This fuel loading is for the South Texas Assembly Class (Assembly Type Code WST17W). The next largest fuel loading value is 464 kgU/assembly. This value is given for most of the B&W 15x15 Assembly Class (Assembly Type Code starts with the letter B) and the Westinghouse 17x17 Assembly Class (Assembly Type Code W17x17WVH and W17x17WVJ). The fuel loading per unit height of each of these three assembly classes and assembly types is essentially the same (the active fuel length for WST17W is approximately 14 feet, whereas the active fuel length for W17x17WVH, W17x17WVJ, and the B&W 15x15 Assembly Class is approximately 12 feet). It is seen from Table B5 that the South Texas fuel assemblies and Westinghouse 17x17 fuel assemblies contain 264 fuel rods, while the B&W 15x15 fuel assemblies contain 208 fuel rods. The fuel loading per fuel rod is larger for the B&W 15x15 fuel class. The total surface area of the fuel in the fuel rods (208 rods) for the B&W fuel assemblies is approximately 10% less than the surface area of the fuel in the fuel rods (264 rods) for the other assembly classes. This is based on the fuel pellet diameters presented in Table 3-1 of Punatar (2001), CRWMS M&O (1998c), and CRWMS M&O (1998c). The smaller surface area results in greater self-shielding and higher fissile isotope content with burnup. Thus, for any given fuel enrichment and burnup combination, the isotopic concentrations for the B&W 15x15 fuel class will be conservative with respect to all other fuel assembly classes.

Table 3-1 of Wimmer (2001) lists the Mark-B9 and Mark-B10 assemblies as having the largest fuel loading of the B&W 15x15 assembly types. From the data in Tables 3-1 and 4-1 of Wimmer (2001), it is determined that the kgU per unit height for these assemblies is larger than for the other Mark-B assemblies. These fuel assemblies were designed for two-year fuel cycles (the longest fuel cycle designs for the current inventory of fuel assemblies). Thus, the isotopic concentrations of the Mark-B10 (or Mark-B9) fuel assembly for any burnup/fuel enrichment pair will be conservative relative to other B&W fuel assembly types, as well as all other fuel assembly classes.

This assumption is used in Section 5.1.

4. USE OF COMPUTER SOFTWARE AND MODELS

4.1 SOFTWARE

4.1.1 SAS2H

The SAS2H control module of the baselined SCALE, Version 4.4a, modular code system (CRWMS M&O 2000b) was used to perform the fuel assembly depletion calculations required for generating the isotopic database for the PWR application model. The software specifications are as follows:

- Program Name: SAS2H of the SCALE Modular Code System
- Version/Revision Number: Version 4.4A, 10129-4.4A-00
- Status/Operating System: Qualified/HP-UX B.10.20
- Software Tracking Number (STN) Number: 10129-4.4A-00
- Computer Type: Hewlett Packard (HP) 9000 Series Workstations
- Computer processing unit number: Software is installed on the Framatome ANP workstation “gr1” whose CPU number is E 9000/785 2008515632 and “gr0” whose CPU number is E 9000/782 2002611431

The input and output files for the various SAS2H calculations are documented in Attachment 1 and 2. The SAS2H code sequence of SCALE that was used is: (a) appropriate for the application of commercial fuel assembly depletion, (b) used only within the range of validation as documented in CRWMS M&O (2000a and 2000c), and (c) obtained from Software Configuration Management in accordance with appropriate procedures.

4.1.2 MCNP

The baselined MCNP code (CRWMS M&O 1998b) is used to calculate the k_{eff} of the waste packages and CRCs for application model confirmation. The software specifications are as follow:

- Program Name: MCNP
- Version/Revision Number: Version 4B2LV
- Status/Operating System: Qualified/HP-UX B.10.20
- Computer Software Configuration Item Number: 30033 V4B2LV
- Computer Type: HP 9000 Series Workstations
- Computer processing unit number: Software is installed on the Framatome ANP workstation “gr1” whose CPU number is E 9000/785 2008515632 and “gr0” whose CPU number is E 9000/782 2002611431.

The input and output files for the various MCNP calculations are documented in Attachment 1 and 2. The MCNP software used is: (a) appropriate for the application of k_{eff} calculations, (b) used only within the range of validation as documented in CRWMS M&O (1998a) and Briesmeister (1997), and (c) obtained from Software Configuration Management in accordance with appropriate procedures.

5. CALCULATION

This section describes the calculations performed to create the isotopic database to represent CSNF from PWRs and to confirm the conservatism in the isotopic concentrations for use in criticality analyses with burnup credit. The basis for the choice of fuel assembly and operating history parameters that will produce isotopic concentrations that are conservative with respect to criticality is also presented.

5.1 SAS2H

5.1.1 Fuel Depletion Calculations

The isotopic database consists of a set of 14 actinides and 15 fission products that are known as the “Principal Isotopes,” plus the oxygen isotope from the UO_2 fuel. A listing of the principal isotope set is provided in Table 1.

Fuel depletion calculations to generate the isotopic database are performed using the SAS2H sequence of SCALE 4.4a with the 44-group, ENDF/B-V cross section library (CRWMS M&O 2000a). SAS2H is the control module for the analytical sequence that is used for calculating isotopic concentrations of CSNF. The functional modules (or codes) within the sequence are BONAMI, NITAWL-II, XSDRNPM, COUPLE, and ORIGEN-S. The isotopic concentrations are obtained from the ORIGEN-S SAS2H module. This module performs point depletion calculations for a fuel assembly or a section of a fuel assembly. ORIGEN-S uses cell-weighted cross-sections obtained from a one-dimensional (1-D) neutron transport calculation performed by the XSDRNPM module. The COUPLE module updates cross section constants included on an ORIGEN-S working nuclear data library with data from the cell-weighted cross section library obtained from the XSDRNPM calculation. The BONAMI and NITAWL-II SAS2H modules perform problem-dependent resonance weighting of cross sections. One-dimensional transport calculations are performed to obtain energy-dependent spatial neutron flux distributions that are used in calculating cell-weighted cross sections for both the SAS2H Path A and Path B models defined below.

Table 1. Principal Isotopes for Commercial SNF Burnup Credit

^{95}Mo	^{145}Nd	^{151}Eu	^{236}U	^{241}Pu
^{99}Tc	^{147}Sm	^{153}Eu	^{238}U	^{242}Pu
^{101}Ru	^{149}Sm	^{155}Gd	^{237}Np	^{241}Am
^{103}Rh	^{150}Sm	^{233}U	^{238}Pu	^{242m}Am
^{109}Ag	^{151}Sm	^{234}U	^{239}Pu	^{243}Am
^{143}Nd	^{152}Sm	^{235}U	^{240}Pu	

Source: YMP 2000, p. 3-34

The SAS2H Path A model represents a fuel pin cell from the assembly lattice. The fuel pellet, gap, and clad are modeled explicitly, and the water associated with the fuel pin cell is modeled in an annular ring surrounding the cladding. The square lattice of the fuel pin cell is represented in the 1-D transport calculation as an equivalent cylinder (i.e., conserving volumes of various materials). Flux-weighted cross sections (by energy group) are obtained for the fuel pin cell from the 1-D transport calculation. These cross sections are used in the homogenized fuel region of the path B model.

The SAS2H Path B model is used for performing best-estimate analyses of the 45 PWR statepoints to establish CL values for PWR CSNF (BSC 2003a). These analyses are documented in four engineering calculation reports (CRWMS M&O 1998f, CRWMS M&O 1998g, CRWMS M&O 1998h, and CRWMS M&O 1998i). The number of regions or zones for the Path B model discussed in the four calculation reports varies from 5 to 11 – ranging from an assembly with no burnable poison rods (BPRs) or control rods (CRs) to an assembly with annular burnable poison rods. The application model for the isotopic database uses an 8-region Path B model. As noted in Figure 1, the central cell comprises regions 1 through 6. Region 1 represents BPR material, and region 2 represents the gap between the poison material and the cladding in region 3. Region 4 contains the water between the cladding (region 3) and the guide tube in region 5. The remaining water in the BPR cell is represented by region 6.

The fuel pin cells in the assembly associated with the central cell (BPR) are presented in region 7 of the Path B model – the homogenized fuel region. As previously noted, flux-weighted cross sections from the Path A model calculation are used for region 7 in the Path B model. The water around the periphery of the fuel assembly (i.e., water in the channel between fuel assemblies) is presented in region 8.

The fuel depletion calculation for the isotopic database is based on conservative input values for fuel assembly and operating history parameters. The Babcock & Wilcox (B&W), Mark-B10 fuel assembly (Wimmer 2001) is the representative fuel assembly type chosen for the depletion calculations. The equations for the radii of the various regions are provided following Figure 1. The various Mark-B10 parameter values presented are based on data from Table 2-2 and Table 3-1, as well as data on page 2-49 of Wimmer (2001). The additional information including operating history parameter values is provided in Sections 5.1.1.1 through 5.1.1.7. The basis for the choice of conservative input values for fuel assembly and operating history parameters is also provided in these sections.

The radii for the Path B model presented in Figure 1 are provided in equations 1 through 8. The values for the radii are calculated using the parameter values presented in Table 2.

Table 2. Parameter Values Used for Calculating Radii for Path B Model

Parameter	Symbol	Parameter Value
Pin pitch (cm)	p_p	1.44272
Assembly pitch (cm)	p_a	21.811
Burnable poison rod (BPR) outer diameter (cm)	BPR_{OD}	0.8636
BPR clad inner diameter (cm)	C_{ID}	0.9144
BPR clad outer diameter (cm)	C_{OD}	1.0922
Guide tube inner diameter (cm)	GT_{ID}	1.2649
Guide tube outer diameter (cm)	GT_{OD}	1.3462
Number of BPR cells in fuel assembly	N_{bpr}	16
Number of fuel cells in fuel assembly	N_{fc}	208

Source: Wimmer (2001), Table 2-2, Table 3-1, p. 2-49

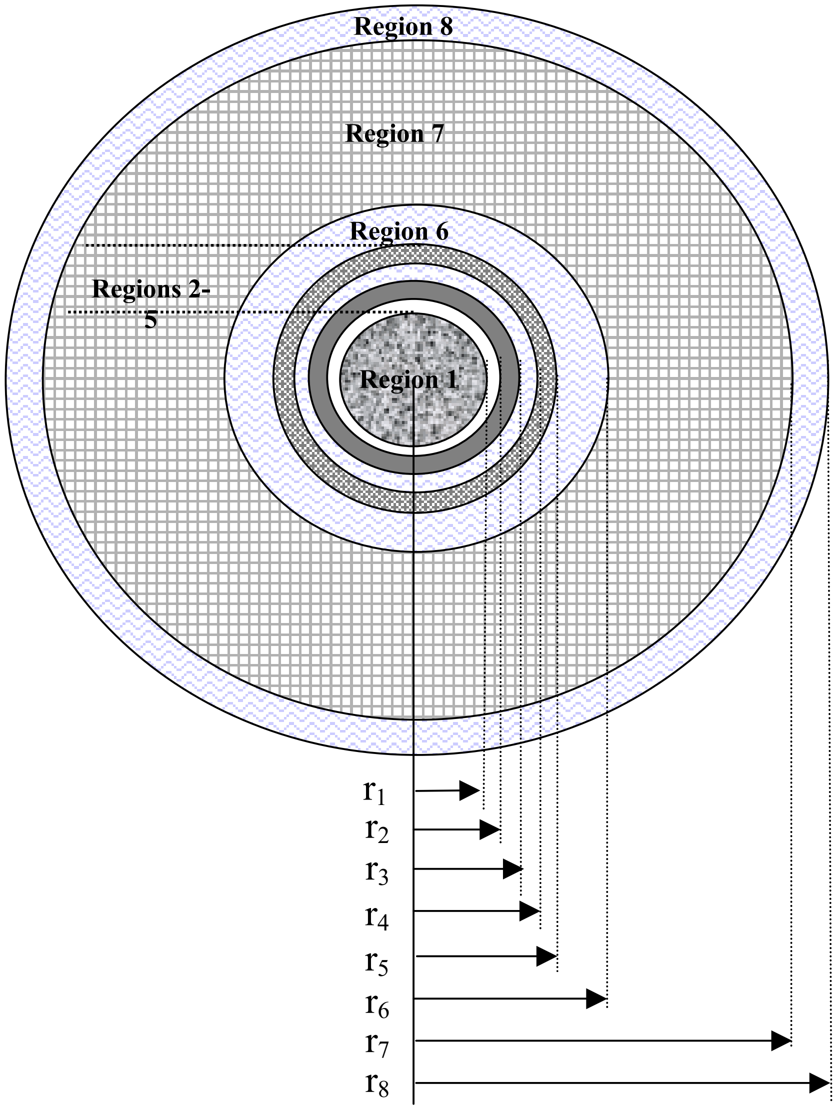

Figure 1. Path B Model with Central Cell Representing a Burnable Poison Rod

Region 1: BPR material
Region 2: Gap
Region 3: BPR cladding
Region 4: Water
Region 5: Guide tube (GT)
Region 6: Water
Region 7: Homogenized fuel region
Region 8: Water between assemblies

$r_1 = (BPR_{OD}) / 2 = 0.4318$ cm (Eq. 1)

$r_2 = (C_{ID}) / 2 = 0.4572$ cm (Eq. 2)

$r_3 = (C_{OD}) / 2 = 0.5461$ cm (Eq. 3)

$r_4 = (GT_{ID}) / 2 = 0.6325$ cm (Eq. 4)

$r_5 = (GT_{OD}) / 2 = 0.6731$ cm (Eq. 5)

Area of BPR or CR cells in fuel assembly = $(N_{bpr}) (p_p)^2 = (N_{bpr}) \pi (r_6)^2$

Area of central cell in Path B model (i.e., one BPR or CR cell) = $\pi (r_6)^2$

$r_6 = (p_p) / [\pi]^{1/2} = 0.8140$ cm (Eq. 6)

Area of homogenized fuel cells in assembly = $(N_{fc}) (p_p)^2 = (N_{fc}) \pi (r_6)^2$

Area of homogenized fuel cells in Path B model (i.e., per BPR or CR cell)

$= \pi (r_6)^2 (N_{fc} / N_{bpr})$

$\pi (r_7)^2 = \pi (r_6)^2 + \pi (r_6)^2 (N_{fc} / N_{bpr}) = \pi (r_6)^2 (1 + N_{fc} / N_{bpr})$,

$r_7 = r_6 [1 + N_{fc} / N_{bpr}]^{1/2} = 3.0456$ cm (Eq. 7)

Area of fuel assembly = $(p_a)^2$

Area of Path B model (i.e., fuel assembly area per BPR cell) = $(p_a)^2 / (N_{bpr})$

$\pi (r_8)^2 = (p_a)^2 / (N_{bpr})$

$r_8 = (p_a) / [(N_{bpr}) (\pi)]^{1/2} = 3.0764$ cm (Eq. 8)

The following fuel assembly and operating history values are used for the SAS2H fuel depletion calculations or are provided for information purposes. The justification for the choice of fuel assembly and operating history values is provided.

5.1.1.1 Assembly Type

The Mark-B10 fuel assembly was chosen as the representative fuel assembly because of its large initial fuel loading (DOE 1996, Table B5, pp.130 and 131; Wimmer 2001, Table 3-1, p. 3-2 and Table 4-1, p. 4-1 and 4-2).

The largest fuel loading value in DOE (1996, Table B5) is 542 kgU/assembly. This fuel loading is for the South Texas Assembly Class (Assembly Type Code WST17W). The next largest fuel loading value is 464 kgU/assembly. This value is given for most of the B&W 15x15 Assembly Class (Assembly Type Code starts with the letter B) and the Westinghouse 17x17 Assembly Class (Assembly Type Code W17x17WVH and W17x17WVJ). The fuel loading per unit height of each of these three assembly classes and assembly types is essentially the same (the active fuel length for WST17W is approximately 14 feet, whereas the active fuel length for W17x17WVH, W17x17WVJ, and the B&W 15x15 Assembly Class is approximately 12 feet). It is seen from Table B5 that the South Texas fuel assemblies and Westinghouse 17x17 fuel assemblies contain 264 fuel rods, while the B&W 15x15 fuel assemblies contain 208 fuel rods. The fuel loading per fuel rod is larger for the B&W 15x15 fuel class. The total surface area of the fuel in the fuel rods (208 rods) for the B&W fuel assemblies is approximately 10% less than the surface area of the fuel in the fuel rods (264 rods) for the other assembly classes. This is based on the fuel pellet diameters presented in Table 3-1 of Punatar (2001) and CRWMS M&O (1998c). The smaller surface area results in greater self-shielding and higher fissile isotope content with burnup. Thus, for any given fuel enrichment and burnup combination, the isotopic concentrations for the B&W 15x15 fuel class will be conservative with respect to all other fuel assembly classes.

Table 3-1 of Wimmer (2001) lists the Mark-B9 and Mark-B10 assemblies as having the largest fuel loading of the B&W 15x15 assembly types. From the data in Tables 3-1 and 4-1 of Wimmer (2001), it is determined that the kgU per unit height for these assemblies is larger than for the other Mark-B assemblies. These fuel assemblies were designed for two-year fuel cycles (the longest fuel cycle designs for the current inventory of fuel assemblies). Thus, the isotopic concentrations of the Mark-B10 (or Mark-B9) fuel assembly for any burnup/fuel enrichment pair will be conservative relative to other B&W fuel assembly types, as well as all other fuel assembly classes

5.1.1.2 Burnup and Fuel Enrichments

The burnup and fuel enrichment range covered by the isotopic database is presented in Table 3. The burnup values presented in Table 3 are assembly average values. The burnup range chosen for the isotopic database bounds the allowable burnup range for the commercial nuclear industry today. The allowable fuel rod average burnup is 62 GWd/mtU (FCF 2000, p. 2 of Enclosure 1). The value quoted in the reference is representative of the pressurized water reactor industry. The assembly average burnup value is less than the rod average value. Thus, considerable margin is provided in the isotopic database by including assembly average burnup values up to 75 GWd/mtU.

The current enrichment limit on commercial fuel plants is 5.0 wt% ^{235}U. The upper enrichment value of 5.5 wt% ^{235}U bounds the current inventory of commercial spent nuclear fuel.

Table 3. Selected Enrichments and Burnups for the Isotopic Database

Enrichment (^{235}U wt%)	Burnup (GWd/mtU)
1.5	0.001, 2.5, 5, 7.5, 10, 12.5,15, 17.5, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75
2.0	0.001, 2.5, 5, 7.5, 10, 12.5,15, 17.5, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75
2.5	0.001, 2.5, 5, 7.5, 10, 12.5,15, 17.5, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75
3.0	0.001, 2.5, 5, 7.5, 10, 12.5,15, 17.5, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75
3.5	0.001, 2.5, 5, 7.5, 10, 12.5,15, 17.5, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75
4.0	0.001, 2.5, 5, 7.5, 10, 12.5,15, 17.5, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75
4.5	0.001, 2.5, 5, 7.5, 10, 12.5,15, 17.5, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75
5.0	0.001, 2.5, 5, 7.5, 10, 12.5,15, 17.5, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75
5.5	0.001, 2.5, 5, 7.5, 10, 12.5,15, 17.5, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75

5.1.1.3 Fuel Temperature

A fuel temperature value of 1600 F (or 1144.1 K) was chosen as a bounding value for the fuel depletion calculations. The basis for this choice is the fuel temperature operating history data from Section 4 of the commercial reactor criticality data summary reports (Punatar 2001, Wimmer 2001, CRWMS M&O 1998c, and CRWMS M&O 1998d). The largest fuel temperature values that are observed in these reports are summarized in Table 4. A higher fuel temperature value results in more ^{239}Pu production and is therefore conservative with respect to criticality. The fuel temperatures presented in Table 4 for each fuel assembly are from the axial node that has the largest fuel temperature at the lowest burnup data point. The fuel temperature values presented at higher burnups for a given fuel assembly are from the same axial node. It is observed that the fuel temperatures that exceed the 1600 F value are for the lowest burnup value and at least two thirds of the operating history for these fuel assemblies is at fuel temperatures below 1600 F. Based on the fuel temperature operating history data from Punatar (2001), Wimmer (2001), CRWMS M&O (1998c), and CRWMS M&O (1998d), most fuel assemblies fuel temperature never exceeds 1600 F. Thus, a fuel temperature of 1600 F is bounding.

Table 4. Limiting Fuel Temperature Data for Pressurized Water Reactors

Assembly ID	Temperature of Fuel (F)	Temperature of Fuel (K)	Effective Full Power Days	Burnup (GWd/mtU)
D6	1721.1	1211.5	40.7	1.7
	1400.3	1033.3	253.0	10.8
	865.6	736.3	598.7	18.8
	1142.8	890.3	948.3	27.6
	1083.6	857.4	1095.9	32.8
D10	1756.4	1231.2	40.7	1.8
	1378.8	1021.4	253.0	11.0
	1148.8	893.6	598.7	24.2
D12	1799.5	1255.1	40.7	1.9
	1423.6	1046.3	253.0	11.5
	1026.2	825.5	598.7	23.0
D17	1777.0	1242.6	40.7	1.8
	1385.7	1025.2	253.0	11.1
	819.0	710.4	598.7	18.1
	732.5	662.3	948.3	22.8
	733.1	662.7	1095.9	24.3
D19a	1801.8	1256.4	40.7	1.8
	1406.9	1037.0	253.0	11.2
	1140.3	888.9	598.7	24.0
D23	1816.0	1264.3	40.7	1.9
	1426.3	1047.8	253.0	11.6
	1131.8	884.2	598.7	24.0
D27	1652.8	1173.6	40.7	1.6
	1326.7	992.4	253.0	9.8
	827.4	715.0	598.7	16.1
	1211.8	928.6	948.3	24.5
	1140.4	888.9	1095.9	30.0
J4	1709.5	1205.1	104.5	5.1
	1476.3	1075.5	304.1	14.6
	1303.5	979.5	504.9	23.6
	1275.1	963.8	583.4	27.0
	1237.2	942.7	642.3	29.4

Source: Punatar (2001), Table 3-2, Table 4-64, Table 4-65, Table 4-66, Table 4-68, Table 4-70, Table 4-71, Table 4-74, and Table 4-140

5.1.1.4 Moderator Temperature

A moderator temperature value of 600 F (or 588.7 K) was chosen as a bounding value for the fuel depletion calculations. The basis for this choice is operating history data from Section 4 of Punatar (2001), Wimmer (2001), CRWMS M&O (1998c), and CRWMS M&O (1998d). The moderator temperature values for each axial node is obtained from ASME (1993) based on system pressure data in Table 2-2 of Section 2 and moderator specific volume values from the operating history data in Section 4 of the criticality data summary reports. The density of the moderator at these conditions is 0.6905 g/cm^3. The 600 F moderator temperature value is approximately 20 degrees above the core average value. Eleven cycles of operating history data for Crystal River Unit 3 is presented in Punatar (2001). The largest nodal moderator temperature value observed for the eleven cycles is less than 620 F (assembly F17, Table 4-93 and assembly J4, Table 4-140). The fraction of total operating time that the moderator temperature in an assembly exceeds 600 F is small.

A larger moderator temperature usually results in more ^{239}Pu production and is therefore conservative with respect to criticality. However, the amount of conservatism is dependent upon the soluble boron concentration and the presence of burnable poison rods in the fuel assembly. The soluble boron concentration affects the trade off between thermalization of neutrons (moderating effect of the water) and the absorption (parasitic loss) of neutrons in the moderator. Burnable poison rods displace moderator in the fuel assembly, thus minimizing both moderator temperature (and density) effects and soluble boron effects.

5.1.1.5 Soluble Boron in Moderator

A soluble boron concentration value of 1000 ppmB was chosen as a bounding value for the fuel depletion calculations. The operating history data in Punatar (2001) represents 4441 effective full power days of operation. From the all-rods-out-critical-boron data Table 4-221 of this reference, it is observed that the soluble boron concentration is below 1000 ppmB for 3297 EFPD or 74.4 percent of the time. Similarly, the operating history data in Wimmer (2001) represents 4907 effective full power days of operation. From the all-rods-out-critical-boron data Table 4-147 of this reference, it is observed that the soluble boron concentration is below 1000 ppmB for 3804 EFPD or 77.5 percent of the time. A larger soluble boron concentration results in more ^{239}Pu production and is therefore conservative with respect to criticality. As noted in Section 5.1.1.4, the amount of conservatism is dependent upon the moderator temperature (and density) and the presence of burnable poison rods in the fuel assembly.

5.1.1.6 Burnable Poison Rods

The isotopic database generation includes burnable poison rods inserted in every guide tube location for all depletion calculations (i.e., depleted burnable poison rods are not removed from the guide tubes). Burnable poison rod insertion in every guide tube location for all depletion calculations results in maximizing the fissile isotope content (primarily ^{235}U and ^{239}Pu) for any burnup value and is therefore conservative with respect to criticality. The maximizing of the fissile isotope content is a direct result of the harder (faster) neutron spectrum caused by the extra neutron absorbing material (burnable poison material) in the fuel assembly and the moderator displaced by the rods. Burnable poison rods are generally inserted in fresh fuel and remain for one cycle of operation, where most of the absorber material in the rods is depleted. Although the absorber material is depleted and will have little effect on subsequent cycles of operation, the moderator displacement remains if the rods are not removed and will continue to harden the neutron spectrum and is therefore bounding with respect to criticality.

The burnable poison rod used in the B&W Mark-B10 fuel assembly is chosen for the depletion calculations. This rod is a solid rod with Al_2O_3-B_4C as the absorber material (Punatar 2001 and Wimmer 2001) and zircaloy-4 as the cladding material. The wet annular burnable absorber (CRWMS M&O 1998c and CRWMS M&O 1998d) also uses Al_2O_3-B_4C as the absorber material. Because this is an annular rod the overall conservatism with respect to criticality of this rod is less than the conservatism for the solid rod. The absorber material in the solid rod will deplete at a slower rate than for an annular rod (because of self-shielding). In addition, the annular rod displaces less moderator than the solid rod, thus the long term conservative effect of keeping the rods inserted for subsequent cycles is less for the annular rod. Similar arguments can be made for B_2O_3-SiO_2 (Pyrex) tubes being less conservative. Integral burnable absorbers (e.g., Gd_2O_3-UO_2) are less conservative with respect to criticality than removable burnable absorbers because they tend to deplete faster and do not have the moderator displacement effect.

The largest burnable poison loading presented in Table 3-4 of Punatar (2001) and Wimmer (2001) is 3.5 wt% B_4C. The burnable poison loading presented in Table 3-1 of CRWMS M&O (1998c) and CRWMS M&O (1998d) for the wet annular burnable absorber is 14.0 wt% B_4C. From Table 2, the diameter of the solid burnable poison rod is 0.8636 cm. From Table 3-1 of CRWMS M&O (1998c) and CRWMS M&O (1998d), the outer diameter of the wet annular burnable absorber rod is 0.8077 cm and the inner diameter is 0.7061 cm. The cross sectional area of the solid rod is 0.5858 cm^2 and the cross sectional area of the annular rod is 0.1208 cm^2. Thus, the amount of B_4C in the solid rod is equivalent to 21 % more B_4C (by weight) than in the annular rod. This loading, along with the extended operating history (i.e., inserted in every guide tube location for all depletion calculations) is bounding with respect to criticality.

5.1.1.7 Additional SAS2H Input

Additional parameter values used for the fuel depletion calculations are presented in Table 5. These include fuel pin information needed for the Path A model, as well as fuel assembly and power information for the depletion calculations.

The depletion time steps are divided into 50-day intervals with the final time step adjusted to accommodate the desired end-point burnup value. An 80-day (or less) depletion time step interval was recommended in BSC (2003b). However, the analysis performed in that report did not consider burnable poison rods, which are more limiting. The 50-day interval will accommodate the presence of burnable poison rods in the fuel assembly.

Table 5. Parameter Values Used for Fuel Depletion Calculations

Parameter	Symbol	Parameter Value
Active fuel height (cm)[a]	H_f	357.111
Fuel pellet diameter (cm)[a]	d_f	0.9398
Fuel clad inner diameter (cm)[a]	FC_{ID}	0.95758
Fuel clad outer diameter (cm)[a]	FC_{OD}	1.0922
Number of fuel assemblies in core[a]	N_{fa}	177
Core power (MWt)[b]	P_c	2568
UO_2 fuel density (g/cm^3)[c]	ρ_f	10.741

Notes:
[a] Wimmer (2001), Table 2-2
[b] Wimmer (2001), Table 3-2
[c] Lide (1994). Value given is 98% theoretical density

The power input for the depletion calculations (i.e., power per fuel assembly based on a relative power density of 1.0) is

$$\text{SAS2H Power} = P_{SAS2H} = P_c / N_{fc} = 14.51 \text{ MWt}$$

The mass of the uranium in the Mark-B10 fuel assembly (i.e., the assembly chosen for the isotopic database) is 463.66 KgU/assembly (Wimmer 2001, Table 3-1). However, this value was for 95% theoretical density and included a dish pellet factor. From the data in Table 2 and Table 5 the equivalent mass of uranium used for the depletion calculations is determined as follows:

$$\text{Fuel Volume of Assembly} = V_f = (\pi / 4)\, (d_f)^2\, (H_f)\, (N_{fc}) = 51,526.1 \text{ cm}^3$$

$$\text{Mass of } UO_2 \text{ in Assembly} = M_{UO2} = (\rho_f)\, (V_f)\, (1 \text{ Kg} / 1000 \text{ g}) = 553.44 \text{ Kg}$$

$$\text{Mass of U in Assembly} = M_U = (M_{UO2})\, (A_U / A_{UO2}) = 487.86 \text{ Kg}$$

where $A_U / A_{UO2} = 238.0289 / 270.0277 = 0.8815$

based on atomic mass values from Parrington et al. (1996). As previously discussed, the B&W Mark-B10 fuel assembly was chosen to be bounding respect to criticality based on fuel loading values reported in DOE (1996, Table B5) and additional information from Punatar (2001), Wimmer (2001), CRWMS M&O (1998c), and CRWMS M&O (1998d). Based on the density of UO_2 used for the depletion calculations (10.741 g/cm^3 – from Table 5) the equivalent fuel loading value (487.86 KgU) is over 5% greater than the values for the bounding Mark-B10 assembly. From the above calculations, the greater uranium loading is based on 98% theoretical density and no dish pellet factors. The larger fuel density value is conservative and chosen to bound future higher density fuel.

From the SAS2H power (power per fuel assembly) and the uranium loading, the equivalent specific power for the depletion calculations is

$$\text{Specific Power} = P_{SAS2H} / M_U = 14.51 \text{ MWt} / (487.86 \text{ KgU x 1 mt} / 1000 \text{ kg}) = 29.74 \text{ MWt} / \text{mtU}$$

This specific power is based on a relative power density value of 1.0.

5.1.2 Material Specifications for SAS2H

The selected ^{235}U enrichment and burnup value combinations are presented in Table 3. The SAS2H input values for isotopes ^{234}U, ^{236}U, and ^{238}U are calculated from the initial ^{235}U enrichment based on the following equations (BSC 2002).

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

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

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

The material used for the fuel pin cladding and guide tube is Zircaloy-4. The Zircaloy-4 specifications are provided in Table 6 and were used in the SAS2H calculations.

Table 6. Composition and Density of Zircaloy-4

Composition ID	Element	Wt%
8016	O	0.125
24000	Cr	0.100
26000	Fe	0.210
40000	Zr	98.115
50000	Sn	1.450
Density = 6.56 g/cm^3		

Source: BSC 2002, Table 2

The burnable absorber material consists of B_4C in Al_2O_3. As noted earlier, the weight percent of B_4C is taken as 3.5 wt% (based on the highest value used to date in a B&W fuel assembly) and is bounding with respect to criticality. Table 7 provides the SAS2H input data calculated for the burnable poison material.

Table 7. Composition and Density of Burnable Poison

Isotope / Element	(A) Number of Atoms	(B) Atomic Weight	(C) Percent Abundance*	(A)*(B)*(C)	Normalized to 1.0	wt% B_4C	wt%
Boron-10	4	10.0129	0.198	7.9302	0.1435	3.5	0.5023
Boron-11	4	11.0093	0.802	35.3178	0.6391	3.5	2.2370
Carbon	1	12.011	1.000	12.0110	0.2174	3.5	0.7608
				55.2590	1.0000		
Isotope / Element	**(A) Number of Atoms**	**(B) Atomic Weight**	**(C) Percent Abundance**	**(A)*(B)*(C)**	**Normalized to 1.0**	**wt% Al2O3**	**wt%**
Aluminum	2	26.9815	1.000	53.9630	0.5293	96.5	51.0727
Oxygen	3	15.9994	1.000	47.9982	0.4707	96.5	45.4273
				101.9612	1.0000		
Density = 3.7 $g.cm^3$							

Source: Wimmer 2001, p.2-49 and Parrington et. al. 1996
* Natural variation in boron from 19.1% ^{10}B to 20.3% has been measured (Parrington et. al. 1996, p.7). A value of 19.8% was used for these analyses.

5.2 MCNP

The MCNP code (CRWMS M&O 1998a, CRWMS M&O 1998b) is a general-purpose Monte Carlo N-Particle code that can be used for neutron transport and has the capability to calculate k_{eff} for systems containing fissionable material. The MCNP code is used in criticality calculations to confirm the conservatism in the isotopic database.

To confirm the bounding nature of the isotopic database, isotopic concentrations generated by the database are compared to RCA data, CRC data and nominal assembly data taken from BSC (2003b), section 7.5. The MCNP calculations performed in confirming the conservatism in the isotopic database versus the RCA data and CRC data are discussed in the following two sections. Section 7 of BSC (2003b) discussed the comparison to a nominal depletion assembly.

5.2.1 RCA k_{eff} Calculations

The RCA data (isotopic concentrations) from CSNF samples are used in waste package calculations to establish k_{eff} values for the waste package. The RCA data previously evaluated in a 21 PWR waste package (BSC 2002) are not re-evaluated in this calculation. Of the 74 RCA samples analyzed in BSC (2002), a subset of 34 samples is analyzed in the calculations for this document. The samples analyzed for this document are summarized in Table 8. Those samples that are not bounding in the BSC (2002) calculations (Tables 69 – 75, pp.90 and 91 and Figure 24 on p. 96) based on SAS2H best-estimate isotopic concentrations are chosen for evaluation here. This includes sample 1 of Trino Vercelles, samples 1 – 6 of Yankee Rowe, samples 3 and 4 of Turkey Point, samples 1 – 9 of Mihama, and sample 3 of H.B. Robinson. In addition to the non-bounding cases from Figure 24 of BSC (2002), the remaining samples from Trino Vercelles (samples 2 – 14) and Yankee Rowe (samples 7 and 8) are evaluated to assess the affects of stainless steel cladding versus the bounding isotopic concentrations generated in the isotopic database. Table 8 contains a list of the RCA samples evaluated. The table includes the samples initial enrichment values and estimated burnup values.

BSC (2002) evaluated the RCA data by placing the sample data in all nodes of all assemblies within a 21 PWR WP. The resulting k_{eff} values are recorded in BSC (2002 pp. 89 – 91). These values are reported in Section 6 of the current document along with the k_{eff} values calculated using the isotopic database. The isotopic database concentrations replace the RCA sample data in the fuel material cards in the MCNP input files. Also, the material density was increased from 9.886 g/cm^3 to 10.741 g/cm^3 because this is the density used in the SAS2H calculations for the isotopic database.

Because the isotopic database reports concentrations for all the principal isotopes, but the RCA samples included only a subset of those, the material definition using the isotopic database concentrations included only those isotopes that were included in the RCA sample being evaluated. In some cases, the RCA sample data includes isotopes not included in the principal isotope set. In those cases, the RCA data are used for the missing isotopes in both sets of analyses.

Table 8. RCA Samples Used for Isotopic Database Comparisons

Reactor	Sample Name	MCNP Input File Name (Sample Identifier)	Initial Enrichment (wt% ^{235}U)	Burnup (GWd/mtU)
Trino Vercelles	509-104 (M11)	tvs1	3.897	12.042
	509-032(E11)	tvs2	3.130	15.377
	509-032(E11)	tvs3	3.130	15.898
	509-032(E11)	tvs4	3.130	11.529
	509-069(E11)	tvs5	3.130	12.859
	509-069(E11)	tvs6	3.130	20.602
	509-069(E11)	tvs7	3.130	23.718
	509-069(E11)	tvs8	3.130	24.304
	509-069(E5)	tvs9	3.130	23.867
	509-069(E5)	tvs10	3.130	24.548
	509-069(L11)	tvs11	3.130	23.928
	509-069(L11)	tvs12	3.130	24.362
	509-069(L5)	tvs13	3.130	24.330
	509-069(L5)	tvs14	3.130	24.313
Yankee Rowe	E6-C-f6 (220.22)	yrs1	3.400	15.950
	E6-C-f6 (138.94)	yrs2	3.400	30.390
	E6-C-f6 (57.66)	yrs3	3.400	31.330
	E6-C-f6 (17.02)	yrs4	3.400	20.190
	E6-SE-c2 (138.94)	yrs5	3.400	32.030
	E6-SE-c2 (57.66)	yrs6	3.400	31.410
	E6-SE-e4 (138.94)	yrs7	3.400	35.970
	E6-SE-e4 (57.66)	yrs8	3.400	35.260
Turkey Point	D01 (H09)	tps3	2.556	31.560
	D04 (G09)	tps4	2.556	31.260
Mihama	86b02	ms1	3.208	8.300
	86b03	ms2	3.208	6.920
	86g03	ms3	3.203	21.290
	86g05	ms4	3.203	15.360
	86g07	ms5	3.203	14.660
	87c03	ms6	3.210	29.500
	87c04	ms7	3.210	32.200
	87c07	ms8	3.210	33.710
	87c08	ms9	3.210	34.320
HB Robinson	N-9C-J	hbrs3	2.561	28.470

5.2.2 CRC Calculations

For the CRC calculations, the documentation for all of the PWR CRC statepoints presented in CRWMS M&O 1998e was reviewed to identify the expected limiting (with respect to criticality) assemblies for the evaluated statepoints. The most limiting assemblies were selected based on the control rod insertion history and burnable absorber rod history. Assemblies with past control rod or burnable absorber rod history will have a higher fissile isotope content than assemblies with equivalent burnup but no past control rod or absorber rod history. The information regarding control rod and burnable absorber rod history is found in Table 3-4 in the following references: CRWMS M&O 1998c, CRWMS M&O 1998d, and Punatar 2001. Enrichment and burnup were also taken into consideration. This process identified twelve assemblies for consideration in these confirmation calculations. The "most limiting assemblies" are listed in Table 9.

Table 9. Most Limiting Fuel Assemblies for CRC Confirmation

Reactor	Assembly	Control Rod History	Burnable Absorber	Initial Enrichment (wt% ^{235}U)	Burnup[a] (GWD/MtU)
Sequoyah, Unit-2	A06[b]	CD Inserted	20 Pyrex	2.60	30.509
Sequoyah, Unit-2	B19[b]	None	12 WABA[g]	3.50	23.179
Sequoyah, Unit-2	C04[b]	None	24 WABA[g]	3.60	9.703
McGuire, Unit 1	B25b[c]	CD Inserted	4 Pyrex	3.204	22.051
McGuire, Unit 1	E02[d]	None	4 WABA[g]	2.92	23.080
McGuire, Unit 1	E14a[c]	CD Inserted	8 WABA[g]	3.40	32.723
McGuire, Unit 1	G02[c]	None	16 WABA[g]	3.75	14.321
Crystal River, Unit 3	A07[e]	CR-6 & CR-7 Inserted	None	2.83	27.913
Crystal River, Unit 3	A26[e]	CR-7 & CR-8 Inserted	None	1.93	11.857
Crystal River, Unit 3	O01[e]	CR-6 & CR-7 Inserted	None	2.00	13.403
Crystal River, Unit 3	I12a[f]	CR-7 Inserted	2.0 wt% B_4C	3.84	44.079
Crystal River, Unit 3	I23[f]	CR-8 Inserted	2.1 wt% B_4C	3.84	42.548

Notes:

[a] Average Burnup
[b] Westinghouse 17x17 Standard Fuel Assembly (STD)
[c] Westinghouse 17x17 Optimized Fuel Assembly (OFA)
[d] Framatome Cogema Fuels Mark-BW Fuel Assembly (MKBW)
[e] Framatome Cogema Fuels Mark-B3 Fuel Assembly
[f] Framatome Cogema Fuels Mark-B9 Fuel Assembly
[g] WABA - Wet Annular Burnable Absorber

The reactor-specific data are taken from the applicable references as noted in Table 10.

Table 10. Reactor-specific Data for the Most Limiting Fuel Assemblies

Reactor	Reference	Cycle	Loading Pattern	Assembly	Axial Burnup Profile
Sequoyah Unit 2	CRWMS M&O 1998d	3	p. 31	A06	p. 37
				B19	p. 51
				C04	p. 55
McGuire Unit 1	CRWMS M&O 1998c	6	p. 53	B25b	p. 60
		7	p. 54	E02	p. 71
				E14a	p. 77
				G02	p. 94
Crystal River Unit 3	Punatar 2001	1B	p. 3-20	A26	p. 4-27
				O01	p. 4-31
		3	p. 3-22	A07	p. 4-8
		10	p. 3-29	I12a	p. 4-186
				I23	p. 4-192

The average burnup values listed in Table 9 were calculated based on the reactor-specific data using the following equation:

$$Average\ Burnup = \frac{\sum (Node\ Height)\ (Node\ Burnup)}{\sum (Node\ Height)}$$

The relative axial burnup profiles for the twelve assemblies considered here (Table 9) are shown in Figures 2 and 3. Figure 2 contains the assemblies modeled with 16 axial nodes in MCNP. These include the Sequoyah and McGuire assemblies. Figure 3 shows the relative axial burnup profiles for the 18-node Crystal River assemblies. The figures demonstrate that the selected assemblies exhibit extreme "end-effect" burnup profiles (sharp burnup gradients at the end of the assemblies), and in the case of the Crystal River assemblies some non-standard axial profile shapes are observed. Wagner et al. (2003, p. 42) report that of the 12 bounding profiles (for burnup groups 1 through 12) presented, 11 of these profiles are from B&W 15 x 15 plants. The explanation offered in this report (p. 42, item 1 of Section 4.2.3) for the number of bounding profiles from the B&W plants is the use of control rods for routine reactor control and the use of axial power shaping rods (part length rods). An example cited for control rods suppressing the burnup near the top that leads to a more reactive axial profile is assembly O01 for Crystal River Unit 3, which is analyzed in this report (Table 9, Table 10, and Figure 3).

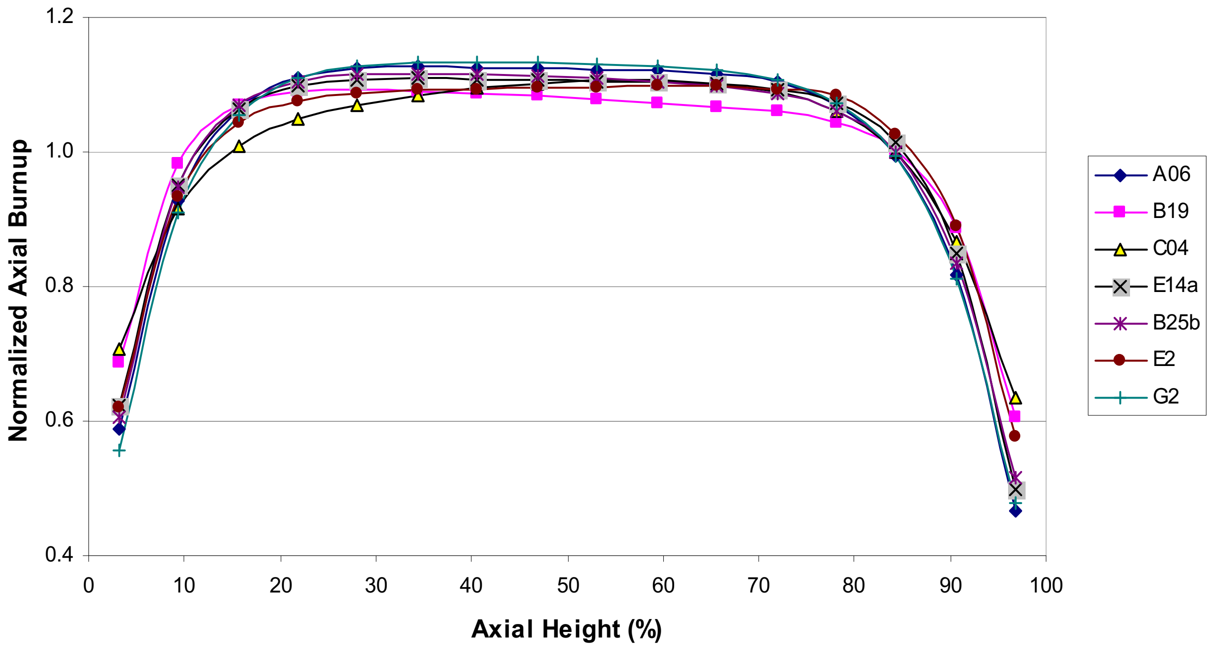

Figure 2. Axial Burnup Profiles for the Sequoyah and McGuire Assemblies (16-node)

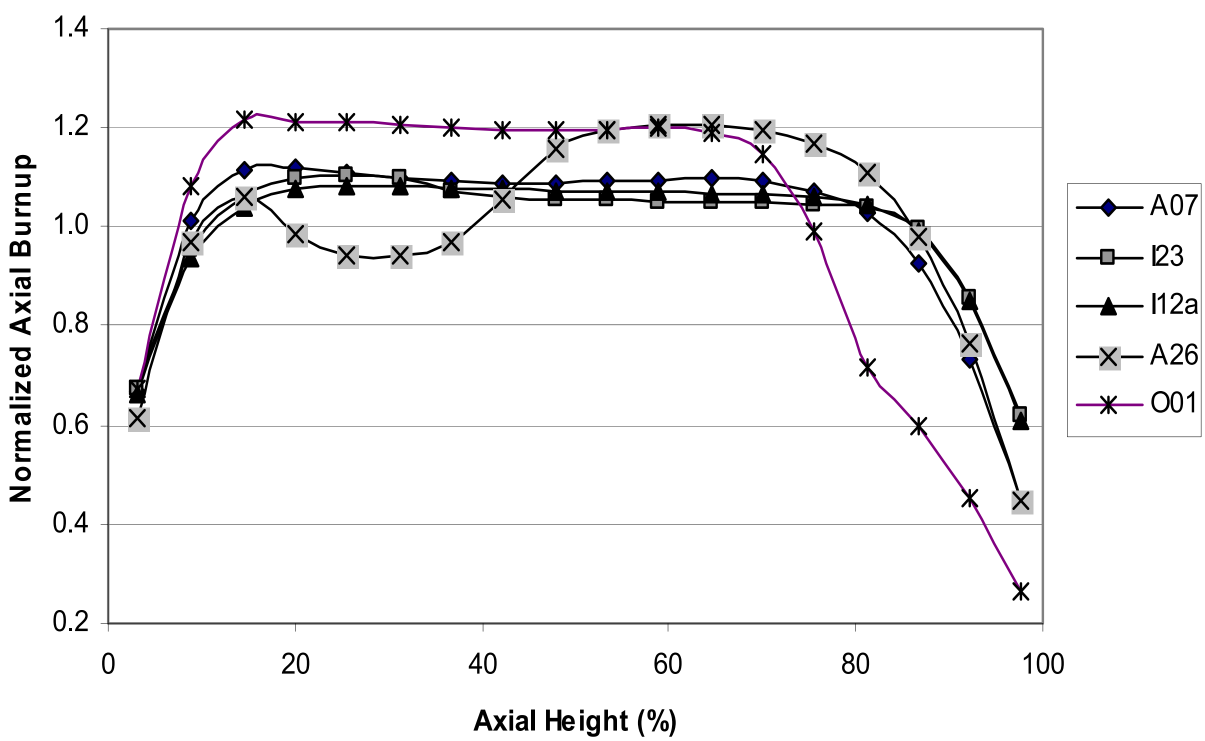

Figure 3. Axial Burnup Profiles for the Crystal River Assemblies (18-node)

Assembly O01 from Crystal River Unit 3 is the assembly represented in Figure 15 of Wagner et al. (2003, p.25). This assembly is referred to as the bounding profile for burnup group 9. The burnup range for burnup group 9 is from 14 to 18 GWd/mtU. The axial burnup profile for this assembly is presented in Figure 4. The data labeled CR3 O01 is taken from Punatar (2001, p.4-31) and is for 411 effective-full-power-days in cycle 1B of Crystal River. This particular assembly had previously operated for one cycle in Oconee Unit 1 with control rods inserted approximately 25-percent for the entire cycle. This assembly was then inserted in cycle 1B of Crystal River Unit 3 and operated with control rods inserted between 80 and 85-percent.

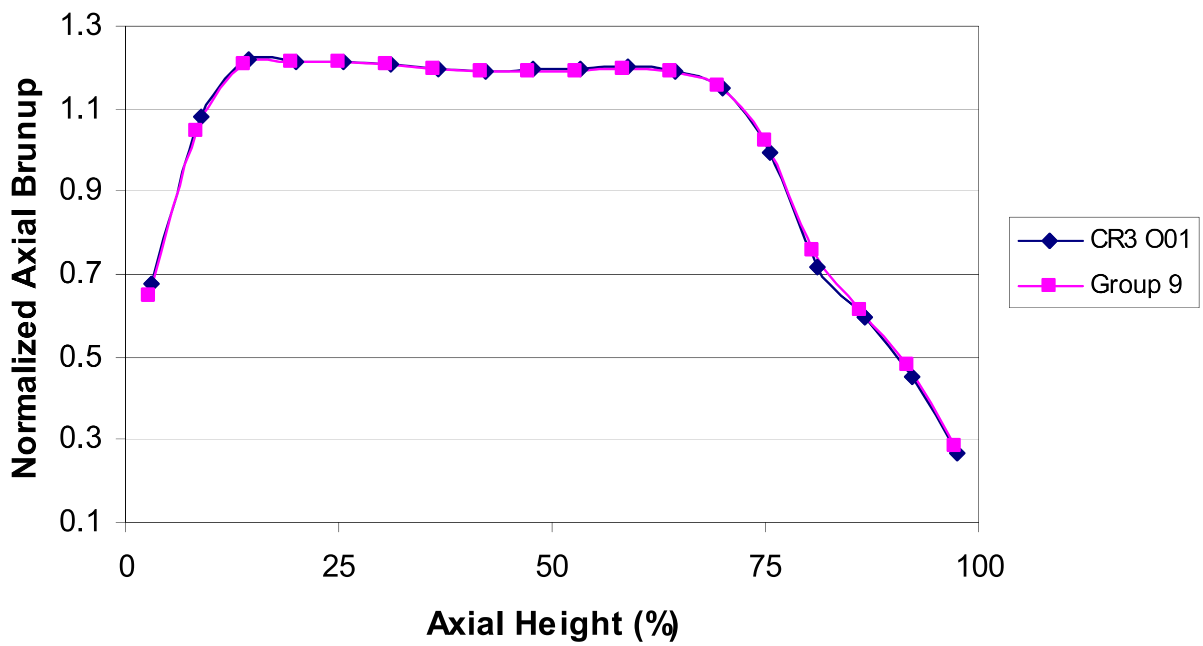

Figure 4. Axial Burnup Profile for the Crystal River Assembly O01

6. RESULTS

6.1 SAS2H RESULTS

The resulting isotopics calculated by SAS2H are presented in Tables 11 through 19. Each table is based on a single enrichment and includes all selected burnup steps from 0.001 to 75 GWd/mtU. The outputs (isotopic concentrations) are reasonable compared to the inputs and the results are suitable for the intended use. Confirmation is provided in Section 6.2 of this report.

Table 11. Isotopics as a Function of Enrichment (1.5 wt%) and Burnup

Isotope	Isotopic Concentrations (atoms/barn – cm)							
	GWd/mtU 0.001	GWd/mtU 2.5	GWd/mtU 5	GWd/mtU 7.5	GWd/mtU 10	GWd/mtU 12.5	GWd/mtU 15	GWd/mtU 17.5
^{16}O	4.79E-02	4.78E-02	4.78E-02	4.77E-02	4.76E-02	4.75E-02	4.74E-02	4.73E-02
^{95}Mo	1.44E-09	3.86E-06	7.50E-06	1.10E-05	1.43E-05	1.75E-05	2.07E-05	2.37E-05
^{99}Tc	1.38E-09	3.87E-06	7.63E-06	1.13E-05	1.48E-05	1.83E-05	2.17E-05	2.50E-05
^{101}Ru	1.17E-09	3.30E-06	6.64E-06	9.99E-06	1.34E-05	1.67E-05	2.00E-05	2.34E-05
^{103}Rh	8.44E-10	2.35E-06	4.93E-06	7.55E-06	1.01E-05	1.26E-05	1.50E-05	1.73E-05
^{109}Ag	1.60E-11	1.71E-07	5.20E-07	9.67E-07	1.47E-06	2.01E-06	2.57E-06	3.14E-06
^{143}Nd	1.31E-09	3.41E-06	6.42E-06	9.13E-06	1.16E-05	1.38E-05	1.59E-05	1.77E-05
^{145}Nd	8.91E-10	2.34E-06	4.52E-06	6.58E-06	8.55E-06	1.04E-05	1.22E-05	1.40E-05
^{147}Sm	3.90E-10	9.76E-07	1.80E-06	2.52E-06	3.14E-06	3.70E-06	4.20E-06	4.64E-06
^{149}Sm	2.53E-10	7.64E-08	9.06E-08	1.01E-07	1.08E-07	1.14E-07	1.19E-07	1.23E-07
^{150}Sm	7.83E-15	6.67E-07	1.48E-06	2.36E-06	3.28E-06	4.21E-06	5.16E-06	6.10E-06
^{151}Sm	9.99E-11	1.28E-07	1.74E-07	2.07E-07	2.38E-07	2.64E-07	2.89E-07	3.15E-07
^{152}Sm	6.62E-11	3.68E-07	8.36E-07	1.31E-06	1.76E-06	2.19E-06	2.61E-06	3.00E-06
^{151}Eu	3.92E-12	5.09E-09	6.95E-09	8.32E-09	9.56E-09	1.06E-08	1.16E-08	1.27E-08
^{153}Eu	4.21E-11	1.56E-07	3.96E-07	7.02E-07	1.06E-06	1.45E-06	1.88E-06	2.32E-06
^{155}Gd	5.15E-12	7.26E-09	1.25E-08	1.90E-08	2.69E-08	3.64E-08	4.71E-08	5.90E-08
^{233}U	2.05E-15	5.44E-12	1.01E-11	1.42E-11	1.77E-11	2.07E-11	2.33E-11	2.56E-11
^{234}U	2.92E-06	2.73E-06	2.57E-06	2.42E-06	2.29E-06	2.16E-06	2.05E-06	1.95E-06
^{235}U	3.64E-04	3.05E-04	2.59E-04	2.21E-04	1.90E-04	1.64E-04	1.41E-04	1.22E-04
^{236}U	1.70E-06	1.22E-05	2.01E-05	2.65E-05	3.16E-05	3.57E-05	3.91E-05	4.18E-05
^{238}U	2.36E-02	2.35E-02	2.35E-02	2.34E-02	2.33E-02	2.33E-02	2.32E-02	2.31E-02
^{237}Np	1.15E-10	4.50E-07	1.06E-06	1.76E-06	2.50E-06	3.27E-06	4.04E-06	4.80E-06
^{238}Pu	2.24E-18	1.58E-08	7.67E-08	1.91E-07	3.62E-07	5.91E-07	8.78E-07	1.22E-06
^{239}Pu	2.24E-08	5.03E-05	8.25E-05	1.04E-04	1.20E-04	1.31E-04	1.39E-04	1.46E-04
^{240}Pu	8.37E-14	3.34E-06	9.49E-06	1.62E-05	2.28E-05	2.92E-05	3.51E-05	4.06E-05
^{241}Pu	4.07E-19	5.32E-07	2.57E-06	5.53E-06	8.79E-06	1.21E-05	1.52E-05	1.81E-05
^{242}Pu	4.29E-24	2.20E-08	2.19E-07	7.21E-07	1.56E-06	2.73E-06	4.17E-06	5.85E-06
^{241}Am	1.11E-19	1.47E-07	7.19E-07	1.57E-06	2.53E-06	3.52E-06	4.49E-06	5.41E-06
^{242m}Am	9.89E-31	1.41E-11	2.22E-10	8.89E-10	2.12E-09	3.87E-09	6.05E-09	8.55E-09
^{243}Am	2.21E-29	4.58E-10	9.52E-09	4.84E-08	1.42E-07	3.10E-07	5.68E-07	9.26E-07

Table 11. Isotopics as a Function of Enrichment (1.5 wt%) and Burnup (Continued)

Isotope	Isotopic Concentrations (atoms/barn – cm)							
	GWd/mtU 20	GWd/mtU 25	GWd/mtU 30	GWd/mtU 35	GWd/mtU 40	GWd/mtU 45	GWd/mtU 50	GWd/mtU 55
^{16}O	4.72E-02	4.71E-02	4.69E-02	4.67E-02	4.65E-02	4.63E-02	4.61E-02	4.59E-02
^{95}Mo	2.66E-05	3.22E-05	3.76E-05	4.27E-05	4.77E-05	5.24E-05	5.70E-05	6.15E-05
^{99}Tc	2.82E-05	3.44E-05	4.02E-05	4.58E-05	5.11E-05	5.61E-05	6.09E-05	6.55E-05
^{101}Ru	2.67E-05	3.32E-05	3.97E-05	4.60E-05	5.22E-05	5.84E-05	6.44E-05	7.03E-05
^{103}Rh	1.94E-05	2.34E-05	2.69E-05	2.99E-05	3.27E-05	3.50E-05	3.72E-05	3.90E-05
^{109}Ag	3.71E-06	4.84E-06	5.94E-06	6.98E-06	7.98E-06	8.92E-06	9.81E-06	1.07E-05
^{143}Nd	1.95E-05	2.25E-05	2.51E-05	2.74E-05	2.94E-05	3.11E-05	3.27E-05	3.42E-05
^{145}Nd	1.57E-05	1.89E-05	2.19E-05	2.47E-05	2.73E-05	2.99E-05	3.23E-05	3.46E-05
^{147}Sm	5.04E-06	5.71E-06	6.26E-06	6.71E-06	7.08E-06	7.40E-06	7.67E-06	7.91E-06
^{149}Sm	1.27E-07	1.34E-07	1.39E-07	1.43E-07	1.46E-07	1.49E-07	1.52E-07	1.55E-07
^{150}Sm	7.04E-06	8.88E-06	1.07E-05	1.23E-05	1.40E-05	1.55E-05	1.69E-05	1.82E-05
^{151}Sm	3.39E-07	3.88E-07	4.35E-07	4.81E-07	5.25E-07	5.67E-07	6.08E-07	6.45E-07
^{152}Sm	3.38E-06	4.06E-06	4.68E-06	5.24E-06	5.75E-06	6.21E-06	6.64E-06	7.03E-06
^{151}Eu	1.36E-08	1.56E-08	1.75E-08	1.94E-08	2.12E-08	2.28E-08	2.45E-08	2.60E-08
^{153}Eu	2.77E-06	3.69E-06	4.60E-06	5.47E-06	6.29E-06	7.05E-06	7.75E-06	8.41E-06
^{155}Gd	7.18E-08	9.93E-08	1.28E-07	1.58E-07	1.86E-07	2.14E-07	2.40E-07	2.64E-07
^{233}U	2.77E-11	3.12E-11	3.40E-11	3.62E-11	3.80E-11	3.94E-11	4.07E-11	4.17E-11
^{234}U	1.86E-06	1.70E-06	1.58E-06	1.47E-06	1.39E-06	1.33E-06	1.29E-06	1.26E-06
^{235}U	1.05E-04	7.84E-05	5.87E-05	4.42E-05	3.34E-05	2.54E-05	1.93E-05	1.48E-05
^{236}U	4.40E-05	4.70E-05	4.86E-05	4.92E-05	4.91E-05	4.85E-05	4.75E-05	4.63E-05
^{238}U	2.31E-02	2.29E-02	2.28E-02	2.27E-02	2.25E-02	2.24E-02	2.23E-02	2.22E-02
^{237}Np	5.55E-06	6.99E-06	8.29E-06	9.44E-06	1.04E-05	1.12E-05	1.19E-05	1.25E-05
^{238}Pu	1.62E-06	2.54E-06	3.61E-06	4.76E-06	5.95E-06	7.14E-06	8.30E-06	9.41E-06
^{239}Pu	1.51E-04	1.59E-04	1.65E-04	1.70E-04	1.74E-04	1.77E-04	1.80E-04	1.83E-04
^{240}Pu	4.55E-05	5.41E-05	6.12E-05	6.71E-05	7.20E-05	7.62E-05	7.99E-05	8.31E-05
^{241}Pu	2.08E-05	2.55E-05	2.94E-05	3.25E-05	3.51E-05	3.72E-05	3.90E-05	4.05E-05
^{242}Pu	7.71E-06	1.18E-05	1.63E-05	2.08E-05	2.52E-05	2.95E-05	3.37E-05	3.76E-05
^{241}Am	6.28E-06	7.83E-06	9.14E-06	1.02E-05	1.11E-05	1.19E-05	1.26E-05	1.31E-05
^{242m}Am	1.13E-08	1.70E-08	2.26E-08	2.79E-08	3.28E-08	3.72E-08	4.12E-08	4.47E-08
^{243}Am	1.39E-06	2.60E-06	4.15E-06	5.96E-06	7.92E-06	9.97E-06	1.21E-05	1.41E-05

Table 11. Isotopics as a Function of Enrichment (1.5 wt%) and Burnup (Continued)

Isotope	Isotopic Concentrations (atoms/barn – cm)			
	GWd/mtU 60	GWd/mtU 65	GWd/mtU 70	GWd/mtU 75
^{16}O	4.57E-02	4.55E-02	4.53E-02	4.51E-02
^{95}Mo	6.58E-05	7.01E-05	7.42E-05	7.82E-05
^{99}Tc	6.99E-05	7.42E-05	7.82E-05	8.21E-05
^{101}Ru	7.61E-05	8.18E-05	8.74E-05	9.29E-05
^{103}Rh	4.07E-05	4.22E-05	4.35E-05	4.46E-05
^{109}Ag	1.15E-05	1.22E-05	1.29E-05	1.36E-05
^{143}Nd	3.55E-05	3.67E-05	3.78E-05	3.88E-05
^{145}Nd	3.68E-05	3.89E-05	4.09E-05	4.28E-05
^{147}Sm	8.11E-06	8.30E-06	8.46E-06	8.60E-06
^{149}Sm	1.57E-07	1.60E-07	1.62E-07	1.64E-07
^{150}Sm	1.95E-05	2.07E-05	2.19E-05	2.29E-05
^{151}Sm	6.83E-07	7.19E-07	7.52E-07	7.85E-07
^{152}Sm	7.40E-06	7.74E-06	8.06E-06	8.36E-06
^{151}Eu	2.75E-08	2.90E-08	3.03E-08	3.17E-08
^{153}Eu	9.01E-06	9.56E-06	1.01E-05	1.05E-05
^{155}Gd	2.87E-07	3.09E-07	3.29E-07	3.47E-07
^{233}U	4.25E-11	4.33E-11	4.39E-11	4.45E-11
^{234}U	1.23E-06	1.22E-06	1.21E-06	1.20E-06
^{235}U	1.14E-05	8.83E-06	6.87E-06	5.38E-06
^{236}U	4.50E-05	4.35E-05	4.20E-05	4.05E-05
^{238}U	2.20E-02	2.19E-02	2.18E-02	2.16E-02
^{237}Np	1.29E-05	1.32E-05	1.34E-05	1.35E-05
^{238}Pu	1.04E-05	1.14E-05	1.23E-05	1.31E-05
^{239}Pu	1.85E-04	1.87E-04	1.89E-04	1.91E-04
^{240}Pu	8.59E-05	8.85E-05	9.08E-05	9.29E-05
^{241}Pu	4.17E-05	4.29E-05	4.38E-05	4.47E-05
^{242}Pu	4.13E-05	4.47E-05	4.80E-05	5.10E-05
^{241}Am	1.36E-05	1.40E-05	1.44E-05	1.47E-05
^{242m}Am	4.79E-08	5.08E-08	5.34E-08	5.58E-08
^{243}Am	1.61E-05	1.81E-05	1.99E-05	2.17E-05

Table 12. Isotopics as a Function of Enrichment (2.0 wt%) and Burnup

Isotope	Isotopic Concentrations (atoms/barn – cm)							
	GWd/mtU 0.001	GWd/mtU 2.5	GWd/mtU 5	GWd/mtU 7.5	GWd/mtU 10	GWd/mtU 12.5	GWd/mtU 15	GWd/mtU 17.5
^{16}O	4.79E-02	4.78E-02	4.78E-02	4.77^{E}-02	4.76E-02	4.75E-02	4.74E-02	4.73E-02
^{95}Mo	1.45E-09	3.93E-06	7.68E-06	1.13E-05	1.48E-05	1.81E-05	2.14E-05	2.45E-05
^{99}Tc	1.39E-09	3.90E-06	7.70E-06	1.14E-05	1.50E-05	1.85E-05	2.19E-05	2.53E-05
^{101}Ru	1.17E-09	3.29E-06	6.62E-06	9.95E-06	1.33E-05	1.66E-05	1.99E-05	2.33E-05
^{103}Rh	8.39E-10	2.27E-06	4.71E-06	7.19E-06	9.64E-06	1.20E-05	1.43E-05	1.66E-05
^{109}Ag	1.53E-11	1.32E-07	4.07E-07	7.73E-07	1.20E-06	1.66E-06	2.16E-06	2.68E-06
^{143}Nd	1.32E-09	3.50E-06	6.66E-06	9.54E-06	1.22E-05	1.46E-05	1.69E-05	1.89E-05
^{145}Nd	8.95E-10	2.39E-06	4.63E-06	6.76E-06	8.80E-06	1.08E-05	1.27E-05	1.45E-05
^{147}Sm	3.91E-10	9.93E-07	1.85E-06	2.60E-06	3.27E-06	3.87E-06	4.40E-06	4.88E-06
^{149}Sm	2.53E-10	8.66E-08	1.00E-07	1.11E-07	1.18E-07	1.24E-07	1.29E-07	1.33E-07
^{150}Sm	7.58E-15	6.49E-07	1.45E-06	2.31E-06	3.20E-06	4.12E-06	5.05E-06	5.99E-06
^{151}Sm	9.93E-11	1.46E-07	1.99E-07	2.35E-07	2.67E-07	2.94E-07	3.18E-07	3.43E-07
^{152}Sm	6.59E-11	3.38E-07	7.82E-07	1.23E-06	1.67E-06	2.10E-06	2.51E-06	2.90E-06
^{151}Eu	3.90E-12	5.81E-09	8.01E-09	9.48E-09	1.08E-08	1.18E-08	1.28E-08	1.39E-08
^{153}Eu	4.16E-11	1.46E-07	3.61E-07	6.38E-07	9.64E-07	1.33E-06	1.72E-06	2.14E-06
^{155}Gd	5.02E-12	7.16E-09	1.18E-08	1.73E-08	2.41E-08	3.24E-08	4.20E-08	5.28E-08
^{233}U	2.39E-15	6.49E-12	1.23E-11	1.74E-11	2.19E-11	2.59E-11	2.94E-11	3.25E-11
^{234}U	3.90E-06	3.68E-06	3.49E-06	3.31E-06	3.14E-06	2.99E-06	2.84E-06	2.71E-06
^{235}U	4.85E-04	4.22E-04	3.69E-04	3.25E-04	2.86E-04	2.51E-04	2.21E-04	1.94E-04
^{236}U	2.18E-06	1.37E-05	2.31E-05	3.09E-05	3.75E-05	4.31E-05	4.79E-05	5.19E-05
^{238}U	2.35E-02	2.34E-02	2.34E-02	2.33E-02	2.32E-02	2.32E-02	2.31E-02	2.31E-02
^{237}Np	1.07E-10	4.25E-07	1.03E-06	1.75E-06	2.54E-06	3.37E-06	4.23E-06	5.10E-06
^{238}Pu	1.70E-18	1.26E-08	6.38E-08	1.64E-07	3.18E-07	5.31E-07	8.04E-07	1.14E-06
^{239}Pu	1.90E-08	4.52E-05	7.68E-05	9.98E-05	1.17E-04	1.30E-04	1.40E-04	1.47E-04
^{240}Pu	6.09E-14	2.50E-06	7.51E-06	1.33E-05	1.92E-05	2.51E-05	3.08E-05	3.62E-05
^{241}Pu	2.54E-19	3.58E-07	1.90E-06	4.36E-06	7.29E-06	1.04E-05	1.34E-05	1.64E-05
^{242}Pu	2.08E-24	1.17E-08	1.29E-07	4.58E-07	1.05E-06	1.91E-06	3.02E-06	4.37E-06
^{241}Am	6.90E-20	9.87E-08	5.31E-07	1.24E-06	2.10E-06	3.02E-06	3.96E-06	4.89E-06
^{242m}Am	5.00E-31	8.32E-12	1.50E-10	6.60E-10	1.69E-09	3.26E-09	5.31E-09	7.75E-09
^{243}Am	9.37E-30	2.14E-10	4.95E-09	2.72E-08	8.48E-08	1.95E-07	3.73E-07	6.31E-07

Table 12. Isotopics as a Function of Enrichment (2.0 wt%) and Burnup (Continued)

Isotope	Isotopic Concentrations (atoms/barn – cm)							
	GWd/mtU 20	GWd/mtU 25	GWd/mtU 30	GWd/mtU 35	GWd/mtU 40	GWd/mtU 45	GWd/mtU 50	GWd/mtU 55
^{16}O	4.72E-02	4.71E-02	4.69E-02	4.67E-02	4.65E-02	4.63E-02	4.61E-02	4.59E-02
^{95}Mo	2.76E-05	3.35E-05	3.90E-05	4.43E-05	4.94E-05	5.43E-05	5.89E-05	6.35E-05
^{99}Tc	2.86E-05	3.49E-05	4.08E-05	4.65E-05	5.19E-05	5.70E-05	6.19E-05	6.66E-05
^{101}Ru	2.66E-05	3.31E-05	3.95E-05	4.59E-05	5.21E-05	5.82E-05	6.43E-05	7.02E-05
^{103}Rh	1.87E-05	2.27E-05	2.63E-05	2.94E-05	3.22E-05	3.47E-05	3.69E-05	3.89E-05
^{109}Ag	3.20E-06	4.27E-06	5.34E-06	6.38E-06	7.38E-06	8.34E-06	9.26E-06	1.01E-05
^{143}Nd	2.08E-05	2.42E-05	2.70E-05	2.95E-05	3.16E-05	3.34E-05	3.49E-05	3.63E-05
^{145}Nd	1.62E-05	1.96E-05	2.27E-05	2.56E-05	2.83E-05	3.09E-05	3.33E-05	3.57E-05
^{147}Sm	5.31E-06	6.04E-06	6.63E-06	7.10E-06	7.49E-06	7.80E-06	8.06E-06	8.28E-06
^{149}Sm	1.36E-07	1.42E-07	1.46E-07	1.49E-07	1.52E-07	1.54E-07	1.57E-07	1.59E-07
^{150}Sm	6.92E-06	8.77E-06	1.06E-05	1.23E-05	1.39E-05	1.55E-05	1.69E-05	1.83E-05
^{151}Sm	3.67E-07	4.14E-07	4.58E-07	5.02E-07	5.45E-07	5.85E-07	6.25E-07	6.61E-07
^{152}Sm	3.28E-06	3.97E-06	4.60E-06	5.17E-06	5.69E-06	6.17E-06	6.61E-06	7.02E-06
^{151}Eu	1.48E-08	1.67E-08	1.85E-08	2.03E-08	2.20E-08	2.36E-08	2.52E-08	2.67E-08
^{153}Eu	2.58E-06	3.47E-06	4.37E-06	5.25E-06	6.09E-06	6.88E-06	7.61E-06	8.29E-06
^{155}Gd	6.47E-08	9.08E-08	1.19E-07	1.48E-07	1.77E-07	2.06E-07	2.33E-07	2.59E-07
^{233}U	3.52E-11	3.99E-11	4.36E-11	4.65E-11	4.89E-11	5.08E-11	5.23E-11	5.35E-11
^{234}U	2.59E-06	2.37E-06	2.19E-06	2.04E-06	1.91E-06	1.81E-06	1.73E-06	1.67E-06
^{235}U	1.71E-04	1.32E-04	1.02E-04	7.81E-05	6.01E-05	4.62E-05	3.57E-05	2.76E-05
^{236}U	5.53E-05	6.04E-05	6.37E-05	6.55E-05	6.63E-05	6.62E-05	6.55E-05	6.44E-05
^{238}U	2.30E-02	2.29E-02	2.28E-02	2.26E-02	2.25E-02	2.24E-02	2.22E-02	2.21E-02
^{237}Np	5.97E-06	7.68E-06	9.29E-06	1.08E-05	1.21E-05	1.32E-05	1.42E-05	1.49E-05
^{238}Pu	1.53E-06	2.48E-06	3.61E-06	4.88E-06	6.24E-06	7.63E-06	9.01E-06	1.04E-05
^{239}Pu	1.53E-04	1.62E-04	1.69E-04	1.73E-04	1.77E-04	1.80E-04	1.83E-04	1.86E-04
^{240}Pu	4.12E-05	5.02E-05	5.79E-05	6.44E-05	6.99E-05	7.45E-05	7.85E-05	8.20E-05
^{241}Pu	1.91E-05	2.41E-05	2.83E-05	3.18E-05	3.46E-05	3.70E-05	3.89E-05	4.06E-05
^{242}Pu	5.92E-06	9.50E-06	1.35E-05	1.78E-05	2.21E-05	2.64E-05	3.06E-05	3.46E-05
^{241}Am	5.78E-06	7.41E-06	8.83E-06	1.00E-05	1.10E-05	1.19E-05	1.26E-05	1.32E-05
^{242m}Am	1.05E-08	1.64E-08	2.25E-08	2.83E-08	3.36E-08	3.83E-08	4.25E-08	4.62E-08
^{243}Am	9.75E-07	1.93E-06	3.23E-06	4.81E-06	6.61E-06	8.55E-06	1.06E-05	1.26E-05

Table 12. Isotopics as a Function of Enrichment (2.0 wt%) and Burnup (Continued)

Isotope	Isotopic Concentrations (atoms/barn – cm)			
	GWd/mtU 60	GWd/mtU 65	GWd/mtU 70	GWd/mtU 75
^{16}O	4.57E-02	4.55E-02	4.53E-02	4.51E-02
^{95}Mo	6.78E-05	7.21E-05	7.62E-05	8.02E-05
^{99}Tc	7.10E-05	7.53E-05	7.93E-05	8.32E-05
^{101}Ru	7.60E-05	8.17E-05	8.73E-05	9.28E-05
^{103}Rh	4.06E-05	4.21E-05	4.35E-05	4.47E-05
^{109}Ag	1.10E-05	1.18E-05	1.25E-05	1.32E-05
^{143}Nd	3.76E-05	3.87E-05	3.97E-05	4.06E-05
^{145}Nd	3.79E-05	4.00E-05	4.20E-05	4.39E-05
^{147}Sm	8.46E-06	8.62E-06	8.76E-06	8.88E-06
^{149}Sm	1.61E-07	1.63E-07	1.65E-07	1.67E-07
^{150}Sm	1.96E-05	2.08E-05	2.20E-05	2.31E-05
^{151}Sm	6.98E-07	7.34E-07	7.66E-07	7.99E-07
^{152}Sm	7.39E-06	7.74E-06	8.06E-06	8.37E-06
^{151}Eu	2.82E-08	2.96E-08	3.09E-08	3.23E-08
^{153}Eu	8.91E-06	9.49E-06	1.00E-05	1.05E-05
^{155}Gd	2.83E-07	3.05E-07	3.26E-07	3.46E-07
^{233}U	5.46E-11	5.55E-11	5.62E-11	5.69E-11
^{234}U	1.62E-06	1.59E-06	1.56E-06	1.54E-06
^{235}U	2.14E-05	1.66E-05	1.30E-05	1.01E-05
^{236}U	6.29E-05	6.12E-05	5.94E-05	5.75E-05
^{238}U	2.20E-02	2.19E-02	2.17E-02	2.16E-02
^{237}Np	1.56E-05	1.61E-05	1.64E-05	1.67E-05
^{238}Pu	1.16E-05	1.28E-05	1.39E-05	1.50E-05
^{239}Pu	1.88E-04	1.90E-04	1.92E-04	1.93E-04
^{240}Pu	8.51E-05	8.78E-05	9.03E-05	9.25E-05
^{241}Pu	4.20E-05	4.31E-05	4.42E-05	4.51E-05
^{242}Pu	3.84E-05	4.21E-05	4.55E-05	4.87E-05
^{241}Am	1.37E-05	1.42E-05	1.45E-05	1.49E-05
^{242m}Am	4.95E-08	5.25E-08	5.51E-08	5.75E-08
^{243}Am	1.46E-05	1.66E-05	1.85E-05	2.03E-05

Table 13. Isotopics as a Function of Enrichment (2.5 wt%) and Burnup

Isotope	Isotopic Concentrations (atoms/barn – cm)							
	GWd/mtU 0.001	GWd/mtU 2.5	GWd/mtU 5	GWd/mtU 7.5	GWd/mtU 10	GWd/mtU 12.5	GWd/mtU 15	GWd/mtU 17.5
^{16}O	4.79E-02	4.78E-02	4.78E-02	4.77E-02	4.76E-02	4.75E-02	4.74E-02	4.73E-02
^{95}Mo	1.46E-09	3.97E-06	7.79E-06	1.15E-05	1.51E-05	1.85E-05	2.19E-05	2.51E-05
^{99}Tc	1.39E-09	3.92E-06	7.74E-06	1.15E-05	1.51E-05	1.87E-05	2.21E-05	2.56E-05
^{101}Ru	1.18E-09	3.29E-06	6.61E-06	9.93E-06	1.33E-05	1.66E-05	1.99E-05	2.32E-05
^{103}Rh	8.36E-10	2.22E-06	4.57E-06	6.95E-06	9.31E-06	1.16E-05	1.39E-05	1.61E-05
^{109}Ag	1.49E-11	1.09E-07	3.35E-07	6.42E-07	1.01E-06	1.41E-06	1.85E-06	2.32E-06
^{143}Nd	1.33E-09	3.55E-06	6.82E-06	9.83E-06	1.26E-05	1.52E-05	1.77E-05	1.99E-05
^{145}Nd	8.98E-10	2.41E-06	4.70E-06	6.89E-06	8.99E-06	1.10E-05	1.30E-05	1.49E-05
^{147}Sm	3.91E-10	1.00E-06	1.89E-06	2.67E-06	3.37E-06	4.00E-06	4.57E-06	5.09E-06
^{149}Sm	2.53E-10	9.77E-08	1.11E-07	1.22E-07	1.29E-07	1.35E-07	1.40E-07	1.43E-07
^{150}Sm	7.42E-15	6.34E-07	1.42E-06	2.26E-06	3.14E-06	4.04E-06	4.96E-06	5.89E-06
^{151}Sm	9.90E-11	1.61E-07	2.25E-07	2.66E-07	2.99E-07	3.27E-07	3.52E-07	3.77E-07
^{152}Sm	6.56E-11	3.15E-07	7.38E-07	1.18E-06	1.60E-06	2.02E-06	2.42E-06	2.81E-06
^{151}Eu	3.89E-12	6.43E-09	9.07E-09	1.07E-08	1.21E-08	1.32E-08	1.43E-08	1.53E-08
^{153}Eu	4.14E-11	1.40E-07	3.38E-07	5.93E-07	8.94E-07	1.23E-06	1.60E-06	2.00E-06
^{155}Gd	4.94E-12	7.20E-09	1.14E-08	1.62E-08	2.22E-08	2.95E-08	3.81E-08	4.79E-08
^{233}U	2.83E-15	7.75E-12	1.48E-11	2.11E-11	2.68E-11	3.18E-11	3.63E-11	4.03E-11
^{234}U	5.12E-06	4.87E-06	4.64E-06	4.42E-06	4.21E-06	4.02E-06	3.85E-06	3.68E-06
^{235}U	6.06E-04	5.40E-04	4.83E-04	4.33E-04	3.88E-04	3.47E-04	3.11E-04	2.78E-04
^{236}U	2.90E-06	1.51E-05	2.56E-05	3.46E-05	4.24E-05	4.93E-05	5.53E-05	6.06E-05
^{238}U	2.33E-02	2.33E-02	2.32E-02	2.32E-02	2.31E-02	2.31E-02	2.30E-02	2.30E-02
^{237}Np	1.03E-10	4.13E-07	1.01E-06	1.74E-06	2.55E-06	3.43E-06	4.35E-06	5.29E-06
^{238}Pu	1.43E-18	1.08E-08	5.56E-08	1.45E-07	2.85E-07	4.83E-07	7.40E-07	1.06E-06
^{239}Pu	1.68E-08	4.14E-05	7.22E-05	9.58E-05	1.14E-04	1.28E-04	1.39E-04	1.48E-04
^{240}Pu	4.85E-14	1.99E-06	6.18E-06	1.12E-05	1.65E-05	2.19E-05	2.72E-05	3.24E-05
^{241}Pu	1.80E-19	2.61E-07	1.47E-06	3.54E-06	6.14E-06	9.00E-06	1.19E-05	1.48E-05
^{242}Pu	1.21E-24	7.08E-09	8.30E-08	3.10E-07	7.37E-07	1.39E-06	2.26E-06	3.34E-06
^{241}Am	4.90E-20	7.18E-08	4.12E-07	1.00E-06	1.76E-06	2.62E-06	3.52E-06	4.42E-06
^{242m}Am	3.02E-31	5.43E-12	1.07E-10	5.07E-10	1.37E-09	2.77E-09	4.68E-09	7.04E-09
^{243}Am	4.95E-30	1.17E-10	2.88E-09	1.67E-08	5.44E-08	1.30E-07	2.56E-07	4.45E-07

Table 13. Isotopics as a Function of Enrichment (2.5 wt%) and Burnup (Continued)

Isotope	Isotopic Concentrations (atoms/barn – cm)							
	GWd/mtU 20	GWd/mtU 25	GWd/mtU 30	GWd/mtU 35	GWd/mtU 40	GWd/mtU 45	GWd/mtU 50	GWd/mtU 55
^{16}O	4.72E-02	4.71E-02	4.69E-02	4.67E-02	4.65E-02	4.63E-02	4.61E-02	4.59E-02
^{95}Mo	2.83E-05	3.44E-05	4.02E-05	4.57E-05	5.09E-05	5.60E-05	6.08E-05	6.54E-05
^{99}Tc	2.89E-05	3.53E-05	4.14E-05	4.72E-05	5.27E-05	5.79E-05	6.29E-05	6.76E-05
^{101}Ru	2.65E-05	3.30E-05	3.94E-05	4.58E-05	5.20E-05	5.81E-05	6.42E-05	7.01E-05
^{103}Rh	1.82E-05	2.21E-05	2.58E-05	2.90E-05	3.19E-05	3.45E-05	3.68E-05	3.88E-05
^{109}Ag	2.80E-06	3.79E-06	4.81E-06	5.82E-06	6.82E-06	7.78E-06	8.71E-06	9.61E-06
^{143}Nd	2.20E-05	2.57E-05	2.88E-05	3.15E-05	3.38E-05	3.57E-05	3.74E-05	3.88E-05
^{145}Nd	1.67E-05	2.01E-05	2.34E-05	2.64E-05	2.92E-05	3.19E-05	3.44E-05	3.67E-05
^{147}Sm	5.55E-06	6.35E-06	6.99E-06	7.50E-06	7.91E-06	8.24E-06	8.50E-06	8.70E-06
^{149}Sm	1.46E-07	1.51E-07	1.55E-07	1.57E-07	1.59E-07	1.61E-07	1.63E-07	1.64E-07
^{150}Sm	6.82E-06	8.66E-06	1.05E-05	1.22E-05	1.39E-05	1.54E-05	1.69E-05	1.83E-05
^{151}Sm	4.00E-07	4.45E-07	4.88E-07	5.30E-07	5.71E-07	6.09E-07	6.48E-07	6.83E-07
^{152}Sm	3.19E-06	3.88E-06	4.52E-06	5.11E-06	5.64E-06	6.13E-06	6.58E-06	7.00E-06
^{151}Eu	1.62E-08	1.80E-08	1.97E-08	2.14E-08	2.31E-08	2.46E-08	2.62E-08	2.76E-08
^{153}Eu	2.41E-06	3.28E-06	4.16E-06	5.04E-06	5.89E-06	6.69E-06	7.45E-06	8.16E-06
^{155}Gd	5.88E-08	8.33E-08	1.11E-07	1.39E-07	1.69E-07	1.98E-07	2.26E-07	2.53E-07
^{233}U	4.39E-11	4.99E-11	5.46E-11	5.84E-11	6.14E-11	6.37E-11	6.55E-11	6.70E-11
^{234}U	3.52E-06	3.24E-06	2.99E-06	2.77E-06	2.59E-06	2.44E-06	2.31E-06	2.21E-06
^{235}U	2.48E-04	1.98E-04	1.56E-04	1.23E-04	9.67E-05	7.58E-05	5.93E-05	4.64E-05
^{236}U	6.51E-05	7.24E-05	7.75E-05	8.10E-05	8.30E-05	8.38E-05	8.38E-05	8.30E-05
^{238}U	2.29E-02	2.28E-02	2.27E-02	2.26E-02	2.24E-02	2.23E-02	2.22E-02	2.21E-02
^{237}Np	6.24E-06	8.16E-06	1.00E-05	1.18E-05	1.34E-05	1.48E-05	1.61E-05	1.71E-05
^{238}Pu	1.44E-06	2.38E-06	3.54E-06	4.88E-06	6.34E-06	7.89E-06	9.47E-06	1.10E-05
^{239}Pu	1.55E-04	1.65E-04	1.72E-04	1.78E-04	1.82E-04	1.85E-04	1.87E-04	1.89E-04
^{240}Pu	3.74E-05	4.65E-05	5.45E-05	6.15E-05	6.74E-05	7.26E-05	7.70E-05	8.08E-05
^{241}Pu	1.76E-05	2.28E-05	2.72E-05	3.10E-05	3.42E-05	3.68E-05	3.89E-05	4.07E-05
^{242}Pu	4.62E-06	7.67E-06	1.12E-05	1.52E-05	1.93E-05	2.34E-05	2.76E-05	3.17E-05
^{241}Am	5.32E-06	7.00E-06	8.51E-06	9.82E-06	1.09E-05	1.19E-05	1.26E-05	1.33E-05
^{242m}Am	9.75E-09	1.59E-08	2.23E-08	2.87E-08	3.45E-08	3.97E-08	4.43E-08	4.83E-08
^{243}Am	7.04E-07	1.46E-06	2.52E-06	3.89E-06	5.49E-06	7.28E-06	9.20E-06	1.12E-05

Table 13. Isotopics as a Function of Enrichment (2.5 wt%) and Burnup (Continued)

Isotope	Isotopic Concentrations (atoms/barn – cm)			
	GWd/mtU 60	GWd/mtU 65	GWd/mtU 70	GWd/mtU 75
^{16}O	4.57E-02	4.55E-02	4.53E-02	4.51E-02
^{95}Mo	6.98E-05	7.41E-05	7.83E-05	8.23E-05
^{99}Tc	7.22E-05	7.64E-05	8.05E-05	8.45E-05
^{101}Ru	7.59E-05	8.17E-05	8.73E-05	9.28E-05
^{103}Rh	4.06E-05	4.22E-05	4.36E-05	4.48E-05
^{109}Ag	1.05E-05	1.13E-05	1.21E-05	1.28E-05
^{143}Nd	4.00E-05	4.11E-05	4.20E-05	4.28E-05
^{145}Nd	3.90E-05	4.11E-05	4.31E-05	4.50E-05
^{147}Sm	8.87E-06	9.01E-06	9.13E-06	9.22E-06
^{149}Sm	1.66E-07	1.67E-07	1.69E-07	1.70E-07
^{150}Sm	1.97E-05	2.09E-05	2.21E-05	2.32E-05
^{151}Sm	7.19E-07	7.53E-07	7.85E-07	8.17E-07
^{152}Sm	7.38E-06	7.74E-06	8.07E-06	8.38E-06
^{151}Eu	2.90E-08	3.04E-08	3.17E-08	3.30E-08
^{153}Eu	8.81E-06	9.41E-06	9.96E-06	1.05E-05
^{155}Gd	2.78E-07	3.01E-07	3.24E-07	3.44E-07
^{233}U	6.82E-11	6.92E-11	7.00E-11	7.06E-11
^{234}U	2.13E-06	2.06E-06	2.01E-06	1.96E-06
^{235}U	3.63E-05	2.84E-05	2.23E-05	1.76E-05
^{236}U	8.17E-05	8.00E-05	7.81E-05	7.59E-05
^{238}U	2.19E-02	2.18E-02	2.17E-02	2.16E-02
^{237}Np	1.80E-05	1.87E-05	1.93E-05	1.97E-05
^{238}Pu	1.25E-05	1.40E-05	1.53E-05	1.66E-05
^{239}Pu	1.91E-04	1.93E-04	1.95E-04	1.96E-04
^{240}Pu	8.42E-05	8.72E-05	8.98E-05	9.22E-05
^{241}Pu	4.22E-05	4.35E-05	4.46E-05	4.55E-05
^{242}Pu	3.56E-05	3.93E-05	4.29E-05	4.63E-05
^{241}Am	1.39E-05	1.43E-05	1.47E-05	1.51E-05
^{242m}Am	5.17E-08	5.48E-08	5.74E-08	5.98E-08
^{243}Am	1.32E-05	1.52E-05	1.71E-05	1.90E-05

Table 14. Isotopics as a Function of Enrichment (3.0 wt%) and Burnup

Isotope	Isotopic Concentrations (atoms/barn – cm)							
	GWd/mtU 0.001	GWd/mtU 2.5	GWd/mtU 5	GWd/mtU 7.5	GWd/mtU 10	GWd/mtU 12.5	GWd/mtU 15	GWd/mtU 17.5
^{16}O	4.79E-02	4.78E-02	4.78E-02	4.77E-02	4.76E-02	4.75E-02	4.74E-02	4.73E-02
^{95}Mo	1.46E-09	4.00E-06	7.87E-06	1.16E-05	1.53E-05	1.88E-05	2.23E-05	2.56E-05
^{99}Tc	1.39E-09	3.94E-06	7.78E-06	1.15E-05	1.52E-05	1.88E-05	2.23E-05	2.58E-05
^{101}Ru	1.18E-09	3.30E-06	6.60E-06	9.92E-06	1.32E-05	1.65E-05	1.98E-05	2.31E-05
^{103}Rh	8.33E-10	2.19E-06	4.48E-06	6.78E-06	9.07E-06	1.13E-05	1.35E-05	1.57E-05
^{109}Ag	1.45E-11	9.33E-08	2.85E-07	5.49E-07	8.65E-07	1.22E-06	1.61E-06	2.03E-06
^{143}Nd	1.33E-09	3.59E-06	6.93E-06	1.01E-05	1.30E-05	1.57E-05	1.83E-05	2.07E-05
^{145}Nd	9.00E-10	2.43E-06	4.75E-06	6.98E-06	9.13E-06	1.12E-05	1.32E-05	1.52E-05
^{147}Sm	3.92E-10	1.01E-06	1.91E-06	2.72E-06	3.45E-06	4.11E-06	4.71E-06	5.26E-06
^{149}Sm	2.53E-10	1.10E-07	1.23E-07	1.34E-07	1.41E-07	1.47E-07	1.52E-07	1.55E-07
^{150}Sm	7.32E-15	6.18E-07	1.39E-06	2.22E-06	3.09E-06	3.98E-06	4.88E-06	5.80E-06
^{151}Sm	9.88E-11	1.74E-07	2.50E-07	2.96E-07	3.32E-07	3.62E-07	3.89E-07	4.14E-07
^{152}Sm	6.55E-11	2.97E-07	7.01E-07	1.13E-06	1.54E-06	1.95E-06	2.35E-06	2.74E-06
^{151}Eu	3.88E-12	6.96E-09	1.01E-08	1.20E-08	1.35E-08	1.47E-08	1.58E-08	1.68E-08
^{153}Eu	4.12E-11	1.35E-07	3.21E-07	5.58E-07	8.39E-07	1.16E-06	1.51E-06	1.88E-06
^{155}Gd	4.89E-12	7.29E-09	1.12E-08	1.55E-08	2.08E-08	2.73E-08	3.51E-08	4.40E-08
^{233}U	3.17E-15	8.74E-12	1.68E-11	2.41E-11	3.07E-11	3.67E-11	4.21E-11	4.69E-11
^{234}U	6.09E-06	5.82E-06	5.57E-06	5.33E-06	5.11E-06	4.89E-06	4.69E-06	4.50E-06
^{235}U	7.28E-04	6.60E-04	5.99E-04	5.45E-04	4.95E-04	4.50E-04	4.09E-04	3.70E-04
^{236}U	3.39E-06	1.62E-05	2.75E-05	3.75E-05	4.64E-05	5.43E-05	6.14E-05	6.77E-05
^{238}U	2.32E-02	2.32E-02	2.31E-02	2.31E-02	2.30E-02	2.30E-02	2.29E-02	2.29E-02
^{237}Np	1.00E-10	4.02E-07	9.88E-07	1.71E-06	2.54E-06	3.44E-06	4.40E-06	5.39E-06
^{238}Pu	1.23E-18	9.45E-09	4.92E-08	1.29E-07	2.58E-07	4.40E-07	6.79E-07	9.80E-07
^{239}Pu	1.53E-08	3.86E-05	6.85E-05	9.22E-05	1.11E-04	1.26E-04	1.38E-04	1.48E-04
^{240}Pu	4.06E-14	1.64E-06	5.22E-06	9.62E-06	1.44E-05	1.93E-05	2.43E-05	2.92E-05
^{241}Pu	1.38E-19	1.99E-07	1.18E-06	2.94E-06	5.24E-06	7.87E-06	1.06E-05	1.34E-05
^{242}Pu	7.90E-25	4.63E-09	5.68E-08	2.19E-07	5.38E-07	1.04E-06	1.72E-06	2.60E-06
^{241}Am	3.75E-20	5.50E-08	3.29E-07	8.33E-07	1.51E-06	2.29E-06	3.14E-06	4.01E-06
^{242m}Am	2.03E-31	3.78E-12	7.96E-11	3.99E-10	1.13E-09	2.37E-09	4.13E-09	6.38E-09
^{243}Am	2.98E-30	7.07E-11	1.82E-09	1.09E-08	3.67E-08	9.01E-08	1.82E-07	3.23E-07

Table 14. Isotopics as a Function of Enrichment (3.0 wt%) and Burnup (Continued)

Isotope	Isotopic Concentrations (atoms/barn – cm)							
	GWd/mtU 20	GWd/mtU 25	GWd/mtU 30	GWd/mtU 35	GWd/mtU 40	GWd/mtU 45	GWd/mtU 50	GWd/mtU 55
^{16}O	4.72E-02	4.71E-02	4.69E-02	4.67E-02	4.65E-02	4.63E-02	4.61E-02	4.60E-02
^{95}Mo	2.89E-05	3.52E-05	4.12E-05	4.69E-05	5.23E-05	5.75E-05	6.25E-05	6.72E-05
^{99}Tc	2.92E-05	3.57E-05	4.19E-05	4.78E-05	5.34E-05	5.88E-05	6.39E-05	6.87E-05
^{101}Ru	2.64E-05	3.29E-05	3.93E-05	4.57E-05	5.19E-05	5.81E-05	6.41E-05	7.01E-05
^{103}Rh	1.78E-05	2.17E-05	2.53E-05	2.86E-05	3.16E-05	3.43E-05	3.66E-05	3.87E-05
^{109}Ag	2.47E-06	3.39E-06	4.35E-06	5.32E-06	6.29E-06	7.24E-06	8.18E-06	9.08E-06
^{143}Nd	2.29E-05	2.70E-05	3.05E-05	3.34E-05	3.60E-05	3.81E-05	3.99E-05	4.14E-05
^{145}Nd	1.70E-05	2.06E-05	2.40E-05	2.71E-05	3.00E-05	3.28E-05	3.54E-05	3.78E-05
^{147}Sm	5.76E-06	6.62E-06	7.33E-06	7.89E-06	8.34E-06	8.69E-06	8.96E-06	9.17E-06
^{149}Sm	1.58E-07	1.62E-07	1.65E-07	1.67E-07	1.68E-07	1.69E-07	1.70E-07	1.71E-07
^{150}Sm	6.72E-06	8.55E-06	1.04E-05	1.21E-05	1.38E-05	1.54E-05	1.69E-05	1.84E-05
^{151}Sm	4.37E-07	4.82E-07	5.23E-07	5.64E-07	6.04E-07	6.40E-07	6.77E-07	7.10E-07
^{152}Sm	3.11E-06	3.81E-06	4.45E-06	5.04E-06	5.58E-06	6.09E-06	6.55E-06	6.98E-06
^{151}Eu	1.78E-08	1.96E-08	2.12E-08	2.29E-08	2.45E-08	2.59E-08	2.74E-08	2.87E-08
^{153}Eu	2.28E-06	3.11E-06	3.97E-06	4.84E-06	5.69E-06	6.51E-06	7.28E-06	8.01E-06
^{155}Gd	5.40E-08	7.69E-08	1.03E-07	1.31E-07	1.60E-07	1.89E-07	2.18E-07	2.46E-07
^{233}U	5.13E-11	5.86E-11	6.45E-11	6.92E-11	7.29E-11	7.58E-11	7.81E-11	7.99E-11
^{234}U	4.32E-06	3.99E-06	3.69E-06	3.43E-06	3.21E-06	3.02E-06	2.85E-06	2.71E-06
^{235}U	3.35E-04	2.74E-04	2.22E-04	1.79E-04	1.44E-04	1.15E-04	9.14E-05	7.25E-05
^{236}U	7.34E-05	8.27E-05	8.99E-05	9.50E-05	9.86E-05	1.01E-04	1.02E-04	1.02E-04
^{238}U	2.28E-02	2.27E-02	2.26E-02	2.25E-02	2.24E-02	2.23E-02	2.21E-02	2.20E-02
^{237}Np	6.40E-06	8.46E-06	1.05E-05	1.25E-05	1.44E-05	1.61E-05	1.76E-05	1.89E-05
^{238}Pu	1.34E-06	2.25E-06	3.40E-06	4.77E-06	6.30E-06	7.95E-06	9.68E-06	1.14E-05
^{239}Pu	1.56E-04	1.68E-04	1.76E-04	1.82E-04	1.86E-04	1.89E-04	1.92E-04	1.94E-04
^{240}Pu	3.40E-05	4.30E-05	5.12E-05	5.85E-05	6.48E-05	7.04E-05	7.52E-05	7.95E-05
^{241}Pu	1.62E-05	2.14E-05	2.61E-05	3.01E-05	3.36E-05	3.64E-05	3.88E-05	4.08E-05
^{242}Pu	3.65E-06	6.25E-06	9.38E-06	1.29E-05	1.67E-05	2.07E-05	2.47E-05	2.88E-05
^{241}Am	4.89E-06	6.60E-06	8.17E-06	9.57E-06	1.08E-05	1.18E-05	1.27E-05	1.34E-05
^{242m}Am	9.04E-09	1.53E-08	2.21E-08	2.89E-08	3.54E-08	4.12E-08	4.63E-08	5.07E-08
^{243}Am	5.20E-07	1.11E-06	1.99E-06	3.15E-06	4.56E-06	6.18E-06	7.96E-06	9.84E-06

Table 14. Isotopics as a Function of Enrichment (3.0 wt%) and Burnup (Continued)

Isotope	Isotopic Concentrations (atoms/barn – cm)			
	GWd/mtU 60	GWd/mtU 65	GWd/mtU 70	GWd/mtU 75
^{16}O	4.58E-02	4.56E-02	4.54E-02	4.52E-02
^{95}Mo	7.17E-05	7.61E-05	8.04E-05	8.44E-05
^{99}Tc	7.33E-05	7.77E-05	8.18E-05	8.58E-05
^{101}Ru	7.59E-05	8.16E-05	8.73E-05	9.28E-05
^{103}Rh	4.06E-05	4.22E-05	4.37E-05	4.50E-05
^{109}Ag	9.96E-06	1.08E-05	1.16E-05	1.24E-05
^{143}Nd	4.26E-05	4.37E-05	4.46E-05	4.54E-05
^{145}Nd	4.01E-05	4.22E-05	4.43E-05	4.62E-05
^{147}Sm	9.33E-06	9.46E-06	9.55E-06	9.63E-06
^{149}Sm	1.72E-07	1.72E-07	1.74E-07	1.74E-07
^{150}Sm	1.97E-05	2.10E-05	2.22E-05	2.34E-05
^{151}Sm	7.44E-07	7.77E-07	8.08E-07	8.39E-07
^{152}Sm	7.37E-06	7.73E-06	8.08E-06	8.39E-06
^{151}Eu	3.01E-08	3.14E-08	3.27E-08	3.39E-08
^{153}Eu	8.69E-06	9.32E-06	9.89E-06	1.04E-05
^{155}Gd	2.72E-07	2.97E-07	3.20E-07	3.42E-07
^{233}U	8.13E-11	8.24E-11	8.33E-11	8.41E-11
^{234}U	2.60E-06	2.50E-06	2.43E-06	2.37E-06
^{235}U	5.74E-05	4.55E-05	3.60E-05	2.85E-05
^{236}U	1.01E-04	9.93E-05	9.74E-05	9.52E-05
^{238}U	2.19E-02	2.18E-02	2.17E-02	2.15E-02
^{237}Np	2.01E-05	2.10E-05	2.18E-05	2.24E-05
^{238}Pu	1.32E-05	1.48E-05	1.64E-05	1.79E-05
^{239}Pu	1.96E-04	1.97E-04	1.98E-04	2.00E-04
^{240}Pu	8.31E-05	8.64E-05	8.92E-05	9.18E-05
^{241}Pu	4.25E-05	4.38E-05	4.50E-05	4.60E-05
^{242}Pu	3.27E-05	3.65E-05	4.02E-05	4.37E-05
^{241}Am	1.40E-05	1.45E-05	1.50E-05	1.53E-05
^{242m}Am	5.44E-08	5.76E-08	6.04E-08	6.27E-08
^{243}Am	1.18E-05	1.38E-05	1.57E-05	1.76E-05

Table 15. Isotopics as a Function of Enrichment (3.5 wt%) and Burnup

Isotope	Isotopic Concentrations (atoms/barn – cm)							
	GWd/mtU 0.001	GWd/mtU 2.5	GWd/mtU 5	GWd/mtU 7.5	GWd/mtU 10	GWd/mtU 12.5	GWd/mtU 15	GWd/mtU 17.5
^{16}O	4.79E-02	4.78E-02	4.78E-02	4.77E-02	4.76E-02	4.75E-02	4.74E-02	4.73E-02
^{95}Mo	1.47E-09	4.02E-06	7.93E-06	1.17E-05	1.54E-05	1.91E-05	2.26E-05	2.60E-05
^{99}Tc	1.40E-09	3.95E-06	7.80E-06	1.16E-05	1.53E-05	1.89E-05	2.25E-05	2.59E-05
^{101}Ru	1.18E-09	3.30E-06	6.60E-06	9.91E-06	1.32E-05	1.65E-05	1.98E-05	2.31E-05
^{103}Rh	8.31E-10	2.17E-06	4.41E-06	6.66E-06	8.90E-06	1.11E-05	1.33E-05	1.54E-05
^{109}Ag	1.43E-11	8.25E-08	2.50E-07	4.80E-07	7.59E-07	1.08E-06	1.43E-06	1.81E-06
^{143}Nd	1.34E-09	3.62E-06	7.02E-06	1.02E-05	1.32E-05	1.61E-05	1.88E-05	2.13E-05
^{145}Nd	9.01E-10	2.44E-06	4.79E-06	7.05E-06	9.23E-06	1.14E-05	1.34E-05	1.54E-05
^{147}Sm	3.91E-10	1.02E-06	1.93E-06	2.76E-06	3.52E-06	4.20E-06	4.83E-06	5.41E-06
^{149}Sm	2.53E-10	1.22E-07	1.36E-07	1.46E-07	1.54E-07	1.60E-07	1.65E-07	1.68E-07
^{150}Sm	7.24E-15	6.03E-07	1.37E-06	2.19E-06	3.04E-06	3.92E-06	4.81E-06	5.72E-06
^{151}Sm	9.86E-11	1.85E-07	2.74E-07	3.27E-07	3.67E-07	3.99E-07	4.27E-07	4.53E-07
^{152}Sm	6.54E-11	2.83E-07	6.69E-07	1.08E-06	1.49E-06	1.90E-06	2.29E-06	2.67E-06
^{151}Eu	3.87E-12	7.39E-09	1.11E-08	1.33E-08	1.49E-08	1.63E-08	1.74E-08	1.85E-08
^{153}Eu	4.10E-11	1.32E-07	3.09E-07	5.31E-07	7.96E-07	1.10E-06	1.43E-06	1.78E-06
^{155}Gd	4.84E-12	7.41E-09	1.12E-08	1.51E-08	1.99E-08	2.58E-08	3.28E-08	4.09E-08
^{233}U	3.59E-15	9.94E-12	1.91E-11	2.76E-11	3.53E-11	4.24E-11	4.88E-11	5.45E-11
^{234}U	7.31E-06	7.01E-06	6.73E-06	6.47E-06	6.21E-06	5.97E-06	5.74E-06	5.52E-06
^{235}U	8.49E-04	7.80E-04	7.17E-04	6.59E-04	6.06E-04	5.57E-04	5.11E-04	4.68E-04
^{236}U	3.87E-06	1.72E-05	2.92E-05	4.00E-05	4.97E-05	5.86E-05	6.66E-05	7.39E-05
^{238}U	2.31E-02	2.31E-02	2.30E-02	2.30E-02	2.29E-02	2.29E-02	2.28E-02	2.28E-02
^{237}Np	9.82E-11	3.93E-07	9.71E-07	1.69E-06	2.52E-06	3.44E-06	4.42E-06	5.44E-06
^{238}Pu	1.10E-18	8.48E-09	4.44E-08	1.17E-07	2.35E-07	4.04E-07	6.28E-07	9.11E-07
^{239}Pu	1.42E-08	3.64E-05	6.54E-05	8.90E-05	1.08E-04	1.24E-04	1.37E-04	1.48E-04
^{240}Pu	3.52E-14	1.39E-06	4.51E-06	8.43E-06	1.28E-05	1.73E-05	2.19E-05	2.65E-05
^{241}Pu	1.11E-19	1.59E-07	9.69E-07	2.48E-06	4.53E-06	6.94E-06	9.54E-06	1.22E-05
^{242}Pu	5.54E-25	3.21E-09	4.07E-08	1.62E-07	4.06E-07	7.98E-07	1.35E-06	2.06E-06
^{241}Am	3.01E-20	4.37E-08	2.71E-07	7.03E-07	1.30E-06	2.02E-06	2.81E-06	3.65E-06
^{242m}Am	1.46E-31	2.77E-12	6.13E-11	3.20E-10	9.42E-10	2.04E-09	3.65E-09	5.77E-09
^{243}Am	1.96E-30	4.60E-11	1.22E-09	7.52^{E}-09	2.59E-08	6.48E-08	1.34E-07	2.41E-07

Table 15. Isotopics as a Function of Enrichment (3.5 wt%) and Burnup (Continued)

Isotope	Isotopic Concentrations (atoms/barn – cm)							
	GWd/mtU 20	GWd/mtU 25	GWd/mtU 30	GWd/mtU 35	GWd/mtU 40	GWd/mtU 45	GWd/mtU 50	GWd/mtU 55
^{16}O	4.72E-02	4.71E-02	4.69E-02	4.67E-02	4.65E-02	4.63E-02	4.62E-02	4.60E-02
^{95}Mo	2.94E-05	3.59E-05	4.20E-05	4.79E-05	5.35E-05	5.89E-05	6.40E-05	6.89E-05
^{99}Tc	2.94E-05	3.60E-05	4.23E-05	4.84E-05	5.41E-05	5.96E-05	6.48E-05	6.97E-05
^{101}Ru	2.63E-05	3.28E-05	3.93E-05	4.56E-05	5.19E-05	5.80E-05	6.41E-05	7.00E-05
^{103}Rh	1.74E-05	2.13E-05	2.50E-05	2.83E-05	3.13E-05	3.41E-05	3.65E-05	3.87E-05
^{109}Ag	2.21E-06	3.06E-06	3.95E-06	4.87E-06	5.81E-06	6.74E-06	7.67E-06	8.57E-06
^{143}Nd	2.37E-05	2.81E-05	3.19E-05	3.52E-05	3.80E-05	4.03E-05	4.23E-05	4.40E-05
^{145}Nd	1.73E-05	2.10E-05	2.45E-05	2.77E-05	3.08E-05	3.36E-05	3.63E-05	3.88E-05
^{147}Sm	5.94E-06	6.86E-06	7.63E-06	8.25E-06	8.74E-06	9.13E-06	9.43E-06	9.66E-06
^{149}Sm	1.71E-07	1.75E-07	1.77E-07	1.78E-07	1.79E-07	1.79E-07	1.79E-07	1.79E-07
^{150}Sm	6.63E-06	8.45E-06	1.02E-05	1.20E-05	1.37E-05	1.53E-05	1.69E-05	1.84E-05
^{151}Sm	4.77E-07	5.22E-07	5.63E-07	6.03E-07	6.42E-07	6.77E-07	7.12E-07	7.43E-07
^{152}Sm	3.04E-06	3.73E-06	4.38E-06	4.98E-06	5.53E-06	6.04E-06	6.51E-06	6.95E-06
^{151}Eu	1.95E-08	2.13E-08	2.29E-08	2.45E-08	2.61E-08	2.75E-08	2.89E-08	3.01E-08
^{153}Eu	2.16E-06	2.96E-06	3.80E-06	4.65E-06	5.50E-06	6.32E-06	7.11E-06	7.86E-06
^{155}Gd	5.01E-08	7.14E-08	9.60E-08	1.23E-07	1.51E-07	1.81E-07	2.10E-07	2.38E-07
^{233}U	5.97E-11	6.86E-11	7.58E-11	8.16E-11	8.61E-11	8.97E-11	9.24E-11	9.45E-11
^{234}U	5.31E-06	4.92E-06	4.57E-06	4.26E-06	3.98E-06	3.74E-06	3.53E-06	3.35E-06
^{235}U	4.29E-04	3.58E-04	2.97E-04	2.45E-04	2.00E-04	1.63E-04	1.32E-04	1.07E-04
^{236}U	8.05E-05	9.18E-05	1.01E-04	1.08E-04	1.13E-04	1.17E-04	1.19E-04	1.20E-04
^{238}U	2.27E-02	2.26E-02	2.25E-02	2.24E-02	2.23E-02	2.22E-02	2.21E-02	2.20E-02
^{237}Np	6.50E-06	8.67E-06	1.09E-05	1.30E-05	1.51E-05	1.70E-05	1.88E-05	2.04E-05
^{238}Pu	1.26E-06	2.13E-06	3.26E-06	4.61E-06	6.17E-06	7.89E-06	9.72E-06	1.16E-05
^{239}Pu	1.57E-04	1.70E-04	1.80E-04	1.86E-04	1.91E-04	1.94E-04	1.97E-04	1.99E-04
^{240}Pu	3.11E-05	3.99E-05	4.80E-05	5.55E-05	6.22E-05	6.81E-05	7.33E-05	7.79E-05
^{241}Pu	1.49E-05	2.01E-05	2.49E-05	2.92E-05	3.29E-05	3.60E-05	3.86E-05	4.08E-05
^{242}Pu	2.94E-06	5.14E-06	7.87E-06	1.10E-05	1.45E-05	1.82E-05	2.21E-05	2.60E-05
^{241}Am	4.51E-06	6.21E-06	7.82E-06	9.30E-06	1.06E-05	1.17E-05	1.27E-05	1.35E-05
^{242m}Am	8.35E-09	1.46E-08	2.17E-08	2.90E-08	3.61E-08	4.26E-08	4.84E-08	5.33E-08
^{243}Am	3.94E-07	8.66E-07	1.59E-06	2.56E-06	3.79E-06	5.24E-06	6.87E-06	8.63E-06

Table 15. Isotopics as a Function of Enrichment (3.5 wt%) and Burnup (Continued)

Isotope	Isotopic Concentrations (atoms/barn – cm)			
	GWd/mtU 60	GWd/mtU 65	GWd/mtU 70	GWd/mtU 75
^{16}O	4.58E-02	4.56E-02	4.54E-02	4.52E-02
^{95}Mo	7.36E-05	7.81E-05	8.24E-05	8.65E-05
^{99}Tc	7.44E-05	7.89E-05	8.31E-05	8.71E-05
^{101}Ru	7.59E-05	8.17E-05	8.73E-05	9.28E-05
^{103}Rh	4.06E-05	4.24E-05	4.39E-05	4.52E-05
^{109}Ag	9.45E-06	1.03E-05	1.11E-05	1.19E-05
^{143}Nd	4.54E-05	4.65E-05	4.74E-05	4.82E-05
^{145}Nd	4.12E-05	4.34E-05	4.55E-05	4.74E-05
^{147}Sm	9.82E-06	9.94E-06	1.00E-05	1.01E-05
^{149}Sm	1.79E-07	1.79E-07	1.79E-07	1.80E-07
^{150}Sm	1.98E-05	2.11E-05	2.23E-05	2.35E-05
^{151}Sm	7.76E-07	8.07E-07	8.36E-07	8.65E-07
^{152}Sm	7.35E-06	7.73E-06	8.08E-06	8.40E-06
^{151}Eu	3.14E-08	3.27E-08	3.38E-08	3.50E-08
^{153}Eu	8.56E-06	9.21E-06	9.81E-06	1.04E-05
^{155}Gd	2.66E-07	2.91E-07	3.16E-07	3.39E-07
^{233}U	9.61E-11	9.74E-11	9.83E-11	9.91E-11
^{234}U	3.19E-06	3.06E-06	2.95E-06	2.86E-06
^{235}U	8.56E-05	6.86E-05	5.49E-05	4.38E-05
^{236}U	1.20E-04	1.19E-04	1.17E-04	1.15E-04
^{238}U	2.19E-02	2.17E-02	2.16E-02	2.15E-02
^{237}Np	2.18E-05	2.30E-05	2.41E-05	2.49E-05
^{238}Pu	1.35E-05	1.54E-05	1.72E-05	1.90E-05
^{239}Pu	2.00E-04	2.02E-04	2.03E-04	2.04E-04
^{240}Pu	8.19E-05	8.54E-05	8.85E-05	9.13E-05
^{241}Pu	4.27E-05	4.42E-05	4.55E-05	4.65E-05
^{242}Pu	2.99E-05	3.37E-05	3.75E-05	4.11E-05
^{241}Am	1.42E-05	1.47E-05	1.52E-05	1.56E-05
^{242m}Am	5.75E-08	6.10E-08	6.39E-08	6.63E-08
^{243}Am	1.05E-05	1.24E-05	1.43E-05	1.62E-05

Table 16. Isotopics as a Function of Enrichment (4.0 wt%) and Burnup

Isotope	Isotopic Concentrations (atoms/barn – cm)							
	GWd/mtU 0.001	GWd/mtU 2.5	GWd/mtU 5	GWd/mtU 7.5	GWd/mtU 10	GWd/mtU 12.5	GWd/mtU 15	GWd/mtU 17.5
^{16}O	4.79E-02	4.78E-02	4.78E-02	4.77E-02	4.76E-02	4.75E-02	4.74E-02	4.73E-02
^{95}Mo	1.47E-09	4.04E-06	7.98E-06	1.18E-05	1.56E-05	1.92E-05	2.28E-05	2.63E-05
^{99}Tc	1.40E-09	3.95E-06	7.82E-06	1.16E-05	1.53E-05	1.90E-05	2.26E-05	2.61E-05
^{101}Ru	1.18E-09	3.30E-06	6.60E-06	9.90E-06	1.32E-05	1.65E-05	1.98E-05	2.30E-05
^{103}Rh	8.30E-10	2.15E-06	4.36E-06	6.57E-06	8.76E-06	1.09E-05	1.30E-05	1.51E-05
^{109}Ag	1.41E-11	7.46E-08	2.23E-07	4.27E-07	6.77E-07	9.63E-07	1.28E-06	1.63E-06
^{143}Nd	1.34E-09	3.64E-06	7.08E-06	1.04E-05	1.35E-05	1.64E-05	1.92E-05	2.19E-05
^{145}Nd	9.02E-10	2.45E-06	4.81E-06	7.10E-06	9.32E-06	1.15E-05	1.36E-05	1.56E-05
^{147}Sm	3.92E-10	1.02E-06	1.95E-06	2.80E-06	3.57E-06	4.28E-06	4.94E-06	5.54E-06
^{149}Sm	2.53E-10	1.35E-07	1.49E-07	1.60E-07	1.68E-07	1.74E-07	1.79E-07	1.82E-07
^{150}Sm	7.19E-15	5.88E-07	1.35E-06	2.16E-06	3.00E-06	3.86E-06	4.75E-06	5.64E-06
^{151}Sm	9.84E-11	1.94E-07	2.95E-07	3.56E-07	4.01E-07	4.36E-07	4.66E-07	4.94E-07
^{152}Sm	6.53E-11	2.71E-07	6.41E-07	1.04E-06	1.45E-06	1.84E-06	2.23E-06	2.61E-06
^{151}Eu	3.86E-12	7.75E-09	1.19E-08	1.45E-08	1.64E-08	1.78E-08	1.91E-08	2.02E-08
^{153}Eu	4.09E-11	1.30E-07	2.99E-07	5.10E-07	7.61E-07	1.05E-06	1.36E-06	1.70E-06
^{155}Gd	4.81E-12	7.53E-09	1.12E-08	1.49E-08	1.92E-08	2.46E-08	3.10E-08	3.84E-08
^{233}U	4.00E-15	1.11E-11	2.15E-11	3.10E-11	3.99E-11	4.79E-11	5.53E-11	6.20E-11
^{234}U	8.53E-06	8.21E-06	7.90E-06	7.61E-06	7.33E-06	7.06E-06	6.81E-06	6.56E-06
^{235}U	9.70E-04	9.00E-04	8.35E-04	7.75E-04	7.19E-04	6.66E-04	6.17E-04	5.71E-04
^{236}U	4.35E-06	1.81E-05	3.07E-05	4.21E-05	5.27E-05	6.23E-05	7.12E-05	7.94E-05
^{238}U	2.30E-02	2.29E-02	2.29E-02	2.29E-02	2.28E-02	2.28E-02	2.27E-02	2.27E-02
^{237}Np	9.69E-11	3.87E-07	9.58E-07	1.67E-06	2.51E-06	3.43E-06	4.42E-06	5.47E-06
^{238}Pu	9.99E-19	7.73E-09	4.06E-08	1.08E-07	2.17E-07	3.74E-07	5.84E-07	8.51E-07
^{239}Pu	1.33E-08	3.45E-05	6.28E-05	8.63E-05	1.06E-04	1.22E-04	1.36E-04	1.48E-04
^{240}Pu	3.13E-14	1.20E-06	3.96E-06	7.48E-06	1.14E-05	1.56E-05	1.99E-05	2.42E-05
^{241}Pu	9.22E-20	1.30E-07	8.13E-07	2.13E-06	3.96E-06	6.16E-06	8.60E-06	1.12E-05
^{242}Pu	4.09E-25	2.33E-09	3.03E-08	1.23E-07	3.14E-07	6.28E-07	1.08E-06	1.67E-06
^{241}Am	2.51E-20	3.57E-08	2.27E-07	6.03E-07	1.14E-06	1.79E-06	2.53E-06	3.33E-06
^{242m}Am	1.11E-31	2.10E-12	4.84E-11	2.62E-10	7.94E-10	1.76E-09	3.24E-09	5.23E-09
^{243}Am	1.37E-30	3.16E-11	8.54E-10	5.38E-09	1.89E-08	4.81E-08	1.01E-07	1.84E-07

Table 16. Isotopics as a Function of Enrichment (4.0 wt%) and Burnup (Continued)

Isotope	Isotopic Concentrations (atoms/barn – cm)							
	GWd/mtU 20	GWd/mtU 25	GWd/mtU 30	GWd/mtU 35	GWd/mtU 40	GWd/mtU 45	GWd/mtU 50	GWd/mtU 55
^{16}O	4.72E-02	4.71E-02	4.69E-02	4.67E-02	4.65E-02	4.63E-02	4.62E-02	4.60E-02
^{95}Mo	2.98E-05	3.64E-05	4.27E-05	4.88E-05	5.46E-05	6.01E-05	6.54E-05	7.04E-05
^{99}Tc	2.95E-05	3.62E-05	4.27E-05	4.88E-05	5.47E-05	6.03E-05	6.56E-05	7.07E-05
^{101}Ru	2.63E-05	3.28E-05	3.92E-05	4.55E-05	5.18E-05	5.80E-05	6.41E-05	7.00E-05
^{103}Rh	1.71E-05	2.10E-05	2.46E-05	2.80E-05	3.11E-05	3.39E-05	3.64E-05	3.87E-05
^{109}Ag	1.99E-06	2.78E-06	3.61E-06	4.48E-06	5.38E-06	6.28E-06	7.18E-06	8.08E-06
^{143}Nd	2.44E-05	2.90E-05	3.31E-05	3.67E-05	3.98E-05	4.24E-05	4.47E-05	4.66E-05
^{145}Nd	1.76E-05	2.14E-05	2.49E-05	2.83E-05	3.14E-05	3.44E-05	3.72E-05	3.98E-05
^{147}Sm	6.10E-06	7.08E-06	7.90E-06	8.58E-06	9.12E-06	9.56E-06	9.89E-06	1.01E-05
^{149}Sm	1.85E-07	1.88E-07	1.90E-07	1.90E-07	1.90E-07	1.90E-07	1.89E-07	1.88E-07
^{150}Sm	6.54E-06	8.35E-06	1.01E-05	1.19E-05	1.36E-05	1.53E-05	1.69E-05	1.84E-05
^{151}Sm	5.19E-07	5.65E-07	6.06E-07	6.46E-07	6.84E-07	7.18E-07	7.52E-07	7.82E-07
^{152}Sm	2.98E-06	3.67E-06	4.32E-06	4.92E-06	5.48E-06	6.00E-06	6.48E-06	6.93E-06
^{151}Eu	2.12E-08	2.31E-08	2.48E-08	2.64E-08	2.79E-08	2.92E-08	3.06E-08	3.18E-08
^{153}Eu	2.06E-06	2.83E-06	3.65E-06	4.48E-06	5.32E-06	6.14E-06	6.94E-06	7.70E-06
^{155}Gd	4.69E-08	6.68E-08	9.00E-08	1.16E-07	1.44E-07	1.72E-07	2.02E-07	2.31E-07
^{233}U	6.81E-11	7.86E-11	8.72E-11	9.41E-11	9.96E-11	1.04E-10	1.07E-10	1.10E-10
^{234}U	6.33E-06	5.89E-06	5.49E-06	5.13E-06	4.80E-06	4.51E-06	4.25E-06	4.02E-06
^{235}U	5.27E-04	4.48E-04	3.79E-04	3.18E-04	2.65E-04	2.20E-04	1.81E-04	1.49E-04
^{236}U	8.68E-05	9.99E-05	1.11E-04	1.19E-04	1.26E-04	1.31E-04	1.35E-04	1.37E-04
^{238}U	2.26E-02	2.25E-02	2.24E-02	2.23E-02	2.22E-02	2.21E-02	2.20E-02	2.19E-02
^{237}Np	6.56E-06	8.81E-06	1.11E-05	1.34E-05	1.57E-05	1.78E-05	1.98E-05	2.17E-05
^{238}Pu	1.18E-06	2.02E-06	3.10E-06	4.44E-06	6.00E-06	7.74E-06	9.64E-06	1.16E-05
^{239}Pu	1.57E-04	1.72E-04	1.83E-04	1.90E-04	1.96E-04	2.00E-04	2.02E-04	2.04E-04
^{240}Pu	2.86E-05	3.71E-05	4.51E-05	5.26E-05	5.95E-05	6.56E-05	7.12E-05	7.61E-05
^{241}Pu	1.38E-05	1.89E-05	2.38E-05	2.82E-05	3.21E-05	3.54E-05	3.83E-05	4.08E-05
^{242}Pu	2.40E-06	4.28E-06	6.66E-06	9.48E-06	1.26E-05	1.61E-05	1.97E-05	2.35E-05
^{241}Am	4.16E-06	5.84E-06	7.47E-06	9.00E-06	1.04E-05	1.16E-05	1.27E-05	1.36E-05
^{242m}Am	7.70E-09	1.39E-08	2.11E-08	2.89E-08	3.66E-08	4.38E-08	5.03E-08	5.59E-08
^{243}Am	3.05E-07	6.85E-07	1.28E-06	2.11E-06	3.17E-06	4.45E-06	5.93E-06	7.56E-06

Table 16. Isotopics as a Function of Enrichment (4.0 wt%) and Burnup (Continued)

Isotope	Isotopic Concentrations (atoms/barn – cm)			
	GWd/mtU 60	GWd/mtU 65	GWd/mtU 70	GWd/mtU 75
^{16}O	4.58E-02	4.56E-02	4.54E-02	4.52E-02
^{95}Mo	7.53E-05	7.99E-05	8.43E-05	8.86E-05
^{99}Tc	7.55E-05	8.01E-05	8.44E-05	8.85E-05
^{101}Ru	7.59E-05	8.17E-05	8.73E-05	9.29E-05
^{103}Rh	4.07E-05	4.25E-05	4.41E-05	4.55E-05
^{109}Ag	8.96E-06	9.82E-06	1.07E-05	1.15E-05
^{143}Nd	4.81E-05	4.94E-05	5.04E-05	5.12E-05
^{145}Nd	4.22E-05	4.45E-05	4.66E-05	4.86E-05
^{147}Sm	1.03E-05	1.05E-05	1.05E-05	1.06E-05
^{149}Sm	1.88E-07	1.87E-07	1.87E-07	1.86E-07
^{150}Sm	1.98E-05	2.11E-05	2.24E-05	2.36E-05
^{151}Sm	8.13E-07	8.42E-07	8.69E-07	8.97E-07
^{152}Sm	7.34E-06	7.72E-06	8.08E-06	8.41E-06
^{151}Eu	3.30E-08	3.42E-08	3.52E-08	3.63E-08
^{153}Eu	8.41E-06	9.08E-06	9.71E-06	1.03E-05
^{155}Gd	2.59E-07	2.85E-07	3.11E-07	3.35E-07
^{233}U	1.12E-10	1.13E-10	1.14E-10	1.15E-10
^{234}U	3.83E-06	3.66E-06	3.51E-06	3.39E-06
^{235}U	1.21E-04	9.85E-05	7.97E-05	6.43E-05
^{236}U	1.38E-04	1.38E-04	1.37E-04	1.35E-04
^{238}U	2.18E-02	2.17E-02	2.16E-02	2.14E-02
^{237}Np	2.33E-05	2.48E-05	2.60E-05	2.71E-05
^{238}Pu	1.37E-05	1.58E-05	1.78E-05	1.97E-05
^{239}Pu	2.06E-04	2.07E-04	2.07E-04	2.08E-04
^{240}Pu	8.04E-05	8.43E-05	8.77E-05	9.07E-05
^{241}Pu	4.28E-05	4.45E-05	4.59E-05	4.71E-05
^{242}Pu	2.73E-05	3.10E-05	3.48E-05	3.84E-05
^{241}Am	1.43E-05	1.49E-05	1.54E-05	1.59E-05
^{242m}Am	6.07E-08	6.46E-08	6.78E-08	7.04E-08
^{243}Am	9.31E-06	1.11E-05	1.30E-05	1.49E-05

Table 17. Isotopics as a Function of Enrichment (4.5 wt%) and Burnup

Isotope	Isotopic Concentrations (atoms/barn – cm)							
	GWd/mtU 0.001	GWd/mtU 2.5	GWd/mtU 5	GWd/mtU 7.5	GWd/mtU 10	GWd/mtU 12.5	GWd/mtU 15	GWd/mtU 17.5
^{16}O	4.79E-02	4.78E-02	4.78E-02	4.77E-02	4.76E-02	4.75E-02	4.74E-02	4.73E-02
^{95}Mo	1.47E-09	4.05E-06	8.01E-06	1.19E-05	1.57E-05	1.94E-05	2.30E-05	2.66E-05
^{99}Tc	1.40E-09	3.96E-06	7.84E-06	1.16E-05	1.54E-05	1.91E-05	2.27E-05	2.62E-05
^{101}Ru	1.18E-09	3.30E-06	6.60E-06	9.89E-06	1.32E-05	1.65E-05	1.97E-05	2.30E-05
^{103}Rh	8.29E-10	2.13E-06	4.32E-06	6.50E-06	8.66E-06	1.08E-05	1.29E-05	1.49E-05
^{109}Ag	1.40E-11	6.86E-08	2.02E-07	3.86E-07	6.11E-07	8.71E-07	1.16E-06	1.48E-06
^{143}Nd	1.34E-09	3.65E-06	7.14E-06	1.05E-05	1.36E-05	1.67E-05	1.95E-05	2.23E-05
^{145}Nd	9.03E-10	2.46E-06	4.84E-06	7.14E-06	9.39E-06	1.16E-05	1.37E-05	1.58E-05
^{147}Sm	3.92E-10	1.03E-06	1.97E-06	2.83E-06	3.62E-06	4.35E-06	5.02E-06	5.65E-06
^{149}Sm	2.53E-10	1.49E-07	1.63E-07	1.74E-07	1.82E-07	1.89E-07	1.94E-07	1.97E-07
^{150}Sm	7.14E-15	5.73E-07	1.33E-06	2.13E-06	2.96E-06	3.82E-06	4.69E-06	5.58E-06
^{151}Sm	9.83E-11	2.01E-07	3.13E-07	3.83E-07	4.34E-07	4.73E-07	5.06E-07	5.35E-07
^{152}Sm	6.52E-11	2.62E-07	6.17E-07	1.01E-06	1.40E-06	1.80E-06	2.18E-06	2.56E-06
^{151}Eu	3.86E-12	8.05E-09	1.27E-08	1.56E-08	1.77E-08	1.94E-08	2.08E-08	2.20E-08
^{153}Eu	4.08E-11	1.28E-07	2.91E-07	4.93E-07	7.31E-07	1.00E-06	1.30E-06	1.63E-06
^{155}Gd	4.78E-12	7.66E-09	1.14E-08	1.48E-08	1.88E-08	2.37E-08	2.96E-08	3.64E-08
^{233}U	4.34E-15	1.21E-11	2.34E-11	3.39E-11	4.36E-11	5.26E-11	6.09E-11	6.84E-11
^{234}U	9.50E-06	9.17E-06	8.85E-06	8.54E-06	8.25E-06	7.96E-06	7.69E-06	7.43E-06
^{235}U	1.09E-03	1.02E-03	9.54E-04	8.92E-04	8.33E-04	7.78E-04	7.26E-04	6.76E-04
^{236}U	5.08E-06	1.93E-05	3.23E-05	4.44E-05	5.55E-05	6.59E-05	7.55E-05	8.44E-05
^{238}U	2.29E-02	2.28E-02	2.28E-02	2.27E-02	2.27E-02	2.27E-02	2.26E-02	2.26E-02
^{237}Np	9.75E-11	3.86E-07	9.54E-07	1.67E-06	2.50E-06	3.43E-06	4.44E-06	5.50E-06
^{238}Pu	9.36E-19	7.22E-09	3.80E-08	1.01E-07	2.03E-07	3.51E-07	5.49E-07	8.01E-07
^{239}Pu	1.26E-08	3.30E-05	6.05E-05	8.38E-05	1.04E-04	1.20E-04	1.35E-04	1.47E-04
^{240}Pu	2.83E-14	1.05E-06	3.52E-06	6.71E-06	1.03E-05	1.42E-05	1.82E-05	2.23E-05
^{241}Pu	7.87E-20	1.08E-07	6.92E-07	1.85E-06	3.50E-06	5.51E-06	7.78E-06	1.02E-05
^{242}Pu	3.14E-25	1.75E-09	2.32E-08	9.59E-08	2.49E-07	5.03E-07	8.73E-07	1.37E-06
^{241}Am	2.14E-20	2.98E-08	1.93E-07	5.24E-07	1.00E-06	1.60E-06	2.29E-06	3.05E-06
^{242m}Am	7.45E-27	1.64E-12	3.90E-11	2.17E-10	6.75E-10	1.54E-09	2.88E-09	4.73E-09
^{243}Am	1.01E-30	2.26E-11	6.21E-10	3.98E-09	1.42E-08	3.66E-08	7.75E-08	1.43E-07

Table 17. Isotopics as a Function of Enrichment (4.5 wt%) and Burnup (Continued)

Isotope	Isotopic Concentrations (atoms/barn – cm)							
	GWd/mtU 20	GWd/mtU 25	GWd/mtU 30	GWd/mtU 35	GWd/mtU 40	GWd/mtU 45	GWd/mtU 50	GWd/mtU 55
^{16}O	4.73E-02	4.71E-02	4.69E-02	4.67E-02	4.65E-02	4.64E-02	4.62E-02	4.60E-02
^{95}Mo	3.01E-05	3.68E-05	4.33E-05	4.95E-05	5.55E-05	6.12E-05	6.66E-05	7.18E-05
^{99}Tc	2.97E-05	3.65E-05	4.30E-05	4.92E-05	5.52E-05	6.09E-05	6.64E-05	7.16E-05
^{101}Ru	2.63E-05	3.27E-05	3.92E-05	4.55E-05	5.18E-05	5.79E-05	6.40E-05	7.00E-05
^{103}Rh	1.69E-05	2.08E-05	2.44E-05	2.77E-05	3.09E-05	3.37E-05	3.63E-05	3.86E-05
^{109}Ag	1.81E-06	2.54E-06	3.32E-06	4.14E-06	5.00E-06	5.86E-06	6.74E-06	7.62E-06
^{143}Nd	2.49E-05	2.98E-05	3.41E-05	3.80E-05	4.14E-05	4.44E-05	4.69E-05	4.90E-05
^{145}Nd	1.78E-05	2.16E-05	2.53E-05	2.88E-05	3.20E-05	3.51E-05	3.80E-05	4.06E-05
^{147}Sm	6.23E-06	7.27E-06	8.14E-06	8.88E-06	9.48E-06	9.96E-06	1.03E-05	1.06E-05
^{149}Sm	1.99E-07	2.02E-07	2.04E-07	2.04E-07	2.03E-07	2.02E-07	2.01E-07	1.99E-07
^{150}Sm	6.47E-06	8.26E-06	1.00E-05	1.18E-05	1.35E-05	1.52E-05	1.68E-05	1.83E-05
^{151}Sm	5.62E-07	6.10E-07	6.52E-07	6.92E-07	7.29E-07	7.63E-07	7.96E-07	8.25E-07
^{152}Sm	2.92E-06	3.61E-06	4.26E-06	4.87E-06	5.43E-06	5.96E-06	6.44E-06	6.90E-06
^{151}Eu	2.31E-08	2.50E-08	2.67E-08	2.83E-08	2.98E-08	3.12E-08	3.25E-08	3.36E-08
^{153}Eu	1.98E-06	2.72E-06	3.51E-06	4.33E-06	5.15E-06	5.97E-06	6.77E-06	7.53E-06
^{155}Gd	4.43E-08	6.29E-08	8.48E-08	1.10E-07	1.36E-07	1.65E-07	1.94E-07	2.23E-07
^{233}U	7.53E-11	8.74E-11	9.72E-11	1.05E-10	1.12E-10	1.17E-10	1.21E-10	1.24E-10
^{234}U	7.18E-06	6.70E-06	6.27E-06	5.87E-06	5.51E-06	5.19E-06	4.89E-06	4.64E-06
^{235}U	6.30E-04	5.44E-04	4.67E-04	3.98E-04	3.38E-04	2.85E-04	2.38E-04	1.98E-04
^{236}U	9.27E-05	1.07E-04	1.20E-04	1.30E-04	1.39E-04	1.45E-04	1.50E-04	1.54E-04
^{238}U	2.25E-02	2.24E-02	2.23E-02	2.22E-02	2.21E-02	2.20E-02	2.19E-02	2.18E-02
^{237}Np	6.61E-06	8.93E-06	1.13E-05	1.37E-05	1.61E-05	1.84E-05	2.06E-05	2.27E-05
^{238}Pu	1.11E-06	1.91E-06	2.97E-06	4.27E-06	5.81E-06	7.56E-06	9.49E-06	1.16E-05
^{239}Pu	1.57E-04	1.74E-04	1.85E-04	1.94E-04	2.00E-04	2.04E-04	2.08E-04	2.10E-04
^{240}Pu	2.64E-05	3.45E-05	4.24E-05	4.99E-05	5.68E-05	6.32E-05	6.89E-05	7.41E-05
^{241}Pu	1.27E-05	1.78E-05	2.26E-05	2.71E-05	3.12E-05	3.48E-05	3.79E-05	4.06E-05
^{242}Pu	1.99E-06	3.60E-06	5.68E-06	8.19E-06	1.11E-05	1.42E-05	1.76E-05	2.11E-05
^{241}Am	3.84E-06	5.49E-06	7.12E-06	8.69E-06	1.01E-05	1.14E-05	1.26E-05	1.36E-05
^{242m}Am	7.09E-09	1.31E-08	2.05E-08	2.86E-08	3.68E-08	4.48E-08	5.20E-08	5.84E-08
^{243}Am	2.40E-07	5.50E-07	1.04E-06	1.75E-06	2.66E-06	3.80E-06	5.12E-06	6.61E-06

Table 17. Isotopics as a Function of Enrichment (4.5 wt%) and Burnup (Continued)

Isotope	Isotopic Concentrations (atoms/barn – cm)			
	GWd/mtU 60	GWd/mtU 65	GWd/mtU 70	GWd/mtU 75
^{16}O	4.58E-02	4.56E-02	4.54E-02	4.52E-02
^{95}Mo	7.68E-05	8.16E-05	8.61E-05	9.05E-05
^{99}Tc	7.65E-05	8.12E-05	8.56E-05	8.98E-05
^{101}Ru	7.59E-05	8.17E-05	8.74E-05	9.30E-05
^{103}Rh	4.07E-05	4.26E-05	4.43E-05	4.57E-05
^{109}Ag	8.49E-06	9.35E-06	1.02E-05	1.10E-05
^{143}Nd	5.07E-05	5.22E-05	5.33E-05	5.42E-05
^{145}Nd	4.32E-05	4.55E-05	4.77E-05	4.98E-05
^{147}Sm	1.08E-05	1.10E-05	1.11E-05	1.11E-05
^{149}Sm	1.98E-07	1.96E-07	1.95E-07	1.94E-07
^{150}Sm	1.98E-05	2.12E-05	2.25E-05	2.37E-05
^{151}Sm	8.54E-07	8.82E-07	9.07E-07	9.33E-07
^{152}Sm	7.32E-06	7.71E-06	8.08E-06	8.42E-06
^{151}Eu	3.48E-08	3.59E-08	3.69E-08	3.79E-08
^{153}Eu	8.26E-06	8.95E-06	9.60E-06	1.02E-05
^{155}Gd	2.51E-07	2.79E-07	3.05E-07	3.30E-07
^{233}U	1.26E-10	1.28E-10	1.29E-10	1.30E-10
^{234}U	4.41E-06	4.21E-06	4.04E-06	3.89E-06
^{235}U	1.64E-04	1.35E-04	1.11E-04	9.06E-05
^{236}U	1.56E-04	1.57E-04	1.57E-04	1.56E-04
^{238}U	2.17E-02	2.16E-02	2.15E-02	2.14E-02
^{237}Np	2.46E-05	2.63E-05	2.78E-05	2.91E-05
^{238}Pu	1.37E-05	1.59E-05	1.81E-05	2.03E-05
^{239}Pu	2.11E-04	2.12E-04	2.13E-04	2.13E-04
^{240}Pu	7.88E-05	8.29E-05	8.66E-05	8.99E-05
^{241}Pu	4.28E-05	4.47E-05	4.63E-05	4.76E-05
^{242}Pu	2.48E-05	2.85E-05	3.22E-05	3.58E-05
^{241}Am	1.44E-05	1.51E-05	1.57E-05	1.62E-05
^{242m}Am	6.39E-08	6.84E-08	7.20E-08	7.49E-08
^{243}Am	8.24E-06	9.98E-06	1.18E-05	1.36E-05

Table 18. Isotopics as a Function of Enrichment (5.0 wt%) and Burnup

Isotope	Isotopic Concentrations (atoms/barn – cm)							
	GWd/mtU 0.001	GWd/mtU 2.5	GWd/mtU 5	GWd/mtU 7.5	GWd/mtU 10	GWd/mtU 12.5	GWd/mtU 15	GWd/mtU 17.5
^{16}O	4.79E-02	4.79E-02	4.78E-02	4.77E-02	4.76E-02	4.75E-02	4.74E-02	4.73E-02
^{95}Mo	1.47E-09	4.06E-06	8.04E-06	1.19E-05	1.58E-05	1.95E-05	2.32E-05	2.68E-05
^{99}Tc	1.40E-09	3.97E-06	7.86E-06	1.17E-05	1.54E-05	1.91E-05	2.27E-05	2.63E-05
^{101}Ru	1.18E-09	3.30E-06	6.59E-06	9.89E-06	1.32E-05	1.65E-05	1.97E-05	2.30E-05
^{103}Rh	8.28E-10	2.12E-06	4.29E-06	6.44E-06	8.58E-06	1.07E-05	1.27E-05	1.48E-05
^{109}Ag	1.39E-11	6.38E-08	1.85E-07	3.52E-07	5.58E-07	7.95E-07	1.06E-06	1.35E-06
^{143}Nd	1.34E-09	3.67E-06	7.18E-06	1.05E-05	1.38E-05	1.69E-05	1.98E-05	2.27E-05
^{145}Nd	9.04E-10	2.46E-06	4.85E-06	7.18E-06	9.44E-06	1.16E-05	1.38E-05	1.59E-05
^{147}Sm	3.92E-10	1.03E-06	1.98E-06	2.85E-06	3.66E-06	4.41E-06	5.10E-06	5.75E-06
^{149}Sm	2.53E-10	1.63E-07	1.77E-07	1.88E-07	1.97E-07	2.04E-07	2.09E-07	2.12E-07
^{150}Sm	7.11E-15	5.58E-07	1.31E-06	2.10E-06	2.92E-06	3.77E-06	4.64E-06	5.51E-06
^{151}Sm	9.82E-11	2.08E-07	3.30E-07	4.09E-07	4.65E-07	5.09E-07	5.45E-07	5.77E-07
^{152}Sm	6.51E-11	2.53E-07	5.96E-07	9.75E-07	1.36E-06	1.75E-06	2.13E-06	2.50E-06
^{151}Eu	3.86E-12	8.31E-09	1.34E-08	1.67E-08	1.91E-08	2.09E-08	2.24E-08	2.38E-08
^{153}Eu	4.07E-11	1.26E-07	2.85E-07	4.78E-07	7.07E-07	9.67E-07	1.26E-06	1.57E-06
^{155}Gd	4.76E-12	7.79E-09	1.15E-08	1.48E-08	1.85E-08	2.30E-08	2.85E-08	3.48E-08
^{233}U	4.75E-15	1.32E-11	2.56E-11	3.72E-11	4.80E-11	5.80E-11	6.73E-11	7.58E-11
^{234}U	1.07E-05	1.04E-05	1.00E-05	9.70E-06	9.38E-06	9.07E-06	8.78E-06	8.49E-06
^{235}U	1.21E-03	1.14E-03	1.07E-03	1.01E-03	9.48E-04	8.91E-04	8.36E-04	7.84E-04
^{236}U	5.56E-06	2.01E-05	3.36E-05	4.62E-05	5.79E-05	6.89E-05	7.92E-05	8.88E-05
^{238}U	2.27E-02	2.27E-02	2.27E-02	2.26E-02	2.26E-02	2.25E-02	2.25E-02	2.25E-02
^{237}Np	9.69E-11	3.82E-07	9.44E-07	1.65E-06	2.48E-06	3.41E-06	4.42E-06	5.50E-06
^{238}Pu	8.74E-19	6.74E-09	3.55E-08	9.43E-08	1.90E-07	3.29E-07	5.16E-07	7.55E-07
^{239}Pu	1.20E-08	3.17E-05	5.85E-05	8.15E-05	1.01E-04	1.18E-04	1.33E-04	1.46E-04
^{240}Pu	2.59E-14	9.35E-07	3.16E-06	6.08E-06	9.41E-06	1.30E-05	1.67E-05	2.06E-05
^{241}Pu	6.85E-20	9.17E-08	5.98E-07	1.62E-06	3.11E-06	4.96E-06	7.08E-06	9.37E-06
^{242}Pu	2.48E-25	1.35E-09	1.82E-08	7.62E-08	2.00E-07	4.10E-07	7.18E-07	1.13E-06
^{241}Am	1.86E-20	2.53E-08	1.67E-07	4.59E-07	8.92E-07	1.44E-06	2.08E-06	2.80E-06
^{242m}Am	6.02E-27	1.31E-12	3.19E-11	1.82E-10	5.79E-10	1.34E-09	2.56E-09	4.28E-09
^{243}Am	7.62E-31	1.67E-11	4.64E-10	3.02E-09	1.09E-08	2.84E-08	6.08E-08	1.13E-07

Table 18. Isotopics as a Function of Enrichment (5.0 wt%) and Burnup (Continued)

Isotope	Isotopic Concentrations (atoms/barn – cm)							
	GWd/mtU 20	GWd/mtU 25	GWd/mtU 30	GWd/mtU 35	GWd/mtU 40	GWd/mtU 45	GWd/mtU 50	GWd/mtU 55
^{16}O	4.73E-02	4.71E-02	4.69E-02	4.67E-02	4.65E-02	4.64E-02	4.62E-02	4.60E-02
^{95}Mo	3.03E-05	3.72E-05	4.38E-05	5.02E-05	5.63E-05	6.21E-05	6.77E-05	7.31E-05
^{99}Tc	2.98E-05	3.67E-05	4.32E-05	4.96E-05	5.57E-05	6.15E-05	6.71E-05	7.24E-05
^{101}Ru	2.62E-05	3.27E-05	3.91E-05	4.55E-05	5.17E-05	5.79E-05	6.40E-05	7.00E-05
^{103}Rh	1.67E-05	2.06E-05	2.42E-05	2.75E-05	3.07E-05	3.36E-05	3.62E-05	3.86E-05
^{109}Ag	1.66E-06	2.34E-06	3.07E-06	3.85E-06	4.65E-06	5.49E-06	6.33E-06	7.19E-06
^{143}Nd	2.54E-05	3.05E-05	3.50E-05	3.92E-05	4.28E-05	4.61E-05	4.89E-05	5.12E-05
^{145}Nd	1.79E-05	2.19E-05	2.56E-05	2.92E-05	3.25E-05	3.57E-05	3.86E-05	4.14E-05
^{147}Sm	6.35E-06	7.43E-06	8.36E-06	9.15E-06	9.80E-06	1.03E-05	1.08E-05	1.11E-05
^{149}Sm	2.15E-07	2.17E-07	2.18E-07	2.18E-07	2.17E-07	2.15E-07	2.13E-07	2.11E-07
^{150}Sm	6.40E-06	8.18E-06	9.95E-06	1.17E-05	1.34E-05	1.51E-05	1.67E-05	1.83E-05
^{151}Sm	6.05E-07	6.55E-07	6.99E-07	7.40E-07	7.77E-07	8.11E-07	8.44E-07	8.72E-07
^{152}Sm	2.87E-06	3.56E-06	4.21E-06	4.82E-06	5.38E-06	5.91E-06	6.41E-06	6.87E-06
^{151}Eu	2.49E-08	2.70E-08	2.87E-08	3.04E-08	3.19E-08	3.32E-08	3.45E-08	3.56E-08
^{153}Eu	1.90E-06	2.62E-06	3.39E-06	4.19E-06	5.00E-06	5.81E-06	6.60E-06	7.37E-06
^{155}Gd	4.21E-08	5.95E-08	8.03E-08	1.04E-07	1.30E-07	1.57E-07	1.86E-07	2.15E-07
^{233}U	8.36E-11	9.73E-11	1.09E-10	1.18E-10	1.26E-10	1.32E-10	1.36E-10	1.40E-10
^{234}U	8.22E-06	7.70E-06	7.23E-06	6.79E-06	6.38E-06	6.01E-06	5.68E-06	5.38E-06
^{235}U	7.35E-04	6.43E-04	5.59E-04	4.84E-04	4.16E-04	3.56E-04	3.03E-04	2.56E-04
^{236}U	9.77E-05	1.14E-04	1.28E-04	1.40E-04	1.50E-04	1.58E-04	1.64E-04	1.69E-04
^{238}U	2.24E-02	2.23E-02	2.22E-02	2.22E-02	2.21E-02	2.20E-02	2.19E-02	2.18E-02
^{237}Np	6.62E-06	8.99E-06	1.14E-05	1.39E-05	1.64E-05	1.89E-05	2.13E-05	2.35E-05
^{238}Pu	1.05E-06	1.82E-06	2.83E-06	4.09E-06	5.60E-06	7.34E-06	9.27E-06	1.14E-05
^{239}Pu	1.57E-04	1.74E-04	1.87E-04	1.97E-04	2.04E-04	2.09E-04	2.13E-04	2.15E-04
^{240}Pu	2.45E-05	3.23E-05	4.00E-05	4.73E-05	5.42E-05	6.07E-05	6.66E-05	7.21E-05
^{241}Pu	1.18E-05	1.67E-05	2.15E-05	2.60E-05	3.02E-05	3.40E-05	3.73E-05	4.02E-05
^{242}Pu	1.66E-06	3.05E-06	4.88E-06	7.11E-06	9.69E-06	1.26E-05	1.57E-05	1.90E-05
^{241}Am	3.56E-06	5.15E-06	6.78E-06	8.36E-06	9.85E-06	1.12E-05	1.24E-05	1.35E-05
^{242m}Am	6.51E-09	1.24E-08	1.98E-08	2.81E-08	3.68E-08	4.54E-08	5.34E-08	6.06E-08
^{243}Am	1.92E-07	4.47E-07	8.60E-07	1.46E-06	2.25E-06	3.25E-06	4.44E-06	5.79E-06

Table 18. Isotopics as a Function of Enrichment (5.0 wt%) and Burnup (Continued)

Isotope	Isotopic Concentrations (atoms/barn – cm)			
	GWd/mtU 60	GWd/mtU 65	GWd/mtU 70	GWd/mtU 75
^{16}O	4.58E-02	4.56E-02	4.54E-02	4.52E-02
^{95}Mo	7.82E-05	8.31E-05	8.78E-05	9.23E-05
^{99}Tc	7.74E-05	8.22E-05	8.68E-05	9.11E-05
^{101}Ru	7.59E-05	8.17E-05	8.75E-05	9.31E-05
^{103}Rh	4.08E-05	4.27E-05	4.45E-05	4.60E-05
^{109}Ag	8.04E-06	8.89E-06	9.73E-06	1.06E-05
^{143}Nd	5.32E-05	5.49E-05	5.62E-05	5.72E-05
^{145}Nd	4.41E-05	4.65E-05	4.88E-05	5.09E-05
^{147}Sm	1.13E-05	1.15E-05	1.16E-05	1.16E-05
^{149}Sm	2.09E-07	2.06E-07	2.05E-07	2.03E-07
^{150}Sm	1.98E-05	2.12E-05	2.25E-05	2.38E-05
^{151}Sm	9.00E-07	9.27E-07	9.50E-07	9.75E-07
^{152}Sm	7.30E-06	7.70E-06	8.08E-06	8.43E-06
^{151}Eu	3.67E-08	3.78E-08	3.87E-08	3.96E-08
^{153}Eu	8.11E-06	8.82E-06	9.48E-06	1.01E-05
^{155}Gd	2.44E-07	2.72E-07	2.99E-07	3.25E-07
^{233}U	1.43E-10	1.45E-10	1.46E-10	1.47E-10
^{234}U	5.11E-06	4.88E-06	4.67E-06	4.49E-06
^{235}U	2.15E-04	1.79E-04	1.49E-04	1.23E-04
^{236}U	1.73E-04	1.75E-04	1.76E-04	1.75E-04
^{238}U	2.17E-02	2.15E-02	2.14E-02	2.13E-02
^{237}Np	2.56E-05	2.75E-05	2.92E-05	3.08E-05
^{238}Pu	1.36E-05	1.59E-05	1.83E-05	2.06E-05
^{239}Pu	2.17E-04	2.18E-04	2.18E-04	2.19E-04
^{240}Pu	7.70E-05	8.14E-05	8.54E-05	8.89E-05
^{241}Pu	4.27E-05	4.48E-05	4.65E-05	4.80E-05
^{242}Pu	2.25E-05	2.61E-05	2.97E-05	3.33E-05
^{241}Am	1.44E-05	1.52E-05	1.59E-05	1.64E-05
^{242m}Am	6.68E-08	7.21E-08	7.63E-08	7.96E-08
^{243}Am	7.30E-06	8.93E-06	1.06E-05	1.24E-05

Table 19. Isotopics as a Function of Enrichment (5.5 wt%) and Burnup

Isotope	Isotopic Concentrations (atoms/barn – cm)							
	GWd/mtU 0.001	GWd/mtU 2.5	GWd/mtU 5	GWd/mtU 7.5	GWd/mtU 10	GWd/mtU 12.5	GWd/mtU 15	GWd/mtU 17.5
^{16}O	4.79E-02	4.79E-02	4.78E-02	4.77E-02	4.76E-02	4.75E-02	4.74E-02	4.73E-02
^{95}Mo	1.47E-09	4.07E-06	8.07E-06	1.20E-05	1.58E-05	1.96E-05	2.33E-05	2.70E-05
^{99}Tc	1.40E-09	3.97E-06	7.87E-06	1.17E-05	1.55E-05	1.92E-05	2.28E-05	2.64E-05
^{101}Ru	1.18E-09	3.30E-06	6.59E-06	9.89E-06	1.32E-05	1.64E-05	1.97E-05	2.30E-05
^{103}Rh	8.27E-10	2.12E-06	4.26E-06	6.40E-06	8.51E-06	1.06E-05	1.26E-05	1.46E-05
^{109}Ag	1.38E-11	5.99E-08	1.71E-07	3.25E-07	5.13E-07	7.32E-07	9.77E-07	1.25E-06
^{143}Nd	1.34E-09	3.68E-06	7.22E-06	1.06E-05	1.39E-05	1.70E-05	2.01E-05	2.30E-05
^{145}Nd	9.04E-10	2.47E-06	4.87E-06	7.21E-06	9.49E-06	1.17E-05	1.39E-05	1.60E-05
^{147}Sm	3.92E-10	1.03E-06	1.99E-06	2.87E-06	3.69E-06	4.46E-06	5.17E-06	5.84E-06
^{149}Sm	2.53E-10	1.77E-07	1.92E-07	2.04E-07	2.13E-07	2.19E-07	2.25E-07	2.28E-07
^{150}Sm	7.08E-15	5.43E-07	1.29E-06	2.07E-06	2.89E-06	3.73E-06	4.59E-06	5.46E-06
^{151}Sm	9.81E-11	2.13E-07	3.45E-07	4.32E-07	4.95E-07	5.44E-07	5.83E-07	6.18E-07
^{152}Sm	6.51E-11	2.47E-07	5.78E-07	9.47E-07	1.33E-06	1.71E-06	2.09E-06	2.46E-06
^{151}Eu	3.85E-12	8.53E-09	1.40E-08	1.77E-08	2.04E-08	2.24E-08	2.41E-08	2.55E-08
^{153}Eu	4.07E-11	1.25E-07	2.79E-07	4.66E-07	6.86E-07	9.36E-07	1.21E-06	1.52E-06
^{155}Gd	4.74E-12	7.92E-09	1.17E-08	1.48E-08	1.83E-08	2.26E-08	2.76E-08	3.35E-08
^{233}U	5.15E-15	1.44E-11	2.79E-11	4.05E-11	5.24E-11	6.34E-11	7.36E-11	8.31E-11
^{234}U	1.19E-05	1.16E-05	1.12E-05	1.09E-05	1.05E-05	1.02E-05	9.88E-06	9.57E-06
^{235}U	1.33E-03	1.26E-03	1.19E-03	1.13E-03	1.06E-03	1.01E-03	9.48E-04	8.94E-04
^{236}U	6.04E-06	2.09E-05	3.48E-05	4.79E-05	6.01E-05	7.17E-05	8.25E-05	9.27E-05
^{238}U	2.26E-02	2.26E-02	2.25E-02	2.25E-02	2.25E-02	2.24E-02	2.24E-02	2.23E-02
^{237}Np	9.67E-11	3.80E-07	9.37E-07	1.64E-06	2.47E-06	3.40E-06	4.41E-06	5.49E-06
^{238}Pu	8.23E-19	6.34E-09	3.33E-08	8.88E-08	1.79E-07	3.10E-07	4.87E-07	7.14E-07
^{239}Pu	1.15E-08	3.05E-05	5.67E-05	7.94E-05	9.92E-05	1.17E-04	1.32E-04	1.45E-04
^{240}Pu	2.40E-14	8.40E-07	2.86E-06	5.54E-06	8.63E-06	1.20E-05	1.55E-05	1.91E-05
^{241}Pu	6.05E-20	7.89E-08	5.21E-07	1.43E-06	2.78E-06	4.48E-06	6.46E-06	8.62E-06
^{242}Pu	2.01E-25	1.07E-09	1.45E-08	6.17E-08	1.64E-07	3.38E-07	5.98E-07	9.52E-07
^{241}Am	1.65E-20	2.17E-08	1.46E-07	4.06E-07	7.98E-07	1.30E-06	1.90E-06	2.57E-06
^{242m}Am	4.96E-27	1.06E-12	2.65E-11	1.55E-10	5.00E-10	1.18E-09	2.29E-09	3.88E-09
^{243}Am	5.94E-31	1.26E-11	3.56E-10	2.34E-09	8.50E-09	2.24E-08	4.84E-08	9.12E-08

Table 19. Isotopics as a Function of Enrichment (5.5 wt%) and Burnup (Continued)

Isotope	Isotopic Concentrations (atoms/barn – cm)							
	GWd/mtU 20	GWd/mtU 25	GWd/mtU 30	GWd/mtU 35	GWd/mtU 40	GWd/mtU 45	GWd/mtU 50	GWd/mtU 55
^{16}O	4.73E-02	4.71E-02	4.69E-02	4.67E-02	4.65E-02	4.64E-02	4.62E-02	4.60E-02
^{95}Mo	3.06E-05	3.75E-05	4.42E-05	5.07E-05	5.70E-05	6.30E-05	6.87E-05	7.42E-05
^{99}Tc	2.99E-05	3.68E-05	4.35E-05	4.99E-05	5.61E-05	6.20E-05	6.77E-05	7.31E-05
^{101}Ru	2.62E-05	3.27E-05	3.91E-05	4.54E-05	5.17E-05	5.79E-05	6.40E-05	7.00E-05
^{103}Rh	1.66E-05	2.04E-05	2.40E-05	2.73E-05	3.05E-05	3.34E-05	3.61E-05	3.86E-05
^{109}Ag	1.53E-06	2.16E-06	2.85E-06	3.58E-06	4.35E-06	5.15E-06	5.96E-06	6.79E-06
^{143}Nd	2.58E-05	3.10E-05	3.58E-05	4.02E-05	4.41E-05	4.76E-05	5.07E-05	5.33E-05
^{145}Nd	1.81E-05	2.21E-05	2.59E-05	2.95E-05	3.30E-05	3.62E-05	3.93E-05	4.22E-05
^{147}Sm	6.46E-06	7.58E-06	8.56E-06	9.39E-06	1.01E-05	1.07E-05	1.11E-05	1.15E-05
^{149}Sm	2.31E-07	2.33E-07	2.34E-07	2.33E-07	2.32E-07	2.29E-07	2.27E-07	2.24E-07
^{150}Sm	6.33E-06	8.10E-06	9.87E-06	1.16E-05	1.33E-05	1.50E-05	1.66E-05	1.82E-05
^{151}Sm	6.48E-07	7.02E-07	7.47E-07	7.89E-07	8.27E-07	8.62E-07	8.94E-07	9.23E-07
^{152}Sm	2.82E-06	3.51E-06	4.16E-06	4.77E-06	5.34E-06	5.87E-06	6.37E-06	6.84E-06
^{151}Eu	2.68E-08	2.90E-08	3.08E-08	3.25E-08	3.40E-08	3.54E-08	3.67E-08	3.78E-08
^{153}Eu	1.84E-06	2.53E-06	3.28E-06	4.06E-06	4.85E-06	5.65E-06	6.44E-06	7.22E-06
^{155}Gd	4.04E-08	5.67E-08	7.63E-08	9.89E-08	1.24E-07	1.51E-07	1.79E-07	2.07E-07
^{233}U	9.18E-11	1.07E-10	1.20E-10	1.31E-10	1.39E-10	1.47E-10	1.52E-10	1.57E-10
^{234}U	9.28E-06	8.72E-06	8.20E-06	7.72E-06	7.28E-06	6.87E-06	6.50E-06	6.16E-06
^{235}U	8.42E-04	7.45E-04	6.55E-04	5.74E-04	5.00E-04	4.33E-04	3.73E-04	3.19E-04
^{236}U	1.02E-04	1.20E-04	1.35E-04	1.49E-04	1.60E-04	1.70E-04	1.77E-04	1.84E-04
^{238}U	2.23E-02	2.22E-02	2.21E-02	2.21E-02	2.20E-02	2.19E-02	2.18E-02	2.17E-02
^{237}Np	6.63E-06	9.02E-06	1.15E-05	1.41E-05	1.67E-05	1.93E-05	2.17E-05	2.41E-05
^{238}Pu	9.94E-07	1.73E-06	2.70E-06	3.92E-06	5.39E-06	7.10E-06	9.02E-06	1.11E-05
^{239}Pu	1.56E-04	1.75E-04	1.89E-04	2.00E-04	2.08E-04	2.13E-04	2.18E-04	2.20E-04
^{240}Pu	2.28E-05	3.03E-05	3.77E-05	4.49E-05	5.18E-05	5.83E-05	6.44E-05	7.00E-05
^{241}Pu	1.09E-05	1.57E-05	2.04E-05	2.50E-05	2.93E-05	3.32E-05	3.67E-05	3.97E-05
^{242}Pu	1.40E-06	2.61E-06	4.22E-06	6.21E-06	8.54E-06	1.12E-05	1.41E-05	1.72E-05
^{241}Am	3.30E-06	4.84E-06	6.45E-06	8.03E-06	9.55E-06	1.10E-05	1.23E-05	1.34E-05
^{242m}Am	5.98E-09	1.16E-08	1.90E-08	2.74E-08	3.65E-08	4.56E-08	5.44E-08	6.24E-08
^{243}Am	1.56E-07	3.67E-07	7.16E-07	1.23E-06	1.92E-06	2.80E-06	3.86E-06	5.09E-06

Table 19. Isotopics as a Function of Enrichment (5.5 wt%) and Burnup (Continued)

Isotope	Isotopic Concentrations (atoms/barn – cm)			
	GWd/mtU 60	GWd/mtU 65	GWd/mtU 70	GWd/mtU 75
^{16}O	4.58E-02	4.56E-02	4.54E-02	4.52E-02
^{95}Mo	7.95E-05	8.46E-05	8.94E-05	9.40E-05
^{99}Tc	7.83E-05	8.32E-05	8.79E-05	9.23E-05
^{101}Ru	7.60E-05	8.18E-05	8.75E-05	9.31E-05
^{103}Rh	4.08E-05	4.28E-05	4.46E-05	4.62E-05
^{109}Ag	7.62E-06	8.46E-06	9.29E-06	1.01E-05
^{143}Nd	5.56E-05	5.75E-05	5.90E-05	6.02E-05
^{145}Nd	4.49E-05	4.74E-05	4.98E-05	5.20E-05
^{147}Sm	1.18E-05	1.20E-05	1.21E-05	1.22E-05
^{149}Sm	2.21E-07	2.18E-07	2.15E-07	2.13E-07
^{150}Sm	1.97E-05	2.12E-05	2.25E-05	2.39E-05
^{151}Sm	9.50E-07	9.75E-07	9.98E-07	1.02E-06
^{152}Sm	7.28E-06	7.69E-06	8.07E-06	8.43E-06
^{151}Eu	3.89E-08	3.98E-08	4.07E-08	4.16E-08
^{153}Eu	7.96E-06	8.68E-06	9.35E-06	9.99E-06
^{155}Gd	2.36E-07	2.65E-07	2.93E-07	3.20E-07
^{233}U	1.60E-10	1.62E-10	1.64E-10	1.65E-10
^{234}U	5.85E-06	5.58E-06	5.33E-06	5.12E-06
^{235}U	2.72E-04	2.30E-04	1.93E-04	1.62E-04
^{236}U	1.88E-04	1.92E-04	1.94E-04	1.95E-04
^{238}U	2.16E-02	2.15E-02	2.14E-02	2.13E-02
^{237}Np	2.64E-05	2.85E-05	3.05E-05	3.22E-05
^{238}Pu	1.34E-05	1.58E-05	1.82E-05	2.07E-05
^{239}Pu	2.22E-04	2.23E-04	2.24E-04	2.24E-04
^{240}Pu	7.51E-05	7.97E-05	8.40E-05	8.78E-05
^{241}Pu	4.24E-05	4.47E-05	4.67E-05	4.83E-05
^{242}Pu	2.04E-05	2.38E-05	2.73E-05	3.08E-05
^{241}Am	1.44E-05	1.53E-05	1.60E-05	1.66E-05
^{242m}Am	6.95E-08	7.55E-08	8.05E-08	8.44E-08
^{243}Am	6.47E-06	7.98E-06	9.60E-06	1.13E-05

The isotopic concentrations presented in Tables 11 through 19 comprise the isotopic database for the 29 principal isotopes plus oxygen in the UO_2 fuel. The isotopic concentrations from these tables are compared to RCA and CRC data to confirm the bounding nature of the isotopic database. The comparisons are based on k_{eff} calculations using database concentrations and RCA concentrations or database concentrations and best-estimate concentrations for CRC statepoints (i.e., statepoints used in establishing CL values).

6.2 MCNP RESULTS

6.2.1 Confirmation of Isotopic Database Using RCA Data

BSC (2002) evaluated RCA data by placing the sample data in all nodes of all assemblies within a 21 PWR waste package. The resulting k_{eff} values are recorded in BSC (2002 pp. 89 through 91) along with k_{eff} values calculated using best-estimate isotopic concentrations. These values are reported in Table 20 along with the k_{eff} values calculated using isotopic database concentration values in the fuel material cards for the MCNP input files to replace RCA sample values and the best-estimate concentration values. Also, the material density was increased from 9.886 g/cm^3 to 10.741 g/cm^3. This density change is consistent with the density used in the bounding isotopic concentration calculations.

Section 2 of this report presents two requirements imposed in the Disposal Criticality Analysis Methodology Topical Report (YMP 2000, p. 3-43) to ensure that the isotopic concentrations used for burnup credit are conservative with respect to criticality. For the second requirement the k_{eff} values for waste package calculations with concentrations from the isotopic database must always be greater than the k_{eff} values obtained when using either measured (RCA) isotopic concentration values or best-estimate values. The last two columns of Table 20 present Δk_{eff} values for waste package calculations with concentrations from the isotopic database compared with waste package calculations with measured isotopic concentrations and best-estimate values. A positive value indicates a "bounded sample". That is to say that the k_{eff} value for the 21 PWR waste package containing the material concentrations from the isotopic database exceeds the k_{eff} value for the 21 PWR waste package containing the material concentrations based on the RCAs or best-estimate values. In all cases, except for one Mihama case and three Yankee Rowe cases, the isotopic database materials were bounding when compared to the RCAs. The isotopic database materials were bounding when compared to all of the best-estimate cases.

The Yankee Rowe cases include very unusual assembly designs. The Yankee Rowe assemblies are 18x18 assemblies that are cropped in two corners to facilitate control blades. The assemblies include only one instrument location and no guide tubes. Also, the fuel rods are clad with stainless steel, not with a zirconium-based material. This design creates a faster spectrum than a normal PWR.

Another oddity in the Yankee Rowe samples is that they are the only samples for which the ^{241}Pu concentrations were adjusted to represent the isotopic concentration at discharge (DOE 1997, p. 2-10). In other words, the measured ^{241}Pu concentration reported in the literature was "back-decayed" to the time of discharge. The isotopic database assumes a cooling time of five years. For ^{241}Pu (half-life = 14.4 years, [Parrington et. al. 1996]), this is a substantial decay time, and results in a much lower ^{241}Pu concentration.

Table 20. Comparison of RCA Samples to Isotopic Database Concentration in a 21 PWR Waste Package

MCNP Input File Name	RCA[a]		Best-Estimate[b] (BE)		Δk_{eff}[c]	Isotopic Database (ID)		Δk_{eff}[d]	Δk_{eff}[e]
	k_{eff}	σ	k_{eff}	σ	(BE–RCA)	k_{eff}	σ	(ID–RCA)	(ID–BE)
Tvs1	0.9694	0.0004	0.9680	0.0004	-0.0014	0.9793	0.0005	0.0099	0.0113
tvs2	0.9115	0.0004	0.9140	0.0004	0.0025	0.9268	0.0004	0.0153	0.0128
tvs3	0.9053	0.0004	0.9099	0.0004	0.0046	0.9241	0.0004	0.0188	0.0142
tvs4	0.9257	0.0004	0.9263	0.0005	0.0006	0.9408	0.0004	0.0151	0.0145
tvs5	0.9211	0.0004	0.9213	0.0005	0.0002	0.9356	0.0004	0.0145	0.0143
tvs6	0.8914	0.0004	0.8954	0.0004	0.0040	0.9077	0.0004	0.0163	0.0123
tvs7	0.8757	0.0004	0.8844	0.0004	0.0087	0.8965	0.0004	0.0208	0.0121
tvs8	0.8761	0.0004	0.8802	0.0004	0.0041	0.8949	0.0004	0.0188	0.0147
tvs9	0.8816	0.0004	0.8840	0.0004	0.0024	0.8972	0.0004	0.0156	0.0132
tvs10	0.8750	0.0004	0.8795	0.0004	0.0045	0.8938	0.0004	0.0188	0.0143
tvs11	0.8820	0.0004	0.8839	0.0004	0.0019	0.8961	0.0004	0.0141	0.0122
tvs12	0.8749	0.0004	0.8794	0.0005	0.0045	0.8950	0.0005	0.0201	0.0156
tvs13	0.8832	0.0004	0.8835	0.0004	0.0003	0.8943	0.0004	0.0111	0.0108
tvs14	0.8766	0.0004	0.8799	0.0004	0.0033	0.8952	0.0004	0.0186	0.0153
yrs1	0.7943	0.0004	0.7859	0.0004	-0.0084	0.8031	0.0004	0.0088	0.0172
yrs2	0.7667	0.0004	0.7461	0.0004	-0.0206	0.7633	0.0004	[-0.0034]	0.0172
yrs3	0.7639	0.0004	0.7436	0.0004	-0.0203	0.7619	0.0004	[-0.0020]	0.0183
yrs4	0.7848	0.0004	0.7712	0.0004	-0.0136	0.7912	0.0004	0.0064	0.0200
yrs5	0.7613	0.0004	0.7442	0.0004	-0.0171	0.7601	0.0004	[-0.0012]	0.0159
yrs6	0.7584	0.0004	0.7430	0.0004	-0.0154	0.7611	0.0004	0.0027	0.0181
yrs7	0.7267	0.0004	0.7356	0.0004	0.0089	0.7517	0.0004	0.0250	0.0161
yrs8	0.7260	0.0004	0.7345	0.0004	0.0085	0.7527	0.0004	0.0267	0.0182
tps3	0.8297	0.0007	0.8237	0.0007	-0.0060	0.9104	0.0006	0.0807	0.0867
tps4	0.8286	0.0007	0.8258	0.0007	-0.0028	0.9139	0.0007	0.0853	0.0881
ms1	1.0129	0.0007	1.0070	0.0008	-0.0059	1.0361	0.0007	0.0232	0.0291
ms2	1.0265	0.0007	1.0200	0.0008	-0.0065	1.0435	0.0007	0.0170	0.0235
ms3	0.9747	0.0007	0.9584	0.0007	-0.0163	0.9703	0.0006	[-0.0044]	0.0119
ms4	0.9362	0.0007	0.9201	0.0007	-0.0161	1.0027	0.0007	0.0665	0.0826
ms5	0.9766	0.0006	0.9647	0.0007	-0.0119	1.0045	0.0006	0.0279	0.0398
ms6	0.8738	0.0007	0.8552	0.0007	-0.0186	0.9373	0.0007	0.0635	0.0821
ms7	0.8666	0.0006	0.8416	0.0007	-0.0250	0.9250	0.0006	0.0584	0.0834
ms8	0.8313	0.0007	0.8300	0.0007	-0.0013	0.9189	0.0007	0.0876	0.0889
ms9	0.8399	0.0006	0.8383	0.0007	-0.0016	0.9132	0.0007	0.0733	0.0749
hbrs3	0.8418	0.0007	0.8336	0.0006	-0.0082	0.9212	0.0006	0.0794	0.0876

Notes:
a. RCA k_{eff} and σ values are taken from BSC (2002 pp. 89 through 91).
b. Best-Estimate (BE) k_{eff} and σ values are taken from BSC (2002 pp. 89 through 91).
c. $\Delta k_{eff} = k_{eff}$(Best-Estimate) - k_{eff}(RCA)
d. $\Delta k_{eff} = k_{eff}$(Isotopic Database) - k_{eff}(RCA)
e. $\Delta k_{eff} = k_{eff}$(Isotopic Database) - k_{eff}(Best-Estimate)

Because the reported RCA values for ^{241}Pu were for zero cooling time, the isotopic database concentrations for ^{241}Pu were back-decayed five years (the cooling time used to calculate the isotopic concentrations reported in the isotopic database). The k_{eff} values for Yankee Rowe reported in Table 20 are based on time of discharge ^{241}Pu concentrations. The back decay was performed using the equation listed below.

$$I = I_o \, e^{(-\lambda t)} \qquad \text{(Eq. 9)}$$

where:

I = Current isotopic concentration, from the isotopic database

I_o = The original isotopic concentration at the time 0 cooling

λ = The reciprocal of the half-life (14.4 y, Parrington et. al. 1996.)

t = The cooling time (5 y)

Plugging the values into the equation, and solving for the original isotopic concentration at discharge (I_o) gives the following equation.

$$I_o = I \, e^{\frac{5}{14.4}} \qquad \text{(Eq. 10)}$$

Table 21 contains the values for I and I_o for all eight Yankee Rowe Samples. Table 21 also includes the k_{eff} values for the calculations using I and I_o, and the corresponding Δk_{eff} values.

Table 21. Evaluation of the Effects of ^{241}Pu Decay Calculations

MCNP Input	I (10^{-5} atms/b·cm)	I_o (10^{-5} atms/b·cm)	Isotopic Database (Adjusted ^{241}Pu)		Isotopic Database (Unadjusted ^{241}Pu)		
			k_{eff}	σ	k_{eff}	σ	Δk_{eff} [a]
yr1b	1.079138E-05	1.527122E-05	0.8031	0.0004	0.8000	0.0004	0.0031
yr2b	2.547393E-05	3.604895E-05	0.7633	0.0004	0.7531	0.0003	0.0102
yr3b	2.626530E-05	3.716884E-05	0.7619	0.0004	0.7513	0.0004	0.0106
yr4b	1.537674E-05	2.176010E-05	0.7912	0.0004	0.7861	0.0004	0.0051
yr5b	2.685462E-05	3.800281E-05	0.7601	0.0004	0.7484	0.0004	0.0117
yr6b	2.633265E-05	3.726415E-05	0.7611	0.0004	0.7505	0.0004	0.0106
yr7b	3.006081E-05	4.253999E-05	0.7517	0.0004	0.7376	0.0004	0.0141
yr8b	2.954419E-05	4.180890E-05	0.7527	0.0004	0.7401	0.0004	0.0126

Notes:
[a] Δk_{eff} = k_{eff}(Adjusted ^{241}Pu) – k_{eff}(Unadjusted ^{241}Pu)

The data in Table 21 shows an increase in the k_{eff} values for the isotopic database when the ^{241}Pu effects are accounted for. However, the isotopic database approach fails to bound three of the Yankee Rowe samples.

In an attempt to resolve discrepancies in the failing Mihama sample, it was noted that the density for the fuel materials in the RCA waste package calculations was maintained at 9.886 g/cm^3. This value was used for all samples despite the variance in the actual fuel densities, and the exclusion of many isotopes from the model. Although this fixed density provides sufficient information for comparisons between k_{eff} values using RCA measured and k_{eff} values using RCA calculated, it does not provide adequate information for comparing k_{eff} values using RCA measured data to k_{eff} values for application (e.g. bounding model) calculations. Because the MCNP calculations for the RCA samples reported in BSC (2002) modeled the material constituents using the weight-percent option available in MCNP, the fixed density value results in incorrect isotopic concentrations. Assessing, in terms of k_{eff} in a waste package, the effect of the fixed density for all of the RCA samples requires recalculating all of the samples at a correct density. This is beyond the scope of the current calculation.

With the adjustments to the Yankee Rowe samples, all of the samples fall above a Δk_{eff} of -0.0045. This is well within the calculated bias and uncertainty value for RCA samples of -0.0259 (BSC 2003b, Section 6.2.2). With the proposed added bias and uncertainty applied to the CL (Δk_I discussed in Section 3.5.3.2.10 of YMP 2000), the RCA samples would be adequately bounded by the bounding approach presented in this report. Also, comparison of the k_{eff} values documented in Table 20 to the best-estimate k_{eff} values calculated in BSC (2002, pp. 89-91) demonstrates that the best-estimate k_{eff} values calculated in BSC (2002, pp. 89-91) are bounded by the isotopic database k_{eff} values presented in this report. Thus, requirement B discussed in Section 2 of this document and in Section 3.5.3.1.2 of YMP (2000) is satisfied.

6.2.2 Confirmation of Isotopic Database Using CRC Data

The CRCs have been previously evaluated using MCNP. The calculated k_{eff} values for the CRCs are documented in CRWMS M&O (1998e) and are not re-evaluated in this calculation. The comparison of CRC data is based on the best-estimate k_{eff} results reported in Table 4.1.1-1 in CRWMS M&O (1998e). The applicable k_{eff} values are listed in Table 22, along with the new values calculated using the isotopic database material compositions. For each cycle reported, the first k_{eff} and σ values are the original best-estimate CRC k_{eff} values taken from CRWMS M&O (1998e). Using the best-estimate CRC k_{eff} values identifies the full range of conservatism built into the isotopic database, including the conservatism resulting from the use of the principal isotopes instead of the entire best-estimate material description.

The revised MCNP input files are based on the actual MCNP input files taken from the CRC reactivity calculation reports (CRWMS M&O 1998c, CRWMS M&O 1998d, and Punatar 2001). For each evaluated assembly, the isotopic database concentrations replaced the CRC material data in the MCNP fuel material cards for all fuel nodes of the affected assembly. Also, the material density for each axial fuel node was changed to 10.741 g/cm^3. This density change is consistent with the density used in the bounding isotopic concentration calculations. Only one set of assembly fuel data was modified in each of the MCNP calculations reported in Table 22. The total number of affected assemblies in the entire core is listed in Table 22.

The data reported in Table 22 demonstrates that the isotopic database provides bounding material definitions for all tested assemblies. Because these assemblies are expected to be the most difficult to bound in the CRC database, this demonstrates that the isotopic database approach will bound the current CRC database. Thus, requirement A discussed in Section 2 of this document and in Section 3.5.3.1.2 of YMP (2000) is satisfied. However, additional confirmation should be performed using assemblies that may be bounding, but are not currently included in the CRC database (e.g. assemblies containing gadolinium rods). Also, it would be advisable to investigate the relative effect of the bounding model in a waste package, similar to the RCA confirmation calculations documented above. This may be accomplished by calculating k_{eff} values for the each assembly listed in Table 9 in a 21 PWR waste package. All 21 locations in the waste package could be filled with the same assembly using the best-estimate isotopic concentrations present in the CRC calculations. The calculations would then be repeated using the isotopic database isotopic concentrations. These “best-estimate” k_{eff} values could be compared to the “Isotopic Database” k_{eff} values to determine the level of relative conservatism.

Table 22. Comparison of CRCs to Isotopic Database Concentrations

Reactor	Cycle	Assembly	Number of Affected Assemblies	k_{eff}	σ	Δk_{eff}[a]
Sequoyah, Unit 2	Cycle 3			0.9918	0.0005	
		A06	4	0.9933	0.0005	0.0015
		B19	8	0.9954	0.0005	0.0036
		C04	4	0.9932	0.0005	0.0014
McGuire, Unit 1	Cycle 6			0.9877	0.0005	
		B25b	1	0.9895	0.0005	0.0019
	Cycle 7			0.9872	0.0005	
		E2	3	0.9895	0.0005	0.0023
		E14a	4	0.9908	0.0004	0.0036
		G2	4	0.9896	0.0005	0.0024
Crystal River, Unit 3	Cycle 1B			0.9950	0.0005	
		A26	4	0.9962	0.0004	0.0012
		O01	4	0.9963	0.0005	0.0013
	Cycle 3			0.9907	0.0005	
		A07	4	0.9922	0.0005	0.0015
	Cycle 10			0.9873	0.0005	
		I12a	4	0.9886	0.0005	0.0013
		I23	8	0.9917	0.0005	0.0044

Notes:
[a] $\Delta k_{eff} = k_{eff}$(Isotopic Database) - k_{eff}(CRC)

6.2.3 Confirmation of Isotopic Database Using Nominal Depletion Data

An arbitrary "nominal depletion" assembly has been previously evaluated using. The calculated k_{eff} values for the nominal depletion assembly in a 21 PWR Waste Package are documented in BSC 2003b and are not re-evaluated in this calculation. The comparison of nominal depletion assembly is based on the Principal Isotope k_{eff} results reported in Attachment III in BSC 2003b. The applicable k_{eff} values are listed in Table 23, along with the new values calculated using the isotopic database material compositions. The calculated Δk_{eff} values are shown in Figure 5. For each cycle reported, the first k_{eff} and σ values are the original Principal Isotope nominal depletion assembly k_{eff} values taken from BSC 2003b.

Table 23. Comparison of Nominal Depletion Assemblies to Isotopic Database Concentrations

MCNP File Name	Enrichment (wt% ^{235}U)	Burnup (GWd/mtU)	Nominal Depletion Assembly		Isotopic Database		Δk_{eff} [a]
			k_{eff}	σ	k_{eff}	σ	
wp310	3.0	10.0	0.95195	0.00052	0.97705	0.00115	0.02510
wp320	3.0	20.0	0.86272	0.00052	0.91071	0.00103	0.04799
wp330	3.0	30.0	0.78164	0.00048	0.85625	0.00114	0.07461
wp340	3.0	40.0	0.70346	0.00047	0.81149	0.00112	0.10803
wp410	4.0	10.0	1.02618	0.0006	1.0418	0.00106	0.01562
wp420	4.0	20.0	0.94854	0.00059	0.981	0.00107	0.03246
wp430	4.0	30.0	0.87029	0.00048	0.92069	0.00102	0.05040
wp440	4.0	40.0	0.79104	0.0005	0.86954	0.00105	0.07850
wp510	5.0	10.0	1.07907	0.0006	1.08671	0.00114	0.00764
wp520	5.0	20.0	1.01112	0.00057	1.02984	0.00124	0.01872
wp530	5.0	30.0	0.94252	0.00057	0.97383	0.00121	0.03131
wp540	5.0	40.0	0.86993	0.00056	0.92081	0.001	0.05088

Notes:
[a] $\Delta k_{eff} = k_{eff}$(Isotopic Database) - k_{eff}(nominal depletion assembly)

The MCNP input files are based on the actual 21 PWR Waste Package input files similar to the input files used in BSC 2003b. For each evaluated assembly, the isotopic database concentrations replaced the nominal depletion assembly material data in the MCNP fuel material cards. Also, the fuel material density was set to 10.741 g/cm^3. This density is consistent with the density used in the bounding isotopic concentration calculations. The fuel material definitions for all twenty-one assemblies in the 21 PWR Waste Package were modified in the MCNP calculations reported in Table 23.

Figure 5 shows the calculated Δk_{eff} relative to the calculated bias plus uncertainty for the CRCs (0.0068, BSC 2003b Table 5) and the lower limit and uncertainty for the RCAs (0.0259, BSC 2003b Table 9). Figure 5 indicates that the isotopic database bounding depletion model is conservative with respect to the arbitrary nominal depletion model for all three enrichments presented over the entire range of burnups presented. However, for 5.0 wt% with burnup values below 10.0 GWd/mtU, the calculated k_{eff} value may not meet the criteria for conservatism presented in BSC 2003b. The figure also demonstrates that the isotopic database bounding depletion model is conservative with respect to the calculated limit and uncertainty for the RCAs for 3.0 wt% with burnups greater than 11.7 GWd/mtU, 4.0 wt% with burnups greater than 21.3 GWd/mtU, and 5.0 wt% with burnups greater than 27.2 GWd/mtU.

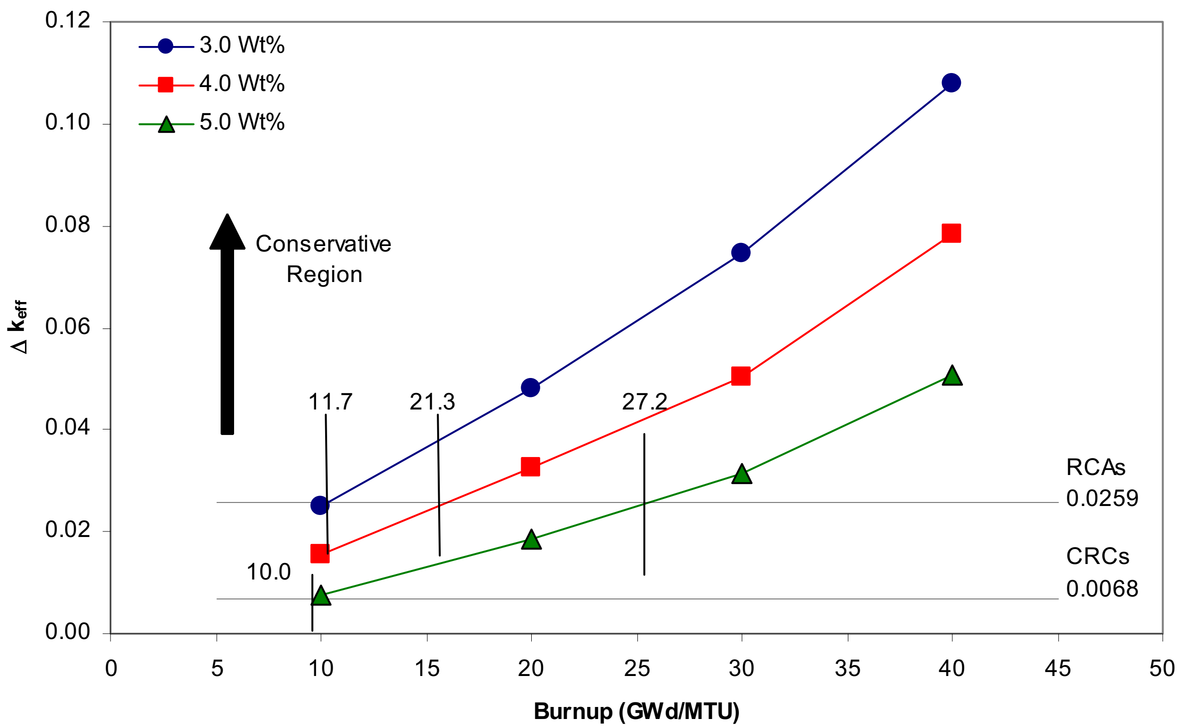

Figure 5. Comparison of Δk_{eff} for Isotopic Database versus Nominal Depletion

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8. ATTACHMENTS

Attachment 1: Attachment 1 contains the descriptions of the SAS2H and MCNP input and output files contained in Attachment 2

Attachment 2: Attachment 2 is a Compact Disk (CD) containing the SAS2H files listed in Table 24 and the MCNP files listed in Table 25.

Table 24. SAS2H Input and Output Files

File Name	File Size (bytes)	Date of Last Update	Time
e15bu001	925	28-Jan-03	6:59
e15bu001.output	294053	28-Jan-03	6:41
e15bu001.t72	24710	28-Jan-03	6:41
e15bu02.5	941	5-Feb-03	14:12
e15bu02.5.output	447921	5-Feb-03	14:15
e15bu02.5.t72	36313	5-Feb-03	14:15
e15bu05	942	28-Jan-03	6:41
e15bu05.output	738775	28-Jan-03	6:45
e15bu05.t72	57997	28-Jan-03	6:45
e15bu07.5	949	5-Feb-03	14:15
e15bu07.5.output	1028850	5-Feb-03	14:21
e15bu07.5.t72	79758	5-Feb-03	14:21
e15bu10	948	28-Jan-03	6:45
e15bu10.output	1175577	28-Jan-03	6:51
e15bu10.t72	90476	28-Jan-03	6:51
e15bu12.5	952	5-Feb-03	14:21
e15bu12.5.output	1467564	5-Feb-03	14:29
e15bu12.5.t72	111920	5-Feb-03	14:29
e15bu15	950	28-Jan-03	6:52
e15bu15.output	1757102	28-Jan-03	7:02
e15bu15.t72	133651	28-Jan-03	7:02
e15bu17.5	955	5-Feb-03	14:29
e15bu17.5.output	1904175	5-Feb-03	14:40
e15bu17.5.t72	144413	5-Feb-03	14:40
e15bu20	954	28-Jan-03	7:02
e15bu20.output	2194875	28-Jan-03	7:15

Table 24. SAS2H Input and Output Files (continued)

File Name	File Size (bytes)	Date of Last Update	Time
e15bu20.t72	165973	28-Jan-03	7:15
e15bu25	962	28-Jan-03	7:15
e15bu25.output	2632775	28-Jan-03	7:30
e15bu25.t72	198458	28-Jan-03	7:30
e15bu30	964	28-Jan-03	7:30
e15bu30.output	3214813	28-Jan-03	7:49
e15bu30.t72	241776	28-Jan-03	7:49
e15bu35	969	28-Jan-03	7:49
e15bu35.output	3647420	28-Jan-03	8:13
e15bu35.t72	274119	28-Jan-03	8:13
e15bu40	970	28-Jan-03	8:13
e15bu40.output	4083217	28-Jan-03	8:40
e15bu40.t72	306543	28-Jan-03	8:40
e15bu45	975	28-Jan-03	8:40
e15bu45.output	4665512	28-Jan-03	9:07
e15bu45.t72	349812	28-Jan-03	9:07
e15bu50	980	28-Jan-03	9:08
e15bu50.output	5102556	28-Jan-03	9:39
e15bu50.t72	382324	28-Jan-03	9:39
e15bu55	983	28-Jan-03	9:39
e15bu55.output	5538867	28-Jan-03	10:11
e15bu55.t72	414749	28-Jan-03	10:11
e15bu60	988	28-Jan-03	10:12
e15bu60.output	6118856	28-Jan-03	10:47
e15bu60.t72	458000	28-Jan-03	10:47
e15bu65	990	28-Jan-03	10:47
e15bu65.output	6551166	28-Jan-03	11:26
e15bu65.t72	490369	28-Jan-03	11:26
e15bu70	994	28-Jan-03	11:26
e15bu70.output	7133910	28-Jan-03	12:08
e15bu70.t72	533718	28-Jan-03	12:08
e15bu75	996	28-Jan-03	12:08
e15bu75.output	7571883	28-Jan-03	12:52
e15bu75.t72	566143	28-Jan-03	12:52
e20bu001	922	28-Jan-03	12:52

Table 24. SAS2H Input and Output Files (continued)

File Name	File Size (bytes)	Date of Last Update	Time
e20bu001.output	294914	28-Jan-03	12:54
e20bu001.t72	24638	28-Jan-03	12:54
e20bu02.5	938	5-Feb-03	14:40
e20bu02.5.output	447881	5-Feb-03	14:43
e20bu02.5.t72	36249	5-Feb-03	14:43
e20bu05	942	28-Jan-03	12:54
e20bu05.output	737879	28-Jan-03	12:58
e20bu05.t72	58073	28-Jan-03	12:58
e20bu07.5	948	5-Feb-03	14:43
e20bu07.5.output	1027900	5-Feb-03	14:48
e20bu07.5.t72	79626	5-Feb-03	14:48
e20bu10	949	28-Jan-03	12:53
e20bu10.output	1173473	28-Jan-03	13:05
e20bu10.t72	90535	28-Jan-03	13:05
e20bu12.5	953	5-Feb-03	14:49
e20bu12.5.output	1466055	5-Feb-03	14:57
e20bu12.5.t72	112012	5-Feb-03	14:57
e20bu15	951	28-Jan-03	13:05
e20bu15.output	1756187	28-Jan-03	13:15
e20bu15.t72	133662	28-Jan-03	13:15
e20bu17.5	955	5-Feb-03	14:57
e20bu17.5.output	1902170	5-Feb-03	15:08
e20bu17.5.t72	144433	5-Feb-03	15:08
e20bu20	957	28-Jan-03	13:15
e20bu20.output	2195016	28-Jan-03	13:27
e20bu20.t72	166017	28-Jan-03	13:27
e20bu25	959	28-Jan-03	13:28
e20bu25.output	2631418	28-Jan-03	13:42
e20bu25.t72	198508	28-Jan-03	13:42
e20bu30	964	28-Jan-03	13:43
e20bu30.output	3213249	28-Jan-03	14:01
e20bu30.t72	241682	28-Jan-03	14:01
e20bu35	968	28-Jan-03	14:01
e20bu35.output	3652452	28-Jan-03	14:22
e20bu35.t72	274115	28-Jan-03	14:22

Table 24. SAS2H Input and Output Files (continued)

File Name	File Size (bytes)	Date of Last Update	Time
e20bu40	969	28-Jan-03	14:22
e20bu40.output	4089687	28-Jan-03	14:46
e20bu40.t72	306458	28-Jan-03	14:46
e20bu45	975	28-Jan-03	14:46
e20bu45.output	4668409	28-Jan-03	15:13
e20bu45.t72	349714	28-Jan-03	15:13
e20bu50	981	28-Jan-03	15:13
e20bu50.output	5104065	28-Jan-03	15:44
e20bu50.t72	382218	28-Jan-03	15:44
e20bu55	982	28-Jan-03	15:44
e20bu55.output	5538919	28-Jan-03	16:17
e20bu55.t72	414684	28-Jan-03	16:17
e20bu60	987	28-Jan-03	16:17
e20bu60.output	6121062	28-Jan-03	16:53
e20bu60.t72	457778	28-Jan-03	16:53
e20bu65	988	28-Jan-03	16:53
e20bu65.output	6557075	28-Jan-03	17:31
e20bu65.t72	490244	28-Jan-03	17:31
e20bu70	993	28-Jan-03	17:31
e20bu70.output	39534805	28-Jan-03	18:13
e20bu70.t72	533418	28-Jan-03	18:13
e20bu75	995	28-Jan-03	18:13
e20bu75.output	7568818	28-Jan-03	18:58
e20bu75.t72	565818	28-Jan-03	18:58
e25bu001	923	28-Jan-03	18:58
e25bu001.output	294578	28-Jan-03	19:00
e25bu001.t72	24676	28-Jan-03	19:00
e25bu02.5	939	5-Feb-03	15:08
e25bu02.5.output	2478703	5-Feb-03	15:10
e25bu02.5.t72	36259	5-Feb-03	15:10
e25bu05	943	28-Jan-03	19:00
e25bu05.output	737023	28-Jan-03	19:04
e25bu05.t72	57914	28-Jan-03	19:04

Table 24. SAS2H Input and Output Files (continued)

File Name	File Size (bytes)	Date of Last Update	Time
e25bu07.5	950	5-Feb-03	15:10
e25bu07.5.output	1026120	5-Feb-03	15:16
e25bu07.5.t72	79691	5-Feb-03	15:16
e25bu10	949	28-Jan-03	19:04
e25bu10.output	6464258	28-Jan-03	19:10
e25bu10.t72	90538	28-Jan-03	19:10
e25bu12.5	954	5-Feb-03	15:16
e25bu12.5.output	1462783	5-Feb-03	15:24
e25bu12.5.t72	112018	5-Feb-03	15:24
e25bu15	954	28-Jan-03	19:11
e25bu15.output	1754542	28-Jan-03	19:20
e25bu15.t72	133755	28-Jan-03	19:20
e25bu17.5	956	5-Feb-03	15:24
e25bu17.5.output	1901837	5-Feb-03	15:35
e25bu17.5.t72	144487	5-Feb-03	15:35
e25bu20	958	28-Jan-03	19:20
e25bu20.output	2193867	28-Jan-03	19:33
e25bu20.t72	166010	28-Jan-03	19:33
e25bu25	959	28-Jan-03	19:33
e25bu25.output	2633090	28-Jan-03	19:48
e25bu25.t72	198562	28-Jan-03	19:48
e25bu30	965	28-Jan-03	19:48
e25bu30.output	3215070	28-Jan-03	20:06
e25bu30.t72	241833	28-Jan-03	20:06
e25bu35	968	28-Jan-03	20:07
e25bu35.output	3654364	28-Jan-03	20:27
e25bu35.t72	274217	28-Jan-03	20:27
e25bu40	970	28-Jan-03	20:28
e25bu40.output	4091646	28-Jan-03	20:51
e25bu40.t72	306617	28-Jan-03	20:51
e25bu45	976	28-Jan-03	20:51
e25bu45.output	4672530	28-Jan-03	21:18
e25bu45.t72	349835	28-Jan-03	21:18

Table 24. SAS2H Input and Output Files (continued)

File Name	File Size (bytes)	Date of Last Update	Time
e25bu50	980	28-Jan-03	21:18
e25bu50.output	5111199	28-Jan-03	21:47
e25bu50.t72	382365	28-Jan-03	21:47
e25bu55	984	28-Jan-03	21:48
e25bu55.output	5544885	28-Jan-03	22:20
e25bu55.t72	414824	28-Jan-03	22:20
e25bu60	988	28-Jan-03	22:20
e25bu60.output	6126322	28-Jan-03	22:56
e25bu60.t72	458085	28-Jan-03	22:56
e25bu65	989	28-Jan-03	22:56
e25bu65.output	6563279	28-Jan-03	23:35
e25bu65.t72	490653	28-Jan-03	23:35
e25bu70	993	28-Jan-03	23:35
e25bu70.output	7140142	29-Jan-03	0:19
e25bu70.t72	533946	29-Jan-03	0:19
e25bu75	996	29-Jan-03	0:19
e25bu75.output	7570946	29-Jan-03	1:04
e25bu75.t72	566395	29-Jan-03	1:04
e30bu001	924	27-Jan-03	8:10
e30bu001.output	293911	27-Jan-03	8:12
e30bu001.t72	121986	27-Jan-03	8:12
e30bu02.5	940	5-Feb-03	15:36
e30bu02.5.output	447400	5-Feb-03	15:38
e30bu02.5.t72	36250	5-Feb-03	15:38
e30bu05	941	27-Jan-03	8:12
e30bu05.output	736512	27-Jan-03	8:16
e30bu05.t72	57873	27-Jan-03	8:16
e30bu07.5	948	5-Feb-03	15:38
e30bu07.5.output	1027466	5-Feb-03	15:44
e30bu07.5.t72	79500	5-Feb-03	15:44
e30bu10	947	27-Jan-03	8:16
e30bu10.output	1172195	27-Jan-03	8:22
e30bu10.t72	90395	27-Jan-03	8:22
e30bu12.5	953	5-Feb-03	15:44
e30bu12.5.output	1463973	5-Feb-03	15:52

Table 24. SAS2H Input and Output Files (continued)

File Name	File Size (bytes)	Date of Last Update	Time
e30bu12.5.t72	111867	5-Feb-03	15:52
e30bu15	951	27-Jan-03	8:23
e30bu15.output	1754590	27-Jan-03	8:32
e30bu15.t72	133526	27-Jan-03	8:32
e30bu17.5	955	5-Feb-03	15:52
e30bu17.5.output	1900523	5-Feb-03	16:03
e30bu17.5.t72	144228	5-Feb-03	16:03
e30bu20	958	27-Jan-03	8:32
e30bu20.output	2191494	27-Jan-03	8:45
e30bu20.t72	165855	27-Jan-03	8:45
e30bu25	961	27-Jan-03	8:45
e30bu25.output	2629262	27-Jan-03	9:00
e30bu25.t72	198351	27-Jan-03	9:00
e30bu30	961	27-Jan-03	9:00
e30bu30.output	3213447	27-Jan-03	9:18
e30bu30.t72	241577	27-Jan-03	9:18
e30bu35	967	27-Jan-03	9:18
e30bu35.output	3652168	27-Jan-03	9:39
e30bu35.t72	274023	27-Jan-03	9:39
e30bu40	969	27-Jan-03	9:39
e30bu40.output	4089571	27-Jan-03	10:02
e30bu40.t72	306447	27-Jan-03	10:02
e30bu45	975	27-Jan-03	10:02
e30bu45.output	4670805	27-Jan-03	10:29
e30bu45.t72	349722	27-Jan-03	10:29
e30bu50	980	27-Jan-03	10:29
e30bu50.output	5108800	27-Jan-03	10:59
e30bu50.t72	382206	27-Jan-03	10:59
e30bu55	981	27-Jan-03	11:00
e30bu55.output	5542534	27-Jan-03	11:31
e30bu55.t72	414660	27-Jan-03	11:31
e30bu60	987	27-Jan-03	11:32
e30bu60.output	6126208	27-Jan-03	12:07
e30bu60.t72	457940	27-Jan-03	12:07
e30bu65	987	27-Jan-03	12:07

Table 24. SAS2H Input and Output Files (continued)

File Name	File Size (bytes)	Date of Last Update	Time
e30bu65.output	6565620	27-Jan-03	12:45
e30bu65.t72	490349	27-Jan-03	12:45
e30bu70	992	27-Jan-03	12:45
e30bu70.output	7143549	27-Jan-03	13:30
e30bu70.t72	533658	27-Jan-03	13:30
e30bu75	994	27-Jan-03	13:30
e30bu75.output	7580928	27-Jan-03	14:14
e30bu75.t72	566111	27-Jan-03	14:14
e35bu001	923	27-Jan-03	14:15
e35bu001.output	295065	27-Jan-03	14:16
e35bu001.t72	24711	27-Jan-03	14:16
e35bu02.5	939	5-Feb-03	16:03
e35bu02.5.output	447402	5-Feb-03	16:06
e35bu02.5.t72	36273	5-Feb-03	16:06
e35bu05	941	27-Jan-03	14:16
e35bu05.output	737357	27-Jan-03	14:20
e35bu05.t72	57984	27-Jan-03	14:20
e35bu07.5	948	5-Feb-03	16:06
e35bu07.5.output	1025861	5-Feb-03	16:12
e35bu07.5.t72	79667	5-Feb-03	16:12
e35bu10	947	27-Jan-03	14:20
e35bu10.output	1173718	27-Jan-03	14:27
e35bu10.t72	90492	27-Jan-03	14:27
e35bu12.5	953	5-Feb-03	16:12
e35bu12.5.output	1463038	5-Feb-03	16:20
e35bu12.5.t72	111987	5-Feb-03	16:20
e35bu15	951	27-Jan-03	14:27
e35bu15.output	1755830	27-Jan-03	14:37
e35bu15.t72	133722	27-Jan-03	14:37
e35bu17.5	955	5-Feb-03	16:20
e35bu17.5.output	1901931	5-Feb-03	16:31
e35bu17.5.t72	144421	5-Feb-03	16:31
e35bu20	957	27-Jan-03	14:37
e35bu20.output	2195183	27-Jan-03	14:49
e35bu20.t72	165903	27-Jan-03	14:49

Table 24. SAS2H Input and Output Files (continued)

File Name	File Size (bytes)	Date of Last Update	Time
e35bu25	960	27-Jan-03	14:50
e35bu25.output	2633198	27-Jan-03	15:05
e35bu25.t72	198372	27-Jan-03	15:05
e35bu30	960	27-Jan-03	15:06
e35bu30.output	3215591	27-Jan-03	15:24
e35bu30.t72	241528	27-Jan-03	15:24
e35bu35	966	27-Jan-03	15:24
e35bu35.output	3654515	27-Jan-03	15:44
e35bu35.t72	273961	27-Jan-03	15:44
e35bu40	969	27-Jan-03	15:45
e35bu40.output	4090177	27-Jan-03	16:08
e35bu40.t72	306486	27-Jan-03	16:08
e35bu45	975	27-Jan-03	16:08
e35bu45.output	4673634	27-Jan-03	16:34
e35bu45.t72	349765	27-Jan-03	16:34
e35bu50	979	27-Jan-03	16:35
e35bu50.output	5112370	27-Jan-03	17:04
e35bu50.t72	382128	27-Jan-03	17:04
e35bu55	981	27-Jan-03	17:04
e35bu55.output	5548463	27-Jan-03	17:36
e35bu55.t72	414562	27-Jan-03	17:36
e35bu60	987	27-Jan-03	17:36
e35bu60.output	6131290	27-Jan-03	18:12
e35bu60.t72	457829	27-Jan-03	18:12
e35bu65	987	27-Jan-03	18:12
e35bu65.output	6566102	27-Jan-03	18:50
e35bu65.t72	490356	27-Jan-03	18:50
e35bu70	993	27-Jan-03	18:50
e35bu70.output	7146973	27-Jan-03	19:31
e35bu70.t72	533625	27-Jan-03	19:31
e35bu75	995	27-Jan-03	19:31
e35bu75.output	7586701	27-Jan-03	20:16
e35bu75.t72	566158	27-Jan-03	20:16
e40bu001	919	29-Jan-03	15:33
e40bu001.output	294431	29-Jan-03	15:35

Table 24. SAS2H Input and Output Files (continued)

File Name	File Size (bytes)	Date of Last Update	Time
e40bu001.t72	24653	29-Jan-03	15:35
e40bu02.5	937	5-Feb-03	16:31
e40bu02.5.output	447355	5-Feb-03	16:34
e40bu02.5.t72	36317	5-Feb-03	16:34
e40bu05	941	29-Jan-03	15:35
e40bu05.output	737008	29-Jan-03	15:41
e40bu05.t72	58041	29-Jan-03	15:41
e40bu07.5	946	5-Feb-03	16:34
e40bu07.5.output	1025838	5-Feb-03	16:40
e40bu07.5.t72	79790	5-Feb-03	16:40
e40bu10	946	29-Jan-03	15:41
e40bu10.output	1173675	29-Jan-03	15:50
e40bu10.t72	90585	29-Jan-03	15:50
e40bu12.5	952	5-Feb-03	16:40
e40bu12.5.output	1463617	5-Feb-03	16:48
e40bu12.5.t72	112126	5-Feb-03	16:48
e40bu15	950	29-Jan-03	15:50
e40bu15.output	1754626	29-Jan-03	16:02
e40bu15.t72	133773	29-Jan-03	16:02
e40bu17.5	953	5-Feb-03	16:48
e40bu17.5.output	1901609	5-Feb-03	16:59
e40bu17.5.t72	144564	5-Feb-03	16:59
e40bu20	957	29-Jan-03	16:02
e40bu20.output	2194309	29-Jan-03	16:18
e40bu20.t72	166143	29-Jan-03	16:18
e40bu25	959	29-Jan-03	16:18
e40bu25.output	2634592	29-Jan-03	16:35
e40bu25.t72	198548	29-Jan-03	16:35
e40bu30	960	29-Jan-03	16:35
e40bu30.output	3220121	29-Jan-03	16:53
e40bu30.t72	241770	29-Jan-03	16:53
e40bu35	966	29-Jan-03	16:54
e40bu35.output	3658025	29-Jan-03	17:14
e40bu35.t72	274240	29-Jan-03	17:14

Table 24. SAS2H Input and Output Files (continued)

File Name	File Size (bytes)	Date of Last Update	Time
e40bu40	967	29-Jan-03	17:14
e40bu40.output	4096472	29-Jan-03	17:37
e40bu40.t72	306625	29-Jan-03	17:37
e40bu45	972	29-Jan-03	17:38
e40bu45.output	4681035	29-Jan-03	18:04
e40bu45.t72	349941	29-Jan-03	18:04
e40bu50	978	29-Jan-03	18:04
e40bu50.output	5114492	29-Jan-03	18:33
e40bu50.t72	382407	29-Jan-03	18:33
e40bu55	981	29-Jan-03	18:34
e40bu55.output	5554128	29-Jan-03	19:05
e40bu55.t72	414790	29-Jan-03	19:05
e40bu60	985	29-Jan-03	19:05
e40bu60.output	6136588	29-Jan-03	19:41
e40bu60.t72	457939	29-Jan-03	19:41
e40bu65	986	29-Jan-03	19:41
e40bu65.output	6575715	29-Jan-03	20:18
e40bu65.t72	490460	29-Jan-03	20:18
e40bu70	990	29-Jan-03	20:19
e40bu70.output	7160914	29-Jan-03	21:00
e40bu70.t72	533911	29-Jan-03	21:00
e40bu75	993	29-Jan-03	21:00
e40bu75.output	7598076	29-Jan-03	21:44
e40bu75.t72	566425	29-Jan-03	21:44
e45bu001	921	29-Jan-03	21:44
e45bu001.output	295533	29-Jan-03	21:46
e45bu001.t72	24646	29-Jan-03	21:46
e45bu02.5	940	5-Feb-03	16:59
e45bu02.5.output	447364	5-Feb-03	17:02
e45bu02.5.t72	36237	5-Feb-03	17:02
e45bu05	942	29-Jan-03	21:46
e45bu05.output	737668	29-Jan-03	21:50
e45bu05.t72	57932	29-Jan-03	21:50

Table 24. SAS2H Input and Output Files (continued)

File Name	File Size (bytes)	Date of Last Update	Time
e45bu07.5	949	5-Feb-03	17:02
e45bu07.5.output	1026036	5-Feb-03	17:08
e45bu07.5.t72	79596	5-Feb-03	17:08
e45bu10	948	29-Jan-03	21:50
e45bu10.output	1173355	29-Jan-03	21:57
e45bu10.t72	90385	29-Jan-03	21:57
e45bu12.5	954	5-Feb-03	17:08
e45bu12.5.output	1462129	5-Feb-03	17:16
e45bu12.5.t72	111940	5-Feb-03	17:16
e45bu15	953	29-Jan-03	21:57
e45bu15.output	1755346	29-Jan-03	22:07
e45bu15.t72	133669	29-Jan-03	22:07
e45bu17.5	956	5-Feb-03	17:16
e45bu17.5.output	1902339	5-Feb-03	17:27
e45bu17.5.t72	144420	5-Feb-03	17:27
e45bu20	958	29-Jan-03	22:07
e45bu20.output	2195110	29-Jan-03	22:19
e45bu20.t72	165934	29-Jan-03	22:19
e45bu25	960	29-Jan-03	22:19
e45bu25.output	2634372	29-Jan-03	22:34
e45bu25.t72	198365	29-Jan-03	22:34
e45bu30	964	29-Jan-03	22:34
e45bu30.output	3222223	29-Jan-03	22:52
e45bu30.t72	241525	29-Jan-03	22:52
e45bu35	967	29-Jan-03	22:52
e45bu35.output	3660310	29-Jan-03	23:13
e45bu35.t72	273931	29-Jan-03	23:13
e45bu40	969	29-Jan-03	23:13
e45bu40.output	4098523	29-Jan-03	23:36
e45bu40.t72	306326	29-Jan-03	23:36
e45bu45	974	29-Jan-03	23:36
e45bu45.output	4683001	30-Jan-03	0:03
e45bu45.t72	349561	30-Jan-03	0:03
e45bu50	980	30-Jan-03	0:03
e45bu50.output	5112870	30-Jan-03	0:32

Table 24. SAS2H Input and Output Files (continued)

File Name	File Size (bytes)	Date of Last Update	Time
e45bu50.t72	381945	30-Jan-03	0:32
e45bu55	983	30-Jan-03	0:32
e45bu55.output	5550583	30-Jan-03	1:04
e45bu55.t72	414379	30-Jan-03	1:04
e45bu60	987	30-Jan-03	1:04
e45bu60.output	6131505	30-Jan-03	1:40
e45bu60.t72	457609	30-Jan-03	1:40
e45bu65	989	30-Jan-03	1:40
e45bu65.output	6572341	30-Jan-03	2:18
e45bu65.t72	490042	30-Jan-03	2:18
e45bu70	993	30-Jan-03	2:18
e45bu70.output	7157580	30-Jan-03	2:59
e45bu70.t72	533449	30-Jan-03	2:59
e45bu75	996	30-Jan-03	2:59
e45bu75.output	7586127	30-Jan-03	3:43
e45bu75.t72	565934	30-Jan-03	3:43
e50bu001	922	30-Jan-03	3:44
e50bu001.output	294492	30-Jan-03	3:45
e50bu001.t72	24636	30-Jan-03	3:45
e50bu02.5	940	5-Feb-03	17:27
e50bu02.5.output	447492	5-Feb-03	17:30
e50bu02.5.t72	36228	5-Feb-03	17:30
e50bu05	943	30-Jan-03	3:45
e50bu05.output	735671	30-Jan-03	3:50
e50bu05.t72	58004	30-Jan-03	3:50
e50bu07.5	948	5-Feb-03	17:30
e50bu07.5.output	1025543	5-Feb-03	17:36
e50bu07.5.t72	79651	5-Feb-03	17:36
e50bu10	947	30-Jan-03	3:50
e50bu10.output	1170724	30-Jan-03	3:56
e50bu10.t72	90428	30-Jan-03	3:56
e50bu12.5	954	5-Feb-03	17:36
e50bu12.5.output	1462814	5-Feb-03	17:45
e50bu12.5.t72	112056	5-Feb-03	17:45

Table 24. SAS2H Input and Output Files (continued)

File Name	File Size (bytes)	Date of Last Update	Time
e50bu15	952	30-Jan-03	3:56
e50bu15.output	1754892	30-Jan-03	4:06
e50bu15.t72	133735	30-Jan-03	4:06
e50bu17.5	955	5-Feb-03	17:45
e50bu17.5.output	1903231	5-Feb-03	17:55
e50bu17.5.t72	144539	5-Feb-03	17:55
e50bu20	958	30-Jan-03	4:06
e50bu20.output	2195636	30-Jan-03	4:19
e50bu20.t72	650592	30-Jan-03	4:19
e50bu25	961	30-Jan-03	4:19
e50bu25.output	2635337	30-Jan-03	4:34
e50bu25.t72	772578	30-Jan-03	4:34
e50bu30	962	30-Jan-03	4:34
e50bu30.output	3222105	30-Jan-03	4:52
e50bu30.t72	935226	30-Jan-03	4:52
e50bu35	968	30-Jan-03	4:52
e50bu35.output	3656610	30-Jan-03	5:13
e50bu35.t72	1057212	30-Jan-03	5:13
e50bu40	969	30-Jan-03	5:13
e50bu40.output	4096162	30-Jan-03	5:37
e50bu40.t72	306640	30-Jan-03	5:37
e50bu45	975	30-Jan-03	5:37
e50bu45.output	4679175	30-Jan-03	6:04
e50bu45.t72	349847	30-Jan-03	6:04
e50bu50	979	30-Jan-03	6:04
e50bu50.output	5116955	30-Jan-03	6:33
e50bu50.t72	382309	30-Jan-03	6:33
e50bu55	982	30-Jan-03	6:33
e50bu55.output	5556191	30-Jan-03	7:11
e50bu55.t72	414548	30-Jan-03	7:11
e50bu60	987	30-Jan-03	7:11
e50bu60.output	6142786	30-Jan-03	7:49
e50bu60.t72	457853	30-Jan-03	7:49
e50bu65	989	30-Jan-03	7:49
e50bu65.output	6574431	30-Jan-03	8:27

Table 24. SAS2H Input and Output Files (continued)

File Name	File Size (bytes)	Date of Last Update	Time
e50bu65.t72	490395	30-Jan-03	8:27
e50bu70	993	30-Jan-03	8:27
e50bu70.output	7155611	30-Jan-03	9:09
e50bu70.t72	533691	30-Jan-03	9:09
e50bu75	995	30-Jan-03	9:09
e50bu75.output	7598686	30-Jan-03	9:55
e50bu75.t72	566119	30-Jan-03	9:55
e55bu001	923	30-Jan-03	9:56
e55bu001.output	294860	30-Jan-03	9:57
e55bu001.t72	24658	30-Jan-03	9:57
e55bu02.5	942	5-Feb-03	17:56
e55bu02.5.output	446966	5-Feb-03	17:58
e55bu02.5.t72	36264	5-Feb-03	17:58
e55bu05	944	30-Jan-03	9:57
e55bu05.output	735325	30-Jan-03	10:02
e55bu05.t72	57876	30-Jan-03	10:02
e55bu07.5	950	5-Feb-03	17:58
e55bu07.5.output	1024791	5-Feb-03	18:04
e55bu07.5.t72	79581	5-Feb-03	18:04
e55bu10	949	30-Jan-03	10:02
e55bu10.output	1171494	30-Jan-03	10:10
e55bu10.t72	90409	30-Jan-03	10:10
e55bu12.5	954	5-Feb-03	18:04
e55bu12.5.output	1461566	5-Feb-03	18:12
e55bu12.5.t72	112009	5-Feb-03	18:12
e55bu15	953	30-Jan-03	10:10
e55bu15.output	1755258	30-Jan-03	10:21
e55bu15.t72	133723	30-Jan-03	10:21
e55bu17.5	955	5-Feb-03	18:13
e55bu17.5.output	1902358	5-Feb-03	18:24
e55bu17.5.t72	144529	5-Feb-03	18:24
e55bu20	958	30-Jan-03	10:21
e55bu20.output	2194836	30-Jan-03	10:34
e55bu20.t72	166052	30-Jan-03	10:34

Table 24. SAS2H Input and Output Files (continued)

File Name	File Size (bytes)	Date of Last Update	Time
e55bu25	961	30-Jan-03	10:34
e55bu25.output	2634742	30-Jan-03	10:49
e55bu25.t72	198481	30-Jan-03	10:49
e55bu30	963	30-Jan-03	10:49
e55bu30.output	3218416	30-Jan-03	11:10
e55bu30.t72	241703	30-Jan-03	11:10
e55bu35	968	30-Jan-03	11:10
e55bu35.output	3656422	30-Jan-03	11:32
e55bu35.t72	274108	30-Jan-03	11:32
e55bu40	970	30-Jan-03	11:32
e55bu40.output	4096653	30-Jan-03	11:55
e55bu40.t72	306590	30-Jan-03	11:55
e55bu45	976	30-Jan-03	11:55
e55bu45.output	4681303	30-Jan-03	12:22
e55bu45.t72	349884	30-Jan-03	12:22
e55bu50	979	30-Jan-03	12:22
e55bu50.output	5121982	30-Jan-03	12:52
e55bu50.t72	382306	30-Jan-03	12:52
e55bu55	983	30-Jan-03	12:52
e55bu55.output	5556381	30-Jan-03	13:26
e55bu55.t72	414697	30-Jan-03	13:26
e55bu60	987	30-Jan-03	13:26
e55bu60.output	6139000	30-Jan-03	14:02
e55bu60.t72	457908	30-Jan-03	14:02
e55bu65	989	30-Jan-03	14:02
e55bu65.output	6583819	30-Jan-03	14:40
e55bu65.t72	490369	30-Jan-03	14:40
e55bu70	993	30-Jan-03	14:40
e55bu70.output	7163171	30-Jan-03	15:22
e55bu70.t72	533727	30-Jan-03	15:22
e55bu75	996	30-Jan-03	15:22
e55bu75.output	7600454	30-Jan-03	16:06
e55bu75.t72	566217	30-Jan-03	16:06

Table 25. MCNP Input and Output Files

File Name	File Size (bytes)	Date of Last Update	Time
hbrs3	9831	10-Feb-03	13:59
hbrs3.out	314147	11-Feb-03	0:14
ms1	10167	10-Feb-03	15:11
ms1.out	320228	10-Feb-03	23:19
ms2	10136	11-Feb-03	14:30
ms2.out	320555	12-Feb-03	11:47
ms3	10136	11-Feb-03	14:30
ms3.out	318685	11-Feb-03	20:43
ms4	10105	11-Feb-03	14:29
ms4.out	320106	12-Feb-03	13:05
ms5	10136	11-Feb-03	14:29
ms5.out	320757	12-Feb-03	23:53
ms6	10043	11-Feb-03	14:29
ms6.out	319063	12-Feb-03	23:45
ms7	10198	10-Feb-03	15:28
ms7.out	321841	11-Feb-03	20:45
ms8	10198	10-Feb-03	15:32
ms8.out	320897	12-Feb-03	13:23
ms9	10198	10-Feb-03	15:34
ms9.out	323010	12-Feb-03	19:38
tps3	9894	10-Feb-03	13:56
tps3.out	316092	10-Feb-03	21:49
tps4	9894	10-Feb-03	13:56

Table 25. MCNP Input and Output Files (continued)

File Name	File Size (bytes)	Date of Last Update	Time
tps4.out	316189	11-Feb-03	2:32
tvs1	14943	13-Feb-03	7:43
tvs1.out	536582	13-Feb-03	10:12
tvs10	15106	13-Feb-03	15:55
tvs10.out	539648	14-Feb-03	17:48
tvs11	15106	13-Feb-03	15:56
tvs11.out	539960	14-Feb-03	12:18
tvs12	15106	13-Feb-03	15:57
tvs12.out	539860	14-Feb-03	12:16
tvs13	15044	13-Feb-03	15:59
tvs13.out	538532	14-Feb-03	11:05
tvs14	15013	13-Feb-03	15:28
tvs14.out	537942	14-Feb-03	7:56
tvs2	14951	13-Feb-03	15:39
tvs2.out	536826	14-Feb-03	12:53
tvs3	14951	13-Feb-03	15:40
tvs3.out	535350	14-Feb-03	12:52
tvs4	14951	13-Feb-03	15:40
tvs4.out	535626	14-Feb-03	13:14
tvs5	14951	13-Feb-03	15:41
tvs5.out	535626	14-Feb-03	13:17
tvs6	15106	13-Feb-03	15:48
tvs6.out	541156	14-Feb-03	22:35
tvs7	15106	13-Feb-03	15:51
tvs7.out	542632	14-Feb-03	22:30
tvs8	15106	13-Feb-03	15:52
tvs8.out	542632	14-Feb-03	22:32
tvs9	15044	13-Feb-03	15:54
tvs9.out	538596	14-Feb-03	22:05
yrs1	15626	10-Feb-03	12:49
yrs1.out	541954	11-Feb-03	5:17
yrs1b	15660	24-Feb-03	15:59
yrs1b.out	541954	25-Feb-03	10:40

Table 25. MCNP Input and Output Files (continued)

File Name	File Size (bytes)	Date of Last Update	Time
yrs2	15626	10-Feb-03	13:06
yrs2.out	541954	11-Feb-03	6:07
yrs2a	15674	19-Feb-03	9:06
yrs2a.out	541642	19-Feb-03	12:42
yrs2b	15660	24-Feb-03	16:00
yrs2b.out	541954	25-Feb-03	10:40
yrs3	15626	10-Feb-03	13:06
yrs3.out	541954	12-Feb-03	16:55
yrs3b	15660	24-Feb-03	16:01
yrs3b.out	541954	25-Feb-03	10:43
yrs4	15626	10-Feb-03	13:06
yrs4.out	541954	12-Feb-03	19:56
yrs4b	15660	24-Feb-03	16:01
yrs4b.out	541954	25-Feb-03	10:43
yrs5	15626	10-Feb-03	13:05
yrs5.out	541954	13-Feb-03	3:45
yrs5b	15660	24-Feb-03	16:01
yrs5b.out	541954	25-Feb-03	10:43
yrs6	15626	10-Feb-03	13:04
yrs6.out	541954	13-Feb-03	3:44
yrs6b	15660	24-Feb-03	16:02
yrs6b.out	541954	25-Feb-03	19:12
yrs7	15632	14-Feb-03	14:39
yrs7.out	541642	14-Feb-03	20:59
yrs7b	15666	24-Feb-03	16:02
yrs7b.out	541954	25-Feb-03	19:04
yrs8	15632	14-Feb-03	14:39
yrs8.out	540442	18-Feb-03	11:32
yrs8b	15666	24-Feb-03	16:02
yrs8b.out	544938	25-Feb-03	10:59
cr33l12a	1765818	20-Feb-03	16:25
cr33l12a.out	14145159	21-Feb-03	23:08
cr33l23	1765818	20-Feb-03	16:26

Table 25. MCNP Input and Output Files (continued)

File Name	File Size (bytes)	Date of Last Update	Time
cr33I23.out	14149037	21-Feb-03	21:43
cr3A26	1758401	20-Feb-03	16:22
cr3A26.out	13806776	21-Feb-03	20:43
cr3O01	1758385	26-Feb-03	11:28
cr3O01.out	13801986	26-Feb-03	19:08
cr7A07	1674438	20-Feb-03	16:23
cr7A07.out	13576308	21-Feb-03	21:07
mg3B25b	1614573	20-Feb-03	14:36
mg3B25b.out	67973328	21-Feb-03	17:40
mg6E02	1817828	20-Feb-03	14:39
mg6E02.out	2.04E+08	25-Feb-03	23:17
mg6E14a	1817949	26-Feb-03	13:58
mg6E14a.out	2.04E+08	26-Feb-03	19:37
mg6G02	1819082	20-Feb-03	14:40
mg6G02.out	2.04E+08	26-Feb-03	13:39
seq3A06	1788628	20-Feb-03	10:36
seq3A06.out	14976160	20-Feb-03	15:28
seq3B19	1788945	20-Feb-03	10:35
seq3B19.out	14983620	21-Feb-03	4:19
seq3C04	1791308	20-Feb-03	10:34
seq3C04.out	14994254	21-Feb-03	16:53
wp01	23817	9-Jun-03	14:02
wp310	24620	9-Jun-03	14:16
wp310.out	505729	9-Jun-03	17:13
wp320	24620	9-Jun-03	14:16
wp320.out	505730	9-Jun-03	17:17
wp330	24620	9-Jun-03	14:16
wp330.out	505778	9-Jun-03	17:18
wp340	24620	9-Jun-03	14:16
wp340.out	504625	9-Jun-03	17:01
wp410	24620	9-Jun-03	14:17
wp410.out	505057	9-Jun-03	17:00

Table 25. MCNP Input and Output Files (continued)

File Name	File Size (bytes)	Date of Last Update	Time
wp420	24620	9-Jun-03	14:17
wp420.out	505154	9-Jun-03	17:00
wp430	24620	9-Jun-03	14:17
wp430.out	503798	9-Jun-03	17:00
wp440	24620	9-Jun-03	14:17
wp440.out	503960	9-Jun-03	16:59
wp510	24620	9-Jun-03	14:17
wp510.out	505154	10-Jun-03	8:31
wp520	24620	9-Jun-03	14:17
wp520.out	505057	10-Jun-03	8:31
wp530	24620	9-Jun-03	14:18
wp530.out	505730	10-Jun-03	9:18
wp540	24620	9-Jun-03	14:18
wp540.out	503404	10-Jun-03	9:21

ATTACHMENT 1

This attachment contains a listing and descriptions of the zip files contained on the attached CD (Attachment 2). The iso file system on the CD was created using mkisofs, version 1.14. The CD was created using cdrecord, version 1.10. The zip archives were created using GNU version of zip, version 2.3 (compatible with PKZIP, version 2.04). In addition, the SAS2H input, output and tape 72 (.t72) files were compressed using gzip, version 1.3, prior to the final archiving using GNU version of zip. The zip file attributes are listed in Table 1-1.

Table 1-1. File Listing for Attachment 2

Archive Filename	File Size (kilobytes)	File Date	File Time
mcnp.zip	80,607	11-Jun-03	9:36
sas.zip	626,900	11-Jun-03	10:00

There are 130 total files (not including folders) contained in the file mcnp.zip, and 540 files (not including folders) contained in the file sas.zip. The files are organized in a unique directory structure. The extracted directory structure corresponds as follows:

./mcnp/: contains MCNP input and output files (listed in Table 25).

./sas/: subdirectory containing two additional sub-directories (input, output, and t72)

./sas/input/: contains SAS2H input files listed in Table 24.

./sas/output/: contains SAS2H output files and tape 72 (t72) files listed in Table 24.