CRWMS/M&O

Calculation Cover Sheet

Complete only applicable items.

1. QA: ✓ QA LMM 08-12-1999

Page: 1 Of: 68

2. Calculation Title	MOL.19990812.0351
Waste Package, LCE, CRC, and Radiochemical Assay Comparison Evaluation	

3. Document Identifier (including Revision Number)	4. Total Pages
B00000000-01717-0210-00107 REV 00	68

5. Total Attachments	6. Attachment Numbers - Number of pages in each
5	I-1, II-2, III-2, IV-1, V-1 (See Box 10)

	Print Name	Signature	Date
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10. Remarks

Attachments II through V are contained on an attachment compact disc of this calculation file (the attachment compact disc has been moved to Reference 7.15). The numbers shown in Box 6 for Attachments II through V refer to the number of pages in the hard-copy listing of each file's attributes on the compact disc.

ELECTRONIC ATTACHMENTS HAVE BEEN CHECKED DPH 8/5/99

Revision History

11. Revision No.	12. Description of Revision
00	Initial Issuance

CONTENTS

1. PURPOSE

The purpose of this calculation is to document the validity of the commercial reactor criticals (CRC) as a source for a spent nuclear fuel benchmark, and to characterize the neutronic similarities between a CRC and a waste package (WP). This report illustrates comparisons of neutron spectrum and the effects on criticality arising from physical differences between a WP and a CRC. This report is an engineering calculation supporting the development of the disposal criticality analysis methodology, performed under Quality Administrative Procedure (QAP)-3-15 Revision 0.

2. METHOD

The calculation method used to perform the reactivity calculations consists of using the methodology presented in the *Disposal Criticality Analysis Methodology Topical Report* (Ref. 7.22). This methodology involves the simulation of the burnup and decay of fuel assemblies, and the calculation of the effective multiplication factor for specific configurations. The calculational method used to perform the depletion calculations consisted of using the SAS2H control sequence of the SCALE, Version 4.3, code system (Ref. 7.1) to deplete the selected fuel assemblies. The various fuel assemblies were depleted through their unique operating histories such that their modified fuel compositions would be available at specific exposure times (statepoints) corresponding to the times at which detailed core reactivity calculations were performed. The fuel assembly depletion calculations were based on detailed core follow information for each assembly.

The MCNP code (Reference 7.4) was used to calculate the effective neutron multiplication factor (k_{eff}) and the fluence spectrum. The calculations were performed using continuous-energy neutron cross-section libraries as selected in the *Selection of MCNP Cross Section Libraries* report [pp. 61-68, Ref. 7.6]). Statepoint critical core configurations were simulated, and the results reported from the MCNP calculations were the normalized neutron fluence over different energy bins, and the combined average values of k_{eff} from three estimates (collision, absorption, and track length) listed in the final generation summary in the MCNP output. Each of the core configurations was modeled in detail using measured critical conditions for the CRC calculations, and WP dimensions as shown in Attachment I. The various fuel assemblies were modeled explicitly in the core configurations. The CRC configurations analyzed were actual pressurized water reactor (PWR) cores which contained various fuel loadings, including some that were fresh beginning-of-life (BOL) assemblies, and some that were a mixture of all burned fuel (mid-cycle restart).

In the comparisons of the radiochemical assay measured fuel isotopics and the SAS2H calculated fuel isotopics comparisons, MCNP was used to model a WP which consisted of fuel material made up of either the SAS2H calculated fuel isotopics, or the measured fuel isotopics. The intact assembly designs modeled in MCNP match that of the fuel assemblies that the radiochemical assay samples were taken from. These samples were from the following commercial power plants: Calvert Cliffs, Obrigheim, Turkey Point, Mihama, and H. B. Robinson.

3. ASSUMPTIONS

3.1 The oxygen weight fraction was assumed to remain constant for the burned fuel in the radiochemical assay measured isotopic concentrations and the SAS2H calculated isotopic concentrations. The basis for this assumption is that as long as this is kept constant when comparing the k_{eff} from the two different calculations, it will have no effect on the difference in k_{eff}. This assumption was used in Section 5.

3.2 Assumed that the use of Westinghouse 14x14 STD/SC assembly design parameters as listed in Drawing 1097E36 of Reference 7.14, are similar to the Obergheim assembly for the upper and lower end-fitting regions. The basis for this assumption is that these are similar assembly designs and the Siemens 14x14 assembly was designed to fit into Westinghouse reactors. This assumption was used in Section 5.

3.3 Assumed that the omission of the plenum spring and spacers has no impact on the difference in k_{eff} in the Obergheim assembly representation. The basis for this assumption is that since the parameter of interest is the difference in k_{eff}, as long as the MCNP geometric model remains the same, there is no impact on the difference in k_{eff} when using one set of fuel compositions versus the other. This assumption was used in Section 5.

3.4 Assumed that the fuel rod end cap length in the Obergheim assembly is 0.8636 cm. The basis for this assumption is that this is the size determined from the specifications used for the Westinghouse 15x15 assembly design with 20 guide tubes (pp. 2A-321 and 2A-322, Reference 7.14), and this end cap size will have no effect on the difference in k_{eff} between different fuel compositions as long as the MCNP geometric model is kept constant. This assumption was used in Section 5.

3.5 Assumed that the mass of U-238 present in the Obergheim assembly fuel isotopics is the difference between one metric ton of uranium and the sum of the U-235 and U-236 isotope masses. The basis of this assumption is that the results are presented in terms of g/MTU on pages 14 and 25 of Reference 7.20, and since the uranium content of the spent fuel is mostly composed of U-235, U-236, and U-238, the mass of U-238 can be solved for. This assumption is used in Section 5.

4. USE OF COMPUTER SOFTWARE AND MODELS

4.1 SOFTWARE APPROVED FOR QA WORK

The MCNP code was used to calculate k_{eff} and the neutron spectrums for the CRC and WP configurations. The software specifications are as follows:

Program Name: MCNP

Version/Revision Number: Version 4B2
CSCI Number: 30033 V4B2LV
Computer Type: HP 9000 Series Workstations
Computer Processing Unit Number: (Bloom) 700887

The input and output files for the various MCNP calculations are documented in the attachments to this calculation file as described in Sections 5 and 8 (the attachment compact disc [CD] has been moved to Reference 7.15), such that an independent repetition of the software use may be performed. The MCNP software used was: (a) appropriate for the application of k_{eff} neutron spectrum calculations, (b) used only within the range of validation as documented throughout References 7.4 and 7.5, and (c) obtained from the Software Configuration Manager in accordance with appropriate procedures.

4.2 SOFTWARE ROUTINES

4.2.1 Excel

- Title: Excel
- Version/Revision Number: Microsoft® Excel 97

The Excel spreadsheet program was used for simple numeric calculations and graphical illustrations as documented in Sections 5 and 6 of this calculation file. The user-defined formulas, inputs, and results were documented in sufficient detail in Sections 5 and 6 to allow an independent repetition of the various computations.

4.3 MODELS

None.

5. CALCULATION

This report compares the neutron energy spectrum observed in a waste package and in a commercial reactor critical reactivity calculation; evaluates the effect on k_{eff} from differences that arise between radiochemical assay measurements of spent nuclear fuel isotopics and SAS2H calculated spent nuclear fuel isotopics; and quantifies the difference in k_{eff} that arises from using fuel cross section data at two different temperatures (570 K and 300 K).

Each CRC statepoint represents a specific time when the reactor was brought to the critical condition ($k_{eff} = 1$) and the corresponding reactor core conditions were measured. The CRC evaluations of each of these critical statepoints involved the use of SAS2H to deplete the various fuel assemblies and MCNP4B2 (Ref. 7.4) to model the reactor core such that the k_{eff} value at each of the critical statepoints could be predicted to demonstrate the ability of the dual code system. The core statepoints selected for use in this report are from Crystal River Unit 3 for PWRs. Boiling water reactor (BWR) data will be incorporated into a future revision of this document. The CRC depletion and reactivity calculations for the various fuel assemblies used in this evaluation are documented throughout References 7.7 and 7.8 for Crystal River Unit 3.

MCNP has been benchmarked to calculate k_{eff} accurately to measured values within a certain tolerance from actual laboratory critical experiments (LCEs) where experiments with known conditions were modeled (Ref. 7.2). Numerous LCEs have shown MCNP to accurately predict k_{eff} = unity for fresh fuel for various enrichments, fuel types, and core configurations. The ability of MCNP to accurately predict k_{eff} for fresh fuel is based on standard evaluated nuclear data file cross section data.

Radiochemical assay data has shown that SAS2H can predict spent fuel isotopic concentrations accurately. Two reports documenting the validation of the SCALE code system for PWR and BWR spent fuel have been written by Oak Ridge National Laboratories (References 7.9 and 7.10). Page xi of Reference 7.9 states that the SCALE depletion analysis properly qualifies as a basic tool for predicting isotopic compositions of spent fuel from PWR power plants.

A PWR CRC is a simulation of when a hot-zero-power measurement of k_{eff} was performed at the reactor at a specified time. This measurement comes from actual reactor operating history data and shows the exact reactor conditions for the specified time. A CRC uses SAS2H to simulate the burnup of the assemblies in a reactor from actual operating history data until the time of the statepoint calculation. Thus, using the SAS2H burned fuel compositions in an explicit, detailed model of the reactor in MCNP should give an accurate representation of the measured k_{eff} within a certain tolerance, depending on the isotope set utilized. The different isotope sets are discussed on pages 212 and 213 of Reference 7.8. The calculations in this report use the best-estimate isotope set (p. 212, Ref. 7.8) for the spent fuel isotopic compositions.

5.1 CHARACTERISTICS OF LCES, CRCS, AND WPS

The bias value, that is representative of a code system's (code and data) ability to accurately predict k_{eff} for a given configuration, must be derived from benchmark evaluations that have neutronic characteristics which bound those of the configuration to which the bias value will be applied. For the purpose of waste package criticality evaluations in a deep geologic repository environment the applicable critical benchmarks have been classified into two groups: LCEs and CRCs. The ranges of characteristics influencing neutronic behavior that are represented by these two groups bound the anticipated WP characteristic ranges in the repository environment.

The following discussion provides a general description of the characteristic ranges that influence the neutronic behavior in the LCEs, CRCs, and WP. The LCE, CRC, and WP characteristics may be described in terms of three categories: (1) geometry, (2) materials, and (3) other conditions affecting criticality. Tables 5.1-1 through 5.1-3 provide the characteristics of the LCEs, CRCs, and WPs.

Table 5.1-1. Geometry Characteristics

<table>
<tr><th rowspan="2">LCEs</th><th colspan="2">CRCs</th><th rowspan="2">WP Intact Fuel Configuration</th></tr>
<tr><th>PWR</th><th>BWR</th></tr>
<tr><td>Lattices of rods containing fuel with variable rod diameter, height, and pitches</td><td>Fuel assembly design specifications utilized</td><td>Fuel assembly design specifications utilized</td><td>Fuel assembly design specifications utilized</td></tr>
<tr><td rowspan="3">Heterogeneous absorbing rods may be present</td><td>Rod Cluster Control Assembly (RCCA) design specifications utilized</td><td rowspan="3">Fuel assembly channel specifications utilized</td><td>Disposal Control Rod Assembly (DCRA) may be present in some fuel assemblies</td></tr>
<tr><td>Burnable Poison Rod Assembly (BPRA) design specifications utilized</td><td rowspan="2">Basket composed of tubes and plates</td></tr>
<tr><td>Axial Power Shaping Rod Assembly (APSRA) design specifications utilized</td></tr>
<tr><td>Non-absorbing and/or absorbing plates may be present</td><td>No blades</td><td>Control blade specifications utilized</td><td>Tube, basket, inner barrier, outer barrier, and other structural design specifications utilized</td></tr>
<tr><td>Independent rod lattice separation may vary</td><td>Core loading patterns utilized</td><td>Core loading patterns utilized</td><td>Variable loading pattern utilized</td></tr>
<tr><td>Configuration structure will usually be designed to have a minimal effect on the system neutronics</td><td>Core structure design specifications utilized</td><td>Core structure design specifications utilized</td><td>Internal structure design specifications utilized</td></tr>
</table>

Table 5.1-2. Materials Characteristics

LCEs	CRCs		WP Intact Fuel Configuration
	PWR	BWR	
Fresh UO_2 with varying enrichments	Spent and fresh fuel compositions utilized	Spent and fresh fuel compositions utilized	Spent fuel compositions utilized
PuO_2/UO_2 with varying Pu/U ratios			
UO_2-Gd_2O_3 with varying Gd/U ratios			
Heterogeneous absorbing materials may include B_4C, Ag-In-Cd, borated stainless steel, BORAL	Fuel assembly, RCCA, BPRA, and APSRA structural materials utilized	Fuel assembly, channel, and control blade structural materials utilized	Reactivity control materials utilized (B_4C in DCRA, steel doped with neutron absorbing material)
Various concentrations of soluble boron may be present	Reactivity control materials utilized (RCCA, BPRA, APSRA, chemical shim)	Reactivity control materials utilized (B_4C, Hf, Gd)	Fuel assembly and DCRA structural materials utilized
Rod, plate, and configuration structural materials (stainless steel, carbon steel, plexiglass, Pyrex)	Core structural materials utilized	Core structural materials utilized	Tube, basket, inner barrier, outer barrier, and other structural materials utilized

Table 5.1-3. Condition Characteristics

LCEs	CRCs		WP Intact Fuel Configuration
	PWR	BWR	
$k_{eff} \leq 1.0$ (Sometimes the critical configuration is determined by extrapolation from an exponential approach to critical)	$k_{eff} = 1.0$	$k_{eff} = 1.0$	k_{eff} variable but less than 1.0
Soluble boron concentration may vary from zero to thousands of ppmb[1]	Soluble boron concentration within a general range of 300 to 2000 ppmb	No soluble boron present	No soluble boron present
System at room temperature	Temperature of system approximately 535 °F	Temperature of system approximately 200 °F	Temperature range from 140 °F to 212 °F
System at atmospheric pressure (moderator density = 1.0 g/cm^3)	Pressure of system either 2200 psia or 2250 psia (moderator density approximately 0.75 g/cm^3)	Pressure of system = 1 atmosphere (moderator density approximately 1.0 g/cm^3)	1 atmosphere pressure (optimal moderator density utilized, 1.0 g/cm^3)
Heterogeneous absorbing materials present in system	Heterogeneous reactivity control mechanisms present in system	Heterogeneous reactivity control mechanisms present in system	Heterogeneous reactivity control mechanisms present
No spent fuel present	Decay of spent fuel within a general range of 2 to 2400 days	Decay of spent fuel within a general range of 2 to 2400 days	Decay times up to hundreds of thousands of years

[1] ppmb = parts per million boron by mass

5.2 PROCEDURE

The following is a listing of the comparisons being performed in this report:

- Calculation of the effect on k_{eff} from using cross sections at reactor operating temperature (587 K) and at room temperature (300 K) in the reactor core environment (CRC). These cases are denoted as cr3i1a and cr3i1b, respectively.
- Calculation of the effect on k_{eff} from using cross sections at reactor operating temperature (587 K) and at room temperature (300 K) in the waste package (WP) environment. These cases are denoted as cr3i2a and cr3i2b, respectively.
- Calculation of the neutron spectrum for a centralized burned fuel assembly within the reactor core during a CRC statepoint calculation, and the spectrum observed when the same fuel assembly and surrounding assemblies are placed into a WP environment. These cases are denoted as cr3i3a and cr3i3b for the PWR fuel, respectively.
- Calculation of the neutron spectrum observed within the CRC versus that observed within the WP. These cases are denoted as crc2 and wp2, respectively.
- Calculations performed to determine the effect on k_{eff} when burned fuel assemblies are represented in the WP in which radiochemical assay measured isotopic compositions are used, and when SAS2H predicted values are used. These cases are further discussed in Section 5.4.

5.3 FUEL ASSEMBLY MCNP GEOMETRIC DESCRIPTIONS

The sketch referenced for the 21-PWR waste package dimensions is contained in Attachment I. The MCNP virtual model of the 21-PWR waste package follows the same description as that shown in the sketch of Attachment I. The package skirts and lids were not represented in the models which provides for a more conservative value of k_{eff} due to less moderator displacement. An effectively infinite water reflector surrounds each waste package. Figures 5-1 and 5-2 show an eighth core representation of the assemblies used in the CRC evaluations for the BOL and Cycle 6, 400 effective full power days (EFPDs) statepoint calculations, respectively. In order to evaluate the difference in neutron spectrum for a burned fuel assembly in the reactor environment and in the WP environment, an F4 tally in MCNP was specified. This tally tracks the flux averaged over a cell in the MCNP model. The fuel assembly chosen for this comparison for a PWR was the E08 fuel assembly as shown in Figures 5-2 and 5-3 for the centralized assembly spectrum calculation, and assemblies D17 and E17 as shown in Figures 5-2 and 5-3 for the edge assembly spectrum calculation. Figure 5-3 shows the assemblies taken from the PWR CRC calculation and placed in the WP for the WP spectrum calculations.

The physical dimensions for the assemblies modeled in the radiochemical assay comparisons were obtained from Reference 7.11 for the specific assembly designs.

	08	09	10	11	12	13	14	15
H	F (1A) 2	F (1A) 2	F (1A) 1	F (1A) 2	F (1A) 1	F (1A) 2	F (1A) 3	F (1A) 3
K		F (1A) 1	F (1A) 2	F (1A) 1	F (1A) 2	F (1A) 1	F (1A) 2	F (1A) 3
L			F (1A) 1	F (1A) 2	F (1A) 1	F (1A) 2	F (1A) 3	F (1A) 3
M				F (1A) 1	F (1A) 2	F (1A) 1	F (1A) 3	
N					F (1A) 1	F (1A) 3	F (1A) 3	
O						F (1A) 3		

RC	= Previous Fuel Assembly Position, Row (R), Column (C), {normalized to 1/8 core}
F(c)	= Cycle (c) in which the Fuel Assembly was Fresh (F)
B	= Fuel Batch Identifier (B)

Wt% U-235 Enrichments		
Fresh Cycle	Batch	Wt%
1A	1	1.93
	2	2.54
	3	2.83

Burnable Poison Rod Assembly (BPRA) Locations	
Wt% B_4C in BPRA	1/8 Core Row & Column
1. 01	L11, M12
1.18	H11, H13, K12, L13, N13
1.34	H09, K10, K14

Rod Cluster Control Assembly (RCCA) Locations			
RCCA Bank Identifier	1/8 Core Row & Column	RCCA Bank Identifier	1/8 Core Row & Column
Bank 5	K09, M13	Bank 7	H08, L14
Bank 6	H12, M11	Bank 8 (Black Axial Power Shaping Rod)	L12

Figure 5-1. BOL CRC Fuel Assembly Locations
(p. 218, Ref. 7.8)

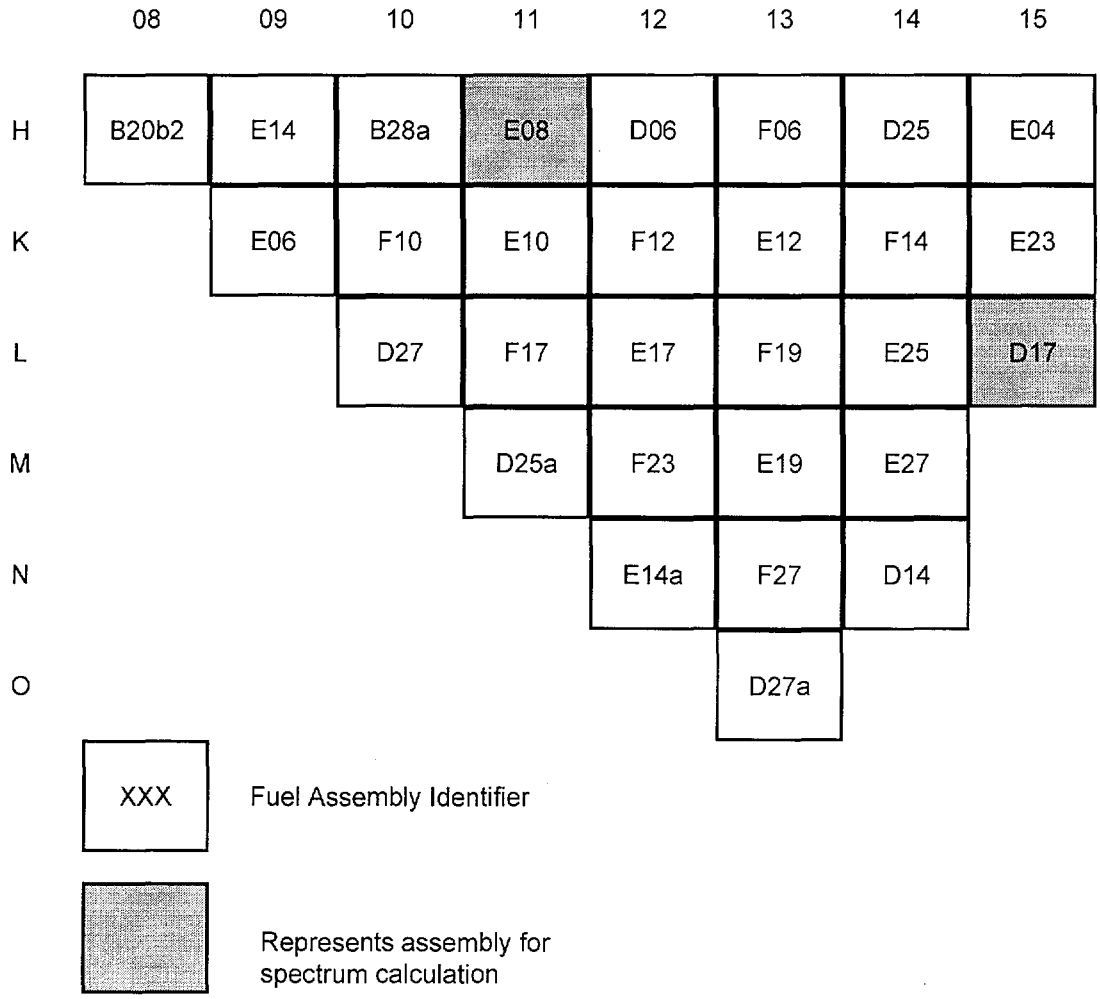


Figure 5-2. Cycle 6 CRC Fuel Assembly Identification & Locations for Spectral Comparison (p. 235, Ref. 7.8)

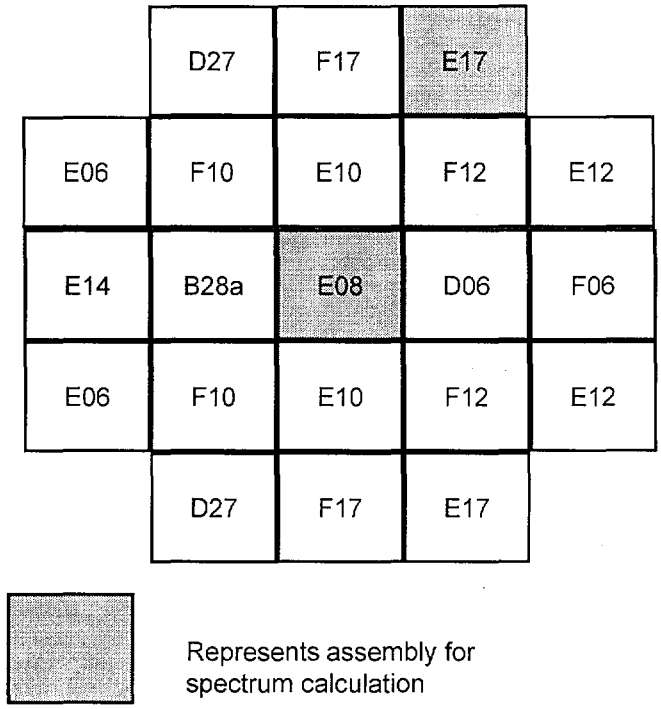


Figure 5-3. Waste Package Assembly Layout for Centralized Assembly Spectral Comparison

5.4 MATERIAL DESCRIPTIONS

5.4.1 CRC Material Descriptions

All material compositions as modeled in MCNP used in the CRC analyses in this report come directly from Attachment II of Reference 7.8 for the Statepoint 1 (BOL) and Statepoint 6 (Cycle 6, 400 EFPD) reactivity calculation files. The isotopes modified to observe the cross section temperature effects were U-235 and U-238. The MCNP ZAIDs were changed from the original 92235.53c and 92238.53c, to 92235.50c and 92238.50c, for U-235 and U-238, respectively.

5.4.2 Waste Package MCNP Material Descriptions

The single corrosion resistant material (CRM) 21-PWR waste package follows the same description as that shown in the sketch of Attachment I. The outer barrier was represented as Alloy 22, which is a specific type of nickel-based alloy (ASTM B 575 is referred to by the name Alloy 22) as described in Table 5.4-1. The inner barrier was represented as nuclear grade stainless steel 316 (316NG) as described in Table 5.4-2, and the basket side and corner guides were represented as Grade 70 A 516 carbon steel as described in Table 5.4-5. The fuel basket plates were represented as Neutronit A978 as described in Table 5.4-3, and the thermal shunts were represented as aluminum 6061 as described in Table 5.4-4. An effectively infinite water reflector surrounds the waste package. The water composition is normal H_2O at 1.0 g/cm^3

density.

The various material compositions shown in Tables 5.4-1 through 5.4-5 were obtained from various references. The chromium, nickel, and iron elemental weight percents obtained from the references were expanded into their constituent natural isotopic weight percents for use in MCNP. This expansion was performed by: (1) calculating a natural weight fraction of each isotope in the elemental state, and (2) multiplying the elemental weight percent in the material of interest by the natural weight fraction of the isotope in the elemental state to obtain the weight percent of the isotope in the material of interest. This is described mathematically in Equations 5.4-1 and 5.4-2.

The material compositions that were obtained from Reference 7.13 are considered accepted data. This reference is a compilation of data taken from standard handbooks, and due to the nature of the sources of this compilation, the data in it are established fact are therefore considered accepted. Data taken from Reference 7.12 is considered accepted data due to the documentation referenced originating from the company that manufactures the material.

Equation 5.4-1. Natural Weight Fraction of Isotope in the Element

$$\begin{pmatrix} \text{Weight Fraction} \\ \text{of Isotope}_i \text{ in the} \\ \text{Natural Element} \end{pmatrix} = \frac{(\text{Atomic Mass of Isotope}_i)(\text{Atom Percent of Isotope}_i \text{ in Natural Element})}{\sum_{i=1}^{I} (\text{Atomic Mass of Isotope}_i)(\text{Atom Percent of Isotope}_i \text{ in Natural Element})}$$

where (I) is the total number of isotopes in the natural element.

Equation 5.4-2. Weight Percent of Isotope in Material Composition

$$\begin{pmatrix} \text{Weight Percent} \\ \text{of Isotope}_i \text{ in} \\ \text{Material Composition} \end{pmatrix} = \begin{pmatrix} \text{Weight Fraction} \\ \text{of Isotope}_i \text{ in the} \\ \text{Natural Element} \end{pmatrix} \begin{pmatrix} \text{Reference Weight Percent of} \\ \text{Element in Material Composition} \end{pmatrix}$$

The tables presenting calculated material compositions in this section show additional significant digits. The number of significant digits in the composition values are a result of the composition calculation and should not be interpreted as reflecting an excessively high level of accuracy.

Table 5.4-1. Alloy 22 (SB-575 N06022) Material Composition

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.0100	Mo-nat	42000.50c	13.0000
Mn-55	25055.50c	0.5000	Co-59	27059.50c	2.0600
Si-nat	14000.50c	0.0800	W-182	74182.55c	0.7818

Table 5.4-1. Alloy 22 (SB-575 N06022) Material Composition

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
Cr-50	24050.60c	0.9182	W-183	74183.55c	0.4268
Cr-52	24052.60c	18.4141	W-184	74184.55c	0.9226
Cr-53	24053.60c	2.1280	W-186	74186.55c	0.8688
Cr-54	24054.60c	0.5397	V	23000.50c	0.3500
Ni-58	28058.60c	37.7410	Fe-54	26054.60c	0.1710
Ni-60	28060.60c	14.9255	Fe-56	26056.60c	2.7561
Ni-61	28061.60c	0.6570	Fe-57	26057.60c	0.0642
Ni-62	28062.60c	2.1214	Fe-58	26058.60c	0.0087
Ni-64	28064.60c	0.5551	Density = 8.69 g/cm^3		

Source: p. 30, Ref. 7.11

Table 5.4-2. Material Specifications for SS316NG

Element/Isotope	Zaid	Wt%	Element/Isotope	Zaid	Wt%
C-nat	6000.50c	0.02000	Fe-56	26056.60c	60.24316
N-14	7014.50c	0.08000	Fe-57	26057.60c	1.40399
Si-nat	14000.50c	0.75000	Fe-58	26058.60c	0.19048
P-31	15031.50c	0.04500	Co-59	27059.50c	0.00000
S-nat	16032.50c	0.03000	Ni-58	28058.60c	8.08737
Cr-50	24050.60c	0.70953	Ni-60	28060.60c	3.19832
Cr-52	24052.60c	14.22904	Ni-61	28061.60c	0.14078
Cr-53	24053.60c	1.64435	Ni-62	28062.60c	0.45458
Cr-54	24054.60c	0.41708	Ni-64	28064.60c	0.11895
Mn-55	25055.50c	2.00000	Mo-nat	42000.50c	2.50000
Fe-54	26054.60c	3.73699	Density = 7.98 g/cm^3		

Source: Ref. 7.12 and p. 13 of Ref. 7.13

Table 5.4-3. Material Specifications for Neutronit A978 with 1.62 wt% Boron

Element/Isotope	ZAID	Wt%	Element/Isotope	ZAID	Wt%
B-10	5010.50c	0.29095	Fe-57	26057.60c	1.37969
B-11	5011.56c	1.32905	Fe-58	26058.60c	0.18718
C-nat	6000.50c	0.04000	Co-59	27059.50c	0.20000
Cr-50	24050.60c	0.77214	Ni-58	28058.60c	8.76131
Cr-52	24052.60c	15.48455	Ni-60	28060.60c	3.46485
Cr-53	24053.60c	1.78944	Ni-61	28061.60c	0.15252
Cr-54	24054.60c	0.45388	Ni-62	28062.60c	0.49246
Fe-54	26054.60c	3.67231	Ni-64	28064.60c	0.12886
Fe-56	26056.60c	59.20045	Mo-nat	42000.50c	2.20000
Density = 7.76 g/cm^3					

Source: p. 39, Ref. 7.13; p. 15, Ref. 7.25

Table 5.4-4. Material Specifications for Al 6061

Element/Isotope	ZAID	Wt%	Element/Isotope	ZAID	Wt%
Si-nat	14000.50c	0.60000	Mg-nat	12000.50c	1.00000
Fe-54	26054.60c	0.03989	Cr-50	24050.60c	0.00814
Fe-56	26056.60c	0.64308	Cr-52	24052.60c	0.16322
Fe-57	26057.60c	0.01499	Cr-53	24053.60c	0.01886
Fe-58	26058.60c	0.00203	Cr-54	24054.60c	0.00478
Cu-63	29063.60c	0.18837	Ti-nat	22000.50c	0.15000
Cu-65	29065.60c	0.08663	Al-27	13027.50c	96.93000
Mn-55	25055.50c	0.15000	Density = 2.71 g/cm^3		

Source: p. 56, Ref. 7.13

Table 5.4-5. Grade 70 A516 Carbon Steel Composition

Element/Isotope	ZAID	Wt%	Element/Isotope	ZAID	Wt%
C-nat	6000.50c	0.0027	Fe-54	26054.60c	0.0560
Si-nat	14000.50c	0.0029	Fe-56	26056.60c	0.9033
P-31	15031.50c	0.0004	Fe-57	26057.60c	0.0211
S-32	16032.50c	0.0004	Fe-58	26058.60c	0.0029
Mn-55	25055.50c	0.0105	Density = 7.850 g/cm^3		

Source: p. 10, Ref. 7.13

5.4.3 Fuel Assembly Material Descriptions

The fuel assembly materials listed in this section refer to the upper and lower end-fitting materials and the spacer grid materials. The primary material components in the upper and lower end-fitting regions are SS304, Inconel, and moderator. Both the upper and lower end-fitting regions are modeled with material compositions that represent the homogenization of all of the components in the regions. Table 5.4-6 presents the material composition of SS304. Table 5.4-8 presents the material composition of Inconel 718. Table 5.4-9 presents the assembly end-fitting hardware component masses used in conjunction with Equations 5.4-6 and 5.4-7 for determining the end-fitting material volume fractions. Table 5.4-10 presents the component material volume fractions for the upper end-fitting regions for the different assembly designs. Table 5.4-11 presents the component material volume fractions for the lower end-fitting region for the different assembly designs. Tables 5.4-12 through 5.4-15 present the lower end-fitting homogenized material compositions for each assembly design. Tables 5.4-16 through 5.4-19 presents the upper end-fitting homogenized material compositions for each assembly design. Tables 5.4-20 and 5.4-22 present the spacer grid dimensions for the different assembly designs, and Tables 5.4-21 and 5.4-23 present the spacer grid homogenized material compositions. These homogenized material compositions are made of various base components such as SS304, Inconel, Zircaloy-4, and moderator that are present in certain volume fractions. The homogenization of the base components into single homogenized material compositions is performed using Equations 5.4-3 through 5.4-5.

Equation 5.4-3. Homogenized Material Density Calculation

$$Homogenized\ Material\ Density = \sum_{m}^{M} \left[(\rho)_m \left(Volume\ Fraction\ in\ Homogenized\ Material \right)_m \right]$$

where, m=a single component material of the homogenized material, M=the total number of component materials in the homogenized material, and ρ=the mass density of the component material.

Equation 5.4-4. Calculation of Mass Fraction of Component Material in Homogenized Material

$$\begin{pmatrix} Mass\ Fraction\ of\ Component \\ Material\ in\ Homogenized\ Material \end{pmatrix} = \left[\frac{(\rho)_m \left(Volume\ Fraction\ in\ Homogenized\ Material \right)_m}{Homogenized\ Material\ Density} \right]$$

Equation 5.4-5. Calculation of Weight Percent of Component Material Constituent in Homogenized Material

$$\begin{pmatrix} Weight\ Percent\ of \\ Component\ Material \\ Constituent\ in \\ Homogenized\ Material \end{pmatrix} = \begin{pmatrix} Mass\ Fraction\ of \\ Component\ Material\ in \\ Homogenized\ Material \end{pmatrix} \begin{pmatrix} Weight\ Percent\ of\ Component \\ Material\ Constituent \\ in\ Component\ Material \end{pmatrix}$$

Equation 5.4-6. Calculation of Assembly Hardware Component Volumes in End-Fitting Region

$$\begin{pmatrix} End-Fitting\ Material \\ Volume \end{pmatrix} = \frac{\sum mass_i}{density_i}$$

where i represents a common material, e.g., SS304.

Equation 5.4-7. Calculation of Assembly End-Fitting Region Volume Fractions

$$\left(Volume\ Fraction \right)_i = \frac{\begin{pmatrix} End-Fitting\ Material \\ Volume \end{pmatrix}_i}{\begin{pmatrix} Total\ End-Fitting \\ Volume \end{pmatrix}}$$

where i represents a common material, e.g., SS304.

Table 5.4-6. SS304 Material Composition

Element/Isotope	MCNP ZAID	Wt%	Element/Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.080	Fe-54	26054.60c	3.918
N-14	7014.50c	0.100	Fe-56	26056.60c	63.156
Si-nat	14000.50c	0.750	Fe-57	26057.60c	1.472
P-31	15031.50c	0.045	Fe-58	26058.60c	0.200
S-nat	16032.50c	0.030	Ni-58	28058.60c	6.234
Cr-50	24050.60c	0.793	Ni-60	28060.60c	2.465
Cr-52	24052.60c	15.903	Ni-61	28061.60c	0.109
Cr-53	24053.60c	1.838	Ni-62	28062.60c	0.350
Cr-54	24054.60c	0.466	Ni-64	28064.60c	0.092
Mn-55	25055.50c	2.000	Density = 7.90 g/cm^3		

Source: p. 12, Ref. 7.23

Table 5.4-7. Zircaloy-4 Composition

Element/Isotope	MCNP ZAID	Wt%	Element/Isotope	MCNP ZAID	Wt%
Cr-50	24050.60c	0.0042	Fe-57	26057.60c	0.0043
Cr-52	24052.60c	0.0837	Fe-58	26058.60c	0.0006
Cr-53	24053.60c	0.0097	O-16	8016.50c	0.1200
Cr-54	24054.60c	0.0025	Zr-nat	40000.60c	98.1800
Fe-54	26054.60c	0.0114	Sn-nat	50000.35c	1.4000
Fe-56	26056.60c	0.1837	Density = 6.56 g/cm^3		

Source: p. 44, Ref. 13

Table 5.4-8. Inconel 718 Material Composition

Element/Isotope	MCNP ZAID	Wt%	Element/Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.080	Ni-60	28060.60c	13.993
Si-nat	14000.50c	0.350	Ni-61	28061.60c	0.616
P-31	15031.50c	0.015	Ni-62	28062.60c	1.989
S-32	16032.50c	0.015	Ni-64	28064.60c	0.520
Cr-50	24050.60c	0.793	B-10	5010.50c	1.078E-03
Cr-52	24052.60c	15.903	B-11	5011.56c	4.925E-03
Cr-53	24053.60c	1.838	Ti-nat	22000.50c	0.900
Cr-54	24054.60c	0.466	Al-27	13027.50c	0.500
Mn-55	25055.50c	0.350	Co-59	27059.50c	1.000
Fe-54	26054.60c	0.958	Cu-63	29063.60c	0.205
Fe-56	26056.60c	15.442	Cu-65	29065.60c	0.095
Fe-57	26057.60c	0.360	Nb-93	41093.50c	2.563
Fe-58	26058.60c	0.049	Mo-nat	42000.50c	3.050
Ni-58	28058.60c	35.382	Ta-181	73181.50c	2.563
Density = 8.19 g/cm^3					

Source: pp. 1, 2, Ref. 7.24

Table 5.4-9. Assembly End-Fitting Hardware Component Masses

Upper End-Fitting			
Hardware Part Name	**CE 14x14[1]**	**Siemens 14x14[2]**	**W 15x15[3]**
Locking posts (kg/assembly)	2.63 (SS304)	N/A[4]	N/A
Hold-down spring (kg/assembly)	1.1 (Inconel 718)[5]	0.41 (Inconel 718)	1.14 (Inconel 718)
Flow plate (kg/assembly)	1.45 (SS304)	N/A	N/A
Hold-down plate (kg/assembly)	1.0 (SS304)	N/A	N/A
Top nozzle (kg/assembly)	N/A	9.21	10.7 (SS304)
Lower End-Fitting			
Bottom nozzle (kg/assembly)	5.0 (SS304)	7.89	5.44 (SS304)

[1] Values are from page 2A-56 of Reference 7.14
[2] Values are from page 2A-308 of Reference 7.14
[3] Values are from page 2A-320 of Reference 7.14
[4] N/A = Not Applicable

Table 5.4-10. Upper End-Fitting Component Material Volume Fractions

Assembly Design	Volume Fractions in Upper End-Fitting Region			
	SS304	**Inconel**	**Zircaloy-4**	**Moderator**
B&W 15x15[1]	0.2756	0.0441	0.0081	0.6722
CE 14x14[2]	9.0209E-02	1.884E-02	N/A	0.890951
Siemens 14x14[2]	0.1438	0.00617	N/A	0.8500
W 15x15[2]	0.33246	0.034166	N/A	0.633374

[1] Values are from page 153 of Reference 7.8
[2] Values were calculated using Equations 5.4-6 and 5.4-7

Table 5.4-11. Lower End-Fitting Component Material Volume Fractions

Assembly Design	Volume Fractions in Lower End-Fitting Region			
	SS304	**Inconel**	**Zircaloy-4**	**Moderator**
B&W 15x15[1]	0.1656	0.0306	0.0125	0.7913
CE 14x14[2]	0.18837	0.0	0.0	0.81163
Siemens 14x14[2]	0.3172	N/A	N/A	0.6828
W 15x15[2]	0.21576	0.0	0.0	0.78424

[1] Values are from page 153 of Reference 7.8
[2] Values were calculated using Equations 5.4-6 and 5.4-7

Table 5.4-12. Lower End Fitting Homogenized Material Compositions for B&W[1] 15x15 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.051	Ni-62	28062.60c	0.393
N-14	7014.50c	0.054	Ni-64	28064.60c	0.103
Si-nat	14000.50c	0.439	H-1	1001.50c	3.641
P-31	15031.50c	0.026	B-10	5010.50c	1.111E-04
S-32	16032.50c	0.018	B-11	5011.56c	5.075E-04
Cr-50	24050.60c	0.508	O-16	8016.50c	28.898
Cr-52	24052.60c	10.196	Al-27	13027.50c	0.052
Cr-53	24053.60c	1.178	Ti-nat	22000.50c	0.093
Cr-54	24054.60c	0.299	Co-59	27059.50c	0.103
Mn-55	25055.50c	1.112	Cu-63	29063.60c	0.021
Fe-54	26054.60c	2.206	Cu-65	29065.60c	0.010
Fe-56	26056.60c	35.569	Nb-93	41093.50c	0.264
Fe-57	26057.60c	0.829	Mo-nat	42000.50c	0.314
Fe-58	26058.60c	0.112	Ta-181	73181.50c	0.264
Ni-58	28058.60c	6.999	Zr-nat	40000.60c	3.310
Ni-60	28060.60c	2.768	Sn-nat	50000.35c	0.047
Ni-61	28061.60c	0.122	Density = 2.4322 g/cm^3		

[1] B&W stands for Babcock & Wilcox

Table 5.4-13. Lower End Fitting Homogenized Material Compositions for CE 14x14 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.052	Fe-56	26056.60c	40.867
N-14	7014.50c	0.065	Fe-57	26057.60c	0.952
Si-nat	14000.50c	0.485	Fe-58	26058.60c	0.129
P-31	15031.50c	0.029	Ni-58	28058.60c	4.034
S-nat	16032.50c	0.019	Ni-60	28060.60c	1.595
Cr-50	24050.60c	0.513	Ni-61	28061.60c	0.070
Cr-52	24052.60c	10.291	Ni-62	28062.60c	0.227
Cr-53	24053.60c	1.189	Ni-64	28064.60c	0.059
Cr-54	24054.60c	0.302	H-1	1001.50c	3.950
Mn-55	25055.50c	1.294	O-16	8016.50c	31.342
Fe-54	26054.60c	2.535	Density = 2.2998 g/cm^3		

Table 5.4-14. Lower End Fitting Homogenized Material Compositions for Siemens 14x14 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.063	Fe-56	26056.60c	49.632
N-14	7014.50c	0.079	Fe-57	26057.60c	1.157
Si-nat	14000.50c	0.589	Fe-58	26058.60c	0.157
P-31	15031.50c	0.035	Ni-58	28058.60c	4.899
S-nat	16032.50c	0.024	Ni-60	28060.60c	1.937
Cr-50	24050.60c	0.623	Ni-61	28061.60c	0.085
Cr-52	24052.60c	12.498	Ni-62	28062.60c	0.275

Table 5.4-14. Lower End Fitting Homogenized Material Compositions for Siemens 14x14 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
Cr-53	24053.60c	1.444	Ni-64	28064.60c	0.072
Cr-54	24054.60c	0.366	H-1	1001.50c	2.396
Mn-55	25055.50c	1.572	O-16	8016.50c	19.017
Fe-54	26054.60c	3.079	Density = 2.2998 g/cm^3		

Table 5.4-15. Lower End Fitting Homogenized Material Compositions for W[1] 15x15 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.055	Fe-56	26056.60c	43.254
N-14	7014.50c	0.068	Fe-57	26057.60c	1.008
Si-nat	14000.50c	0.514	Fe-58	26058.60c	0.137
P-31	15031.50c	0.031	Ni-58	28058.60c	4.270
S-nat	16032.50c	0.021	Ni-60	28060.60c	1.688
Cr-50	24050.60c	0.543	Ni-61	28061.60c	0.074
Cr-52	24052.60c	10.892	Ni-62	28062.60c	0.240
Cr-53	24053.60c	1.259	Ni-64	28064.60c	0.063
Cr-54	24054.60c	0.319	H-1	1001.50c	3.527
Mn-55	25055.50c	1.370	O-16	8016.50c	27.985
Fe-54	26054.60c	2.683	Density = 2.4887 g/cm^3		

[1] W stands for Westinghouse

Table 5.4-16. Upper End Fitting Homogenized Material Compositions for B&W 15x15 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.062	Ni-62	28062.60c	0.454
N-14	7014.50c	0.067	Ni-64	28064.60c	0.119
Si-nat	14000.50c	0.539	H-1	1001.50c	2.305
P-31	15031.50c	0.032	B-10	5010.50c	1.193E-04
S-32	16032.50c	0.022	B-11	5011.56c	5.450E-04
Cr-50	24050.60c	0.617	O-16	8016.50c	18.293
Cr-52	24052.60c	12.370	Al-27	13027.50c	0.055
Cr-53	24053.60c	1.430	Ti-nat	22000.50c	0.100
Cr-54	24054.60c	0.363	Co-59	27059.50c	0.111
Mn-55	25055.50c	1.373	Cu-63	29063.60c	0.023
Fe-54	26054.60c	2.720	Cu-65	29065.60c	0.010
Fe-56	26056.60c	43.843	Nb-93	41093.50c	0.284
Fe-57	26057.60c	1.022	Mo-nat	42000.50c	0.338
Fe-58	26058.60c	0.139	Ta-181	73181.50c	0.284
Ni-58	28058.60c	8.074	Zr-nat	40000.60c	1.598
Ni-60	28060.60c	3.193	Sn-nat	50000.35c	0.023
Ni-61	28061.60c	0.141	Density = 3.2638 g/cm^3		

Table 5.4-17. Upper End Fitting Homogenized Material Compositions for CE[1] 14x14 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.039	Ni-61	28061.60c	0.098
N-14	7014.50c	0.041	Ni-62	28062.60c	0.317
Si-nat	14000.50c	0.335	Ni-64	28064.60c	0.083
P-31	15031.50c	0.020	H-1	1001.50c	5.672
S-nat	16032.50c	0.013	B-10	5010.50c	9.458E-05
Cr-50	24050.60c	0.391	B-11	5011.56c	4.321E-04
Cr-52	24052.60c	7.843	O-16	8016.50c	45.010
Cr-53	24053.60c	0.906	Al-27	13027.50c	0.044
Cr-54	24054.60c	0.230	Ti-nat	22000.50c	0.079
Mn-55	25055.50c	0.842	Co-59	27059.50c	0.088
Fe-54	26054.60c	1.672	Cu-63	29063.60c	0.018
Fe-56	26056.60c	26.959	Cu-65	29065.60c	0.008
Fe-57	26057.60c	0.628	Nb-93	41093.50c	0.225
Fe-58	26058.60c	0.085	Mo-nat	42000.50c	0.268
Ni-58	28058.60c	5.633	Ta-181	73181.50c	0.225
Ni-60	28060.60c	2.228	Density = 1.7579 g/cm^3		

[1] CE stands for Combustion Engineering

Table 5.4-18. Upper End Fitting Homogenized Material Compositions for Siemens 14x14 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.047	Ni-61	28061.60c	0.076
N-14	7014.50c	0.056	Ni-62	28062.60c	0.245
Si-nat	14000.50c	0.427	Ni-64	28064.60c	0.064
P-31	15031.50c	0.025	H-1	1001.50c	4.671
S-nat	16032.50c	0.017	B-10	5010.50c	2.674E-05
Cr-50	24050.60c	0.462	B-11	5011.56c	1.221E-04
Cr-52	24052.60c	9.266	O-16	8016.50c	37.066
Cr-53	24053.60c	1.071	Al-27	13027.50c	0.012
Cr-54	24054.60c	0.272	Ti-nat	22000.50c	0.022
Mn-55	25055.50c	1.124	Co-59	27059.50c	0.025
Fe-54	26054.60c	2.209	Cu-63	29063.60c	0.005
Fe-56	26056.60c	35.612	Cu-65	29065.60c	0.002
Fe-57	26057.60c	0.830	Nb-93	41093.50c	0.064
Fe-58	26058.60c	0.113	Mo-nat	42000.50c	0.076
Ni-58	28058.60c	4.355	Ta-181	73181.50c	0.064
Ni-60	28060.60c	1.722	Density = 2.0366 g/cm^3		

Table 5.4-19. Upper End Fitting Homogenized Material Compositions for W 15x15 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.066	Ni-61	28061.60c	0.129
N-14	7014.50c	0.074	Ni-62	28062.60c	0.417
Si-nat	14000.50c	0.584	Ni-64	28064.60c	0.109

Table 5.4-19. Upper End Fitting Homogenized Material Compositions for W 15x15 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
P-31	15031.50c	0.035	H-1	1001.50c	2.003
S-nat	16032.50c	0.023	B-10	5010.50c	8.519E-05
Cr-50	24050.60c	0.651	B-11	5011.56c	3.891E-04
Cr-52	24052.60c	13.057	O-16	8016.50c	15.891
Cr-53	24053.60c	1.509	Al-27	13027.50c	0.040
Cr-54	24054.60c	0.383	Ti-nat	22000.50c	0.071
Mn-55	25055.50c	1.512	Co-59	27059.50c	0.079
Fe-54	26054.60c	2.983	Cu-63	29063.60c	0.016
Fe-56	26056.60c	48.083	Cu-65	29065.60c	0.007
Fe-57	26057.60c	1.121	Nb-93	41093.50c	0.203
Fe-58	26058.60c	0.152	Mo-nat	42000.50c	0.241
Ni-58	28058.60c	7.423	Ta-181	73181.50c	0.203
Ni-60	28060.60c	2.935	Density = 3.5396 g/cm^3		

Table 5.4-20. Dimensions for Intermediate Spacer Grid Homogenization

Dimension	Assembly Design			
	B&W 15x15[1]	CE 14x14[2,3]	Siemens 14x14[2,3]	W 15x15[4]
Spacer Grid Height (cm)	3.81	4.284	3.81	3.81
Spacer Grid Volume (cm^3)	88.676	103.659	70.818	138.38

[1] Values are from page 152 of Reference 7.8
[2] Values are from page 28 of Reference 7.11
[3] The spacer grid volumes were calculated by dividing the spacer mass by its material density. The spacer masses are listed on pages 2A-56 and 2A-308 of Reference 7.14 for the CE 14x14 and W 14x14 assembly designs, respectively.
[4] The spacer grid dimension is from Drawing No. 1598E32 of Reference 7.14. The spacer grid volume was calculated by taking the spacer mass listed on page 2A-320 and dividing it by it's material density.

Table 5.4-21. Intermediate Spacer Grid Homogenized Material Compositions

Assembly Design		B&W 15x15	CE 14x14	Siemens 14x14	W 15x15
Element/ Isotope	MCNP ZAID	Wt%			
O-16	8016.50c	50.396530	51.944098	52.191187	38.605671
H-1	1001.50c	6.350877	6.539613	6.577037	4.865015
B-10	5010.50c	0.000466	--	0.000444	0.000609
B-11	5011.56c	0.002129	--	0.002030	0.002783
Cr-50	24050.60c	0.342993	0.001735	0.326968	0.448277
Cr-52	24052.60c	6.878460	0.034791	6.557089	8.989857
Cr-53	24053.60c	0.794983	0.004021	0.757840	1.039009
Cr-54	24054.60c	0.201557	0.001019	0.192140	0.263427
Si-nat	14000.50c	0.151384	--	0.144311	0.197853
P-31	15031.50c	0.006488	--	0.006185	0.008479
S-nat	16032.50c	0.006488	--	0.006185	0.008479

Table 5.4-21. Intermediate Spacer Grid Homogenized Material Compositions

Assembly Design		B&W 15x15	CE 14x14	Siemens 14x14	W 15x15
Element/ Isotope	MCNP ZAID	Wt%			
C-nat	6000.50c	0.034602	--	0.032985	0.045223
Mn-55	25055.50c	0.151384	--	0.144311	0.197853
Fe-54	26054.60c	0.414360	0.004738	0.395000	0.541550
Fe-56	26056.60c	6.679142	0.076372	6.367083	8.729356
Fe-57	26057.60c	0.155676	0.001780	0.148402	0.203462
Fe-58	26058.60c	0.021152	0.000242	0.020163	0.027644
Ni-58	28058.60c	15.303703	--	14.588694	20.001294
Ni-60	28060.60c	6.051272	--	5.768548	7.908757
Ni-61	28061.60c	0.267581	--	0.255080	0.349718
Ni-62	28062.60c	0.859207	--	0.819064	1.122947
Ni-64	28064.60c	0.225849	--	0.215297	0.295175
Al-27	13027.50c	0.216263	--	0.206159	0.282647
Ti-nat	22000.50c	0.389273	--	0.371086	0.508764
Co-59	27059.50c	0.432526	--	0.412318	0.565293
Cu-63	29063.60c	0.088625	--	0.084484	0.115829
Cu-65	29065.60c	0.041133	--	0.039211	0.053759
Nb-93	41093.50c	1.108348	--	1.056564	1.448564
Mo-nat	42000.50c	1.319204	--	1.257569	1.724144
Ta-181	73181.50c	1.108348	--	1.056564	1.448564
Zr-nat	40000.60c	--	40.809664	--	--
Sn-nat	50000.35c	--	0.581926	--	--
Density (g/cm^3)		1.6122	1.5439	1.5673	1.9852

Table 5.4-22. Dimensions for Bottom Spacer Grid Homogenization

Dimension	Assembly Design
	CE 14x14
Spacer Grid Height (cm)	9.044
Spacer Grid Volume (cm^3)	161.14

Source: p. 51, Ref. 7.11

Table 5.4-23. Bottom Spacer Grid Homogenized Material Compositions

Assembly Design		CE 14x14
Element/Isotope	MCNP ZAID	Wt%
O-16	8016.50c	53.110976
H-1	1001.50c	6.692947
Cr-50	24050.60c	0.360696
Cr-52	24052.60c	7.233485
Cr-53	24053.60c	0.836015
Cr-54	24054.60c	0.211960
Si-nat	14000.50c	0.200980
P-31	15031.50c	0.006029
S-nat	16032.50c	0.006029
C-nat	6000.50c	0.040196
Mn-55	25055.50c	0.200980
Fe-54	26054.60c	0.114545

Table 5.4-23. Bottom Spacer Grid Homogenized Material Compositions

Assembly Design		CE 14x14
Element/Isotope	**MCNP ZAID**	**Wt%**
Fe-56	26056.60c	1.846377
Fe-57	26057.60c	0.043035
Fe-58	26058.60c	0.005847
Ni-58	28058.60c	15.712190
Ni-60	28060.60c	6.212793
Ni-61	28061.60c	0.274724
Ni-62	28062.60c	0.882141
Ni-64	28064.60c	0.231877
Al-27	13027.50c	0.160784
Ti-nat	22000.50c	0.160784
Co-59	27059.50c	0.401961
Mo-nat	42000.50c	3.617647
Ta-181	73181.50c	1.467157
Density (g/cm^3)		1.5488

Source: p. 52, Ref. 7.11

5.4.4 Fuel Material

The burned fuel from CRC statepoint 15 is delineated into eighteen axial regions (p. 16, Ref. 7.8) each having a unique material composition. The height of the top node is 17.7800 cm, the height of the bottom node is 22.3520 cm, and the height of the other axial nodes is 20.0025 cm (p. 16, Ref. 7.8). These nodal heights correspond directly to the nodal heights utilized in the fuel depletion calculations. Each nodal depleted fuel composition is obtained from Attachment II of Reference 7.8. The MCNP output files for each calculation are contained in Attachment III (moved to Reference 7.15). The nodal fuel isotopic compositions are listed in the input files in terms of ZAID's, weight percents, and density (g/cm^3). Each nodal fuel composition is identified by assembly and node in the material specification section of the input files.

The fuel rod components include the fuel rod cladding, the upper and lower fuel rod plenums (including end-caps), and the fuel. The fuel rod cladding was represented as Zircaloy-4 for all of the assembly designs in this analysis as presented in Table 5.4-7. The upper and lower fuel rod plenum regions were represented as containing SS304 springs in each of the assembly designs except the Siemens 14x14 assembly. No data was available for the spring material so it was modeled as void in the MCNP cases. Table 5.4-25 contains the upper and lower fuel rod plenum volume fractions. The volume fractions for the CE assembly designs and the W 15x15 assembly design were calculated by determining the spring volume from its mass and dividing it by the total plenum volume. Tables 5.4-26 and 5.4-27 contain the homogenized material compositions for the upper and lower fuel rod plenum regions. The average composition of the fresh fuel for the WP fresh fuel calculation is presented in Table 5.4-24. The isotopic weight percentages of the fresh fuel composition were calculated using Equations 5.4-8 through 5.4-12.

Equation 5.4-8. Calculation of Average Fresh Fuel Enrichment in CRC for use in WP

$$e_o(x) = \frac{\sum_i e_i(x) N_i}{N}$$

where: $e_o(x)$ = the initial enrichment of the fuel in the average fuel assembly in wt%
x = Isotope (e.g., U-233, U-235, U-238, etc.)
$e_i(x)$ = Enrichment of fuel in assembly "i" in wt%
N_i = Number of fuel assemblies containing fuel with enrichment ei(x)
N = Total number of fuel assemblies in reactor

Equation 5.4-9. Uranium Isotope Weight Percents in Fabricated UO_2 (p. 208, Ref. 7.8)

$$U^{234}\ wt\% = (0.007731) * (U^{235}\ wt\%)^{1.083}$$

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

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

Equation 5.4-10. Uranium Mass per mol of UO_2

$$\frac{U\ Mass}{mol\ UO_2} = (1.008664904)\left[\begin{matrix}(232.030)(U^{234}wt\%) + (233.025)(U^{235}wt\%) + \\ (234.018)(U^{236}wt\%) + (236.006)(U^{238}wt\%)\end{matrix}\right](0.01)$$

where the weight percentages of the uranium isotopes (U^{234}, U^{235}, U^{236}, and U^{238}) in uranium are calculated using Equation 5.4-9.

Equation 5.4-11. Oxygen Mass per mol of UO_2

$$\frac{O\ Mass}{mol\ UO_2} = (2)(1.008664904)(15.86196)$$

Equation 5.4-12. Oxygen Mass in UO_2

$$O\ Mass\ in\ UO_2 = \left(\frac{O\ Mass / mol\ UO_2}{U\ Mass / mol\ UO_2}\right)(U\ Mass\ in\ UO_2)$$

The wt% of each uranium isotope in the fresh UO_2 composition is determined by multiplying the wt% of each uranium isotope in the enriched uranium by the weight fraction of uranium in the UO_2. The wt% of oxygen in the UO_2 is the weight fraction of oxygen in UO_2 multiplied by 100.

Table 5.4-24. Average Composition of Fresh Fuel from Crystal River Unit 3 BOL Core

Element/Isotope	Wt%
U-234	0.01800
U-235	2.15961
U-236	0.00993
U-238	85.95995
O	11.85250
Density (g/cm^3)	10.1211

Table 5.4-25. Fuel Rod Plenum Material Volume Fractions

Assembly Design	Plenum Location	Type 304 Stainless Steel	Gas (modeled as void)	Zircaloy-4
B&W 15x15[1]	Upper	0.0811	0.7793	0.1396
	Lower	0.1569	0.5973	0.2458
CE 14x14[2]	Upper	0.0162	0.9838	0.0000
	Lower	0.0000	0.0000	0.0000
Siemens 14x14[3]	Upper	N/A	N/A	N/A
	Lower	N/A	N/A	N/A
W 15x15[2]	Upper	0.0006	0.9994	0.0000
	Lower	N/A	N/A	N/A

[1] Volume fractions are from pages 209 and 210 of Ref. 7.8
[2] Values are from p. 54, Ref. 7.11
[3] See Assumption 3.3

Table 5.4-26. Fuel Rod Plenum Homogenized Material Compositions for B&W 15x15 Assembly Design

MCNP ZAID	Wt% of Element/Isotope in Material Composition	
	Upper Fuel Rod Plenum	Lower Fuel Rod Plenum
6000.50c	0.033	0.035
7014.50c	0.041	0.043
14000.50c	0.309	0.326
15031.50c	0.019	0.020
16032.50c	0.012	0.013
24050.60c	0.329	0.347
24052.60c	6.595	6.961
24053.60c	0.762	0.804
24054.60c	0.193	0.204
25055.50c	0.823	0.869
26054.60c	1.619	1.710
26056.60c	26.105	27.560
26057.60c	0.608	0.642
26058.60c	0.083	0.087
28058.60c	2.566	2.710
28060.60c	1.015	1.072
28061.60c	0.045	0.047
28062.60c	0.144	0.152
28064.60c	0.038	0.040

Table 5.4-26. Fuel Rod Plenum Homogenized Material Compositions for B&W 15x15 Assembly Design

MCNP ZAID	Wt% of Element/Isotope in Material Composition	
	Upper Fuel Rod Plenum	Lower Fuel Rod Plenum
8016.50c	0.071	0.068
40000.60c	57.766	55.498
50000.35c	0.824	0.791
Density (g/cm^3)	1.5565	2.8521

Source: p. 210, Ref. 7.8

Table 5.4-27. Upper Fuel Rod Plenum Homogenized Material Compositions for CE 14x14 and W 15x15 Assembly Designs

MCNP ZAID	Wt% of Element/Isotope in Material Composition	
	CE 14x14	W 15x15
6000.50c	0.080	0.080
7014.50c	0.100	0.100
14000.50c	0.750	0.750
15031.50c	0.045	0.045
16032.50c	0.030	0.030
24050.60c	0.793	0.793
24052.60c	15.903	15.903
24053.60c	1.838	1.838
24054.60c	0.466	0.466
25055.50c	2.000	2.000
26054.60c	3.918	3.918
26056.60c	63.156	63.156
26057.60c	1.472	1.472
26058.60c	0.200	0.200
28058.60c	6.234	6.234
28060.60c	2.465	2.465
28061.60c	0.109	0.109
28062.60c	0.350	0.350
28064.60c	0.092	0.092
Homogenized density (g/cm^3)	0.1280	0.0045

5.4.4.1 Radiochemical Assay and SAS2H Predicted Spent Fuel

This section discusses measured spent fuel isotopic concentrations that were performed using radiochemical analyses, and the results from SAS2H simulated depletion calculations. These isotopic concentrations were modeled in MCNP in order to determine the effect on k_{eff} arising from differences between the measured and predicted isotopic concentrations. The various assay samples being evaluated originate from commercial reactors. Samples analyzed were taken from fuel assemblies from Mihama PWR, Turkey Point PWR, Calvert Cliffs PWR, H.B. Robinson PWR, and Obrigheim PWR. The physical dimensions of these fuel assembly designs are discussed in Reference 7.14.

The fuel assembly design for Mihama, Turkey Point, and H.B. Robinson is a Westinghouse 15x15 assembly with 20 guide tubes. Tables 5.4-28, 5.4-29, and 5.4-31 present the measured

and calculated isotopic concentrations for the Mihama, Turkey Point, and H.B. Robinson PWRs, respectively.

The fuel assembly design for Calvert Cliffs is a Combustion Engineering 14x14 assembly design with 5 guide tubes. The Obrigheim fuel assembly is a Siemens 14x14 design with 16 guide tubes that was designed for Westinghouse reactors. Tables 5.4-30 and 5.4-32 present the measured and calculated isotopic concentrations for the Calvert Cliffs PWR and Obrigheim PWRs, respectively.

Table 5.4-28. Isotopic Concentrations for Mihama PWR

Isotope/ Experiment Identifier	U-234 (g/MTU)	U-235 (g/MTU)	U-236 (g/MTU)	U-238 (g/MTU)	Pu-238 (g/MTU)	Pu-239 (g/MTU)	Pu-240 (g/MTU)	Pu-241 (g/MTU)	Pu-242 (g/MTU)
mih1a[1]	267	23900	1650	962000	4.51	3020	422	109	9.49
mih1b[2]	2.53E+02	2.34E+04	1.75E+03	9.62E+05	4.54E+00	3.05E+03	4.30E+02	1.09E+02	1.02E+01
mih2a	N/A	25200	1460	962000	3.41	2830	344	82.8	6.04
mih2b	N/A	2.48E+04	1.53E+03	9.63E+05	3.30E+00	2.81E+03	3.47E+02	8.16E+01	6.26E+00
mih3a	N/A	18500	2650	956000	25.9	4650	1030	408	73.9
mih3b	N/A	1.77E+04	2.63E+03	9.57E+05	2.18E+01	4.30E+03	1.01E+03	3.62E+02	7.04E+01
mih4a	N/A	14500	3270	952000	57.2	5080	1490	651	176
mih4b	N/A	1.39E+04	3.25E+03	9.52E+05	5.01E+01	4.98E+03	1.51E+03	6.14E+02	1.76E+02
mih5a[3]	N/A	18400	2660	957000	26.8	4740	1060	425	75.1
mih5b	N/A	1.83E+04	2.54E+03	9.57E+05	2.03E+01	4.29E+03	9.69E+02	3.47E+02	6.33E+01
mih6a	N/A	9790	3830	947000	131	5300	2100	955	408
mih6b	N/A	9.40E+03	4.08E+03	9.46E+05	1.15E+02	5.11E+03	2.05E+03	8.43E+02	3.81E+02
mih7a	174	9070	4000	944000	159	5470	2270	1060	490
mih7b	1.82E+02	8.31E+03	4.23E+03	9.44E+05	1.41E+02	5.21E+03	2.23E+03	9.31E+02	4.69E+02
mih8a	174	7890	4180	944000	168	4970	2320	983	534
mih8b	1.78E+02	7.63E+03	4.31E+03	9.43E+05	1.54E+02	5.19E+03	2.30E+03	9.58E+02	5.19E+02
mih9a	N/A	8040	4200	942000	186	5320	2430	1080	570
mih9b	N/A	7.77E+03	4.32E+03	9.42E+05	1.69E+02	5.45E+03	2.39E+03	1.03E+03	5.45E+02

Source: pp. 13, 24, Ref. 7.16
[1] a indicates radiochemical assay measured fuel isotopics
[2] b indicates SAS2H calculated fuel isotopics
[3] p. 2-19 of Reference 7.21 indicates that an inconsistency exists between the isotopic concentrations and the associated burnup for this sample

Table 5.4-29. Isotopic Concentrations for Turkey Point PWR

Isotope/ Experiment Identifier	U-234 (g/MTU)	U-235 (g/MTU)	U-236 (g/MTU)	U-238 (g/MTU)	Pu-238 (g/MTU)	Pu-239 (g/MTU)	Pu-240 (g/MTU)	Pu-241 (g/MTU)	Pu-242 (g/MTU)
tp1a[1]	1.32E+02	5.87E+03	3.25E+03	9.50E+05	1.37E+02	4.84E+03	2.27E+03	1.06E+03	5.02E+02
tp1b[2]	1.34E+02	5.55E+03	3.35E+03	9.49E+05	1.35E+02	5.05E+03	2.34E+03	1.07E+03	5.45E+02
tp2a	1.32E+02	5.68E+03	3.26E+03	9.51E+05	1.36E+02	4.84E+03	2.29E+03	1.07E+03	5.25E+02
tp2b	1.35E+02	5.61E+03	3.34E+03	9.49E+05	1.33E+02	5.05E+03	2.33E+03	1.06E+03	5.37E+02
tp3a	1.23E+02	5.58E+03	3.17E+03	9.50E+05	1.43E+02	4.93E+03	2.30E+03	1.10E+03	5.48E+02
tp3b	1.32E+02	5.29E+03	3.37E+03	9.48E+05	1.42E+02	5.06E+03	2.39E+03	1.09E+03	5.77E+02
tp4a	1.13E+02	5.51E+03	3.16E+03	9.50E+05	1.38E+02	4.94E+03	2.32E+03	1.12E+03	5.43E+02
tp4b	1.33E+02	5.38E+03	3.36E+03	9.49E+05	1.40E+02	5.06E+03	2.37E+03	1.08E+03	5.65E+02

Table 5.4-29. Isotopic Concentrations for Turkey Point PWR

Isotope/ Experiment Identifier	U-234 (g/MTU)	U-235 (g/MTU)	U-236 (g/MTU)	U-238 (g/MTU)	Pu-238 (g/MTU)	Pu-239 (g/MTU)	Pu-240 (g/MTU)	Pu-241 (g/MTU)	Pu-242 (g/MTU)
tp5a	1.32E+02	5.66E+03	3.25E+03	9.50E+05	1.37E+02	4.79E+03	2.28E+03	1.07E+03	5.24E+02
tp5b	1.33E+02	5.37E+03	3.37E+03	9.49E+05	1.40E+02	5.06E+03	2.38E+03	1.08E+03	5.67E+02

Source: pp. 11, 21, Ref. 7.17
[1] a indicates radiochemical assay measured fuel isotopics
[2] b indicates SAS2H calculated fuel isotopics

Table 5.4-30. Isotopic Concentrations for Calvert Cliffs PWR

Isotope/ Experiment Identifier	U-234 ($g/MTUO_2$)	U-235 ($g/MTUO_2$)	U-236 ($g/MTUO_2$)	U-238 ($g/MTUO_2$)	Np-237 ($g/MTUO_2$)	Pu-238 ($g/MTUO_2$)	Pu-239 ($g/MTUO_2$)	Pu-240 ($g/MTUO_2$)	Pu-241 ($g/MTUO_2$)	Pu-242 ($g/MTUO_2$)	Am-241 ($g/MTUO_2$)
ce1a[1]	1.60E+02	8.47E+03	3.14E+03	8.43E+05	2.68E+02	1.01E+02	4.26E+03	1.72E+03	6.81E+02	2.89E+02	8.56E+02
ce1b[2]	1.59E+02	8.33E+03	3.23E+03	8.37E+05	2.78E+02	9.56E+01	3.67E+03	1.80E+03	6.66E+02	3.37E+02	2.37E+02
ce2a	1.40E+02	5.17E+03	3.53E+03	8.33E+05	3.56E+02	1.89E+02	4.36E+03	2.24E+03	9.03E+02	5.76E+02	1.18E+03
ce2b	1.38E+02	5.06E+03	3.65E+03	8.30E+05	4.00E+02	1.83E+02	3.71E+03	2.28E+03	8.51E+02	6.67E+02	2.95E+02
ce3a	1.20E+02	3.54E+03	3.69E+03	8.25E+05	4.68E+02	2.69E+02	4.36E+03	2.54E+03	1.02E+03	8.40E+02	1.31E+03
ce3b	1.22E+02	3.30E+03	3.75E+03	8.24E+05	5.01E+02	2.48E+02	4.52E+03	2.53E+03	9.95E+02	8.44E+02	3.42E+02
ce4a	1.40E+02	1.03E+04	2.50E+03	8.55E+05	N/A	4.85E+01	3.95E+03	1.24E+03	4.54E+02	1.39E+02	6.67E+02
ce4b	1.58E+02	1.03E+04	2.44E+03	8.46E+05	1.67E+02	3.81E+01	3.38E+03	1.32E+03	4.25E+02	1.50E+02	1.80E+02
ce5a	1.21E+02	6.94E+03	2.99E+03	8.54E+05	N/A	9.69E+01	4.25E+03	1.77E+03	6.82E+02	3.30E+02	9.91E+02
ce5b	1.40E+02	7.05E+03	2.93E+03	8.40E+05	2.64E+02	8.88E+01	3.42E+03	1.89E+03	6.48E+02	3.74E+02	2.71E+02
ce6a	1.20E+02	4.78E+03	3.26E+03	8.42E+05	N/A	1.48E+02	4.19E+03	2.11E+03	8.13E+02	5.47E+02	1.20E+03
ce6b	1.28E+02	5.16E+03	3.18E+03	8.35E+05	3.46E+02	1.48E+02	3.46E+03	2.25E+03	7.99E+02	6.16E+02	3.30E+02

Source: pp. 19, 36, Ref. 7.18
[1] a indicates radiochemical assay measured fuel isotopics
[2] b indicates SAS2H calculated fuel isotopics

Table 5.4-31. Isotopic Concentrations for H.B. Robinson PWR

Isotope/ Experiment Identifier	U-235 ($g/MTUO_2$)	U-236 ($g/MTUO_2$)	U-238 ($g/MTUO_2$)	Np-237 ($g/MTUO_2$)	Pu-238 ($g/MTUO_2$)	Pu-239 ($g/MTUO_2$)	Pu-240 ($g/MTUO_2$)	Pu-241 ($g/MTUO_2$)
hb1a[1]	1.07E+04	2.19E+03	8.47E+05	1.55E+02	2.83E+01	3.64E+03	1.09E+03	3.04E+02
hb1b[2]	1.11E+04	2.13E+03	8.47E+05	1.49E+02	2.76E+01	4.02E+03	1.16E+03	3.14E+02
hb2a	7.21E+03	2.74E+03	8.47E+05	2.60E+02	6.95E+01	4.02E+03	1.67E+03	5.04E+02
hb2b	7.64E+03	2.66E+03	8.42E+05	2.47E+02	6.62E+01	4.40E+03	1.73E+03	5.12E+02
hb3a	6.18E+03	2.82E+03	8.34E+05	3.04E+02	1.14E+02	4.39E+03	1.97E+03	6.81E+02
hb3b	6.21E+03	2.88E+03	8.38E+05	3.12E+02	1.00E+02	4.61E+03	2.03E+03	6.54E+02
hb4a	4.86E+03	3.00E+03	8.42E+05	3.33E+02	1.30E+02	4.20E+03	2.12E+03	6.92E+02
hb4b	5.32E+03	2.99E+03	8.35E+05	3.54E+02	1.25E+02	4.68E+03	2.21E+03	7.18E+02

Source: pp. 13, 26, Ref. 7.19
[1] a indicates radiochemical assay measured fuel isotopics
[2] b indicates SAS2H calculated fuel isotopics in

Table 5.4-32 Isotopic Concentrations for Obrigheim PWR

Isotope/ Experiment Identifier	U-235 (g/MTU)	U-236 (g/MTU)	U-238 (g/MTU)	Pu-238 (g/MTU)	Pu-239 (g/MTU)	Pu-240 (g/MTU)	Pu-241 (g/MTU)	Pu-242 (g/MTU)
ob1a[1]	10950	3590	9.85E+05	80.1	4805	1800	978	312
ob1b[2]	1.11E+04	3.60E+03	9.85E+05	8.72E+01	4.17E+03	1.99E+03	1.01E+03	3.46E+02
ob2a	10580	3620	9.86E+05	88.9	4713	1830	978	328
ob2b	1.08E+04	3.64E+03	9.86E+05	9.22E+01	4.24E+03	2.06E+03	1.03E+03	3.47E+02
ob3a	9850	3700	9.86E+05	94.8	4925	1920	1058	372
ob3b	1.01E+04	3.74E+03	9.86E+05	1.05E+02	4.23E+03	2.14E+03	1.08E+03	4.05E+02
ob4a	9680	3730	9.87E+05	105.4	5013	2020	1103	407
ob4b	9.98E+03	3.76E+03	9.86E+05	1.08E+02	4.21E+03	2.17E+03	1.10E+03	4.24E+02
ob5a	9580	3750	9.87E+05	101.3	4957	2000	1107	405
ob5b	9.70E+03	3.80E+03	9.87E+05	1.14E+02	4.21E+03	2.21E+03	1.13E+03	4.48E+02
ob6a	9180	3810	9.87E+05	107.1	4943	2040	1128	438
ob6b	9.48E+03	3.83E+03	9.87E+05	1.19E+02	4.21E+03	2.25E+03	1.15E+03	4.61E+02

Source: pp. 14, 25, Ref. 7.20
[1] a indicates radiochemical assay measured fuel isotopics
[2] b indicates SAS2H calculated fuel isotopics

6. RESULTS

The following results are presented in this section:

- k_{eff} for CRC using fresh fuel with U-235 and U-238 fuel cross section data at 587 K (cr3i1a)
- k_{eff} for CRC using fresh fuel with U-235 and U-238 fuel cross section data at 300 K (cr3i1b)
- k_{eff} for WP using fresh fuel with U-235 and U-238 fuel cross section data at 587 K (cr3i2a)
- k_{eff} for WP using fresh fuel with U-235 and U-238 fuel cross section data at 300 K (cr3i2b)
- k_{eff} for CRC using depleted fuel with U-235 and U-238 fuel cross section data at 587 K (cr3i3a)
- k_{eff} for CRC using depleted fuel with U-235 and U-238 fuel cross section data at 300 K (cr3i4a)
- k_{eff} for WP using depleted fuel with U-235 and U-238 fuel cross section data at 587 K (cr3i4b)
- k_{eff} for WP using depleted fuel with U-235 and U-238 fuel cross section data at 300 K (cr3i3b)
- Normalized neutron spectrum for an assembly by axial node in inner region of CRC and in center region of WP
- Normalized neutron spectrum for whole core region of CRC and in internal cavity of WP
- Normalized neutron spectrum for an assembly by axial node at outer edge of CRC core and at outer edge of WP
- Δk_{eff} for various cases using measured radiochemical assay spent fuel compositions and SAS2H predicted compositions

The k_{eff} results represent the average combined collision, absorption, and track-length estimator from the MCNP calculations. The standard deviation (σ) represents the standard deviation of k_{eff}

about the average combined collision, absorption, and track-length estimate due to the Monte Carlo calculation statistics.

6.1 RESULTS OF CROSS SECTION TEMPERATURE EFFECTS

This section presents the results of the effect on k_{eff} from using U-235 and U-238 fuel cross section data at 587 K versus 300 K. The results are presented in Table 6.1-1. As can be seen from the results, the difference in cross section temperature data results in a maximum of a 1% increase in k_{eff} when going from 587 K to 300 K. This shows increased conservatism when using the 300 K cross section data.

Table 6-1. Effects of Cross Section Temperature Results

Case Description	587 K Cross Section Results		300 K Cross Section Results		Difference	
	k_{eff}	σ	k_{eff}	σ	$\Delta\rho$[1]	σ
BOL Fresh Fuel in CRC Environment[2]	0.99601	0.00043	1.00681	0.00049	0.0108	0.00065
Average BOL Fresh Fuel Enrichment in WP Environment[3]	0.96268	0.00073	0.97096	0.00085	0.00886	0.00112
Burned Fuel Assemblies in CRC Environment[4]	0.99295	0.00026	1.00132	0.00026	0.00842	0.00037
Burned Fuel Assemblies in WP Environment[5]	0.84153	0.00025	0.84655	0.00025	0.00705	0.00035

[1] ρ is defined as (k-1)/k and is a measure of reactivity
[2] MCNP files for the 587 K cases cr3i1a and for the 300 K case was cr3i1b
[3] MCNP files for the 587 K case was cr3i2a and for the 300 K case was cr3i2b
[4] MCNP files for the 587 K case was cr3i3a and for the 300 K case was cr3i4a
[5] MCNP files for the 587 K case was cr3i4b and for the 300 K case was cr3i3b

6.2 NEUTRON SPECTRUM RESULTS

This section presents the neutron spectrum results present in the reactor environment versus the waste package environment. The results presented in Table 6.2-1 and Figures 6-4, 6-6, and 6-8 are for a centralized assembly within the two environments. Additional plots for the remaining nodes are contained in Attachment IV (the attachment CD has been moved to Reference 7.15). The energy group structure for the neutron spectrum plots is based on equal lethargy increments for the fast and slowing down regions, and selected based on resonance absorption peaks in the thermal region.

Figures 6-5, 6-7, and 6-9 show the number of neutrons per energy group causing fission (fission reaction rate). The energy groups for these plots are based on the 44-group energy structure from page 2 of Reference 7.24. Tabulated results and additional plots for the remaining nodes are provided in the attached spreadsheet file - Attachment V. Table 6.2-2 and Figures 6-10 and 6-11 present the average spectrum observed over the entire CRC core and the entire inner cavity of the WP, with Figure 6-11 presenting a more detailed plot over the thermal region. Table 6.2-3 and Figures 6-12, 6-14, and 6-16 present the results of the spectrum from an assembly at the outer

edge of the CRC core and at the outer edge of the WP configuration. The nodes represented in these plots are 1, 10, and 18. Results for the remaining nodes are similar to those shown, and are presented in the spreadsheet in Attachment IV. Figures 6-13, 6-15, and 6-17 show the fission reaction rate per energy group. Tabulated results and additional plots for the remaining nodes are provided in the spreadsheet file in Attachment V.

From the results presented in Figures 6-4, 6-6, 6-8, 6-12, 6-14, and 6-16, it can be seen that that the overall spectral characteristics for a particular assembly are in very good agreement between the WP environment and the CRC environment. The energy dependent reaction rates are the product of the neutron flux spectrum and the energy dependent total macroscopic cross section. With constant source distribution functions, and the total macroscopic cross sections for the fuel region in the CRCs and WP being composed of the same isotopics, the resulting relative flux spectra in the CRCs and WP are very nearly the same. It should be noted that the normalized flux results are similar, but the absolute magnitude of the number of neutrons per energy group is much different, based on the CRC having a $k_{eff} \sim 1.00$ and the WP k_{eff} being ~ 0.85. From Figures 6-10 and 6-11 it can be seen that the spectral characteristics for the WP environment and the CRC environment are very similar when looking at the core average and the WP average over the entire fuel region present in each system.

The results for the number of neutrons per energy group that cause fission is a measure of the reaction rate. From Figures 6-5, 6-7, 6-9, 6-13, 6-15, and 6-17, it can be seen that the WP has a greater fraction of neutrons causing fission at lower energies than in the CRC environment. This observation reflects the harder neutron spectrum present in the CRC environment.

Figure 6-11 shows that the CRC relative flux spectra is lower at energies below 0.1 eV than the comparable WP. The differences appear to be caused by temperature effects which result in the Westcott g-factors changing, and the Maxwellian distribution changing. However, the relative energy distribution of the absorption, fission, and scattering reaction rates in the CRCs is essentially the same as the WPs.

Table 6.2-1. Neutron Spectrum Results for Centralized PWR Assembly (E08)

Axial Node	Energy Range (MeV)	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
1	0 to 1.25E-09	1.60E-08	0.64750	1.42E-07	0.17890
	1.25E-09 to 5.00E-09	3.47E-07	0.13530	3.87E-06	0.03820
	5.00E-09 to 5.63E-09	5.52E-08	0.27960	9.30E-07	0.07860
	5.63E-09 to 1.00E-08	1.15E-06	0.08500	1.14E-05	0.02540
	1.00E-08 to 2.00E-08	4.33E-06	0.04990	4.86E-05	0.01440
	2.00E-08 to 4.60E-08	2.01E-05	0.02890	1.71E-04	0.01000
	4.60E-08 to 6.25E-08	1.41E-05	0.03250	9.54E-05	0.01210
	6.25E-08 to 1.00E-07	2.96E-05	0.02640	1.44E-04	0.01100
	1.00E-07 to 1.88E-07	3.90E-05	0.02490	1.24E-04	0.01170
	1.88E-07 to 2.50E-07	1.07E-05	0.03960	3.43E-05	0.01950
	2.50E-07 to 3.13E-07	5.75E-06	0.04860	2.10E-05	0.02360
	3.13E-07 to 3.75E-07	4.55E-06	0.05610	1.90E-05	0.02560

Table 6.2-1. Neutron Spectrum Results for Centralized PWR Assembly (E08)

Axial Node	Energy Range (MeV)	CRC Environment		WP Environment	
		Tally (#/cm^3/source particle)	Relative Error	Tally (#/cm^3/source particle)	Relative Error
	3.75E-07 to 4.38E-07	3.78E-06	0.06850	1.87E-05	0.02680
	4.38E-07 to 5.00E-07	3.57E-06	0.07010	1.75E-05	0.02800
	5.00E-07 to 5.63E-07	3.18E-06	0.07190	1.59E-05	0.03040
	5.63E-07 to 6.25E-07	2.83E-06	0.07570	1.33E-05	0.03310
	6.25E-07 to 1.86E-06	2.67E-05	0.02990	1.29E-04	0.01210
	1.86E-06 to 5.04E-06	2.79E-05	0.03030	1.25E-04	0.01240
	5.04E-06 to 1.37E-05	2.28E-05	0.03080	1.13E-04	0.01240
	1.37E-05 to 3.73E-05	2.55E-05	0.02940	1.24E-04	0.01200
	3.73E-05 to 1.01E-04	2.98E-05	0.02840	1.43E-04	0.01160
	1.01E-04 to 2.75E-04	2.99E-05	0.02810	1.48E-04	0.01150
	2.75E-04 to 7.49E-04	3.36E-05	0.02720	1.54E-04	0.01140
	7.49E-04 to 2.03E-03	3.09E-05	0.02890	1.59E-04	0.01130
	2.03E-03 to 5.53E-03	3.56E-05	0.02780	1.65E-04	0.01130
	5.53E-03 to 0.0150	3.91E-05	0.02680	1.74E-04	0.01110
	0.0150 to 0.0409	4.04E-05	0.02690	1.97E-04	0.01060
	0.0409 to 0.111	5.32E-05	0.02430	2.49E-04	0.01000
	0.111 to 0.302	8.14E-05	0.02160	3.91E-04	0.00870
	0.302 to 0.821	1.38E-04	0.01840	6.67E-04	0.00740
	0.821 to 2.23	1.66E-04	0.01750	8.41E-04	0.00690
	2.23 to 20.00	1.28E-04	0.02050	6.33E-04	0.00830
	Total	1.05E-03	0.01000	5.15E-03	0.00410
2	0 to 1.25E-09	9.09E-09	4.22E-01	2.28E-07	0.12800
	1.25E-09 to 5.00E-09	5.30E-07	1.11E-01	5.98E-06	0.03020
	5.00E-09 to 5.63E-09	1.55E-07	2.24E-01	1.64E-06	0.05860
	5.63E-09 to 1.00E-08	1.43E-06	7.72E-02	1.67E-05	0.02020
	1.00E-08 to 2.00E-08	6.21E-06	3.93E-02	6.89E-05	0.01170
	2.00E-08 to 4.60E-08	3.00E-05	2.35E-02	2.43E-04	0.00810
	4.60E-08 to 6.25E-08	2.09E-05	2.61E-02	1.35E-04	0.00970
	6.25E-08 to 1.00E-07	4.13E-05	2.17E-02	2.06E-04	0.00870
	1.00E-07 to 1.88E-07	5.26E-05	1.97E-02	1.78E-04	0.00930
	1.88E-07 to 2.50E-07	1.59E-05	3.06E-02	4.72E-05	0.01560
	2.50E-07 to 3.13E-07	7.68E-06	3.76E-02	2.97E-05	0.01840
	3.13E-07 to 3.75E-07	6.39E-06	4.61E-02	2.66E-05	0.02020
	3.75E-07 to 4.38E-07	5.56E-06	5.23E-02	2.59E-05	0.02170
	4.38E-07 to 5.00E-07	5.74E-06	5.27E-02	2.41E-05	0.02250
	5.00E-07 to 5.63E-07	4.62E-06	5.83E-02	2.27E-05	0.02380
	5.63E-07 to 6.25E-07	3.96E-06	6.15E-02	1.90E-05	0.02600
	6.25E-07 to 1.86E-06	3.82E-05	2.26E-02	1.82E-04	0.00950
	1.86E-06 to 5.04E-06	3.80E-05	2.36E-02	1.81E-04	0.00980
	5.04E-06 to 1.37E-05	3.32E-05	2.36E-02	1.59E-04	0.00970
	1.37E-05 to 3.73E-05	3.69E-05	2.29E-02	1.78E-04	0.00950
	3.73E-05 to 1.01E-04	4.40E-05	2.22E-02	2.04E-04	0.00900
	1.01E-04 to 2.75E-04	4.58E-05	2.16E-02	2.11E-04	0.00900
	2.75E-04 to 7.49E-04	4.91E-05	2.15E-02	2.24E-04	0.00900
	7.49E-04 to 2.03E-03	5.21E-05	2.12E-02	2.28E-04	0.00890
	2.03E-03 to 5.53E-03	5.16E-05	2.16E-02	2.38E-04	0.00880
	5.53E-03 to 0.0150	5.59E-05	2.09E-02	2.53E-04	0.00870
	0.0150 to 0.0409	6.18E-05	2.02E-02	2.84E-04	0.00850
	0.0409 to 0.111	7.90E-05	1.90E-02	3.59E-04	0.00790
	0.111 to 0.302	1.25E-04	1.68E-02	5.60E-04	0.00680
	0.302 to 0.821	2.02E-04	1.44E-02	9.38E-04	0.00590

Table 6.2-1. Neutron Spectrum Results for Centralized PWR Assembly (E08)

Axial Node	Energy Range (MeV)	CRC Environment		WP Environment	
		Tally (#/cm^3/source particle)	Relative Error	Tally (#/cm^3/source particle)	Relative Error
	0.821 to 2.23	2.36E-04	1.39E-02	1.18E-03	0.00560
	2.23 to 20.00	1.90E-04	1.63E-02	8.88E-04	0.00670
	Total	1.54E-03	7.90E-03	7.31E-03	0.00330
3	0 to 1.25E-09	3.32E-08	4.70E-01	2.29E-07	1.31E-01
	1.25E-09 to 5.00E-09	5.39E-07	1.09E-01	5.56E-06	3.19E-02
	5.00E-09 to 5.63E-09	1.45E-07	2.17E-01	1.24E-06	6.49E-02
	5.63E-09 to 1.00E-08	1.46E-06	7.14E-02	1.55E-05	2.10E-02
	1.00E-08 to 2.00E-08	6.97E-06	3.80E-02	6.30E-05	1.23E-02
	2.00E-08 to 4.60E-08	3.09E-05	2.20E-02	2.21E-04	8.40E-03
	4.60E-08 to 6.25E-08	2.12E-05	2.53E-02	1.26E-04	1.01E-02
	6.25E-08 to 1.00E-07	4.34E-05	2.06E-02	1.86E-04	9.20E-03
	1.00E-07 to 1.88E-07	5.72E-05	1.89E-02	1.58E-04	9.70E-03
	1.88E-07 to 2.50E-07	1.60E-05	3.02E-02	4.50E-05	1.62E-02
	2.50E-07 to 3.13E-07	8.25E-06	3.74E-02	2.64E-05	1.90E-02
	3.13E-07 to 3.75E-07	6.52E-06	4.35E-02	2.43E-05	2.10E-02
	3.75E-07 to 4.38E-07	6.33E-06	4.73E-02	2.45E-05	2.24E-02
	4.38E-07 to 5.00E-07	5.96E-06	5.05E-02	2.20E-05	2.45E-02
	5.00E-07 to 5.63E-07	5.28E-06	5.50E-02	2.05E-05	2.50E-02
	5.63E-07 to 6.25E-07	4.65E-06	5.80E-02	1.74E-05	2.72E-02
	6.25E-07 to 1.86E-06	3.99E-05	2.19E-02	1.64E-04	9.80E-03
	1.86E-06 to 5.04E-06	4.07E-05	2.25E-02	1.63E-04	1.03E-02
	5.04E-06 to 1.37E-05	3.69E-05	2.25E-02	1.45E-04	1.03E-02
	1.37E-05 to 3.73E-05	4.31E-05	2.18E-02	1.61E-04	9.90E-03
	3.73E-05 to 1.01E-04	4.89E-05	2.08E-02	1.89E-04	9.60E-03
	1.01E-04 to 2.75E-04	5.25E-05	2.04E-02	1.93E-04	9.50E-03
	2.75E-04 to 7.49E-04	5.40E-05	2.06E-02	2.00E-04	9.40E-03
	7.49E-04 to 2.03E-03	5.42E-05	2.04E-02	2.11E-04	9.30E-03
	2.03E-03 to 5.53E-03	5.90E-05	2.01E-02	2.20E-04	9.30E-03
	5.53E-03 to 0.0150	6.36E-05	1.97E-02	2.33E-04	9.10E-03
	0.0150 to 0.0409	6.95E-05	1.97E-02	2.58E-04	8.90E-03
	0.0409 to 0.111	8.85E-05	1.83E-02	3.30E-04	8.20E-03
	0.111 to 0.302	1.33E-04	1.61E-02	5.08E-04	7.20E-03
	0.302 to 0.821	2.21E-04	1.39E-02	8.58E-04	6.20E-03
	0.821 to 2.23	2.67E-04	1.32E-02	1.06E-03	5.90E-03
	2.23 to 20.00	2.05E-04	1.57E-02	7.99E-04	7.10E-03
	Total	1.69E-03	7.50E-03	6.65E-03	3.50E-03
4	0 to 1.25E-09	2.41E-08	3.61E-01	1.55E-07	1.62E-01
	1.25E-09 to 5.00E-09	6.32E-07	1.05E-01	4.99E-06	3.34E-02
	5.00E-09 to 5.63E-09	1.81E-07	2.03E-01	1.29E-06	6.64E-02
	5.63E-09 to 1.00E-08	1.97E-06	6.25E-02	1.45E-05	2.19E-02
	1.00E-08 to 2.00E-08	8.00E-06	3.56E-02	5.88E-05	1.27E-02
	2.00E-08 to 4.60E-08	3.67E-05	2.10E-02	2.05E-04	8.90E-03
	4.60E-08 to 6.25E-08	2.54E-05	2.35E-02	1.13E-04	1.07E-02
	6.25E-08 to 1.00E-07	5.07E-05	1.95E-02	1.68E-04	9.70E-03
	1.00E-07 to 1.88E-07	6.49E-05	1.80E-02	1.42E-04	1.04E-02
	1.88E-07 to 2.50E-07	1.81E-05	2.78E-02	3.89E-05	1.73E-02
	2.50E-07 to 3.13E-07	9.69E-06	3.53E-02	2.30E-05	2.05E-02
	3.13E-07 to 3.75E-07	7.13E-06	4.36E-02	2.13E-05	2.24E-02
	3.75E-07 to 4.38E-07	7.46E-06	4.48E-02	2.11E-05	2.44E-02
	4.38E-07 to 5.00E-07	6.44E-06	4.86E-02	1.92E-05	2.55E-02
	5.00E-07 to 5.63E-07	5.75E-06	5.04E-02	1.72E-05	2.69E-02

Table 6.2-1. Neutron Spectrum Results for Centralized PWR Assembly (E08)

Axial Node	Energy Range (MeV)	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
	5.63E-07 to 6.25E-07	4.92E-06	5.85E-02	1.50E-05	2.88E-02
	6.25E-07 to 1.86E-06	4.56E-05	2.08E-02	1.40E-04	1.07E-02
	1.86E-06 to 5.04E-06	4.58E-05	2.13E-02	1.45E-04	1.09E-02
	5.04E-06 to 1.37E-05	4.04E-05	2.15E-02	1.30E-04	1.07E-02
	1.37E-05 to 3.73E-05	4.56E-05	2.05E-02	1.43E-04	1.05E-02
	3.73E-05 to 1.01E-04	5.40E-05	1.97E-02	1.61E-04	1.02E-02
	1.01E-04 to 2.75E-04	5.52E-05	2.01E-02	1.68E-04	1.01E-02
	2.75E-04 to 7.49E-04	6.05E-05	1.92E-02	1.78E-04	1.01E-02
	7.49E-04 to 2.03E-03	6.20E-05	1.93E-02	1.83E-04	9.90E-03
	2.03E-03 to 5.53E-03	6.38E-05	1.92E-02	1.88E-04	9.90E-03
	5.53E-03 to 0.0150	6.91E-05	1.88E-02	2.00E-04	9.70E-03
	0.0150 to 0.0409	7.77E-05	1.82E-02	2.25E-04	9.40E-03
	0.0409 to 0.111	9.63E-05	1.73E-02	2.83E-04	8.80E-03
	0.111 to 0.302	1.49E-04	1.52E-02	4.41E-04	7.70E-03
	0.302 to 0.821	2.42E-04	1.33E-02	7.46E-04	6.60E-03
	0.821 to 2.23	2.84E-04	1.27E-02	9.35E-04	6.30E-03
	2.23 to 20.00	2.22E-04	1.49E-02	7.07E-04	7.60E-03
	Total	1.86E-03	7.20E-03	5.84E-03	3.70E-03
5	0 to 1.25E-09	8.56E-09	4.14E-01	1.13E-07	1.94E-01
	1.25E-09 to 5.00E-09	5.10E-07	1.10E-01	3.92E-06	3.81E-02
	5.00E-09 to 5.63E-09	1.54E-07	2.10E-01	8.70E-07	7.69E-02
	5.63E-09 to 1.00E-08	1.88E-06	6.29E-02	1.09E-05	2.51E-02
	1.00E-08 to 2.00E-08	7.57E-06	3.71E-02	4.22E-05	1.50E-02
	2.00E-08 to 4.60E-08	3.41E-05	2.16E-02	1.50E-04	1.04E-02
	4.60E-08 to 6.25E-08	2.36E-05	2.43E-02	8.31E-05	1.24E-02
	6.25E-08 to 1.00E-07	4.79E-05	1.98E-02	1.22E-04	1.13E-02
	1.00E-07 to 1.88E-07	6.23E-05	1.86E-02	1.06E-04	1.21E-02
	1.88E-07 to 2.50E-07	1.68E-05	2.85E-02	2.82E-05	2.01E-02
	2.50E-07 to 3.13E-07	8.17E-06	3.66E-02	1.67E-05	2.39E-02
	3.13E-07 to 3.75E-07	7.32E-06	4.20E-02	1.64E-05	2.56E-02
	3.75E-07 to 4.38E-07	7.01E-06	4.54E-02	1.71E-05	2.76E-02
	4.38E-07 to 5.00E-07	6.39E-06	4.86E-02	1.43E-05	2.96E-02
	5.00E-07 to 5.63E-07	5.50E-06	5.18E-02	1.32E-05	3.09E-02
	5.63E-07 to 6.25E-07	4.66E-06	5.81E-02	1.18E-05	3.32E-02
	6.25E-07 to 1.86E-06	4.18E-05	2.16E-02	1.04E-04	1.25E-02
	1.86E-06 to 5.04E-06	4.29E-05	2.23E-02	1.08E-04	1.27E-02
	5.04E-06 to 1.37E-05	3.81E-05	2.20E-02	9.67E-05	1.24E-02
	1.37E-05 to 3.73E-05	4.39E-05	2.11E-02	1.08E-04	1.22E-02
	3.73E-05 to 1.01E-04	5.23E-05	2.02E-02	1.23E-04	1.18E-02
	1.01E-04 to 2.75E-04	5.34E-05	2.04E-02	1.25E-04	1.18E-02
	2.75E-04 to 7.49E-04	5.64E-05	2.01E-02	1.34E-04	1.16E-02
	7.49E-04 to 2.03E-03	5.69E-05	1.99E-02	1.35E-04	1.15E-02
	2.03E-03 to 5.53E-03	6.12E-05	1.97E-02	1.42E-04	1.14E-02
	5.53E-03 to 0.0150	6.52E-05	1.94E-02	1.52E-04	1.13E-02
	0.0150 to 0.0409	7.26E-05	1.91E-02	1.75E-04	1.08E-02
	0.0409 to 0.111	9.32E-05	1.77E-02	2.13E-04	1.02E-02
	0.111 to 0.302	1.38E-04	1.58E-02	3.32E-04	8.90E-03
	0.302 to 0.821	2.30E-04	1.36E-02	5.63E-04	7.70E-03
	0.821 to 2.23	2.69E-04	1.31E-02	6.94E-04	7.30E-03
	2.23 to 20.00	2.14E-04	1.53E-02	5.29E-04	8.80E-03
	Total	1.76E-03	7.40E-03	4.37E-03	4.30E-03

Table 6.2-1. Neutron Spectrum Results for Centralized PWR Assembly (E08)

Axial Node	Energy Range (MeV)	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
6	0 to 1.25E-09	2.61E-09	7.35E-01	1.05E-07	1.95E-01
	1.25E-09 to 5.00E-09	6.95E-07	9.80E-02	3.12E-06	4.39E-02
	5.00E-09 to 5.63E-09	1.43E-07	1.85E-01	7.38E-07	8.51E-02
	5.63E-09 to 1.00E-08	1.67E-06	6.30E-02	8.12E-06	2.88E-02
	1.00E-08 to 2.00E-08	7.87E-06	3.62E-02	3.29E-05	1.72E-02
	2.00E-08 to 4.60E-08	3.35E-05	2.15E-02	1.18E-04	1.17E-02
	4.60E-08 to 6.25E-08	2.28E-05	2.48E-02	6.47E-05	1.42E-02
	6.25E-08 to 1.00E-07	4.74E-05	1.98E-02	9.50E-05	1.29E-02
	1.00E-07 to 1.88E-07	5.98E-05	1.89E-02	8.08E-05	1.38E-02
	1.88E-07 to 2.50E-07	1.70E-05	2.85E-02	2.22E-05	2.29E-02
	2.50E-07 to 3.13E-07	8.28E-06	3.72E-02	1.24E-05	2.77E-02
	3.13E-07 to 3.75E-07	6.75E-06	4.32E-02	1.15E-05	3.08E-02
	3.75E-07 to 4.38E-07	6.78E-06	4.69E-02	1.26E-05	3.20E-02
	4.38E-07 to 5.00E-07	6.22E-06	4.95E-02	1.13E-05	3.37E-02
	5.00E-07 to 5.63E-07	5.18E-06	5.46E-02	1.02E-05	3.62E-02
	5.63E-07 to 6.25E-07	4.86E-06	5.89E-02	8.85E-06	3.84E-02
	6.25E-07 to 1.86E-06	4.38E-05	2.11E-02	8.15E-05	1.39E-02
	1.86E-06 to 5.04E-06	4.32E-05	2.19E-02	8.46E-05	1.43E-02
	5.04E-06 to 1.37E-05	3.84E-05	2.22E-02	7.32E-05	1.45E-02
	1.37E-05 to 3.73E-05	4.29E-05	2.13E-02	7.96E-05	1.39E-02
	3.73E-05 to 1.01E-04	4.92E-05	2.09E-02	9.32E-05	1.35E-02
	1.01E-04 to 2.75E-04	5.26E-05	2.04E-02	9.52E-05	1.35E-02
	2.75E-04 to 7.49E-04	5.30E-05	2.03E-02	1.01E-04	1.33E-02
	7.49E-04 to 2.03E-03	5.73E-05	1.99E-02	1.05E-04	1.32E-02
	2.03E-03 to 5.53E-03	6.01E-05	1.99E-02	1.07E-04	1.33E-02
	5.53E-03 to 0.0150	6.21E-05	1.98E-02	1.14E-04	1.30E-02
	0.0150 to 0.0409	6.84E-05	1.95E-02	1.29E-04	1.25E-02
	0.0409 to 0.111	8.96E-05	1.83E-02	1.60E-04	1.18E-02
	0.111 to 0.302	1.37E-04	1.58E-02	2.52E-04	1.03E-02
	0.302 to 0.821	2.19E-04	1.37E-02	4.19E-04	8.80E-03
	0.821 to 2.23	2.72E-04	1.31E-02	5.24E-04	8.40E-03
	2.23 to 20.00	2.12E-04	1.56E-02	3.98E-04	1.01E-02
	Total	1.73E-03	7.40E-03	3.31E-03	4.90E-03
7	0 to 1.25E-09	2.09E-09	8.12E-01	7.33E-08	2.04E-01
	1.25E-09 to 5.00E-09	6.89E-07	1.00E-01	2.28E-06	4.89E-02
	5.00E-09 to 5.63E-09	1.93E-07	1.86E-01	5.67E-07	9.42E-02
	5.63E-09 to 1.00E-08	2.01E-06	6.25E-02	6.34E-06	3.32E-02
	1.00E-08 to 2.00E-08	7.90E-06	3.53E-02	2.51E-05	1.92E-02
	2.00E-08 to 4.60E-08	3.50E-05	2.14E-02	9.17E-05	1.35E-02
	4.60E-08 to 6.25E-08	2.32E-05	2.45E-02	5.09E-05	1.60E-02
	6.25E-08 to 1.00E-07	4.70E-05	2.02E-02	7.27E-05	1.48E-02
	1.00E-07 to 1.88E-07	6.10E-05	1.87E-02	6.25E-05	1.57E-02
	1.88E-07 to 2.50E-07	1.67E-05	2.94E-02	1.69E-05	2.63E-02
	2.50E-07 to 3.13E-07	8.42E-06	3.75E-02	9.58E-06	3.14E-02
	3.13E-07 to 3.75E-07	7.57E-06	4.18E-02	8.86E-06	3.42E-02
	3.75E-07 to 4.38E-07	6.71E-06	4.76E-02	9.10E-06	3.73E-02
	4.38E-07 to 5.00E-07	6.19E-06	5.05E-02	8.38E-06	3.88E-02
	5.00E-07 to 5.63E-07	5.36E-06	5.23E-02	7.41E-06	4.19E-02
	5.63E-07 to 6.25E-07	4.67E-06	5.68E-02	6.72E-06	4.34E-02
	6.25E-07 to 1.86E-06	4.25E-05	2.16E-02	6.00E-05	1.62E-02
	1.86E-06 to 5.04E-06	4.32E-05	2.19E-02	6.18E-05	1.64E-02

Table 6.2-1. Neutron Spectrum Results for Centralized PWR Assembly (E08)

Axial Node	Energy Range (MeV)	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
	5.04E-06 to 1.37E-05	3.86E-05	2.21E-02	5.52E-05	1.65E-02
	1.37E-05 to 3.73E-05	4.18E-05	2.19E-02	6.18E-05	1.59E-02
	3.73E-05 to 1.01E-04	4.85E-05	2.07E-02	7.08E-05	1.56E-02
	1.01E-04 to 2.75E-04	5.18E-05	2.04E-02	7.32E-05	1.55E-02
	2.75E-04 to 7.49E-04	5.41E-05	2.01E-02	7.55E-05	1.53E-02
	7.49E-04 to 2.03E-03	5.72E-05	2.03E-02	7.99E-05	1.50E-02
	2.03E-03 to 5.53E-03	6.09E-05	1.96E-02	8.32E-05	1.50E-02
	5.53E-03 to 0.0150	6.21E-05	1.99E-02	8.65E-05	1.48E-02
	0.0150 to 0.0409	6.97E-05	1.92E-02	9.80E-05	1.43E-02
	0.0409 to 0.111	9.01E-05	1.80E-02	1.26E-04	1.35E-02
	0.111 to 0.302	1.36E-04	1.58E-02	1.90E-04	1.18E-02
	0.302 to 0.821	2.22E-04	1.39E-02	3.26E-04	1.00E-02
	0.821 to 2.23	2.67E-04	1.32E-02	4.00E-04	9.50E-03
	2.23 to 20.00	2.14E-04	1.53E-02	3.06E-04	1.15E-02
	Total	1.73E-03	7.40E-03	2.53E-03	5.60E-03
8	0 to 1.25E-09	2.10E-08	3.72E-01	5.21E-08	2.41E-01
	1.25E-09 to 5.00E-09	5.06E-07	1.11E-01	1.57E-06	6.12E-02
	5.00E-09 to 5.63E-09	1.06E-07	2.30E-01	4.52E-07	1.05E-01
	5.63E-09 to 1.00E-08	1.49E-06	6.85E-02	4.35E-06	4.06E-02
	1.00E-08 to 2.00E-08	6.58E-06	3.88E-02	1.79E-05	2.34E-02
	2.00E-08 to 4.60E-08	3.03E-05	2.29E-02	6.12E-05	1.62E-02
	4.60E-08 to 6.25E-08	2.05E-05	2.61E-02	3.41E-05	1.95E-02
	6.25E-08 to 1.00E-07	4.29E-05	2.11E-02	5.05E-05	1.76E-02
	1.00E-07 to 1.88E-07	5.41E-05	1.98E-02	4.36E-05	1.89E-02
	1.88E-07 to 2.50E-07	1.53E-05	2.97E-02	1.20E-05	3.19E-02
	2.50E-07 to 3.13E-07	7.24E-06	3.89E-02	7.20E-06	3.76E-02
	3.13E-07 to 3.75E-07	6.32E-06	4.45E-02	6.38E-06	4.13E-02
	3.75E-07 to 4.38E-07	5.83E-06	4.96E-02	6.33E-06	4.65E-02
	4.38E-07 to 5.00E-07	5.71E-06	5.23E-02	5.97E-06	4.69E-02
	5.00E-07 to 5.63E-07	4.62E-06	5.76E-02	5.76E-06	4.89E-02
	5.63E-07 to 6.25E-07	4.06E-06	6.16E-02	4.82E-06	5.08E-02
	6.25E-07 to 1.86E-06	3.80E-05	2.31E-02	4.35E-05	1.91E-02
	1.86E-06 to 5.04E-06	3.83E-05	2.38E-02	4.64E-05	1.94E-02
	5.04E-06 to 1.37E-05	3.38E-05	2.33E-02	3.98E-05	1.92E-02
	1.37E-05 to 3.73E-05	3.83E-05	2.25E-02	4.54E-05	1.88E-02
	3.73E-05 to 1.01E-04	4.58E-05	2.16E-02	5.15E-05	1.82E-02
	1.01E-04 to 2.75E-04	4.70E-05	2.11E-02	5.11E-05	1.83E-02
	2.75E-04 to 7.49E-04	4.64E-05	2.15E-02	5.47E-05	1.80E-02
	7.49E-04 to 2.03E-03	5.11E-05	2.15E-02	5.67E-05	1.79E-02
	2.03E-03 to 5.53E-03	5.27E-05	2.13E-02	5.87E-05	1.78E-02
	5.53E-03 to 0.0150	5.74E-05	2.07E-02	6.14E-05	1.75E-02
	0.0150 to 0.0409	6.27E-05	2.06E-02	6.95E-05	1.72E-02
	0.0409 to 0.111	8.01E-05	1.93E-02	8.71E-05	1.60E-02
	0.111 to 0.302	1.25E-04	1.68E-02	1.36E-04	1.40E-02
	0.302 to 0.821	2.04E-04	1.45E-02	2.33E-04	1.20E-02
	0.821 to 2.23	2.31E-04	1.41E-02	2.83E-04	1.14E-02
	2.23 to 20.00	1.84E-04	1.65E-02	2.13E-04	1.38E-02
	Total	1.54E-03	7.90E-03	1.79E-03	6.70E-03
9	0 to 1.25E-09	5.52E-10	1.00E+00	3.43E-08	2.89E-01
	1.25E-09 to 5.00E-09	3.98E-07	1.25E-01	1.15E-06	6.92E-02
	5.00E-09 to 5.63E-09	1.06E-07	2.26E-01	3.38E-07	1.25E-01

Table 6.2-1. Neutron Spectrum Results for Centralized PWR Assembly (E08)

Axial Node	Energy Range (MeV)	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
	5.63E-09 to 1.00E-08	1.44E-06	6.79E-02	3.50E-06	4.43E-02
	1.00E-08 to 2.00E-08	6.64E-06	3.95E-02	1.39E-05	2.61E-02
	2.00E-08 to 4.60E-08	2.99E-05	2.29E-02	4.71E-05	1.84E-02
	4.60E-08 to 6.25E-08	2.02E-05	2.65E-02	2.75E-05	2.16E-02
	6.25E-08 to 1.00E-07	4.26E-05	2.12E-02	3.96E-05	1.99E-02
	1.00E-07 to 1.88E-07	5.32E-05	2.03E-02	3.43E-05	2.14E-02
	1.88E-07 to 2.50E-07	1.47E-05	3.10E-02	9.09E-06	3.61E-02
	2.50E-07 to 3.13E-07	7.50E-06	3.90E-02	5.65E-06	4.26E-02
	3.13E-07 to 3.75E-07	5.89E-06	4.51E-02	5.01E-06	4.81E-02
	3.75E-07 to 4.38E-07	5.93E-06	5.04E-02	4.94E-06	5.00E-02
	4.38E-07 to 5.00E-07	5.05E-06	5.40E-02	4.29E-06	5.27E-02
	5.00E-07 to 5.63E-07	4.90E-06	5.85E-02	4.47E-06	5.30E-02
	5.63E-07 to 6.25E-07	3.87E-06	6.13E-02	3.58E-06	5.91E-02
	6.25E-07 to 1.86E-06	3.65E-05	2.32E-02	3.45E-05	2.18E-02
	1.86E-06 to 5.04E-06	3.95E-05	2.35E-02	3.41E-05	2.27E-02
	5.04E-06 to 1.37E-05	3.34E-05	2.36E-02	3.02E-05	2.26E-02
	1.37E-05 to 3.73E-05	3.88E-05	2.29E-02	3.42E-05	2.15E-02
	3.73E-05 to 1.01E-04	4.20E-05	2.26E-02	3.83E-05	2.08E-02
	1.01E-04 to 2.75E-04	4.50E-05	2.18E-02	3.93E-05	2.10E-02
	2.75E-04 to 7.49E-04	4.85E-05	2.17E-02	4.27E-05	2.05E-02
	7.49E-04 to 2.03E-03	4.81E-05	2.15E-02	4.30E-05	2.06E-02
	2.03E-03 to 5.53E-03	5.13E-05	2.15E-02	4.35E-05	2.07E-02
	5.53E-03 to 0.0150	5.42E-05	2.11E-02	4.62E-05	2.03E-02
	0.0150 to 0.0409	6.29E-05	2.07E-02	5.18E-05	1.98E-02
	0.0409 to 0.111	7.56E-05	1.96E-02	6.67E-05	1.82E-02
	0.111 to 0.302	1.18E-04	1.70E-02	1.04E-04	1.59E-02
	0.302 to 0.821	1.95E-04	1.48E-02	1.73E-04	1.36E-02
	0.821 to 2.23	2.33E-04	1.42E-02	2.19E-04	1.30E-02
	2.23 to 20.00	1.76E-04	1.68E-02	1.64E-04	1.57E-02
	Total	1.50E-03	8.00E-03	1.37E-03	7.70E-03
10	0 to 1.25E-09	2.67E-08	4.84E-01	4.79E-08	3.48E-01
	1.25E-09 to 5.00E-09	4.91E-07	1.06E-01	9.52E-07	7.83E-02
	5.00E-09 to 5.63E-09	7.68E-08	2.37E-01	2.58E-07	1.45E-01
	5.63E-09 to 1.00E-08	1.38E-06	6.89E-02	2.48E-06	5.36E-02
	1.00E-08 to 2.00E-08	6.30E-06	3.94E-02	9.75E-06	3.08E-02
	2.00E-08 to 4.60E-08	2.65E-05	2.43E-02	3.38E-05	2.19E-02
	4.60E-08 to 6.25E-08	1.94E-05	2.70E-02	1.91E-05	2.62E-02
	6.25E-08 to 1.00E-07	3.82E-05	2.26E-02	2.84E-05	2.35E-02
	1.00E-07 to 1.88E-07	4.80E-05	2.13E-02	2.31E-05	2.56E-02
	1.88E-07 to 2.50E-07	1.37E-05	3.22E-02	6.51E-06	4.18E-02
	2.50E-07 to 3.13E-07	6.55E-06	4.07E-02	3.66E-06	5.29E-02
	3.13E-07 to 3.75E-07	5.69E-06	4.77E-02	3.34E-06	5.81E-02
	3.75E-07 to 4.38E-07	5.19E-06	5.23E-02	3.43E-06	6.07E-02
	4.38E-07 to 5.00E-07	4.97E-06	5.57E-02	3.12E-06	6.30E-02
	5.00E-07 to 5.63E-07	4.56E-06	6.24E-02	2.98E-06	6.50E-02
	5.63E-07 to 6.25E-07	4.03E-06	6.57E-02	2.68E-06	7.16E-02
	6.25E-07 to 1.86E-06	3.54E-05	2.43E-02	2.28E-05	2.60E-02
	1.86E-06 to 5.04E-06	3.36E-05	2.51E-02	2.52E-05	2.62E-02
	5.04E-06 to 1.37E-05	2.90E-05	2.49E-02	2.10E-05	2.66E-02
	1.37E-05 to 3.73E-05	3.23E-05	2.46E-02	2.36E-05	2.61E-02
	3.73E-05 to 1.01E-04	3.87E-05	2.36E-02	2.77E-05	2.46E-02

Table 6.2-1. Neutron Spectrum Results for Centralized PWR Assembly (E08)

Axial Node	Energy Range (MeV)	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
	1.01E-04 to 2.75E-04	4.20E-05	2.27E-02	2.79E-05	2.47E-02
	2.75E-04 to 7.49E-04	4.15E-05	2.26E-02	2.99E-05	2.43E-02
	7.49E-04 to 2.03E-03	4.39E-05	2.28E-02	2.95E-05	2.50E-02
	2.03E-03 to 5.53E-03	4.88E-05	2.22E-02	3.21E-05	2.43E-02
	5.53E-03 to 0.0150	4.96E-05	2.23E-02	3.36E-05	2.41E-02
	0.0150 to 0.0409	5.63E-05	2.18E-02	3.75E-05	2.33E-02
	0.0409 to 0.111	7.13E-05	2.01E-02	4.72E-05	2.14E-02
	0.111 to 0.302	1.11E-04	1.76E-02	7.33E-05	1.93E-02
	0.302 to 0.821	1.73E-04	1.54E-02	1.24E-04	1.63E-02
	0.821 to 2.23	2.12E-04	1.47E-02	1.51E-04	1.55E-02
	2.23 to 20.00	1.66E-04	1.74E-02	1.18E-04	1.85E-02
	Total	1.37E-03	8.30E-03	9.68E-04	9.10E-03
11	0 to 1.25E-09	7.88E-09	4.77E-01	1.62E-08	4.41E-01
	1.25E-09 to 5.00E-09	3.84E-07	1.27E-01	7.95E-07	8.97E-02
	5.00E-09 to 5.63E-09	1.09E-07	2.59E-01	1.96E-07	1.77E-01
	5.63E-09 to 1.00E-08	1.13E-06	8.09E-02	1.90E-06	6.11E-02
	1.00E-08 to 2.00E-08	5.73E-06	4.25E-02	6.88E-06	3.74E-02
	2.00E-08 to 4.60E-08	2.35E-05	2.61E-02	2.63E-05	2.48E-02
	4.60E-08 to 6.25E-08	1.59E-05	2.95E-02	1.41E-05	2.99E-02
	6.25E-08 to 1.00E-07	3.26E-05	2.39E-02	2.05E-05	2.76E-02
	1.00E-07 to 1.88E-07	4.39E-05	2.24E-02	1.75E-05	2.99E-02
	1.88E-07 to 2.50E-07	1.13E-05	3.48E-02	4.75E-06	4.93E-02
	2.50E-07 to 3.13E-07	5.71E-06	4.40E-02	2.96E-06	5.92E-02
	3.13E-07 to 3.75E-07	5.19E-06	5.23E-02	2.51E-06	6.40E-02
	3.75E-07 to 4.38E-07	4.24E-06	5.73E-02	2.85E-06	6.73E-02
	4.38E-07 to 5.00E-07	4.38E-06	5.96E-02	2.44E-06	7.12E-02
	5.00E-07 to 5.63E-07	3.58E-06	6.49E-02	2.03E-06	7.56E-02
	5.63E-07 to 6.25E-07	2.94E-06	6.98E-02	1.96E-06	7.97E-02
	6.25E-07 to 1.86E-06	2.94E-05	2.59E-02	1.86E-05	2.95E-02
	1.86E-06 to 5.04E-06	3.10E-05	2.67E-02	1.89E-05	2.96E-02
	5.04E-06 to 1.37E-05	2.70E-05	2.64E-02	1.62E-05	3.05E-02
	1.37E-05 to 3.73E-05	3.14E-05	2.50E-02	1.76E-05	3.00E-02
	3.73E-05 to 1.01E-04	3.53E-05	2.52E-02	2.11E-05	2.84E-02
	1.01E-04 to 2.75E-04	3.55E-05	2.45E-02	2.24E-05	2.77E-02
	2.75E-04 to 7.49E-04	3.82E-05	2.40E-02	2.33E-05	2.76E-02
	7.49E-04 to 2.03E-03	4.10E-05	2.37E-02	2.33E-05	2.75E-02
	2.03E-03 to 5.53E-03	4.17E-05	2.39E-02	2.46E-05	2.77E-02
	5.53E-03 to 0.0150	4.42E-05	2.39E-02	2.70E-05	2.70E-02
	0.0150 to 0.0409	4.91E-05	2.35E-02	2.97E-05	2.64E-02
	0.0409 to 0.111	6.31E-05	2.16E-02	3.72E-05	2.43E-02
	0.111 to 0.302	9.35E-05	1.90E-02	5.72E-05	2.13E-02
	0.302 to 0.821	1.57E-04	1.66E-02	9.64E-05	1.86E-02
	0.821 to 2.23	1.89E-04	1.57E-02	1.17E-04	1.76E-02
	2.23 to 20.00	1.45E-04	1.87E-02	8.87E-05	2.15E-02
	Total	1.21E-03	8.90E-03	7.47E-04	1.04E-02
12	0 to 1.25E-09	9.50E-09	5.03E-01	3.02E-08	3.79E-01
	1.25E-09 to 5.00E-09	4.31E-07	1.22E-01	5.13E-07	1.02E-01
	5.00E-09 to 5.63E-09	8.61E-08	2.36E-01	2.11E-07	1.62E-01
	5.63E-09 to 1.00E-08	1.35E-06	7.78E-02	1.52E-06	6.55E-02
	1.00E-08 to 2.00E-08	4.94E-06	4.39E-02	6.31E-06	3.89E-02
	2.00E-08 to 4.60E-08	2.38E-05	2.66E-02	2.13E-05	2.76E-02

Table 6.2-1. Neutron Spectrum Results for Centralized PWR Assembly (E08)

Axial Node	Energy Range (MeV)	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
	4.60E-08 to 6.25E-08	1.57E-05	2.97E-02	1.13E-05	3.37E-02
	6.25E-08 to 1.00E-07	3.24E-05	2.42E-02	1.79E-05	3.01E-02
	1.00E-07 to 1.88E-07	4.21E-05	2.27E-02	1.44E-05	3.22E-02
	1.88E-07 to 2.50E-07	1.18E-05	3.43E-02	3.77E-06	5.38E-02
	2.50E-07 to 3.13E-07	5.63E-06	4.48E-02	2.25E-06	6.69E-02
	3.13E-07 to 3.75E-07	4.71E-06	5.34E-02	2.46E-06	6.95E-02
	3.75E-07 to 4.38E-07	3.97E-06	5.94E-02	2.14E-06	7.36E-02
	4.38E-07 to 5.00E-07	3.61E-06	6.62E-02	1.99E-06	7.87E-02
	5.00E-07 to 5.63E-07	3.62E-06	6.34E-02	1.82E-06	7.95E-02
	5.63E-07 to 6.25E-07	3.20E-06	7.22E-02	1.79E-06	8.04E-02
	6.25E-07 to 1.86E-06	2.74E-05	2.62E-02	1.44E-05	3.31E-02
	1.86E-06 to 5.04E-06	3.05E-05	2.65E-02	1.56E-05	3.28E-02
	5.04E-06 to 1.37E-05	2.50E-05	2.78E-02	1.31E-05	3.40E-02
	1.37E-05 to 3.73E-05	2.79E-05	2.65E-02	1.39E-05	3.30E-02
	3.73E-05 to 1.01E-04	3.25E-05	2.55E-02	1.72E-05	3.14E-02
	1.01E-04 to 2.75E-04	3.32E-05	2.51E-02	1.73E-05	3.19E-02
	2.75E-04 to 7.49E-04	3.64E-05	2.46E-02	1.87E-05	3.16E-02
	7.49E-04 to 2.03E-03	3.85E-05	2.46E-02	1.87E-05	3.09E-02
	2.03E-03 to 5.53E-03	3.96E-05	2.48E-02	1.98E-05	3.03E-02
	5.53E-03 to 0.0150	4.02E-05	2.46E-02	2.02E-05	3.06E-02
	0.0150 to 0.0409	4.92E-05	2.33E-02	2.29E-05	2.97E-02
	0.0409 to 0.111	5.91E-05	2.18E-02	2.94E-05	2.79E-02
	0.111 to 0.302	8.98E-05	1.96E-02	4.52E-05	2.43E-02
	0.302 to 0.821	1.48E-04	1.69E-02	7.46E-05	2.08E-02
	0.821 to 2.23	1.79E-04	1.62E-02	9.58E-05	1.95E-02
	2.23 to 20.00	1.39E-04	1.89E-02	7.21E-05	2.35E-02
	Total	1.15E-03	9.10E-03	5.98E-04	1.15E-02
13	0 to 1.25E-09	1.69E-08	5.97E-01	2.26E-08	3.72E-01
	1.25E-09 to 5.00E-09	3.60E-07	1.37E-01	4.47E-07	1.15E-01
	5.00E-09 to 5.63E-09	1.40E-07	2.36E-01	1.14E-07	1.86E-01
	5.63E-09 to 1.00E-08	1.11E-06	8.67E-02	1.23E-06	7.26E-02
	1.00E-08 to 2.00E-08	4.57E-06	4.73E-02	4.92E-06	4.41E-02
	2.00E-08 to 4.60E-08	2.03E-05	2.69E-02	1.69E-05	3.09E-02
	4.60E-08 to 6.25E-08	1.47E-05	3.12E-02	9.68E-06	3.66E-02
	6.25E-08 to 1.00E-07	2.98E-05	2.52E-02	1.41E-05	3.32E-02
	1.00E-07 to 1.88E-07	3.71E-05	2.37E-02	1.20E-05	3.64E-02
	1.88E-07 to 2.50E-07	1.04E-05	3.66E-02	2.98E-06	6.02E-02
	2.50E-07 to 3.13E-07	5.08E-06	4.80E-02	1.99E-06	7.26E-02
	3.13E-07 to 3.75E-07	4.43E-06	5.55E-02	1.80E-06	7.62E-02
	3.75E-07 to 4.38E-07	4.29E-06	5.86E-02	1.72E-06	8.62E-02
	4.38E-07 to 5.00E-07	3.37E-06	6.51E-02	1.55E-06	8.53E-02
	5.00E-07 to 5.63E-07	2.90E-06	7.15E-02	1.51E-06	1.08E-01
	5.63E-07 to 6.25E-07	2.75E-06	7.30E-02	1.11E-06	1.06E-01
	6.25E-07 to 1.86E-06	2.52E-05	2.80E-02	1.15E-05	3.71E-02
	1.86E-06 to 5.04E-06	2.60E-05	2.84E-02	1.18E-05	3.79E-02
	5.04E-06 to 1.37E-05	2.31E-05	2.88E-02	1.01E-05	3.78E-02
	1.37E-05 to 3.73E-05	2.52E-05	2.79E-02	1.12E-05	3.71E-02
	3.73E-05 to 1.01E-04	3.02E-05	2.63E-02	1.42E-05	3.47E-02
	1.01E-04 to 2.75E-04	3.14E-05	2.67E-02	1.34E-05	3.62E-02
	2.75E-04 to 7.49E-04	3.27E-05	2.64E-02	1.56E-05	3.47E-02
	7.49E-04 to 2.03E-03	3.54E-05	2.60E-02	1.55E-05	3.40E-02

Table 6.2-1. Neutron Spectrum Results for Centralized PWR Assembly (E08)

Axial Node	Energy Range (MeV)	CRC Environment		WP Environment	
		Tally (#/cm^3/source particle)	Relative Error	Tally (#/cm^3/source particle)	Relative Error
	2.03E-03 to 5.53E-03	3.61E-05	2.55E-02	1.60E-05	3.39E-02
	5.53E-03 to 0.0150	3.73E-05	2.59E-02	1.67E-05	3.46E-02
	0.0150 to 0.0409	4.35E-05	2.52E-02	1.82E-05	3.33E-02
	0.0409 to 0.111	5.38E-05	2.31E-02	2.37E-05	3.08E-02
	0.111 to 0.302	8.33E-05	2.04E-02	3.68E-05	2.65E-02
	0.302 to 0.821	1.40E-04	1.74E-02	6.18E-05	2.29E-02
	0.821 to 2.23	1.61E-04	1.68E-02	7.64E-05	2.20E-02
	2.23 to 20.00	1.29E-04	1.97E-02	5.81E-05	2.65E-02
	Total	1.05E-03	9.50E-03	4.83E-04	1.28E-02
14	0 to 1.25E-09	2.20E-09	6.02E-01	3.15E-08	3.32E-01
	1.25E-09 to 5.00E-09	3.89E-07	1.42E-01	3.84E-07	1.26E-01
	5.00E-09 to 5.63E-09	6.53E-08	2.69E-01	1.08E-07	2.11E-01
	5.63E-09 to 1.00E-08	1.13E-06	8.04E-02	1.06E-06	8.38E-02
	1.00E-08 to 2.00E-08	4.57E-06	4.69E-02	4.12E-06	4.63E-02
	2.00E-08 to 4.60E-08	2.10E-05	2.75E-02	1.51E-05	3.30E-02
	4.60E-08 to 6.25E-08	1.44E-05	3.18E-02	8.55E-06	3.88E-02
	6.25E-08 to 1.00E-07	2.87E-05	2.60E-02	1.31E-05	3.45E-02
	1.00E-07 to 1.88E-07	3.62E-05	2.45E-02	1.06E-05	3.85E-02
	1.88E-07 to 2.50E-07	9.85E-06	3.75E-02	2.86E-06	6.64E-02
	2.50E-07 to 3.13E-07	4.98E-06	4.69E-02	1.67E-06	7.42E-02
	3.13E-07 to 3.75E-07	4.45E-06	5.32E-02	1.64E-06	8.67E-02
	3.75E-07 to 4.38E-07	3.95E-06	6.38E-02	1.45E-06	9.21E-02
	4.38E-07 to 5.00E-07	3.55E-06	6.46E-02	1.23E-06	9.91E-02
	5.00E-07 to 5.63E-07	3.16E-06	6.72E-02	1.37E-06	9.49E-02
	5.63E-07 to 6.25E-07	2.90E-06	7.26E-02	1.03E-06	1.09E-01
	6.25E-07 to 1.86E-06	2.55E-05	2.84E-02	1.04E-05	3.91E-02
	1.86E-06 to 5.04E-06	2.49E-05	2.89E-02	1.07E-05	4.10E-02
	5.04E-06 to 1.37E-05	2.33E-05	2.83E-02	8.91E-06	4.10E-02
	1.37E-05 to 3.73E-05	2.57E-05	2.82E-02	9.89E-06	3.95E-02
	3.73E-05 to 1.01E-04	2.92E-05	2.70E-02	1.22E-05	3.75E-02
	1.01E-04 to 2.75E-04	3.03E-05	2.69E-02	1.27E-05	3.71E-02
	2.75E-04 to 7.49E-04	3.45E-05	2.54E-02	1.24E-05	3.83E-02
	7.49E-04 to 2.03E-03	3.38E-05	2.63E-02	1.35E-05	3.70E-02
	2.03E-03 to 5.53E-03	3.55E-05	2.58E-02	1.38E-05	3.69E-02
	5.53E-03 to 0.0150	3.82E-05	2.56E-02	1.38E-05	3.76E-02
	0.0150 to 0.0409	4.10E-05	2.50E-02	1.51E-05	3.60E-02
	0.0409 to 0.111	5.40E-05	2.34E-02	2.01E-05	3.38E-02
	0.111 to 0.302	8.09E-05	2.05E-02	3.07E-05	2.93E-02
	0.302 to 0.821	1.37E-04	1.75E-02	5.31E-05	2.48E-02
	0.821 to 2.23	1.58E-04	1.71E-02	6.60E-05	2.37E-02
	2.23 to 20.00	1.27E-04	2.00E-02	4.99E-05	2.90E-02
	Total	1.04E-03	9.60E-03	4.18E-04	1.39E-02
15	0 to 1.25E-09	3.99E-09	6.77E-01	9.18E-09	5.76E-01
	1.25E-09 to 5.00E-09	3.62E-07	1.32E-01	3.46E-07	1.24E-01
	5.00E-09 to 5.63E-09	6.89E-08	2.56E-01	1.26E-07	2.11E-01
	5.63E-09 to 1.00E-08	1.01E-06	8.38E-02	9.92E-07	8.42E-02
	1.00E-08 to 2.00E-08	5.37E-06	4.33E-02	4.45E-06	4.85E-02
	2.00E-08 to 4.60E-08	2.24E-05	2.69E-02	1.48E-05	3.36E-02
	4.60E-08 to 6.25E-08	1.52E-05	3.02E-02	8.31E-06	3.98E-02
	6.25E-08 to 1.00E-07	3.10E-05	2.48E-02	1.16E-05	3.63E-02
	1.00E-07 to 1.88E-07	3.78E-05	2.31E-02	9.97E-06	3.97E-02

Table 6.2-1. Neutron Spectrum Results for Centralized PWR Assembly (E08)

Axial Node	Energy Range (MeV)	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
	1.88E-07 to 2.50E-07	1.07E-05	3.54E-02	2.92E-06	6.38E-02
	2.50E-07 to 3.13E-07	5.60E-06	4.46E-02	1.72E-06	7.63E-02
	3.13E-07 to 3.75E-07	4.25E-06	5.47E-02	1.41E-06	8.28E-02
	3.75E-07 to 4.38E-07	4.18E-06	5.80E-02	1.24E-06	9.33E-02
	4.38E-07 to 5.00E-07	4.01E-06	6.66E-02	1.61E-06	9.49E-02
	5.00E-07 to 5.63E-07	3.45E-06	6.86E-02	1.20E-06	1.08E-01
	5.63E-07 to 6.25E-07	3.01E-06	7.10E-02	1.10E-06	1.02E-01
	6.25E-07 to 1.86E-06	2.74E-05	2.74E-02	9.95E-06	4.03E-02
	1.86E-06 to 5.04E-06	2.65E-05	2.77E-02	1.06E-05	4.05E-02
	5.04E-06 to 1.37E-05	2.33E-05	2.77E-02	8.89E-06	4.03E-02
	1.37E-05 to 3.73E-05	2.74E-05	2.75E-02	1.01E-05	3.98E-02
	3.73E-05 to 1.01E-04	3.12E-05	2.61E-02	1.12E-05	3.85E-02
	1.01E-04 to 2.75E-04	3.15E-05	2.64E-02	1.16E-05	3.81E-02
	2.75E-04 to 7.49E-04	3.52E-05	2.52E-02	1.26E-05	3.82E-02
	7.49E-04 to 2.03E-03	3.51E-05	2.54E-02	1.30E-05	3.81E-02
	2.03E-03 to 5.53E-03	3.74E-05	2.54E-02	1.33E-05	3.75E-02
	5.53E-03 to 0.0150	4.02E-05	2.49E-02	1.37E-05	3.74E-02
	0.0150 to 0.0409	4.35E-05	2.44E-02	1.58E-05	3.58E-02
	0.0409 to 0.111	5.52E-05	2.29E-02	2.03E-05	3.36E-02
	0.111 to 0.302	8.61E-05	2.00E-02	2.94E-05	2.94E-02
	0.302 to 0.821	1.39E-04	1.74E-02	5.49E-05	2.52E-02
	0.821 to 2.23	1.67E-04	1.66E-02	6.33E-05	2.39E-02
	2.23 to 20.00	1.28E-04	1.95E-02	4.98E-05	2.88E-02
	Total	1.08E-03	9.40E-03	4.10E-04	1.40E-02
16	0 to 1.25E-09	1.68E-08	4.85E-01	1.62E-08	4.12E-01
	1.25E-09 to 5.00E-09	3.18E-07	1.39E-01	4.64E-07	1.20E-01
	5.00E-09 to 5.63E-09	9.71E-08	2.41E-01	1.05E-07	2.15E-01
	5.63E-09 to 1.00E-08	1.05E-06	8.55E-02	1.09E-06	7.86E-02
	1.00E-08 to 2.00E-08	5.08E-06	4.39E-02	4.34E-06	4.62E-02
	2.00E-08 to 4.60E-08	2.15E-05	2.66E-02	1.49E-05	3.27E-02
	4.60E-08 to 6.25E-08	1.54E-05	3.07E-02	8.13E-06	4.01E-02
	6.25E-08 to 1.00E-07	3.16E-05	2.46E-02	1.14E-05	3.70E-02
	1.00E-07 to 1.88E-07	4.04E-05	2.29E-02	1.01E-05	3.97E-02
	1.88E-07 to 2.50E-07	1.04E-05	3.80E-02	2.63E-06	6.52E-02
	2.50E-07 to 3.13E-07	5.07E-06	4.55E-02	1.66E-06	7.46E-02
	3.13E-07 to 3.75E-07	4.80E-06	5.27E-02	1.43E-06	7.83E-02
	3.75E-07 to 4.38E-07	4.45E-06	5.56E-02	1.56E-06	8.86E-02
	4.38E-07 to 5.00E-07	3.86E-06	6.33E-02	1.37E-06	9.77E-02
	5.00E-07 to 5.63E-07	3.25E-06	6.57E-02	1.21E-06	1.03E-01
	5.63E-07 to 6.25E-07	2.83E-06	7.22E-02	1.14E-06	1.06E-01
	6.25E-07 to 1.86E-06	2.72E-05	2.71E-02	1.14E-05	3.92E-02
	1.86E-06 to 5.04E-06	2.83E-05	2.76E-02	1.11E-05	3.93E-02
	5.04E-06 to 1.37E-05	2.58E-05	2.67E-02	9.39E-06	4.09E-02
	1.37E-05 to 3.73E-05	2.78E-05	2.61E-02	1.05E-05	3.85E-02
	3.73E-05 to 1.01E-04	3.18E-05	2.60E-02	1.23E-05	3.77E-02
	1.01E-04 to 2.75E-04	3.37E-05	2.51E-02	1.15E-05	3.80E-02
	2.75E-04 to 7.49E-04	3.56E-05	2.49E-02	1.32E-05	3.75E-02
	7.49E-04 to 2.03E-03	3.68E-05	2.48E-02	1.21E-05	3.90E-02
	2.03E-03 to 5.53E-03	3.92E-05	2.47E-02	1.31E-05	3.78E-02
	5.53E-03 to 0.0150	3.96E-05	2.46E-02	1.44E-05	3.64E-02
	0.0150 to 0.0409	4.59E-05	2.36E-02	1.66E-05	3.49E-02

Table 6.2-1. Neutron Spectrum Results for Centralized PWR Assembly (E08)

Axial Node	Energy Range (MeV)	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
	0.0409 to 0.111	5.93E-05	2.24E-02	2.10E-05	3.29E-02
	0.111 to 0.302	8.74E-05	1.99E-02	3.20E-05	2.89E-02
	0.302 to 0.821	1.46E-04	1.71E-02	5.64E-05	2.46E-02
	0.821 to 2.23	1.73E-04	1.66E-02	6.90E-05	2.33E-02
	2.23 to 20.00	1.36E-04	1.92E-02	5.18E-05	2.78E-02
	Total	1.12E-03	9.20E-03	4.27E-04	1.37E-02
17	0 to 1.25E-09	6.55E-09	5.00E-01	1.71E-08	5.31E-01
	1.25E-09 to 5.00E-09	4.22E-07	1.27E-01	4.04E-07	1.16E-01
	5.00E-09 to 5.63E-09	1.05E-07	2.27E-01	9.23E-08	2.60E-01
	5.63E-09 to 1.00E-08	1.23E-06	7.67E-02	1.20E-06	7.68E-02
	1.00E-08 to 2.00E-08	5.59E-06	4.29E-02	4.83E-06	4.46E-02
	2.00E-08 to 4.60E-08	2.31E-05	2.57E-02	1.70E-05	3.11E-02
	4.60E-08 to 6.25E-08	1.59E-05	2.99E-02	8.92E-06	3.81E-02
	6.25E-08 to 1.00E-07	3.27E-05	2.38E-02	1.31E-05	3.43E-02
	1.00E-07 to 1.88E-07	4.11E-05	2.28E-02	1.18E-05	3.62E-02
	1.88E-07 to 2.50E-07	1.11E-05	3.41E-02	3.27E-06	5.91E-02
	2.50E-07 to 3.13E-07	5.98E-06	4.35E-02	2.04E-06	7.50E-02
	3.13E-07 to 3.75E-07	5.15E-06	5.12E-02	1.68E-06	7.99E-02
	3.75E-07 to 4.38E-07	4.60E-06	5.55E-02	1.87E-06	8.03E-02
	4.38E-07 to 5.00E-07	4.31E-06	6.05E-02	1.34E-06	9.03E-02
	5.00E-07 to 5.63E-07	3.52E-06	6.89E-02	1.54E-06	8.99E-02
	5.63E-07 to 6.25E-07	2.82E-06	7.47E-02	1.02E-06	1.07E-01
	6.25E-07 to 1.86E-06	2.97E-05	2.64E-02	1.12E-05	3.80E-02
	1.86E-06 to 5.04E-06	3.00E-05	2.67E-02	1.24E-05	3.84E-02
	5.04E-06 to 1.37E-05	2.72E-05	2.65E-02	1.06E-05	3.80E-02
	1.37E-05 to 3.73E-05	2.85E-05	2.64E-02	1.11E-05	3.73E-02
	3.73E-05 to 1.01E-04	3.32E-05	2.49E-02	1.32E-05	3.66E-02
	1.01E-04 to 2.75E-04	3.52E-05	2.46E-02	1.38E-05	3.62E-02
	2.75E-04 to 7.49E-04	3.80E-05	2.46E-02	1.47E-05	3.42E-02
	7.49E-04 to 2.03E-03	4.00E-05	2.42E-02	1.54E-05	3.46E-02
	2.03E-03 to 5.53E-03	4.06E-05	2.43E-02	1.62E-05	3.51E-02
	5.53E-03 to 0.0150	4.35E-05	2.39E-02	1.69E-05	3.35E-02
	0.0150 to 0.0409	4.78E-05	2.35E-02	1.91E-05	3.33E-02
	0.0409 to 0.111	6.13E-05	2.17E-02	2.29E-05	3.12E-02
	0.111 to 0.302	9.15E-05	1.93E-02	3.76E-05	2.64E-02
	0.302 to 0.821	1.55E-04	1.65E-02	6.20E-05	2.30E-02
	0.821 to 2.23	1.89E-04	1.57E-02	7.59E-05	2.23E-02
	2.23 to 20.00	1.40E-04	1.89E-02	5.81E-05	2.60E-02
	Total	1.19E-03	9.00E-03	4.81E-04	1.31E-02
18	0 to 1.25E-09	7.28E-09	5.09E-01	1.24E-08	3.51E-01
	1.25E-09 to 5.00E-09	2.37E-07	1.43E-01	2.81E-07	1.28E-01
	5.00E-09 to 5.63E-09	5.49E-08	2.83E-01	9.09E-08	2.35E-01
	5.63E-09 to 1.00E-08	7.82E-07	9.05E-02	8.90E-07	8.16E-02
	1.00E-08 to 2.00E-08	4.02E-06	4.61E-02	3.66E-06	4.79E-02
	2.00E-08 to 4.60E-08	1.62E-05	2.88E-02	1.32E-05	3.28E-02
	4.60E-08 to 6.25E-08	1.14E-05	3.29E-02	7.59E-06	3.91E-02
	6.25E-08 to 1.00E-07	2.38E-05	2.68E-02	1.08E-05	3.68E-02
	1.00E-07 to 1.88E-07	3.08E-05	2.50E-02	8.96E-06	3.90E-02
	1.88E-07 to 2.50E-07	9.36E-06	3.72E-02	2.60E-06	6.26E-02
	2.50E-07 to 3.13E-07	4.55E-06	4.96E-02	1.62E-06	7.31E-02
	3.13E-07 to 3.75E-07	3.60E-06	5.85E-02	1.38E-06	8.38E-02

Table 6.2-1. Neutron Spectrum Results for Centralized PWR Assembly (E08)

Axial Node	Energy Range (MeV)	CRC Environment		WP Environment	
		Tally (#/cm^3/source particle)	Relative Error	Tally (#/cm^3/source particle)	Relative Error
	3.75E-07 to 4.38E-07	3.25E-06	6.28E-02	1.40E-06	9.08E-02
	4.38E-07 to 5.00E-07	2.88E-06	7.41E-02	1.21E-06	9.63E-02
	5.00E-07 to 5.63E-07	2.54E-06	7.37E-02	1.29E-06	9.96E-02
	5.63E-07 to 6.25E-07	2.37E-06	7.48E-02	1.14E-06	1.05E-01
	6.25E-07 to 1.86E-06	2.19E-05	2.92E-02	8.76E-06	4.16E-02
	1.86E-06 to 5.04E-06	2.08E-05	2.99E-02	9.06E-06	4.08E-02
	5.04E-06 to 1.37E-05	1.82E-05	3.08E-02	8.39E-06	4.11E-02
	1.37E-05 to 3.73E-05	2.08E-05	2.95E-02	9.33E-06	3.89E-02
	3.73E-05 to 1.01E-04	2.42E-05	2.79E-02	1.04E-05	3.82E-02
	1.01E-04 to 2.75E-04	2.67E-05	2.72E-02	1.06E-05	3.89E-02
	2.75E-04 to 7.49E-04	2.78E-05	2.68E-02	1.18E-05	3.75E-02
	7.49E-04 to 2.03E-03	2.77E-05	2.74E-02	1.13E-05	3.74E-02
	2.03E-03 to 5.53E-03	2.93E-05	2.67E-02	1.17E-05	3.75E-02
	5.53E-03 to 0.0150	3.20E-05	2.66E-02	1.37E-05	3.60E-02
	0.0150 to 0.0409	3.42E-05	2.67E-02	1.51E-05	3.51E-02
	0.0409 to 0.111	4.48E-05	2.43E-02	1.92E-05	3.31E-02
	0.111 to 0.302	6.79E-05	2.15E-02	2.87E-05	2.83E-02
	0.302 to 0.821	1.13E-04	1.83E-02	5.01E-05	2.44E-02
	0.821 to 2.23	1.40E-04	1.77E-02	6.17E-05	2.33E-02
	2.23 to 20.00	1.05E-04	2.09E-02	4.58E-05	2.80E-02

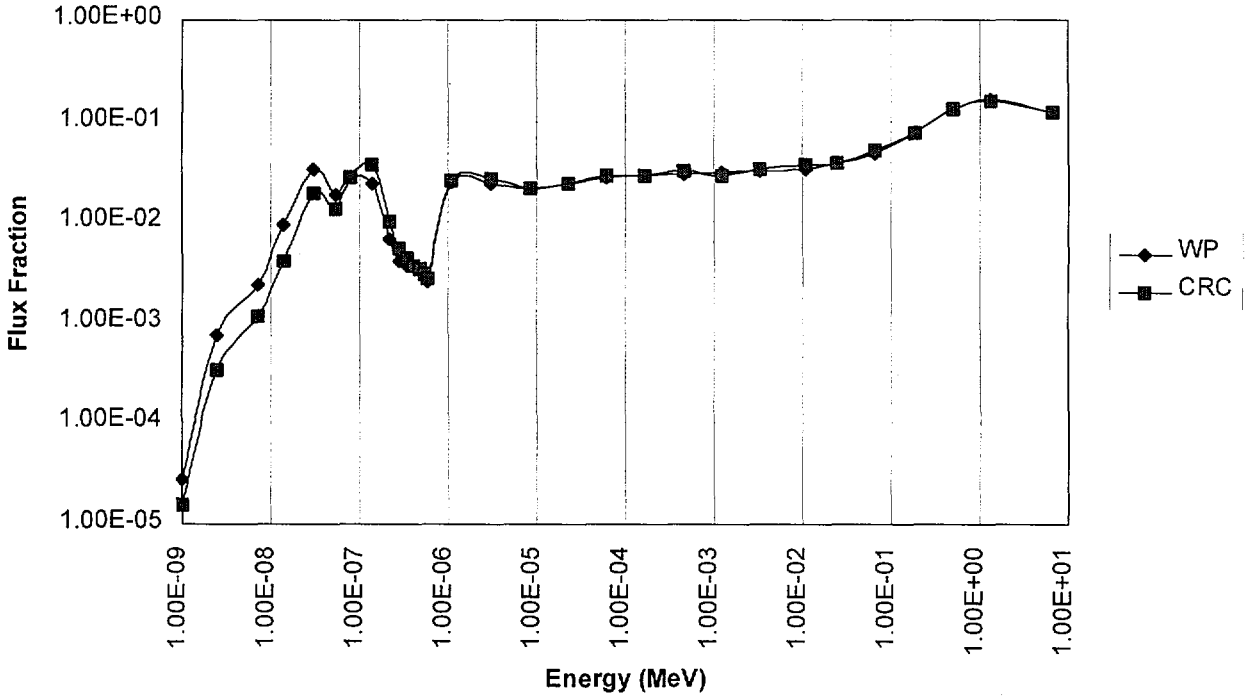


Figure 6-4. Neutron Spectrum for Node 1 of E08 Assembly

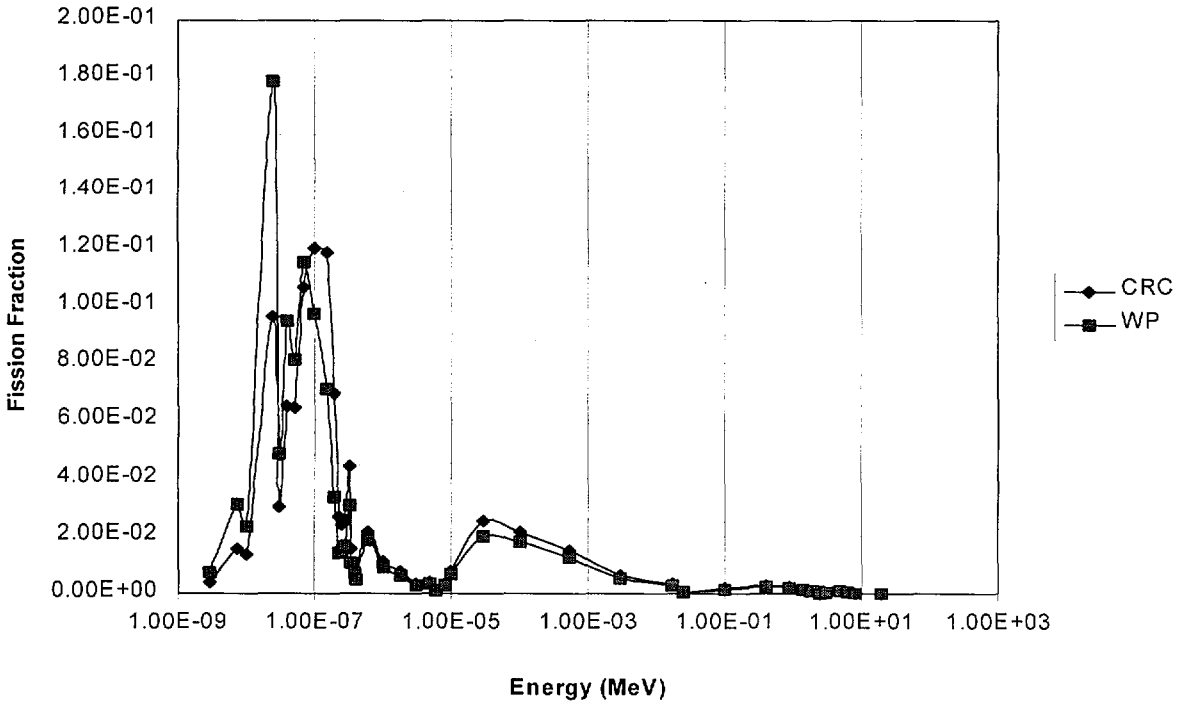


Figure 6-5. Fission Spectrum Results for Node 1 of E08 Assembly

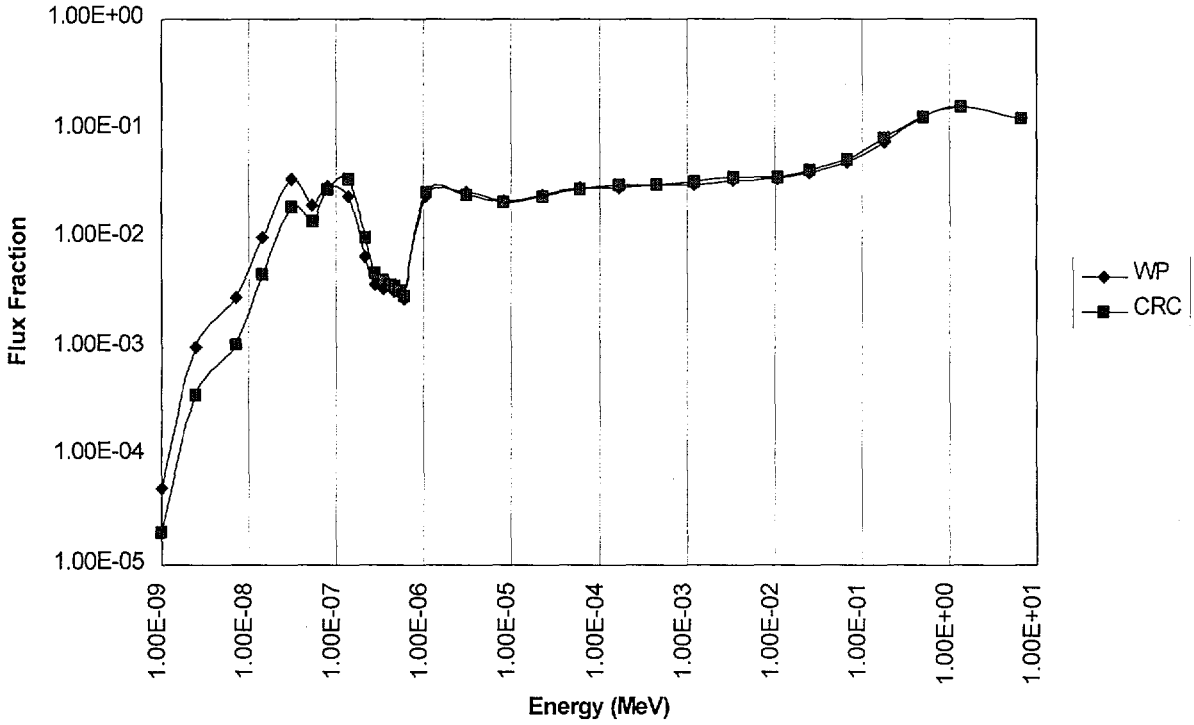


Figure 6-6. Neutron Spectrum for Node 10 of E08 Assembly

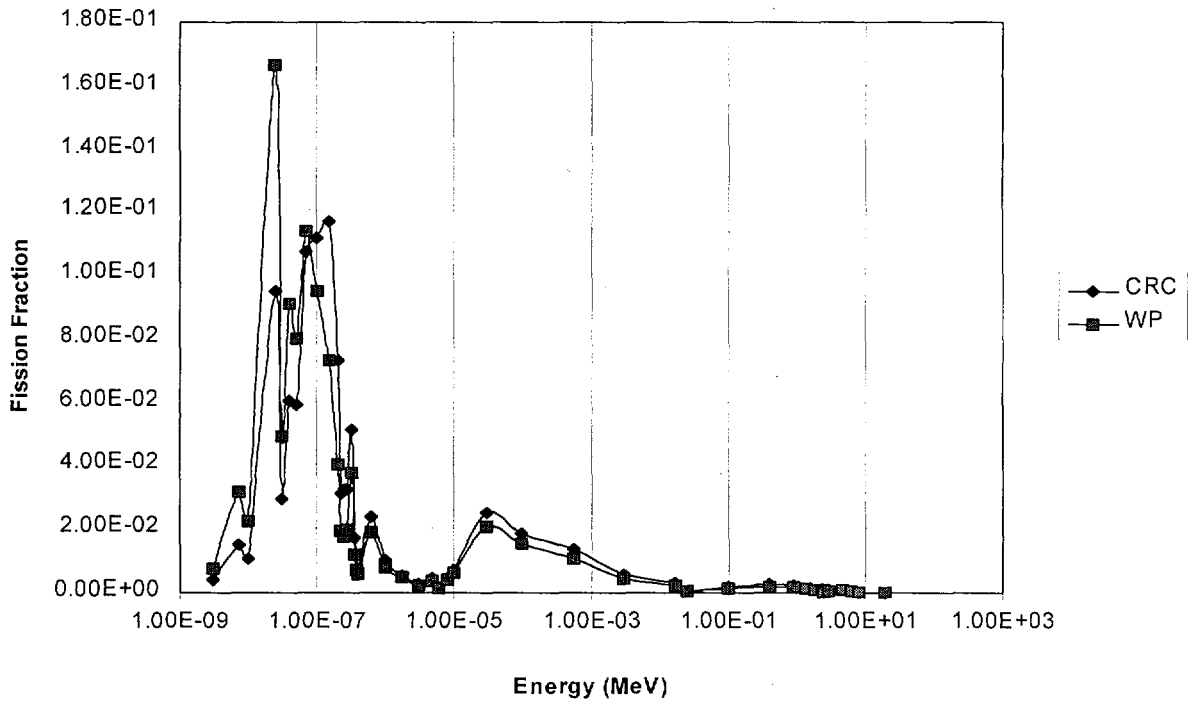


Figure 6-7. Fission Spectrum Results for Node 10 of E08 Assembly

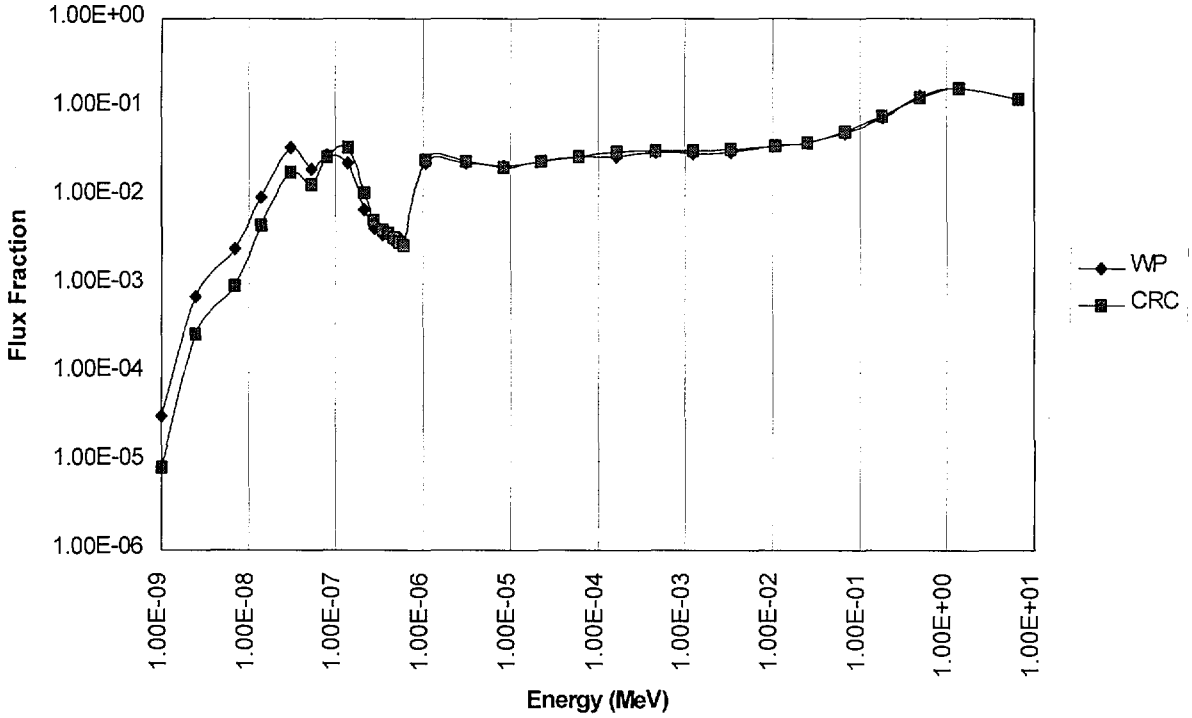


Figure 6-8. Normalized Neutron Spectrum for Node 18 of E08 Assembly

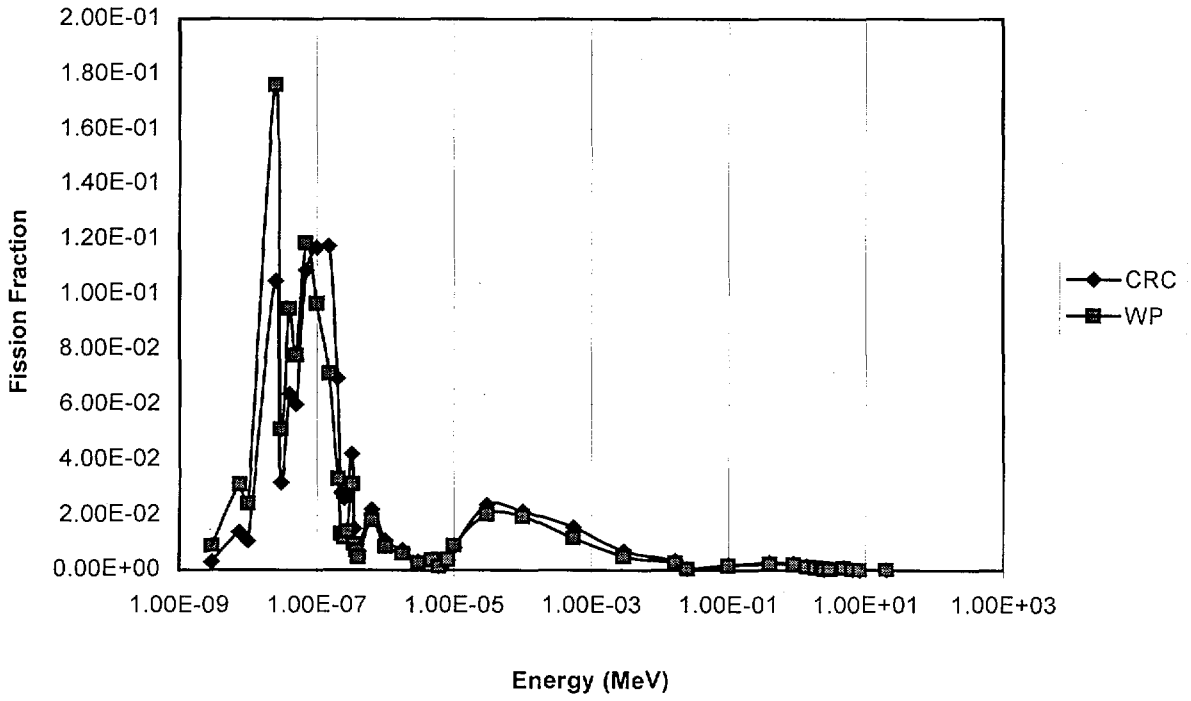


Figure 6-9. Fission Spectrum Results for Node 18 of E08 Assembly

Table 6.2-2. Neutron Spectrum Results for Whole WP and CRC Core

Energy Range (eV)	CRC Environment		WP Environment	
	Tally	Relative Error	Tally	Relative Error
0 to 1.25E-09	1.70E-10	0.007	1.01E-09	0.0045
1.25E-09 to 5.00E-09	4.43E-09	0.002	1.98E-08	0.0017
5.00E-09 to 5.63E-09	1.01E-09	0.004	4.58E-09	0.0029
5.63E-09 to 1.00E-08	1.17E-08	0.0015	4.69E-08	0.0014
1.00E-08 to 2.00E-08	4.50E-08	0.001	1.72E-07	0.001
2.00E-08 to 4.60E-08	1.87E-07	0.0008	5.46E-07	0.0009
4.60E-08 to 6.25E-08	1.24E-07	0.0008	2.88E-07	0.0009
6.25E-08 to 1.00E-07	2.51E-07	0.0007	4.05E-07	0.0008
1.00E-07 to 1.88E-07	3.15E-07	0.0007	3.20E-07	0.0008
1.88E-07 to 2.50E-07	9.05E-08	0.0009	8.56E-08	0.0013
2.50E-07 to 3.13E-07	4.96E-08	0.0011	5.58E-08	0.0015
3.13E-07 to 3.75E-07	3.66E-08	0.0013	4.70E-08	0.0017
3.75E-07 to 4.38E-07	3.18E-08	0.0015	4.26E-08	0.0019
4.38E-07 to 5.00E-07	2.83E-08	0.0016	3.88E-08	0.002
5.00E-07 to 5.63E-07	2.55E-08	0.0017	3.49E-08	0.0022
5.63E-07 to 6.25E-07	2.19E-08	0.0019	3.03E-08	0.0023
6.25E-07 to 1.86E-06	2.08E-07	0.0007	2.98E-07	0.0008
1.86E-06 to 5.04E-06	2.01E-07	0.0007	2.89E-07	0.0009
5.04E-06 to 1.37E-05	1.89E-07	0.0007	2.81E-07	0.0008
1.37E-05 to 3.73E-05	2.10E-07	0.0006	3.08E-07	0.0008
3.73E-05 to 1.01E-04	2.34E-07	0.0006	3.37E-07	0.0008
1.01E-04 to 2.75E-04	2.45E-07	0.0006	3.53E-07	0.0008
2.75E-04 to 7.49E-04	2.57E-07	0.0006	3.64E-07	0.0008
7.49E-04 to 2.03E-03	2.66E-07	0.0006	3.76E-07	0.0008
2.03E-03 to 5.53E-03	2.75E-07	0.0006	3.89E-07	0.0008
5.53E-03 to 0.0150	2.90E-07	0.0006	4.06E-07	0.0008
0.0150 to 0.0409	3.24E-07	0.0006	4.53E-07	0.0008
0.0409 to 0.111	4.04E-07	0.0006	5.67E-07	0.0008
0.111 to 0.302	6.09E-07	0.0005	8.56E-07	0.0007
0.302 to 0.821	9.80E-07	0.0005	1.40E-06	0.0007
0.821 to 2.23	1.15E-06	0.0006	1.68E-06	0.0007
2.23 to 20.00	8.86E-07	0.0008	1.25E-06	0.001
Total	7.95E-06	0.0002	1.18E-05	0.0002

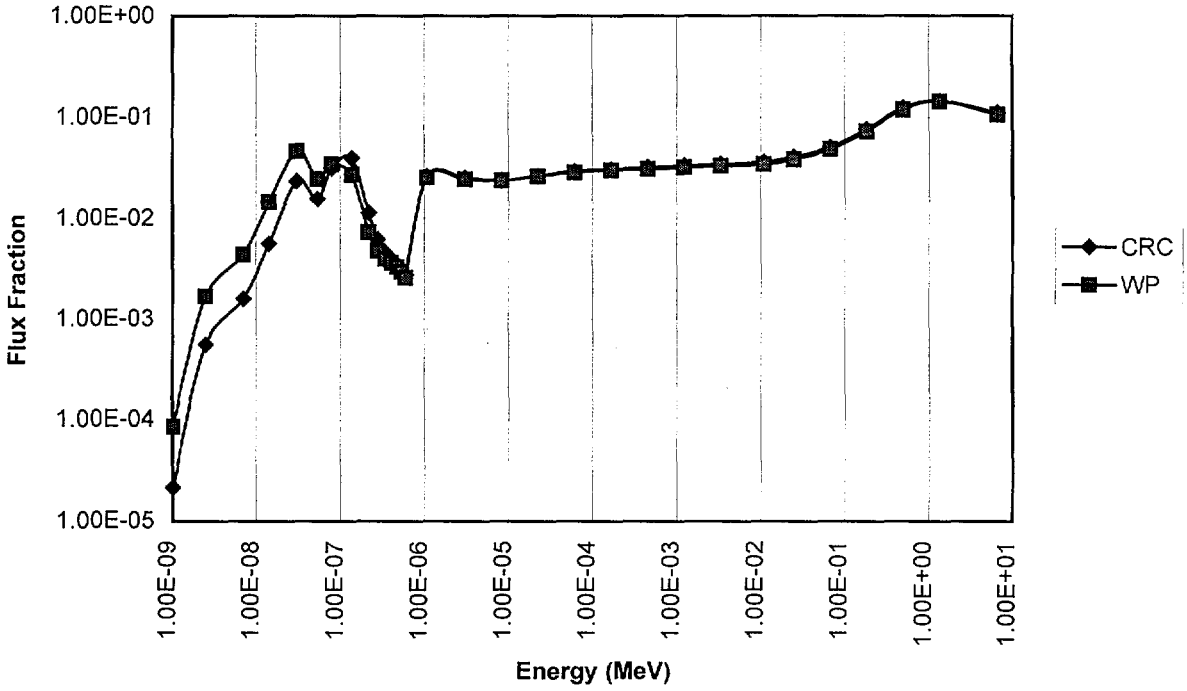


Figure 6-10. Normalized Neutron Spectrum Results for Whole WP and CRC Core

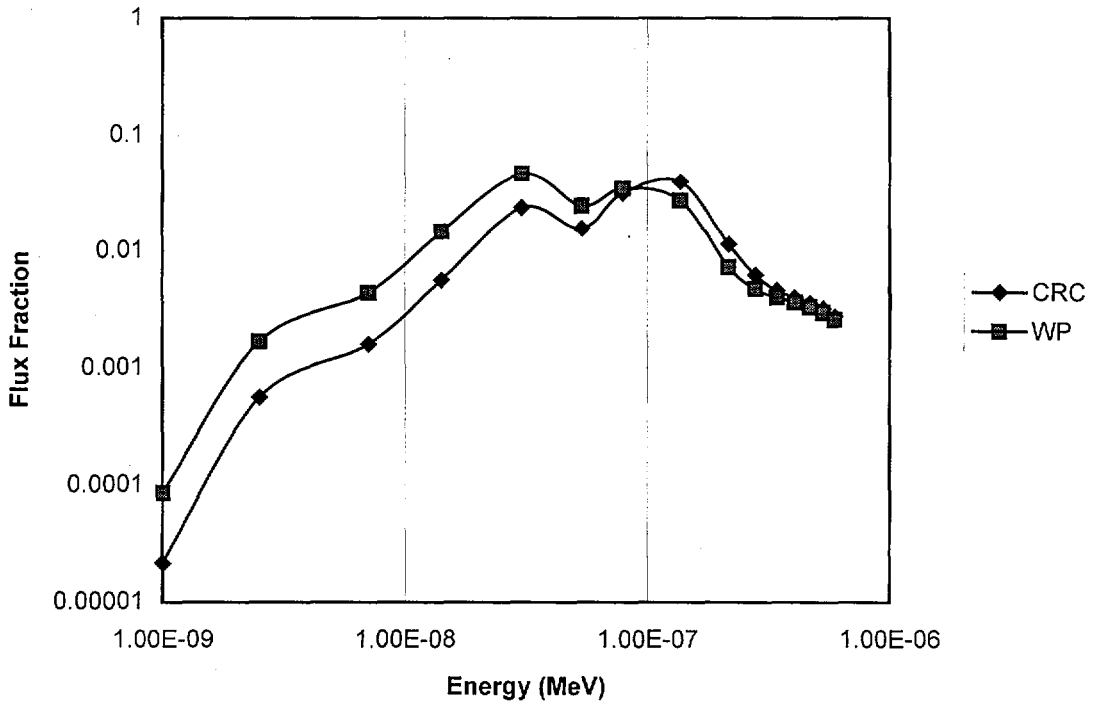


Figure 6-11. Detailed Thermal Range Normalized Neutron Spectrum Results

Table 6.2-3. Neutron Spectrum Results for Outer Edge PWR Assembly

Axial Node	Energy Range	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
1	0 to 1.25E-09	2.22E-09	1.00000	1.13E-07	0.17500
	1.25E-09 to 5.00E-09	1.83E-07	0.17510	4.51E-06	0.03800
	5.00E-09 to 5.63E-09	5.81E-08	0.35290	1.19E-06	0.07150
	5.63E-09 to 1.00E-08	6.54E-07	0.11440	1.20E-05	0.02510
	1.00E-08 to 2.00E-08	2.46E-06	0.06850	4.80E-05	0.01470
	2.00E-08 to 4.60E-08	1.09E-05	0.03930	1.72E-04	0.01000
	4.60E-08 to 6.25E-08	6.96E-06	0.04630	9.83E-05	0.01190
	6.25E-08 to 1.00E-07	1.52E-05	0.03760	1.46E-04	0.01080
	1.00E-07 to 1.88E-07	2.10E-05	0.03460	1.23E-04	0.01180
	1.88E-07 to 2.50E-07	5.62E-06	0.05530	3.42E-05	0.01970
	2.50E-07 to 3.13E-07	2.62E-06	0.07180	1.96E-05	0.02350
	3.13E-07 to 3.75E-07	1.93E-06	0.08970	1.80E-05	0.02560
	3.75E-07 to 4.38E-07	2.22E-06	0.09420	1.77E-05	0.02840
	4.38E-07 to 5.00E-07	1.99E-06	0.09670	1.68E-05	0.02930
	5.00E-07 to 5.63E-07	1.85E-06	0.09910	1.51E-05	0.03140
	5.63E-07 to 6.25E-07	1.54E-06	0.11030	1.35E-05	0.03360
	6.25E-07 to 1.86E-06	1.38E-05	0.04300	1.24E-04	0.01230
	1.86E-06 to 5.04E-06	1.22E-05	0.04420	1.20E-04	0.01270
	5.04E-06 to 1.37E-05	1.11E-05	0.04460	1.05E-04	0.01270
	1.37E-05 to 3.73E-05	1.20E-05	0.04370	1.18E-04	0.01230
	3.73E-05 to 1.01E-04	1.39E-05	0.04170	1.31E-04	0.01200
	1.01E-04 to 2.75E-04	1.42E-05	0.04200	1.40E-04	0.01190
	2.75E-04 to 7.49E-04	1.54E-05	0.04140	1.45E-04	0.01170
	7.49E-04 to 2.03E-03	1.62E-05	0.03950	1.53E-04	0.01160
	2.03E-03 to 5.53E-03	1.62E-05	0.04000	1.55E-04	0.01150
	5.53E-03 to 0.0150	1.77E-05	0.03950	1.68E-04	0.01130
	0.0150 to 0.0409	1.87E-05	0.03910	1.89E-04	0.01080
	0.0409 to 0.111	2.35E-05	0.03640	2.40E-04	0.01020
	0.111 to 0.302	3.70E-05	0.03200	3.71E-04	0.00890
	0.302 to 0.821	6.33E-05	0.02700	6.35E-04	0.00760
	0.821 to 2.23	7.94E-05	0.02560	8.02E-04	0.00710
	2.23 to 20.00	5.55E-05	0.03110	6.13E-04	0.00850
	Total	4.95E-04	0.01480	4.95E-03	0.00420
2	0 to 1.25E-09	1.04E-08	0.54920	1.65E-07	1.32E-01
	1.25E-09 to 5.00E-09	3.48E-07	0.13950	5.95E-06	3.02E-02
	5.00E-09 to 5.63E-09	6.58E-08	0.27580	1.35E-06	5.97E-02
	5.63E-09 to 1.00E-08	9.35E-07	0.08790	1.66E-05	2.02E-02
	1.00E-08 to 2.00E-08	3.77E-06	0.05190	6.88E-05	1.16E-02
	2.00E-08 to 4.60E-08	1.68E-05	0.03100	2.41E-04	8.10E-03
	4.60E-08 to 6.25E-08	1.18E-05	0.03490	1.34E-04	9.70E-03
	6.25E-08 to 1.00E-07	2.27E-05	0.02890	1.99E-04	8.80E-03
	1.00E-07 to 1.88E-07	3.03E-05	0.02720	1.67E-04	9.50E-03
	1.88E-07 to 2.50E-07	9.44E-06	0.04020	4.43E-05	1.60E-02
	2.50E-07 to 3.13E-07	4.31E-06	0.05240	2.71E-05	1.89E-02
	3.13E-07 to 3.75E-07	3.55E-06	0.06120	2.44E-05	2.09E-02
	3.75E-07 to 4.38E-07	2.72E-06	0.07070	2.52E-05	2.20E-02
	4.38E-07 to 5.00E-07	2.95E-06	0.07290	2.27E-05	2.38E-02
	5.00E-07 to 5.63E-07	2.66E-06	0.07150	2.19E-05	2.49E-02
	5.63E-07 to 6.25E-07	1.99E-06	0.08860	1.84E-05	2.62E-02
	6.25E-07 to 1.86E-06	2.01E-05	0.03170	1.68E-04	9.80E-03
	1.86E-06 to 5.04E-06	1.96E-05	0.03350	1.72E-04	9.90E-03

Table 6.2-3. Neutron Spectrum Results for Outer Edge PWR Assembly

Axial Node	Energy Range	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
	5.04E-06 to 1.37E-05	1.77E-05	0.03260	1.51E-04	1.00E-02
	1.37E-05 to 3.73E-05	1.86E-05	0.03290	1.70E-04	9.60E-03
	3.73E-05 to 1.01E-04	2.16E-05	0.03140	1.93E-04	9.40E-03
	1.01E-04 to 2.75E-04	2.20E-05	0.03150	2.02E-04	9.30E-03
	2.75E-04 to 7.49E-04	2.47E-05	0.02990	2.14E-04	9.20E-03
	7.49E-04 to 2.03E-03	2.45E-05	0.03090	2.15E-04	9.20E-03
	2.03E-03 to 5.53E-03	2.65E-05	0.02950	2.22E-04	9.20E-03
	5.53E-03 to 0.0150	2.70E-05	0.02990	2.38E-04	8.90E-03
	0.0150 to 0.0409	3.12E-05	0.02940	2.66E-04	8.70E-03
	0.0409 to 0.111	3.89E-05	0.02700	3.40E-04	8.10E-03
	0.111 to 0.302	6.08E-05	0.02390	5.27E-04	7.00E-03
	0.302 to 0.821	1.00E-04	0.02110	8.94E-04	6.10E-03
	0.821 to 2.23	1.21E-04	0.01940	1.12E-03	5.70E-03
	2.23 to 20.00	9.10E-05	0.02320	8.50E-04	6.90E-03
	Total	7.79E-04	0.01120	6.96E-03	3.40E-03
3	0 to 1.25E-09	5.16E-09	0.95280	2.19E-07	1.29E-01
	1.25E-09 to 5.00E-09	4.35E-07	0.13010	5.86E-06	3.11E-02
	5.00E-09 to 5.63E-09	9.14E-08	0.29030	1.43E-06	6.06E-02
	5.63E-09 to 1.00E-08	9.72E-07	0.08740	1.62E-05	2.04E-02
	1.00E-08 to 2.00E-08	4.12E-06	0.04780	6.59E-05	1.21E-02
	2.00E-08 to 4.60E-08	1.96E-05	0.02860	2.31E-04	8.30E-03
	4.60E-08 to 6.25E-08	1.32E-05	0.03290	1.29E-04	9.90E-03
	6.25E-08 to 1.00E-07	2.66E-05	0.02640	1.90E-04	9.00E-03
	1.00E-07 to 1.88E-07	3.35E-05	0.02580	1.62E-04	9.70E-03
	1.88E-07 to 2.50E-07	9.67E-06	0.03860	4.32E-05	1.62E-02
	2.50E-07 to 3.13E-07	4.44E-06	0.05190	2.53E-05	1.93E-02
	3.13E-07 to 3.75E-07	3.54E-06	0.06220	2.41E-05	2.09E-02
	3.75E-07 to 4.38E-07	3.57E-06	0.06420	2.36E-05	2.28E-02
	4.38E-07 to 5.00E-07	3.47E-06	0.06750	2.21E-05	2.41E-02
	5.00E-07 to 5.63E-07	2.91E-06	0.07170	2.06E-05	2.51E-02
	5.63E-07 to 6.25E-07	2.40E-06	0.07660	1.76E-05	2.71E-02
	6.25E-07 to 1.86E-06	2.33E-05	0.02910	1.60E-04	1.00E-02
	1.86E-06 to 5.04E-06	2.32E-05	0.03180	1.67E-04	1.01E-02
	5.04E-06 to 1.37E-05	1.94E-05	0.03090	1.47E-04	1.02E-02
	1.37E-05 to 3.73E-05	2.29E-05	0.03070	1.62E-04	9.90E-03
	3.73E-05 to 1.01E-04	2.57E-05	0.02870	1.84E-04	9.60E-03
	1.01E-04 to 2.75E-04	2.53E-05	0.02920	1.92E-04	9.60E-03
	2.75E-04 to 7.49E-04	2.79E-05	0.02850	2.06E-04	9.30E-03
	7.49E-04 to 2.03E-03	2.80E-05	0.02810	2.10E-04	9.40E-03
	2.03E-03 to 5.53E-03	2.95E-05	0.02920	2.20E-04	9.30E-03
	5.53E-03 to 0.0150	3.00E-05	0.02860	2.31E-04	9.10E-03
	0.0150 to 0.0409	3.27E-05	0.02780	2.63E-04	8.80E-03
	0.0409 to 0.111	4.58E-05	0.02550	3.27E-04	8.30E-03
	0.111 to 0.302	6.88E-05	0.02210	5.07E-04	7.30E-03
	0.302 to 0.821	1.11E-04	0.01950	8.59E-04	6.20E-03
	0.821 to 2.23	1.33E-04	0.01870	1.06E-03	5.90E-03
	2.23 to 20.00	1.00E-04	0.02210	7.99E-04	7.10E-03
	Total	8.76E-04	0.01050	6.67E-03	3.40E-03
4	0 to 1.25E-09	4.79E-09	6.00E-01	2.12E-07	1.26E-01
	1.25E-09 to 5.00E-09	4.34E-07	1.21E-01	5.37E-06	3.20E-02
	5.00E-09 to 5.63E-09	1.19E-07	2.57E-01	1.35E-06	6.46E-02

Table 6.2-3. Neutron Spectrum Results for Outer Edge PWR Assembly

Axial Node	Energy Range	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
	5.63E-09 to 1.00E-08	1.28E-06	7.65E-02	1.52E-05	2.13E-02
	1.00E-08 to 2.00E-08	5.57E-06	4.29E-02	6.16E-05	1.25E-02
	2.00E-08 to 4.60E-08	2.38E-05	2.69E-02	2.12E-04	8.70E-03
	4.60E-08 to 6.25E-08	1.65E-05	3.04E-02	1.15E-04	1.04E-02
	6.25E-08 to 1.00E-07	3.17E-05	2.53E-02	1.75E-04	9.50E-03
	1.00E-07 to 1.88E-07	3.92E-05	2.40E-02	1.45E-04	1.01E-02
	1.88E-07 to 2.50E-07	1.05E-05	3.74E-02	3.96E-05	1.70E-02
	2.50E-07 to 3.13E-07	5.12E-06	4.77E-02	2.28E-05	2.04E-02
	3.13E-07 to 3.75E-07	4.24E-06	5.84E-02	2.05E-05	2.24E-02
	3.75E-07 to 4.38E-07	3.84E-06	6.15E-02	2.15E-05	2.36E-02
	4.38E-07 to 5.00E-07	3.68E-06	6.41E-02	1.99E-05	2.53E-02
	5.00E-07 to 5.63E-07	3.10E-06	7.05E-02	1.90E-05	2.63E-02
	5.63E-07 to 6.25E-07	2.79E-06	8.20E-02	1.62E-05	2.79E-02
	6.25E-07 to 1.86E-06	2.43E-05	2.89E-02	1.42E-04	1.04E-02
	1.86E-06 to 5.04E-06	2.56E-05	2.94E-02	1.49E-04	1.07E-02
	5.04E-06 to 1.37E-05	2.21E-05	2.97E-02	1.31E-04	1.07E-02
	1.37E-05 to 3.73E-05	2.34E-05	2.83E-02	1.45E-04	1.06E-02
	3.73E-05 to 1.01E-04	2.97E-05	2.66E-02	1.62E-04	1.02E-02
	1.01E-04 to 2.75E-04	3.06E-05	2.70E-02	1.72E-04	1.00E-02
	2.75E-04 to 7.49E-04	3.06E-05	2.67E-02	1.80E-04	9.90E-03
	7.49E-04 to 2.03E-03	3.13E-05	2.67E-02	1.87E-04	9.90E-03
	2.03E-03 to 5.53E-03	3.37E-05	2.61E-02	1.94E-04	9.90E-03
	5.53E-03 to 0.0150	3.59E-05	2.67E-02	2.05E-04	9.70E-03
	0.0150 to 0.0409	4.08E-05	2.57E-02	2.33E-04	9.30E-03
	0.0409 to 0.111	5.11E-05	2.36E-02	2.91E-04	8.80E-03
	0.111 to 0.302	7.81E-05	2.12E-02	4.52E-04	7.70E-03
	0.302 to 0.821	1.27E-04	1.82E-02	7.73E-04	6.50E-03
	0.821 to 2.23	1.52E-04	1.75E-02	9.54E-04	6.20E-03
	2.23 to 20.00	1.19E-04	2.06E-02	7.29E-04	7.40E-03
	Total	1.01E-03	9.90E-03	5.99E-03	3.60E-03
5	0 to 1.25E-09	1.38E-08	4.72E-01	1.43E-07	1.60E-01
	1.25E-09 to 5.00E-09	4.21E-07	1.25E-01	3.91E-06	3.74E-02
	5.00E-09 to 5.63E-09	9.66E-08	2.31E-01	1.07E-06	7.30E-02
	5.63E-09 to 1.00E-08	1.10E-06	7.84E-02	1.11E-05	2.45E-02
	1.00E-08 to 2.00E-08	5.32E-06	4.38E-02	4.56E-05	1.44E-02
	2.00E-08 to 4.60E-08	2.39E-05	2.66E-02	1.60E-04	9.90E-03
	4.60E-08 to 6.25E-08	1.55E-05	3.02E-02	8.87E-05	1.19E-02
	6.25E-08 to 1.00E-07	3.10E-05	2.46E-02	1.32E-04	1.08E-02
	1.00E-07 to 1.88E-07	3.85E-05	2.37E-02	1.14E-04	1.15E-02
	1.88E-07 to 2.50E-07	1.10E-05	3.57E-02	3.02E-05	1.91E-02
	2.50E-07 to 3.13E-07	5.02E-06	4.76E-02	1.71E-05	2.36E-02
	3.13E-07 to 3.75E-07	4.81E-06	5.25E-02	1.63E-05	2.53E-02
	3.75E-07 to 4.38E-07	4.40E-06	5.77E-02	1.59E-05	2.78E-02
	4.38E-07 to 5.00E-07	3.70E-06	6.88E-02	1.51E-05	2.92E-02
	5.00E-07 to 5.63E-07	3.05E-06	6.84E-02	1.39E-05	3.00E-02
	5.63E-07 to 6.25E-07	2.90E-06	7.78E-02	1.20E-05	3.22E-02
	6.25E-07 to 1.86E-06	2.58E-05	2.75E-02	1.14E-04	1.18E-02
	1.86E-06 to 5.04E-06	2.76E-05	2.79E-02	1.16E-04	1.21E-02
	5.04E-06 to 1.37E-05	2.26E-05	2.88E-02	9.99E-05	1.22E-02
	1.37E-05 to 3.73E-05	2.52E-05	2.83E-02	1.17E-04	1.17E-02
	3.73E-05 to 1.01E-04	2.95E-05	2.69E-02	1.34E-04	1.13E-02

Table 6.2-3. Neutron Spectrum Results for Outer Edge PWR Assembly

Axial Node	Energy Range	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
	1.01E-04 to 2.75E-04	2.96E-05	2.67E-02	1.38E-04	1.13E-02
	2.75E-04 to 7.49E-04	3.32E-05	2.62E-02	1.41E-04	1.12E-02
	7.49E-04 to 2.03E-03	3.25E-05	2.63E-02	1.50E-04	1.11E-02
	2.03E-03 to 5.53E-03	3.35E-05	2.64E-02	1.54E-04	1.10E-02
	5.53E-03 to 0.0150	3.79E-05	2.59E-02	1.62E-04	1.09E-02
	0.0150 to 0.0409	4.14E-05	2.48E-02	1.80E-04	1.06E-02
	0.0409 to 0.111	5.46E-05	2.34E-02	2.34E-04	9.90E-03
	0.111 to 0.302	7.79E-05	2.11E-02	3.53E-04	8.70E-03
	0.302 to 0.821	1.38E-04	1.79E-02	6.03E-04	7.40E-03
	0.821 to 2.23	1.57E-04	1.72E-02	7.45E-04	7.00E-03
	2.23 to 20.00	1.20E-04	2.05E-02	5.72E-04	8.40E-03
	Total	1.04E-03	9.70E-03	4.69E-03	4.10E-03
6	0 to 1.25E-09	1.18E-08	5.62E-01	1.35E-07	1.63E-01
	1.25E-09 to 5.00E-09	4.96E-07	1.20E-01	3.08E-06	4.30E-02
	5.00E-09 to 5.63E-09	1.38E-07	2.19E-01	8.60E-07	8.36E-02
	5.63E-09 to 1.00E-08	1.35E-06	7.58E-02	9.01E-06	2.71E-02
	1.00E-08 to 2.00E-08	5.59E-06	4.32E-02	3.63E-05	1.61E-02
	2.00E-08 to 4.60E-08	2.45E-05	2.66E-02	1.26E-04	1.12E-02
	4.60E-08 to 6.25E-08	1.64E-05	3.06E-02	7.12E-05	1.34E-02
	6.25E-08 to 1.00E-07	3.37E-05	2.45E-02	1.02E-04	1.23E-02
	1.00E-07 to 1.88E-07	4.13E-05	2.34E-02	8.78E-05	1.34E-02
	1.88E-07 to 2.50E-07	1.12E-05	3.53E-02	2.28E-05	2.23E-02
	2.50E-07 to 3.13E-07	5.54E-06	4.56E-02	1.37E-05	2.65E-02
	3.13E-07 to 3.75E-07	4.75E-06	5.23E-02	1.27E-05	2.85E-02
	3.75E-07 to 4.38E-07	3.99E-06	6.03E-02	1.25E-05	3.08E-02
	4.38E-07 to 5.00E-07	3.84E-06	6.64E-02	1.21E-05	3.23E-02
	5.00E-07 to 5.63E-07	3.38E-06	6.48E-02	1.07E-05	3.39E-02
	5.63E-07 to 6.25E-07	2.80E-06	7.30E-02	9.34E-06	3.78E-02
	6.25E-07 to 1.86E-06	2.55E-05	2.77E-02	8.71E-05	1.35E-02
	1.86E-06 to 5.04E-06	2.70E-05	2.78E-02	8.86E-05	1.38E-02
	5.04E-06 to 1.37E-05	2.35E-05	2.80E-02	7.82E-05	1.38E-02
	1.37E-05 to 3.73E-05	2.59E-05	2.79E-02	8.95E-05	1.34E-02
	3.73E-05 to 1.01E-04	3.18E-05	2.61E-02	1.00E-04	1.29E-02
	1.01E-04 to 2.75E-04	2.98E-05	2.64E-02	1.04E-04	1.30E-02
	2.75E-04 to 7.49E-04	3.41E-05	2.55E-02	1.10E-04	1.28E-02
	7.49E-04 to 2.03E-03	3.46E-05	2.60E-02	1.16E-04	1.27E-02
	2.03E-03 to 5.53E-03	3.63E-05	2.55E-02	1.17E-04	1.27E-02
	5.53E-03 to 0.0150	3.74E-05	2.57E-02	1.25E-04	1.24E-02
	0.0150 to 0.0409	4.27E-05	2.42E-02	1.39E-04	1.22E-02
	0.0409 to 0.111	5.21E-05	2.35E-02	1.74E-04	1.13E-02
	0.111 to 0.302	7.99E-05	2.09E-02	2.72E-04	9.90E-03
	0.302 to 0.821	1.38E-04	1.78E-02	4.58E-04	8.40E-03
	0.821 to 2.23	1.63E-04	1.70E-02	5.68E-04	8.00E-03
	2.23 to 20.00	1.24E-04	2.03E-02	4.38E-04	9.60E-03
	Total	1.06E-03	9.60E-03	3.60E-03	4.70E-03
7	0 to 1.25E-09	3.42E-08	3.95E-01	8.74E-08	1.93E-01
	1.25E-09 to 5.00E-09	4.97E-07	1.10E-01	2.45E-06	4.77E-02
	5.00E-09 to 5.63E-09	1.79E-07	2.14E-01	7.15E-07	9.06E-02
	5.63E-09 to 1.00E-08	1.36E-06	7.67E-02	6.66E-06	3.17E-02
	1.00E-08 to 2.00E-08	5.03E-06	4.52E-02	2.73E-05	1.85E-02
	2.00E-08 to 4.60E-08	2.44E-05	2.66E-02	9.62E-05	1.28E-02

Table 6.2-3. Neutron Spectrum Results for Outer Edge PWR Assembly

Axial Node	Energy Range	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
	4.60E-08 to 6.25E-08	1.61E-05	2.99E-02	5.42E-05	1.53E-02
	6.25E-08 to 1.00E-07	3.27E-05	2.48E-02	8.01E-05	1.39E-02
	1.00E-07 to 1.88E-07	4.16E-05	2.31E-02	6.56E-05	1.50E-02
	1.88E-07 to 2.50E-07	1.13E-05	3.56E-02	1.70E-05	2.57E-02
	2.50E-07 to 3.13E-07	5.42E-06	4.60E-02	1.05E-05	3.06E-02
	3.13E-07 to 3.75E-07	4.49E-06	5.25E-02	9.04E-06	3.32E-02
	3.75E-07 to 4.38E-07	3.92E-06	6.09E-02	9.23E-06	3.63E-02
	4.38E-07 to 5.00E-07	3.84E-06	6.34E-02	8.99E-06	3.73E-02
	5.00E-07 to 5.63E-07	3.10E-06	7.22E-02	8.08E-06	3.91E-02
	5.63E-07 to 6.25E-07	3.00E-06	7.58E-02	7.27E-06	4.42E-02
	6.25E-07 to 1.86E-06	2.54E-05	2.72E-02	6.42E-05	1.56E-02
	1.86E-06 to 5.04E-06	2.65E-05	2.81E-02	6.71E-05	1.58E-02
	5.04E-06 to 1.37E-05	2.38E-05	2.88E-02	5.97E-05	1.61E-02
	1.37E-05 to 3.73E-05	2.59E-05	2.82E-02	6.66E-05	1.55E-02
	3.73E-05 to 1.01E-04	3.00E-05	2.63E-02	7.43E-05	1.50E-02
	1.01E-04 to 2.75E-04	3.20E-05	2.64E-02	7.77E-05	1.49E-02
	2.75E-04 to 7.49E-04	3.31E-05	2.57E-02	8.11E-05	1.48E-02
	7.49E-04 to 2.03E-03	3.55E-05	2.57E-02	8.53E-05	1.47E-02
	2.03E-03 to 5.53E-03	3.61E-05	2.57E-02	8.99E-05	1.45E-02
	5.53E-03 to 0.0150	3.65E-05	2.55E-02	9.11E-05	1.44E-02
	0.0150 to 0.0409	4.11E-05	2.52E-02	1.03E-04	1.40E-02
	0.0409 to 0.111	5.49E-05	2.31E-02	1.30E-04	1.30E-02
	0.111 to 0.302	8.14E-05	2.08E-02	2.08E-04	1.13E-02
	0.302 to 0.821	1.34E-04	1.79E-02	3.42E-04	9.70E-03
	0.821 to 2.23	1.62E-04	1.71E-02	4.25E-04	9.30E-03
	2.23 to 20.00	1.22E-04	2.04E-02	3.29E-04	1.11E-02
	Total	1.06E-03	9.70E-03	2.70E-03	5.40E-03
8	0 to 1.25E-09	9.14E-09	6.10E-01	7.35E-08	2.12E-01
	1.25E-09 to 5.00E-09	4.61E-07	1.24E-01	1.70E-06	5.89E-02
	5.00E-09 to 5.63E-09	1.15E-07	3.37E-01	3.26E-07	1.26E-01
	5.63E-09 to 1.00E-08	1.26E-06	7.78E-02	4.64E-06	3.90E-02
	1.00E-08 to 2.00E-08	4.97E-06	4.80E-02	1.85E-05	2.23E-02
	2.00E-08 to 4.60E-08	2.06E-05	2.83E-02	6.40E-05	1.56E-02
	4.60E-08 to 6.25E-08	1.41E-05	3.18E-02	3.60E-05	1.88E-02
	6.25E-08 to 1.00E-07	3.07E-05	2.56E-02	5.44E-05	1.69E-02
	1.00E-07 to 1.88E-07	3.64E-05	2.43E-02	4.65E-05	1.80E-02
	1.88E-07 to 2.50E-07	1.05E-05	3.78E-02	1.24E-05	3.04E-02
	2.50E-07 to 3.13E-07	5.28E-06	4.94E-02	6.80E-06	3.64E-02
	3.13E-07 to 3.75E-07	4.11E-06	5.59E-02	6.73E-06	3.96E-02
	3.75E-07 to 4.38E-07	3.27E-06	6.15E-02	6.41E-06	4.51E-02
	4.38E-07 to 5.00E-07	3.70E-06	6.43E-02	6.41E-06	4.49E-02
	5.00E-07 to 5.63E-07	3.02E-06	7.01E-02	5.59E-06	4.63E-02
	5.63E-07 to 6.25E-07	2.68E-06	7.32E-02	4.68E-06	5.10E-02
	6.25E-07 to 1.86E-06	2.43E-05	2.91E-02	4.53E-05	1.84E-02
	1.86E-06 to 5.04E-06	2.41E-05	3.07E-02	4.62E-05	1.90E-02
	5.04E-06 to 1.37E-05	2.07E-05	3.04E-02	4.15E-05	1.93E-02
	1.37E-05 to 3.73E-05	2.47E-05	2.87E-02	4.72E-05	1.84E-02
	3.73E-05 to 1.01E-04	2.82E-05	2.75E-02	5.59E-05	1.78E-02
	1.01E-04 to 2.75E-04	2.91E-05	2.73E-02	5.51E-05	1.84E-02
	2.75E-04 to 7.49E-04	3.18E-05	2.67E-02	5.75E-05	1.76E-02
	7.49E-04 to 2.03E-03	3.21E-05	2.71E-02	6.08E-05	1.74E-02

Table 6.2-3. Neutron Spectrum Results for Outer Edge PWR Assembly

Axial Node	Energy Range	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
	2.03E-03 to 5.53E-03	3.17E-05	2.69E-02	6.48E-05	1.72E-02
	5.53E-03 to 0.0150	3.42E-05	2.72E-02	6.42E-05	1.73E-02
	0.0150 to 0.0409	3.85E-05	2.59E-02	7.33E-05	1.67E-02
	0.0409 to 0.111	4.89E-05	2.44E-02	9.21E-05	1.57E-02
	0.111 to 0.302	7.41E-05	2.14E-02	1.45E-04	1.36E-02
	0.302 to 0.821	1.26E-04	1.83E-02	2.42E-04	1.16E-02
	0.821 to 2.23	1.42E-04	1.79E-02	3.04E-04	1.10E-02
	2.23 to 20.00	1.10E-04	2.12E-02	2.25E-04	1.34E-02
	Total	9.62E-04	1.01E-02	1.89E-03	6.50E-03
9	0 to 1.25E-09	5.56E-09	6.59E-01	4.61E-08	2.21E-01
	1.25E-09 to 5.00E-09	3.38E-07	1.36E-01	1.24E-06	6.63E-02
	5.00E-09 to 5.63E-09	4.62E-08	3.48E-01	3.17E-07	1.37E-01
	5.63E-09 to 1.00E-08	1.17E-06	8.14E-02	3.73E-06	4.18E-02
	1.00E-08 to 2.00E-08	4.97E-06	4.67E-02	1.56E-05	2.44E-02
	2.00E-08 to 4.60E-08	2.23E-05	2.78E-02	5.30E-05	1.73E-02
	4.60E-08 to 6.25E-08	1.48E-05	3.12E-02	2.98E-05	2.10E-02
	6.25E-08 to 1.00E-07	3.04E-05	2.56E-02	4.34E-05	1.88E-02
	1.00E-07 to 1.88E-07	3.64E-05	2.46E-02	3.68E-05	2.02E-02
	1.88E-07 to 2.50E-07	1.01E-05	3.78E-02	9.25E-06	3.56E-02
	2.50E-07 to 3.13E-07	5.29E-06	4.86E-02	5.87E-06	3.99E-02
	3.13E-07 to 3.75E-07	3.76E-06	5.74E-02	5.35E-06	4.51E-02
	3.75E-07 to 4.38E-07	3.48E-06	6.46E-02	5.59E-06	4.71E-02
	4.38E-07 to 5.00E-07	3.62E-06	6.70E-02	4.91E-06	4.98E-02
	5.00E-07 to 5.63E-07	3.12E-06	7.23E-02	4.49E-06	5.26E-02
	5.63E-07 to 6.25E-07	2.48E-06	7.79E-02	4.20E-06	5.33E-02
	6.25E-07 to 1.86E-06	2.43E-05	2.90E-02	3.59E-05	2.10E-02
	1.86E-06 to 5.04E-06	2.36E-05	3.02E-02	3.74E-05	2.14E-02
	5.04E-06 to 1.37E-05	2.05E-05	3.06E-02	3.26E-05	2.15E-02
	1.37E-05 to 3.73E-05	2.30E-05	2.89E-02	3.72E-05	2.06E-02
	3.73E-05 to 1.01E-04	2.86E-05	2.74E-02	4.27E-05	1.99E-02
	1.01E-04 to 2.75E-04	2.89E-05	2.85E-02	4.32E-05	2.00E-02
	2.75E-04 to 7.49E-04	2.97E-05	2.74E-02	4.54E-05	1.99E-02
	7.49E-04 to 2.03E-03	3.08E-05	2.81E-02	4.62E-05	1.99E-02
	2.03E-03 to 5.53E-03	3.31E-05	2.70E-02	4.95E-05	1.94E-02
	5.53E-03 to 0.0150	3.48E-05	2.65E-02	5.19E-05	1.93E-02
	0.0150 to 0.0409	3.92E-05	2.60E-02	5.71E-05	1.87E-02
	0.0409 to 0.111	4.98E-05	2.40E-02	7.26E-05	1.74E-02
	0.111 to 0.302	7.40E-05	2.14E-02	1.15E-04	1.53E-02
	0.302 to 0.821	1.20E-04	1.87E-02	1.91E-04	1.32E-02
	0.821 to 2.23	1.42E-04	1.81E-02	2.39E-04	1.24E-02
	2.23 to 20.00	1.12E-04	2.09E-02	1.83E-04	1.48E-02
	Total	9.56E-04	1.01E-02	1.50E-03	7.30E-03
10	0 to 1.25E-09	2.02E-09	5.45E-01	3.24E-08	2.97E-01
	1.25E-09 to 5.00E-09	4.05E-07	1.35E-01	9.64E-07	7.87E-02
	5.00E-09 to 5.63E-09	7.94E-08	2.42E-01	3.28E-07	1.31E-01
	5.63E-09 to 1.00E-08	9.88E-07	9.25E-02	2.70E-06	5.17E-02
	1.00E-08 to 2.00E-08	4.08E-06	5.06E-02	1.08E-05	2.88E-02
	2.00E-08 to 4.60E-08	1.90E-05	2.92E-02	3.85E-05	2.04E-02
	4.60E-08 to 6.25E-08	1.37E-05	3.21E-02	2.17E-05	2.44E-02
	6.25E-08 to 1.00E-07	2.74E-05	2.63E-02	3.17E-05	2.22E-02
	1.00E-07 to 1.88E-07	3.59E-05	2.53E-02	2.64E-05	2.40E-02

Table 6.2-3. Neutron Spectrum Results for Outer Edge PWR Assembly

Axial Node	Energy Range	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
	1.88E-07 to 2.50E-07	9.27E-06	3.95E-02	7.31E-06	3.93E-02
	2.50E-07 to 3.13E-07	4.67E-06	4.87E-02	4.24E-06	4.69E-02
	3.13E-07 to 3.75E-07	3.72E-06	5.85E-02	3.78E-06	5.14E-02
	3.75E-07 to 4.38E-07	3.41E-06	6.56E-02	3.67E-06	5.55E-02
	4.38E-07 to 5.00E-07	3.12E-06	6.69E-02	3.65E-06	5.90E-02
	5.00E-07 to 5.63E-07	3.09E-06	7.17E-02	3.20E-06	6.33E-02
	5.63E-07 to 6.25E-07	2.46E-06	8.10E-02	2.96E-06	6.88E-02
	6.25E-07 to 1.86E-06	2.22E-05	2.97E-02	2.58E-05	2.46E-02
	1.86E-06 to 5.04E-06	2.26E-05	3.09E-02	2.76E-05	2.45E-02
	5.04E-06 to 1.37E-05	2.00E-05	2.98E-02	2.38E-05	2.49E-02
	1.37E-05 to 3.73E-05	2.23E-05	3.06E-02	2.83E-05	2.43E-02
	3.73E-05 to 1.01E-04	2.43E-05	2.94E-02	3.15E-05	2.33E-02
	1.01E-04 to 2.75E-04	2.47E-05	2.95E-02	3.10E-05	2.38E-02
	2.75E-04 to 7.49E-04	2.78E-05	2.86E-02	3.43E-05	2.29E-02
	7.49E-04 to 2.03E-03	2.86E-05	2.84E-02	3.37E-05	2.32E-02
	2.03E-03 to 5.53E-03	3.00E-05	2.81E-02	3.59E-05	2.31E-02
	5.53E-03 to 0.0150	3.07E-05	2.80E-02	3.63E-05	2.26E-02
	0.0150 to 0.0409	3.57E-05	2.72E-02	4.17E-05	2.17E-02
	0.0409 to 0.111	4.35E-05	2.61E-02	5.36E-05	2.06E-02
	0.111 to 0.302	6.77E-05	2.28E-02	8.27E-05	1.80E-02
	0.302 to 0.821	1.12E-04	1.96E-02	1.39E-04	1.54E-02
	0.821 to 2.23	1.31E-04	1.88E-02	1.74E-04	1.44E-02
	2.23 to 20.00	9.92E-05	2.23E-02	1.37E-04	1.73E-02
	Total	8.73E-04	1.06E-02	1.10E-03	8.50E-03
11	0 to 1.25E-09	2.47E-09	6.73E-01	2.64E-08	3.15E-01
	1.25E-09 to 5.00E-09	2.94E-07	1.49E-01	6.94E-07	9.53E-02
	5.00E-09 to 5.63E-09	5.72E-08	3.14E-01	1.77E-07	1.68E-01
	5.63E-09 to 1.00E-08	1.01E-06	9.37E-02	1.85E-06	6.03E-02
	1.00E-08 to 2.00E-08	3.77E-06	5.14E-02	7.57E-06	3.50E-02
	2.00E-08 to 4.60E-08	1.74E-05	3.12E-02	2.66E-05	2.41E-02
	4.60E-08 to 6.25E-08	1.16E-05	3.45E-02	1.49E-05	2.89E-02
	6.25E-08 to 1.00E-07	2.35E-05	2.83E-02	2.25E-05	2.63E-02
	1.00E-07 to 1.88E-07	3.06E-05	2.72E-02	1.91E-05	2.83E-02
	1.88E-07 to 2.50E-07	8.25E-06	4.22E-02	4.90E-06	4.84E-02
	2.50E-07 to 3.13E-07	3.93E-06	5.46E-02	2.97E-06	5.66E-02
	3.13E-07 to 3.75E-07	3.43E-06	6.34E-02	2.65E-06	6.07E-02
	3.75E-07 to 4.38E-07	2.77E-06	6.96E-02	2.81E-06	6.73E-02
	4.38E-07 to 5.00E-07	2.86E-06	7.49E-02	2.81E-06	6.61E-02
	5.00E-07 to 5.63E-07	2.48E-06	7.95E-02	2.41E-06	7.31E-02
	5.63E-07 to 6.25E-07	2.04E-06	8.82E-02	2.07E-06	7.76E-02
	6.25E-07 to 1.86E-06	1.96E-05	3.19E-02	1.93E-05	2.91E-02
	1.86E-06 to 5.04E-06	1.95E-05	3.27E-02	1.90E-05	2.95E-02
	5.04E-06 to 1.37E-05	1.71E-05	3.23E-02	1.70E-05	2.91E-02
	1.37E-05 to 3.73E-05	1.90E-05	3.21E-02	2.01E-05	2.78E-02
	3.73E-05 to 1.01E-04	2.18E-05	3.07E-02	2.26E-05	2.82E-02
	1.01E-04 to 2.75E-04	2.28E-05	3.18E-02	2.22E-05	2.74E-02
	2.75E-04 to 7.49E-04	2.38E-05	3.07E-02	2.37E-05	2.73E-02
	7.49E-04 to 2.03E-03	2.56E-05	2.98E-02	2.56E-05	2.68E-02
	2.03E-03 to 5.53E-03	2.70E-05	3.01E-02	2.53E-05	2.69E-02
	5.53E-03 to 0.0150	2.82E-05	2.97E-02	2.73E-05	2.66E-02
	0.0150 to 0.0409	3.32E-05	2.84E-02	3.09E-05	2.57E-02

Table 6.2-3. Neutron Spectrum Results for Outer Edge PWR Assembly

Axial Node	Energy Range	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
	0.0409 to 0.111	3.94E-05	2.72E-02	4.00E-05	2.38E-02
	0.111 to 0.302	6.15E-05	2.40E-02	6.01E-05	2.08E-02
	0.302 to 0.821	1.00E-04	2.08E-02	1.03E-04	1.80E-02
	0.821 to 2.23	1.17E-04	1.98E-02	1.25E-04	1.70E-02
	2.23 to 20.00	8.84E-05	2.38E-02	9.61E-05	2.07E-02
	Total	7.78E-04	1.12E-02	7.92E-04	1.00E-02
12	0 to 1.25E-09	2.32E-09	8.75E-01	1.54E-08	4.42E-01
	1.25E-09 to 5.00E-09	3.70E-07	1.34E-01	7.20E-07	9.10E-02
	5.00E-09 to 5.63E-09	5.75E-08	3.36E-01	1.28E-07	1.86E-01
	5.63E-09 to 1.00E-08	1.03E-06	8.76E-02	1.71E-06	6.61E-02
	1.00E-08 to 2.00E-08	4.18E-06	4.85E-02	6.34E-06	3.88E-02
	2.00E-08 to 4.60E-08	1.72E-05	3.05E-02	2.21E-05	2.74E-02
	4.60E-08 to 6.25E-08	1.17E-05	3.53E-02	1.30E-05	3.13E-02
	6.25E-08 to 1.00E-07	2.37E-05	2.89E-02	1.82E-05	2.92E-02
	1.00E-07 to 1.88E-07	3.00E-05	2.76E-02	1.54E-05	3.18E-02
	1.88E-07 to 2.50E-07	8.40E-06	4.29E-02	4.25E-06	5.21E-02
	2.50E-07 to 3.13E-07	4.59E-06	5.08E-02	2.26E-06	6.54E-02
	3.13E-07 to 3.75E-07	3.25E-06	6.35E-02	2.26E-06	6.89E-02
	3.75E-07 to 4.38E-07	3.06E-06	7.23E-02	2.12E-06	7.70E-02
	4.38E-07 to 5.00E-07	2.81E-06	7.47E-02	1.96E-06	8.14E-02
	5.00E-07 to 5.63E-07	2.25E-06	8.46E-02	1.97E-06	8.65E-02
	5.63E-07 to 6.25E-07	2.12E-06	8.30E-02	1.66E-06	8.50E-02
	6.25E-07 to 1.86E-06	1.85E-05	3.18E-02	1.52E-05	3.22E-02
	1.86E-06 to 5.04E-06	1.92E-05	3.27E-02	1.55E-05	3.34E-02
	5.04E-06 to 1.37E-05	1.69E-05	3.42E-02	1.27E-05	3.40E-02
	1.37E-05 to 3.73E-05	1.75E-05	3.36E-02	1.59E-05	3.19E-02
	3.73E-05 to 1.01E-04	2.28E-05	3.16E-02	1.72E-05	3.10E-02
	1.01E-04 to 2.75E-04	2.33E-05	3.05E-02	1.82E-05	3.01E-02
	2.75E-04 to 7.49E-04	2.56E-05	3.11E-02	1.92E-05	3.04E-02
	7.49E-04 to 2.03E-03	2.48E-05	3.07E-02	1.85E-05	3.15E-02
	2.03E-03 to 5.53E-03	2.59E-05	3.00E-02	1.99E-05	3.03E-02
	5.53E-03 to 0.0150	2.81E-05	3.00E-02	2.17E-05	3.05E-02
	0.0150 to 0.0409	3.14E-05	2.87E-02	2.47E-05	2.87E-02
	0.0409 to 0.111	3.87E-05	2.71E-02	3.08E-05	2.71E-02
	0.111 to 0.302	6.01E-05	2.41E-02	4.84E-05	2.36E-02
	0.302 to 0.821	9.87E-05	2.08E-02	7.96E-05	2.03E-02
	0.821 to 2.23	1.14E-04	2.01E-02	9.99E-05	1.91E-02
	2.23 to 20.00	9.09E-05	2.38E-02	7.83E-05	2.30E-02
	Total	7.72E-04	1.13E-02	6.30E-04	1.13E-02
13	0 to 1.25E-09	5.35E-09	7.63E-01	6.17E-09	5.01E-01
	1.25E-09 to 5.00E-09	3.59E-07	1.41E-01	4.57E-07	1.17E-01
	5.00E-09 to 5.63E-09	6.32E-08	3.43E-01	9.76E-08	1.92E-01
	5.63E-09 to 1.00E-08	7.96E-07	9.58E-02	1.25E-06	7.72E-02
	1.00E-08 to 2.00E-08	3.61E-06	5.32E-02	4.95E-06	4.37E-02
	2.00E-08 to 4.60E-08	1.54E-05	3.24E-02	1.77E-05	3.01E-02
	4.60E-08 to 6.25E-08	1.08E-05	3.61E-02	1.01E-05	3.63E-02
	6.25E-08 to 1.00E-07	2.07E-05	3.07E-02	1.43E-05	3.32E-02
	1.00E-07 to 1.88E-07	2.80E-05	2.87E-02	1.17E-05	3.65E-02
	1.88E-07 to 2.50E-07	7.43E-06	4.48E-02	3.14E-06	5.91E-02
	2.50E-07 to 3.13E-07	3.69E-06	5.64E-02	1.70E-06	7.47E-02
	3.13E-07 to 3.75E-07	3.04E-06	6.65E-02	1.85E-06	7.70E-02

Table 6.2-3. Neutron Spectrum Results for Outer Edge PWR Assembly

Axial Node	Energy Range	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
	3.75E-07 to 4.38E-07	2.66E-06	7.26E-02	1.96E-06	8.26E-02
	4.38E-07 to 5.00E-07	2.17E-06	7.99E-02	1.69E-06	8.51E-02
	5.00E-07 to 5.63E-07	2.33E-06	8.04E-02	1.32E-06	9.36E-02
	5.63E-07 to 6.25E-07	1.98E-06	8.93E-02	1.23E-06	9.79E-02
	6.25E-07 to 1.86E-06	1.73E-05	3.42E-02	1.13E-05	3.76E-02
	1.86E-06 to 5.04E-06	1.67E-05	3.53E-02	1.24E-05	3.76E-02
	5.04E-06 to 1.37E-05	1.43E-05	3.59E-02	1.04E-05	3.82E-02
	1.37E-05 to 3.73E-05	1.78E-05	3.36E-02	1.18E-05	3.79E-02
	3.73E-05 to 1.01E-04	1.87E-05	3.35E-02	1.38E-05	3.51E-02
	1.01E-04 to 2.75E-04	1.99E-05	3.30E-02	1.46E-05	3.49E-02
	2.75E-04 to 7.49E-04	2.20E-05	3.20E-02	1.59E-05	3.46E-02
	7.49E-04 to 2.03E-03	2.19E-05	3.30E-02	1.40E-05	3.49E-02
	2.03E-03 to 5.53E-03	2.42E-05	3.20E-02	1.48E-05	3.53E-02
	5.53E-03 to 0.0150	2.46E-05	3.21E-02	1.64E-05	3.41E-02
	0.0150 to 0.0409	2.81E-05	3.08E-02	1.78E-05	3.38E-02
	0.0409 to 0.111	3.55E-05	2.89E-02	2.39E-05	3.07E-02
	0.111 to 0.302	5.50E-05	2.57E-02	3.76E-05	2.73E-02
	0.302 to 0.821	8.83E-05	2.19E-02	6.17E-05	2.30E-02
	0.821 to 2.23	1.02E-04	2.11E-02	7.62E-05	2.23E-02
	2.23 to 20.00	7.77E-05	2.50E-02	5.87E-05	2.60E-02
	Total	6.87E-04	1.20E-02	4.85E-04	1.29E-02
14	0 to 1.25E-09	1.60E-09	6.55E-01	7.65E-09	5.68E-01
	1.25E-09 to 5.00E-09	2.43E-07	1.49E-01	4.38E-07	1.15E-01
	5.00E-09 to 5.63E-09	7.52E-08	2.92E-01	9.97E-08	2.17E-01
	5.63E-09 to 1.00E-08	8.90E-07	1.00E-01	1.05E-06	7.64E-02
	1.00E-08 to 2.00E-08	3.63E-06	5.47E-02	3.99E-06	4.78E-02
	2.00E-08 to 4.60E-08	1.49E-05	3.36E-02	1.50E-05	3.42E-02
	4.60E-08 to 6.25E-08	1.06E-05	3.69E-02	7.42E-06	4.08E-02
	6.25E-08 to 1.00E-07	2.12E-05	3.10E-02	1.17E-05	3.68E-02
	1.00E-07 to 1.88E-07	2.52E-05	2.92E-02	1.01E-05	3.86E-02
	1.88E-07 to 2.50E-07	7.36E-06	4.43E-02	2.85E-06	6.27E-02
	2.50E-07 to 3.13E-07	3.44E-06	5.54E-02	1.45E-06	8.21E-02
	3.13E-07 to 3.75E-07	3.06E-06	6.76E-02	1.47E-06	8.97E-02
	3.75E-07 to 4.38E-07	2.50E-06	7.68E-02	1.77E-06	8.88E-02
	4.38E-07 to 5.00E-07	2.20E-06	8.51E-02	1.32E-06	9.52E-02
	5.00E-07 to 5.63E-07	2.07E-06	8.56E-02	1.19E-06	1.13E-01
	5.63E-07 to 6.25E-07	1.76E-06	9.01E-02	1.11E-06	1.23E-01
	6.25E-07 to 1.86E-06	1.60E-05	3.54E-02	9.54E-06	4.17E-02
	1.86E-06 to 5.04E-06	1.60E-05	3.58E-02	9.33E-06	4.22E-02
	5.04E-06 to 1.37E-05	1.42E-05	3.63E-02	8.54E-06	4.16E-02
	1.37E-05 to 3.73E-05	1.56E-05	3.67E-02	9.34E-06	3.98E-02
	3.73E-05 to 1.01E-04	1.85E-05	3.48E-02	1.14E-05	3.99E-02
	1.01E-04 to 2.75E-04	1.86E-05	3.37E-02	1.17E-05	3.93E-02
	2.75E-04 to 7.49E-04	1.97E-05	3.44E-02	1.21E-05	3.83E-02
	7.49E-04 to 2.03E-03	2.15E-05	3.23E-02	1.17E-05	3.95E-02
	2.03E-03 to 5.53E-03	2.19E-05	3.38E-02	1.33E-05	3.78E-02
	5.53E-03 to 0.0150	2.27E-05	3.24E-02	1.30E-05	3.78E-02
	0.0150 to 0.0409	2.52E-05	3.18E-02	1.49E-05	3.71E-02
	0.0409 to 0.111	3.36E-05	2.97E-02	1.88E-05	3.46E-02
	0.111 to 0.302	5.03E-05	2.65E-02	2.94E-05	3.03E-02
	0.302 to 0.821	8.13E-05	2.29E-02	4.89E-05	2.56E-02

Table 6.2-3. Neutron Spectrum Results for Outer Edge PWR Assembly

Axial Node	Energy Range	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
	0.821 to 2.23	9.85E-05	2.20E-02	6.04E-05	2.42E-02
	2.23 to 20.00	7.55E-05	2.58E-02	4.80E-05	2.92E-02
	Total	6.48E-04	1.23E-02	3.91E-04	1.42E-02
15	0 to 1.25E-09	2.60E-08	5.34E-01	3.98E-08	3.22E-01
	1.25E-09 to 5.00E-09	3.13E-07	1.44E-01	3.63E-07	1.15E-01
	5.00E-09 to 5.63E-09	9.72E-08	2.42E-01	8.93E-08	2.30E-01
	5.63E-09 to 1.00E-08	8.97E-07	9.44E-02	9.71E-07	8.58E-02
	1.00E-08 to 2.00E-08	3.64E-06	5.26E-02	3.89E-06	4.98E-02
	2.00E-08 to 4.60E-08	1.67E-05	3.31E-02	1.46E-05	3.36E-02
	4.60E-08 to 6.25E-08	1.14E-05	3.67E-02	8.19E-06	4.01E-02
	6.25E-08 to 1.00E-07	2.10E-05	3.07E-02	1.19E-05	3.62E-02
	1.00E-07 to 1.88E-07	2.88E-05	2.83E-02	1.03E-05	3.80E-02
	1.88E-07 to 2.50E-07	8.15E-06	4.43E-02	2.61E-06	6.80E-02
	2.50E-07 to 3.13E-07	3.98E-06	5.36E-02	1.53E-06	7.59E-02
	3.13E-07 to 3.75E-07	2.94E-06	6.56E-02	1.29E-06	9.12E-02
	3.75E-07 to 4.38E-07	2.65E-06	7.32E-02	1.20E-06	9.78E-02
	4.38E-07 to 5.00E-07	2.72E-06	7.60E-02	1.27E-06	1.00E-01
	5.00E-07 to 5.63E-07	2.06E-06	8.35E-02	1.19E-06	1.03E-01
	5.63E-07 to 6.25E-07	1.92E-06	8.70E-02	1.12E-06	1.14E-01
	6.25E-07 to 1.86E-06	1.73E-05	3.41E-02	9.35E-06	4.12E-02
	1.86E-06 to 5.04E-06	1.78E-05	3.50E-02	9.30E-06	4.27E-02
	5.04E-06 to 1.37E-05	1.60E-05	3.48E-02	8.27E-06	4.26E-02
	1.37E-05 to 3.73E-05	1.71E-05	3.39E-02	9.75E-06	4.02E-02
	3.73E-05 to 1.01E-04	1.97E-05	3.26E-02	1.10E-05	3.95E-02
	1.01E-04 to 2.75E-04	1.95E-05	3.27E-02	1.05E-05	4.02E-02
	2.75E-04 to 7.49E-04	2.16E-05	3.20E-02	1.20E-05	3.78E-02
	7.49E-04 to 2.03E-03	2.18E-05	3.27E-02	1.23E-05	3.78E-02
	2.03E-03 to 5.53E-03	2.28E-05	3.26E-02	1.25E-05	3.86E-02
	5.53E-03 to 0.0150	2.56E-05	3.10E-02	1.36E-05	3.77E-02
	0.0150 to 0.0409	2.82E-05	3.12E-02	1.57E-05	3.58E-02
	0.0409 to 0.111	3.44E-05	2.91E-02	1.90E-05	3.40E-02
	0.111 to 0.302	5.58E-05	2.46E-02	2.97E-05	2.97E-02
	0.302 to 0.821	8.59E-05	2.20E-02	5.02E-05	2.55E-02
	0.821 to 2.23	1.02E-04	2.12E-02	6.25E-05	2.42E-02
	2.23 to 20.00	7.90E-05	2.49E-02	4.67E-05	2.96E-02
	Total	6.92E-04	1.19E-02	3.93E-04	1.43E-02
16	0 to 1.25E-09	1.34E-08	6.48E-01	1.34E-08	4.91E-01
	1.25E-09 to 5.00E-09	2.75E-07	1.58E-01	3.46E-07	1.22E-01
	5.00E-09 to 5.63E-09	5.28E-08	3.01E-01	5.99E-08	2.79E-01
	5.63E-09 to 1.00E-08	7.23E-07	1.00E-01	1.09E-06	7.91E-02
	1.00E-08 to 2.00E-08	3.65E-06	5.28E-02	4.05E-06	4.94E-02
	2.00E-08 to 4.60E-08	1.52E-05	3.19E-02	1.41E-05	3.36E-02
	4.60E-08 to 6.25E-08	1.06E-05	3.69E-02	8.20E-06	4.01E-02
	6.25E-08 to 1.00E-07	2.14E-05	2.97E-02	1.19E-05	3.62E-02
	1.00E-07 to 1.88E-07	2.77E-05	2.79E-02	9.99E-06	3.93E-02
	1.88E-07 to 2.50E-07	7.22E-06	4.38E-02	2.83E-06	6.30E-02
	2.50E-07 to 3.13E-07	3.55E-06	5.50E-02	1.59E-06	7.56E-02
	3.13E-07 to 3.75E-07	2.77E-06	6.99E-02	1.49E-06	8.60E-02
	3.75E-07 to 4.38E-07	3.05E-06	7.71E-02	1.50E-06	8.57E-02
	4.38E-07 to 5.00E-07	2.34E-06	8.32E-02	1.51E-06	9.69E-02
	5.00E-07 to 5.63E-07	2.38E-06	7.95E-02	1.17E-06	1.07E-01

Table 6.2-3. Neutron Spectrum Results for Outer Edge PWR Assembly

Axial Node	Energy Range	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
	5.63E-07 to 6.25E-07	1.91E-06	9.45E-02	1.11E-06	1.05E-01
	6.25E-07 to 1.86E-06	1.69E-05	3.42E-02	9.01E-06	4.11E-02
	1.86E-06 to 5.04E-06	1.73E-05	3.52E-02	9.80E-06	4.09E-02
	5.04E-06 to 1.37E-05	1.50E-05	3.45E-02	8.90E-06	4.12E-02
	1.37E-05 to 3.73E-05	1.71E-05	3.45E-02	9.64E-06	4.03E-02
	3.73E-05 to 1.01E-04	1.88E-05	3.29E-02	1.05E-05	3.86E-02
	1.01E-04 to 2.75E-04	2.07E-05	3.33E-02	1.17E-05	3.88E-02
	2.75E-04 to 7.49E-04	2.19E-05	3.22E-02	1.22E-05	3.94E-02
	7.49E-04 to 2.03E-03	2.30E-05	3.23E-02	1.24E-05	3.82E-02
	2.03E-03 to 5.53E-03	2.29E-05	3.32E-02	1.31E-05	3.74E-02
	5.53E-03 to 0.0150	2.42E-05	3.15E-02	1.40E-05	3.74E-02
	0.0150 to 0.0409	2.73E-05	3.07E-02	1.59E-05	3.70E-02
	0.0409 to 0.111	3.56E-05	2.89E-02	2.00E-05	3.38E-02
	0.111 to 0.302	5.44E-05	2.55E-02	2.84E-05	3.04E-02
	0.302 to 0.821	8.59E-05	2.22E-02	4.95E-05	2.61E-02
	0.821 to 2.23	1.06E-04	2.10E-02	6.35E-05	2.43E-02
	2.23 to 20.00	7.71E-05	2.50E-02	4.82E-05	2.85E-02
	Total	6.86E-04	1.19E-02	3.98E-04	1.41E-02
17	0 to 1.25E-09	1.35E-08	6.38E-01	2.19E-08	4.60E-01
	1.25E-09 to 5.00E-09	2.59E-07	1.59E-01	3.24E-07	1.19E-01
	5.00E-09 to 5.63E-09	6.17E-08	3.55E-01	1.03E-07	2.33E-01
	5.63E-09 to 1.00E-08	9.48E-07	8.67E-02	1.07E-06	7.56E-02
	1.00E-08 to 2.00E-08	3.35E-06	5.45E-02	4.52E-06	4.64E-02
	2.00E-08 to 4.60E-08	1.53E-05	3.29E-02	1.66E-05	3.18E-02
	4.60E-08 to 6.25E-08	1.05E-05	3.62E-02	9.39E-06	3.79E-02
	6.25E-08 to 1.00E-07	2.28E-05	2.97E-02	1.32E-05	3.41E-02
	1.00E-07 to 1.88E-07	2.77E-05	2.89E-02	1.16E-05	3.69E-02
	1.88E-07 to 2.50E-07	7.91E-06	4.18E-02	3.06E-06	5.82E-02
	2.50E-07 to 3.13E-07	4.29E-06	5.42E-02	1.71E-06	7.25E-02
	3.13E-07 to 3.75E-07	2.80E-06	6.43E-02	1.72E-06	7.59E-02
	3.75E-07 to 4.38E-07	2.53E-06	7.62E-02	1.54E-06	9.17E-02
	4.38E-07 to 5.00E-07	2.47E-06	7.65E-02	1.49E-06	9.18E-02
	5.00E-07 to 5.63E-07	2.00E-06	8.43E-02	1.23E-06	1.01E-01
	5.63E-07 to 6.25E-07	1.94E-06	8.64E-02	9.39E-07	1.14E-01
	6.25E-07 to 1.86E-06	1.72E-05	3.39E-02	1.05E-05	3.89E-02
	1.86E-06 to 5.04E-06	1.74E-05	3.65E-02	1.14E-05	3.98E-02
	5.04E-06 to 1.37E-05	1.57E-05	3.49E-02	1.01E-05	3.92E-02
	1.37E-05 to 3.73E-05	1.86E-05	3.35E-02	1.10E-05	3.73E-02
	3.73E-05 to 1.01E-04	1.95E-05	3.31E-02	1.24E-05	3.67E-02
	1.01E-04 to 2.75E-04	2.08E-05	3.33E-02	1.22E-05	3.71E-02
	2.75E-04 to 7.49E-04	2.11E-05	3.24E-02	1.38E-05	3.70E-02
	7.49E-04 to 2.03E-03	2.31E-05	3.19E-02	1.29E-05	3.80E-02
	2.03E-03 to 5.53E-03	2.31E-05	3.32E-02	1.33E-05	3.71E-02
	5.53E-03 to 0.0150	2.46E-05	3.14E-02	1.48E-05	3.59E-02
	0.0150 to 0.0409	2.67E-05	3.13E-02	1.71E-05	3.46E-02
	0.0409 to 0.111	3.56E-05	2.91E-02	2.11E-05	3.24E-02
	0.111 to 0.302	5.59E-05	2.44E-02	3.39E-05	2.82E-02
	0.302 to 0.821	8.68E-05	2.20E-02	5.39E-05	2.44E-02
	0.821 to 2.23	1.06E-04	2.09E-02	6.92E-05	2.34E-02
	2.23 to 20.00	8.17E-05	2.46E-02	5.23E-05	2.79E-02
	Total	6.99E-04	1.19E-02	4.38E-04	1.36E-02

Table 6.2-3. Neutron Spectrum Results for Outer Edge PWR Assembly

Axial Node	Energy Range	CRC Environment		WP Environment	
		Tally (#/cm³/source particle)	Relative Error	Tally (#/cm³/source particle)	Relative Error
18	0 to 1.25E-09	3.78E-09	6.91E-01	4.47E-09	5.22E-01
	1.25E-09 to 5.00E-09	1.86E-07	1.56E-01	2.49E-07	1.41E-01
	5.00E-09 to 5.63E-09	5.09E-08	3.41E-01	8.20E-08	2.39E-01
	5.63E-09 to 1.00E-08	6.34E-07	1.00E-01	7.17E-07	9.32E-02
	1.00E-08 to 2.00E-08	2.76E-06	5.66E-02	3.10E-06	5.15E-02
	2.00E-08 to 4.60E-08	1.22E-05	3.56E-02	1.13E-05	3.56E-02
	4.60E-08 to 6.25E-08	8.02E-06	3.94E-02	6.01E-06	4.19E-02
	6.25E-08 to 1.00E-07	1.62E-05	3.25E-02	9.36E-06	3.89E-02
	1.00E-07 to 1.88E-07	2.14E-05	3.08E-02	8.45E-06	4.16E-02
	1.88E-07 to 2.50E-07	5.77E-06	4.74E-02	2.16E-06	7.39E-02
	2.50E-07 to 3.13E-07	2.96E-06	6.10E-02	1.26E-06	8.73E-02
	3.13E-07 to 3.75E-07	2.24E-06	7.17E-02	9.45E-07	1.05E-01
	3.75E-07 to 4.38E-07	1.98E-06	8.38E-02	1.07E-06	1.03E-01
	4.38E-07 to 5.00E-07	1.88E-06	8.50E-02	9.66E-07	1.07E-01
	5.00E-07 to 5.63E-07	1.88E-06	8.32E-02	9.21E-07	1.09E-01
	5.63E-07 to 6.25E-07	1.32E-06	1.03E-01	9.13E-07	1.22E-01
	6.25E-07 to 1.86E-06	1.38E-05	3.72E-02	7.79E-06	4.29E-02
	1.86E-06 to 5.04E-06	1.32E-05	3.80E-02	7.62E-06	4.54E-02
	5.04E-06 to 1.37E-05	1.14E-05	3.82E-02	7.00E-06	4.54E-02
	1.37E-05 to 3.73E-05	1.20E-05	3.77E-02	7.45E-06	4.46E-02
	3.73E-05 to 1.01E-04	1.40E-05	3.69E-02	8.88E-06	4.23E-02
	1.01E-04 to 2.75E-04	1.52E-05	3.57E-02	8.88E-06	4.22E-02
	2.75E-04 to 7.49E-04	1.57E-05	3.55E-02	9.05E-06	4.17E-02
	7.49E-04 to 2.03E-03	1.68E-05	3.53E-02	9.51E-06	4.13E-02
	2.03E-03 to 5.53E-03	1.68E-05	3.59E-02	1.00E-05	4.13E-02
	5.53E-03 to 0.0150	1.78E-05	3.53E-02	1.01E-05	3.95E-02
	0.0150 to 0.0409	1.99E-05	3.44E-02	1.19E-05	3.93E-02
	0.0409 to 0.111	2.62E-05	3.22E-02	1.55E-05	3.71E-02
	0.111 to 0.302	3.95E-05	2.78E-02	2.33E-05	3.18E-02
	0.302 to 0.821	6.42E-05	2.44E-02	3.87E-05	2.76E-02
	0.821 to 2.23	7.90E-05	2.31E-02	4.95E-05	2.56E-02
	2.23 to 20.00	6.04E-05	2.74E-02	3.89E-05	3.07E-02
	Total	5.15E-04	1.33E-02	3.12E-04	1.53E-02

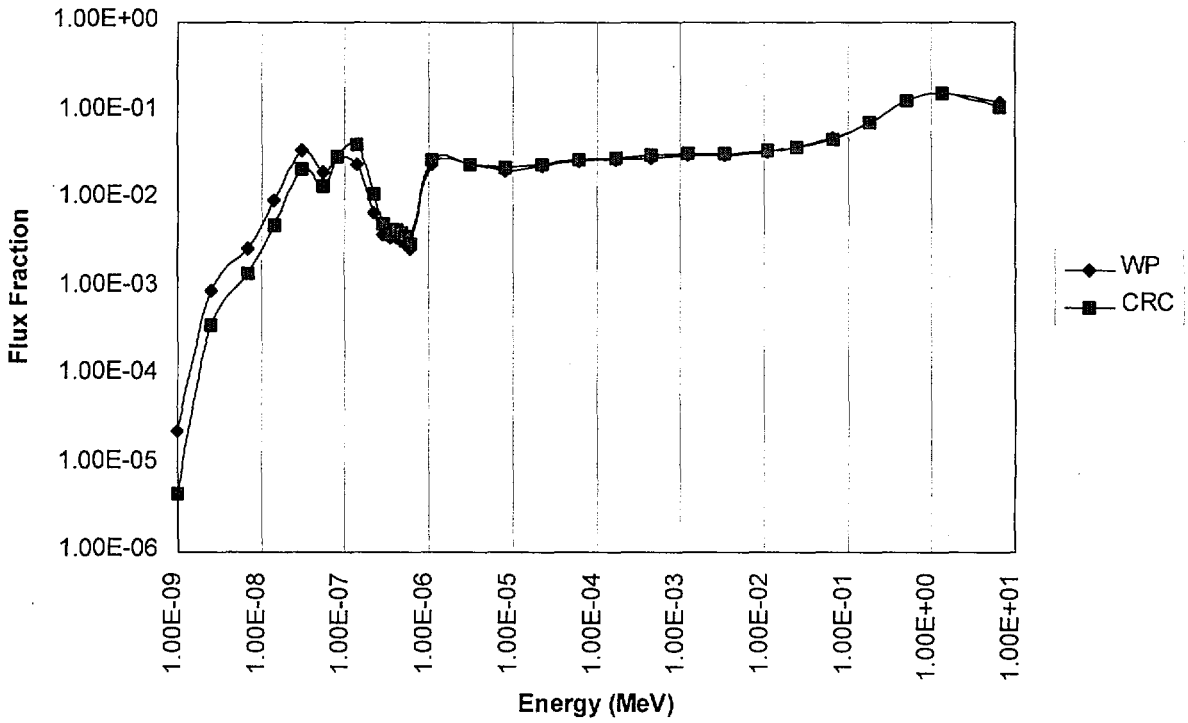


Figure 6-12. Neutron Spectrum for Node 1 of Edge Assemblies

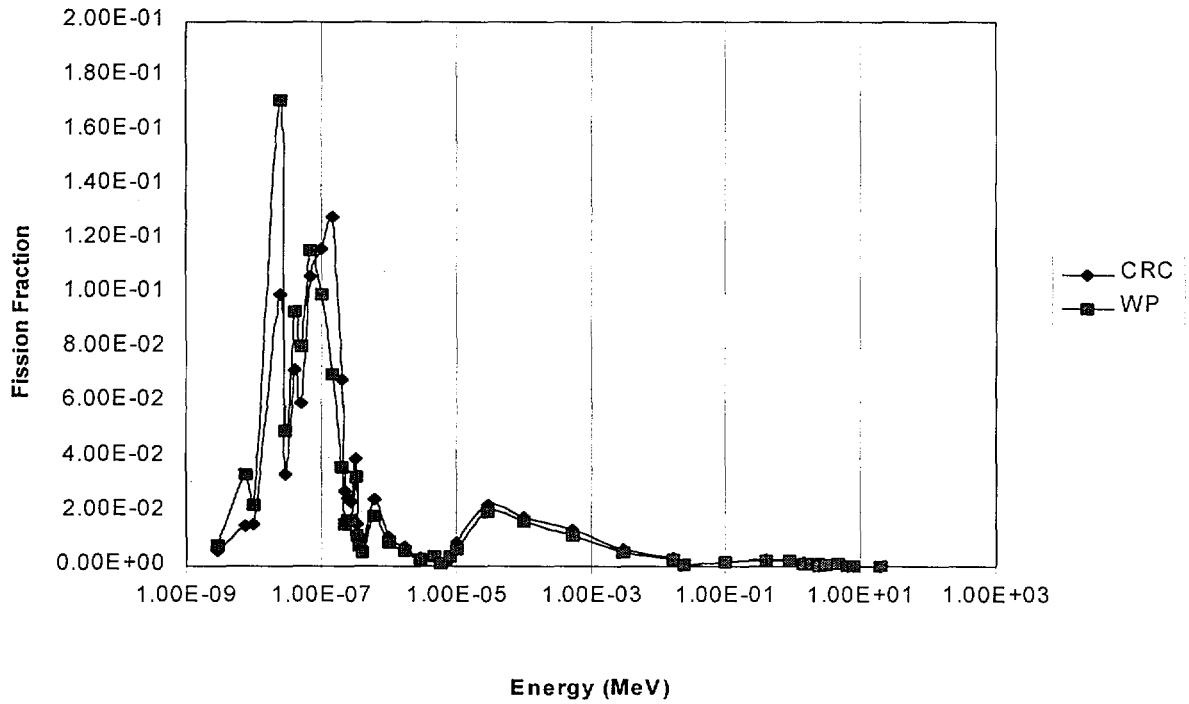


Figure 6-13. Fission Spectrum Results for Node 1 of Edge Assemblies

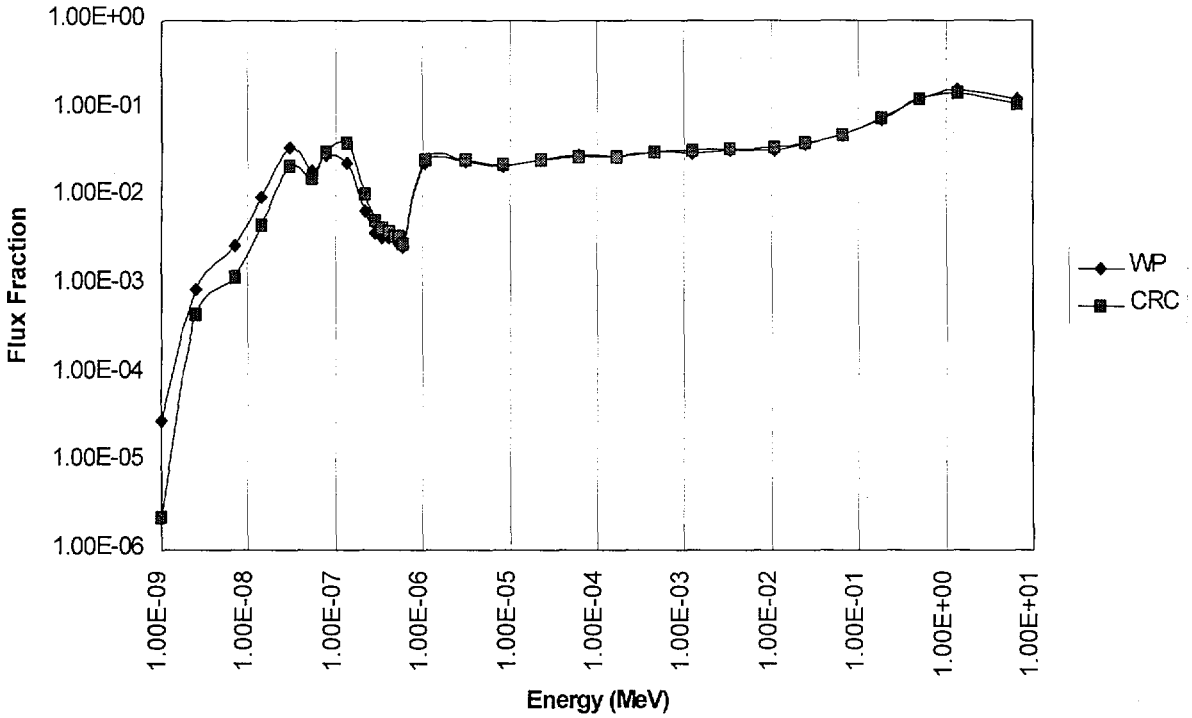


Figure 6-14. Neutron Spectrum for Node 10 of Edge Assemblies

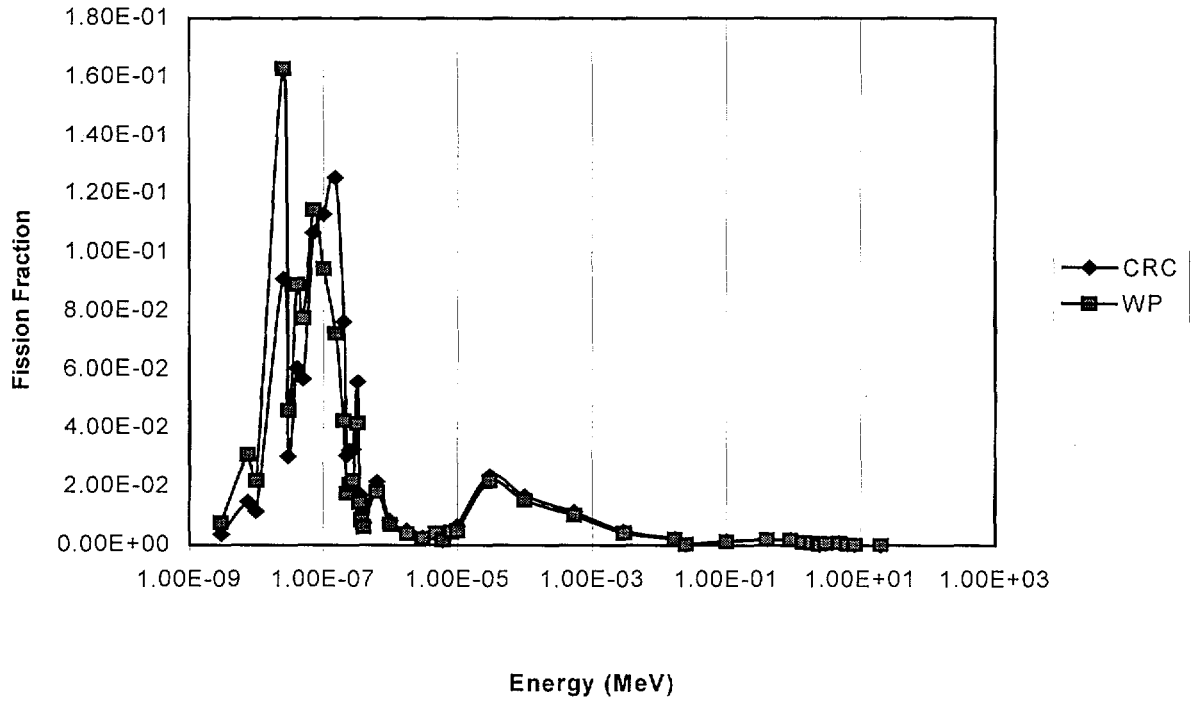


Figure 6-15. Fission Spectrum Results for Node 10 of Edge Assemblies

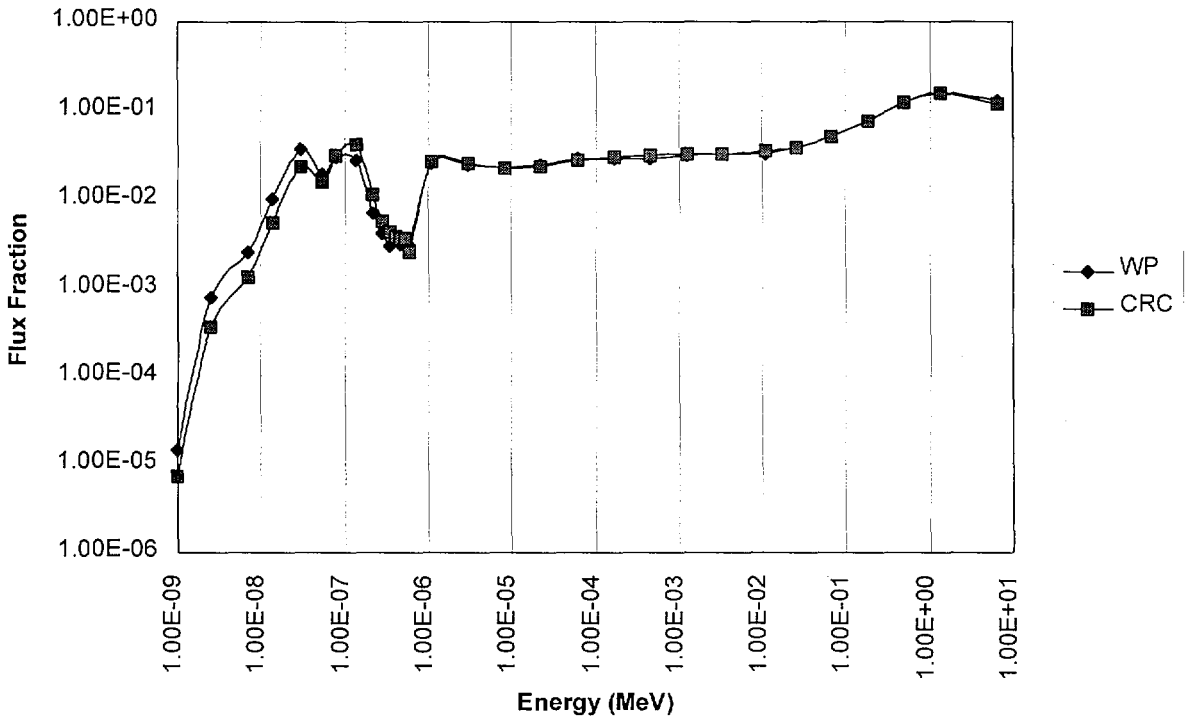


Figure 6-16. Neutron Spectrum for Node 18 of Edge Assemblies

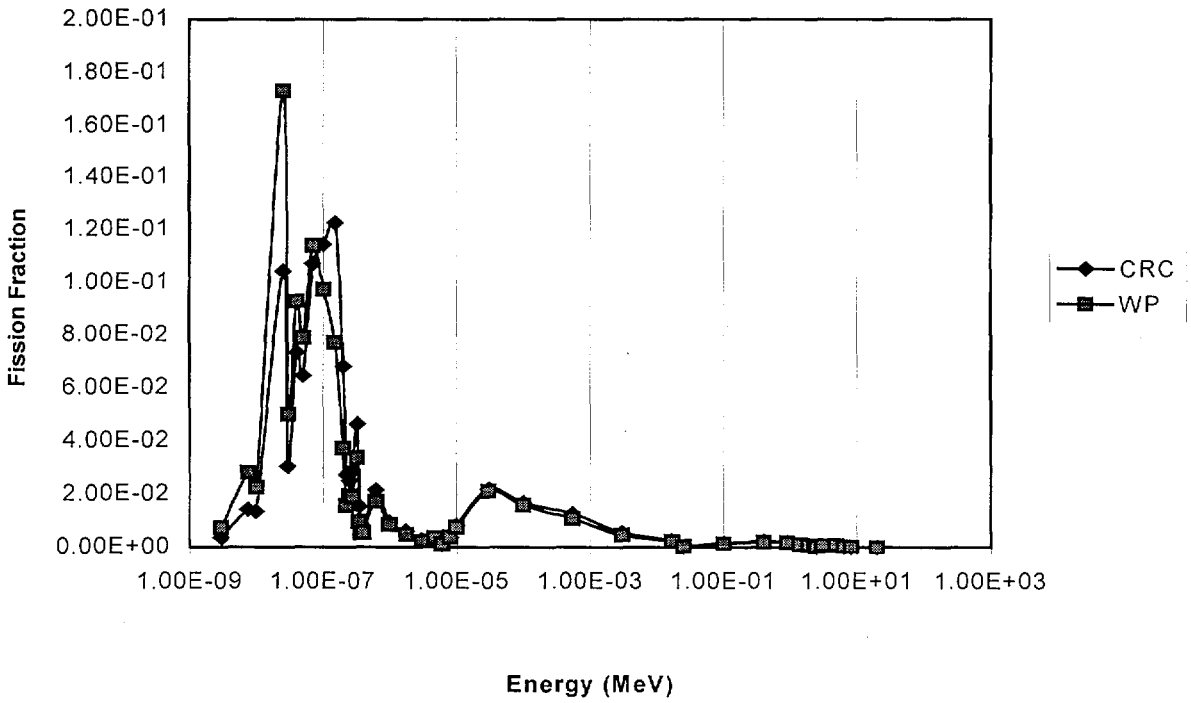


Figure 6-17. Fission Spectrum Results for Node 18 of Edge Assemblies

6.3 SAS2H AND RADIOCHEMICAL ASSAY COMPARISON

This section presents the results from modeling the fuel composition in MCNP with the SAS2H calculated isotopic concentrations and the radiochemical assay measured concentrations. The results are presented in Table 6.3-1.

Table 6.3-1. SAS2H and Radiochemical Assay Isotopic Concentration Results

MCNP Case	SAS2H Isotopic Results		Measured Isotopic Results		Difference	
	k_{eff}	σ	k_{eff}	σ	k_{eff}	σ
mih1	1.00665	0.00108	1.01019	0.00118	-0.00354	0.00160
mih2	1.01670	0.00117	1.02099	0.00099	0.00429	0.00153
mih3	0.96586	0.00111	0.97876	0.00102	0.01290	0.00151
mih4	0.93275	0.00112	0.93908	0.00106	0.00633	0.00154
mih5[1]	0.97044	0.00101	0.97849	0.00107	0.00805	0.00147
mih6	0.87615	0.00102	0.88771	0.00112	0.01156	0.00151
mih7	0.86174	0.00103	0.88133	0.00103	0.01959	0.00146
mih8	0.84824	0.00094	0.8491	0.00109	0.00086	0.00144
mih9	0.861	0.00097	0.86262	0.00103	0.00162	0.00141
tp1	0.82336	0.00098	0.82325	0.00106	-0.00011	0.00144
tp2	0.82305	0.00099	0.81758	0.00088	-0.00547	0.00132
tp3	0.81763	0.00107	0.82118	0.00099	0.00355	0.00146
tp4	0.8169	0.00097	0.82039	0.00097	0.00349	0.00137
tp5	0.81833	0.00099	0.81683	0.0009	-0.00150	0.00134
ce1	0.81116	0.00099	0.81006	0.00098	-0.00110	0.00139
ce2	0.7483	0.00083	0.74809	0.0011	-0.00021	0.00138
ce3	0.74206	0.00098	0.71145	0.00091	-0.03061	0.00134
ce4	0.84058	0.00104	0.8404	0.00108	-0.00018	0.00150
ce5	0.77806	0.0011	0.78535	0.00111	0.00729	0.00156
ce6	0.73509	0.00114	0.73383	0.00088	-0.00126	0.00144
hb1	0.90415	0.00115	0.89008	0.00095	-0.01407	0.00149
hb2	0.85376	0.0009	0.83251	0.00099	-0.02125	0.00134
hb3	0.83752	0.00105	0.83043	0.0009	-0.00709	0.00138
hb4	0.82135	0.00105	0.79081	0.00098	-0.03054	0.00144
ob1	0.82901	0.00093	0.84676	0.00104	0.01775	0.00140
ob2	0.8281	0.00111	0.8381	0.00102	0.01000	0.00151
ob3	0.81766	0.00106	0.83671	0.00115	0.01905	0.00156
ob4	0.81655	0.00109	0.83551	0.00098	0.01896	0.00147
ob5	0.81315	0.001	0.83336	0.00091	0.02021	0.00135
ob6	0.81035	0.00107	0.82618	0.00106	0.01583	0.00151

The corresponding MCNP input and output filenames for the cases shown in Tables 6.3-1 are presented in Attachments II and III. The MCNP input files are presented in Attachment II. The MCNP output files are presented in Attachment III (the attachment CDs have been moved to Reference 7.15). The output file names differ from the inputs in that they either have a "O" or ".O" at the end of the input filename.

7. REFERENCES

7.1 Oak Ridge National Laboratory (ORNL) 1995. *SCALE 4.3, RSIC Computer Code Collection, (CCC-545)*. NUREG/CR-0200 REV 5. Oak Ridge, Tennessee: ORNL. TIC: 235920

7.2 Organization for Economic Cooperation and Development-Nuclear Energy Agency (OECD-NEA) 1998. *International Handbook of Evaluated Criticality Safety Benchmark Experiments*. NEA/NSC/DOC(95)03, September 1998 Edition. Paris, France: Nuclear Energy Agency. TIC: 243013

7.3 [Reserved]

7.4 Briesmeister, Judith F., ed. 1997. *MCNP—A General Monte Carlo N-Particle Transport Code*. User Manual, Report Number: LA-12625-M, Version 4B. Los Alamos, New Mexico: Los Alamos National Laboratory. TIC: 241044

7.5 Civilian Radioactive Waste Management System (CRWMS) Management & Operating Contractor (M&O) 1998. *Software Qualification Report for MCNP Version 4B2, A General Monte Carlo N-Particle Transport Code*. 30033-2003 REV 01; CSCI: 30033 V4B2LV. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980622.0637

7.6 CRWMS M&O 1998. *Selection of MCNP Cross Section Libraries*. B00000000-01717-5705-00099 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980722.0042

7.7 CRWMS M&O 1998. *CRC Depletion Calculations for Crystal River Unit 3*. B00000000-01717-0210-00001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980810.0299

7.8 CRWMS M&O 1998. *CRC Reactivity Calculations for Crystal River Unit 3*. B00000000-01717-0210-00002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980728.0004

7.9 ORNL 1995. *Validation of the Scale System for PWR Spent Fuel Isotopic Composition Analyses*. ORNL/TM-12667. Oak Ridge, Tennessee: ORNL. TIC: 245043

7.10 ORNL 1998. *Validation of Scale (SAS2H) Isotopic Predictions for BWR Spent Fuel*. ORNL/TM-13315. Oak Ridge, Tennessee: ORNL. TIC: 245042

7.11 CRWMS M&O 1999. *Waste Package Criticality Control Parametric Analysis*. B00000000-01717-0210-00041 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990216.0199

7.12 CRWMS M&O 1999. *Waste Package Structural Material.* Interoffice Correspondence from Venkataraman Pasupathi to T.W. Doering. LV.WP.VP.05/99-073. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990518.0316

7.13 CRWMS M&O 1999. *Waste Package Materials Properties.* BBA000000-01717-0210-00017 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990407.0172

7.14 Department of Energy (DOE) 1987. *Characteristics of Spent Fuel, High Level Waste, and Other Radioactive Wastes Which May Require Long-Term Isolation. Appendix 2A: Physical Descriptions of LWR Fuel Assemblies.* DOE/RW-0184. Washington, D.C.: DOE. TIC: 241194

7.15 CRWMS M&O 1999. *Two (2) CDs for Waste Package, LCE, CRC, and Radiochemical Assay Comparison Evaluation.* B00000000-01717-0210-00107 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990804.0307

7.16 CRWMS M&O 1997. *SAS2H Analysis of Radiochemical Assay Samples from Mihama PWR Reactor.* B00000000-01717-0200-00144 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971230.0145

7.17 CRWMS M&O 1997. *SAS2H Analysis of Radiochemical Assay Samples from Turkey Point PWR Reactor.* B00000000-01717-0200-00141 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971229.0350

7.18 CRWMS M&O 1997. *SAS2H Analysis of Radiochemical Assay Samples from Calvert Cliffs PWR Reactor.* B00000000-01717-0200-00138 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971210.0578

7.19 CRWMS M&O 1997. *SAS2H Analysis of Radiochemical Assay Samples from H.B. Robinson PWR Reactor.* B00000000-01717-0200-00140 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971229.0158

7.20 CRWMS M&O 1997. *SAS2H Analysis of Radiochemical Assay Samples from Obrigheim PWR Reactor.* B00000000-01717-0200-00139 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971229.0159

7.21 DOE 1997. *Isotopic and Criticality Validation for PWR Actinide-Only Burnup Credit.* DOE/RW-0497. Vienna, Virginia: Office of Civilian Radioactive Waste Management. ACC: MOV.19970625.0081

7.22 CRWMS M&O 1998. *Disposal Criticality Analysis Methodology Topical Report.* B00000000-01717-5705-00095 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980918.0005

7.23 CRMWS M&O 1996. *Material Compositions and Number Densities for Neutronics Calculations.* BBA000000-01717-0200-00002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19960624.0023

7.24 ORNL 1994. *Validation of the SCALE Broad Structure 44-Group ENDF/B-Y Cross-Section Library for Use in Criticality Safety Analyses.* NUREG/CR-6102, ORNL/TM-12460. Oak Ridge, Tennessee: ORNL. TIC: 212672

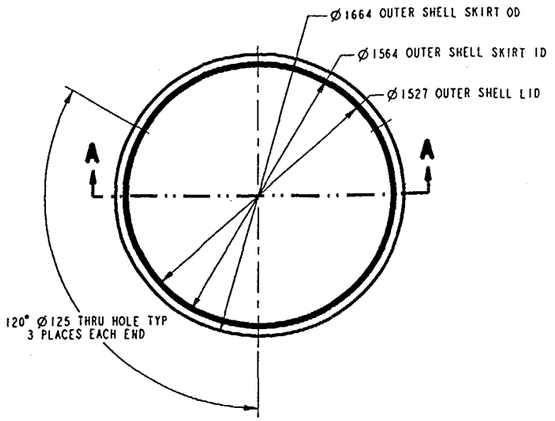
7.25 CRWMS M&O 1996. *Documentation of Product Literature from Bohler (SCPB: N/A).* Interoffice Correspondence from J.K. McCoy to W.E. Wallin. LV.WP.JKM.07/96-176. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19961118.0164

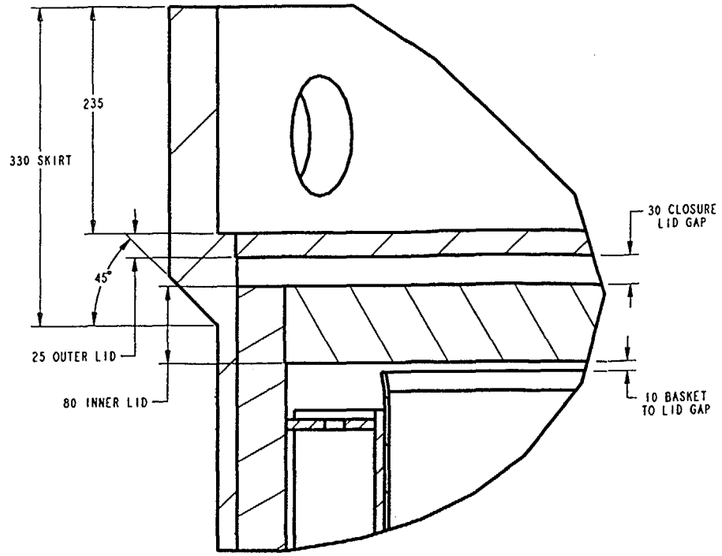
8. ATTACHMENTS

Table 8-1 presents the attachment specifications for this calculation file.

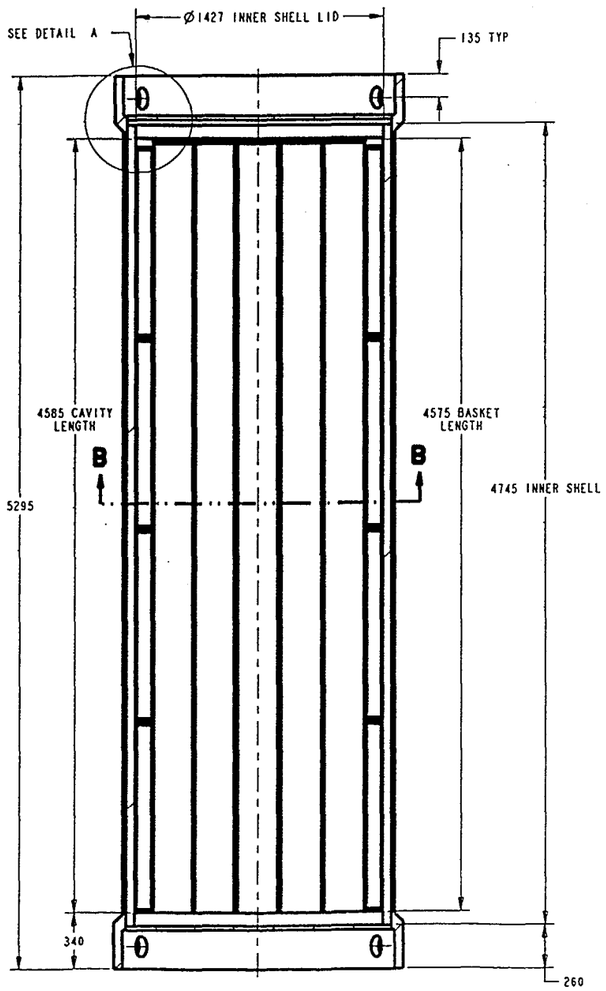
Table 8-1. Attachment Listing

Attachment #	# of Pages	Date Created	Description
I	1	06/14/99	Single CRM 21-PWR Waste Package Sketch
II	2	07/29/99 (written to CD)	MCNP input files (the attachment CD has been moved to Reference 7.15)
III	2	07/29/99 (written to CD)	MCNP output files (the attachment CD has been moved to Reference 7.15)
IV	1	N/A	Excel spreadsheet with nodal neutron spectrum results and figures
V	1	N/A	Excel spreadsheet with nodal fission neutron spectrum results and figures





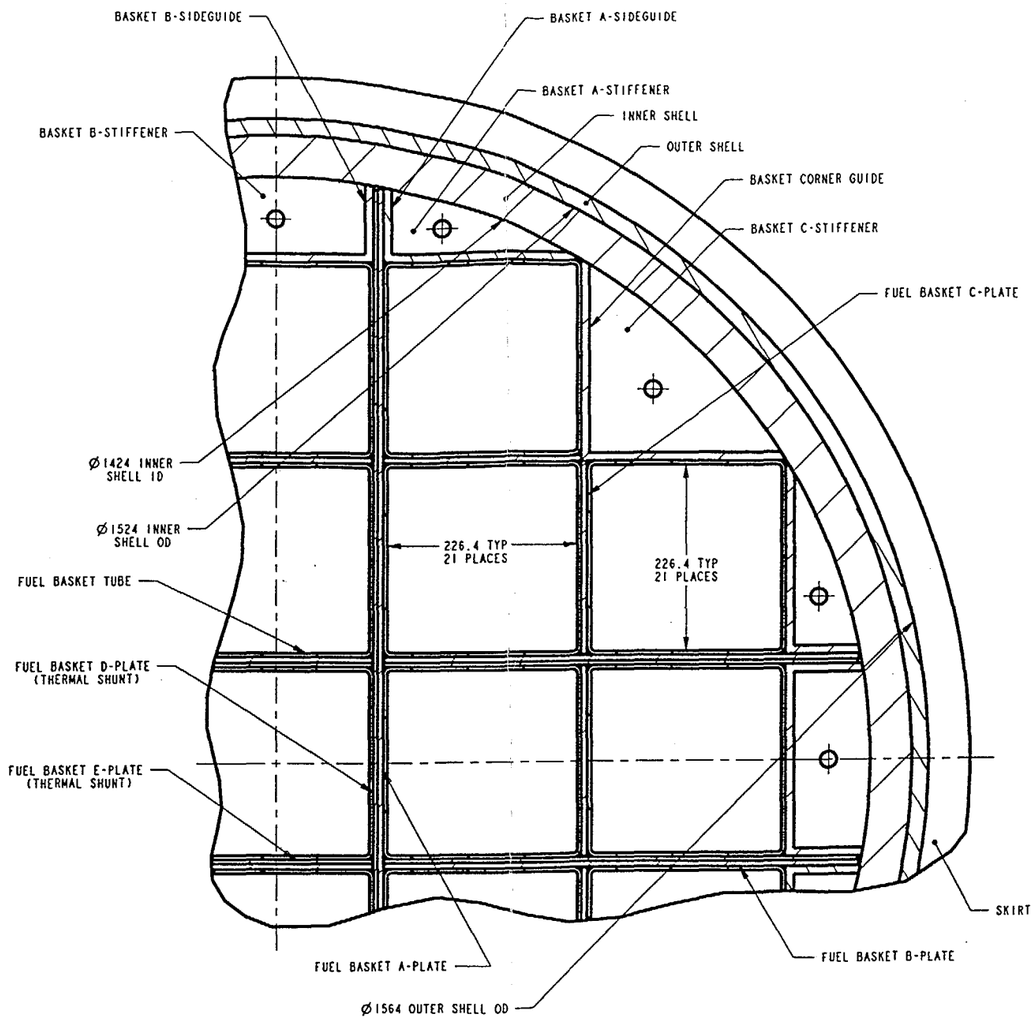
DETAIL A



SECTION A-A

COMPONENT NAME	MATERIAL	THICKNESS	MASS (KG)	QTY ROD
BASKET A-SIDEGUIDE	SA-516 K02700	10	27	32
BASKET A-STIFFENER	SA-516 K02700	10	0.72	64
BASKET B-SIDEGUIDE	SA-516 K02700	10	36	16
BASKET B-STIFFENER	SA-516 K02700	10	1.5	32
BASKET C-STIFFENER	SA-516 K02700	10	2.3	32
BASKET CORNER GUIDE	SA-516 K02700	10	42	16
FUEL BASKET A-PLATE	NEUTRONIT A 978	7	85	8
FUEL BASKET B-PLATE	NEUTRONIT A 978	7	85	8
FUEL BASKET C-PLATE	NEUTRONIT A 978	7	44	16
FUEL BASKET D-PLATE	SB-209 A96061 T4	5	21	8
FUEL BASKET E-PLATE	SB-209 A96061 T4	5	21	8
FUEL BASKET TUBE	SA-516 K02700	5	164	21
INNER SHELL	SA-240 (316NG)	50	8759	1
INNER SHELL LID	SA-240 (316NG)	80	1021	2
OUTER SHELL	SB-575 N06022	20	5375	1
OUTER SHELL LID	SB-575 N06022	25	398	2
WASTE PACKAGE ASSEMBLY	-	-	25094	1
PWR FUEL ASSEMBLY	-	-	773.44	21
WP ASSEMBLY WITH SNF	-	-	41335	1

* CRWMS M&O 1997. WASTE CONTAINER CAVITY SIZE DETERMINATION. BBAA00000-01717-0200-00026 REV 00. LAS VEGAS, NV: CRWMS M&O. ACC: MOL.19980106.0061



SECTION B-B

"FOR INFORMATION ONLY"

SINGLE CRM 21-PWR WASTE PACKAGE

SKETCH NUMBER: SK-0132 REV 01
SKETCHED BY: BRYAN HARKINS BH 04 June 99 SMS 06/14/99 FOR TWD 06/14/99
DATE: 06/04/99
FILE: /home/harkins/proe/21-pwr_rev01/sk-0132_rev01.dwg

UNITS: mm
DO NOT SCALE FROM SKETCH

BBOOOOOOO-01717-0210-00107 REV 00 ATTACHMENT II PAGE I-1 OF 1

ATTACHMENT II

This attachment contains the MCNP input files for the Waste Package, LCE, CRC, and Radiochemical Assay Comparison Evaluation. The input files are contained on an attachment CD of this calculation file (the attachment CD has been moved to Reference 7.15). The information contained in this hard-copy representation of Attachment II is a listing of the various MCNP input files and their attributes. The files are listed in Table II-1. The CD containing Attachment II was written using the Hewlett Packard (HP) CD-Writer Plus model 7200e external CD-rewritable drive for personal computers.

Table II-1. MCNP Input File Listing

Filename	File Type	File Size (bytes)	File Date	File Time
cr3i1a	ASCII	582,873	5/24/99	5:34p
cr3i1b	ASCII	582,911	6/14/99	8:24a
cr3i2a	ASCII	27,156	7/12/99	3:47p
cr3i2b	ASCII	27,153	7/12/99	3:48p
cr3i3a	ASCII	1,910,427	7/16/99	4:29p
cr3i3a3	ASCII	1,909,599	7/16/99	4:30p
cr3i3b	ASCII	714,687	7/16/99	4:29p
cr3i3b3	ASCII	714,675	7/16/99	4:30p
cr3i4a	ASCII	1,909,425	6/29/99	9:41a
cr3i4b	ASCII	714,475	6/27/99	2:05p
crc2	ASCII	1,908,999	7/16/99	4:27p
crcD17	ASCII	1,911,634	6/27/99	2:07p
crcE08	ASCII	1,911,623	6/27/99	2:12p
wp2	ASCII	705,199	7/16/99	4:27p
WPE08	ASCII	716,644	6/25/99	3:48p
WPE17	ASCII	716,707	6/27/99	2:10p
ce1a	ASCII	23,708	6/27/99	2:25p
ce1b	ASCII	23,694	6/27/99	2:25p
ce2a	ASCII	23,709	6/27/99	2:25p
ce2b	ASCII	23,700	6/27/99	2:25p
ce3a	ASCII	23,710	6/27/99	2:25p
ce3b	ASCII	23,698	6/27/99	2:25p
ce4a	ASCII	23,680	6/27/99	2:25p
ce4b	ASCII	23,699	6/27/99	2:25p
ce5a	ASCII	23,690	6/28/99	7:11a
ce5b	ASCII	23,700	6/27/99	2:25p
ce6a	ASCII	23,680	6/27/99	2:25p
ce6b	ASCII	23,699	6/27/99	2:25p
hb1a	ASCII	25,065	6/27/99	2:24p
hb1b	ASCII	25,057	6/27/99	2:24p
hb2a	ASCII	25,065	6/27/99	2:24p
hb2b	ASCII	25,062	6/27/99	2:24p
hb3a	ASCII	25,066	6/27/99	2:24p
hb3b	ASCII	25,062	6/27/99	2:24p
hb4a	ASCII	25,065	6/27/99	2:24p
hb4b	ASCII	25,061	6/27/99	2:24p
mih1a	ASCII	25,092	6/27/99	2:43p
mih1b	ASCII	25,087	7/28/99	2:52p
mih2a	ASCII	25,057	6/27/99	2:24p
mih2b	ASCII	25,059	7/23/99	7:44a
mih3a	ASCII	25,060	6/27/99	2:24p
mih3b	ASCII	25,054	6/27/99	2:24p
mih4a	ASCII	25,060	6/27/99	2:24p
mih4b	ASCII	25,055	6/27/99	2:24p
mih5a	ASCII	25,060	6/27/99	2:24p

Table II-1. MCNP Input File Listing

Filename	File Type	File Size (bytes)	File Date	File Time
mih5b	ASCII	25,055	6/27/99	2:24p
mih6a	ASCII	25,057	6/27/99	2:24p
mih6b	ASCII	25,055	6/27/99	2:24p
mih7a	ASCII	25,089	6/27/99	2:24p
mih7b	ASCII	25,088	6/27/99	2:24p
mih8a	ASCII	25,088	6/27/99	2:24p
mih8b	ASCII	25,088	6/27/99	2:24p
mih9a	ASCII	25,060	6/27/99	2:24p
mih9b	ASCII	25,056	6/27/99	2:24p
ob1a	ASCII	24,985	6/27/99	2:25p
ob1b	ASCII	24,988	6/27/99	2:25p
ob2a	ASCII	24,986	6/27/99	2:25p
ob2b	ASCII	24,989	6/27/99	2:25p
ob3a	ASCII	24,987	6/27/99	2:25p
ob3b	ASCII	24,989	6/27/99	2:25p
ob4a	ASCII	24,985	6/27/99	2:25p
ob4b	ASCII	24,988	6/27/99	2:25p
ob5a	ASCII	24,987	6/27/99	2:25p
ob5b	ASCII	24,987	6/27/99	2:25p
ob6a	ASCII	24,987	6/27/99	2:25p
ob6b	ASCII	24,989	6/27/99	2:25p
tp1a	ASCII	25,096	6/27/99	2:25p
tp1b	ASCII	25,096	6/27/99	2:25p
tp2a	ASCII	25,099	6/27/99	2:25p
tp2b	ASCII	25,096	6/27/99	2:25p
tp3a	ASCII	25,098	6/27/99	2:25p
tp3b	ASCII	25,094	6/27/99	2:25p
tp4a	ASCII	25,098	6/27/99	2:25p
tp4b	ASCII	25,096	6/27/99	2:25p
tp5a	ASCII	25,098	6/27/99	2:25p
tp5b	ASCII	25,094	6/27/99	2:25p

ATTACHMENT III

This attachment contains the MCNP output files for the Waste Package, LCE, CRC, and Radiochemical Assay Comparison Evaluation. The output files are contained on an attachment CD of this calculation file (the attachment CD has been moved to Reference 7.15). The information contained in this hard-copy representation of Attachment III is a listing of the various MCNP output files and their attributes. The files are listed in Table III-1. The CD containing Attachment III was written using the HP CD-Writer Plus model 7200e external CD-rewritable drive for personal computers.

Table III-1. MCNP Input File Listing

Filename	File Type	File Size (bytes)	File Date	File Time
ce1a.O	ASCII	425,914	6/27/99	2:22p
ce1b.O	ASCII	427,270	6/27/99	2:22p
ce2a.O	ASCII	427,270	6/27/99	2:22p
ce2b.O	ASCII	426,497	6/27/99	2:22p
ce3a.O	ASCII	427,270	6/27/99	2:22p
ce3b.O	ASCII	427,157	6/27/99	2:22p
ce4a.O	ASCII	426,702	6/27/99	2:22p
ce4b.O	ASCII	427,263	6/27/99	2:22p
ce5a.O	ASCII	425,953	6/28/99	8:09a
ce5b.O	ASCII	427,060	6/27/99	2:22p
ce6a.O	ASCII	426,718	6/27/99	2:22p
ce6b.O	ASCII	427,270	6/27/99	2:22p
hb1a.O	ASCII	443,503	6/27/99	2:23p
hb1b.O	ASCII	443,600	6/27/99	2:23p
hb2a.O	ASCII	443,600	6/27/99	2:23p
hb2b.O	ASCII	443,593	6/27/99	2:23p
hb3a.O	ASCII	443,600	6/27/99	2:23p
hb3b.O	ASCII	443,600	6/27/99	2:23p
hb4a.O	ASCII	443,503	6/27/99	2:23p
hb4b.O	ASCII	443,600	6/27/99	2:23p
mih1a.O	ASCII	444,187	6/27/99	3:37p
mih1b.O	ASCII	442,859	7/29/99	9:57a
mih2a.O	ASCII	443,534	6/27/99	2:23p
mih2b.O	ASCII	443,755	7/23/99	8:39a
mih3a.O	ASCII	443,534	6/27/99	2:23p
mih3b.O	ASCII	443,502	6/27/99	2:23p
mih4a.O	ASCII	443,437	6/27/99	2:23p
mih4b.O	ASCII	443,437	6/27/99	2:23p
mih5a.O	ASCII	443,534	6/27/99	2:23p
mih5b.O	ASCII	443,437	6/27/99	2:23p
mih6a.O	ASCII	443,486	6/27/99	2:23p
mih6b.O	ASCII	443,534	6/27/99	2:23p
mih7a.O	ASCII	444,086	6/27/99	2:23p
mih7b.O	ASCII	443,116	6/27/99	2:23p
mih8a.O	ASCII	444,086	6/27/99	2:23p
mih8b.O	ASCII	442,633	6/27/99	2:23p
mih9a.O	ASCII	443,534	6/27/99	2:23p
mih9b.O	ASCII	443,437	6/27/99	2:23p
ob1a.O	ASCII	425,105	6/27/99	2:22p
ob1b.O	ASCII	425,105	6/27/99	2:22p
ob2a.O	ASCII	425,105	6/27/99	2:22p
ob2b.O	ASCII	425,105	6/27/99	2:22p
ob3a.O	ASCII	425,105	6/27/99	2:22p
ob3b.O	ASCII	425,105	6/27/99	2:22p
ob4a.O	ASCII	425,105	6/27/99	2:22p

Table III-1. MCNP Input File Listing

Filename	File Type	File Size (bytes)	File Date	File Time
ob4b.O	ASCII	423,975	6/27/99	2:22p
ob5a.O	ASCII	425,105	6/27/99	2:22p
ob5b.O	ASCII	422,779	6/27/99	2:22p
ob6a.O	ASCII	425,008	6/27/99	2:22p
ob6b.O	ASCII	425,105	6/27/99	2:22p
tp1a.O	ASCII	443,989	6/27/99	2:22p
tp1b.O	ASCII	444,086	6/27/99	2:22p
tp2a.O	ASCII	443,989	6/27/99	2:22p
tp2b.O	ASCII	442,730	6/27/99	2:22p
tp3a.O	ASCII	443,989	6/27/99	2:22p
tp3b.O	ASCII	444,086	6/27/99	2:22p
tp4a.O	ASCII	443,989	6/27/99	2:22p
tp4b.O	ASCII	442,755	6/27/99	2:22p
tp5a.O	ASCII	443,989	6/27/99	2:22p
tp5b.O	ASCII	444,086	6/27/99	2:22p
cr3i1a.O	ASCII	7,102,556	5/24/99	5:34p
cr3i1b.O	ASCII	7,100,762	6/14/99	8:24a
cr3i2aO	ASCII	595,995	7/14/99	7:50a
cr3i2bO	ASCII	595,975	7/14/99	7:50a
cr3i3a3O	ASCII	16,687,405	7/19/99	7:33a
cr3i3aO	ASCII	16,669,210	7/19/99	7:34a
cr3i3b3O	ASCII	6,594,694	7/19/99	5:09p
cr3i3bO	ASCII	6,601,252	7/19/99	7:31a
cr3i4aO	ASCII	16,145,586	6/29/99	9:40a
cr3i4bO	ASCII	6,518,687	6/27/99	2:05p
crc2O	ASCII	16,174,212	7/19/99	5:08p
crcD17O	ASCII	16,611,897	6/27/99	2:07p
crcE08O	ASCII	16,622,108	6/27/99	2:11p
wp2O	ASCII	5,808,308	7/19/99	5:08p
WPE08O	ASCII	6,553,446	6/26/99	5:05p
WPE17O	ASCII	6,555,296	6/27/99	2:10p

ATTACHMENT IV

This attachment contains an Excel spreadsheet of the results from the nodal neutron spectrum comparisons for a CRC and a WP. This spreadsheet is contained on an attachment CD of this calculation file (the attachment CD has been moved to Reference 7.15). The information contained in this hard-copy representation of Attachment IV is a listing of the spreadsheet file attributes. The attributes are listed in Table IV-1. The CD containing Attachment IV was written using the HP CD-Writer Plus model 7200e external CD-rewritable drive for personal computers.

Table IV-1. Attachment IV File Listing

Filename	File Type	File Size (bytes)	File Date	File Time
assresult.xls	Spreadsheet	1,764,352	07/22/99	10:29a

ATTACHMENT V

This attachment contains an Excel spreadsheet of the results from the nodal fission neutron spectrum comparisons for an assembly in a CRC and a WP. This spreadsheet is contained on an attachment CD of this calculation file (the attachment CD has been moved to Reference 7.15). The information contained in this hard-copy representation of Attachment V is a listing of the spreadsheet file attributes. The attributes are listed in Table V-1. The CD containing Attachment V was written using the HP CD-Writer Plus model 7200e external CD-rewritable drive for personal computers.

Table V-1. Attachment V File Listing

Filename	File Type	File Size (bytes)	File Date	File Time
fission spectrum.xls	Spreadsheet	723,968	06/28/99	2:14p