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Title: **Monte Carlo Calculations of Neutron Spectra on Irradiation Channels of RA-6 Reactor New Core in Function of Burnup at 1 MW Power**

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Abstract

A new RA6 core will start normal operation on next year (2009) with all fresh 20 % fuels and a raise of thermal power from 500 kW up to 3 MW. On this report are included: a schematic diagram of the new RA6 core layout, a Monte Carlo calculation model, a method for follow-up the changes introduced during burnup and results of calculated neutron spectra and integral fluxes on three energy ranges at 2 typical irradiation facility positions. The main results of this work are: 1) a detailed model and methods for Monte Carlo calculations of the new RA6 core ready for use in different applications, including spectra calculations on different spatial regions as a function of burnup, 2) results of neutron flux calculations in 3 energy groups at 2 irradiation positions and neutron spectra on 640 and 69 energy groups are ready for use on further analysis of analytical and calculated spectrum shapes.

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1. INTRODUCTION

In the framework of the IAEA Coordinated Research Project on “Reference Database for Neutron Activation Analysis”, a detailed characterization of the neutron energy spectrum at irradiation positions of research reactors is needed for the introduction of correction factors for the sake of consistency between flux modeling and experiments. Details of the methodology of adjusting and uses of the final spectra can be found on reference documentation of the CRP.

The modeling of the “old” RA6 reactor using MCNP5 code was used for obtaining detailed spectra calculated at the irradiation zones [1]. These spectra were used on analysis of measurements performed by the LAAN (Laboratory of Activation Analysis of RA6-CAB-CNEA starting from the calculated neutron spectrum in 640 energy groups of the SAND-II structure [2, 3].

A “new” RA6 core will start normal operation on next year (2009) with all fresh 20 % fuels and maybe also a raise of thermal power from 500 KW up to 3 MW.

On this report it is included a schematic diagram of the new RA6 core layout, a Monte Carlo calculation model, a method for follow-up the changes introduced during burnup, and results of calculated neutron spectra and integral flux on several energy ranges at 2 typical irradiation facility positions.

The verification of the model by comparing induced activities at different irradiation positions with measurements and other results are expected to be made during 2009.

2. RA-6 NEW CORE

General Data of RA6 new core

Thermal Power:

Up to 3 MW (on first stage it is planned to operate at about 1 MW).

Fuel Elements:

Type MTR with 19 fuel plates for normal fuel elements and 15 fuel plates for control fuel elements, where control plates of Ag-In-Cd with stainless steel cladding are introduced.

The material of the meat of fuel plates is U_3Si_2 -Al alloy.

The dimensions of the meat are 0.052 cm x 6.0 cm x 61.9 cm.

The enrichment of U-235 is 19.70 w%.

The material of fuel plate clad, frames and other support components is Al-6061.

The frames contain Cd-wires for reactivity reduction of fresh core to acceptable levels.

Moderator/Coolant/ Reflector:

Demineralized H₂O (and Graphite as reflector in boxes with Al walls).

Figure 1 shows a general view of RA6 reactor. Figure 2 is an horizontal section of the projected new core for normal irradiations on the first stage at 1 MW thermal power.

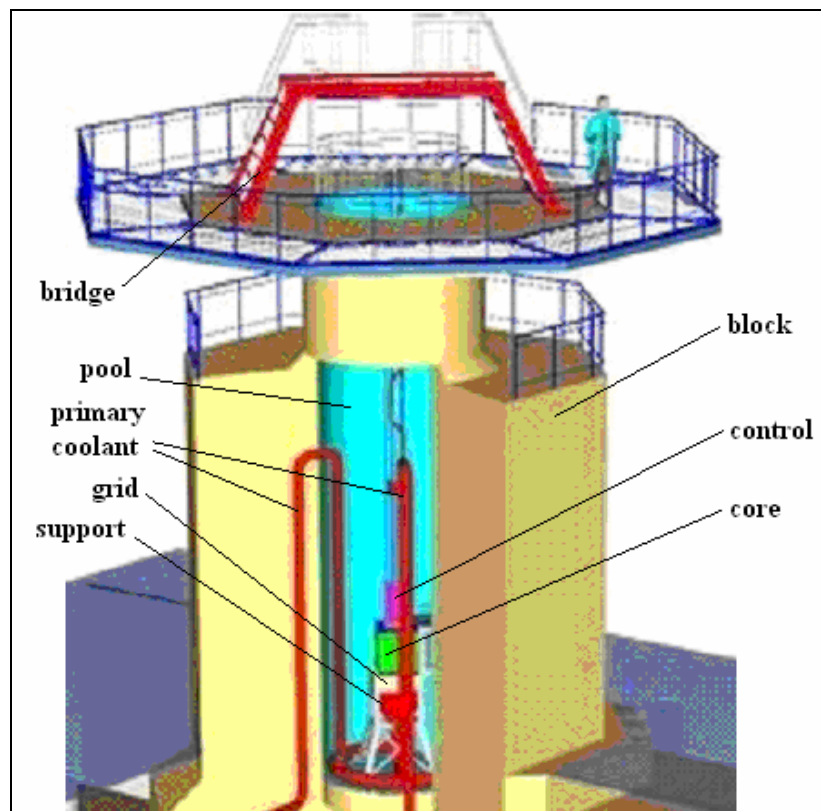
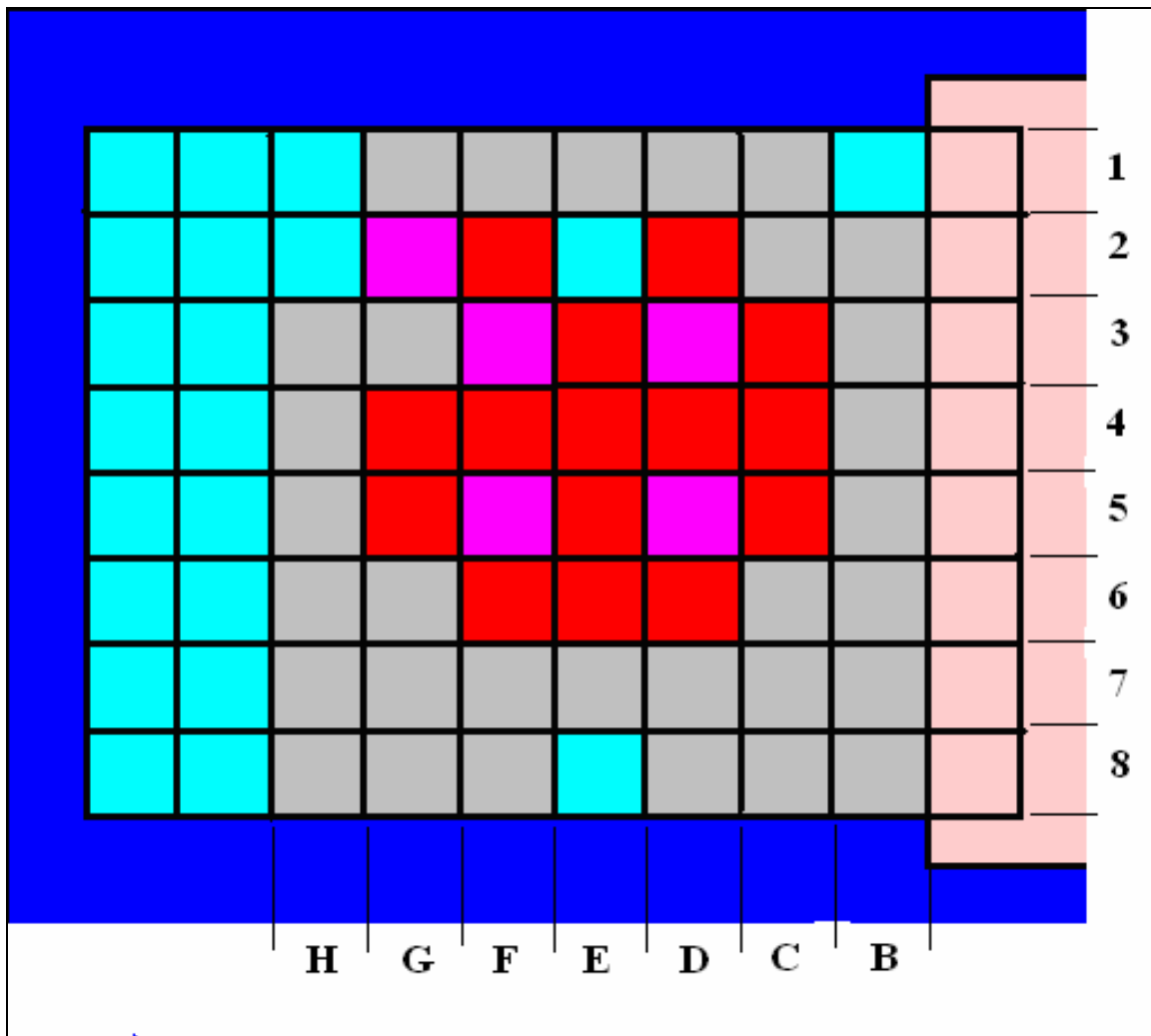


Figure 1. General View of RA6 Reactor



References:



Normal Fuel Element	Control Fuel Element(*)	Graphite Reflector	H2O- Irrad. Boxes	BNCT Filter (Al)
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*Control Fuel Element numbers and positions: 1:D3, 2:D5, 3:F5, 4:F3, 5:G2

Figure 2. Horizontal Section of RA6 Core

3. MCNP5 MODEL OF RA-6 NEW CORE

The RA6 core configuration modeled with MCNP5 code [5] is shown in Figures 3 to 5, including the two irradiation positions where detailed and integrated neutron spectra were calculated.

Neutron spectra were calculated inside two cylinders with Al walls (1 cm width and 7 cm height) on the centers of positions E2 and E8 (see Figure 2 of Section 2).

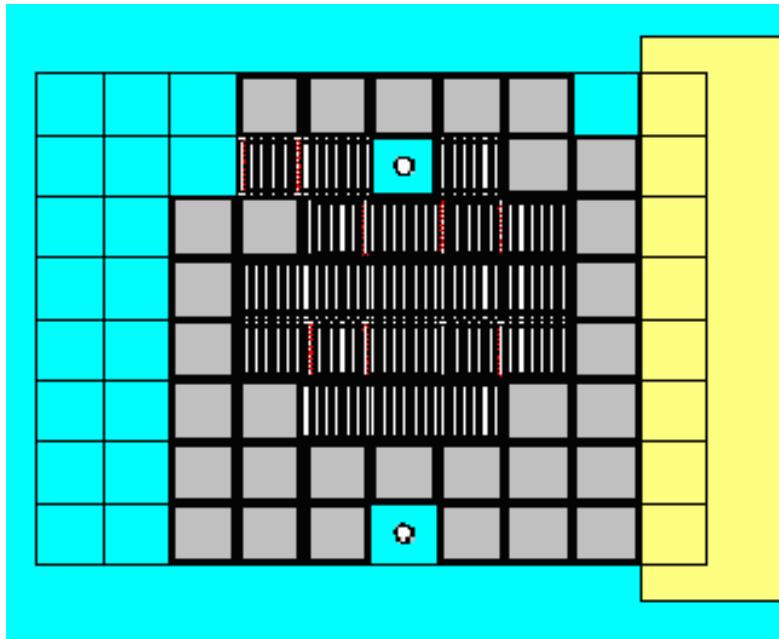


Figure 3. Horizontal Section of MCNP5 Model of RA6 Core

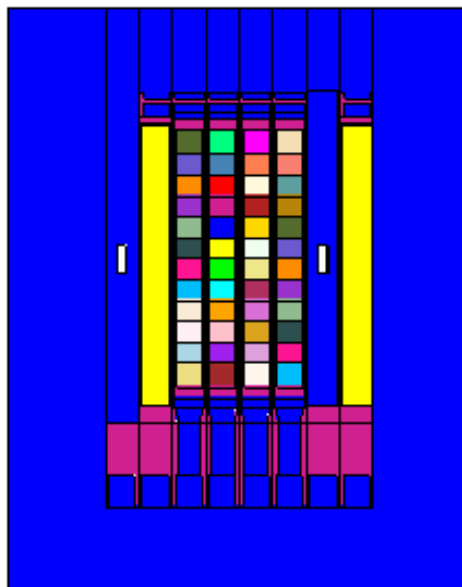


Figure 4. Vertical Section of MCNP5 Model of RA6 Core

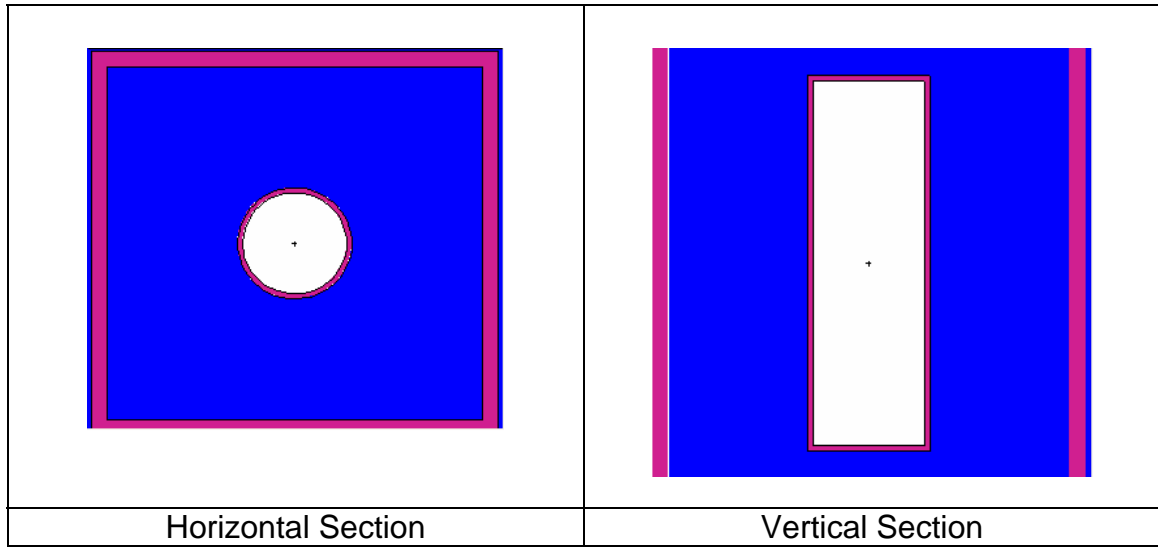


Figure 5. Details of Cylinder of Al Were Neutron Spectra Were Calculated with MCNP5 Model of RA6 Core

4. METHODS FOR MONTE CARLO CALCULATIONS WITH BURNUP

4.1 Introduction

Current calculations of power and research reactors with significant thermal power for the study of fuel management strategies and follow-up of burnup cores are made on two steps: 1) with multigroup neutron transport cell codes for obtaining a set of few group constants in function of burnup, and 2) with a diffusion code that uses the constants obtained in step 1) for 3D calculations of reactivity and power distribution in the core.

If detailed neutron spectra are needed for activation analysis and other experiments, it is necessary to implement a more detailed model (in geometry and energy).

With the speed growth of computers, today it is possible de adoption of MonteCarlo codes combined with other auxiliary programs and depletion codes for burnup calculations of nuclear reactors.

In this Section, three methods for using MCNP5 for burnup calculations of nuclear reactor cores are presented. It is planned to use all the three methods (plus the conventional cell-diffusion method) for the follow-up the operation of RA6 to compare, improve and validate all the methods.

4.2 The methods

Method 1 (Fig.6).

Using a procedure for coupling the MonteCarlo code and a depletion code (for example, ORIGEN [3]) at core level, for obtaining the concentrations of nuclides to be used on full reactor calculations with MonteCarlo code on successive time burnup steps. The output of MonteCarlo code is spatial power distribution and reaction rates of a selected set of fission products and actinides according to burnup chains. Then, with auxiliary programs, the libraries of depletion code are updated for each fuel region were new concentrations of nuclides will be calculated. The output of depletion code is processed with other auxiliary program for preparing the MonteCarlo input for the next burnup step.

This method is the most accurate approach but it is a very slow and complicated process because it is necessary to calculate with good statistical precision a large number of reaction rates and fluxes with the Monte Carlo code and a large number of depletion calculations (one for each fuel region in which the core is sub-divided) using the updated 1-group cross section libraries from the fluxes and reaction rates calculated with the Monte Carlo code on the previous burnup step.

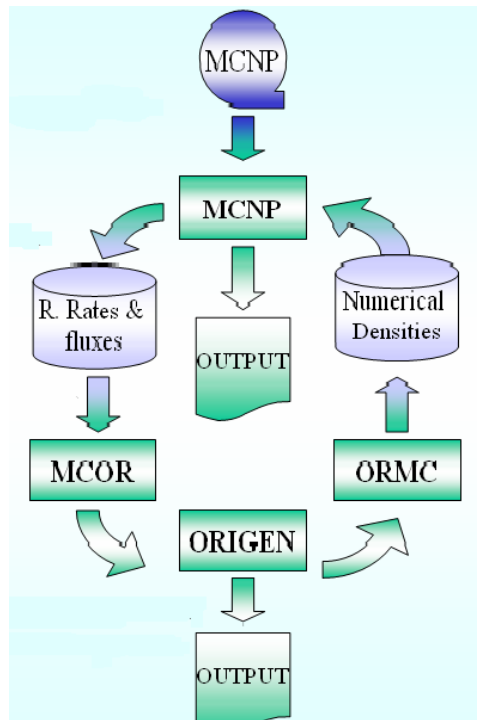


Figure 6. MCNP5 Calculations with Burnup - Method 1

A system (MCQ) [6,7] has been developed by introducing a microscopic burnup scheme which uses the Monte Carlo calculated fluxes and microscopic reaction rates as a basis for solving nuclide material balance equations for each spatial region.

The resulting predictions for the system at successive burnup time steps are thus based on a calculation route where both geometry and cross sections are accurately represented with continuous energy data, providing an independent approach for benchmarking other methods.

Basically, the method includes four tasks for each burnup step (see Fig.6):

- Monte Carlo calculation of the full system (criticality or fixed source options) tallying fluxes and nuclide reaction rates for each spatial region of interest integrated over energy;
- Preparation of depletion code input and cross section libraries from Monte Carlo output, including normalized power density of each spatial zone (MCOR auxiliary program);
- Depletion calculations of isotope concentrations on the input burnup time-step; and
- Preparation of next step Monte Carlo input with the new isotope concentrations output of depletion code (ORMC auxiliary program).

This sequence is implemented in an automatic way and can include a predictor-corrector scheme. There are no limitations on the number of isotopes and materials, but a selection of the most important fission products and actinides applied to the particular problem has to be made.

On the first stage, the method has been developed and implemented with the name MCQ and preliminary tests were performed. On the second stage, a set of experimental and numerical benchmarks were used for testing and improving the method. On the third stage some practical applications were included. On the present stage it is improved the management of fission products related to the quantity and quality of explicit included isotopes, and it is updated decay and fission yield data.

Method 2 (Fig.7).

Using a method for coupling MonteCarlo code at core level and a cell transport code with depletion calculations (for example, DRAGON [8]), for obtaining the concentrations of nuclides to be used on full reactor calculation with MonteCarlo code on burnup steps. The output of MonteCarlo code is the spatial power distribution. Then, with auxiliary programs, the nuclide concentrations obtained with the cell depletion code are updated for each fuel region by interpolations on burnup. The output of depletion code is processed with an auxiliary program for preparing the MonteCarlo input for the next burnup step.

This method is less accurate but faster and less complicated than Method 1 because it is not necessary to calculate the large number of reaction rates and fluxes with the MonteCarlo code and only a step is necessary for calculating the concentrations of fission products and actinides in function of burnup at cell level.

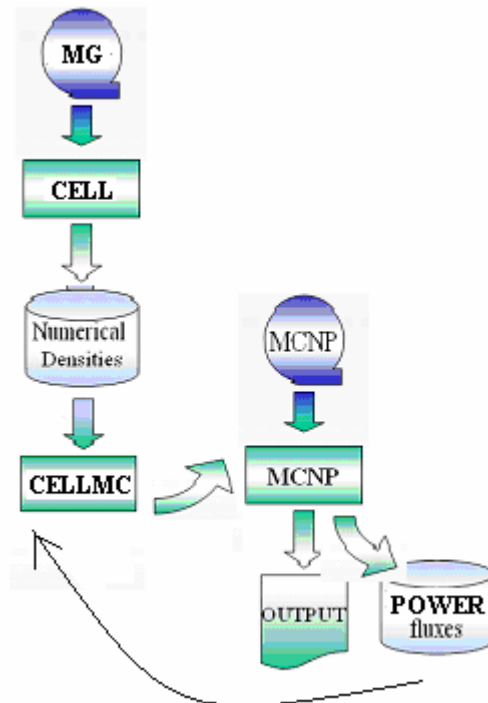


Figure 7. MCNP5 Calculations with Burnup - Method 2

Method 3 (Fig.8).

This method is on a development stage and uses the multigroup calculation capacity of MCNP5 code [9]. Using a method for coupling MonteCarlo code at core level and a cell transport code with depletion calculations (for example, DRAGON [8]), for obtaining multigroup cross sections of fuel regions to be used on full reactor calculation with multigroup Monte Carlo code on burnup steps. The output of MonteCarlo code is the spatial power distribution. Then, with auxiliary programs the cross sections obtained with the cell depletion code are updated for each fuel region interpolating on the corresponding burnup. The output of depletion code is processed with an auxiliary program for preparing multigroup MonteCarlo libraries.

This method is least accurate but faster and less complicated than Methods 1 and 2 because it is not necessary to include in MonteCarlo input concentrations of a large number of nuclides and only one step is necessary for calculating the multigroup cross sections of fuel regions in function of burnup at cell level.

This method has been applied on the present work and compared with point MonteCarlo calculations for fresh cases with good performance.

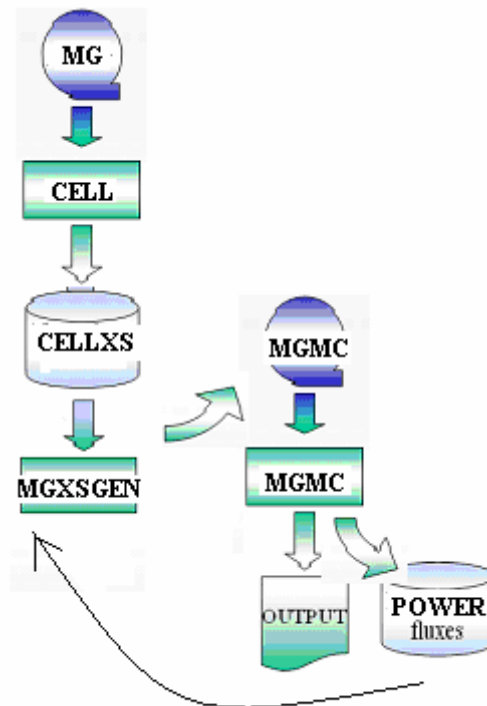


Figure 8. MCNP5 Calculations with Burnup - Method 3

5. GENERATION OF POINT AND MULTIGROUP NUCLEAR DATA LIBRARIES IN ACE FORMAT FOR RA6 CALCULATIONS WITH MCNP5 CODE

5.1 Introduction

MCNP5 standard cross sections libraries included on the package distributed by RSICC [4] are not sufficient for reactor core calculations at working power and for different burnup steps because they are given at temperatures that do not match with the conditions of the particular case.

In the case of multigroup libraries, the standard files are given for 30 neutron energy groups only, weighted with general spectra, and they do not contain up-scattering and self-shielding effects [9]. Multigroup MonteCarlo nuclear data are very dependent of the particular case.

Then, the generation of particular nuclear data libraries in the format that MCNP5 can read (ACE –format) is a necessary first step.

On this Section it is briefly described the procedures used for generation of libraries for RA6 calculations.

5.2 Point (continuous) cross section libraries

For methods 1 and 2 of Section 4, a set of cross section data in ACE format are needed for all nuclides present on the reactor core for fresh cases and for cases after burnup steps at the appropriated material temperatures of working conditions.

Nuclear data libraries for all the isotopes included in all the materials needed for MCNP5 calculations (ACE-format) of RA6 reactor were generated with NJOY-99.161 system [10] at full power temperature conditions. The basic nuclear data file from which the ACES data were generated is ENDF/B-VII [11] because this is the most updated basic nuclear library up to date and it has good performance in many previously calculated benchmarks.

The standard procedure for generating ACE libraries with NJOY is a sequence of calls to the following 6 NJOY-modules: MODER, RECONR, BROADR, HEATR, PURR and ACER.

5.3 Multigroup cross section libraries

For Method 3 of Section 4, a set of multigroup cross section data in multigroup-ACE format are needed for all nuclides (or materials) present on the reactor core for fresh cases and for cases after burnup steps.

The procedure for obtaining these data is very different to the continuous cases. Here it is described the methodology used on the present work for RA6 calculations with the multigroup option of MCNP5 code.

The first step is the preparation of input data for the cell code. On this work it is used DRAGON code because its output is very clear and detailed, it contains all the needed information from which the MonteCarlo multigroup library can be generated, and the RA6 cells can be modeled on two dimensions without geometry approximations.

The adopted input multigroup library is the WLUP-WIMS- ENDF/B-VII.0, 69 groups library [12] as a first approach. It is planned for future calculations to generate libraries on MATXS format (that DRAGON code accepts as input also) with NJOY system because this format accept Legendre scattering orders larger than 1 for all materials (WIMS libraries includes P1 order and for 4 moderators: H1, H2, O16 and C only. All the other materials have P0 data).

RA6 fuel cells are very complex. There are 6 different cells that must be modeled and calculated for obtaining all the necessary cross section data for core calculations (all in function of burnup). In Figure 9 it is shown the normal fuel element cells (with and without Cd wires). In Figure 10, the 4 control fuel element cells are included (without control rod with and without Cd wires and with control rod with and without Cd wires).

The results of cell calculations are processed with an auxiliary program that extract multigroup cross sections (without condensation in energy) for MCNP- Multigroup calculations in ACE-multigroup format for all materials (or homogenized regions) needed for full core calculations. Besides, nuclide concentrations can be stored on separate files to apply the Method 2 (Fig.7 of Section 4).

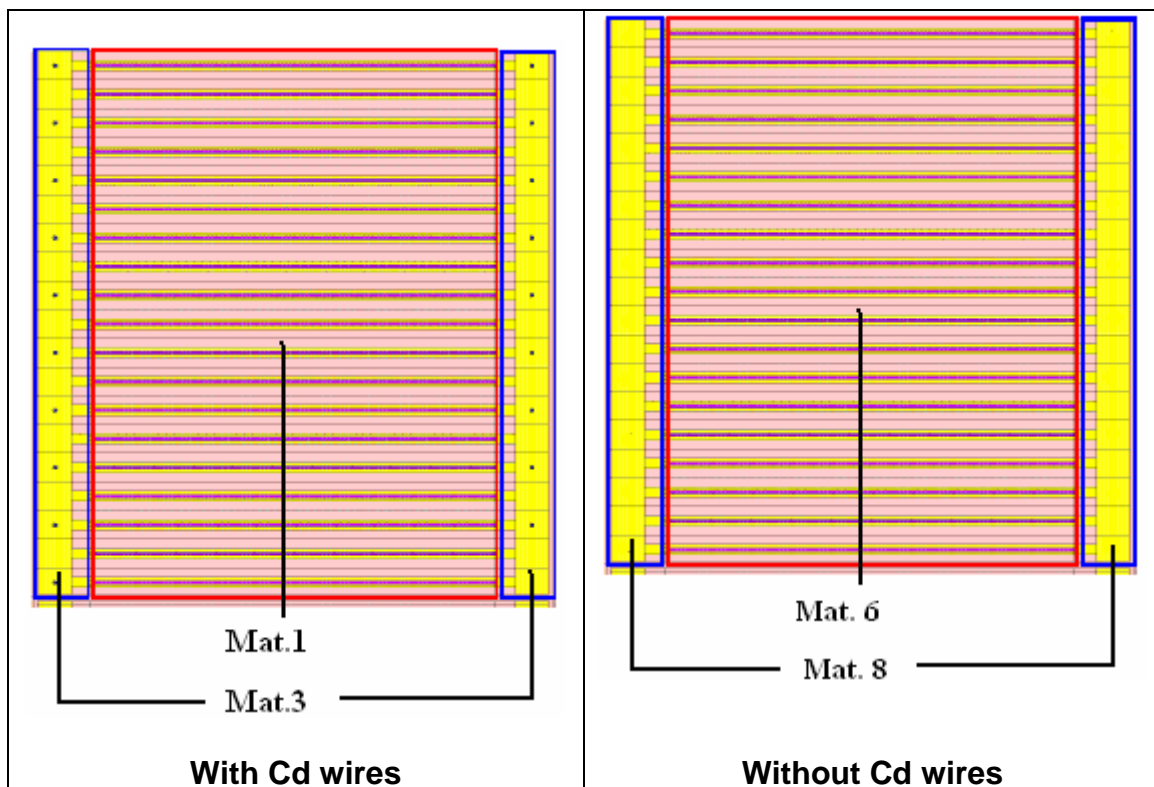


Figure 9. Normal Fuel Element Horizontal Sections

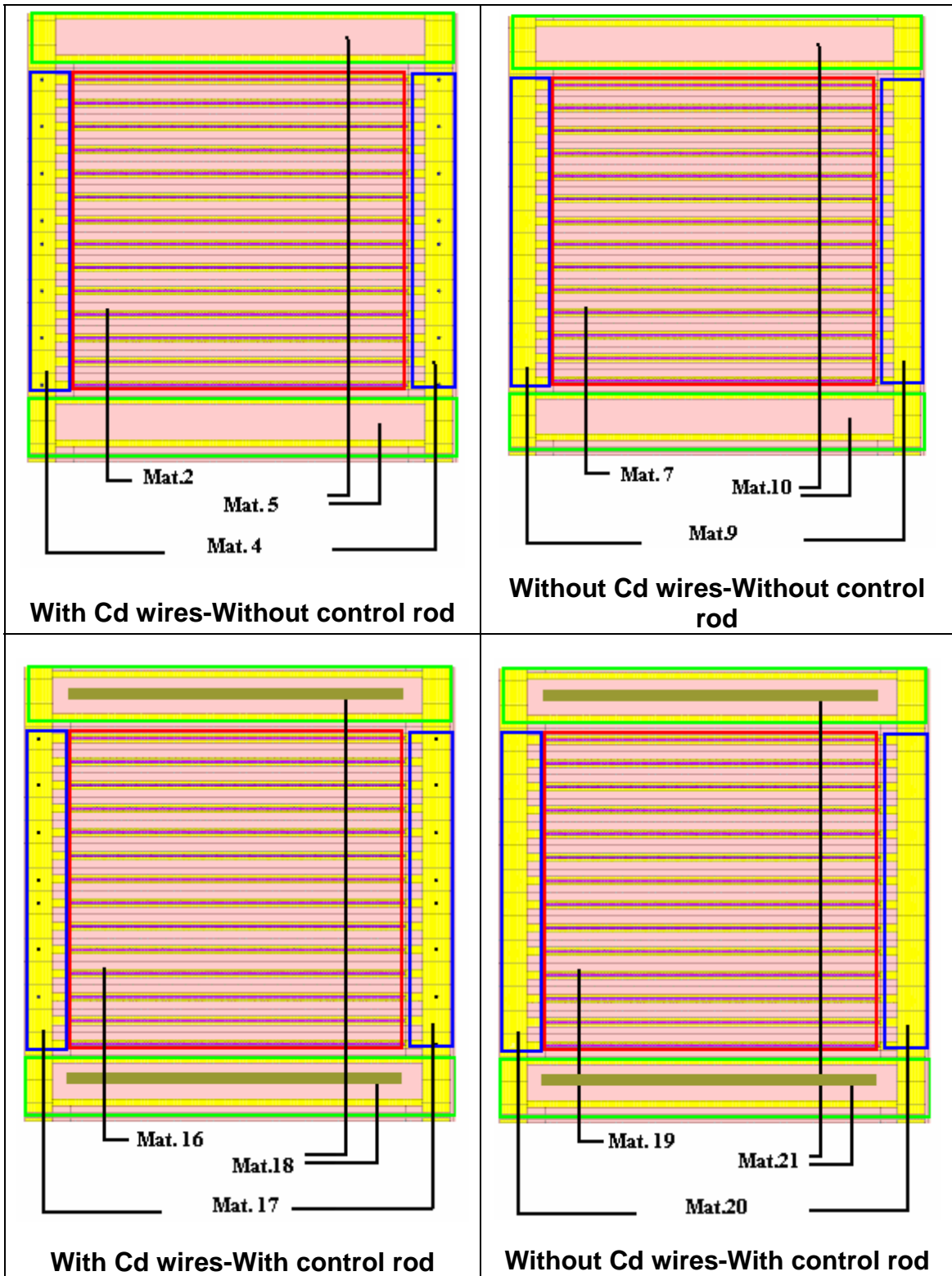


Figure 10. Control Fuel Element Horizontal Sections

6. CALCULATIONS

MonteCarlo (MCNP5) calculations using methods and models described on previous sections, for RA6 core, with neutron spectrum tallies and integral values of neutron flux on the two irradiation positions shown in Figures 3 to 5 of Section 3, were run for the following cases:

- 1) Fresh core-full power (1 MW) condition-**continuous** option (with cross section data generated with NJOY from ENDF/B-VII.0).
- 2) Fresh core-full power (1 MW) condition-**multigroup** option (with multigroup cross section data from WLUP-WIMS ENDF/B-VII.0, 69 group library and processed with DRAGON code for fissionable materials (with homogenization of fuel plate regions). Results of this calculation are compared with case 1).
- 3) 7 calculations with Method 3 of burnup at full power (1 MW) condition-**multigroup** option: 4 days of operation, 3 days of decay and beginning of operation after de 7 previous days. Results were obtained for 1 hour, 12 hours, 1 day, 2 days, 3 days, 4 days of continuous irradiation and at 7 days after 3 days of decay (typical time for projected operations of RA6), for the first 7 days from fresh case. These calculations are included for testing the Method 3 and for detecting any change on neutron spectra shape on irradiation channel in function of operation time (this practice will be useful for long burnup periods).

All calculations were made on critical conditions. This condition was obtained by adjusting the control rod positions (rods 1 and 3). Control rods 2 and 4 were 0 % extracted for all cases. Fine control rod has been fixed at 50 % of extraction in all cases (see Fig.2 of Section 2).

Neutron spectra on irradiation channels E2 and E8 were obtained at 640 groups (SAND-2 structure) for case 1), and at 69 groups for cases 2) and 3). Besides, integral values of neutron flux were calculated for three energy ranges: (0.0, 0.5 eV), (0.5 eV, 0.1 MeV) and (0.1, 10.0 MeV).

The results were processed with an auxiliary program for obtaining punctual (in energy) values and for normalizing to 1 MW of total core power.

Other results (reactivity and power distribution) and other calculations performed in order to test multigroup method with continuous method are not presented on this paper but were processed and compared between cases with good performance of multigroup option for fresh case. It is planned to compare Method 1 with Method 3 on future works in function of burnup.

All calculations were made with 50000 histories by cycle and the total number of cycle were 5000 for punctual case 1), 2500 for multigroup case 2), and 1000 cycles for all cases 3).

The tally type for calculation of spectra and neutron flux integrated in energy was F4 (average cell flux). In multigroup option it is not possible to use the F5 tally (point detector).

The calculations were run on a PC with Dual-Quad processor, with LINUX OS and with MCNP5 installed in parallel processing mode, using 4 nodes. The cpu time by cycle for all cases on this installation is about 1 min for point case and 0.7 min for multigroup cases. Then each calculation with 1000 cycles for multigroup case in function of time is completed in 12 hours.

7. RESULTS

Results included on this report are integral neutron fluxes and spectra on the center of channels E2 (SP1) and E8 (SP2) (see Fig.2-Section 2). All values were normalized to 1 MW of thermal power.

Calculated Neutron Fluxes in 3 Energy Ranges

In Table 1, results of integrated neutron flux in 3 energy ranges and total are included for all calculated cases with the statistical error in % (R%). The cases named 0PUNT and 0MG refers to fresh condition calculated with point and multigroup cross sections respectively. Its are included also percent differences of multigroup with punctual results (D(M/P)%). The other values were all obtained with multigroup calculations in function of irradiation time: 1H, 12H: 1 and 12 hours of irradiation, 1D, 2D, 3D, 4D; 1 to 4 days of irradiation, and 7D: at new start-up after 3 days of reactor shut-down. The values of fluxes are expressed in abbreviated form (ej: 8.460+12 is 8.460×10^{12}).

Table 1. Integrated Neutron Flux at 3 energy ranges

SP1 (E2 channel)									
Case	$\Phi(0-.5\text{eV})$ (ns/cm ² seg)	R %	$\Phi(.5\text{eV}-.1\text{MeV})$ (ns/cm ² seg)	R %	$\Phi(.1-10\text{MeV})$ (ns/cm ² seg)	R %	$\Phi(0-10\text{MeV})$ (ns/cm ² seg)	R %	
0PUNT	8.460+12	2.0	3.113+12	2.5	2.737+12	2.6	1.431+13	1.2	
0MG	8.413+12	2.5	3.168+12	3.0	2.678+12	3.1	1.426+13	1.8	
D(M/P)%		-0.56		1.77		-2.16		-0.36	
1H	8.368+12	3.3	3.182+12	4.1	2.678+12	4.2	1.423+13	2.4	
12H	8.463+12	4.0	3.202+12	5.0	2.712+12	5.1	1.438+13	2.9	
1D	8.589+12	3.9	3.265+12	4.8	2.743+12	4.9	1.460+13	2.9	
2D	8.746+12	3.9	3.320+12	4.8	2.819+12	4.8	1.489+13	2.8	
3D	8.731+12	3.9	3.302+12	4.8	2.800+12	4.9	1.483+13	2.8	
4D	8.691+12	3.9	3.295+12	4.8	2.773+12	4.9	1.476+13	2.8	
3 DAYS DEC									
7D	8.371+12	4.0	3.167+12	4.9	2.681+12	5.0	1.422+13	2.9	
SP2 (E8 channel)									
Case	$\Phi(0-.5\text{eV})$ (ns/cm ² seg)	R %	$\Phi(.5\text{eV}-.1\text{MeV})$ (ns/cm ² seg)	R %	$\Phi(.1-10\text{MeV})$ (ns/cm ² seg)	R %	$\Phi(0-10\text{MeV})$ (ns/cm ² seg)	R %	
0PUNT	4.518+12	2.5	9.152+11	4.0	6.060+11	4.5	6.039+12	2.2	
0MG	4.492+12	3.3	9.413+11	5.5	6.219+11	6.3	6.056+12	2.8	
D(M/P)%		-0.57		2.86		2.63		0.27	
1H	4.475+12	4.5	9.255+11	7.6	6.250+11	8.6	6.025+12	3.8	
12H	4.535+12	5.4	9.554+11	9.0	6.124+11	10.5	6.103+12	4.6	
1D	4.501+12	5.3	9.374+11	9.0	6.224+11	10.3	6.061+12	4.5	
2D	4.484+12	5.3	9.312+11	8.9	6.238+11	10.2	6.039+12	4.5	
3D	4.524+12	5.3	9.433+11	8.9	6.128+11	10.3	6.081+12	4.5	
4D	4.503+12	5.3	9.330+11	8.9	6.312+11	10.2	6.067+12	4.5	
3 DAYS DEC									
7D	4.506+12	5.3	9.365+11	9.0	6.156+11	10.3	6.058+12	4.5	

From Table 1 it can be seen that:

- differences of multigroup with punctual results for fresh core are very small for thermal fluxes (less than 0.6 %) and less to 2.2 and 2.9 % for epithermal and fast groups for SP1 and SP2 respectively;
- the thermal flux in SP1 is about twice the flux in SP2. Epithermal and fast fluxes in SP1 are about 3-4 times the flux in SP2;
- statistical errors (R) in SP2 are larger than values at SP1 doubt to differences in flux values on the two positions;
- it is noted a slow raise of neutron fluxes (for the 3 energy ranges) in function of burnup (more visible for SP1 than for SP2). After 3 days of decay, the fluxes return (in average) to the fresh case values.

Calculated spectra

The detailed (640 energy groups) calculated spectra for SP1 (E2) and SP2 (E8) channels of the RA6 reactor-fresh case are shown in Figure 11. In Figure 12, the spectra multiplied by energy are shown. It is marked the region where 1/E shape is accomplished. It is noted that the spectrum shape match the 1/E form between 2 eV and 30 KeV for SP1 very much than for SP2.

It is shown in Figs.11 and 12 that there are not found the very strong spurious picks found on previous calculations of spectra with MonteCarlo. It is doubt to improvement on computer speed that allows run more histories on less time than before, for obtaining better statistical averaged values. Nevertheless, for low and high energies the statistical errors remains higher than for intermediate energies.

In Table A.1 of the Appendix, the numerical values of spectra plotted in Figure 11 are included.

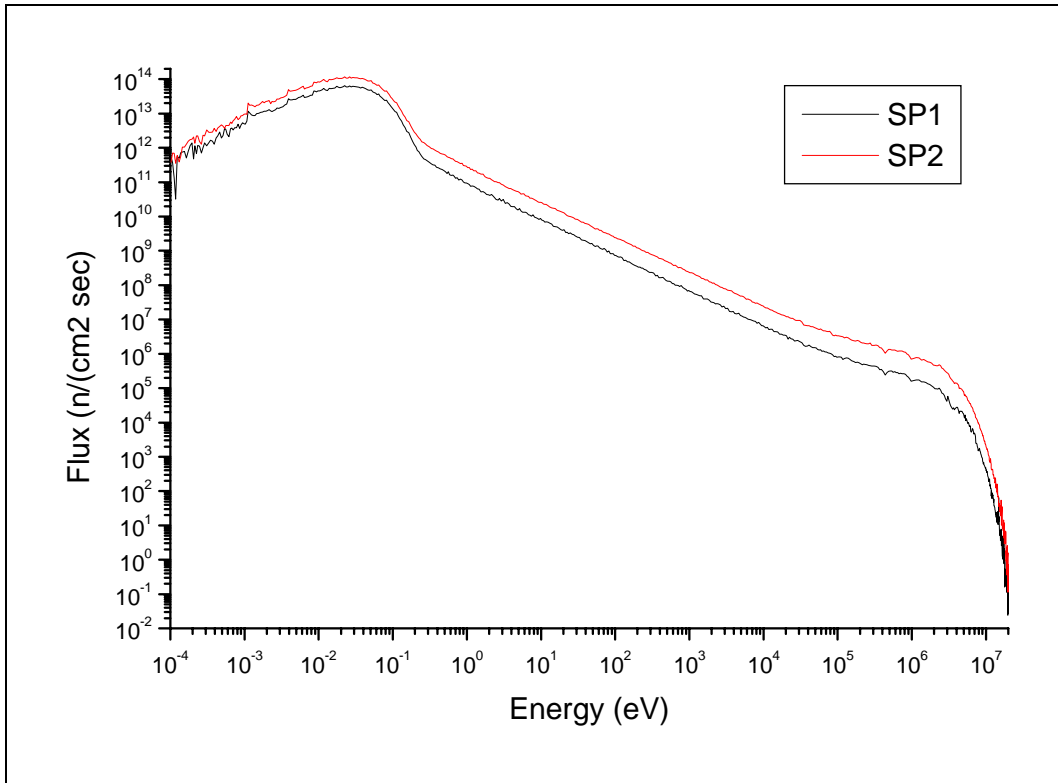


Figure 11. Detailed Neutron Spectra for Fresh RA6 Core in 2 Irradiation Channels

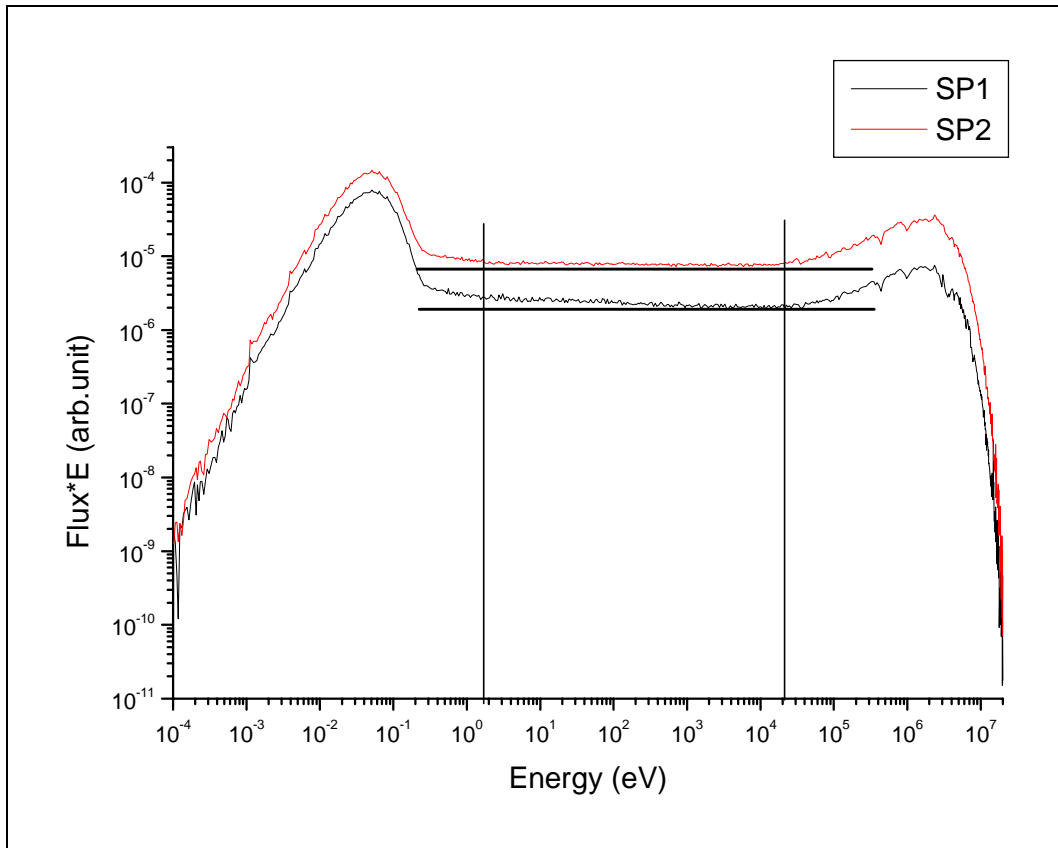


Figure 12. Detailed Neutron Spectra Energy for Fresh RA6 Core in 2 Irradiation Channels

The spectra calculated with the multigroup method with DRAGON/MCNP5 coupled codes at 69 energy groups are superimposed with the detailed (640 energy groups) calculated spectra for SP1 (E2) and SP2 (E8) channels of the RA6 reactor-fresh case and are shown in Figure 13. In Figure 14, the spectra multiplied by energy are shown.

It is shown in Figs.13 and 14 that multigroup points are very close to continuous (punctual) values. This is an important result from the point of view of the possibility of uses of multigroup MonteCarlo method for obtaining neutron spectra in irradiation channels without great details in energy but conserving the general shapes of these spectra. It can be useful for fast studies of the best irradiation positions respect to the spectrum shapes in function of energy with burnup cases.

The spectra calculated with the multigroup method with DRAGON/MCNP5 coupled codes at 69 energy groups for the 8 burnup time steps (Method 3 of Section 4) are superimposed and shown in Figure 15 for SP1 and Figure 16 for SP2 (spectra multiplied by energy). It is seen that the shapes of spectra are conserved for the burnup steps included on the figures.

In Tables A.2 and A.3 of the Appendix, the numerical values of spectra obtained vs.burnup with MCNP5 multigroup option are included.

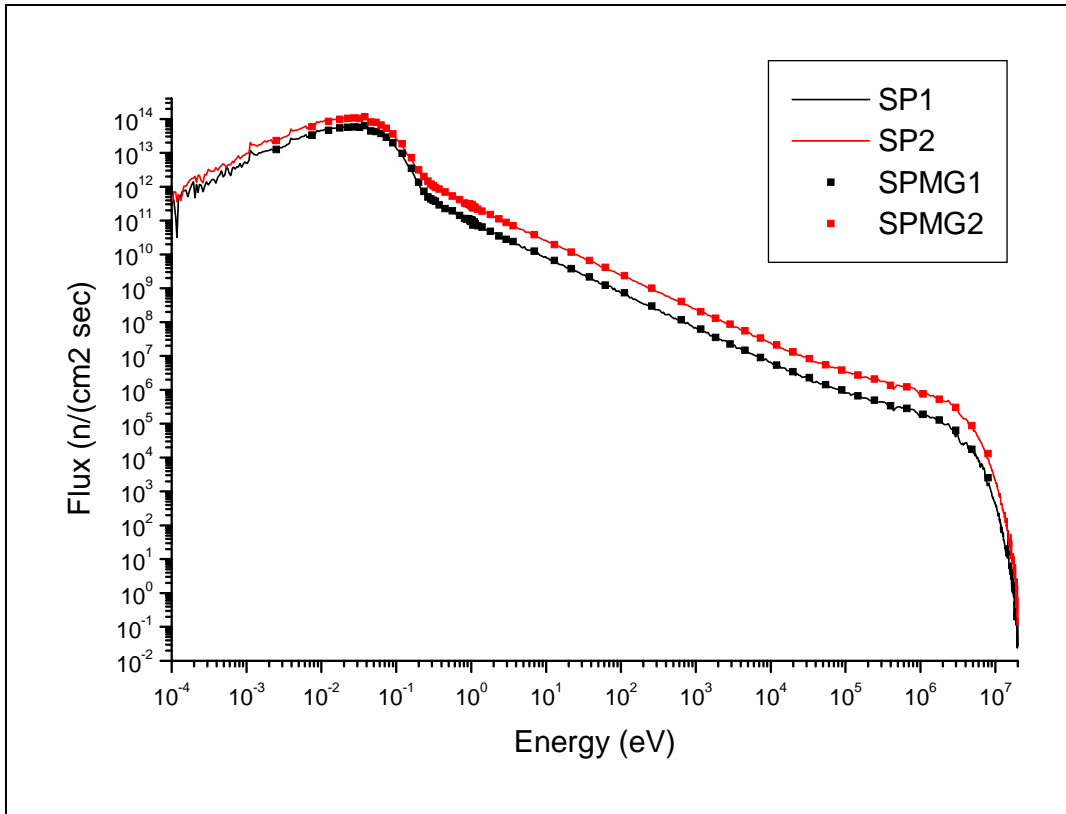


Figure 13. Detailed and MultiGroup Neutron Spectra for Fresh RA6 Core in 2 Irradiation Channels

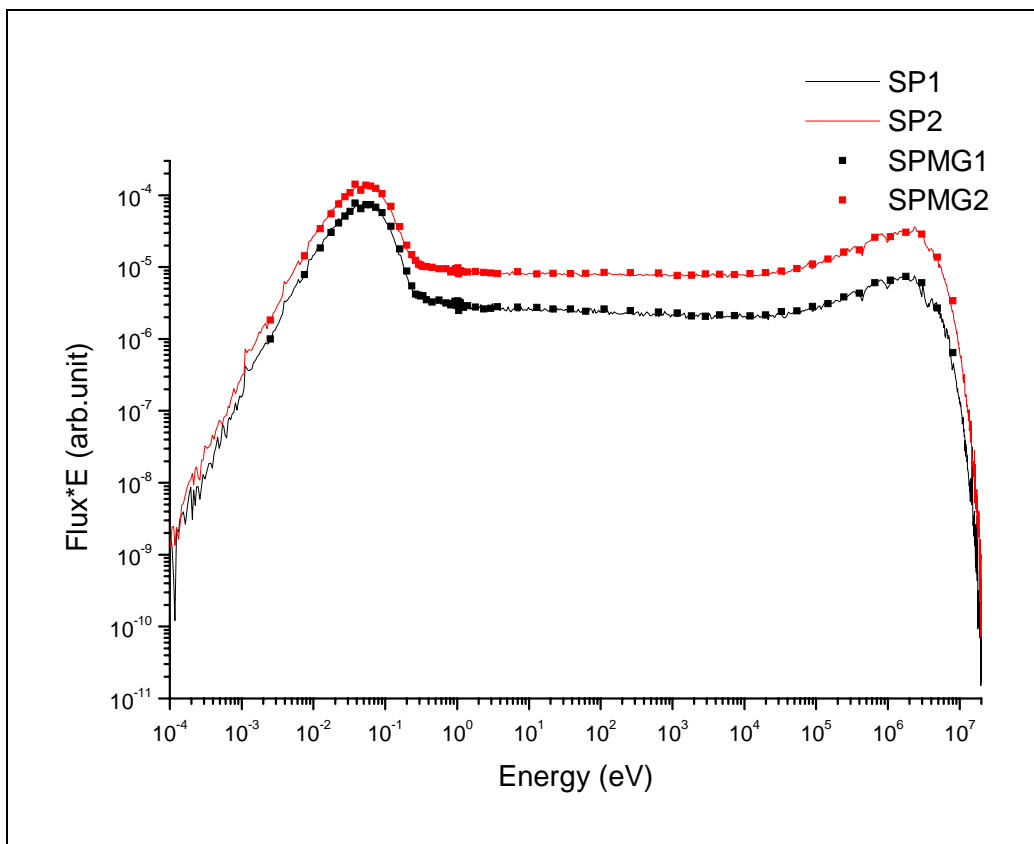


Figure 14. Detailed and MultiGroup Neutron Spectra Energy for Fresh RA6 Core in 2 Irradiation Channels

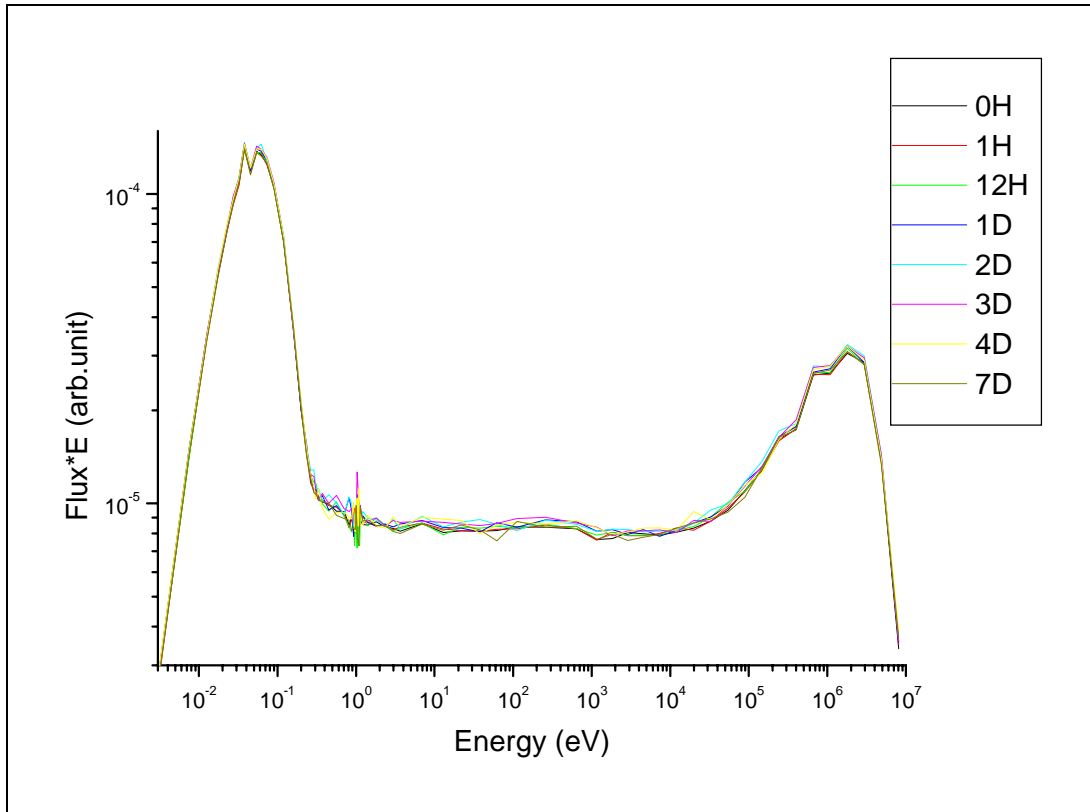


Figure 15. MultiGroup Neutron Spectra for 7 Burnup Steps of E2 irradiation Channel of RA6 Core

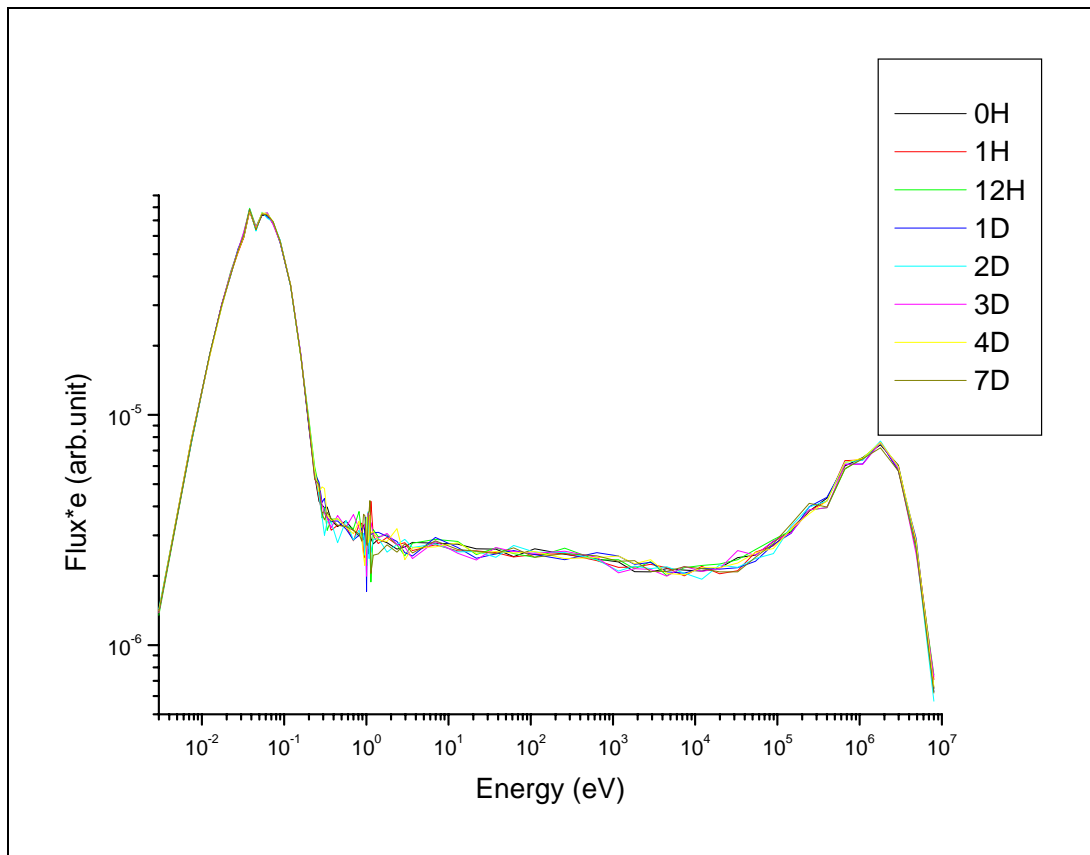


Figure 16. MultiGroup Neutron Spectra for 7 Burnup Steps of E8 irradiation Channel of RA6 Core

8. SUMMARY

A new RA6 core will start its normal operation on next year (2009) with all fresh 20 % fuels and maybe also a raise of power from 500 kW up to 3 MW.

On this report presented: a schematic diagram of the new RA6 core layout for Monte Carlo calculation model, a method for follow-up the changes introduced during burnup, and results of calculated neutron spectra and integral flux on three energy ranges at 2 typical irradiation facility positions.

The main results of this work are:

- 1) A detailed model and methods for Monte Carlo calculations of the new RA6 core is ready for using on different applications, including spectra calculations on different spatial regions in function of burnup.
- 2) Results of neutron flux calculations in 3 energy groups at 2 irradiation positions and neutron spectra on 640 and 69 energy groups are ready for using on further analysis of analytical and calculated spectrum shapes.

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APPENDIX. Numerical Values of Spectra

The following tables are included on this Appendix:

- Table A.1. Detailed Neutron Spectra for Fresh RA6 Core in 2 Irradiation Channels (Figure 11-Section 7)
- Table A.2. MultiGroup Neutron Spectra for Fresh RA6 Core in 2 Irradiation Channels (Figure 13-Section 7)
- Table A.3. MultiGroup Neutron Spectra for 7 Burnup Steps of E2 irradiation Channel of RA6 Core (Figure 15-Section 7)
- Table A.4. MultiGroup Neutron Spectra for 7 Burnup Steps of E8 irradiation Channel of RA6 Core (Figure 16-Section 7).

Table A.1. Detailed Neutron Spectra for Fresh RA6 Core in 2 Irradiation Channels (Figure 11-Section 7)

ENERGY (eV)	SPECTRUM1	SPECTRUM2	R1%	R2%
1.0250E-04	5.660E+11	3.844E+11	70.10	45.03
1.0750E-04	3.686E+11	7.067E+11	45.53	44.91
1.1250E-04	1.291E+11	6.913E+11	95.21	47.83
1.1750E-04	3.230E+10	3.593E+11	39.99	52.35
1.2375E-04	5.727E+11	5.998E+11	47.93	49.32
1.3125E-04	4.940E+11	3.902E+11	42.73	32.18
1.3875E-04	7.226E+11	5.803E+11	48.85	33.62
1.4625E-04	7.630E+11	1.046E+12	44.43	36.70
1.5500E-04	7.942E+11	1.042E+12	30.59	52.23
1.6500E-04	5.038E+11	1.277E+12	57.19	44.74
1.7500E-04	8.052E+11	1.560E+12	37.55	35.62
1.8500E-04	1.166E+12	1.742E+12	43.70	31.45
1.9500E-04	1.388E+12	1.775E+12	57.39	32.25
2.0500E-04	4.728E+11	2.062E+12	44.80	31.26
2.1500E-04	1.153E+12	1.358E+12	37.41	22.83
2.2500E-04	6.731E+11	2.202E+12	40.11	26.29
2.3500E-04	1.167E+12	2.204E+12	37.86	36.64
2.4750E-04	1.122E+12	1.521E+12	37.94	21.73
2.6250E-04	7.026E+11	1.293E+12	30.77	21.01
2.7500E-04	1.010E+12	2.333E+12	32.86	23.11
2.9000E-04	1.405E+12	2.225E+12	22.76	18.72
3.1000E-04	1.141E+12	3.291E+12	27.85	16.85
3.3000E-04	1.435E+12	2.865E+12	19.85	19.21
3.5000E-04	1.655E+12	2.834E+12	23.46	18.08
3.7000E-04	1.577E+12	2.928E+12	17.17	21.43
3.9000E-04	1.276E+12	3.695E+12	17.77	17.04
4.1250E-04	1.961E+12	3.062E+12	17.91	14.19
4.3750E-04	2.205E+12	3.756E+12	20.72	11.30
4.6250E-04	2.913E+12	4.193E+12	18.17	16.34
4.8750E-04	1.942E+12	4.746E+12	17.34	12.26
5.1250E-04	2.250E+12	4.279E+12	15.71	13.00
5.3750E-04	3.704E+12	3.703E+12	24.93	12.72
5.6250E-04	3.386E+12	4.466E+12	13.97	10.99
5.8750E-04	2.484E+12	4.464E+12	17.17	13.04
6.1500E-04	2.138E+12	4.495E+12	13.34	11.23
6.4500E-04	3.601E+12	5.592E+12	15.44	10.73
6.7500E-04	3.764E+12	5.168E+12	12.53	9.22
7.0500E-04	3.313E+12	6.138E+12	13.05	10.94
7.4000E-04	3.850E+12	6.840E+12	10.40	7.86

7.8000E-04	3.840E+12	8.149E+12	9.07	8.14
8.2000E-04	4.915E+12	6.683E+12	9.77	9.69
8.6000E-04	3.719E+12	7.280E+12	10.13	7.95
9.0000E-04	4.625E+12	8.455E+12	10.05	7.30
9.4000E-04	5.364E+12	8.662E+12	9.34	7.28
9.8000E-04	4.975E+12	9.458E+12	10.76	6.96
1.0250E-03	4.940E+12	9.734E+12	9.50	6.65
1.0750E-03	6.051E+12	9.535E+12	7.63	6.13
1.1250E-03	1.172E+13	2.033E+13	5.88	4.39
1.1750E-03	1.032E+13	1.722E+13	6.18	4.72
1.2375E-03	9.142E+12	1.769E+13	5.61	3.89
1.3125E-03	8.711E+12	1.690E+13	5.29	4.04
1.3875E-03	8.684E+12	1.575E+13	4.70	3.86
1.4625E-03	9.997E+12	1.715E+13	4.95	3.82
1.5500E-03	1.014E+13	1.775E+13	4.10	3.58
1.6500E-03	1.082E+13	1.995E+13	4.17	3.27
1.7500E-03	1.101E+13	2.246E+13	4.11	3.37
1.8500E-03	1.159E+13	2.052E+13	4.17	3.10
1.9500E-03	1.155E+13	2.268E+13	3.97	3.52
2.0500E-03	1.204E+13	2.324E+13	3.61	3.77
2.1500E-03	1.292E+13	2.391E+13	4.10	2.93
2.2500E-03	1.186E+13	1.932E+13	3.99	3.20
2.3500E-03	1.145E+13	2.248E+13	4.22	3.86
2.4750E-03	1.214E+13	2.213E+13	3.14	2.47
2.6250E-03	1.288E+13	2.328E+13	3.21	2.46
2.7500E-03	1.446E+13	2.608E+13	4.58	2.82
2.9000E-03	1.424E+13	2.622E+13	2.61	2.08
3.1000E-03	1.511E+13	2.859E+13	2.55	2.10
3.3000E-03	1.591E+13	2.965E+13	2.53	1.92
3.5000E-03	1.763E+13	3.136E+13	2.60	2.00
3.7000E-03	1.902E+13	3.453E+13	2.28	1.70
3.9000E-03	2.701E+13	5.020E+13	1.89	1.45
4.1250E-03	2.497E+13	4.464E+13	1.82	1.45
4.3750E-03	2.507E+13	4.587E+13	1.83	1.42
4.6250E-03	2.570E+13	4.633E+13	1.81	1.40
4.8750E-03	2.581E+13	4.812E+13	1.73	1.36
5.1250E-03	2.762E+13	5.031E+13	1.72	1.36
5.3750E-03	2.936E+13	5.244E+13	1.67	1.32
5.6250E-03	3.013E+13	5.556E+13	1.65	1.26
5.8750E-03	3.125E+13	5.826E+13	1.62	1.26
6.1500E-03	3.445E+13	6.154E+13	1.44	1.09
6.4500E-03	2.914E+13	5.209E+13	1.54	1.20
6.7500E-03	3.009E+13	5.517E+13	1.47	1.36
7.0500E-03	3.055E+13	5.664E+13	1.49	1.15
7.4000E-03	3.205E+13	5.834E+13	1.29	1.05
7.8000E-03	3.395E+13	6.155E+13	1.30	1.00
8.2000E-03	3.458E+13	6.303E+13	1.25	0.99
8.6000E-03	4.532E+13	8.239E+13	1.10	0.91
9.0000E-03	4.442E+13	8.029E+13	1.12	0.87
9.4000E-03	4.254E+13	7.970E+13	1.13	0.88
9.8000E-03	4.599E+13	8.454E+13	1.13	0.90
1.0250E-02	4.519E+13	8.341E+13	0.98	0.82
1.0750E-02	4.743E+13	8.597E+13	1.01	0.77
1.1250E-02	4.958E+13	9.152E+13	0.98	0.77
1.1750E-02	5.405E+13	9.818E+13	0.93	0.73
1.2375E-02	4.842E+13	8.908E+13	0.81	0.64
1.3125E-02	4.630E+13	8.524E+13	0.84	0.65
1.3875E-02	5.417E+13	9.802E+13	0.77	0.61
1.4625E-02	5.303E+13	9.733E+13	0.79	0.61
1.5500E-02	5.399E+13	9.818E+13	0.71	0.54
1.6500E-02	5.556E+13	1.032E+14	0.68	0.54

1.7500E-02	6.181E+13	1.114E+14	0.67	0.52
1.8500E-02	5.819E+13	1.055E+14	0.67	0.53
1.9500E-02	5.731E+13	1.057E+14	0.67	0.53
2.0500E-02	5.759E+13	1.061E+14	0.67	0.53
2.1500E-02	6.120E+13	1.104E+14	0.66	0.51
2.2500E-02	6.520E+13	1.188E+14	0.65	0.50
2.3500E-02	5.988E+13	1.087E+14	0.67	0.53
2.4750E-02	5.979E+13	1.090E+14	0.58	0.45
2.6250E-02	6.420E+13	1.173E+14	0.55	0.43
2.7500E-02	5.933E+13	1.084E+14	0.71	0.53
2.9000E-02	6.273E+13	1.136E+14	0.51	0.40
3.1000E-02	6.045E+13	1.103E+14	0.52	0.40
3.3000E-02	6.006E+13	1.094E+14	0.53	0.40
3.5000E-02	5.830E+13	1.053E+14	0.58	0.42
3.7000E-02	5.611E+13	1.035E+14	0.52	0.41
3.9000E-02	5.787E+13	1.054E+14	0.53	0.42
4.1250E-02	5.542E+13	1.008E+14	0.51	0.39
4.3750E-02	5.189E+13	9.388E+13	0.51	0.41
4.6250E-02	4.922E+13	8.937E+13	0.60	0.41
4.8750E-02	4.760E+13	8.755E+13	0.54	0.42
5.1250E-02	4.834E+13	8.953E+13	0.52	0.41
5.3750E-02	4.309E+13	7.812E+13	0.57	0.43
5.6250E-02	4.106E+13	7.543E+13	0.57	0.45
5.8750E-02	3.891E+13	7.119E+13	0.59	0.48
6.1500E-02	3.546E+13	6.595E+13	0.58	0.45
6.4500E-02	3.711E+13	6.798E+13	0.56	0.43
6.7500E-02	3.231E+13	6.022E+13	0.60	0.47
7.0500E-02	2.947E+13	5.448E+13	0.65	0.48
7.4000E-02	2.661E+13	4.935E+13	0.60	0.45
7.8000E-02	2.402E+13	4.428E+13	0.66	0.48
8.2000E-02	2.469E+13	4.541E+13	0.60	0.47
8.6000E-02	2.090E+13	3.955E+13	0.66	0.51
9.0000E-02	1.860E+13	3.494E+13	0.72	0.55
9.4000E-02	1.638E+13	3.024E+13	0.75	0.57
9.8000E-02	1.479E+13	2.732E+13	0.82	0.63
1.0250E-01	1.259E+13	2.379E+13	0.79	0.60
1.0750E-01	1.138E+13	2.145E+13	0.84	0.62
1.1250E-01	1.083E+13	2.050E+13	0.84	0.62
1.1750E-01	8.995E+12	1.729E+13	0.90	0.72
1.2375E-01	7.346E+12	1.440E+13	0.96	0.64
1.3125E-01	5.942E+12	1.171E+13	1.04	0.76
1.3875E-01	4.750E+12	9.345E+12	1.12	0.80
1.4625E-01	3.886E+12	7.777E+12	1.29	0.93
1.5500E-01	3.006E+12	6.324E+12	1.19	0.93
1.6500E-01	2.755E+12	5.721E+12	1.56	1.00
1.7500E-01	2.031E+12	4.379E+12	1.51	1.16
1.8500E-01	1.535E+12	3.493E+12	1.71	1.18
1.9500E-01	1.248E+12	2.921E+12	2.15	1.55
2.0500E-01	1.047E+12	2.539E+12	3.01	1.54
2.1500E-01	8.459E+11	2.240E+12	2.48	1.70
2.2500E-01	7.716E+11	1.956E+12	3.08	1.88
2.3500E-01	6.564E+11	1.772E+12	3.14	1.91
2.4750E-01	5.667E+11	1.511E+12	3.13	1.60
2.6250E-01	4.709E+11	1.416E+12	2.83	1.99
2.7500E-01	4.555E+11	1.296E+12	3.70	2.72
2.9000E-01	4.250E+11	1.181E+12	3.52	1.88
3.1000E-01	3.784E+11	1.065E+12	3.34	1.89
3.3000E-01	3.411E+11	9.705E+11	4.17	1.92
3.5000E-01	3.205E+11	9.346E+11	3.49	2.44
3.7000E-01	3.140E+11	8.706E+11	3.44	2.24
3.9000E-01	2.743E+11	8.011E+11	3.52	2.38

4.1250E-01	2.605E+11	7.601E+11	3.57	2.03
4.3750E-01	2.470E+11	6.926E+11	3.68	2.16
4.6250E-01	2.354E+11	6.554E+11	4.77	2.21
4.8750E-01	2.175E+11	6.418E+11	3.78	2.51
5.1250E-01	2.031E+11	6.244E+11	5.03	3.74
5.3750E-01	1.808E+11	5.494E+11	4.47	2.33
5.6250E-01	2.017E+11	5.348E+11	5.32	2.62
5.8750E-01	1.632E+11	5.134E+11	4.42	2.67
6.1500E-01	1.560E+11	4.870E+11	3.65	2.61
6.4500E-01	1.601E+11	4.733E+11	5.39	3.38
6.7500E-01	1.480E+11	4.354E+11	4.37	2.68
7.0500E-01	1.302E+11	4.070E+11	4.34	2.94
7.4000E-01	1.366E+11	4.026E+11	4.07	3.17
7.8000E-01	1.152E+11	3.755E+11	4.06	2.49
8.2000E-01	1.232E+11	3.458E+11	5.76	2.85
8.6000E-01	1.162E+11	3.529E+11	4.92	4.21
9.0000E-01	1.024E+11	3.031E+11	4.45	3.51
9.4000E-01	9.427E+10	2.959E+11	5.93	3.54
9.8000E-01	9.521E+10	2.909E+11	5.87	3.34
1.0250E+00	9.142E+10	2.692E+11	4.85	2.85
1.0750E+00	8.525E+10	2.697E+11	4.46	3.61
1.1250E+00	7.661E+10	2.360E+11	4.65	3.04
1.1750E+00	7.855E+10	2.376E+11	4.40	3.05
1.2375E+00	7.624E+10	2.149E+11	4.70	2.62
1.3125E+00	7.045E+10	2.167E+11	5.85	5.12
1.3875E+00	6.442E+10	1.888E+11	4.59	2.62
1.4625E+00	6.279E+10	1.858E+11	5.08	3.67
1.5500E+00	5.228E+10	1.714E+11	4.29	2.59
1.6500E+00	5.334E+10	1.711E+11	4.77	3.27
1.7500E+00	4.932E+10	1.459E+11	4.19	2.77
1.8500E+00	4.392E+10	1.360E+11	4.77	2.59
1.9500E+00	4.304E+10	1.289E+11	4.57	2.69
2.0500E+00	4.144E+10	1.283E+11	5.02	3.20
2.1500E+00	4.372E+10	1.179E+11	6.43	3.32
2.2500E+00	3.895E+10	1.106E+11	5.70	2.78
2.3500E+00	3.619E+10	1.040E+11	5.39	3.04
2.4750E+00	3.185E+10	1.038E+11	5.46	3.24
2.6250E+00	2.998E+10	9.796E+10	4.14	3.26
2.7500E+00	3.377E+10	9.679E+10	8.43	3.52
2.9000E+00	2.831E+10	8.743E+10	5.29	2.94
3.1000E+00	3.119E+10	8.300E+10	14.26	2.54
3.3000E+00	2.431E+10	7.427E+10	4.13	3.18
3.5000E+00	2.513E+10	6.981E+10	4.59	2.49
3.7000E+00	2.322E+10	6.501E+10	4.17	2.31
3.9000E+00	1.985E+10	6.582E+10	3.98	2.46
4.1250E+00	1.952E+10	6.169E+10	3.89	2.23
4.3750E+00	1.952E+10	5.706E+10	3.90	2.26
4.6250E+00	1.679E+10	5.467E+10	3.82	2.32
4.8750E+00	1.572E+10	5.310E+10	3.99	2.38
5.1250E+00	1.714E+10	4.968E+10	4.20	2.39
5.3750E+00	1.454E+10	4.479E+10	4.28	2.40
5.6250E+00	1.325E+10	4.548E+10	4.34	2.56
5.8750E+00	1.345E+10	4.633E+10	4.73	2.52
6.1500E+00	1.336E+10	4.061E+10	4.17	2.49
6.4500E+00	1.286E+10	3.962E+10	4.45	2.38
6.7500E+00	1.126E+10	3.843E+10	4.38	2.57
7.0500E+00	1.099E+10	3.481E+10	4.62	2.46
7.4000E+00	1.030E+10	3.436E+10	3.91	2.32
7.8000E+00	1.108E+10	3.276E+10	4.23	2.48
8.2000E+00	9.583E+09	3.066E+10	4.26	2.48
8.6000E+00	9.191E+09	2.904E+10	4.10	2.52

9.0000E+00	8.770E+09	2.720E+10	4.58	2.58
9.4000E+00	8.278E+09	2.605E+10	4.18	2.56
9.8000E+00	8.790E+09	2.591E+10	4.49	2.62
1.0250E+01	7.795E+09	2.506E+10	4.22	2.41
1.0750E+01	7.544E+09	2.336E+10	4.53	2.54
1.1250E+01	6.824E+09	2.257E+10	4.41	2.53
1.1750E+01	7.039E+09	2.272E+10	4.75	2.63
1.2375E+01	6.872E+09	2.087E+10	3.97	2.18
1.3125E+01	6.470E+09	1.887E+10	4.23	2.29
1.3875E+01	6.016E+09	1.791E+10	4.06	2.29
1.4625E+01	5.186E+09	1.732E+10	4.06	2.43
1.5500E+01	5.009E+09	1.684E+10	3.88	2.12
1.6500E+01	4.988E+09	1.511E+10	3.93	2.21
1.7500E+01	4.506E+09	1.461E+10	3.84	2.28
1.8500E+01	4.108E+09	1.385E+10	4.00	2.43
1.9500E+01	3.940E+09	1.334E+10	3.97	2.42
2.0500E+01	4.108E+09	1.271E+10	4.66	2.47
2.1500E+01	3.415E+09	1.141E+10	4.45	2.47
2.2500E+01	3.501E+09	1.064E+10	4.48	2.47
2.3500E+01	3.147E+09	1.024E+10	5.04	2.51
2.4750E+01	3.322E+09	1.006E+10	3.78	2.15
2.6250E+01	3.027E+09	9.616E+09	4.11	2.17
2.7500E+01	2.970E+09	9.144E+09	5.40	2.66
2.9000E+01	2.726E+09	8.411E+09	3.88	1.99
3.1000E+01	2.491E+09	8.143E+09	3.89	2.08
3.3000E+01	2.451E+09	7.446E+09	3.95	2.10
3.5000E+01	2.083E+09	6.904E+09	3.82	2.18
3.7000E+01	2.039E+09	6.895E+09	4.16	2.24
3.9000E+01	1.988E+09	6.338E+09	4.15	2.34
4.1250E+01	1.882E+09	6.215E+09	4.12	2.20
4.3750E+01	1.711E+09	5.921E+09	3.93	2.32
4.6250E+01	1.598E+09	5.458E+09	4.26	2.30
4.8750E+01	1.660E+09	5.057E+09	4.60	2.35
5.1250E+01	1.451E+09	4.707E+09	4.27	2.50
5.3750E+01	1.359E+09	4.315E+09	4.65	2.57
5.6250E+01	1.420E+09	4.474E+09	4.90	2.47
5.8750E+01	1.388E+09	4.299E+09	4.63	2.53
6.1500E+01	1.246E+09	3.925E+09	4.55	2.56
6.4500E+01	1.148E+09	3.981E+09	4.32	2.49
6.7500E+01	1.098E+09	3.574E+09	4.66	2.55
7.0500E+01	1.177E+09	3.418E+09	5.24	2.61
7.4000E+01	1.090E+09	3.336E+09	4.15	2.28
7.8000E+01	9.209E+08	3.179E+09	4.47	2.51
8.2000E+01	9.975E+08	3.091E+09	4.78	2.39
8.6000E+01	8.319E+08	2.916E+09	4.58	2.56
9.0000E+01	8.214E+08	2.698E+09	4.24	2.52
9.4000E+01	8.361E+08	2.653E+09	4.58	2.61
9.8000E+01	7.499E+08	2.467E+09	5.09	2.65
1.0250E+02	7.299E+08	2.370E+09	4.53	2.42
1.0750E+02	6.790E+08	2.258E+09	4.27	2.41
1.1250E+02	6.465E+08	2.200E+09	4.52	2.57
1.1750E+02	6.663E+08	2.162E+09	4.60	2.81
1.2375E+02	6.331E+08	2.050E+09	4.23	2.22
1.3125E+02	5.199E+08	1.964E+09	4.14	2.41
1.3875E+02	5.334E+08	1.806E+09	4.02	2.28
1.4625E+02	4.745E+08	1.668E+09	4.08	2.38
1.5500E+02	4.793E+08	1.596E+09	3.52	2.19
1.6500E+02	4.292E+08	1.494E+09	4.10	2.13
1.7500E+02	4.020E+08	1.391E+09	4.08	2.29
1.8500E+02	3.722E+08	1.364E+09	4.02	2.36
1.9500E+02	3.587E+08	1.236E+09	4.23	2.38

2.0500E+02	3.380E+08	1.209E+09	4.43	2.50
2.1500E+02	3.362E+08	1.130E+09	4.91	2.49
2.2500E+02	3.137E+08	1.061E+09	4.71	2.55
2.3500E+02	3.127E+08	1.015E+09	4.83	2.55
2.4750E+02	2.864E+08	9.866E+08	3.94	2.19
2.6250E+02	2.724E+08	9.033E+08	4.05	2.32
2.7500E+02	2.528E+08	9.024E+08	4.77	2.78
2.9000E+02	2.335E+08	8.261E+08	4.05	2.07
3.1000E+02	2.356E+08	7.705E+08	3.71	2.20
3.3000E+02	2.250E+08	7.450E+08	4.00	2.20
3.5000E+02	1.866E+08	6.983E+08	4.18	2.25
3.7000E+02	1.947E+08	6.650E+08	4.17	2.39
3.9000E+02	1.668E+08	6.071E+08	4.27	2.36
4.1250E+02	1.662E+08	5.925E+08	4.15	2.18
4.3750E+02	1.694E+08	5.649E+08	4.45	2.22
4.6250E+02	1.523E+08	5.186E+08	4.51	2.35
4.8750E+02	1.353E+08	4.950E+08	4.20	2.36
5.1250E+02	1.287E+08	4.728E+08	4.41	2.40
5.3750E+02	1.290E+08	4.440E+08	4.64	2.49
5.6250E+02	1.232E+08	4.409E+08	4.69	2.54
5.8750E+02	1.103E+08	3.985E+08	5.02	2.62
6.1500E+02	1.110E+08	3.739E+08	4.81	2.40
6.4500E+02	9.942E+07	3.796E+08	4.57	2.44
6.7500E+02	1.005E+08	3.584E+08	5.27	2.51
7.0500E+02	9.757E+07	3.222E+08	5.06	2.60
7.4000E+02	9.049E+07	3.310E+08	4.30	2.39
7.8000E+02	9.667E+07	3.183E+08	4.33	2.53
8.2000E+02	8.571E+07	2.960E+08	5.00	2.57
8.6000E+02	7.978E+07	2.811E+08	5.08	2.65
9.0000E+02	7.455E+07	2.586E+08	4.79	2.46
9.4000E+02	6.658E+07	2.500E+08	4.78	2.62
9.8000E+02	6.972E+07	2.436E+08	4.82	2.65
1.0250E+03	6.497E+07	2.329E+08	4.66	2.47
1.0750E+03	6.371E+07	2.320E+08	5.17	2.62
1.1250E+03	5.886E+07	2.213E+08	5.06	2.70
1.1750E+03	5.444E+07	2.053E+08	5.05	2.74
1.2375E+03	5.346E+07	1.920E+08	4.47	2.27
1.3125E+03	5.144E+07	1.852E+08	4.46	2.31
1.3875E+03	4.883E+07	1.751E+08	4.57	2.42
1.4625E+03	4.915E+07	1.591E+08	4.75	2.41
1.5500E+03	3.943E+07	1.553E+08	4.06	2.11
1.6500E+03	3.967E+07	1.435E+08	4.36	2.23
1.7500E+03	3.968E+07	1.416E+08	4.64	2.35
1.8500E+03	3.581E+07	1.241E+08	4.53	2.35
1.9500E+03	3.226E+07	1.214E+08	4.45	2.41
2.0500E+03	3.198E+07	1.127E+08	4.99	2.45
2.1500E+03	3.128E+07	1.167E+08	5.15	2.68
2.2500E+03	2.833E+07	1.047E+08	5.13	2.66
2.3500E+03	2.882E+07	1.022E+08	5.34	2.74
2.4750E+03	2.824E+07	9.609E+07	4.16	2.33
2.6250E+03	2.638E+07	8.647E+07	4.42	2.30
2.7500E+03	2.306E+07	8.532E+07	6.00	3.06
2.9000E+03	2.424E+07	8.031E+07	4.10	2.16
3.1000E+03	2.078E+07	7.828E+07	4.42	2.31
3.3000E+03	2.130E+07	7.161E+07	4.76	2.31
3.5000E+03	1.704E+07	7.037E+07	4.36	2.43
3.7000E+03	1.686E+07	6.847E+07	4.46	2.48
3.9000E+03	1.712E+07	6.112E+07	4.52	2.41
4.1250E+03	1.506E+07	5.777E+07	4.37	2.28
4.3750E+03	1.470E+07	5.472E+07	4.39	2.44
4.6250E+03	1.515E+07	5.093E+07	4.84	2.37

4.8750E+03	1.309E+07	4.802E+07	4.59	2.52
5.1250E+03	1.243E+07	4.809E+07	4.72	2.65
5.3750E+03	1.169E+07	4.608E+07	4.73	2.65
5.6250E+03	1.153E+07	4.192E+07	4.65	2.54
5.8750E+03	1.102E+07	3.841E+07	5.37	2.87
6.1500E+03	1.029E+07	3.915E+07	5.18	2.58
6.4500E+03	1.005E+07	3.822E+07	5.19	2.60
6.7500E+03	9.784E+06	3.653E+07	5.24	2.60
7.0500E+03	9.450E+06	3.258E+07	6.13	2.75
7.4000E+03	9.033E+06	3.183E+07	4.72	2.46
7.8000E+03	8.787E+06	2.939E+07	4.92	2.59
8.2000E+03	7.738E+06	3.036E+07	5.00	2.69
8.6000E+03	8.169E+06	2.817E+07	5.11	2.65
9.0000E+03	7.419E+06	2.702E+07	4.92	2.77
9.4000E+03	6.680E+06	2.555E+07	5.56	2.86
9.8000E+03	6.608E+06	2.505E+07	5.45	2.81
1.0250E+04	6.246E+06	2.336E+07	4.72	2.53
1.0750E+04	5.652E+06	2.178E+07	5.16	2.52
1.1250E+04	5.991E+06	2.191E+07	5.02	2.74
1.1750E+04	5.115E+06	2.056E+07	5.11	2.73
1.2375E+04	5.243E+06	1.915E+07	4.09	2.25
1.3125E+04	5.151E+06	1.849E+07	5.04	2.39
1.3875E+04	4.408E+06	1.701E+07	4.73	2.44
1.4625E+04	4.441E+06	1.653E+07	4.52	2.45
1.5500E+04	4.344E+06	1.522E+07	4.55	2.29
1.6500E+04	3.766E+06	1.467E+07	4.31	2.26
1.7500E+04	3.698E+06	1.357E+07	4.55	2.33
1.8500E+04	3.475E+06	1.348E+07	4.72	2.48
1.9500E+04	3.525E+06	1.286E+07	4.78	2.38
2.0500E+04	3.352E+06	1.207E+07	4.96	2.58
2.1500E+04	2.703E+06	1.203E+07	4.73	2.51
2.2500E+04	3.032E+06	1.126E+07	5.63	2.64
2.3500E+04	2.754E+06	1.065E+07	5.61	2.67
2.4750E+04	2.698E+06	1.070E+07	4.51	2.33
2.6250E+04	2.362E+06	9.892E+06	4.28	2.30
2.7500E+04	2.417E+06	9.377E+06	6.06	2.97
2.9000E+04	2.444E+06	9.521E+06	4.06	2.06
3.1000E+04	2.245E+06	9.410E+06	3.96	2.00
3.3000E+04	2.089E+06	8.431E+06	4.07	2.11
3.5000E+04	1.774E+06	6.938E+06	4.08	2.24
3.7000E+04	1.658E+06	6.842E+06	4.65	2.30
3.9000E+04	1.687E+06	6.665E+06	4.64	2.41
4.1250E+04	1.789E+06	6.564E+06	4.37	2.16
4.3750E+04	1.613E+06	6.159E+06	4.53	2.16
4.6250E+04	1.510E+06	6.251E+06	4.45	2.27
4.8750E+04	1.513E+06	5.823E+06	4.40	2.37
5.1250E+04	1.466E+06	5.599E+06	4.41	2.33
5.3750E+04	1.362E+06	5.358E+06	4.79	2.28
5.6250E+04	1.295E+06	5.087E+06	4.50	2.43
5.8750E+04	1.333E+06	5.364E+06	4.75	2.60
6.1500E+04	1.188E+06	4.960E+06	4.28	2.32
6.4500E+04	1.207E+06	4.617E+06	4.34	2.36
6.7500E+04	1.129E+06	4.663E+06	4.76	2.49
7.0500E+04	1.123E+06	4.528E+06	4.75	2.49
7.4000E+04	1.070E+06	4.483E+06	4.15	2.07
7.8000E+04	1.050E+06	4.583E+06	4.24	2.12
8.2000E+04	9.847E+05	4.016E+06	4.30	2.03
8.6000E+04	9.201E+05	3.491E+06	4.25	2.20
9.0000E+04	8.379E+05	3.322E+06	4.27	2.24
9.4000E+04	8.436E+05	3.475E+06	4.40	2.39
9.8000E+04	7.966E+05	3.364E+06	4.55	2.31

1.0250E+05	8.160E+05	3.357E+06	4.05	2.14
1.0750E+05	8.197E+05	3.299E+06	4.26	2.05
1.1250E+05	8.051E+05	3.200E+06	4.12	2.17
1.1750E+05	6.902E+05	3.101E+06	4.18	2.31
1.2375E+05	7.246E+05	2.911E+06	3.71	1.73
1.3125E+05	7.553E+05	3.058E+06	3.63	1.74
1.3875E+05	7.402E+05	2.943E+06	3.43	1.78
1.4625E+05	6.809E+05	2.655E+06	4.00	1.87
1.5500E+05	6.283E+05	2.507E+06	3.35	1.66
1.6500E+05	5.971E+05	2.383E+06	3.66	1.71
1.7500E+05	5.660E+05	2.359E+06	3.56	1.71
1.8500E+05	5.781E+05	2.449E+06	3.42	1.71
1.9500E+05	5.522E+05	2.328E+06	3.34	1.66
2.0500E+05	5.121E+05	2.139E+06	3.52	1.73
2.1500E+05	4.798E+05	2.072E+06	3.42	1.79
2.2500E+05	5.021E+05	2.061E+06	3.37	1.75
2.3500E+05	4.928E+05	2.025E+06	3.61	1.82
2.4750E+05	4.837E+05	1.989E+06	3.06	1.44
2.6250E+05	4.589E+05	1.986E+06	3.03	1.43
2.7500E+05	4.448E+05	2.043E+06	3.23	1.75
2.9000E+05	4.436E+05	1.777E+06	2.78	1.29
3.1000E+05	4.394E+05	1.780E+06	2.56	1.25
3.3000E+05	4.294E+05	1.800E+06	2.61	1.23
3.5000E+05	4.012E+05	1.721E+06	2.54	1.26
3.7000E+05	3.432E+05	1.507E+06	2.66	1.43
3.9000E+05	3.492E+05	1.472E+06	2.82	1.34
4.1250E+05	3.004E+05	1.278E+06	2.83	1.33
4.3750E+05	2.404E+05	1.033E+06	3.32	1.55
4.6250E+05	2.851E+05	1.218E+06	2.97	1.39
4.8750E+05	3.078E+05	1.360E+06	2.53	1.29
5.1250E+05	3.143E+05	1.350E+06	2.51	1.22
5.3750E+05	3.136E+05	1.308E+06	2.57	1.26
5.6250E+05	2.915E+05	1.281E+06	2.78	1.26
5.8750E+05	3.008E+05	1.288E+06	2.59	1.26
6.1500E+05	2.853E+05	1.231E+06	2.26	1.07
6.4500E+05	2.810E+05	1.196E+06	2.30	1.17
6.7500E+05	2.640E+05	1.208E+06	2.25	1.11
7.0500E+05	2.701E+05	1.199E+06	2.44	1.07
7.4000E+05	2.652E+05	1.199E+06	1.97	0.91
7.8000E+05	2.654E+05	1.136E+06	1.98	0.92
8.2000E+05	2.510E+05	1.113E+06	2.04	0.96
8.6000E+05	2.272E+05	9.866E+05	2.23	1.03
9.0000E+05	2.060E+05	9.217E+05	2.17	1.05
9.4000E+05	1.832E+05	8.184E+05	2.23	1.11
9.8000E+05	1.587E+05	7.032E+05	2.62	1.32
1.0500E+06	1.656E+05	7.260E+05	1.69	0.79
1.1500E+06	1.741E+05	7.747E+05	1.41	0.72
1.2500E+06	1.743E+05	7.615E+05	1.46	0.68
1.3500E+06	1.519E+05	6.601E+05	1.60	0.77
1.4500E+06	1.534E+05	6.837E+05	1.32	0.66
1.5500E+06	1.468E+05	6.260E+05	1.56	0.66
1.6500E+06	1.334E+05	5.856E+05	1.47	0.72
1.7500E+06	1.290E+05	5.744E+05	1.45	0.70
1.8500E+06	1.160E+05	5.319E+05	1.41	0.73
1.9500E+06	1.075E+05	4.738E+05	1.72	0.75
2.0500E+06	9.681E+04	4.612E+05	1.72	0.74
2.1500E+06	9.532E+04	4.536E+05	1.39	0.73
2.2500E+06	9.374E+04	4.492E+05	1.58	0.72
2.3500E+06	9.996E+04	4.840E+05	1.24	0.61
2.4500E+06	8.852E+04	4.445E+05	1.51	0.66
2.5500E+06	7.274E+04	3.812E+05	1.44	0.73

2.6500E+06	6.898E+04	3.723E+05	1.41	0.72
2.7500E+06	5.999E+04	3.289E+05	1.54	0.63
2.8500E+06	4.939E+04	3.076E+05	1.79	0.73
2.9500E+06	4.114E+04	2.827E+05	1.85	0.77
3.0500E+06	5.758E+04	2.731E+05	1.33	0.75
3.1500E+06	4.670E+04	2.546E+05	2.02	0.83
3.2500E+06	3.642E+04	2.109E+05	2.53	0.89
3.3500E+06	3.027E+04	1.906E+05	2.72	0.97
3.4500E+06	2.701E+04	1.766E+05	2.91	1.03
3.5500E+06	2.444E+04	1.624E+05	2.31	1.09
3.6500E+06	2.655E+04	1.530E+05	3.57	1.14
3.7500E+06	2.362E+04	1.379E+05	3.35	1.21
3.8500E+06	2.557E+04	1.423E+05	2.53	1.05
3.9500E+06	2.677E+04	1.398E+05	2.14	1.11
4.0500E+06	2.793E+04	1.392E+05	1.76	1.04
4.1500E+06	2.723E+04	1.293E+05	2.06	0.93
4.2500E+06	2.247E+04	1.210E+05	2.97	0.93
4.3500E+06	1.818E+04	9.765E+04	2.82	1.24
4.4500E+06	2.143E+04	1.011E+05	2.33	1.29
4.5500E+06	2.129E+04	9.780E+04	2.71	1.36
4.6500E+06	2.083E+04	9.512E+04	2.13	1.24
4.7500E+06	2.125E+04	9.272E+04	2.43	1.01
4.8500E+06	1.860E+04	8.163E+04	2.10	1.13
4.9500E+06	1.800E+04	8.116E+04	3.44	1.06
5.0500E+06	1.661E+04	7.294E+04	2.98	1.13
5.1500E+06	1.342E+04	6.034E+04	2.43	1.29
5.2500E+06	1.629E+04	6.474E+04	5.21	1.14
5.3500E+06	1.135E+04	5.840E+04	1.66	1.37
5.4500E+06	1.287E+04	5.777E+04	3.09	1.31
5.5500E+06	1.119E+04	5.293E+04	2.52	1.96
5.6500E+06	9.483E+03	4.526E+04	2.07	1.72
5.7500E+06	1.023E+04	4.356E+04	4.72	1.31
5.8500E+06	9.765E+03	4.199E+04	5.22	1.55
5.9500E+06	7.576E+03	3.743E+04	1.88	1.74
6.0500E+06	7.867E+03	3.531E+04	3.29	1.29
6.1500E+06	8.010E+03	3.519E+04	8.18	1.80
6.2500E+06	5.620E+03	3.316E+04	2.33	1.84
6.3500E+06	5.168E+03	2.934E+04	3.02	1.98
6.4500E+06	5.884E+03	2.809E+04	1.96	2.18
6.5500E+06	6.650E+03	2.722E+04	3.23	1.52
6.6500E+06	6.302E+03	2.453E+04	7.29	1.73
6.7500E+06	5.654E+03	2.158E+04	8.14	1.36
6.8500E+06	4.591E+03	2.051E+04	1.93	1.67
6.9500E+06	4.824E+03	1.970E+04	2.08	1.44
7.0500E+06	4.941E+03	1.809E+04	3.25	1.98
7.1500E+06	4.414E+03	1.740E+04	3.18	3.13
7.2500E+06	3.825E+03	1.423E+04	4.69	1.65
7.3500E+06	2.461E+03	1.365E+04	3.44	1.49
7.4500E+06	2.444E+03	1.309E+04	5.01	1.90
7.5500E+06	2.349E+03	1.216E+04	4.93	1.76
7.6500E+06	2.025E+03	1.186E+04	3.82	2.60
7.7500E+06	1.757E+03	1.006E+04	11.32	1.80
7.8500E+06	1.470E+03	9.543E+03	4.28	2.66
7.9500E+06	1.615E+03	9.623E+03	4.39	2.19
8.0500E+06	1.539E+03	8.905E+03	4.04	1.91
8.1500E+06	1.757E+03	8.544E+03	11.37	4.39
8.2500E+06	1.561E+03	7.026E+03	4.97	3.01
8.3500E+06	1.416E+03	6.566E+03	5.55	2.05
8.4500E+06	1.386E+03	6.540E+03	4.31	3.22
8.5500E+06	1.231E+03	5.984E+03	2.95	2.29
8.6500E+06	1.171E+03	5.817E+03	3.44	3.13

8.7500E+06	9.855E+02	5.168E+03	4.13	2.74
8.8500E+06	9.451E+02	4.724E+03	3.92	2.53
8.9500E+06	9.051E+02	4.640E+03	3.40	4.69
9.0500E+06	7.398E+02	4.075E+03	3.12	2.61
9.1500E+06	6.995E+02	4.171E+03	3.93	3.74
9.2500E+06	6.206E+02	3.721E+03	3.05	2.45
9.3500E+06	6.812E+02	3.450E+03	6.42	3.91
9.4500E+06	5.921E+02	2.992E+03	4.78	2.71
9.5500E+06	5.448E+02	2.845E+03	5.48	3.57
9.6500E+06	5.281E+02	2.851E+03	4.73	5.11
9.7500E+06	4.887E+02	2.361E+03	6.67	3.29
9.8500E+06	4.579E+02	2.362E+03	7.29	6.03
9.9500E+06	4.802E+02	2.233E+03	9.78	5.38
1.0050E+07	3.991E+02	1.965E+03	7.46	3.64
1.0150E+07	4.121E+02	1.839E+03	8.18	4.55
1.0250E+07	3.545E+02	1.759E+03	6.87	4.00
1.0350E+07	3.824E+02	1.639E+03	9.53	6.17
1.0450E+07	3.372E+02	1.712E+03	6.84	6.41
1.0550E+07	2.848E+02	1.456E+03	6.23	4.52
1.0650E+07	2.630E+02	1.465E+03	5.75	5.32
1.0750E+07	2.541E+02	1.171E+03	8.92	3.68
1.0850E+07	1.896E+02	1.087E+03	5.64	3.55
1.0950E+07	2.056E+02	1.056E+03	10.69	7.24
1.1050E+07	2.129E+02	9.482E+02	12.86	7.48
1.1150E+07	2.063E+02	8.009E+02	13.99	4.23
1.1250E+07	2.266E+02	7.473E+02	27.22	4.01
1.1350E+07	1.399E+02	6.835E+02	8.61	4.03
1.1450E+07	1.527E+02	7.013E+02	16.40	5.26
1.1550E+07	1.192E+02	8.684E+02	8.24	21.25
1.1650E+07	1.233E+02	6.761E+02	9.81	15.86
1.1750E+07	1.135E+02	6.213E+02	11.43	14.27
1.1850E+07	7.317E+01	4.765E+02	5.76	5.32
1.1950E+07	1.000E+02	4.148E+02	12.55	5.05
1.2050E+07	6.100E+01	4.212E+02	5.28	6.67
1.2150E+07	8.844E+01	4.349E+02	12.89	14.45
1.2250E+07	7.137E+01	4.281E+02	8.46	7.69
1.2350E+07	7.721E+01	3.724E+02	10.36	6.86
1.2450E+07	6.800E+01	3.124E+02	18.98	6.07
1.2550E+07	6.372E+01	2.895E+02	19.16	5.31
1.2650E+07	4.802E+01	3.018E+02	12.72	15.14
1.2750E+07	5.771E+01	2.511E+02	18.83	7.10
1.2850E+07	3.734E+01	2.329E+02	10.41	12.21
1.2950E+07	3.763E+01	2.358E+02	12.51	11.89
1.3050E+07	3.399E+01	2.445E+02	17.55	13.52
1.3150E+07	3.302E+01	1.979E+02	15.33	8.88
1.3250E+07	3.030E+01	1.722E+02	13.16	9.67
1.3350E+07	2.725E+01	1.846E+02	11.86	14.78
1.3450E+07	2.262E+01	2.416E+02	14.26	40.39
1.3550E+07	2.067E+01	1.626E+02	10.60	13.74
1.3650E+07	2.242E+01	1.224E+02	18.52	8.49
1.3750E+07	1.728E+01	1.592E+02	11.62	23.44
1.3850E+07	2.367E+01	1.601E+02	25.99	36.38
1.3950E+07	1.240E+01	9.992E+01	7.23	19.43
1.4050E+07	1.701E+01	9.459E+01	21.66	14.09
1.4150E+07	2.061E+01	1.006E+02	27.96	14.76
1.4250E+07	1.393E+01	8.051E+01	21.83	16.73
1.4350E+07	2.487E+01	1.590E+02	31.11	64.52
1.4450E+07	1.288E+01	7.948E+01	16.02	26.81
1.4550E+07	1.069E+01	6.755E+01	14.50	11.47
1.4650E+07	1.109E+01	7.179E+01	20.54	19.15
1.4750E+07	1.255E+01	6.286E+01	29.71	12.57

1.4850E+07	6.533E+01	4.064E+01	86.74	12.31
1.4950E+07	1.295E+01	3.543E+01	41.21	17.91
1.5050E+07	1.789E+01	4.409E+01	72.81	22.16
1.5150E+07	6.514E+00	3.816E+01	20.17	19.66
1.5250E+07	5.422E+00	4.102E+01	20.52	14.81
1.5350E+07	5.153E+00	2.502E+01	11.00	15.35
1.5450E+07	5.830E+00	2.918E+01	19.14	15.60
1.5550E+07	6.978E+00	3.736E+01	30.76	36.92
1.5650E+07	3.752E+00	3.053E+01	19.43	19.58
1.5750E+07	3.593E+00	3.608E+01	31.28	18.15
1.5850E+07	6.237E+00	2.184E+01	49.36	21.92
1.5950E+07	3.822E+00	1.903E+01	23.70	24.57
1.6050E+07	7.772E+00	5.477E+01	49.99	58.70
1.6150E+07	2.575E+00	1.022E+01	23.58	15.62
1.6250E+07	3.990E+00	1.431E+01	28.27	24.76
1.6350E+07	2.646E+00	1.872E+01	22.83	33.37
1.6450E+07	2.405E+00	3.471E+01	27.42	51.58
1.6550E+07	2.104E+00	1.533E+01	27.13	23.91
1.6650E+07	1.265E+00	8.424E+00	17.45	21.95
1.6750E+07	4.899E+00	9.199E+00	67.70	20.32
1.6850E+07	1.727E+00	8.078E+00	36.75	25.97
1.6950E+07	1.046E+00	8.724E+00	36.47	19.88
1.7050E+07	2.134E+00	7.171E+00	34.73	44.64
1.7150E+07	1.007E+00	7.414E+00	22.46	43.30
1.7250E+07	1.137E+00	1.082E+01	23.43	30.33
1.7350E+07	1.597E+00	1.451E+01	56.12	67.28
1.7450E+07	6.217E+00	5.594E+00	80.57	31.85
1.7550E+07	7.757E-01	4.320E+00	27.93	21.35
1.7650E+07	2.068E+00	1.191E+01	50.70	60.22
1.7750E+07	1.159E+00	2.871E+00	54.02	23.13
1.7850E+07	7.844E-01	2.998E+00	39.50	29.17
1.7950E+07	1.609E-01	3.965E+00	46.95	44.60
1.8050E+07	3.759E-01	4.070E+00	31.58	60.35
1.8150E+07	5.411E-01	3.083E+00	37.82	63.97
1.8250E+07	3.565E-01	4.348E+00	32.77	30.79
1.8350E+07	2.103E-01	3.024E+00	43.77	59.92
1.8450E+07	2.583E-01	6.905E+00	34.89	64.24
1.8550E+07	1.684E-01	6.226E+00	37.82	33.84
1.8650E+07	3.969E-01	2.899E+00	36.86	45.12
1.8750E+07	4.960E-01	8.920E-01	31.34	43.80
1.8850E+07	1.013E+00	1.881E+00	53.82	36.86
1.8950E+07	2.237E-01	3.674E-01	39.46	48.52
1.9050E+07	1.142E-01	1.786E+00	52.55	73.07
1.9150E+07	2.197E-01	2.318E+00	63.78	62.66
1.9250E+07	3.065E-01	1.050E+00	43.07	42.05
1.9350E+07	3.474E-01	1.871E+00	67.33	55.15
1.9450E+07	6.610E-01	2.600E+00	80.65	57.12
1.9550E+07	2.337E-01	1.994E-01	48.67	58.94
1.9650E+07	2.397E-02	1.157E+00	100.00	74.31
1.9750E+07	2.397E-02	1.599E+00	100.00	41.23
1.9850E+07	1.829E-01	1.124E-01	59.29	70.71
1.9950E+07	2.771E-02	7.288E-01	100.00	49.02

Table A.2. MultiGroup Neutron Spectra for Fresh RA6 Core in 2 Irradiation Channels (Figure 13-Section 7)

ENERGY (eV)	SPECTRUM1	SPECTRUM2	R1%	R2%
2.5000E-03	1.249E+13	2.296E+13	1.71	1.30
7.5000E-03	3.283E+13	5.933E+13	1.07	0.83
1.2500E-02	4.597E+13	8.489E+13	0.90	0.69
1.7500E-02	5.402E+13	9.813E+13	0.84	0.64
2.2500E-02	5.681E+13	1.043E+14	0.81	0.62
2.7500E-02	5.818E+13	1.074E+14	0.79	0.60
3.2500E-02	5.706E+13	1.040E+14	0.80	0.61
3.8000E-02	6.356E+13	1.162E+14	0.70	0.54
4.5500E-02	4.431E+13	8.057E+13	0.69	0.53
5.4000E-02	4.267E+13	7.971E+13	0.73	0.55
6.2500E-02	3.674E+13	6.685E+13	0.74	0.57
7.3500E-02	2.884E+13	5.296E+13	0.70	0.54
9.0000E-02	1.991E+13	3.638E+13	0.69	0.53
1.2000E-01	9.592E+12	1.825E+13	0.71	0.53
1.6000E-01	3.498E+12	7.140E+12	1.16	0.84
2.0000E-01	1.375E+12	3.143E+12	1.91	1.30
2.3500E-01	7.239E+11	1.983E+12	3.12	1.94
2.6500E-01	4.954E+11	1.463E+12	3.98	2.30
2.9000E-01	4.373E+11	1.186E+12	5.28	3.15
3.1000E-01	3.994E+11	1.073E+12	5.50	3.32
3.3500E-01	3.715E+11	9.557E+11	4.70	2.90
3.7500E-01	2.907E+11	8.420E+11	4.11	2.40
4.5000E-01	2.274E+11	6.922E+11	3.32	1.90
5.6250E-01	1.920E+11	5.248E+11	3.26	1.93
7.0250E-01	1.405E+11	4.185E+11	3.41	1.94
8.1500E-01	1.141E+11	3.272E+11	5.60	3.29
8.8000E-01	1.106E+11	3.197E+11	6.30	3.54
9.3000E-01	1.118E+11	3.058E+11	7.57	4.57
9.6100E-01	1.016E+11	3.094E+11	10.02	6.00
9.8400E-01	9.374E+10	2.854E+11	10.20	6.00
1.0080E+00	1.047E+11	2.626E+11	9.79	6.19
1.0325E+00	1.004E+11	2.949E+11	9.90	5.83
1.0580E+00	7.343E+10	2.367E+11	10.96	6.02
1.0840E+00	9.272E+10	2.525E+11	10.26	6.19
1.1100E+00	8.871E+10	2.471E+11	10.08	6.31
1.1365E+00	7.993E+10	2.428E+11	11.16	5.97
1.2250E+00	7.025E+10	2.179E+11	4.85	2.74
1.4000E+00	6.435E+10	1.905E+11	4.48	2.53
1.8000E+00	4.836E+10	1.517E+11	2.90	1.66
2.3500E+00	3.480E+10	1.121E+11	3.75	2.10
2.9500E+00	2.826E+10	8.804E+10	3.56	2.01
3.6500E+00	2.392E+10	6.958E+10	3.89	2.28
6.9385E+00	1.248E+10	3.871E+10	1.88	1.05
1.2922E+01	6.631E+09	1.946E+10	2.51	1.46
2.1834E+01	3.749E+09	1.166E+10	2.40	1.35
3.7876E+01	2.159E+09	6.709E+09	2.40	1.37
6.1776E+01	1.226E+09	4.132E+09	2.76	1.50
1.1212E+02	7.303E+08	2.343E+09	2.18	1.22
2.5799E+02	3.007E+08	1.016E+09	1.96	1.07
6.3708E+02	1.158E+08	4.069E+08	2.00	1.08
1.1660E+03	6.155E+07	2.049E+08	2.82	1.55
1.8323E+03	3.558E+07	1.315E+08	2.92	1.53
2.8793E+03	2.255E+07	8.743E+07	2.93	1.52
4.5246E+03	1.485E+07	5.508E+07	2.91	1.51
7.3240E+03	9.048E+06	3.371E+07	2.80	1.45
1.2074E+04	5.428E+06	2.092E+07	2.79	1.43
1.9905E+04	3.399E+06	1.306E+07	2.78	1.40

3.2815E+04	2.283E+06	8.352E+06	2.74	1.41
5.4095E+04	1.420E+06	5.488E+06	2.60	1.31
8.9170E+04	9.896E+05	3.857E+06	2.46	1.24
1.4700E+05	6.602E+05	2.741E+06	2.33	1.15
2.4275E+05	4.918E+05	2.075E+06	2.08	1.01
4.0125E+05	3.389E+05	1.352E+06	1.96	0.98
6.6050E+05	2.848E+05	1.230E+06	1.65	0.80
1.0870E+06	1.877E+05	7.590E+05	1.59	0.79
1.7920E+06	1.293E+05	5.327E+05	1.44	0.72
2.9550E+06	6.391E+04	3.024E+05	1.61	0.75
4.8723E+06	1.734E+04	8.759E+04	2.35	1.07
8.0328E+06	2.524E+03	1.321E+04	4.66	2.12

Table A.3. MultiGroup Neutron Spectra for 7 Burnup Steps of E2 irradiation Channel of RA6 Core (Figure 15-Section 7)

ENERGY(eV)	0H	1H	12H	1D	2D	3D	4D	7D
2.5000E-03	1.837E-06	1.818E-06	1.851E-06	1.899E-06	1.924E-06	1.909E-06	1.929E-06	1.803E-06
7.5000E-03	1.424E-05	1.424E-05	1.402E-05	1.507E-05	1.475E-05	1.482E-05	1.503E-05	1.436E-05
1.2500E-02	3.396E-05	3.331E-05	3.407E-05	3.445E-05	3.469E-05	3.477E-05	3.430E-05	3.328E-05
1.7500E-02	5.495E-05	5.467E-05	5.557E-05	5.573E-05	5.766E-05	5.673E-05	5.727E-05	5.399E-05
2.2500E-02	7.510E-05	7.554E-05	7.642E-05	7.692E-05	7.846E-05	7.716E-05	7.879E-05	7.460E-05
2.7500E-02	9.452E-05	9.231E-05	9.539E-05	9.680E-05	9.667E-05	9.851E-05	9.641E-05	9.286E-05
3.2500E-02	1.081E-04	1.067E-04	1.115E-04	1.128E-04	1.135E-04	1.120E-04	1.126E-04	1.087E-04
3.8000E-02	1.413E-04	1.400E-04	1.406E-04	1.448E-04	1.470E-04	1.455E-04	1.448E-04	1.398E-04
4.5500E-02	1.173E-04	1.168E-04	1.183E-04	1.192E-04	1.217E-04	1.211E-04	1.215E-04	1.153E-04
5.4000E-02	1.377E-04	1.362E-04	1.363E-04	1.398E-04	1.409E-04	1.430E-04	1.399E-04	1.361E-04
6.2500E-02	1.337E-04	1.356E-04	1.364E-04	1.375E-04	1.450E-04	1.396E-04	1.395E-04	1.323E-04
7.3500E-02	1.246E-04	1.243E-04	1.268E-04	1.277E-04	1.272E-04	1.311E-04	1.302E-04	1.257E-04
9.0000E-02	1.048E-04	1.051E-04	1.042E-04	1.065E-04	1.081E-04	1.085E-04	1.072E-04	1.033E-04
1.2000E-01	7.010E-05	6.994E-05	7.034E-05	7.167E-05	7.359E-05	7.186E-05	7.262E-05	6.992E-05
1.6000E-01	3.656E-05	3.613E-05	3.644E-05	3.698E-05	3.729E-05	3.658E-05	3.781E-05	3.720E-05
2.0000E-01	2.011E-05	2.014E-05	2.029E-05	2.009E-05	2.103E-05	2.111E-05	2.146E-05	2.046E-05
2.3500E-01	1.491E-05	1.430E-05	1.451E-05	1.559E-05	1.526E-05	1.500E-05	1.516E-05	1.441E-05
2.6500E-01	1.241E-05	1.163E-05	1.222E-05	1.189E-05	1.279E-05	1.240E-05	1.231E-05	1.199E-05
2.9000E-01	1.100E-05	1.110E-05	1.169E-05	1.091E-05	1.282E-05	1.222E-05	1.125E-05	1.082E-05
3.1000E-01	1.064E-05	1.069E-05	1.159E-05	1.114E-05	1.114E-05	1.101E-05	1.037E-05	1.066E-05
3.3500E-01	1.024E-05	1.054E-05	1.035E-05	1.038E-05	1.117E-05	1.024E-05	1.111E-05	1.034E-05
3.7500E-01	1.010E-05	1.028E-05	9.990E-06	1.060E-05	1.021E-05	1.078E-05	9.667E-06	1.012E-05
4.5000E-01	9.968E-06	9.847E-06	9.439E-06	9.534E-06	1.066E-05	9.999E-06	8.898E-06	1.001E-05
5.6250E-01	9.447E-06	9.725E-06	1.014E-05	9.850E-06	1.004E-05	1.063E-05	9.352E-06	9.159E-06
7.0250E-01	9.409E-06	9.254E-06	9.064E-06	9.192E-06	9.184E-06	9.621E-06	9.370E-06	8.946E-06
8.1500E-01	8.532E-06	8.350E-06	8.412E-06	1.045E-05	1.050E-05	9.423E-06	9.017E-06	8.842E-06
8.8000E-01	9.002E-06	8.851E-06	8.090E-06	9.454E-06	9.988E-06	9.647E-06	8.914E-06	8.176E-06
9.3000E-01	9.099E-06	8.750E-06	8.871E-06	7.836E-06	8.314E-06	8.890E-06	1.012E-05	8.404E-06
9.6100E-01	9.515E-06	9.664E-06	7.319E-06	8.839E-06	9.263E-06	8.520E-06	8.135E-06	8.252E-06
9.8400E-01	8.987E-06	8.879E-06	8.808E-06	9.280E-06	8.657E-06	9.172E-06	8.118E-06	8.245E-06
1.0080E+00	8.469E-06	9.660E-06	8.102E-06	8.917E-06	8.337E-06	9.176E-06	9.746E-06	9.854E-06
1.0325E+00	9.743E-06	7.958E-06	7.183E-06	9.645E-06	1.007E-05	1.261E-05	1.042E-05	7.975E-06
1.0580E+00	8.014E-06	8.979E-06	8.658E-06	1.069E-05	9.132E-06	1.122E-05	8.454E-06	7.430E-06
1.0840E+00	8.757E-06	8.620E-06	7.331E-06	1.016E-05	9.921E-06	9.806E-06	1.117E-05	7.305E-06
1.1100E+00	8.778E-06	9.347E-06	7.304E-06	9.089E-06	9.972E-06	9.162E-06	8.302E-06	8.642E-06
1.1365E+00	8.832E-06	9.178E-06	9.047E-06	8.835E-06	8.659E-06	9.864E-06	9.238E-06	9.721E-06
1.2250E+00	8.540E-06	9.032E-06	9.098E-06	9.097E-06	9.411E-06	8.619E-06	8.545E-06	8.780E-06
1.4000E+00	8.533E-06	8.670E-06	8.468E-06	8.698E-06	8.954E-06	8.761E-06	9.149E-06	8.861E-06
1.8000E+00	8.737E-06	8.447E-06	8.990E-06	8.457E-06	8.850E-06	8.979E-06	8.458E-06	8.486E-06
2.3500E+00	8.428E-06	8.533E-06	8.516E-06	8.587E-06	8.418E-06	8.436E-06	8.331E-06	8.489E-06
2.9500E+00	8.311E-06	8.234E-06	8.171E-06	8.400E-06	8.881E-06	8.818E-06	9.049E-06	8.110E-06
3.6500E+00	8.127E-06	8.380E-06	8.292E-06	8.576E-06	8.295E-06	8.689E-06	8.423E-06	7.999E-06
6.9385E+00	8.596E-06	8.651E-06	8.648E-06	8.20E-06	9.096E-06	8.775E-06	9.028E-06	8.583E-06
1.2922E+01	8.047E-06	8.259E-06	7.927E-06	8.359E-06	8.414E-06	8.685E-06	8.894E-06	8.188E-06
2.1834E+01	8.147E-06	8.163E-06	8.387E-06	8.324E-06	8.703E-06	8.587E-06	8.820E-06	8.524E-06
3.7876E+01	8.132E-06	8.137E-06	8.317E-06	8.100E-06	8.865E-06	8.486E-06	7.984E-06	8.207E-06
6.1776E+01	8.169E-06	8.254E-06	8.450E-06	8.658E-06	8.562E-06	8.634E-06	8.528E-06	7.579E-06
1.1212E+02	8.406E-06	8.296E-06	8.353E-06	8.387E-06	8.173E-06	8.945E-06	8.707E-06	8.747E-06
2.5799E+02	8.385E-06	8.516E-06	8.572E-06	8.847E-06	8.842E-06	9.023E-06	8.579E-06	8.392E-06
6.3708E+02	8.296E-06	8.282E-06	8.300E-06	8.732E-06	8.575E-06	8.646E-06	8.782E-06	8.446E-06
1.1660E+03	7.644E-06	7.615E-06	7.899E-06	8.124E-06	8.110E-06	8.384E-06	8.337E-06	7.670E-06
1.8323E+03	7.710E-06	8.076E-06	8.052E-06	8.222E-06	8.276E-06	7.871E-06	7.949E-06	7.936E-06
2.8793E+03	8.055E-06	7.873E-06	7.894E-06	7.942E-06	8.237E-06	8.152E-06	8.067E-06	7.593E-06
4.5246E+03	7.974E-06	7.869E-06	7.898E-06	8.223E-06	8.089E-06	8.159E-06	8.320E-06	7.779E-06
7.3240E+03	7.900E-06	8.004E-06	7.874E-06	7.827E-06	8.132E-06	8.218E-06	8.341E-06	7.937E-06
1.2074E+04	8.083E-06	8.344E-06	8.183E-06	8.182E-06	8.210E-06	8.054E-06	8.194E-06	8.335E-06
1.9905E+04	8.318E-06	8.191E-06	8.430E-06	8.641E-06	8.617E-06	8.810E-06	9.421E-06	8.651E-06
3.2815E+04	8.770E-06	8.773E-06	9.043E-06	9.038E-06	9.536E-06	8.744E-06	8.856E-06	8.909E-06
5.4095E+04	9.500E-06	9.654E-06	1.009E-05	9.831E-06	9.965E-06	9.865E-06	9.902E-06	9.359E-06
8.9170E+04	1.100E-05	1.091E-05	1.094E-05	1.174E-05	1.173E-05	1.136E-05	1.145E-05	1.048E-05
1.4700E+05	1.289E-05	1.278E-05	1.291E-05	1.307E-05	1.369E-05	1.319E-05	1.256E-05	1.305E-05
2.4275E+05	1.612E-05	1.596E-05	1.638E-05	1.643E-05	1.715E-05	1.635E-05	1.611E-05	1.637E-05

4.0125E+05 1.735E-05 1.746E-05 1.770E-05 1.774E-05 1.813E-05 1.863E-05 1.809E-05 1.728E-05
6.6050E+05 2.600E-05 2.615E-05 2.644E-05 2.654E-05 2.784E-05 2.749E-05 2.715E-05 2.630E-05
1.0870E+06 2.640E-05 2.607E-05 2.653E-05 2.723E-05 2.765E-05 2.791E-05 2.779E-05 2.698E-05
1.7920E+06 3.055E-05 3.096E-05 3.176E-05 3.229E-05 3.259E-05 3.221E-05 3.233E-05 3.100E-05
2.9550E+06 2.859E-05 2.827E-05 2.803E-05 2.852E-05 2.995E-05 2.955E-05 2.908E-05 2.808E-05
4.8723E+06 1.366E-05 1.382E-05 1.371E-05 1.389E-05 1.439E-05 1.432E-05 1.392E-05 1.331E-05
8.0328E+06 3.395E-06 3.520E-06 3.747E-06 3.572E-06 3.608E-06 3.599E-06 3.886E-06 3.694E-06

Table A.4. MultiGroup Neutron Spectra for 7 Burnup Steps of E8 irradiation Channel of RA6 Core (Figure 16-Section 7)

ENERGY(eV)	0H	1H	12H	1D	2D	3D	4D	7D
2.5000E-03	9.990E-07	9.919E-07	9.594E-07	1.003E-06	1.036E-06	9.801E-07	1.006E-06	9.930E-07
7.5000E-03	7.880E-06	7.612E-06	7.625E-06	7.727E-06	7.624E-06	7.832E-06	7.919E-06	7.712E-06
1.2500E-02	1.839E-05	1.848E-05	1.831E-05	1.835E-05	1.848E-05	1.826E-05	1.808E-05	1.850E-05
1.7500E-02	3.025E-05	2.954E-05	2.994E-05	3.015E-05	2.966E-05	3.024E-05	2.956E-05	2.998E-05
2.2500E-02	4.090E-05	4.088E-05	4.199E-05	4.036E-05	4.094E-05	4.159E-05	4.067E-05	4.069E-05
2.7500E-02	5.120E-05	5.051E-05	5.171E-05	5.253E-05	5.176E-05	5.179E-05	5.096E-05	5.145E-05
3.2500E-02	5.934E-05	5.927E-05	6.196E-05	6.035E-05	6.008E-05	6.257E-05	5.962E-05	6.026E-05
3.8000E-02	7.729E-05	7.652E-05	7.928E-05	7.795E-05	7.851E-05	7.731E-05	7.715E-05	7.813E-05
4.5500E-02	6.451E-05	6.430E-05	6.583E-05	6.364E-05	6.306E-05	6.562E-05	6.409E-05	6.376E-05
5.4000E-02	7.374E-05	7.508E-05	7.498E-05	7.522E-05	7.605E-05	7.458E-05	7.554E-05	7.482E-05
6.2500E-02	7.349E-05	7.394E-05	7.531E-05	7.244E-05	7.166E-05	7.564E-05	7.451E-05	7.399E-05
7.3500E-02	6.782E-05	6.871E-05	6.844E-05	6.895E-05	6.903E-05	6.722E-05	6.935E-05	6.914E-05
9.0000E-02	5.733E-05	5.654E-05	5.602E-05	5.585E-05	5.749E-05	5.624E-05	5.677E-05	5.678E-05
1.2000E-01	3.683E-05	3.653E-05	3.672E-05	3.659E-05	3.641E-05	3.681E-05	3.688E-05	3.663E-05
1.6000E-01	1.791E-05	1.780E-05	1.774E-05	1.820E-05	1.798E-05	1.823E-05	1.787E-05	1.790E-05
2.0000E-01	8.801E-06	9.067E-06	9.567E-06	8.903E-06	9.388E-06	9.042E-06	9.323E-06	9.089E-06
2.3500E-01	5.444E-06	5.587E-06	5.934E-06	5.566E-06	5.693E-06	5.285E-06	5.721E-06	5.235E-06
2.6500E-01	4.201E-06	4.314E-06	4.857E-06	5.091E-06	4.448E-06	4.845E-06	4.635E-06	4.988E-06
2.9000E-01	4.058E-06	3.744E-06	3.566E-06	4.163E-06	3.612E-06	4.076E-06	4.868E-06	3.727E-06
3.1000E-01	3.962E-06	3.796E-06	3.952E-06	4.335E-06	2.995E-06	3.737E-06	4.790E-06	3.500E-06
3.3500E-01	3.983E-06	3.601E-06	3.144E-06	3.563E-06	3.440E-06	3.581E-06	3.665E-06	3.768E-06
3.7500E-01	3.488E-06	3.160E-06	3.522E-06	3.450E-06	3.423E-06	3.234E-06	3.484E-06	3.543E-06
4.5000E-01	3.274E-06	3.319E-06	3.533E-06	3.465E-06	2.789E-06	3.654E-06	3.550E-06	3.319E-06
5.6250E-01	3.456E-06	3.300E-06	3.310E-06	3.196E-06	3.480E-06	3.244E-06	3.251E-06	3.275E-06
7.0250E-01	3.158E-06	2.838E-06	3.201E-06	2.864E-06	2.859E-06	3.691E-06	3.043E-06	3.152E-06
8.1500E-01	2.976E-06	3.339E-06	3.808E-06	2.995E-06	3.155E-06	3.211E-06	3.450E-06	3.043E-06
8.8000E-01	3.114E-06	3.382E-06	2.999E-06	3.226E-06	2.880E-06	3.104E-06	2.884E-06	2.825E-06
9.3000E-01	3.329E-06	2.527E-06	3.052E-06	3.052E-06	3.053E-06	3.232E-06	2.434E-06	3.701E-06
9.6100E-01	3.124E-06	2.391E-06	2.691E-06	3.100E-06	2.458E-06	3.351E-06	2.213E-06	3.651E-06
9.8400E-01	2.952E-06	3.405E-06	2.732E-06	3.597E-06	3.373E-06	3.146E-06	2.594E-06	3.078E-06
1.0080E+00	3.377E-06	2.860E-06	3.437E-06	1.709E-06	3.584E-06	1.992E-06	2.814E-06	2.775E-06
1.0325E+00	3.318E-06	2.909E-06	3.213E-06	3.454E-06	2.220E-06	2.971E-06	3.599E-06	2.711E-06
1.0580E+00	2.486E-06	2.623E-06	3.276E-06	3.369E-06	3.786E-06	3.744E-06	2.791E-06	3.708E-06
1.0840E+00	3.216E-06	3.113E-06	3.651E-06	2.885E-06	2.380E-06	3.461E-06	2.909E-06	3.825E-06
1.1100E+00	3.151E-06	3.197E-06	2.674E-06	3.267E-06	3.145E-06	2.986E-06	3.653E-06	4.245E-06
1.1365E+00	2.907E-06	4.224E-06	1.878E-06	3.022E-06	2.525E-06	3.412E-06	3.066E-06	2.048E-06
1.2250E+00	2.754E-06	2.991E-06	3.173E-06	3.074E-06	2.870E-06	3.024E-06	3.122E-06	2.462E-06
1.4000E+00	2.883E-06	2.758E-06	2.954E-06	3.094E-06	2.916E-06	2.926E-06	2.859E-06	2.491E-06
1.8000E+00	2.785E-06	2.934E-06	3.012E-06	2.970E-06	2.534E-06	3.053E-06	2.819E-06	2.731E-06
2.3500E+00	2.617E-06	2.727E-06	2.728E-06	2.820E-06	2.734E-06	2.732E-06	3.206E-06	2.532E-06
2.9500E+00	2.668E-06	2.784E-06	2.441E-06	2.520E-06	2.881E-06	2.672E-06	2.352E-06	2.752E-06
3.6500E+00	2.794E-06	2.577E-06	2.768E-06	2.437E-06	2.653E-06	2.380E-06	2.644E-06	2.508E-06
6.9385E+00	2.771E-06	2.724E-06	2.882E-06	2.936E-06	2.751E-06	2.821E-06	2.672E-06	2.840E-06
1.2922E+01	2.742E-06	2.566E-06	2.822E-06	2.652E-06	2.546E-06	2.501E-06	2.788E-06	2.607E-06
2.1834E+01	2.620E-06	2.566E-06	2.470E-06	2.385E-06	2.550E-06	2.338E-06	2.504E-06	2.555E-06
3.7876E+01	2.617E-06	2.516E-06	2.645E-06	2.490E-06	2.405E-06	2.653E-06	2.548E-06	2.495E-06
6.1776E+01	2.423E-06	2.414E-06	2.496E-06	2.577E-06	2.713E-06	2.549E-06	2.513E-06	2.647E-06
1.1212E+02	2.620E-06	2.476E-06	2.403E-06	2.476E-06	2.538E-06	2.503E-06	2.553E-06	2.409E-06
2.5799E+02	2.482E-06	2.497E-06	2.636E-06	2.346E-06	2.527E-06	2.561E-06	2.376E-06	2.493E-06
6.3708E+02	2.362E-06	2.324E-06	2.338E-06	2.522E-06	2.348E-06	2.403E-06	2.398E-06	2.443E-06
1.1660E+03	2.297E-06	2.174E-06	2.349E-06	2.435E-06	2.099E-06	2.062E-06	2.433E-06	2.313E-06
1.8323E+03	2.086E-06	2.181E-06	2.146E-06	2.245E-06	2.204E-06	2.152E-06	2.255E-06	2.328E-06
2.8793E+03	2.077E-06	2.244E-06	2.307E-06	2.282E-06	2.151E-06	2.133E-06	2.346E-06	2.091E-06
4.5246E+03	2.151E-06	2.171E-06	2.004E-06	2.081E-06	2.187E-06	1.989E-06	2.045E-06	2.094E-06
7.3240E+03	2.120E-06	1.997E-06	2.169E-06	2.055E-06	2.052E-06	2.194E-06	2.020E-06	2.187E-06
1.2074E+04	2.097E-06	2.198E-06	2.214E-06	2.158E-06	1.930E-06	2.091E-06	2.167E-06	2.152E-06
1.9905E+04	2.165E-06	2.040E-06	2.251E-06	2.134E-06	2.230E-06	2.148E-06	2.167E-06	2.080E-06
3.2815E+04	2.397E-06	2.106E-06	2.350E-06	2.171E-06	2.178E-06	2.574E-06	2.269E-06	2.080E-06
5.4095E+04	2.458E-06	2.535E-06	2.594E-06	2.316E-06	2.376E-06	2.462E-06	2.523E-06	2.407E-06
8.9170E+04	2.824E-06	2.700E-06	2.869E-06	2.737E-06	2.500E-06	2.833E-06	2.628E-06	2.758E-06
1.4700E+05	3.105E-06	3.209E-06	3.134E-06	3.062E-06	3.290E-06	3.073E-06	3.198E-06	3.352E-06
2.4275E+05	3.820E-06	3.825E-06	3.858E-06	3.993E-06	3.984E-06	3.877E-06	3.719E-06	4.134E-06

4.0125E+05 4.351E-06 4.238E-06 3.963E-06 4.389E-06 4.234E-06 3.956E-06 4.226E-06 3.987E-06
6.6050E+05 6.019E-06 6.337E-06 5.820E-06 6.111E-06 6.229E-06 6.098E-06 6.222E-06 5.844E-06
1.0870E+06 6.529E-06 6.378E-06 6.478E-06 6.125E-06 6.357E-06 6.107E-06 6.487E-06 6.445E-06
1.7920E+06 7.414E-06 7.619E-06 7.582E-06 7.652E-06 7.692E-06 7.607E-06 7.593E-06 7.193E-06
2.9550E+06 6.043E-06 5.753E-06 5.830E-06 5.714E-06 5.891E-06 5.853E-06 5.982E-06 5.709E-06
4.8723E+06 2.704E-06 2.772E-06 2.612E-06 2.909E-06 2.623E-06 2.492E-06 2.836E-06 2.617E-06
8.0328E+06 6.487E-07 7.088E-07 7.411E-07 6.275E-07 5.709E-07 7.294E-07 6.582E-07 6.193E-07