PERHITUNGAN FAKTOR PERLIPATAN NEUTRON PADA KONDISI SUB-KRITIK UNTUK STUDI PARAMETER REAKTOR HTGR DENGAN MENGGUNAKAN PROGRAM WIMSD-5B

(*WINFRITH IMPROVED MULTIGROUP SHEME*) VERSI 5B

Skripsi

Untuk Memenuhi Sebagian Syarat Memperoleh

Gelar Sarjana Strata Satu Sains

Program Studi Fisika

Disusun Oleh :

Sarwiyani

NIM : 05620007

PROGRAM STUDI FISIKA

FAKULTAS SAINS DAN TEKNOLOGI

UNIVERSITAS ISLAM NEGERI SUNAN KALIJAGA

YOGYAKARTA

2010

Universitas Islam Negeri Sunan Kalijaga FM-STUINSK-BM-05-03/RO

SURAT PERSETUJUAN SKRIPSI/TUGAS AKHIR

Hal : Persetujuan Skripsi
Lamp : -

Kepada :
Yth. Dekan Fakultas Sains dan Teknologi
UIN Sunan Kalijaga Yogyakarta
Di Yogyakarta

Assalamu Alaikum wr.wb

Setelah membaca, meneliti, memberikan petunjuk dan mengoreksi serta mengadakan perbaikan seperlunya, maka kami selaku pembimbing berpendapat bahwa skripsi Saudara :

Nama	:	Sarwiyani
NIM	:	05620007
Prodi / smt	:	Fisika / X
Fakultas	:	Saintek
Judul Skripsi	:	Perhitungan Faktor Perlipatan Neutron Pada Kondisi Subkritik Untuk Studi Parameter Reaktor HTGR Dengan Menggunakan Program WIMSD-5B (*Winfrith Improve Multigroup Scheme*) Versi 5B

sudah dapat diajukan kembali kepada Fakultas Sains dan Teknologi Jurusan/Program Studi Fisika UIN Sunan Kalijaga Yogyakarta sebagai salah satu syarat untuk memperoleh gelar Sarjana Strara Satu dalam bidang fisika.

Dengan ini kami mengharap agar skripsi/tugas akhir saudara tersebut di atas dapat segera dimunaqsyahkan . Atas perhatiannya kami ucapkan terima kasih.

Wassalamu Alaikum wr.wb

Yogyakarta, 19 Mei 2010

Pembimbing I	Pembimbing II
Dr. Ir. Tri Wulan Tjiptono	Retno Rahmawati, M. Si.
NIP. 19531214 198309 1 001	NIP. 19801217200642002

Universitas Islam Negeri Sunan Kalijaga FM-UINSK-BM-05-07/R0

PENGESAHAN SKRIPSI/TUGAS AKHIR

Nomor : UIN.02/D.ST/PP.01.1/1521/2010

Skripsi/Tugas Akhir dengan judul	:	Perhitungan Faktor Perlipatan Neutron pada Kondisi Subkritik untuk Studi Parameter Reaktor HTGR dengan Menggunakan Program WIMSD-5B (*Winfrith Improved Multigroup Scheme*) Versi 5B
Yang dipersiapkan dan disusun oleh	:	
Nama	:	Sarwiyani
NIM	:	05620007
Telah dimunaqasyahkan pada	:	2 Juni 2010
Nilai Munaqasyah	:	B

Dan dinyatakan telah diterima oleh Fakultas Sains dan Teknologi UIN Sunan Kalijaga

TIM MUNAQASYAH :

Ketua Sidang

Dr. Ir. Tri Wulan Tjiptono
NIP. 19531214 198309 1 001

Penguji I

Widayanti, M.Si
NIP.19760526 200604 2 005

Penguji II

Nita Handayani, M.Si
NIP. 19820126 200801 2 008

Yogyakarta, 5 Juli 2010
UIN Sunan Kalijaga
Fakultas Sains dan Teknologi
Dekan

KEMENTERIAN AGAMA FAKULTAS SAINS DAN TEKNOLOGI YOGYAKARTA UIN SUNAN KALIJAGA

Dra. Maizer Said Nahdi, M.Si
NIP. 19550427 198403 2 001

SKRIPSI

PERHITUNGAN FAKTOR PERLIPATAN NEUTRON PADA KONDISI SUBKRITIK UNTUK STUDI PARAMETER REAKTOR HTGR DENGAN MENGGUNAKAN PROGRAM WIMSD-5B (*WINFRITH IMPROVED MULTIGROUP SCHEME*) VERSI 5B

Sarwiyani
05620007

Telah disetujui dan disahkan oleh Lembaga Pusat Teknologi Akselerator dan Proses Bahan Badan Tenaga Nuklir Nasional (PTAPB-BATAN) Yogyakarta serta dinyatakan telah memenuhi persyaratan.

Yogyakarta, Juli 2010

Kepala Bidang Reaktor

Ir. Puradwi Ismu Wahyono, DEA
NIP. 19611025 198810 1 001

Pembimbing di PTAPB-BATAN

Dr. Ir. Tri Wulan Tjiptono
NIP. 19531214 198309 1 001

Menyetujui,

Kepala PTAPB-BATAN

PUSAT TEKNOLOGI AKSELERATOR DAN PROSES BAHAN * BADAN TENAGA NUKLIR NASIONAL *

Dr. Ir. Widi Setiawan
NIP. 19581208 198009 1 001

SURAT PERNYATAAN

Yang bertanda tangan di bawah ini:

Nama : Sarwiyani

NIM : 05620007

Program Studi : Fisika

Fakultas : Sains dan Teknologi UIN Sunan Kalijaga Yogyakarta

Dengan ini saya menyatakan bahwa skripsi ini tidak terdapat karya yang pernah diajukan untuk memperoleh gelar kesarjanaan di suatu Perguruan Tinggi, dan sepanjang pengetahuan saya juga tidak terdapat karya atau pendapat yang pernah ditulis atau diterbitkan oleh orang lain, kecuali yang secara tertulis diacu dalam naskah ini dan disebutkan dalam daftar pustaka.

Yogyakarta, 19 Mei 2010

Yang menyatakan

METERAI TEMPEL
PAJAK MEMBANGUN BANGSA
TGL. 20
EAD91AAF175787802
ENAM RIBU RUPIAH
6000

Sarwiyani
NIM. 05620007

MOTTO

" Kebahagiaan, kedamaian dan ketentraman hati senantiasa berawal dari Ilmu Pengetahuan, karena Ilmu mampu menemukan sesuatu yang hilang dan menyingkap sesuatu yang tersembunyi"

"Dengan Ilmu menjadi mudah

Dengan seni kehidupan menjadi indah

Dan dengan agama menjadi terarah dan bermakna

(H. A Mukti Ali)"

PERSEMBAHAN

Dengan penuh rasa syukur kepada Allah SWT dengan segala rasa cinta ini ku persembahkan skripsi ini untuk:

- Ayah dan ibu, terima kasih atas do’a, kasih saying dan bimbingannya selama ini.
- Kakakku (Afik) dan adik-adikku (Ika dan Ali), yang selalu memberiku semangat dan dukungan, aku selalu menyayangi kalian.
- Keluarga besarku terima kasih atas bantuan moril maupun materialnya.
- Seseorang yang special selalu ada dihatiku……., dan selalu memberikan semangat untuk belajar melalui kasih sayangnya.
- Teman-teman kontraan Saphir, Tapal Kuda, Mangkey Kos dan Sahabat-sahabatku yang telah menghadirkan makna di sepanjang hidup penulis.
- Almamaterku Program Studi Fisika UIN Sunan Kalijaga Yogyakarta.

KATA PENGANTAR

Allhamdulillah, puji syukur penulis panjatkan kepada Allah SWT yang telah melimpahkan petujuk dan hidayah-Nya, sehingga penulis dapat menyelesaikan skripsi ini dengan baik. Semoga salam serta sholawat tetap terlimpahkan kepada junjungan kita Nabi Besar Muhammad saw, beserta para keluarga dan sahabatnya, serta para pengikutnya hingga pada akhir zaman nanti.

Karya tulis ini tentunya tidak dapat terselesaikan sesuai dengan yang diharapkan apabila tanpa adanya bantuan, bimbingan, saran dan kritik serta bantuan moral maupun material dari berbagai pihak. Oleh karena itu, dalam kesempatan ini penulis menyampaikan terimakasih sebesar-besarnya kepada:

1. Ibu Dra. Maizer Said Nahdi, M. Si., selaku Dekan Fakultas Sains dan Teknologi UIN Sunan Kalijaga Yogyakarta.
2. Bapak Dr. Ir. Widi Setiawan, selaku kepala PTAPB-BATAN Yogyakarta yang telah memberikan izin selama penelitian.
3. Bapak Thaqibul Fikri Niyartama, M. Si., selaku Ketua Program Studi Fisika yang telah membantu proses perizinan pelaksanaan penelitian.
4. Bapak Dr. Ir. Tri Wulan Tjiptono, selaku pembimbing I yang telah dengan sabar meluangkan waktu dalam membimbing, mengarahkan dan memotivasi dalam penelitian skripsi ini.
5. Ibu Retno Rahmawati, M. Si., selaku pembimbing II yang telah memberikan bimbingan dan saran-saran berharga selama skripsi.

6. Ibu Widayanti, M. Si., selaku penguji I dan Ibu Nita Handayani, M. Si., sebagai penguji II yang telah bersedia meluangkan waktu untuk menguji serta memberikan saran-saran perbaikan untuk skripsi ini.
7. Teman-teman senasib seperjuangan angkatan 2005 Fisika, atas tawa, canda dan ilmu yang selalu mewarnai setiap pertemuan: Afriz, Dewi, Ida, Jaenal, Nia, Nurul, Mirza, Ruchin, Sigit, Umar dan Zidat.
8. Seluruh staf dan karyawan bidang reaktor, PTAPB-BATAN Yogyakarta.
9. Seluruh dosen Fisika di lingkungan UIN Sunan Kalijaga yang telah memberikan ilmunya kepada penulis.
10. Perpustakaan UIN Sunan Kalijaga dan PTAPB-BATAN yang telah memberikan pelayanan dan kesempatan dalam penulisan skripsi.
11. Semua pihak yang telah ikut berjasa dalam penyusunan skripsi ini yang tidak dapat penulis sebutkan satu persatu.

Penulis menyadari masih terdapat banyak kekurangan didalam penulisan skripsi ini, semua itu karena keterbatasan penulis sebagai manusia biasa. Tak ada gading yang tak retak, saran dan kritik yangn konstruktif tetap penulis harapkan untuk perbaikan selanjutnya. Semoga tulisan ini bermanfaat bagi semua.

Yogyakarta, Juni 2010

Penulis

DAFTAR ISI

HALAMAN JUDUL ……. i

PERSETUJUAN PEMBIMBING …… ii

HALAMAN PENGESAHAN ……... iii

PENGESAHAN PTAPB-BATAN …… iv

SURAT PERNYATAAN …….. v

HALAMAN MOTTO ……..... vi

HALAMAN PERSEMBAHAN …… vii

KATA PENGANTAR ……... viii

DAFTAR ISI …….. x

DAFTAR SINGKATAN ……... xiii

DAFTAR GAMBAR ……. xv

DAFTAR TABEL ……. xvi

DAFTAR LAMPIRAN ……. xvii

INTISARI ……... xviii

ABSTRAK ……. xix

BAB I. PENDAHULUAN…… 1

1.1. Latar Belakang Masalah…… 1

1.2. Rumusan Masalah ……. 3

1.3.Batasan Masalah……. 3

1.4. Tujuan penelitian …….. 4

1.5.Manfaat penelitian……..... 4

BAB II. TINJAUAN PUSTAKA ……. 5

2.1. Tinjauan Pustaka …….. 5

2.2. Landasan Teori ……..... 6

2.2.1. Reaksi Nuklir …… 6

2.2.2. Reaktor Inti …….. 7

2.2.3. Neutron ……. 9

2.2.4. Faktor Perlipatan Neutron …… 11

2.2.5. Reaktor Nuklir HTGR ……..... 15

2.2.6. Komponen-komponen Dalam Reaktor Nuklir ……..... 18

2.2.7. Diskripsi Program WIMSD-5B …… 24

BAB III. METODE PENELITIAN ……. 30

3.1. Waktu dan Tempat Penelitian …… 30

3.2. Alat dan Bahan Penelitian 30

3.3. Prosedur Penelitian 31

3.4. Metode Analisa Data 31

3.5. Langkah-langkah Menjalankan Program WIMSD-5B 33

BAB IV. HASIL DAN PEMBAHASAN …….. 34

4.1. Hasil Penelitian 34

4.1.1. Geometri penampang perangkat subkritik ……..... 34

4.1.2. Faktor Perlipatan Neutron (k_{eff}) …….. 36

4.2. Pembahasan ……. 37

BAB V. KESIMPULAN DAN SARAN …… 40

5.1. Kesimpulan ……..……... 40

5.2. Saran ..……. 41

DAFTAR PUSTAKA …… 42

LAMPIRAN ……..... 44

DAFTAR SINGKATAN DAN NOTASI

SINGKATAN

WIMSD-5B : *Winfrith Improved Multigroup Scheme*

HTGR : *The High Temperature Gas-Cooled Reactor*

NOTASI

ρ = massa jenis (gram/cm^3)

N_A = bilangan Avogadro (6,02 . 10^{23} atom.mol^{-1})

A = nomor massa (mol)

σ = tampang lintang mikroskopis (barn = 10^{-24} cm^2)

$\sum_f$ = jumlah neutron yang diserap bahan bakar (U-235)

$\sum_{fa}$ = jumlah neutron yang diserap bahan bakar (U-235,U-235)

$\sum_o$ = jumlah neutron yang diserap oksigen

$\sum_c$ = jumlah neutron yang diserap grafit (carbon)

k_∞ = faktor perlipatan tak terhingga

k_{eff} = faktor perlipatan neutron

η = jumlah neutron rata-rata yang dihasilkan per jumlah neutron yang diserap oleh bahan bakar (tetapan = 2,5)

f = faktor pemakaian termal, yang merupakan fraksi neutron termal yang diserap oleh bahan bakar

p = probabilitas resonansi terlepas, yang merupakan probabilitas sebuah neutron akan mencapai energi termal tanpa teresap (tetapan = 1)

ε = faktor fisi cepat, yang merupakan perbandingan total terhadap fisi termal (tetapan = 1,03)

B^2 = kelengkungan reaktor (*buckling*), yang merupakan fungsi dari ukuran reaktor (cm^{-2})

τ = umur Fermi, yang merupakan fungsi dari bahan moderator (cm^2)

L = penampang difusi termal, yang merupakan fungsi dari koefisien absorpsi makroskopis termal dari bahan initi (cm)

$e^{-B^2\tau}$ = probabilitas tak bocor cepat, yang merupakan probabilitas bahwa sebuah neutron cepat tak akan bocor dalam inti reaktor.

DAFTAR GAMBAR

Gambar 2.1. Skema reaksi nuklir yang ditemukan oleh Hahn dan Strasmann …..... 9

Gambar 2.2. Penampang dimensi perangkat bahan bakar HTGR terhadap sumbu *z* ……...……...…..... 17

Gambar 2.3. Diagram skematis untuk sistem daya HTGR ……. 17

Gambar 2.4. Komponen-komponen dalam reaktor HTGR ……. 23

Gambar 3.1. Diagram alir menjalankan program untuk menentukan harga faktor perlipatan neutron (k_{eff}) …….. 33

Gambar 4.1. *Lay out* geometri perangkat subkritik kisi bujur sangkar terhadap sumbu z ……..... 34

Gambar 4.2. *Lay out* geometri perangkat subkritik kisi *hexagonal* terhadap sumbu z ……. 35

DAFTAR TABEL

Tabel 2.1 Harga η isotop bahan bakar …… 14

Tabel 3.1 Material penyusun reaktor jenis HTGR 30

Tabel 3.2 Diameter penyusun reaktor jenis HTGR 30

DAFTAR LAMPIRAN

Lampiran 1 Listing Program Kisi Bujur Sangkar 44

Lampiran 2 Keluaran (Output) Program WIMSD-5B Susunan Moderator Grafit Kisi Bujur Sangkar 45

Lampiran 3 Listing Program Kisi *Hexagonal* 67

Lampiran 4 Keluaran (Output) Program WIMSD-5B Susunan Kisi *Hexagonal* 68

Lampiran 5 Perhitungan faktor perlipatan neutron secara analitis 89

Lampiran 6 Tabel Spesifikasi Unsur-unsur 91

INTISARI

Perhitungan Faktor Perlipatan Neutron Pada Kondisi Subkritik Untuk Studi Parameter Reaktor HTGR Dengan Menggunakan Program WIMSD-5B (*Winfrith Improved Multigroup Scheme*) Versi 5B

Reaktor HTGR (*High Temperature Gas Reaktor*) merupakan jenis reaktor daya berpendingin gas dengan moderator grafit. Salah satu cara untuk mengkarakterisasi Reaktor HTGR adalah dengan mempelajari karakteristik perangkat subkritik U_3O_8 Moderator Grafit berpendingin Helium (He-3). *The Winfrith Improved Multigroup Scheme* (WIMS) adalah kode umum untuk perhitungan sel reaktor pada berbagai sistem reaktor. Tujuan penelitian ini adalah menghitung faktor perlipatan efektif neutron dari perangkat subkritik U_3O_8 dengan Moderator Grafit pada kondisi subkritik yang menggunakan program WIMSD-5B (*Winfrith Improved Multigroup Scheme*) Versi 5B.

Program WIMSD-5B (*Winfrith Improved Multigroup Scheme*) Versi 5B adalah program komputasi yang dapat digunakan untuk menganalisis fluks neutron yang terdistribusi secara acak. Pada tahap pertama dilakukkan fraksi pengayaan bahan bakar U_3O_8 untuk susunan moderator grafit kisi bujur sangkar dan kisi *hexagonal*. Keduanya mengandung fraksi pengayaan sebesar 0,07%. Tahap kedua yaitu menentukan diameter bahan bakar dan kelongsong.

Setelah dilakukan *running* program terhadap faktor perlipatan neutron pada perangkat subkritik U_3O_8 yang mengandung U-235 fraksi pengayaan sebesar 0,07%, untuk nilai faktor perlipatan neutron (k_{eff}) dengan menggunakan program WIMSD-5B (*Winfrith Improved Multigroup Scheme*) Versi 5B untuk geometri penampang perangkat subkritik U_3O_8 dengan moderator grafit kisi bujur sangkar adalah 0,3653 dan geometri penampang perangkat subkritik U_3O_8 dengan moderator grafit kisi *hexagonal* adalah 0,1568.

Dari hasil perhitungan secara komputasi menggunakan program WIMSD-5B (*Winfrith improved multigroup scheme*) versi 5B ternyata geometri susunan moderator mempengaruhi niali faktor perlipatan neutron (k_{eff}). Dimana nilai faktor perlipatan neutron (k_{eef}) geometri penampang perangkat subkritik U_3O_8 kisi *hexagonal* lebih kecil dari pada geometri penampang perangkat subkritik U_3O_8 kisi bujur sangkar.

Kata kunci : *reaktor HTGR, WIMSD-5B, kisi kubus, hexagonal*

ABSTRACT

Calculation of Neutron multiplication factor Subkritik Conditions For HTGR Reactor Parameters Study Using WIMSD-5B (Winfrith Improved Multigroup Scheme) Version 5B

HTGR Reactor (High Temperature Gas Reactor) is a type of gas-cooled reactor with graphite moderator. One way to characterize the HTGR reactors is to study the characteristics of the device cooled Graphite Moderator subkritik U3O8 Helium (He-3). The Winfrith Improved Multigroup Scheme (WIMS) is a general code for the calculation of reactor cells in a variety of reactor systems. This study aims to calculate the effective neutron multiplication factor of the device with the U3O8 subkritik Moderator subkritik Graphite on condition that use the program WIMSD-5B (Winfrith Improved Multigroup Scheme) Version 5B.

Courses WIMSD-5B (Winfrith Improved Multigroup Scheme) Version 5B is a computational program that can be used to analyze the neutron flux is randomly distributed. In the first stage fuel enrichment dilakukkan fraction of U3O8 for the composition of the moderator graphite lattice square and hexagonal lattice. Both contain the enrichment fraction of 0.07%. The second stage of determining the diameter of the fuel and cladding.

After done running the program on neutron multiplication factor of the device subkritik U3O8 containing fraction of U-235 enrichment of 0.07%, to the value of the neutron multiplication factor (keff) using the program WIMSD-5B (Winfrith Improved Multigroup Scheme) for the geometry section 5B Version U3O8 subkritik device with graphite moderator square lattice is 0.3653 and the cross-sectional geometry of the device with the U3O8 subkritik hexagonal lattice of graphite moderator is 0.1568.

From the results of computational calculations using a program WIMSD-5B (Winfrith improved multigroup scheme) 5B version turns out top-up terminal geometry affect the composition of a moderator of neutron multiplication factor (keff). Where the value of the neutron multiplication factor (keef) device cross-sectional geometry of U3O8 subkritik hexagonal lattice is smaller than on the geometry of the device cross section of square lattice subkritik U3O8.

Keywords: HTGR reactor, WIMSD-5B, the lattice cube, hexagonal

BAB I

PENDAHULUAN

1.1. Latar Belakang Masalah

Ilmu pengetahuan dan teknologi yang berkembang pesat pada saat ini telah dirasakan manfaatnya bagi peningkatan hidup umat manusia. Hal ini dapat terjadi karena ilmu yang dipelajari, diterapkan dan diamalkan untuk kepentingan umat manusia itu sendiri. Perkembangan peradaban manusia berjalan seiring dengan perkembangan pemanfaatan energi dan penggunaan teknologi energi (Wardana, 2004).

Teknologi nuklir adalah teknologi yang melibatkan reaksi dari inti atom (*inti=nuclei*), teknologi nuklir merupakan salah satu bentuk teknologi maju pada saat ini dan perkembangan tenaga nuklir telah diterapkan diberbagai bidang. Beberapa contoh manfaat terknologi nuklir untuk kesejahteraan manusia yaitu dalam bidang pertanian, peternakan, industri, kedokteran dan kelistrikan (Suratman, 2001). Salah satu pemanfaatan teknologi nuklir itu sendiri diwujudkan dalam pembangunan reaktor nuklir. Reaktor nuklir adalah bangunan yang didesain dan didirikan sedemikian sehingga didalamnya dapat terjadi reaksi berantai berdasarkan reaksi pembelahan inti (tempat atau perangkat dimana reaksi nuklir berantai dibuat, diatur dan dijaga kesinambungannya pada laju yang tetap) (Sudarsono, 2008).

Reaktor nuklir merupakan tempat berlangsungnya reaksi nuklir yang terkendali. Berdasarkan kegunaannya, reaktor nuklir dibedakan menjadi dua,

yaitu reaktor penelitian (riset) dan reaktor daya (PLTN). Pada reaktor riset, yang dimanfaatkan adalah radiasi neutron yang dihasilkan dari reaksi nuklir, sedangkan panas yang dihasilkan dibuang ke lingkungan. Sebaliknya pada reaktor daya yang dimanfaatkan adalah uap panas dari reaksi inti dihindarkan ke pendingin primer yang menggunakan uap, kemudian dialirkan ke turbin untuk pembangkit tenaga listrik.

Berdasarkan jenis materi yang digunakan sebagai moderator dan pendingin, reaktor diklasifikasikan menjadi reaktor air ringan (H_2O), reaktor air berat (D_2O) dan reaktor grafit. Berdasarkan tujuannya, diklasifikasikan menjadi reaktor riset, reaktor uji material, dan reaktor daya. Dalam setiap operasinya, reaktor nuklir mengalami tiga kondisi penting, yaitu kondisi subkritis , kritis dan superkritis.

Reaktor HTGR (*High Temperature Gas-Cooled Reactor*) merupakan jenis reaktor daya berpendingin gas dengan moderator grafit. Menurut Sutrisna, et al (2009), terdapat 3 bentuk bahan bakar dari reaktor HTGR, yaitu : (a) Bentuk batang seperti reaktor air ringan; (b) Bentuk blok, dimana didalam lubang blok grafit yang terbentuk segienam dimasukkan batang bahan bakar; (c) Bentuk bola (*pebble bed*), dimana butir bahan bakar berlapis didistribusikan dalam bola grafit.

Salah satu cara untuk mengkarakterisasi Reaktor HTGR adalah dengan mempelajari karakteristik perangkat subkritik U_3O_8 Moderator Grafit berpendingin Helium (He-3). Besarnya fluks neutron pada proses reaksi nuklir terdistribusi secara acak sehingga dapat mempengaruhi massa

subkritis reaktor. Salah satu cara yang dapat digunakan untuk menganalisis fluks neutron yang terdistribusi secara acak tersebut adalah program WIMSD-5B (*Winfrith Improved Multigroup Scheme*) versi 5B. *The Winfrith Improved Multigroup Scheme* (WIMS) adalah kode umum untuk perhitungan sel kisi reaktor pada berbagai sistem reaktor. Hal inilah yang melatar belakangi penulis untuk mengadakan penelitian tentang ”perhitungan faktor perlipatan neutron pada kondisi subkritik untuk studi parameter reaktor HTGR dengan menggunakan program WIMSD-5B (*Winfrith Improved Multigroup Scheme*) versi 5B”.

1.2. Rumusan Masalah

Berdasarkan latar belakang masalah diatas, maka dapat dirumuskan suatu permasalahan :

1. Bagaimana perhitungan faktor perlipatan neutron pada kondisi subkritik untuk studi parameter reaktor HTGR dengan menggunakan program WIMSD-5B (*Winfrith Improved Multigroup Scheme*) versi 5B?
2. Berapa nilai k_{eff} yang diperoleh pada kondisi subkritik untuk studi parameter reaktor HTGR dengan menggunakan program WIMSD-5B (*Winfrith Improved Multigroup Scheme*) versi 5B?

1.3. Batasan Masalah

Penelitian ini dibatasi pada kajian perangkat bahan bakar reaktor jenis HTGR yaitu :

1. Bentuk dimensi susunan grafit kisi bujur sangkar dan kisi *hexagonal.*

2. Menggunakan program WIMSD-5B (*Winfrith Improved Multigroup Sheme*) versi 5B.

1.4. Tujuan Penelitian

Tujuan penelitian ini adalah menghitung faktor perlipatan efektif neutron dari perangkat subkritik Uranium Alam (U_3O_8) dengan Moderator Grafit pada kondisi subkritik yang menggunakan program WIMSD-5B (*Winfrith Improved Multigroup Scheme*) versi 5B.

1.5. Manfaat Penelitian

Manfaat dari penelitian ini adalah:

1. Mendapatkan informasi dimensi perangkat subkritik Uranium Alam dengan Moderator Grafit pada kondisi subkritik.
2. Mengetahui pengaruh susunan geometri penampang perangkat subkritik terhadap nilai k_{eff} (faktor perlipatan neutron) dengan menggunakan program WIMSD-5B (*Winfrith Improved Multigroup Scheme*) versi 5B.
3. Mengetahui karakteristik perangkat subkritik berbahan bakar Uranium Alam dengan Moderator Grafit, sebagai fasilitas studi parameter reaktor HTGR.

BAB V

KESIMPULAN DAN SARAN

5.1. Kesimpulan

Setelah dilakukan penelitian mengenai perhitungan faktor perlipatan neutron pada kondisi subkritik untuk studi parameter reaktor HTGR dengan menggunakan program WIMSD-5B (*Winfrith Improved Multigroup Scheme*) versi 5B dengan bahan bakar U_3O_8 yang mengandung U-235 sebesar 0,07% maka dapat disimpulkan bahwa :

1. Perhitungan faktor perlipatan neutron pada kondisi subkritik untuk studi parameter reaktor HTGR dengan menggunakan program WIMSD-5B (*Winfrith Improved Multigroup Scheme*) versi 5B adalah mensimulasikan partikel yang berinteraksi dengan material- material penyusun reaktor HTGR.
2. Hasil keluaran faktor perlipatan neutron (k_{eff}) dengan menggunakan program WIMSD-5B (*Winfrith Improved Multigroup Sheme*) versi 5B untuk geometri penampang prangkat subkritik U_3O_8 dengan moderator grafit kisi bujur sangkar adalah 0,3653 dan geometri penampang prangkat subkritik U_3O_8 dengan moderator grafit kisi *hexagonal* adalah 0,1568. Hal ini menunjukkan bahwa geometri penampang prangkat subkritik U_3O_8 dengan moderator grafit pada reaktor mempengaruhi nilai faktor perlipatan neutron (k_{eff}). Dimana nilai faktor perlipatan neutron (k_{eff}) susunan kisi *hexagonal* lebih kecil dari pada susunan kisi bujur sangkar.

5.2. Saran

Dari hasil penelitian ini, peneliti menyarankan ada penelitian lanjutan untuk menentukan faktor perlipatan neutron dengan metode program WIMSD-5B yang dibandingkan dengan eksperimen secara langsung pada reaktor jenis HTGR (*High Temperatue Gas-Cooled Reactor*).

DAFTAR PUSTAKA

Abidin, Jaenal. 2009. "Perhitungan Parameter Perangkat Bahan Bakar Reaktor HTGR (*Hight Temperature Gas Reaktor*) Dengan Program MCNP (*Monte Carlo N-Particel*) Versi 4c" Skripsi . Sains dan Teknologi UIN Sunan Kalijaga Yogyakarta.

Akhadi, Drs. Mukhlis. 1997. *Pengantar Teknologi Nuklir*. Jakarta: Rineka Cipta.

_____, 2000. *Dasar-Dasar Proteksi Radiasi.* Jakarta: Rineka Cipta.

Beiser, Athur. 1992. *Konsep Fisika Modern.* Jakarta : Erlangga.

Duderstadt, J. James dan J. Hamilton Lous. 1976. *"Nuclear Reactor Analysis"*. Departement Of Nuclear Engineering. The University of Michigan Ann Arbor. Michigan.

El-Wakil, M. M. 1982. *"Nuclear Energy Conversion"*. ANS Publications. American Nuclear Society.

Glastone, Samuel dan C. Enlund milton. 1952. *" The Elements Of Nucler Reactor Theory"*. D. Van Nostrand Company, Inc. Canada

Glastone, Samuel. 1961. *"Principle Of Nuclear Reactor Engineering*". D. Van Nostrand Company, Inc. Canada

Halsall, MJ. 1986. *The '1986' WIMS Nuclear Data Library*. Reaktor Physics Division: United Kingdom.

Kristina. 2007."Pengaruh Penambahan Thorium Terhadap Faktor Perlipatan Neutron Pada Perangkat Bahan Bakar Nuklir Jenis PWR" Skripsi. Jurusan Fisika FMIPA Universitas Negeri Semarang.

Kilikowaska, T. 2002. WIMSD-5B EXTENTSIONS. Work Performed Within The WIMS-D Library Updata Project Of The International Atomic Energy Agency.

Lamarsh, R. Jhon. 1966. *"Intoduction To Nuclear Reactor Theory*". New York Univercity, Adison Wesley. Canada.

Martua, Afnan. 2009. "Penentuan Faktor Perlipatan Neutron Efektif Bahan Bakar U3si$_2$-Al Dengan Paket Program MCNP" Skripsi. FMIPA UNSUD Puwokerto.

Murray, L. Raymon. 1961. *"introcudtion to Nuclear Engineering*". Prentice Hall. USA.

Prayoto. 1995. "*Pengantar teori Nuklir*". FIPA UGM. Bagian Teknik Nuklir. Fakultas Teknik UGM, Sekip Unit IV, Yogyakarta.

Proceedings of A Technical Committe Metting and Worksop Cracow. 1984. "*Nuclear Heat Aplication International Atomic Energy Agency*". Vienna.

Richardina, Very. 2008. "Studi Parameter Reaktor Berbahan Bakar UO_2 dengan Moderator Grafit Berbentuk Bola dan Pendingin Gas Helium." *Laporan Kerja Praktek di BATAN Yogyakarta.* FMIPA UNDIP.

Rudi. 1998. "Studi Karakteristik Distribusi Daya Termal Teras Reaktor Tipe Per Sebagai Fungsi Fraksi Boron Dalam Racun Dapat Bakar". Tesis. UGM Yogyakarta.

Silvennoien, P. 1976. " *Reactor Core Fuel Manajement*". Pergamon Perss.

Sitompul, Darwin M. Eng., 1989. *Prinsip-prinsip Konversi Energi*. Medan : Fakultas Teknik Universitas Sumatra Utara.

Sudarsono, Budi. 2008. " *Pembangkit Listrik Tenaga Nuklir*". Tangerang. Pusat Pengembangan Informatika nuklir, BATAN.

Suhaemi, Tjiptono. 1982. Proceedings Loka Karya Kimia dan Teknologi Pemurnian Bahan Bakar Nuklir dan Pertemuan Ilmiah Bahan Murni, Fisika Reaktor dan Instrumentasi. "*Desain Perangkat Subkritik*". BATAN.

Suratman. 2001. "*Introduksi Proteksi Radiasi Bagi Siswa/Mahasiswa Praktek* ".Puslitbang Teknologi Maju BATAN, Yogyakarta.

Wardana, Wisnu Arya. 2004. "*Al-Quran dan Energi Nuklir*". Pustaka Pelajar. Yogyakarta.

Lampiran 1

Listing Program Kisi Bujur Sangkar

```
cell 7                                  *cluster
 sequence 2                              *dsn
 ngroup 5 2
 nmesh  22
 nregion 22 5
 nmaterial 4
 preout
 initiate
 annulus 1 1.5 4                                 *fuel
 annulus 2 2.2  2
 annulus 3 2.5 4
 annulus 4 3.2 2
 annulus 5 6.2 1
 annulus 6 6.9 2
 annulus 7 7.2 4
 annulus 8 7.9  2
 annulus 9 10.9  4
 annulus 10 11.6 2
 annulus 11 11.9 1
 annulus 12 12.6 2
 annulus 13 15.6 4
 annulus 14 16.3 2
 annulus 15 16.6 4
 annulus 16 17.3 2
 annulus 17 20.3 1
 annulus 18 21.0 2
 annulus 19 21.3 4
 annulus 20 22.0 2
 annulus 21 25.0 4
 annulus 22 25.7 2          *MODERATOR
 rodsub 1 1 1.845 4          *fuel
 rodsub 1 2 1.9   2          *aluminium
 rodsub 2 1 1.845 4          *fuel
 rodsub 2 2 1.9   2          *aluminium
 rodsub 3 1 1.845 4          *fuel
 rodsub 3 2 1.9   2          *aluminium
 rodsub 4 1 1.845 4          *fuel
 rodsub 4 2 1.9   2          *aluminium
 rodsub 5 1 1.845 4          *fuel
 rodsub 5 2 1.9   2          *aluminium
 array 1 1 6  4.5  1
 array 2 1 12 9   1
 array 3 1 18 14  1
 array 4 1 24 18.5 1
 array 5 1 30 23.5 1
 material 1 6.0 300 1 2235 .84748238.0 .00058 6016 .152 *fuel
 material 2 .0178 300 3 3 100.0                         *helium
 material 3 2,7 300 2 27 51.47                          *aluminium
 material 4 1.60 300 4 2012 100.0                       *graphit
 fewgroups 5 14 28 45  69
 mesh 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 beginc
```

Lampiran 2

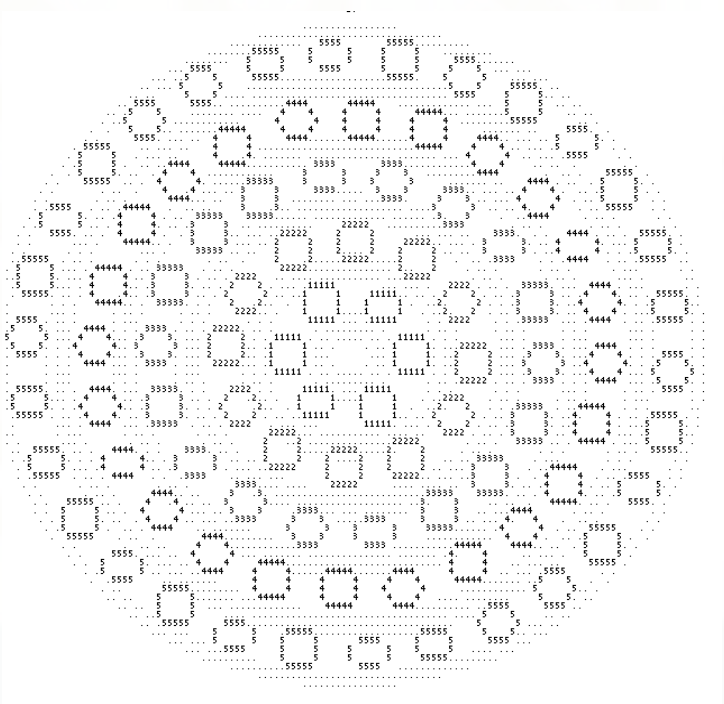
Keluaran (*Output*) Program WIMSD-5B Susunan Moderator Grafit Kisi Bujur Sangkar

```
1

    wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
    wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5
   b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd
   5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wims
   d5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wim
   sd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wi
   msd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b w
   imsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
   wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
    wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5
   b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd
   5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wims
   d5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wim
   sd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wi
   msd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b w
   imsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
   wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
    wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5
   b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd
   5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wims
   d5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wim
   sd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wi
   msd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b w
   imsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
   wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
    wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5
   b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd
   5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wims
   d5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wim
   sd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wi
   msd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b w
   imsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
   wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
    wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5
   b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd
   5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wims
   d5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wim
   sd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wi
   msd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b w
   imsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
1




                         **********************************************************
                         *                                                        *
                         *                   W I M S D - 5 B                      *
                         *                   ---------------                      *
                         *              Version 2003/01 (DOS/Lahey)               *
                         *                                                        *
                         *   This version of WIMSD is based on the original code  *
                         *   written  at  Winfrith  in  1964,  with   subsequent  *
                         *   additions  and  conversion to Fortran 77 and a Unix  *
                         *   operating system.                                    *
                         *   The recent incorporation of features developed by    *
                         *   other users was sponsored by the NEA Data Bank &     *
                         *   carried out by Teresa Kulikowska.                    *
                         *                                                        *

                         *   Users  of  this  code should  be aware  that it was  *
                         *   developed for regular pincell lattices and clusters  *
                         *   of the AGR/CANDU/RBMK type.  Applications  to other  *
                         *   systems ( LWR, HTR, research reactors,  criticality  *
                         *   assessments, etc) are at the discretion of the user. *
                         *   The  authors make no claim for the  accuracy of the  *
                         *   methods when used outside their intended range.      *

                         *   More advanced versions of the WIMS package of codes  *
                         *   are  available from  AEA Technology.  These include  *
                         *   extensive new geometric capabilities, inbuilt Monte  *
                         *   Carlo solution methods,  up-to-date nuclear data, a  *
                         *   great  deal  of  computational  flexibility,  and a  *
                         *   graphical user image. For more information on the    *
                         *   latest range of WIMS products, contact:              *
                         *                                                        *
                         *         The ANSWERS Manager,                           *
                         *         Building A32, Winfrith Technology Centre,      *
                         *         Dorchester, Dorset, DT2 8DH, UK.               *
                         *         Tel (+44) 1305202352  Fax (+44) 1305202746     *
                         *         e-mail  answers@aeat.co.uk                     *
                         *                                                        *
                         *   -------------------------------------------------    *
                         *   WIMS is a Registered Trade-mark of AEA Technology    *
                         *   -------------------------------------------------    *
                         *                                                        *
                         **********************************************************
 files opened in datsets:

 unit  format                access        name
 ----  ------                ------        ----
    5  formatted                           WIMSDINP
    6  formatted                           WIMSDOUT
    2  unformatted                         WIMSDLIB
    1  formatted                           FOR001
    3  unformatted                         FOR003
    4  formatted                           FOR004
    8  formatted                           FOR008
    9  unformatted                         FOR009
   10  unformatted                         FOR010
   12  unformatted                         FOR012
   13  unformatted                         FOR013
   14  formatted                           FOR014
   19  formatted                           FOR019
   20  formatted                           FOR020
1
```

```
000:00:00      entry into main program
    129    69    25    14    13    17    55
             cell 7                              *cluster
             sequence 2                          *dsn
             ngroup 5 2
             nmesh  22
             nregion 22 5
             nmaterial 4
             preout
0available data storage (iq array)  1000001
0unused storage by chain

          1         2         3         4         5         6         7         8
     994281    976785    980905    980246    988359         1    988923         1
          9        10        11        12        13        14        15        16
     988923    994708    992230    972061    992828    992512    989190    993969
0non-essential data storage 972061
000:00:00      entry into chain  1              cpu time =     0.000 secs

1
             initiate
             annulus 1 1.5 4                          *fuel
             annulus 2 2.2  2
             annulus 3 2.5 4
             annulus 4 3.2 2
             annulus 5 6.2 1
             annulus 6 6.9 2
             annulus 7 7.2 4
             annulus 8 7.9  2
             annulus 9 10.9  4
             annulus 10 11.6 2
             annulus 11 11.9 1
             annulus 12 12.6 2
             annulus 13 15.6 4
             annulus 14 16.3 2
             annulus 15 16.6 4
             annulus 16 17.3 2
             annulus 17 20.3 1
             annulus 18 21.0 2
             annulus 19 21.3 4
             annulus 20 22.0 2
             annulus 21 25.0 4
             annulus 22 25.7 2         *MODERATOR
             rodsub 1 1 1.845 4         *fuel
             rodsub 1 2 1.9   2         *aluminium
             rodsub 2 1 1.845 4         *fuel
             rodsub 2 2 1.9   2         *aluminium
             rodsub 3 1 1.845 4         *fuel
             rodsub 3 2 1.9   2         *aluminium
             rodsub 4 1 1.845 4         *fuel
             rodsub 4 2 1.9   2         *aluminium
             rodsub 5 1 1.845 4         *fuel
             rodsub 5 2 1.9   2         *aluminium
             array 1 1 6  4.5  1
             array 2 1 12 9   1
```

```
array 3 1 18 14  1
array 4 1 24 18.5 1
array 5 1 30 23.5 1
material 1 6.0 300 1 2235 .8474 8238.0 .00058 6016 .152 *fuel
material 2 .0178 300 3 3 100.0                          *helium
material 3 2,7 300 2 27 51.47                            *aluminium
material 4 1.60 300 4 2012 100.0                         *graphit
fewgroups 5 14 28 45  69
mesh 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
beginc
```

1 ***** cell type 1 *****



```
1
000:00:00      entry into chain  2              cpu time =     0.000 secs

0isotope number densities for each material
```

	1	2	3	4
temp	300.0000	300.0000	300.0000	300.0000
3001	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3002	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3	0.0000E+00	3.5535E-03	0.0000E+00	0.0000E+00
4	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
7	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
9	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
10	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1010	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1011	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2012	0.0000E+00	0.0000E+00	0.0000E+00	8.0233E-02
2212	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
14	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

6016	3.4343E-02	0.0000E+00	0.0000E+00	0.0000E+00
19	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
23	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
24	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
27	0.0000E+00	0.0000E+00	6.0271E-02	0.0000E+00
29	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
48	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
51	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
52	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1054	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
55	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2056	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
9056	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
58	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1058	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3058	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
8058	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
9058	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1059	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3063	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
84	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
91	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1091	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
93	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
96	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2103	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3109	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2113	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2115	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
121	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
123	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2154	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2155	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2156	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2157	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2158	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
164	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
167	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
176	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2176	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2177	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2178	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2179	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2180	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
178	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
181	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
183	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
197	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
251	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
252	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
253	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
254	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
105	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
135	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
500	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

4083	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4095	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4099	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4101	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5103	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4103	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4105	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5105	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4108	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4109	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4113	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4115	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4127	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4131	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4133	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4134	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6135	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4135	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5135	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4143	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4145	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4147	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5147	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6147	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4148	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5148	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5149	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4149	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4150	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4151	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4152	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4153	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4154	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4155	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4157	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4902	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
207	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2232	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
9233	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1233	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
234	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2235	1.3029E-02	0.0000E+00	0.0000E+00	0.0000E+00
236	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
927	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
8238	8.8051E-06	0.0000E+00	0.0000E+00	0.0000E+00
937	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1939	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
948	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6239	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1240	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1241	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1242	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
951	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
952	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
953	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

```
  1000 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  1003 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  1999 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  2000 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  3000 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  4000 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
000:00:00      entry into chain  3               cpu time =     0.000 secs

 volumes
 0.39750E+02 0.00000E+00 0.00000E+00 0.18304E+03 0.00000E+00 0.40221E+03
 pin cell radii for    90 rods
 0.66458E+00 0.15733E+01
0material     3 not used
1                                                 resonance group  15

0total cross-sections for pin cell regions (except fuel)     3.90736E-02
0dancoff factors 0.19872 0.35737   bell factor 1.16000
0microscopic cross-sections
                        array        cluste       outer
 2235.0  abs         5.96712E+00  5.56860E+00  5.96712E+00
 2235.0  nuf         1.05622E+01  9.85684E+00  1.05622E+01
 8238.0  abs         9.56595E-01  9.56655E-01  9.56595E-01

0p =  0.63608E+00 for each region up to the volume fraction  0.70996E-01 of the modr.
 flux depression factor =  0.80131E+00  0.85916E+00
0         fuel       can       coolant     moderator
 f(p)  8.99591E-01  1.00000E+00  9.55387E-01  9.87210E-01
1                                                 resonance group  16

0total cross-sections for pin cell regions (except fuel)     4.86626E-02
0dancoff factors 0.23770 0.38555   bell factor 1.16000
0microscopic cross-sections
                        array        cluste       outer
 2235.0  abs         7.09519E+00  6.64681E+00  7.09519E+00
 2235.0  nuf         1.23701E+01  1.15884E+01  1.23701E+01
 8238.0  abs         1.23560E+00  1.23571E+00  1.23560E+00

0p =  0.63520E+00 for each region up to the volume fraction  0.77126E-01 of the modr.
 flux depression factor =  0.79068E+00  0.84459E+00
0         fuel       can       coolant     moderator
 f(p)  8.66487E-01  1.00000E+00  9.59221E-01  9.86089E-01
1                                                 resonance group  17

0total cross-sections for pin cell regions (except fuel)     6.01448E-02
0dancoff factors 0.28050 0.41684   bell factor 1.16000
0microscopic cross-sections
                        array        cluste       outer
 2235.0  abs         9.34071E+00  8.71732E+00  9.34071E+00
 2235.0  nuf         1.63028E+01  1.52149E+01  1.63028E+01
 8238.0  abs         9.31384E-01  9.31555E-01  9.31384E-01

0p =  0.58162E+00 for each region up to the volume fraction  0.84035E-01 of the modr.
 flux depression factor =  0.75865E+00  0.81360E+00
0         fuel       can       coolant     moderator
 f(p)  8.37206E-01  1.00000E+00  9.49839E-01  9.81381E-01
```

```
1                                                resonance group  18

0total cross-sections for pin cell regions (except fuel)     7.44831E-02
0dancoff factors 0.32884 0.45260   bell factor 1.16000
0microscopic cross-sections
                        array        cluste       outer
 2235.0  abs         1.17378E+01  1.09706E+01  1.17378E+01
 2235.0  nuf         2.06115E+01  1.92644E+01  2.06115E+01
 8238.0  abs         1.85100E+00  1.85148E+00  1.85100E+00

0p =  0.53801E+00 for each region up to the volume fraction  0.92024E-01 of the modr.
 flux depression factor =  0.73470E+00  0.78681E+00
0         fuel       can       coolant     moderator
 f(p)  8.10196E-01  1.00000E+00  9.41122E-01  9.76089E-01
1                                                resonance group  19

0total cross-sections for pin cell regions (except fuel)     9.22671E-02
0dancoff factors 0.38209 0.49254   bell factor 1.16000
0microscopic cross-sections
                        array        cluste       outer
 2235.0  abs         1.51675E+01  1.41993E+01  1.51675E+01
 2235.0  nuf         2.68945E+01  2.51773E+01  2.68945E+01
 8238.0  abs         2.33250E+00  2.33316E+00  2.33250E+00

0p =  0.48794E+00 for each region up to the volume fraction  0.10109E+00 of the modr.
 flux depression factor =  0.70449E+00  0.75340E+00
0         fuel       can       coolant     moderator
 f(p)  7.76193E-01  1.00000E+00  9.29596E-01  9.68625E-01
1                                                resonance group  20

0total cross-sections for pin cell regions (except fuel)     1.29050E-01
0dancoff factors 0.47365 0.56255   bell factor 1.16000
0microscopic cross-sections
                        array        cluste       outer
 2235.0  abs         2.21526E+01  2.08212E+01  2.21526E+01
 2235.0  nuf         4.04224E+01  3.79925E+01  4.04224E+01
 8238.0  abs         3.13861E+00  3.13913E+00  3.13861E+00

0p =  0.17349E+00 for each region up to the volume fraction  0.11730E+00 of the modr.
 flux depression factor =  0.65356E+00  0.69633E+00
0         fuel       can       coolant     moderator
 f(p)  4.24632E-01  1.00000E+00  6.61898E-01  9.32507E-01
1                                                resonance group  21

0total cross-sections for pin cell regions (except fuel)     2.01274E-01
0dancoff factors 0.60367 0.66497   bell factor 1.16000
0microscopic cross-sections
                        array        cluste       outer
 2235.0  abs         3.19144E+01  3.04741E+01  3.19144E+01
 2235.0  nuf         4.95428E+01  4.73048E+01  4.95428E+01
 8238.0  abs         8.06988E+00  8.07209E+00  8.06988E+00

0p =  0.12885E+00 for each region up to the volume fraction  0.14165E+00 of the modr.
 flux depression factor =  0.61103E+00  0.64088E+00
0         fuel       can       coolant     moderator
```

```
 f(p)  3.56202E-01  1.00000E+00  5.99692E-01  9.08809E-01
1                                                resonance group  22

0total cross-sections for pin cell regions (except fuel)     2.97223E-01
0dancoff factors 0.71618 0.75652   bell factor 1.16000
0microscopic cross-sections
                       array        cluste       outer
 2235.0  abs         5.14295E+01  4.95082E+01  5.14295E+01
 2235.0  nuf         8.02457E+01  7.72368E+01  8.02457E+01
 8238.0  abs         1.67959E+01  1.67976E+01  1.67959E+01

0p =  0.14775E+00 for each region up to the volume fraction  0.16405E+00 of the modr.
 flux depression factor =  0.52844E+00  0.55003E+00
0         fuel       can       coolant     moderator
 f(p)  4.68069E-01  1.00000E+00  6.78695E-01  9.12738E-01
1                                                resonance group  23

0total cross-sections for pin cell regions (except fuel)     3.92340E-01
0dancoff factors 0.78970 0.81784   bell factor 1.16000
0microscopic cross-sections
                       array        cluste       outer
 2235.0  abs         5.16523E+01  5.05129E+01  5.16523E+01
 2235.0  nuf         8.75861E+01  8.56315E+01  8.75861E+01
 8238.0  abs         2.42212E+01  2.42235E+01  2.42212E+01

0p =  0.28964E+00 for each region up to the volume fraction  0.17942E+00 of the modr.
 flux depression factor =  0.54998E+00  0.56339E+00
0         fuel       can       coolant     moderator
 f(p)  5.64325E-01  1.00000E+00  8.50252E-01  8.83061E-01
1                                                resonance group  24

0total cross-sections for pin cell regions (except fuel)     5.03623E-01
0dancoff factors 0.84806 0.86738   bell factor 1.16000
0microscopic cross-sections
                       array        cluste       outer
 2235.0  abs         8.60183E+01  8.42148E+01  8.60183E+01
 2235.0  nuf         1.24012E+02  1.21390E+02  1.24012E+02
 8238.0  abs         7.68115E+01  7.68113E+01  7.68115E+01

0p =  0.14820E+00 for each region up to the volume fraction  0.19205E+00 of the modr.
 flux depression factor =  0.44177E+00  0.45215E+00
0         fuel       can       coolant     moderator
 f(p)  5.70910E-01  1.00000E+00  6.90452E-01  8.09254E-01
1                                                resonance group  25

0total cross-sections for pin cell regions (except fuel)     6.62189E-01
0dancoff factors 0.90136 0.91328   bell factor 1.16000
0microscopic cross-sections
                       array        cluste       outer
 2235.0  abs         1.23158E+02  1.21022E+02  1.23158E+02
 2235.0  nuf         1.67840E+02  1.64915E+02  1.67840E+02
 8238.0  abs         1.09878E+02  1.09876E+02  1.09878E+02

0p =  0.11399E+00 for each region up to the volume fraction  0.20393E+00 of the modr.
 flux depression factor =  0.36860E+00  0.37559E+00
```

```
0         fuel       can       coolant     moderator
 f(p)  5.44877E-01  1.00000E+00  6.02322E-01  7.96068E-01
1                                                resonance group  26

0total cross-sections for pin cell regions (except fuel)     8.55239E-01
0dancoff factors 0.93985 0.94684   bell factor 1.16000
0microscopic cross-sections
                       array        cluste       outer
 2235.0  abs         8.46151E+01  8.41502E+01  8.46151E+01
 2235.0  nuf         1.22598E+02  1.21900E+02  1.22598E+02
 8238.0  abs         3.10076E-01  3.10076E-01  3.10076E-01

0p =  0.19299E+00 for each region up to the volume fraction  0.21273E+00 of the modr.
 flux depression factor =  0.48324E+00  0.48629E+00
0         fuel       can       coolant     moderator
 f(p)  5.02968E-01  1.00000E+00  7.72534E-01  8.01633E-01
1                                                resonance group  27

0total cross-sections for pin cell regions (except fuel)     1.21478E+00
0dancoff factors 0.97480 0.97761   bell factor 1.16000
0microscopic cross-sections
                       array        cluste       outer
 2235.0  abs         7.49044E+01  7.47427E+01  7.49044E+01
 2235.0  nuf         1.21135E+02  1.20873E+02  1.21135E+02
 8238.0  abs         1.41283E+02  1.41285E+02  1.41283E+02

0p =  0.62638E-01 for each region up to the volume fraction  0.22045E+00 of the modr.
 flux depression factor =  0.50362E+00  0.50487E+00
0         fuel       can       coolant     moderator
 f(p)  2.33511E-01  1.00000E+00  4.28153E-01  8.31025E-01
000:00:00      entry into chain  4               cpu time =     0.000 secs

1spectrum calculation

 calculation converged in    90 iterations.

 estimated k-infinity=  0.662360
1flux.

  fuel   9.35707E-02 4.24838E-01 9.63203E-01 1.22749E+00 1.21866E+00 1.25048E+00 9.27443E-01 8.37000E-01 6.47728E-01
         5.07628E-01 4.04779E-01 3.28261E-01 2.69414E-01 2.17048E-01 1.69987E-01 1.21013E-01 9.27236E-02 7.05323E-02
         5.24462E-02 6.44297E-02 3.43146E-02 1.32855E-02 6.58242E-03 4.68857E-03 2.53213E-03 1.87035E-03 1.85309E-03
         2.78168E-04 3.03375E-04 2.38722E-04 2.26146E-04 6.73631E-05 3.28239E-05 3.76105E-06 3.58348E-06 3.82157E-06
         4.12644E-06 4.19793E-06 4.18587E-06 4.27311E-06 3.96256E-06 7.20641E-06 1.05987E-05 1.17549E-05 2.17876E-05
         1.24605E-05 6.14231E-06 1.88047E-06 7.83760E-07 4.10981E-07 3.47461E-07 4.45794E-07 3.69815E-07 3.64280E-07
         2.13455E-07 9.27394E-08 1.86441E-08 6.63953E-09 3.08773E-09 2.08618E-09 1.62231E-09 1.08726E-09 6.26855E-10
         4.92556E-10 3.75819E-10 2.50122E-10 1.51983E-10 6.79897E-11 1.30140E-11
    total    9.95505E+00

  coolnt 8.04652E-02 3.70658E-01 8.53845E-01 1.12507E+00 1.13920E+00 1.17906E+00 9.00827E-01 8.14207E-01 6.39179E-01
         5.06020E-01 4.06194E-01 3.31336E-01 2.72889E-01 2.20846E-01 1.74580E-01 1.25121E-01 9.72067E-02 7.50500E-02
         5.70469E-02 7.31455E-02 4.17087E-02 1.85241E-02 9.31330E-03 8.42748E-03 5.87465E-03 3.75082E-03 4.10855E-03
         6.26885E-04 6.65615E-04 5.14100E-04 6.52448E-04 2.31833E-04 1.82306E-04 3.35140E-05 3.26452E-05 3.29756E-05
         3.33361E-05 3.23558E-05 3.13708E-05 3.16590E-05 2.93323E-05 5.40463E-05 8.28111E-05 9.98797E-05 2.33673E-04
         2.07240E-04 1.84516E-04 1.01727E-04 6.52541E-05 4.57135E-05 4.78036E-05 7.65050E-05 8.38253E-05 1.28690E-04
```

```
        1.56650E-04 2.08806E-04 1.28225E-04 8.69294E-05 5.88949E-05 5.24665E-05 4.90716E-05 4.04641E-05 2.43894E-05
        2.14695E-05 1.65401E-05 1.36524E-05 1.03996E-05 5.34723E-06 1.27871E-06
    total    9.53906E+00

  moder. 3.59783E-02 1.90330E-01 4.16282E-01 7.21185E-01 7.75314E-01 7.76726E-01 7.20514E-01 6.74700E-01 6.26466E-01
        5.85253E-01 5.46676E-01 5.10305E-01 4.76324E-01 4.42612E-01 4.14158E-01 3.47620E-01 3.22431E-01 2.98040E-01
        2.75224E-01 4.77842E-01 4.06098E-01 2.62162E-01 1.62968E-01 1.89447E-01 1.67912E-01 1.28996E-01 1.90039E-01
        3.62385E-02 4.22196E-02 3.59536E-02 5.26939E-02 2.11632E-02 1.78871E-02 3.41069E-03 3.35946E-03 3.42974E-03
        3.50341E-03 3.43743E-03 3.36758E-03 3.43477E-03 3.21668E-03 6.01228E-03 9.45893E-03 1.18368E-02 2.98421E-02
        2.94649E-02 2.92537E-02 1.76002E-02 1.19341E-02 8.68750E-03 9.39159E-03 1.57246E-02 1.83372E-02 3.06125E-02
        4.23273E-02 6.54651E-02 4.58700E-02 3.53454E-02 2.68758E-02 2.48472E-02 2.54910E-02 2.17927E-02 1.54519E-02
        1.45727E-02 1.39648E-02 1.17000E-02 8.56366E-03 6.36863E-03 2.94941E-03
    total    1.19647E+01
000:00:00      entry into chain  5               cpu time =     0.000 secs

000:00:00      entry into chain  6               cpu time =     0.000 secs

1   d s n (hps)
 method 2
0 total fissions               2.6305838E+01    eigenvalue   1.7637700E+00  k-effective   5.6696737E-01
 fission source convergence   1.4855924E-05    rate of fission source convergence        2.5840494E-01
0 total fissions               2.6305853E+01    eigenvalue   1.7637722E+00  k-effective   5.6696665E-01
 fission source convergence   4.5366464E-06    rate of fission source convergence        3.0537626E-01
0 total fissions               2.6305870E+01    eigenvalue   1.7637731E+00  k-effective   5.6696635E-01
 fission source convergence   1.1181869E-06    rate of fission source convergence        2.4647874E-01

1starting at the centre of the system
 volumes
  2.2500000E+00  2.5900002E+00  1.4099998E+00  3.9900002E+00  2.8199997E+01  9.1700039E+00  4.2299957E+00
1.0570004E+01
  5.6399990E+01  1.5750017E+01  7.0499821E+00  1.7150019E+01  8.4600029E+01  2.2329933E+01  9.8700371E+00
2.3729961E+01
  1.1280000E+02  2.8910030E+01  1.2689967E+01  3.0310032E+01  1.4100000E+02
0flux density each zone
 group     1
  1.7559251E+00  1.7995210E+00  1.8183067E+00  1.8688554E+00  1.8502735E+00  1.7563733E+00  1.7075251E+00
1.6686463E+00
  1.6865664E+00  1.7592731E+00  1.7869729E+00  1.7493099E+00  1.6714743E+00  1.6407992E+00  1.6693879E+00
1.7061682E+00
  1.6848688E+00  1.6217188E+00  1.5828868E+00  1.5495052E+00  1.4882884E+00
 group     2
  3.6859732E+00  3.6776125E+00  3.6822817E+00  3.7041836E+00  3.6932385E+00  3.6533289E+00  3.6368828E+00
3.6299708E+00
  3.6326778E+00  3.6410789E+00  3.6433716E+00  3.6373043E+00  3.6114616E+00  3.5901680E+00  3.5956326E+00
3.6075041E+00
  3.5939758E+00  3.5674436E+00  3.5541971E+00  3.5449569E+00  3.5454671E+00
 group     3
  6.1354214E-01  5.5767715E-01  5.5383009E-01  5.7536286E-01  6.0264456E-01  6.0272974E-01  6.0031557E-01
6.2690920E-01
  6.3258427E-01  5.9504467E-01  5.7878494E-01  6.0848373E-01  6.6591322E-01  6.8732268E-01  6.7583597E-01
6.8606311E-01
  7.3203021E-01  7.6358688E-01  7.6802284E-01  7.9320514E-01  9.3481994E-01
 group     4
  3.7908130E-03  7.2764198E-04 -1.5355151E-03  1.4280552E-03  5.2425503E-03  1.4513235E-03 -2.8597559E-03
1.4859874E-03
```

```
  6.1795353E-03  1.5660410E-03 -3.2970696E-03  1.5342550E-03  6.5733963E-03  1.6999895E-03 -3.3837729E-03
1.6574317E-03
  7.3597822E-03  1.5399585E-03 -5.3196875E-03  4.1377475E-03  2.1236058E-02
 group     5
  7.0915243E-04 -1.3275356E-06 -7.8977674E-04  4.7264464E-05  1.1038374E-03  3.6761270E-05 -1.2298914E-03
2.9451683E-05
  1.0808462E-03  7.4505544E-05 -7.4842561E-04  1.0681985E-04  1.5300827E-03 -7.3388792E-06 -2.0870026E-03
1.3669861E-04
  3.4404441E-03 -1.3530896E-04 -5.0488771E-03  4.5269786E-04  8.1235925E-03
 total flux
  6.0599403E+00  6.0355372E+00  6.0520935E+00  6.1498771E+00  6.1525025E+00  6.0139203E+00  5.9406343E+00
5.9270420E+00
  5.9590888E+00  5.9970369E+00  6.0050840E+00  5.9967394E+00  5.9569526E+00  5.9199824E+00  5.9353857E+00
6.0015297E+00
  6.0216756E+00  5.9541540E+00  5.8947387E+00  5.8922577E+00  5.9979348E+00
000:00:00      entry into chain 11              cpu time =     0.000 secs

000:00:00      entry into chain 13              cpu time =     0.000 secs

0number of edit regions =  25, number declared =  36.  see 3rd number in prelude nregion data.
             BUCKLING 0.00097 0.000986
             THERMAL 2
             BEGINC
1 wimsd edit
                    zone                radius              volume              material

                                   0.
                      1            0.15000E+01         0.70686E+01                4
                      2            0.22000E+01         0.81367E+01                2
                      3            0.25000E+01         0.44296E+01                4
                      4            0.32000E+01         0.12535E+02                2
                      5            0.40963E+01         0.20546E+02                1
                      6            0.42445E+01         0.38825E+01                2
                      7            0.62000E+01         0.64164E+02                4
                      8            0.69000E+01         0.28808E+02                2
                      9            0.72000E+01         0.13289E+02                4
                     10            0.79000E+01         0.33207E+02                2
                     11            0.80549E+01         0.77651E+01                2
                     12            0.10900E+02         0.16942E+03                4
                     13            0.11600E+02         0.49480E+02                2
                     14            0.11900E+02         0.22148E+02                1
                     15            0.12600E+02         0.53878E+02                2
                     16            0.12746E+02         0.11648E+02                2
                     17            0.15600E+02         0.25413E+03                4
                     18            0.16300E+02         0.70152E+02                2
                     19            0.16600E+02         0.31008E+02                4
                     20            0.17300E+02         0.74550E+02                2
                     21            0.18040E+02         0.82184E+02                1
                     22            0.18177E+02         0.15530E+02                2
                     23            0.20300E+02         0.25666E+03                4
                     24            0.21000E+02         0.90824E+02                2
                     25            0.21300E+02         0.39867E+02                4
                     26            0.22000E+02         0.95222E+02                2
                     27            0.22140E+02         0.19413E+02                2
                     28            0.25000E+02         0.42355E+03                4
```

```
0flux scale factor 1.210033E-02
1FEW-GROUP REGIONAL AND CELL EDIT

 cross-sections, integrated and averaged fluxes, total events

0REGION  1     material  4        volume  7.068583E+00
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    2.55794E+00  2.93077E-05  0.00000E+00       1.50188E-01  2.12473E-02       3.84172E-01  4.40167E-06
0.00000E+00
    2    1.11858E+00  0.00000E+00  0.00000E+00       3.15269E-01  4.46015E-02       3.52654E-01  0.00000E+00
0.00000E+00
    3    9.29283E-01  3.48599E-06  0.00000E+00       5.24776E-02  7.42406E-03       4.87665E-02  1.82937E-07
0.00000E+00
    4    9.31077E-01  3.64732E-05  0.00000E+00       3.24237E-04  4.58701E-05       3.01889E-04  1.18259E-08
0.00000E+00
    5    9.07854E-01  1.54120E-04  0.00000E+00       6.06554E-05  8.58098E-06       5.50662E-05  9.34820E-09
0.00000E+00
 thermal 9.27417E-01  5.50132E-05  0.00000E+00       3.84892E-04  5.44511E-05       3.56955E-04  2.11741E-08
0.00000E+00
 total   1.51634E+00  8.88597E-06  0.00000E+00       5.18320E-01  7.33273E-02       7.85950E-01  4.60578E-06
0.00000E+00

0REGION  2     material  2        volume  8.136725E+00
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    4.43555E+01  2.72492E-03  0.00000E+00       1.77176E-01  2.17748E-02       7.85871E+00  4.82789E-04
0.00000E+00
    2    2.62364E+01  7.93007E-03  0.00000E+00       3.62087E-01  4.45003E-02       9.49987E+00  2.87137E-03
0.00000E+00
    3    3.15412E+00  1.02899E-01  0.00000E+00       5.49073E-02  6.74808E-03       1.73184E-01  5.64991E-03
0.00000E+00
    4    1.39178E-01  2.39281E+00  0.00000E+00       7.16415E-05  8.80471E-06       9.97089E-06  1.71424E-04
0.00000E+00
    5    4.08195E-02  8.16375E+00  0.00000E+00      -1.30705E-07 -1.60636E-08      -5.33532E-09 -1.06704E-06
0.00000E+00
 thermal 1.39357E-01  2.38226E+00  0.00000E+00       7.15108E-05  8.78864E-06       9.96556E-06  1.70357E-04
0.00000E+00
 total   2.95028E+01  1.54389E-02  0.00000E+00       5.94241E-01  7.30320E-02       1.75318E+01  9.17443E-03
0.00000E+00

0REGION  3     material  4        volume  4.429645E+00
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    2.55794E+00  2.93077E-05  0.00000E+00       9.74615E-02  2.20021E-02       2.49301E-01  2.85637E-06
0.00000E+00
    2    1.11858E+00  0.00000E+00  0.00000E+00       1.97371E-01  4.45568E-02       2.20775E-01  0.00000E+00
0.00000E+00
    3    9.29283E-01  3.48599E-06  0.00000E+00       2.96854E-02  6.70153E-03       2.75861E-02  1.03483E-07
0.00000E+00
    4    9.31077E-01  3.64732E-05  0.00000E+00      -8.23039E-05 -1.85802E-05      -7.66313E-05 -3.00189E-09
0.00000E+00
```

```
    5    9.07854E-01  1.54120E-04  0.00000E+00      -4.23322E-05 -9.55656E-06      -3.84314E-05 -6.52423E-09
0.00000E+00
 thermal 9.23189E-01  7.64315E-05  0.00000E+00      -1.24636E-04 -2.81368E-05      -1.15063E-04 -9.52612E-09
0.00000E+00
 total   1.53378E+00  9.09492E-06  0.00000E+00       3.24393E-01  7.32323E-02       4.97547E-01  2.95033E-06
0.00000E+00

OREGION  4     material  2        volume  1.253496E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf          d*flux*vol  absorptions
nu*fissions
    1    4.43555E+01  2.72492E-03  0.00000E+00       2.83463E-01  2.26138E-02       1.25731E+01  7.72413E-04
0.00000E+00
    2    2.62364E+01  7.93007E-03  0.00000E+00       5.61840E-01  4.48218E-02       1.47407E+01  4.45543E-03
0.00000E+00
    3    3.15412E+00  1.02899E-01  0.00000E+00       8.72694E-02  6.96208E-03       2.75258E-01  8.97995E-03
0.00000E+00
    4    1.39178E-01  2.39281E+00  0.00000E+00       2.16603E-04  1.72799E-05       3.01463E-05  5.18290E-04
0.00000E+00
    5    4.08195E-02  8.16375E+00  0.00000E+00       7.16894E-06  5.71916E-07       2.92632E-07  5.85254E-05
0.00000E+00
 thermal 1.36027E-01  2.57769E+00  0.00000E+00       2.23772E-04  1.78519E-05       3.04390E-05  5.76815E-04
0.00000E+00
 total   2.95768E+01  1.58498E-02  0.00000E+00       9.32796E-01  7.44155E-02       2.75891E+01  1.47846E-02
0.00000E+00

OREGION  5     material  1        volume  2.054601E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf          d*flux*vol  absorptions
nu*fissions
    1    2.94726E+00  1.74941E-02  4.46705E-02       6.90512E-01  3.36081E-02       2.03512E+00  1.20799E-02
3.08455E-02
    2    1.36927E+00  2.69844E-02  5.37092E-02       9.22829E-01  4.49152E-02       1.26360E+00  2.49020E-02
4.95644E-02
    3    6.87315E-01  1.82870E-01  3.08974E-01       3.35484E-02  1.63284E-03       2.30583E-02  6.13501E-03
1.03656E-02
    4    4.78473E-01  4.04885E-01  7.12982E-01       6.72385E-06  3.27258E-07       3.21718E-06  2.72239E-06
4.79399E-06
    5    1.89660E-01  1.47043E+00  3.08979E+00       1.67484E-08  8.15167E-10       3.17651E-09  2.46275E-08
5.17492E-08
 thermal 4.77755E-01  4.07533E-01  7.18888E-01       6.74060E-06  3.28074E-07       3.22036E-06  2.74702E-06
4.84574E-06
 total   2.01700E+00  2.61824E-02  5.51221E-02       1.64690E+00  8.01565E-02       3.32179E+00  4.31197E-02
9.07803E-02

OREGION  6     material  2        volume  3.882542E+00
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf          d*flux*vol  absorptions
nu*fissions
    1    4.43555E+01  2.72492E-03  0.00000E+00       1.18574E-01  3.05403E-02       5.25941E+00  3.23105E-04
0.00000E+00
    2    2.62364E+01  7.93007E-03  0.00000E+00       1.70528E-01  4.39217E-02       4.47404E+00  1.35230E-03
0.00000E+00
    3    3.15412E+00  1.02899E-01  0.00000E+00       6.91672E-03  1.78149E-03       2.18162E-02  7.11725E-04
0.00000E+00
```

```
    4    1.39178E-01  2.39281E+00  0.00000E+00       3.97044E-06  1.02264E-06       5.52596E-07  9.50049E-06
0.00000E+00
    5    4.08195E-02  8.16375E+00  0.00000E+00       2.44071E-07  6.28636E-08       9.96283E-09  1.99253E-06
0.00000E+00
 thermal 1.33481E-01  2.72701E+00  0.00000E+00       4.21451E-06  1.08550E-06       5.62559E-07  1.14930E-05
0.00000E+00
 total   3.29544E+01  8.10282E-03  0.00000E+00       2.96023E-01  7.62446E-02       9.75527E+00  2.39862E-03
0.00000E+00

OREGION  7     material  4        volume  6.416435E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf          d*flux*vol  absorptions
nu*fissions
    1    2.55794E+00  2.93077E-05  0.00000E+00       1.17441E+00  1.83032E-02       3.00408E+00  3.44194E-05
0.00000E+00
    2    1.11858E+00  0.00000E+00  0.00000E+00       2.86581E+00  4.46635E-02       3.20564E+00  0.00000E+00
0.00000E+00
    3    9.29283E-01  3.48599E-06  0.00000E+00       6.05572E-01  9.43782E-03       5.62748E-01  2.11102E-06
0.00000E+00
    4    9.31077E-01  3.64732E-05  0.00000E+00       5.60934E-03  8.74214E-05       5.22273E-03  2.04591E-07
0.00000E+00
    5    9.07854E-01  1.54120E-04  0.00000E+00       1.18306E-03  1.84379E-05       1.07404E-03  1.82333E-07
0.00000E+00
 thermal 9.27032E-01  5.69642E-05  0.00000E+00       6.79239E-03  1.05859E-04       6.29677E-03  3.86923E-07
0.00000E+00
 total   1.45699E+00  7.93479E-06  0.00000E+00       4.65259E+00  7.25104E-02       6.77876E+00  3.69173E-05
0.00000E+00

OREGION  8     material  2        volume  2.880842E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf          d*flux*vol  absorptions
nu*fissions
    1    4.43555E+01  2.72492E-03  0.00000E+00       6.12257E-01  2.12527E-02       2.71569E+01  1.66835E-03
0.00000E+00
    2    2.62364E+01  7.93007E-03  0.00000E+00       1.27352E+00  4.42065E-02       3.34126E+01  1.00991E-02
0.00000E+00
    3    3.15412E+00  1.02899E-01  0.00000E+00       2.10106E-01  7.29323E-03       6.62700E-01  2.16198E-02
0.00000E+00
    4    1.39178E-01  2.39281E+00  0.00000E+00       5.05919E-04  1.75615E-05       7.04126E-05  1.21057E-03
0.00000E+00
    5    4.08195E-02  8.16375E+00  0.00000E+00       1.28147E-05  4.44824E-07       5.23088E-07  1.04616E-04
0.00000E+00
 thermal 1.36748E-01  2.53537E+00  0.00000E+00       5.18734E-04  1.80063E-05       7.09357E-05  1.31518E-03
0.00000E+00
 total   2.92083E+01  1.65533E-02  0.00000E+00       2.09640E+00  7.27704E-02       6.12323E+01  3.47024E-02
0.00000E+00

OREGION  9     material  4        volume  1.328892E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf          d*flux*vol  absorptions
nu*fissions
    1    2.55794E+00  2.93077E-05  0.00000E+00       2.74571E-01  2.06616E-02       7.02335E-01  8.04703E-06
0.00000E+00
    2    1.11858E+00  0.00000E+00  0.00000E+00       5.84812E-01  4.40075E-02       6.54159E-01  0.00000E+00
0.00000E+00
```

```
    3    9.29283E-01  3.48599E-06  0.00000E+00       9.65310E-02  7.26402E-03       8.97046E-02  3.36506E-07
0.00000E+00
    4    9.31077E-01  3.64732E-05  0.00000E+00      -4.59850E-04 -3.46040E-05      -4.28156E-04 -1.67722E-08
0.00000E+00
    5    9.07854E-01  1.54120E-04  0.00000E+00      -1.97767E-04 -1.48821E-05      -1.79544E-04 -3.04798E-08
0.00000E+00
 thermal 9.24093E-01  7.18534E-05  0.00000E+00      -6.57617E-04 -4.94861E-05      -6.07699E-04 -4.72520E-08
0.00000E+00
 total   1.51330E+00  8.72675E-06  0.00000E+00       9.55256E-01  7.18836E-02       1.44559E+00  8.33629E-06
0.00000E+00

OREGION 10     material  2        volume  4.097175E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf          d*flux*vol  absorptions
nu*fissions
    1    4.43555E+01  2.72492E-03  0.00000E+00       9.27374E-01  2.26345E-02       4.11341E+01  2.52702E-03
0.00000E+00
    2    2.62364E+01  7.93007E-03  0.00000E+00       1.79447E+00  4.37976E-02       4.70804E+01  1.42302E-02
0.00000E+00
    3    3.15412E+00  1.02899E-01  0.00000E+00       2.63532E-01  6.43205E-03       8.31212E-01  2.71173E-02
0.00000E+00
    4    1.39178E-01  2.39281E+00  0.00000E+00       6.04186E-04  1.47464E-05       8.40892E-05  1.44570E-03
0.00000E+00
    5    4.08195E-02  8.16375E+00  0.00000E+00       1.21961E-05  2.97671E-07       4.97838E-07  9.95658E-05
0.00000E+00
 thermal 1.37231E-01  2.50699E+00  0.00000E+00       6.16383E-04  1.50441E-05       8.45870E-05  1.54527E-03
0.00000E+00
 total   2.98212E+01  1.52110E-02  0.00000E+00       2.98599E+00  7.28792E-02       8.90458E+01  4.54198E-02
0.00000E+00

OREGION 11     material  4        volume  1.694207E+02
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf          d*flux*vol  absorptions
nu*fissions
    1    2.55794E+00  2.93077E-05  0.00000E+00       3.35912E+00  1.98271E-02       8.59242E+00  9.84480E-05
0.00000E+00
    2    1.11858E+00  0.00000E+00  0.00000E+00       7.45258E+00  4.39886E-02       8.33631E+00  0.00000E+00
0.00000E+00
    3    9.29283E-01  3.48599E-06  0.00000E+00       1.34463E+00  7.93664E-03       1.24954E+00  4.68738E-06
0.00000E+00
    4    9.31077E-01  3.64732E-05  0.00000E+00       1.32419E-02  7.81597E-05       1.23292E-02  4.82973E-07
0.00000E+00
    5    9.07854E-01  1.54120E-04  0.00000E+00       2.31698E-03  1.36759E-05       2.10348E-03  3.57093E-07
0.00000E+00
 thermal 9.27619E-01  5.39928E-05  0.00000E+00       1.55588E-02  9.18356E-05       1.44327E-02  8.40066E-07
0.00000E+00
 total   1.49465E+00  8.54226E-06  0.00000E+00       1.21719E+01  7.18442E-02       1.81927E+01  1.03975E-04
0.00000E+00

OREGION 12     material  2        volume  4.948014E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf          d*flux*vol  absorptions
nu*fissions
    1    4.43555E+01  2.72492E-03  0.00000E+00       1.05332E+00  2.12878E-02       4.67206E+01  2.87022E-03
0.00000E+00
```

```
    2    2.62364E+01  7.93007E-03  0.00000E+00       2.18001E+00  4.40583E-02       5.71956E+01  1.72876E-02
0.00000E+00
    3    3.15412E+00  1.02899E-01  0.00000E+00       3.56269E-01  7.20024E-03       1.12371E+00  3.66598E-02
0.00000E+00
    4    1.39178E-01  2.39281E+00  0.00000E+00       9.37630E-04  1.89496E-05       1.30497E-04  2.24357E-03
0.00000E+00
    5    4.08195E-02  8.16375E+00  0.00000E+00       4.46084E-05  9.01542E-07       1.82089E-06  3.64172E-04
0.00000E+00
 thermal 1.34711E-01  2.65489E+00  0.00000E+00       9.82238E-04  1.98512E-05       1.32318E-04  2.60774E-03
0.00000E+00
 total   2.92543E+01  1.65503E-02  0.00000E+00       3.59058E+00  7.25661E-02       1.05040E+02  5.94254E-02
0.00000E+00

OREGION 13     material  1        volume  2.214817E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    2.94726E+00  1.74941E-02  4.46705E-02       4.78909E-01  2.16230E-02       1.41147E+00  8.37810E-03
2.13931E-02
    2    1.36927E+00  2.69844E-02  5.37092E-02       9.76424E-01  4.40860E-02       1.33699E+00  2.63482E-02
5.24430E-02
    3    6.87315E-01  1.82870E-01  3.08974E-01       1.55114E-01  7.00349E-03       1.06612E-01  2.83658E-02
4.79263E-02
    4    4.78473E-01  4.04885E-01  7.12982E-01      -8.83615E-04 -3.98956E-05      -4.22786E-04 -3.57763E-04 -
6.30002E-04
    5    1.89660E-01  1.47043E+00  3.08979E+00      -2.00578E-04 -9.05620E-06      -3.80416E-05 -2.94937E-04 -
6.19745E-04
 thermal 4.25042E-01  6.02014E-01  1.15270E+00      -1.08419E-03 -4.89518E-05      -4.60827E-04 -6.52700E-04 -
1.24975E-03
 total   1.77375E+00  3.87976E-02  7.48822E-02       1.60936E+00  7.26635E-02       2.85461E+00  6.24395E-02
1.20513E-01

OREGION 14     material  2        volume  6.552596E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    4.43555E+01  2.72492E-03  0.00000E+00       1.52234E+00  2.32327E-02       6.75243E+01  4.14827E-03
0.00000E+00
    2    2.62364E+01  7.93007E-03  0.00000E+00       2.87223E+00  4.38335E-02       7.53572E+01  2.27770E-02
0.00000E+00
    3    3.15412E+00  1.02899E-01  0.00000E+00       4.15068E-01  6.33440E-03       1.30917E+00  4.27101E-02
0.00000E+00
    4    1.39178E-01  2.39281E+00  0.00000E+00       1.01158E-03  1.54378E-05       1.40789E-04  2.42051E-03
0.00000E+00
    5    4.08195E-02  8.16375E+00  0.00000E+00       7.04096E-05  1.07453E-06       2.87408E-06  5.74806E-04
0.00000E+00
 thermal 1.32777E-01  2.76835E+00  0.00000E+00       1.08199E-03  1.65124E-05       1.43663E-04  2.99532E-03
0.00000E+00
 total   2.99728E+01  1.50977E-02  0.00000E+00       4.81073E+00  7.34171E-02       1.44191E+02  7.26307E-02
0.00000E+00

OREGION 15     material  4        volume  2.541312E+02
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
```

```
    1    2.55794E+00  2.93077E-05  0.00000E+00       4.99359E+00  1.96497E-02       1.27733E+01  1.46351E-04
0.00000E+00
    2    1.11858E+00  0.00000E+00  0.00000E+00       1.11136E+01  4.37317E-02       1.24314E+01  0.00000E+00
0.00000E+00
    3    9.29283E-01  3.48599E-06  0.00000E+00       2.12322E+00  8.35480E-03       1.97307E+00  7.40151E-06
0.00000E+00
    4    9.31077E-01  3.64732E-05  0.00000E+00       2.11288E-02  8.31413E-05       1.96725E-02  7.70635E-07
0.00000E+00
    5    9.07854E-01  1.54120E-04  0.00000E+00       4.91999E-03  1.93601E-05       4.46664E-03  7.58269E-07
0.00000E+00
 thermal 9.26691E-01  5.86939E-05  0.00000E+00       2.60488E-02  1.02501E-04       2.41392E-02  1.52890E-06
0.00000E+00
 total   1.48999E+00  8.50555E-06  0.00000E+00       1.82564E+01  7.18387E-02       2.72020E+01  1.55281E-04
0.00000E+00

OREGION 16     material  2        volume  7.015156E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    4.43555E+01  2.72492E-03  0.00000E+00       1.39280E+00  1.98542E-02       6.17785E+01  3.79528E-03
0.00000E+00
    2    2.62364E+01  7.93007E-03  0.00000E+00       3.04754E+00  4.34422E-02       7.99565E+01  2.41672E-02
0.00000E+00
    3    3.15412E+00  1.02899E-01  0.00000E+00       5.83439E-01  8.31683E-03       1.84023E+00  6.00354E-02
0.00000E+00
    4    1.39178E-01  2.39281E+00  0.00000E+00       1.44305E-03  2.05704E-05       2.00840E-04  3.45293E-03
0.00000E+00
    5    4.08195E-02  8.16375E+00  0.00000E+00      -6.22966E-06 -8.88029E-08      -2.54291E-07 -5.08574E-05
0.00000E+00
 thermal 1.39604E-01  2.36778E+00  0.00000E+00       1.43682E-03  2.04816E-05       2.00586E-04  3.40208E-03
0.00000E+00
 total   2.85710E+01  1.81882E-02  0.00000E+00       5.02522E+00  7.16337E-02       1.43575E+02  9.13999E-02
0.00000E+00

OREGION 17     material  4        volume  3.100764E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    2.55794E+00  2.93077E-05  0.00000E+00       6.26359E-01  2.02001E-02       1.60219E+00  1.83571E-05
0.00000E+00
    2    1.11858E+00  0.00000E+00  0.00000E+00       1.34909E+00  4.35083E-02       1.50907E+00  0.00000E+00
0.00000E+00
    3    9.29283E-01  3.48599E-06  0.00000E+00       2.53575E-01  8.17784E-03       2.35643E-01  8.83962E-07
0.00000E+00
    4    9.31077E-01  3.64732E-05  0.00000E+00      -1.26960E-03 -4.09448E-05      -1.18210E-03 -4.63064E-08
0.00000E+00
    5    9.07854E-01  1.54120E-04  0.00000E+00      -7.83049E-04 -2.52534E-05      -7.10894E-04 -1.20683E-07
0.00000E+00
 thermal 9.22218E-01  8.13533E-05  0.00000E+00      -2.05265E-03 -6.61982E-05      -1.89299E-03 -1.66990E-07
0.00000E+00
 total   1.50204E+00  8.56504E-06  0.00000E+00       2.22697E+00  7.18201E-02       3.34501E+00  1.90741E-05
0.00000E+00

OREGION 18     material  2        volume  7.454987E+01
0                 cross-sections                          fluxes                              reactions
```

```
  group   diffusion   absorption   nu*fission           rif          raf          d*flux*vol  absorptions
nu*fissions
    1    4.43555E+01  2.72492E-03  0.00000E+00       1.53910E+00  2.06452E-02       6.82674E+01  4.19392E-03
0.00000E+00
    2    2.62364E+01  7.93007E-03  0.00000E+00       3.25425E+00  4.36520E-02       8.53799E+01  2.58064E-02
0.00000E+00
    3    3.15412E+00  1.02899E-01  0.00000E+00       6.18883E-01  8.30159E-03       1.95203E+00  6.36825E-02
0.00000E+00
    4    1.39178E-01  2.39281E+00  0.00000E+00       1.49513E-03  2.00555E-05       2.08089E-04  3.57756E-03
0.00000E+00
    5    4.08195E-02  8.16375E+00  0.00000E+00       1.23313E-04  1.65410E-06       5.03356E-06  1.00669E-03
0.00000E+00
 thermal 1.31683E-01  2.83251E+00  0.00000E+00       1.61845E-03  2.17096E-05       2.13123E-04  4.58426E-03
0.00000E+00
 total   2.87410E+01  1.81511E-02  0.00000E+00       5.41385E+00  7.26205E-02       1.55600E+02  9.82671E-02
0.00000E+00

OREGION 19     material  1        volume  8.218402E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission           rif          raf          d*flux*vol  absorptions
nu*fissions
    1    2.94726E+00  1.74941E-02  4.46705E-02       2.51513E+00  3.06037E-02       7.41277E+00  4.40001E-02
1.12352E-01
    2    1.36927E+00  2.69844E-02  5.37092E-02       3.59210E+00  4.37080E-02       4.91857E+00  9.69308E-02
1.92929E-01
    3    6.87315E-01  1.82870E-01  3.08974E-01       1.63005E-01  1.98341E-03       1.12035E-01  2.98087E-02
5.03641E-02
    4    4.78473E-01  4.04885E-01  7.12982E-01       3.77573E-05  4.59423E-07       1.80658E-05  1.52874E-05
2.69202E-05
    5    1.89660E-01  1.47043E+00  3.08979E+00       2.08806E-07  2.54072E-09       3.96022E-08  3.07036E-07
6.45168E-07
 thermal 4.76884E-01  4.10745E-01  7.26054E-01       3.79661E-05  4.61964E-07       1.81054E-05  1.55944E-05
2.75654E-05
 total   1.98450E+00  2.72325E-02  5.67236E-02       6.27028E+00  7.62956E-02       1.24434E+01  1.70755E-01
3.55673E-01

OREGION 20     material  2        volume  1.553011E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission           rif          raf          d*flux*vol  absorptions
nu*fissions
    1    4.43555E+01  2.72492E-03  0.00000E+00       4.31895E-01  2.78102E-02       1.91569E+01  1.17688E-03
0.00000E+00
    2    2.62364E+01  7.93007E-03  0.00000E+00       6.63776E-01  4.27412E-02       1.74151E+01  5.26379E-03
0.00000E+00
    3    3.15412E+00  1.02899E-01  0.00000E+00       3.36067E-02  2.16397E-03       1.06000E-01  3.45811E-03
0.00000E+00
    4    1.39178E-01  2.39281E+00  0.00000E+00       2.22956E-05  1.43564E-06       3.10305E-06  5.33490E-05
0.00000E+00
    5    4.08195E-02  8.16375E+00  0.00000E+00       3.04287E-06  1.95934E-07       1.24208E-07  2.48412E-05
0.00000E+00
 thermal 1.27366E-01  3.08583E+00  0.00000E+00       2.53385E-05  1.63157E-06       3.22725E-06  7.81902E-05
0.00000E+00
 total   3.24785E+01  8.83462E-03  0.00000E+00       1.12930E+00  7.27170E-02       3.66780E+01  9.97696E-03
0.00000E+00
```

```
OREGION 21     material  4        volume  2.566575E+02
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf          d*flux*vol  absorptions
nu*fissions
    1    2.55794E+00  2.93077E-05  0.00000E+00       4.27771E+00  1.66670E-02       1.09421E+01  1.25370E-04
0.00000E+00
    2    1.11858E+00  0.00000E+00  0.00000E+00       1.11551E+01  4.34631E-02       1.24779E+01  0.00000E+00
0.00000E+00
    3    9.29283E-01  3.48599E-06  0.00000E+00       2.94235E+00  1.14641E-02       2.73427E+00  1.02570E-05
0.00000E+00
    4    9.31077E-01  3.64732E-05  0.00000E+00       3.14988E-02  1.22727E-04       2.93278E-02  1.14886E-06
0.00000E+00
    5    9.07854E-01  1.54120E-04  0.00000E+00       1.47494E-02  5.74673E-05       1.33903E-02  2.27318E-06
0.00000E+00
 thermal 9.23671E-01  7.39930E-05  0.00000E+00       4.62482E-02  1.80194E-04       4.27181E-02  3.42204E-06
0.00000E+00
 total   1.42209E+00  7.54821E-06  0.00000E+00       1.84214E+01  7.17744E-02       2.61970E+01  1.39049E-04
0.00000E+00

OREGION 22     material  2        volume  9.082354E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf          d*flux*vol  absorptions
nu*fissions
    1    4.43555E+01  2.72492E-03  0.00000E+00       1.78226E+00  1.96233E-02       7.90530E+01  4.85652E-03
0.00000E+00
    2    2.62364E+01  7.93007E-03  0.00000E+00       3.92060E+00  4.31672E-02       1.02863E+02  3.10906E-02
0.00000E+00
    3    3.15412E+00  1.02899E-01  0.00000E+00       8.39178E-01  9.23965E-03       2.64687E+00  8.63507E-02
0.00000E+00
    4    1.39178E-01  2.39281E+00  0.00000E+00       1.69241E-03  1.86340E-05       2.35545E-04  4.04960E-03
0.00000E+00
    5    4.08195E-02  8.16375E+00  0.00000E+00      -1.48704E-04 -1.63728E-06      -6.07001E-06 -1.21398E-03
0.00000E+00
 thermal 1.48652E-01  1.83690E+00  0.00000E+00       1.54370E-03  1.69967E-05       2.29475E-04  2.83562E-03
0.00000E+00
 total   2.82051E+01  1.91231E-02  0.00000E+00       6.54358E+00  7.20472E-02       1.84563E+02  1.25134E-01
0.00000E+00

OREGION 23     material  4        volume  3.986671E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf          d*flux*vol  absorptions
nu*fissions
    1    2.55794E+00  2.93077E-05  0.00000E+00       7.63585E-01  1.91535E-02       1.95320E+00  2.23789E-05
0.00000E+00
    2    1.11858E+00  0.00000E+00  0.00000E+00       1.71455E+00  4.30070E-02       1.91786E+00  0.00000E+00
0.00000E+00
    3    9.29283E-01  3.48599E-06  0.00000E+00       3.70494E-01  9.29333E-03       3.44294E-01  1.29154E-06
0.00000E+00
    4    9.31077E-01  3.64732E-05  0.00000E+00      -2.56622E-03 -6.43700E-05      -2.38935E-03 -9.35983E-08
0.00000E+00
    5    9.07854E-01  1.54120E-04  0.00000E+00      -2.43558E-03 -6.10931E-05      -2.21115E-03 -3.75371E-07
0.00000E+00
 thermal 9.19769E-01  9.37602E-05  0.00000E+00      -5.00180E-03 -1.25463E-04      -4.60050E-03 -4.68970E-07
0.00000E+00
```

```
 total   1.48077E+00  8.15913E-06  0.00000E+00       2.84362E+00  7.13283E-02       4.21076E+00  2.32015E-05
0.00000E+00

OREGION 24     material  2        volume  1.146344E+02
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    4.43555E+01  2.72492E-03  0.00000E+00       2.35209E+00  2.05182E-02       1.04328E+02  6.40926E-03
0.00000E+00
    2    2.62364E+01  7.93007E-03  0.00000E+00       4.90414E+00  4.27807E-02       1.28667E+02  3.88902E-02
0.00000E+00
    3    3.15412E+00  1.02899E-01  0.00000E+00       9.56921E-01  8.34758E-03       3.01824E+00  9.84663E-02
0.00000E+00
    4    1.39178E-01  2.39281E+00  0.00000E+00       4.82857E-03  4.21215E-05       6.72029E-04  1.15538E-02
0.00000E+00
    5    4.08195E-02  8.16375E+00  0.00000E+00       5.28408E-04  4.60951E-06       2.15693E-05  4.31379E-03
0.00000E+00
 thermal 1.29476E-01  2.96205E+00  0.00000E+00       5.35698E-03  4.67310E-05       6.93598E-04  1.58676E-02
0.00000E+00
 total   2.87174E+01  1.94236E-02  0.00000E+00       8.21851E+00  7.16932E-02       2.36014E+02  1.59633E-01
0.00000E+00

OREGION 25     material  4        volume  4.235519E+02
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    2.55794E+00  2.93077E-05  0.00000E+00       7.41053E+00  1.74961E-02       1.89557E+01  2.17185E-04
0.00000E+00
    2    1.11858E+00  0.00000E+00  0.00000E+00       1.81842E+01  4.29326E-02       2.03405E+01  0.00000E+00
0.00000E+00
    3    9.29283E-01  3.48599E-06  0.00000E+00       4.96767E+00  1.17286E-02       4.61638E+00  1.73173E-05
0.00000E+00
    4    9.31077E-01  3.64732E-05  0.00000E+00       1.13765E-01  2.68597E-04       1.05924E-01  4.14936E-06
0.00000E+00
    5    9.07854E-01  1.54120E-04  0.00000E+00       4.35358E-02  1.02787E-04       3.95241E-02  6.70973E-06
0.00000E+00
 thermal 9.24650E-01  6.90341E-05  0.00000E+00       1.57300E-01  3.71384E-04       1.45448E-01  1.08591E-05
0.00000E+00
 total   1.43419E+00  7.98712E-06  0.00000E+00       3.07197E+01  7.25287E-02       4.40580E+01  2.45362E-04
0.00000E+00



 CELL             VOLUME  1.963495E+03
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    1.56604E+01  2.52174E-03  4.21977E-03       3.90047E+01  1.98649E-02       6.10829E+02  9.83599E-02
1.64591E-01
    2    8.48669E+00  4.05569E-03  3.45243E-03       8.54287E+01  4.35085E-02       7.25007E+02  3.46472E-01
2.94936E-01
    3    1.48509E+00  2.95944E-02  6.18631E-03       1.75640E+01  8.94526E-03       2.60841E+01  5.19796E-01
1.08656E-01
```

```
    4    8.80438E-01  1.57227E-01 -3.09699E-03       1.93184E-01  9.83876E-05       1.70086E-01  3.03737E-02 -
5.98288E-04
    5    9.01310E-01  7.83991E-02 -9.70995E-03       6.37540E-02  3.24696E-05       5.74621E-02  4.99825E-03 -
6.19048E-04
 thermal 8.85617E-01  1.37667E-01 -4.73786E-03       2.56938E-01  1.30857E-04       2.27548E-01  3.53719E-02 -
1.21734E-03
 total   9.57544E+00  7.02966E-03  3.98558E-03       1.42254E+02  7.24496E-02       1.36215E+03  1.00000E+00
5.66966E-01

0CELL AVERAGE SCATTERING CROSS SECTIONS

         1           2           3           4           5
  1  7.0739E-02  1.7039E-02  5.9549E-07  0.0000E+00  0.0000E+00
  2  0.0000E+00  2.0043E-01  6.4948E-03  0.0000E+00  0.0000E+00
  3  0.0000E+00  0.0000E+00  2.6586E-01  2.0166E-03  7.0726E-10
  4  0.0000E+00  0.0000E+00  2.4522E-04  3.0839E-01  2.5994E-02
  5  0.0000E+00  0.0000E+00 -1.4952E-25  3.6570E-04  3.6320E-01
0                         modified
           GROUP    removals      spectrum         p           eta.f
             1    6.646396E-01  7.630001E-01  8.710872E-01  1.673353E+00
             2    5.548679E-01  2.367000E-01  6.156036E-01  8.512554E-01
             3    3.537196E-02  3.000000E-04  6.371399E-02  2.090361E-01
             4    4.998254E-03  0.000000E+00  1.413055E-01 -1.969756E-02
             5    0.000000E+00  0.000000E+00  0.000000E+00 -1.238529E-01
0           fast  3.537196E-02  1.000000E+00  3.537196E-02  5.890181E-01
         thermal  0.000000E+00  0.000000E+00  0.000000E+00 -3.441527E-02
000:00:00      entry into chain 14               cpu time =     0.000 secs

1LEAKAGE EDIT
 ======= ====

 RADIAL BUCKLING    9.70000E-04          AXIAL BUCKLING    9.86000E-04


 transport diffusion coefficients
 --------- --------- ------------

 diagonal transport corrected flux solution

          5 GROUPS.....  k-infinity  5.669666E-01   k-effective  3.652836E-01
          2 GROUPS.....  k-infinity  6.004043E-01   k-effective  3.652836E-01

            radial        axial
 GROUP     DIFFUSION    DIFFUSION     ABSORPTION     REMOVAL      NU-FISSION     FLUX-EFF      FLUX-INF
   1     3.691354E+00  3.691354E+00  2.521744E-03  1.703997E-02  4.219767E-03  2.848929E+01  3.900477E+01
   2     1.579892E+00  1.579892E+00  4.055688E-03  6.494815E-03  3.452427E-03  5.293982E+01  8.542879E+01
   3     1.120569E+00  1.120569E+00  2.959444E-02  2.016570E-03  6.186306E-03  1.018195E+01  1.756400E+01
   4     6.777080E-01  6.777080E-01  1.572271E-01  2.623893E-02 -3.096990E-03  1.111847E-01  1.931840E-01
   5     7.542156E-01  7.542156E-01  7.839907E-02  3.656968E-04 -9.709949E-03  3.601831E-02  6.375414E-02
01 of 2  2.185466E+00  2.185466E+00  6.417122E-03  2.241305E-04  3.994907E-03  9.161107E+01  1.505808E+02
 2 of 2  6.964282E-01  6.964282E-01  1.379391E-01  1.852204E-04 -4.715078E-03  1.472030E-01  2.443434E-01
0       partial radial partial axial   fission
         slowing down  slowing down    spectrum
 group       area          area
   1     1.439804E+02  1.439804E+02  7.630001E-01
```

```
   2     1.497008E+02  1.497008E+02  2.367000E-01
   3     3.544871E+01  3.544871E+01  3.000000E-04
   4     3.693916E+00  3.693916E+00  0.000000E+00
   5     9.575546E+00  9.575546E+00  0.000000E+00
01 of 2  3.290743E+02  3.290743E+02
 2 of 2  5.042039E+00  5.042039E+00

        buckling search         given
     radial         axial
 -8.650054E-04 -8.792735E-04    ratio
  9.700001E-04 -2.714279E-03    radial
 -2.730279E-03  9.860001E-04    axial
000:00:00      entry into chain 15              cpu time =     0.000 secs

000:00:00      entry into chain  1              cpu time =     0.000 secs

1



 END OF FILE ON DATASET     5
```

Lampiran 3

Listing Program *Hexagonal*

```
cell 7                                  *cluster
 sequence 2                              *dsn
 ngroup 5 2
 nmesh  22
 nregion 22 5
 nmaterial 4
 preout
initiate
 annulus 1 1.5 4                                 *fuel
 annulus 2 1.75  2
 annulus 3 2.0 4
 annulus 4 2.25 2
 annulus 5 5.25 1
 annulus 6 5.5 2
 annulus 7 5.75 4
 annulus 8 6.0  2
 annulus 9 9.0  4
 annulus 10 9.25 2
 annulus 11 9.5 1
 annulus 12 9.75 2
 annulus 13 12.75 4
 annulus 14 13.0  2
 annulus 15 13.25 4
 annulus 16 13.5 2
 annulus 17 16.5 1
 annulus 18 16.75 2
 annulus 19 17.0 4
 annulus 20 17.25 2
 annulus 21 20.25 4
 annulus 22 20.5 2          *MODERATOR
 rodsub 1 1 1.845 4          *fuel
 rodsub 1 2 1.9   2          *aluminium
 rodsub 2 1 1.845 4          *fuel
 rodsub 2 2 1.9   2          *aluminium
 rodsub 3 1 1.845 4          *fuel
 rodsub 3 2 1.9   2          *aluminium
 rodsub 4 1 1.845 4          *fuel
 rodsub 4 2 1.9   2          *aluminium
 rodsub 5 1 1.845 4          *fuel
 rodsub 5 2 1.9   2          *aluminium
 array 1 1 6  4   1
 array 2 1 12 8   1
 array 3 1 18 11  1
 array 4 1 24 15  1
 array 5 1 30 18.75  1
 material 1 6.0 300 1 2235 .8474 8238.0 .00058 6016 .152 *fuel
 material 2 .0178 300 3 3 100.0                          *helium
 material 3 2.7 300 2 27 51.47                           *aluminium
 material 4 1.60 300 4 2012 100.0                        *graphit
 fewgroups 5 14 28 45  69
 mesh 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 beginc
```

Lampiran 4

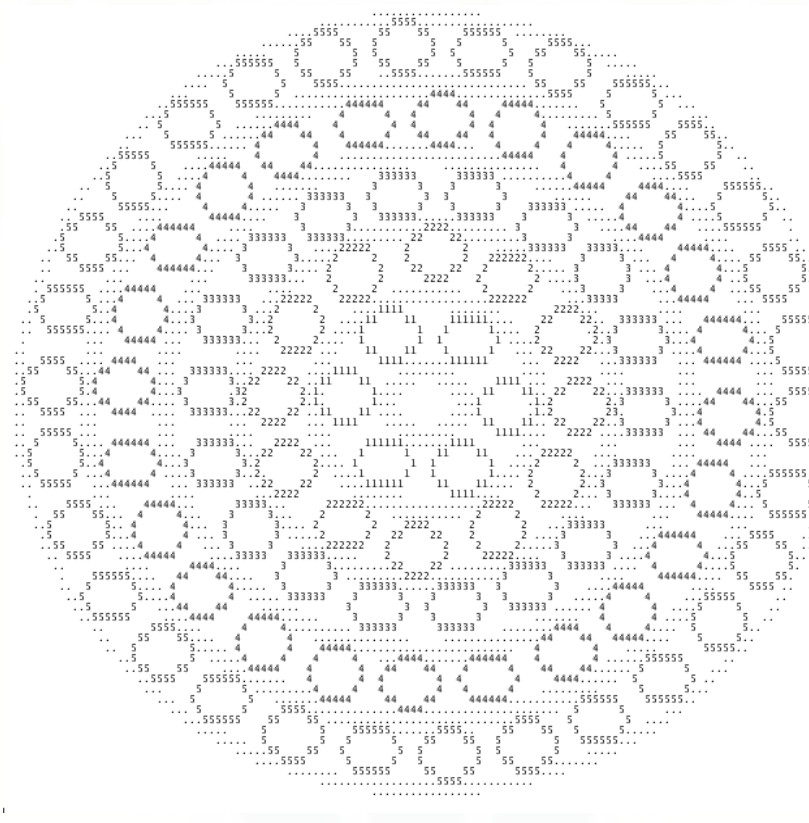
Keluaran (*Output*) Program WIMSD-5B Susunan *Hexagonal*

```
1
 wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
 wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5
b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd
5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wims
d5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wim
sd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wi
msd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b w
imsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
 wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5
b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd
5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wims
d5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wim
sd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wi
msd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b w
imsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
 wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5
b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd
5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wims
d5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wim
sd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wi
msd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b w
imsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
 wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5
b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd
5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wims
d5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wim
sd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wi
msd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b w
imsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
 wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5
b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd
5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wims
d5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wim
sd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wi
msd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b w
imsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b wimsd5b
1


                         ***********************************************************
                         *                                                         *
                         *                   W I M S D - 5 B                       *
                         *                   ---------------                       *
                         *              Version 2003/01 (DOS/Lahey)                *
                         *                                                         *
                         *   This version of WIMSD is based on the original code   *
                         *   written  at  Winfrith  in  1964,  with   subsequent   *
                         *   additions  and  conversion to Fortran 77 and a Unix   *
                         *   operating system.                                     *
                         *   The recent incorporation of features developed by     *
                         *   other users was sponsored by the NEA Data Bank &      *
                         *   carried out by Teresa Kulikowska.                     *
                         *                                                         *

                         *   Users  of  this  code should  be aware  that it was   *
                         *   developed for regular pincell lattices and clusters   *
                         *   of the AGR/CANDU/RBMK type.  Applications  to other   *
                         *   systems ( LWR, HTR, research reactors,  criticality   *
                         *   assessments, etc) are at the discretion of the user.  *
                         *   The  authors make no claim for the  accuracy of the   *
                         *   methods when used outside their intended range.       *

                         *   More advanced versions of the WIMS package of codes   *
                         *   are  available from  AEA Technology.  These include   *
                         *   extensive new geometric capabilities, inbuilt Monte   *
                         *   Carlo solution methods,  up-to-date nuclear data, a   *
                         *   great  deal  of  computational  flexibility,  and a   *
                         *   graphical user image. For more information on the     *
                         *   latest range of WIMS products, contact:               *
                         *                                                         *
                         *         The ANSWERS Manager,                            *
                         *         Building A32, Winfrith Technology Centre,       *
                         *         Dorchester, Dorset, DT2 8DH, UK.                *
                         *         Tel (+44) 1305202352  Fax (+44) 1305202746      *
                         *         e-mail  answers@aeat.co.uk                      *
                         *                                                         *
                         *   -------------------------------------------------     *
                         *   WIMS is a Registered Trade-mark of AEA Technology     *
                         *   -------------------------------------------------     *
                         *                                                         *
                         ***********************************************************
 files opened in datsets:

 unit  format                access        name
 ----  ------                ------        ----
    5  formatted                           WIMSDINP
    6  formatted                           WIMSDOUT
    2  unformatted                         WIMSDLIB
    1  formatted                           FOR001
    3  unformatted                         FOR003
    4  formatted                           FOR004
    8  formatted                           FOR008
    9  unformatted                         FOR009
   10  unformatted                         FOR010
   12  unformatted                         FOR012
   13  unformatted                         FOR013
   14  formatted                           FOR014
   19  formatted                           FOR019
   20  formatted                           FOR020
```

```
1
files opened in datsets:

 unit  format                access        name
 ----  ------                ------        ----
    5  formatted                           WIMSDINP
    6  formatted                           WIMSDOUT
    2  unformatted                         WIMSDLIB
    1  formatted                           FOR001
    3  unformatted                         FOR003
    4  formatted                           FOR004
    8  formatted                           FOR008
    9  unformatted                         FOR009
   10  unformatted                         FOR010
   12  unformatted                         FOR012
   13  unformatted                         FOR013
   14  formatted                           FOR014
   19  formatted                           FOR019
   20  formatted                           FOR020
1
1
000:00:00      entry into main program
    129    69    25    14    13    17    55
              cell 7                              *cluster
              sequence 1                          *dsn
              ngroup 5 2
              nmesh  22
              nregion 22 5
              nmaterial 4
              preout
0available data storage (iq array)  1000001
0unused storage by chain

          1         2         3         4         5         6         7         8
     994281    976785    980905    980246    988359         1    994471         1
          9        10        11        12        13        14        15        16
     994471    994708    993280    972061    992828    992512    989190    993969
0non-essential data storage 972061
000:00:00      entry into chain  1               cpu time =     0.000 secs

1
              initiate
              annulus 1 1.5 4                          *fuel
              annulus 2 1.75  2
              annulus 3 2.0 4
              annulus 4 2.25 2
              annulus 5 5.25 1
              annulus 6 5.5 2
              annulus 7 5.75 4
              annulus 8 6.0  2
              annulus 9 9.0  4
              annulus 10 9.25 2
              annulus 11 9.5 1
              annulus 12 9.75 2
              annulus 13 12.75 4
              annulus 14 13.0  2
              annulus 15 13.25 4
              annulus 16 13.5 2
              annulus 17 16.5 1
              annulus 18 16.75 2
              annulus 19 17.0 4
              annulus 20 17.25 2
              annulus 21 20.25 4
              annulus 22 20.5 2          *MODERATOR
              rodsub 1 1 1.845 4          *fuel
              rodsub 1 2 1.9   2          *aluminium
              rodsub 2 1 1.845 4          *fuel
              rodsub 2 2 1.9   2          *aluminium
              rodsub 3 1 1.845 4          *fuel
              rodsub 3 2 1.9   2          *aluminium
              rodsub 4 1 1.845 4          *fuel
              rodsub 4 2 1.9   2          *aluminium
              rodsub 5 1 1.845 4          *fuel
```

```
rodsub 5 2 1.9   2         *aluminium
array 1 1 6  4   1
array 2 1 12 8   1
array 3 1 18 11  1
array 4 1 24 15  1
array 5 1 30 18.75  1
material 1 6.0 300 1 2235 .8474 8238.0 .00058 6016 .152 *fuel
material 2 .0178 300 3 3 100.0                          *helium
material 3 2.7 300 2 27 51.47                           *aluminium
material 4 1.60 300 4 2012 100.0                        *graphit
fewgroups 5 14 28 45  69
mesh 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
beginc
```

1 ***** cell type 1 *****



```
'
```

1

000:00:00 entry into chain 2 cpu time = 0.000 secs

0isotope number densities for each material

	1	2	3	4
temp	300.0000	300.0000	300.0000	300.0000
3001	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3002	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3	0.0000E+00	3.5535E-03	0.0000E+00	0.0000E+00
4	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
7	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
9	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
10	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1010	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1011	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2012	0.0000E+00	0.0000E+00	0.0000E+00	8.0233E-02
2212	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
14	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6016	3.4343E-02	0.0000E+00	0.0000E+00	0.0000E+00
19	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
23	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
24	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

27	0.0000E+00	0.0000E+00	6.0271E-02	0.0000E+00
29	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
48	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
51	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
52	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1054	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
55	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2056	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
9056	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
58	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1058	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3058	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
8058	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
9058	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1059	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3063	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
84	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
91	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1091	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
93	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
96	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2103	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3109	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2113	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2115	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
121	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
123	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2154	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2155	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2156	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2157	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2158	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
164	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
167	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
176	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2176	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2177	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2178	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2179	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2180	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
178	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
181	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
183	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
197	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
251	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
252	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
253	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
254	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
105	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
135	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
500	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4083	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4095	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4099	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4101	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5103	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4103	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4105	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5105	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4108	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4109	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4113	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4115	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4127	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4131	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4133	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4134	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6135	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4135	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5135	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4143	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4145	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4147	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

```
  5147 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  6147 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  4148 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  5148 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  5149 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  4149 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  4150 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  4151 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  4152 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  4153 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  4154 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  4155 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  4157 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  4902 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
   207 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  2232 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  9233 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  1233 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
   234 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  2235 1.3029E-02 0.0000E+00 0.0000E+00 0.0000E+00
   236 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
   927 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  8238 8.8051E-06 0.0000E+00 0.0000E+00 0.0000E+00
   937 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  1939 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
   948 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  6239 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  1240 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  1241 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  1242 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
   951 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
   952 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
   953 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  1000 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  1003 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  1999 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  2000 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  3000 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
  4000 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
000:00:00      entry into chain  3              cpu time =     0.000 secs

 volumes
 0.88875E+01 0.00000E+00 0.00000E+00 0.75600E+02 0.00000E+00 0.33576E+03
 pin cell radii for    90 rods
 0.31425E+00 0.96889E+00
0material     3 not used
1                                                resonance group  15

0total cross-sections for pin cell regions (except fuel)     3.90736E-02
0dancoff factors 0.17670 0.37664   bell factor 1.16000
0microscopic cross-sections
                        array        cluste       outer
 2235.0  abs         5.55784E+00  5.20021E+00  5.55784E+00
 2235.0  nuf         9.83779E+00  9.20480E+00  9.83779E+00
 8238.0  abs         9.56656E-01  9.56729E-01  9.56656E-01

0p =  0.78767E+00 for each region up to the volume fraction  0.42955E-01 of the modr.
 flux depression factor =  0.86085E+00  0.92118E+00
0         fuel       can       coolant     moderator
 f(p)  9.53786E-01  1.00000E+00  9.77841E-01  9.96195E-01
1                                                resonance group  16

0total cross-sections for pin cell regions (except fuel)     4.86626E-02
0dancoff factors 0.21207 0.39956   bell factor 1.16000
0microscopic cross-sections
                        array        cluste       outer
 2235.0  abs         6.55133E+00  6.16221E+00  6.55133E+00
 2235.0  nuf         1.14219E+01  1.07435E+01  1.14219E+01
 8238.0  abs         1.23574E+00  1.23588E+00  1.23574E+00

0p =  0.78597E+00 for each region up to the volume fraction  0.45774E-01 of the modr.
 flux depression factor =  0.85708E+00  0.91248E+00
0         fuel       can       coolant     moderator
```

```
 f(p)  9.36645E-01  1.00000E+00  9.79779E-01  9.95929E-01
1                                                resonance group  17

0total cross-sections for pin cell regions (except fuel)     6.01448E-02
0dancoff factors 0.25119 0.42527   bell factor 1.16000
0microscopic cross-sections
                       array        cluste       outer
 2235.0  abs         8.45038E+00  7.94344E+00  8.45038E+00
 2235.0  nuf         1.47491E+01  1.38645E+01  1.47491E+01
 8238.0  abs         9.31647E-01  9.31866E-01  9.31647E-01

0p =  0.74907E+00 for each region up to the volume fraction  0.48987E-01 of the modr.
 flux depression factor =  0.83977E+00  0.89496E+00
0         fuel       can       coolant     moderator
 f(p)  9.22744E-01  1.00000E+00  9.75322E-01  9.94685E-01
1                                                resonance group  18

0total cross-sections for pin cell regions (except fuel)     7.44831E-02
0dancoff factors 0.29571 0.45498   bell factor 1.16000
0microscopic cross-sections
                       array        cluste       outer
 2235.0  abs         1.04344E+01  9.84269E+00  1.04344E+01
 2235.0  nuf         1.83231E+01  1.72842E+01  1.83231E+01
 8238.0  abs         1.85192E+00  1.85255E+00  1.85192E+00

0p =  0.71751E+00 for each region up to the volume fraction  0.52742E-01 of the modr.
 flux depression factor =  0.82808E+00  0.87958E+00
0         fuel       can       coolant     moderator
 f(p)  9.09894E-01  1.00000E+00  9.71212E-01  9.93325E-01
1                                                resonance group  19

0total cross-sections for pin cell regions (except fuel)     9.22671E-02
0dancoff factors 0.34519 0.48858   bell factor 1.16000
0microscopic cross-sections
                       array        cluste       outer
 2235.0  abs         1.31946E+01  1.24919E+01  1.31946E+01
 2235.0  nuf         2.33949E+01  2.21479E+01  2.33949E+01
 8238.0  abs         2.33414E+00  2.33508E+00  2.33414E+00

0p =  0.67943E+00 for each region up to the volume fraction  0.57058E-01 of the modr.
 flux depression factor =  0.81236E+00  0.86016E+00
0         fuel       can       coolant     moderator
 f(p)  8.93708E-01  1.00000E+00  9.65839E-01  9.91431E-01
1                                                resonance group  20

0total cross-sections for pin cell regions (except fuel)     1.29050E-01
0dancoff factors 0.43134 0.54861   bell factor 1.16000
0microscopic cross-sections
                       array        cluste       outer
 2235.0  abs         1.84897E+01  1.76339E+01  1.84897E+01
 2235.0  nuf         3.37370E+01  3.21746E+01  3.37370E+01
 8238.0  abs         3.14064E+00  3.14148E+00  3.14064E+00

0p =  0.38750E+00 for each region up to the volume fraction  0.64908E-01 of the modr.
 flux depression factor =  0.78753E+00  0.82819E+00
0         fuel       can       coolant     moderator
 f(p)  6.74439E-01  1.00000E+00  8.20636E-01  9.78868E-01
1                                                resonance group  21

0total cross-sections for pin cell regions (except fuel)     2.01274E-01
0dancoff factors 0.55623 0.63924   bell factor 1.16000
0microscopic cross-sections
                       array        cluste       outer
 2235.0  abs         2.56160E+01  2.48053E+01  2.56160E+01
 2235.0  nuf         3.97523E+01  3.84906E+01  3.97523E+01
 8238.0  abs         8.08716E+00  8.09157E+00  8.08716E+00

0p =  0.32800E+00 for each region up to the volume fraction  0.77034E-01 of the modr.
 flux depression factor =  0.76982E+00  0.79753E+00
0         fuel       can       coolant     moderator
 f(p)  6.19389E-01  1.00000E+00  7.86860E-01  9.70680E-01
1                                                resonance group  22
```

```
0total cross-sections for pin cell regions (except fuel)     2.97223E-01
0dancoff factors 0.66728 0.72359   bell factor 1.16000
0microscopic cross-sections
                        array        cluste       outer
 2235.0  abs         3.84515E+01  3.75773E+01  3.84515E+01
 2235.0  nuf         5.98857E+01  5.85070E+01  5.98857E+01
 8238.0  abs         1.68327E+01  1.68391E+01  1.68327E+01

0p =  0.34955E+00 for each region up to the volume fraction  0.88621E-01 of the modr.
 flux depression factor =  0.72520E+00  0.74518E+00
0         fuel       can       coolant     moderator
 f(p)  6.95175E-01  1.00000E+00  8.44626E-01  9.72986E-01
1                                                resonance group  23

0total cross-sections for pin cell regions (except fuel)     3.92340E-01
0dancoff factors 0.74197 0.78244   bell factor 1.16000
0microscopic cross-sections
                        array        cluste       outer
 2235.0  abs         3.98700E+01  3.93524E+01  3.98700E+01
 2235.0  nuf         6.72499E+01  6.63406E+01  6.72499E+01
 8238.0  abs         2.42872E+01  2.42941E+01  2.42872E+01

0p =  0.50413E+00 for each region up to the volume fraction  0.96889E-01 of the modr.
 flux depression factor =  0.73896E+00  0.75154E+00
0         fuel       can       coolant     moderator
 f(p)  7.92978E-01  1.00000E+00  9.32604E-01  9.71389E-01
1                                                resonance group  24

0total cross-sections for pin cell regions (except fuel)     5.03623E-01
0dancoff factors 0.80315 0.83197   bell factor 1.16000
0microscopic cross-sections
                        array        cluste       outer
 2235.0  abs         6.05319E+01  5.98906E+01  6.05319E+01
 2235.0  nuf         8.67825E+01  8.58315E+01  8.67825E+01
 8238.0  abs         7.70324E+01  7.70534E+01  7.70324E+01

0p =  0.33937E+00 for each region up to the volume fraction  0.10396E+00 of the modr.
 flux depression factor =  0.66991E+00  0.68008E+00
0         fuel       can       coolant     moderator
 f(p)  7.45156E-01  1.00000E+00  8.61962E-01  9.51288E-01
1                                                resonance group  25

0total cross-sections for pin cell regions (except fuel)     6.62189E-01
0dancoff factors 0.86152 0.88038   bell factor 1.16000
0microscopic cross-sections
                        array        cluste       outer
 2235.0  abs         7.72542E+01  7.66161E+01  7.72542E+01
 2235.0  nuf         1.04818E+02  1.03934E+02  1.04818E+02
 8238.0  abs         1.10045E+02  1.10057E+02  1.10045E+02

0p =  0.29397E+00 for each region up to the volume fraction  0.11099E+00 of the modr.
 flux depression factor =  0.63041E+00  0.63751E+00
0         fuel       can       coolant     moderator
 f(p)  7.12724E-01  1.00000E+00  8.37353E-01  9.39309E-01
1                                                resonance group  26

0total cross-sections for pin cell regions (except fuel)     8.55239E-01
0dancoff factors 0.90652 0.91848   bell factor 1.16000
0microscopic cross-sections
                        array        cluste       outer
 2235.0  abs         6.39419E+01  6.37465E+01  6.39419E+01
 2235.0  nuf         9.08838E+01  9.05641E+01  9.08838E+01
 8238.0  abs         3.10076E-01  3.10076E-01  3.10076E-01

0p =  0.39612E+00 for each region up to the volume fraction  0.11659E+00 of the modr.
 flux depression factor =  0.69146E+00  0.69492E+00
0         fuel       can       coolant     moderator
 f(p)  7.49286E-01  1.00000E+00  8.97752E-01  9.50432E-01
1                                                resonance group  27

0total cross-sections for pin cell regions (except fuel)     1.21478E+00
0dancoff factors 0.95221 0.95790   bell factor 1.16000
0microscopic cross-sections
```

```
                        array        cluste       outer
 2235.0  abs         5.70804E+01  5.70099E+01  5.70804E+01
 2235.0  nuf         9.22239E+01  9.21091E+01  9.22239E+01
 8238.0  abs         1.41792E+02  1.41798E+02  1.41792E+02

0p =  0.21326E+00 for each region up to the volume fraction  0.12222E+00 of the modr.
 flux depression factor =  0.71709E+00  0.71863E+00
0         fuel       can       coolant     moderator
 f(p)  4.89196E-01  1.00000E+00  6.98523E-01  9.37568E-01
000:00:00      entry into chain  4               cpu time =     0.000 secs

1spectrum calculation


 calculation converged in   110 iterations.




 estimated k-infinity=  0.302964
1flux.



  fuel   4.03524E-02 1.81484E-01 3.97825E-01 5.09400E-01 4.89575E-01 4.49369E-01 3.41603E-01 2.87707E-01 2.26810E-01
         1.85405E-01 1.55864E-01 1.34223E-01 1.16798E-01 1.00375E-01 8.49233E-02 6.48877E-02 5.36399E-02 4.38023E-02
         3.50377E-02 4.76004E-02 2.83380E-02 1.27308E-02 6.20428E-03 5.07944E-03 3.37745E-03 2.21559E-03 2.54355E-03
         4.09230E-04 4.41248E-04 3.44957E-04 3.78778E-04 1.22677E-04 7.41920E-05 1.02194E-05 9.88022E-06 1.03958E-05
         1.09998E-05 1.10209E-05 1.08901E-05 1.10828E-05 1.02864E-05 1.88341E-05 2.82244E-05 3.24806E-05 6.65315E-05
         4.56713E-05 2.85428E-05 1.09223E-05 5.31089E-06 3.08218E-06 2.81645E-06 3.95584E-06 3.69632E-06 4.37553E-06
         3.41238E-06 2.18097E-06 5.64820E-07 1.95204E-07 7.35701E-08 3.74279E-08 1.90800E-08 8.49508E-09 3.39869E-09
         2.19656E-09 1.49630E-09 9.75938E-10 5.77339E-10 2.65429E-10 5.06137E-11
    total    4.00929E+00

  coolnt 3.26698E-02 1.49057E-01 3.35566E-01 4.46258E-01 4.40864E-01 4.13563E-01 3.24578E-01 2.76692E-01 2.22008E-01
         1.83602E-01 1.55466E-01 1.34571E-01 1.17434E-01 1.01212E-01 8.59651E-02 6.58315E-02 5.47300E-02 4.49409E-02
         3.62443E-02 4.99945E-02 3.04450E-02 1.43212E-02 7.04005E-03 6.25223E-03 4.49533E-03 2.90870E-03 3.52810E-03
         6.07633E-04 6.52852E-04 5.10954E-04 6.61298E-04 2.38181E-04 1.88386E-04 3.46612E-05 3.38261E-05 3.42578E-05
         3.47282E-05 3.37935E-05 3.28405E-05 3.32137E-05 3.08355E-05 5.69722E-05 8.76929E-05 1.06449E-04 2.52306E-04
         2.27926E-04 2.06947E-04 1.16066E-04 7.53753E-05 5.33285E-05 5.63131E-05 9.15025E-05 1.02677E-04 1.64142E-04
         2.13570E-04 3.12490E-04 2.07664E-04 1.47527E-04 1.03186E-04 9.46227E-05 9.07180E-05 7.69246E-05 4.69930E-05
         4.20709E-05 3.25877E-05 2.75176E-05 2.15718E-05 1.10148E-05 2.54660E-06
    total    3.74639E+00

  moder. 1.12131E-02 6.10344E-02 1.31328E-01 2.37223E-01 2.59199E-01 2.52690E-01 2.35943E-01 2.19958E-01 2.05581E-01
         1.94910E-01 1.85796E-01 1.77695E-01 1.70395E-01 1.63034E-01 1.56102E-01 1.34920E-01 1.28651E-01 1.22245E-01
         1.15872E-01 2.08915E-01 1.86126E-01 1.26446E-01 7.90288E-02 9.06462E-02 8.44789E-02 6.77408E-02 1.12959E-01
         2.47183E-02 2.92354E-02 2.52906E-02 3.78480E-02 1.54198E-02 1.31468E-02 2.51925E-03 2.48557E-03 2.54186E-03
         2.60107E-03 2.55671E-03 2.50921E-03 2.56387E-03 2.40538E-03 4.50727E-03 7.12204E-03 8.96885E-03 2.29089E-02
         2.30434E-02 2.33347E-02 1.42818E-02 9.80303E-03 7.20582E-03 7.86432E-03 1.33638E-02 1.59530E-02 2.77192E-02
         4.09497E-02 6.94982E-02 5.26871E-02 4.25425E-02 3.33979E-02 3.17801E-02 3.34214E-02 2.93791E-02 2.11164E-02
         2.02528E-02 1.95240E-02 1.67256E-02 1.26013E-02 9.30294E-03 4.16713E-03
    total    4.90939E+00
000:00:00      entry into chain  5               cpu time =     0.000 secs

000:00:00      entry into chain  6               cpu time =     0.000 secs

1   d s n (hps)
 method 2
0 total fissions               2.6949017E+00    eigenvalue   3.3461919E+00  k-effective   2.9884717E-01
 fission source convergence   1.4385058E-06    rate of fission source convergence        1.6096294E-01
0 total fissions               2.6949005E+00    eigenvalue   3.3462036E+00  k-effective   2.9884613E-01
 fission source convergence   8.9420638E-07    rate of fission source convergence        6.2162167E-01
0 total fissions               2.6948993E+00    eigenvalue   3.3462048E+00  k-effective   2.9884604E-01
 fission source convergence   5.0282932E-07    rate of fission source convergence        5.6231910E-01

1starting at the centre of the system
 volumes
  2.2500000E+00  8.1250000E-01  9.3750000E-01  1.0625000E+00  2.2500000E+01  2.6875000E+00  2.8125000E+00
2.9375000E+00
  4.5000000E+01  4.5625000E+00  4.6875000E+00  4.8125186E+00  6.7500008E+01  6.4375005E+00  6.5624752E+00
6.6875000E+00
```

```
  9.0000000E+01  8.3125000E+00  8.4375000E+00  8.5625000E+00  1.1250000E+02  1.0187500E+01
0flux density each zone
 group     1
  2.5581005E-01  2.5993052E-01  2.6210478E-01  2.6601401E-01  2.6631051E-01  2.6237479E-01  2.5839749E-01
2.5340298E-01
  2.9077539E-01  3.3771539E-01  3.4303245E-01  3.3612809E-01  2.7951545E-01  2.2895043E-01  2.2989428E-01
2.3088957E-01
  2.2194247E-01  2.1157168E-01  2.0897749E-01  2.0650694E-01  2.0071849E-01  1.9586638E-01
 group     2
  5.9714419E-01  5.9693062E-01  5.9768915E-01  5.9935582E-01  5.9892660E-01  5.9678447E-01  5.9524095E-01
5.9349859E-01
  6.0556227E-01  6.2052512E-01  6.2155539E-01  6.1941218E-01  5.8967638E-01  5.6117243E-01  5.6080770E-01
5.6058753E-01
  5.5065519E-01  5.4018855E-01  5.3865761E-01  5.3724456E-01  5.3256059E-01  5.2811348E-01
 group     3
  2.1292776E-01  2.0373178E-01  2.0415902E-01  2.0712140E-01  2.0942077E-01  2.0886774E-01  2.0857890E-01
2.1077177E-01
  2.0324811E-01  1.9185342E-01  1.9015452E-01  1.9259909E-01  2.0355883E-01  2.1169682E-01  2.1063115E-01
2.1101391E-01
  2.1176219E-01  2.1141014E-01  2.1112168E-01  2.1205272E-01  2.1245542E-01  2.1150228E-01
 group     4
  2.6727179E-03  1.3678879E-03  9.6108951E-04  1.9219050E-03  3.0821632E-03  2.0661976E-03  9.4728766E-04
1.9569760E-03
  3.0698567E-03  1.8795973E-03  6.1749405E-04  1.8169829E-03  3.0984590E-03  2.0655512E-03  9.4842212E-04
2.0447837E-03
  3.2121912E-03  2.1156301E-03  9.5462502E-04  2.0451401E-03  3.1661941E-03  2.0229700E-03
 group     5
  2.1523589E-04  2.0461935E-05 -1.7227343E-04  6.0805367E-05  3.6744226E-04  6.6137021E-05 -2.8467402E-04
5.0601997E-05
  3.6102516E-04  8.0567559E-05 -1.6338097E-04  7.5354030E-05  3.7451927E-04  6.2664461E-05 -3.1400498E-04
5.8236106E-05
  4.4114978E-04  6.8825844E-05 -3.1352320E-04  5.0716902E-05  3.3494300E-04  1.0986239E-04
 total flux
  1.0687699E+00  1.0619813E+00  1.0647417E+00  1.0744739E+00  1.0781075E+00  1.0701594E+00  1.0628799E+00
1.0596808E+00
  1.1030166E+00  1.1520541E+00  1.1551964E+00  1.1500317E+00  1.0762237E+00  1.0039480E+00  1.0019675E+00
1.0045941E+00
  9.8801321E-01  9.6535486E-01  9.5939791E-01  9.5790011E-01  9.4923562E-01  9.3761498E-01
000:00:00      entry into chain 11               cpu time =     0.000 secs

000:00:00      entry into chain 13               cpu time =     0.000 secs

0number of edit regions =  26, number declared =  37.  see 3rd number in prelude nregion data.
             BUCKLING 0.0023136 0.00098596
             THERMAL 2
             BEGINC
1 wimsd edit

                    zone                  radius                volume                material

                                     0.
                      1             0.15000E+01           0.70686E+01                 4
                      2             0.17500E+01           0.25525E+01                 2
                      3             0.20000E+01           0.29452E+01                 4
                      4             0.22500E+01           0.33379E+01                 2
                      5             0.24295E+01           0.26389E+01                 1
                      6             0.26718E+01           0.38825E+01                 2
                      7             0.52500E+01           0.64164E+02                 4
                      8             0.55000E+01           0.84430E+01                 2
                      9             0.57500E+01           0.88357E+01                 4
                     10             0.60000E+01           0.92284E+01                 2
                     11             0.62026E+01           0.77651E+01                 2
                     12             0.90000E+01           0.13361E+03                 4
                     13             0.92500E+01           0.14334E+02                 2
                     14             0.95000E+01           0.14726E+02                 1
                     15             0.97500E+01           0.15119E+02                 2
                     16             0.99383E+01           0.11648E+02                 2
                     17             0.12750E+02           0.20041E+03                 4
                     18             0.13000E+02           0.20224E+02                 2
                     19             0.13250E+02           0.20617E+02                 4
                     20             0.13500E+02           0.21009E+02                 2
                     21             0.13624E+02           0.10556E+02                 1
                     22             0.13804E+02           0.15530E+02                 2
```

```
                    23            0.16500E+02            0.25666E+03                4
                    24            0.16750E+02            0.26114E+02                2
                    25            0.17000E+02            0.26507E+02                4
                    26            0.17250E+02            0.26900E+02                2
                    27            0.17428E+02            0.19413E+02                2
                    28            0.20250E+02            0.33402E+03                4
                    29            0.20500E+02            0.32005E+02                2
0flux scale factor 1.179493E-01
1FEW-GROUP REGIONAL AND CELL EDIT

 cross-sections, integrated and averaged fluxes, total events

0REGION  1     material  4        volume  7.068583E+00
0                cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission           rif          raf          d*flux*vol  absorptions
nu*fissions
    1    2.54422E+00  2.79125E-05  0.00000E+00       2.13278E-01  3.01726E-02       5.42624E-01  5.95311E-06
0.00000E+00
    2    1.11327E+00  0.00000E+00  0.00000E+00       4.97860E-01  7.04327E-02       5.54254E-01  0.00000E+00
0.00000E+00
    3    9.29089E-01  4.11782E-06  0.00000E+00       1.77525E-01  2.51147E-02       1.64937E-01  7.31016E-07
0.00000E+00
    4    9.30993E-01  3.67685E-05  0.00000E+00       2.22834E-03  3.15245E-04       2.07457E-03  8.19327E-08
0.00000E+00
    5    9.03278E-01  1.69653E-04  0.00000E+00       1.79450E-04  2.53869E-05       1.62093E-04  3.04441E-08
0.00000E+00
 thermal 9.28928E-01  4.66722E-05  0.00000E+00       2.40779E-03  3.40632E-04       2.23666E-03  1.12377E-07
0.00000E+00
 total   1.41858E+00  7.62735E-06  0.00000E+00       8.91070E-01  1.26061E-01       1.26405E+00  6.79651E-06
0.00000E+00

0REGION  2     material  2        volume  2.552544E+00
0                cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission           rif          raf          d*flux*vol  absorptions
nu*fissions
    1    4.44571E+01  2.71959E-03  0.00000E+00       7.82575E-02  3.06586E-02       3.47910E+00  2.12828E-04
0.00000E+00
    2    2.53840E+01  8.44522E-03  0.00000E+00       1.79718E-01  7.04076E-02       4.56197E+00  1.51776E-03
0.00000E+00
    3    2.73233E+00  1.19217E-01  0.00000E+00       6.13377E-02  2.40300E-02       1.67595E-01  7.31251E-03
0.00000E+00
    4    1.38179E-01  2.41012E+00  0.00000E+00       4.11831E-04  1.61341E-04       5.69064E-05  9.92561E-04
0.00000E+00
    5    3.71173E-02  8.97823E+00  0.00000E+00       6.16049E-06  2.41347E-06       2.28661E-07  5.53103E-05
0.00000E+00
 thermal 1.36689E-01  2.50692E+00  0.00000E+00       4.17992E-04  1.63755E-04       5.71350E-05  1.04787E-03
0.00000E+00
 total   2.56738E+01  3.15608E-02  0.00000E+00       3.19732E-01  1.25260E-01       8.20872E+00  1.00910E-02
0.00000E+00

0REGION  3     material  4        volume  2.945243E+00
0                cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission           rif          raf          d*flux*vol  absorptions
nu*fissions
    1    2.54422E+00  2.79125E-05  0.00000E+00       9.10524E-02  3.09151E-02       2.31657E-01  2.54150E-06
0.00000E+00
    2    1.11327E+00  0.00000E+00  0.00000E+00       2.07631E-01  7.04970E-02       2.31150E-01  0.00000E+00
0.00000E+00
    3    9.29089E-01  4.11782E-06  0.00000E+00       7.09227E-02  2.40804E-02       6.58935E-02  2.92047E-07
0.00000E+00
    4    9.30993E-01  3.67685E-05  0.00000E+00       3.33872E-04  1.13360E-04       3.10833E-04  1.22760E-08
0.00000E+00
    5    9.03278E-01  1.69653E-04  0.00000E+00      -5.98460E-05 -2.03195E-05      -5.40575E-05 -1.01530E-08
0.00000E+00
 thermal 9.37046E-01  7.74733E-06  0.00000E+00       2.74026E-04  9.30403E-05       2.56775E-04  2.12297E-09
0.00000E+00
 total   1.43008E+00  7.66646E-06  0.00000E+00       3.69880E-01  1.25586E-01       5.28957E-01  2.83567E-06
0.00000E+00

0REGION  4     material  2        volume  3.337942E+00
0                cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission           rif          raf          d*flux*vol  absorptions
nu*fissions
```

```
    1    4.44571E+01  2.71959E-03  0.00000E+00       1.04732E-01  3.13762E-02       4.65607E+00  2.84828E-04
0.00000E+00
    2    2.53840E+01  8.44522E-03  0.00000E+00       2.35971E-01  7.06936E-02       5.98989E+00  1.99283E-03
0.00000E+00
    3    2.73233E+00  1.19217E-01  0.00000E+00       8.15454E-02  2.44298E-02       2.22809E-01  9.72161E-03
0.00000E+00
    4    1.38179E-01  2.41012E+00  0.00000E+00       7.56669E-04  2.26687E-04       1.04556E-04  1.82366E-03
0.00000E+00
    5    3.71173E-02  8.97823E+00  0.00000E+00       2.39396E-05  7.17195E-06       8.88572E-07  2.14935E-04
0.00000E+00
 thermal 1.35080E-01  2.61154E+00  0.00000E+00       7.80609E-04  2.33859E-04       1.05444E-04  2.03860E-03
0.00000E+00
 total   2.56930E+01  3.31842E-02  0.00000E+00       4.23029E-01  1.26733E-01       1.08689E+01  1.40379E-02
0.00000E+00

OREGION  5     material  1        volume  2.638941E+00
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf          d*flux*vol  absorptions
nu*fissions
    1    2.96250E+00  1.74974E-02  4.47287E-02       1.73577E-01  6.57752E-02       5.14221E-01  3.03714E-03
7.76387E-03
    2    1.35828E+00  2.76913E-02  5.47951E-02       2.04678E-01  7.75606E-02       2.78010E-01  5.66780E-03
1.12153E-02
    3    6.88894E-01  1.82949E-01  3.05437E-01       1.67082E-02  6.33140E-03       1.15102E-02  3.05674E-03
5.10329E-03
    4    4.47954E-01  4.52340E-01  8.14550E-01       9.10468E-06  3.45013E-06       4.07847E-06  4.11841E-06
7.41622E-06
    5    1.64652E-01  1.74577E+00  3.62475E+00       2.49513E-08  9.45506E-09       4.10828E-09  4.35593E-08
9.04425E-08
 thermal 4.47179E-01  4.55875E-01  8.22230E-01       9.12963E-06  3.45958E-06       4.08258E-06  4.16197E-06
7.50666E-06
 total   2.03494E+00  2.97890E-02  6.09917E-02       3.94972E-01  1.49671E-01       8.03745E-01  1.17658E-02
2.40900E-02

OREGION  6     material  2        volume  3.882544E+00
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf          d*flux*vol  absorptions
nu*fissions
    1    4.44571E+01  2.71959E-03  0.00000E+00       2.21577E-01  5.70700E-02       9.85066E+00  6.02599E-04
0.00000E+00
    2    2.53840E+01  8.44522E-03  0.00000E+00       2.90729E-01  7.48812E-02       7.37988E+00  2.45527E-03
0.00000E+00
    3    2.73233E+00  1.19217E-01  0.00000E+00       2.56208E-02  6.59896E-03       7.00044E-02  3.05444E-03
0.00000E+00
    4    1.38179E-01  2.41012E+00  0.00000E+00       2.54268E-05  6.54901E-06       3.51345E-06  6.12816E-05
0.00000E+00
    5    3.71173E-02  8.97823E+00  0.00000E+00       8.06988E-07  2.07850E-07       2.99532E-08  7.24532E-06
0.00000E+00
 thermal 1.35070E-01  2.61216E+00  0.00000E+00       2.62338E-05  6.75686E-06       3.54340E-06  6.85269E-05
0.00000E+00
 total   3.21599E+01  1.14895E-02  0.00000E+00       5.37953E-01  1.38557E-01       1.73005E+01  6.18084E-03
0.00000E+00

OREGION  7     material  4        volume  6.416435E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf          d*flux*vol  absorptions
nu*fissions
    1    2.54422E+00  2.79125E-05  0.00000E+00       1.82517E+00  2.84452E-02       4.64362E+00  5.09450E-05
0.00000E+00
    2    1.11327E+00  0.00000E+00  0.00000E+00       4.49805E+00  7.01020E-02       5.00756E+00  0.00000E+00
0.00000E+00
    3    9.29089E-01  4.11782E-06  0.00000E+00       1.70368E+00  2.65519E-02       1.58288E+00  7.01546E-06
0.00000E+00
    4    9.30993E-01  3.67685E-05  0.00000E+00       2.56625E-02  3.99950E-04       2.38916E-02  9.43573E-07
0.00000E+00
    5    9.03278E-01  1.69653E-04  0.00000E+00       3.06266E-03  4.77315E-05       2.76643E-03  5.19588E-07
0.00000E+00
 thermal 9.28038E-01  5.09365E-05  0.00000E+00       2.87252E-02  4.47681E-04       2.66581E-02  1.46316E-06
0.00000E+00
 total   1.39787E+00  7.37666E-06  0.00000E+00       8.05563E+00  1.25547E-01       1.12607E+01  5.94237E-05
0.00000E+00

OREGION  8     material  2        volume  8.443030E+00
```

```
0                  cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    4.44571E+01  2.71959E-03  0.00000E+00       2.61286E-01  3.09469E-02       1.16160E+01  7.10591E-04
0.00000E+00
    2    2.53840E+01  8.44522E-03  0.00000E+00       5.94308E-01  7.03903E-02       1.50859E+01  5.01906E-03
0.00000E+00
    3    2.73233E+00  1.19217E-01  0.00000E+00       2.08001E-01  2.46358E-02       5.68327E-01  2.47973E-02
0.00000E+00
    4    1.38179E-01  2.41012E+00  0.00000E+00       2.05762E-03  2.43707E-04       2.84320E-04  4.95911E-03
0.00000E+00
    5    3.71173E-02  8.97823E+00  0.00000E+00       6.58625E-05  7.80082E-06       2.44464E-06  5.91329E-04
0.00000E+00
 thermal 1.35044E-01  2.61383E+00  0.00000E+00       2.12348E-03  2.51507E-04       2.86765E-04  5.55043E-03
0.00000E+00
 total   2.55889E+01  3.38527E-02  0.00000E+00       1.06572E+00  1.26225E-01       2.72705E+01  3.60774E-02
0.00000E+00

OREGION  9     material  4        volume  8.835730E+00
0                  cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    2.54422E+00  2.79125E-05  0.00000E+00       2.69294E-01  3.04778E-02       6.85141E-01  7.51666E-06
0.00000E+00
    2    1.11327E+00  0.00000E+00  0.00000E+00       6.20341E-01  7.02083E-02       6.90610E-01  0.00000E+00
0.00000E+00
    3    9.29089E-01  4.11782E-06  0.00000E+00       2.17374E-01  2.46017E-02       2.01960E-01  8.95107E-07
0.00000E+00
    4    9.30993E-01  3.67685E-05  0.00000E+00       9.87233E-04  1.11732E-04       9.19107E-04  3.62991E-08
0.00000E+00
    5    9.03278E-01  1.69653E-04  0.00000E+00      -2.96678E-04 -3.35771E-05      -2.67983E-04 -5.03322E-08
0.00000E+00
 thermal 9.42901E-01 -2.03215E-05  0.00000E+00       6.90555E-04  7.81548E-05       6.51125E-04 -1.40331E-08
0.00000E+00
 total   1.42490E+00  7.58124E-06  0.00000E+00       1.10770E+00  1.25366E-01       1.57836E+00  8.39773E-06
0.00000E+00

OREGION 10     material  2        volume  1.699351E+01
0                  cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    4.44571E+01  2.71959E-03  0.00000E+00       7.82155E-01  4.60267E-02       3.47723E+01  2.12714E-03
0.00000E+00
    2    2.53840E+01  8.44522E-03  0.00000E+00       1.23624E+00  7.27479E-02       3.13808E+01  1.04403E-02
0.00000E+00
    3    2.73233E+00  1.19217E-01  0.00000E+00       2.77679E-01  1.63403E-02       7.58709E-01  3.31041E-02
0.00000E+00
    4    1.38179E-01  2.41012E+00  0.00000E+00       2.17881E-03  1.28214E-04       3.01066E-04  5.25119E-03
0.00000E+00
    5    3.71173E-02  8.97823E+00  0.00000E+00       5.66028E-05  3.33085E-06       2.10094E-06  5.08193E-04
0.00000E+00
 thermal 1.35620E-01  2.57643E+00  0.00000E+00       2.23541E-03  1.31545E-04       3.03167E-04  5.75938E-03
0.00000E+00
 total   2.91136E+01  2.23777E-02  0.00000E+00       2.29831E+00  1.35246E-01       6.69121E+01  5.14309E-02
0.00000E+00

OREGION 11     material  4        volume  1.336066E+02
0                  cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    2.54422E+00  2.79125E-05  0.00000E+00       4.34226E+00  3.25003E-02       1.10476E+01  1.21203E-04
0.00000E+00
    2    1.11327E+00  0.00000E+00  0.00000E+00       9.50734E+00  7.11592E-02       1.05843E+01  0.00000E+00
0.00000E+00
    3    9.29089E-01  4.11782E-06  0.00000E+00       3.34084E+00  2.50051E-02       3.10394E+00  1.37570E-05
0.00000E+00
    4    9.30993E-01  3.67685E-05  0.00000E+00       5.11402E-02  3.82767E-04       4.76112E-02  1.88035E-06
0.00000E+00
    5    9.03278E-01  1.69653E-04  0.00000E+00       6.01846E-03  4.50461E-05       5.43634E-03  1.02105E-06
0.00000E+00
 thermal 9.28075E-01  5.07604E-05  0.00000E+00       5.71587E-02  4.27813E-04       5.30476E-02  2.90140E-06
0.00000E+00
```

```
 total   1.43724E+00  7.99310E-06  0.00000E+00       1.72476E+01  1.29092E-01       2.47889E+01  1.37862E-04
0.00000E+00

OREGION 12     material  2        volume  1.433352E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    4.44571E+01  2.71959E-03  0.00000E+00       5.70951E-01  3.98333E-02       2.53828E+01  1.55275E-03
0.00000E+00
    2    2.53840E+01  8.44522E-03  0.00000E+00       1.04908E+00  7.31905E-02       2.66298E+01  8.85969E-03
0.00000E+00
    3    2.73233E+00  1.19217E-01  0.00000E+00       3.24353E-01  2.26290E-02       8.86239E-01  3.86684E-02
0.00000E+00
    4    1.38179E-01  2.41012E+00  0.00000E+00       3.17770E-03  2.21697E-04       4.39091E-04  7.65863E-03
0.00000E+00
    5    3.71173E-02  8.97823E+00  0.00000E+00       1.36210E-04  9.50289E-06       5.05574E-06  1.22292E-03
0.00000E+00
 thermal 1.34025E-01  2.68008E+00  0.00000E+00       3.31391E-03  2.31200E-04       4.44147E-04  8.88155E-03
0.00000E+00
 total   2.71599E+01  2.97595E-02  0.00000E+00       1.94770E+00  1.35884E-01       5.28993E+01  5.79624E-02
0.00000E+00

OREGION 13     material  1        volume  1.472622E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    2.96250E+00  1.74974E-02  4.47287E-02       5.95829E-01  4.04604E-02       1.76514E+00  1.04254E-02
2.66507E-02
    2    1.35828E+00  2.76913E-02  5.47951E-02       1.07961E+00  7.33120E-02       1.46641E+00  2.98958E-02
5.91572E-02
    3    6.88894E-01  1.82949E-01  3.05437E-01       3.30288E-01  2.24286E-02       2.27534E-01  6.04258E-02
1.00882E-01
    4    4.47954E-01  4.52340E-01  8.14550E-01       1.07255E-03  7.28330E-05       4.80455E-04  4.85159E-04
8.73649E-04
    5    1.64652E-01  1.74577E+00  3.62475E+00      -2.83784E-04 -1.92707E-05      -4.67256E-05 -4.95422E-04 -
1.02865E-03
 thermal 5.49880E-01 -1.30111E-02 -1.96506E-01       7.88770E-04  5.35623E-05       4.33729E-04 -1.02628E-05 -
1.54998E-04
 total   1.72414E+00  5.02049E-02  9.29647E-02       2.00652E+00  1.36255E-01       3.45952E+00  1.00737E-01
1.86535E-01

OREGION 14     material  2        volume  2.676661E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    4.44571E+01  2.71959E-03  0.00000E+00       1.32949E+00  4.96698E-02       5.91053E+01  3.61568E-03
0.00000E+00
    2    2.53840E+01  8.44522E-03  0.00000E+00       1.96670E+00  7.34758E-02       4.99226E+01  1.66092E-02
0.00000E+00
    3    2.73233E+00  1.19217E-01  0.00000E+00       4.15952E-01  1.55400E-02       1.13652E+00  4.95886E-02
0.00000E+00
    4    1.38179E-01  2.41012E+00  0.00000E+00       3.31386E-03  1.23806E-04       4.57905E-04  7.98678E-03
0.00000E+00
    5    3.71173E-02  8.97823E+00  0.00000E+00       1.36747E-04  5.10886E-06       5.07568E-06  1.22774E-03
0.00000E+00
 thermal 1.34174E-01  2.67041E+00  0.00000E+00       3.45061E-03  1.28915E-04       4.62981E-04  9.21453E-03
0.00000E+00
 total   2.96494E+01  2.12693E-02  0.00000E+00       3.71559E+00  1.38814E-01       1.10165E+02  7.90280E-02
0.00000E+00

OREGION 15     material  4        volume  2.004099E+02
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    2.54422E+00  2.79125E-05  0.00000E+00       6.26117E+00  3.12418E-02       1.59298E+01  1.74765E-04
0.00000E+00
    2    1.11327E+00  0.00000E+00  0.00000E+00       1.38869E+01  6.92924E-02       1.54599E+01  0.00000E+00
0.00000E+00
    3    9.29089E-01  4.11782E-06  0.00000E+00       5.01893E+00  2.50433E-02       4.66303E+00  2.06670E-05
0.00000E+00
    4    9.30993E-01  3.67685E-05  0.00000E+00       7.74251E-02  3.86334E-04       7.20823E-02  2.84681E-06
0.00000E+00
```

```
    5    9.03278E-01  1.69653E-04  0.00000E+00       9.36512E-03  4.67298E-05       8.45931E-03  1.58882E-06
0.00000E+00
 thermal 9.28003E-01  5.11074E-05  0.00000E+00       8.67902E-02  4.33064E-04       8.05416E-02  4.43562E-06
0.00000E+00
 total   1.43081E+00  7.91436E-06  0.00000E+00       2.52538E+01  1.26011E-01       3.61333E+01  1.99868E-04
0.00000E+00

OREGION 16     material  2        volume  2.022400E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    4.44571E+01  2.71959E-03  0.00000E+00       5.46140E-01  2.70045E-02       2.42798E+01  1.48528E-03
0.00000E+00
    2    2.53840E+01  8.44522E-03  0.00000E+00       1.33862E+00  6.61899E-02       3.39797E+01  1.13050E-02
0.00000E+00
    3    2.73233E+00  1.19217E-01  0.00000E+00       5.04983E-01  2.49695E-02       1.37978E+00  6.02027E-02
0.00000E+00
    4    1.38179E-01  2.41012E+00  0.00000E+00       4.92718E-03  2.43630E-04       6.80833E-04  1.18751E-02
0.00000E+00
    5    3.71173E-02  8.97823E+00  0.00000E+00       1.49480E-04  7.39123E-06       5.54831E-06  1.34207E-03
0.00000E+00
 thermal 1.35203E-01  2.60351E+00  0.00000E+00       5.07666E-03  2.51022E-04       6.86381E-04  1.32171E-02
0.00000E+00
 total   2.49037E+01  3.59985E-02  0.00000E+00       2.39482E+00  1.18415E-01       5.96399E+01  8.62101E-02
0.00000E+00

OREGION 17     material  4        volume  2.061662E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    2.54422E+00  2.79125E-05  0.00000E+00       5.59038E-01  2.71159E-02       1.42231E+00  1.56041E-05
0.00000E+00
    2    1.11327E+00  0.00000E+00  0.00000E+00       1.36373E+00  6.61469E-02       1.51820E+00  0.00000E+00
0.00000E+00
    3    9.29089E-01  4.11782E-06  0.00000E+00       5.12195E-01  2.48438E-02       4.75875E-01  2.10913E-06
0.00000E+00
    4    9.30993E-01  3.67685E-05  0.00000E+00       2.30629E-03  1.11866E-04       2.14714E-03  8.47990E-08
0.00000E+00
    5    9.03278E-01  1.69653E-04  0.00000E+00      -7.63571E-04 -3.70367E-05      -6.89717E-04 -1.29542E-07
0.00000E+00
 thermal 9.44711E-01 -2.90025E-05  0.00000E+00       1.54272E-03  7.48291E-05       1.45743E-03 -4.47428E-08
0.00000E+00
 total   1.40277E+00  7.25160E-06  0.00000E+00       2.43650E+00  1.18181E-01       3.41785E+00  1.76685E-05
0.00000E+00

OREGION 18     material  2        volume  2.100940E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    4.44571E+01  2.71959E-03  0.00000E+00       5.72155E-01  2.72333E-02       2.54363E+01  1.55603E-03
0.00000E+00
    2    2.53840E+01  8.44522E-03  0.00000E+00       1.38916E+00  6.61209E-02       3.52625E+01  1.17318E-02
0.00000E+00
    3    2.73233E+00  1.19217E-01  0.00000E+00       5.22902E-01  2.48889E-02       1.42874E+00  6.23389E-02
0.00000E+00
    4    1.38179E-01  2.41012E+00  0.00000E+00       5.06706E-03  2.41181E-04       7.00162E-04  1.22122E-02
0.00000E+00
    5    3.71173E-02  8.97823E+00  0.00000E+00       1.44312E-04  6.86891E-06       5.35646E-06  1.29566E-03
0.00000E+00
 thermal 1.35380E-01  2.59200E+00  0.00000E+00       5.21138E-03  2.48050E-04       7.05518E-04  1.35079E-02
0.00000E+00
 total   2.49568E+01  3.58052E-02  0.00000E+00       2.48943E+00  1.18491E-01       6.21282E+01  8.91346E-02
0.00000E+00

OREGION 19     material  1        volume  1.055579E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    2.96250E+00  1.74974E-02  4.47287E-02       5.78636E-01  5.48169E-02       1.71421E+00  1.01246E-02
2.58816E-02
    2    1.35828E+00  2.76913E-02  5.47951E-02       7.52728E-01  7.13095E-02       1.02241E+00  2.08441E-02
4.12458E-02
```

```
    3    6.88894E-01  1.82949E-01  3.05437E-01       6.75801E-02  6.40218E-03       4.65555E-02  1.23637E-02
2.06415E-02
    4    4.47954E-01  4.52340E-01  8.14550E-01       3.79552E-05  3.59568E-06       1.70022E-05  1.71687E-05
3.09164E-05
    5    1.64652E-01  1.74577E+00  3.62475E+00       1.19826E-07  1.13517E-08       1.97296E-08  2.09189E-07
4.34341E-07
 thermal 4.47062E-01  4.56411E-01  8.23394E-01       3.80751E-05  3.60703E-06       1.70219E-05  1.73779E-05
3.13508E-05
 total   1.98944E+00  3.09866E-02  6.27601E-02       1.39898E+00  1.32532E-01       2.78320E+00  4.33497E-02
8.78002E-02

OREGION 20     material  2        volume  1.553016E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    4.44571E+01  2.71959E-03  0.00000E+00       7.38646E-01  4.75620E-02       3.28380E+01  2.00881E-03
0.00000E+00
    2    2.53840E+01  8.44522E-03  0.00000E+00       1.06919E+00  6.88460E-02       2.71403E+01  9.02954E-03
0.00000E+00
    3    2.73233E+00  1.19217E-01  0.00000E+00       1.03629E-01  6.67274E-03       2.83148E-01  1.23543E-02
0.00000E+00
    4    1.38179E-01  2.41012E+00  0.00000E+00       1.05998E-04  6.82529E-06       1.46467E-05  2.55467E-04
0.00000E+00
    5    3.71173E-02  8.97823E+00  0.00000E+00       3.87546E-06  2.49544E-07       1.43847E-07  3.47948E-05
0.00000E+00
 thermal 1.34614E-01  2.64179E+00  0.00000E+00       1.09873E-04  7.07484E-06       1.47905E-05  2.90262E-04
0.00000E+00
 total   3.15246E+01  1.23892E-02  0.00000E+00       1.91157E+00  1.23088E-01       6.02615E+01  2.36830E-02
0.00000E+00

OREGION 21     material  4        volume  2.566574E+02
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    2.54422E+00  2.79125E-05  0.00000E+00       6.08436E+00  2.37062E-02       1.54799E+01  1.69830E-04
0.00000E+00
    2    1.11327E+00  0.00000E+00  0.00000E+00       1.65421E+01  6.44520E-02       1.84159E+01  0.00000E+00
0.00000E+00
    3    9.29089E-01  4.11782E-06  0.00000E+00       6.89093E+00  2.68487E-02       6.40229E+00  2.83756E-05
0.00000E+00
    4    9.30993E-01  3.67685E-05  0.00000E+00       1.06981E-01  4.16823E-04       9.95983E-02  3.93352E-06
0.00000E+00
    5    9.03278E-01  1.69653E-04  0.00000E+00       1.47081E-02  5.73063E-05       1.32855E-02  2.49526E-06
0.00000E+00
 thermal 9.27643E-01  5.28297E-05  0.00000E+00       1.21689E-01  4.74129E-04       1.12884E-01  6.42878E-06
0.00000E+00
 total   1.36344E+00  6.90420E-06  0.00000E+00       2.96391E+01  1.15481E-01       4.04110E+01  2.04634E-04
0.00000E+00

OREGION 22     material  2        volume  2.611449E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    4.44571E+01  2.71959E-03  0.00000E+00       6.51680E-01  2.49547E-02       2.89718E+01  1.77230E-03
0.00000E+00
    2    2.53840E+01  8.44522E-03  0.00000E+00       1.66388E+00  6.37149E-02       4.22360E+01  1.40518E-02
0.00000E+00
    3    2.73233E+00  1.19217E-01  0.00000E+00       6.51183E-01  2.49357E-02       1.77924E+00  7.76322E-02
0.00000E+00
    4    1.38179E-01  2.41012E+00  0.00000E+00       6.51653E-03  2.49537E-04       9.00448E-04  1.57056E-02
0.00000E+00
    5    3.71173E-02  8.97823E+00  0.00000E+00       2.11996E-04  8.11796E-06       7.86874E-06  1.90335E-03
0.00000E+00
 thermal 1.34995E-01  2.61706E+00  0.00000E+00       6.72853E-03  2.57655E-04       9.08316E-04  1.76090E-02
0.00000E+00
 total   2.45464E+01  3.73520E-02  0.00000E+00       2.97347E+00  1.13863E-01       7.29879E+01  1.11065E-01
0.00000E+00

OREGION 23     material  4        volume  2.650719E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
```

```
    1    2.54422E+00  2.79125E-05  0.00000E+00       6.53369E-01  2.46488E-02       1.66231E+00  1.82372E-05
0.00000E+00
    2    1.11327E+00  0.00000E+00  0.00000E+00       1.68412E+00  6.35343E-02       1.87488E+00  0.00000E+00
0.00000E+00
    3    9.29089E-01  4.11782E-06  0.00000E+00       6.60073E-01  2.49017E-02       6.13267E-01  2.71806E-06
0.00000E+00
    4    9.30993E-01  3.67685E-05  0.00000E+00       2.98464E-03  1.12597E-04       2.77868E-03  1.09741E-07
0.00000E+00
    5    9.03278E-01  1.69653E-04  0.00000E+00      -9.80232E-04 -3.69798E-05      -8.85421E-04 -1.66299E-07
0.00000E+00
 thermal 9.44547E-01 -2.82168E-05  0.00000E+00       2.00441E-03  7.56175E-05       1.89326E-03 -5.65580E-08
0.00000E+00
 total   1.38432E+00  6.96724E-06  0.00000E+00       2.99956E+00  1.13160E-01       4.15235E+00  2.08987E-05
0.00000E+00

OREGION 24     material  2        volume  4.631257E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    4.44571E+01  2.71959E-03  0.00000E+00       1.52899E+00  3.30146E-02       6.79744E+01  4.15823E-03
0.00000E+00
    2    2.53840E+01  8.44522E-03  0.00000E+00       3.00227E+00  6.48261E-02       7.62095E+01  2.53548E-02
0.00000E+00
    3    2.73233E+00  1.19217E-01  0.00000E+00       7.98912E-01  1.72504E-02       2.18289E+00  9.52440E-02
0.00000E+00
    4    1.38179E-01  2.41012E+00  0.00000E+00       6.61436E-03  1.42820E-04       9.13965E-04  1.59414E-02
0.00000E+00
    5    3.71173E-02  8.97823E+00  0.00000E+00       1.64449E-04  3.55084E-06       6.10389E-06  1.47646E-03
0.00000E+00
 thermal 1.35727E-01  2.56945E+00  0.00000E+00       6.77881E-03  1.46371E-04       9.20069E-04  1.74178E-02
0.00000E+00
 total   2.74254E+01  2.66397E-02  0.00000E+00       5.33695E+00  1.15238E-01       1.46368E+02  1.42175E-01
0.00000E+00

OREGION 25     material  4        volume  3.340165E+02
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    2.54422E+00  2.79125E-05  0.00000E+00       7.49352E+00  2.24346E-02       1.90651E+01  2.09163E-04
0.00000E+00
    2    1.11327E+00  0.00000E+00  0.00000E+00       2.09030E+01  6.25808E-02       2.32708E+01  0.00000E+00
0.00000E+00
    3    9.29089E-01  4.11782E-06  0.00000E+00       8.73047E+00  2.61378E-02       8.11139E+00  3.59505E-05
0.00000E+00
    4    9.30993E-01  3.67685E-05  0.00000E+00       1.31863E-01  3.94779E-04       1.22763E-01  4.84840E-06
0.00000E+00
    5    9.03278E-01  1.69653E-04  0.00000E+00       1.39591E-02  4.17918E-05       1.26090E-02  2.36821E-06
0.00000E+00
 thermal 9.28340E-01  4.94892E-05  0.00000E+00       1.45822E-01  4.36571E-04       1.35372E-01  7.21661E-06
0.00000E+00
 total   1.35709E+00  6.76981E-06  0.00000E+00       3.72728E+01  1.11590E-01       5.05827E+01  2.52330E-04
0.00000E+00

OREGION 26     material  2        volume  3.200497E+01
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission            rif          raf           d*flux*vol  absorptions
nu*fissions
    1    4.44571E+01  2.71959E-03  0.00000E+00       7.39389E-01  2.31023E-02       3.28711E+01  2.01084E-03
0.00000E+00
    2    2.53840E+01  8.44522E-03  0.00000E+00       1.99361E+00  6.22906E-02       5.06058E+01  1.68365E-02
0.00000E+00
    3    2.73233E+00  1.19217E-01  0.00000E+00       7.98414E-01  2.49465E-02       2.18153E+00  9.51847E-02
0.00000E+00
    4    1.38179E-01  2.41012E+00  0.00000E+00       7.63664E-03  2.38608E-04       1.05522E-03  1.84052E-02
0.00000E+00
    5    3.71173E-02  8.97823E+00  0.00000E+00       4.14727E-04  1.29582E-05       1.53935E-05  3.72351E-03
0.00000E+00
 thermal 1.32973E-01  2.74844E+00  0.00000E+00       8.05137E-03  2.51566E-04       1.07062E-03  2.21287E-02
0.00000E+00
 total   2.42013E+01  3.84693E-02  0.00000E+00       3.53946E+00  1.10591E-01       8.56595E+01  1.36161E-01
0.00000E+00
```

```
 CELL             VOLUME  1.320254E+03
0                 cross-sections                          fluxes                              reactions
  group   diffusion   absorption   nu*fission           rif          raf          d*flux*vol  absorptions
nu*fissions
    1    1.16980E+01  1.24674E-03  1.61800E-03       3.72660E+01  2.82264E-02       4.35938E+02  4.64608E-02
6.02962E-02
    2    5.54663E+00  2.18342E-03  1.27189E-03       8.77576E+01  6.64702E-02       4.86759E+02  1.91611E-01
1.11618E-01
    3    1.19084E+00  1.98438E-02  3.89477E-03       3.25120E+01  2.46256E-02       3.87166E+01  6.45163E-01
1.26627E-01
    4    8.53686E-01  2.32491E-01  2.04562E-03       4.45821E-01  3.37678E-04       3.80591E-01  1.03649E-01
9.11982E-04
    5    8.79521E-01  2.82526E-01 -2.21463E-02       4.64241E-02  3.51630E-05       4.08310E-02  1.31160E-02 -
1.02812E-03
 thermal 8.56123E-01  2.37210E-01 -2.35941E-04       4.92245E-01  3.72841E-04       4.21422E-01  1.16765E-01 -
1.16141E-04
 total   6.08649E+00  6.32800E-03  1.88844E-03       1.58028E+02  1.19695E-01       9.61835E+02  1.00000E+00
2.98425E-01


0CELL AVERAGE SCATTERING CROSS SECTIONS




         1           2           3           4           5
  1  8.2970E-02  1.9199E-02  2.2756E-07  0.0000E+00  0.0000E+00
  2  0.0000E+00  2.3509E-01  8.6626E-03  0.0000E+00  0.0000E+00
  3  0.0000E+00  0.0000E+00  3.0220E-01  3.5513E-03  6.9587E-10
  4  0.0000E+00  0.0000E+00  2.2715E-04  2.9717E-01  2.6288E-02
  5  0.0000E+00  0.0000E+00 -2.4501E-25  2.4425E-04  3.5720E-01
0                         modified
           GROUP    removals      spectrum         p           eta.f
             1    7.154653E-01  7.630001E-01  9.377002E-01  1.297786E+00
             2    7.602211E-01  2.367000E-01  7.984129E-01  5.825253E-01
             3    1.153577E-01  3.000000E-04  1.516824E-01  1.962714E-01
             4    1.170831E-02  0.000000E+00  1.014958E-01  8.798725E-03
             5    0.000000E+00  0.000000E+00  0.000000E+00 -7.838682E-02
0           fast  1.153589E-01  1.000000E+00  1.155213E-01  3.380093E-01
         thermal  0.000000E+00  0.000000E+00  0.000000E+00 -9.946515E-04
000:00:00      entry into chain 14               cpu time =     0.000 secs

1LEAKAGE EDIT
 ======= ====

 RADIAL BUCKLING    2.31360E-03          AXIAL BUCKLING    9.85960E-04


 transport diffusion coefficients
 --------- --------- ------------


 diagonal transport corrected flux solution


          5 GROUPS.....  k-infinity  2.989565E-01   k-effective  1.568035E-01
          2 GROUPS.....  k-infinity  3.255523E-01   k-effective  1.568034E-01


            radial        axial
 GROUP     DIFFUSION    DIFFUSION     ABSORPTION     REMOVAL      NU-FISSION     FLUX-EFF      FLUX-INF
   1     3.223253E+00  3.223253E+00  1.246735E-03  1.919887E-02  1.617995E-03  2.454882E+01  3.731854E+01
   2     1.355361E+00  1.355361E+00  2.183415E-03  8.662652E-03  1.271895E-03  4.621990E+01  8.788126E+01
   3     1.023759E+00  1.023759E+00  1.984381E-02  3.551271E-03  3.894772E-03  1.496798E+01  3.255788E+01
   4     5.993263E-01  5.993263E-01  2.324909E-01  2.651490E-02  2.045624E-03  2.036908E-01  4.464450E-01
   5     5.208574E-01  5.208574E-01  2.825260E-01  2.442598E-04 -2.214631E-02  1.882177E-02  4.150387E-02
01 of 2  1.832299E+00  1.832299E+00  4.998384E-03  6.199832E-04  1.828897E-03  8.573671E+01  1.780049E+02
 2 of 2  5.926888E-01  5.926888E-01  2.367233E-01  2.079319E-04 -7.100953E-07  2.225126E-01  4.657895E-01
0       partial radial partial axial   fission
         slowing down  slowing down    spectrum
 group       area          area
```

```
   1     1.202871E+02  1.202871E+02  7.630001E-01
   2     1.249259E+02  1.249259E+02  2.367000E-01
   3     4.375957E+01  4.375957E+01  3.000000E-04
   4     2.313949E+00  2.313949E+00  0.000000E+00
   5     1.841981E+00  1.841981E+00  0.000000E+00
01 of 2  3.261267E+02  3.261267E+02
 2 of 2  2.501523E+00  2.501523E+00

        buckling search         given
     radial         axial
 -2.415439E-03 -1.029360E-03    ratio
  2.313600E-03 -5.758399E-03    radial
 -4.430759E-03  9.859600E-04    axial
000:00:00      entry into chain 15              cpu time =     0.000 secs

000:00:00      entry into chain  1              cpu time =     0.000 secs

1



 END OF FILE ON DATASET     5
```