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KENO IV
An Improved Monte Carlo Criticality Program

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OAK RIDGE NATIONAL LABORATORY

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TABLE OF CONTENTS

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ABSTRACT

KENO IV is a multigroup Monte Carlo criticality program written for the IBM 360 computers. It executes rapidly and is flexibly dimensioned so the allowed size of a problem (i.e., the number of energy groups, number of geometry cards, etc. is arbitrary) is limited only by the total data storage required. The input data, with the exception of cross sections, fission spectra and albedos, may be entered in free form. The geometry input is quite simple to prepare and complicated three-dimensional systems can often be described with a minimum of effort.

The results calculated by KENO IV include k-effective, lifetime and generation time, energy-dependent leakages and absorptions, energy- and region-dependent fluxes and region-dependent fission densities. Criticality searches can be made on unit dimensions or on the number of units in an array. This report includes a summary of the theory utilized by KENO IV, a section describing the logical program flow, a compilation of the error messages printed by the code and a comprehensive data guide for preparing input to the code.

INTRODUCTION

KENO IV is an improvement and extension of KENO - A Multigroup Monte Carlo Criticality Program[1] written for the IBM 360 computers. It is flexibly dimensioned, utilizes free-form input and offers more geometry options than KENO. The geometry input for KENO IV consists of geometry key words representing simple types of three-dimensional configurations (SPHERE, CUBE, CYLINDER, etc.). A geometry shape defines a region. These regions can be nested one outside another to construct a desired object. Each region must be completely enclosed by the next larger region (tangency and common faces are allowed but intersecting regions are not). This procedure is used to describe box types, each of which may contain a different geometry configuration. The box types can then be stacked together to form a three-dimensional array of units. When stacking box types, the adjacent faces of adjacent box types must be the same size. Once an array has been described, a reflector can be built around the array by using the automatic reflector option, building it of geometry key words enclosing the entire array, or using the albedo options. KENO IV can calculate k-effective, matrix k-effective, lifetime, generation time, leakages, absorptions, fluxes, and fission densities. It can do a forward calculation or an adjoint calculation, a dimension search or an array search. It can also use a different albedo reflector material on each face of an array. If differential albedos are used, the lifetime and generation time will be incorrect. Cross sections, albedos, and/or geometry data can be used from the preceding case if so desired.

KENO IV executes extensive checks for input data errors and, if it finds any, will print an error message and not execute that case. However, it does continue reading and checking the input data. If it does get lost in the input data, an attempt is made to read to a special end-of-case flag so it can execute the next case. If an error is found in a case, KENO IV will not execute any subsequent case that uses data from that case.

The principal result from KENO IV is an estimate of criticality (k-effective) An optional alternate method of determining k-effective is the matrix method and yields a matrix k-effective (the largest eigenvalue of the matrix of fission probabilities) by unit, box type, or both The matrix method also yields cofactor k-effectives by unit, box type, or both The cofactor k-effective of a unit is the k-effective of the array as though that unit were removed, but using the fission distribution that exists if the unit were there The average unit self-multiplication the source vector, and the fission probability matrix by box type are always printed if a matrix k-effective calculation is made, but the fission probability matrix by unit position may be suppressed

The leakage absorption and fission production by energy group are calculated and printed An option to print leakage and absorption by both energy group and geometry region is available If specified KENO IV will compute fluxes by region and group and or fission densities by region

Criticality searches can be made on the dimensions of a unit the spacing between units, or on the number of units in an array In a dimension search, each surface of each region can be altered independently of the other surfaces Checks are made to see that no geometry restrictions have been violated In an array search, the number of units in an array is increased or decreased, and, if a reflector is present, the dimensions of the reflector regions are altered to maintain the reflector thickness A search is conducted in an iterative manner until the desired value of k-effective is achieved or until the allowed number of iterations have been made

KENO-IV utilizes a weighted tracking method and the weights are specified by region and group The default weight (if a weight is specified as zero) is 0 5 The weight above which splitting occurs is three times the average weight and the weight below which Russian roulette is played is one-third of the average weight

Seven different starting options are available for starting the initial generation This helps avoid source convergence problems by adequately describing the neutron distribution in the initial generation The source distribution for each successive generation is chosen from the fission neutrons generated in the previous generation

The cross-sections and group-dependent data used by KENO IV are not limited to Hansen Roach cross sections or to 16 energy groups The Hansen Roach 16 group cross section data set and compatible weighting functions and albedo data are included in this report Weighting functions and albedo data can be generated for any desired energy group structure

THEORY

1 The Transport Equation

The equation KENO IV solves may be derived in the following manner, starting with the Boltzman neutron transport equation which may be written as[2]

$$\frac{1}{v}\frac{\partial \Phi}{\partial t}(X,E,\Omega,t) + \Omega \cdot \nabla \Phi(X,E,\Omega,t) + \Sigma_t(X,E,\Omega,t)\Phi(X,E,\Omega,t) =$$

$$S(X,E,\Omega,t) + \int_{E'}\int_{\Omega'} \Sigma_s(X,E' \rightarrow E,\Omega' \rightarrow \Omega,t)\Phi(X,E',\Omega',t)\, d\Omega'\, dE', \quad [1]$$

where

$\Phi(X,E,\Omega,t)$ = neutron flux (neutrons/cm^2/sec) per unit energy at energy E per steradian about direction Ω at position X at time t moving at speed v corresponding to E,

$\Sigma_t(X,E,\Omega,t)$ = macroscopic total cross section of the media (cm^{-1}) at position X, energy E, direction Ω and time t,

$\Sigma_s(X,E' \rightarrow E,\Omega' \rightarrow \Omega,t)$ = macroscopic differential cross section of the media (cm^{-1}) at position X, and time t, for scattering from energy E′ and direction Ω' to energy E and direction Ω,

$S(X,E,\Omega,t)$ = neutrons/cm^3/sec born at position X and time t per unit energy at energy E per steradian about direction Ω (excludes scatter source)

Defining $q(X,E,\Omega,t)$ as the total source resulting from the external source, scattering, fission and all other contributions, the following relationship can be written

$$q(X,E,\Omega,t) = S(X,E,\Omega,t) + \int_{E'}\int_{\Omega'} \Sigma_s(X,E' \rightarrow E,\Omega' \rightarrow \Omega,t)\,\Phi(X,E',\Omega',t)\, d\Omega'\, dE' \quad [2]$$

Combining Eqs [1] and [2], assuming the media to be isotropic, ignoring the time dependence of the cross sections and converting the equation to multigroup form yields

$$\frac{1}{v_g}\frac{\partial \Phi_g}{\partial t}(X,\Omega,t) + \Omega \cdot \nabla \Phi_g(X,\Omega,t) + \Sigma_{t_g}(X)\Phi_g(X,\Omega,t) = q_g(X,\Omega,t) \quad [3]$$

where

g is the energy group of interest,

v_g is the average velocity of the neutrons in group g,

$\Phi_g(X,\Omega,t)$ is the angular flux of neutrons having their energies in group g, at position X and time t,

$\Sigma_{t_g}(X)$ is the macroscopic total cross section of the media at position X for group g, corresponding to

$$\Sigma_{t_g}(X) = \frac{\int_{\Delta Eg} \Sigma_t(X,E)\Phi(X,E,\Omega,t)\,dE}{\int_{\Delta Eg} \Phi(X,E,\Omega,t)\,dE}$$ where ΔEg defines group g, and

$q_g(X,\Omega,t)$ is the total source contributing to energy group g at position X, and time t in direction Ω

Utilizing the relationship $X' = X - R\Omega$, defining the problem to be non-time dependent and using an integrating factor[3] on both sides of Eq [3], the following equation can be written

$$\Phi_g(X,\Omega) = \int_0^\infty q_g(X-R\Omega,\Omega)\, e^{-\int_0^R \Sigma_{t_g}(X-R\,\Omega)dR}\, dR \qquad [4]$$

At this point, the problem becomes an eigenvalue problem If there is no external source, the source may be defined as

$$q_g(X,\Omega) = \sum_{g'} \int d\Omega' \Phi_g(X,\Omega')\, \Sigma_s(X,g'\rightarrow g,\Omega'\cdot\Omega) + \frac{1}{k} Q'_g(X,\Omega)\,, \qquad [5]$$

where

k is the largest eigenvalue of the integral equation,

$Q'_g(X,\Omega)$ is the fission source at position X for energy group g and direction Ω (all fission contributions to group g from all energy groups in the previous generation),

$\Sigma_s(X,g'\rightarrow g,\Omega'\cdot\Omega)$ is the scattering cross section for scattering at position X from group g′ and direction Ω' to group g and direction Ω

In terms of energy, the scatter can be defined as

$$\Sigma_s(X,g'\rightarrow g,\Omega'\cdot\Omega) = \frac{\int_{\Delta Eg}\int_{\Delta Eg'} \Sigma_s(X,E'\rightarrow E,\Omega'\cdot\Omega)\Phi(X,E',\Omega')\,dE'\,dE}{\int_{\Delta Eg'} \Phi(X,E',\Omega')\,dE'} \qquad [6]$$

where

ΔE_g is the energy range defining energy group g and
$\Delta E_{g'}$ is the energy range defining energy group g′

Assuming the fission neutrons to be isotropic, the fission source $Q_g'(X\ \Omega)$ can be written as

$$Q_g' (X\ \Omega) = \frac{1}{4\pi} \sum_{g'} \int_{\Omega} d\Omega' \Phi_g\ (X\ \Omega')\chi(X,g'\to g)\, \nu_g\ (X)\ \Sigma_{f_g}\ (X)\,, \qquad [7]$$

where

$\chi(X,g'\to g)$ is the fraction of neutrons born in energy group g from fission in energy group g′ in the media at position X,

$\nu_g{}'(X)$ is the number of neutrons resulting from a fission in energy group g′ at position X,

$\Sigma_{f_g}(X)$ is the macroscopic fission cross section of the material at position X for a neutron in energy group g′

Substituting Eq [5] into Eq [4] yields the following equation

$$\Phi_g (X,\Omega) = \int_0^{\infty} dR\ e^{\int_0^R \Sigma_{t_g}(X\ \ R\ \Omega)dR} \left\{\frac{1}{k} Q_g'\ (X-R\Omega,\Omega) + \sum_g \left[\int_{\Omega} d\Omega' \Phi_g\ (X-R\Omega,\Omega')\ \Sigma_s(X-R\Omega\ g'\to g,\Omega'\cdot\Omega)\right]\right\} \qquad [8]$$

The definition of k may be given as the ratio of the number of neutrons in the n+1 generation to the number of neutrons in the n generation or the largest eigenvalue of the integral equation Using Eq [7], Eq [8] can be written as

$$\Phi_g (X,\Omega) = \int_0^{\infty} dR\ e^{-\int_0^R \Sigma_{t_g}(X-R'\Omega)dR}\ \cdot$$

$$\left\{ \sum_{g'} \frac{1}{k}\int_{\Omega} \nu_g\ (X-R\Omega)\ \Sigma_{f_g}\ (X-R\Omega)\chi(X-R\Omega,g'\to g)\ \Phi_g\ (X-R\Omega,\Omega')\frac{d\Omega'}{4\pi} + \right.$$

$$\left. \sum_{g'}\int_{\Omega} d\Omega'\ \Sigma_{t_g}\ (X-R\Omega)\Phi_g\ (X-R\Omega,\Omega')\ \frac{\Sigma_s(X\ \ R\Omega\ g'\to g\ \Omega'\cdot\Omega)}{\Sigma_{t_g}\ (X-R\Omega)} \right\} \qquad [9]$$

Writing Eq. [9] in "generation notation", multiplying and dividing certain terms by $\Sigma_{t_g}(X)$ and multiplying both sides of the equation by $\nu_g(X)\Sigma_{f_g}(X)$, yield the following equation, which is solved by KENO.

$$\frac{\nu_g(X)\Sigma_{f_g}(X)}{\Sigma_{t_g}(X)}\Sigma_{t_g}(X)\Phi_{g,n}(X,\Omega) = \frac{\nu_g(X)\,\Sigma_{f_g}(X)}{\Sigma_{t_g}(X)}\,\Sigma_{t_g}(X)\int_0^\infty dR\, e^{-\int_0^R \Sigma_{t_g}(X-R'\Omega)dR'}\,\cdot$$

$$\left\{\frac{1}{k}\sum_{g}\int_{\Omega'}\frac{\nu_{g'}(X-R\Omega)\,\Sigma_{f_{g'}}(X-R\Omega)}{\Sigma_{t_{g'}}(X-R\Omega)}\chi(X-R\Omega,g'\to g)\,\Sigma_{t_{g'}}(X-R\Omega)\Phi_{g',n-1}(X-R\Omega,\Omega')\frac{d\Omega'}{4\pi}\right.$$

$$\left.+\sum_{g'}\int_{\Omega'}\frac{\Sigma_S(X-R\Omega,g'\to g,\Omega'\cdot\Omega)}{\Sigma_{t_{g'}}(X-R\Omega)}\Sigma_{t_{g'}}(X-R\Omega)\Phi_{g,n}(X-R\Omega,\Omega')d\Omega'\right\}, \quad [10]$$

where n indicates the n*th* generation and n−1 is the $(n-1)$*th* generation. Note that the left hand side of the equation, $\nu_g(X)\Sigma_{f_g}(X)\Phi_{g,n}(X,\Omega)$, is the fission production for the n*th* generation

The solution strategy utilized by KENO IV solves Eq. [10] by using an iterative procedure and defines the following important quantities

$\frac{1}{k}\sum_{g'}\int_{\Omega}\frac{\nu_g(X)\,\Sigma_{f_{g'}}(X)}{\Sigma_{t_{g'}}(X)}\chi(X,g'\to g)\,\Sigma_{t_g}(X)\,\Phi_{g',n-1}(X,\Omega')\frac{d\Omega'}{4\pi}$ is the fission production at point X in energy group g due to neutrons in the $(n-1)$*th* generation, normalized to the system multiplication.

$e^{-\int_0^R \Sigma_{t_g}(X-R'\Omega)dR'}$ is the probability of transport from any position $X-R\Omega$ to position X The collision points used in KENO are chosen according to this relationship in the portion of subroutine BEGIN that is called PATH

$$\Sigma_{t_g}(X)\int_0^\infty dR\, e^{-\int_0^R \Sigma_{t_g}(X-R'\Omega)dR'}\,\frac{1}{k}\cdot$$

$$\int_{\Omega'}\sum_{g'}\frac{\nu_{g'}(X-R\Omega)\,\Sigma_{f_{g'}}(X-R\Omega)}{\Sigma_{t_{g'}}(X-R\Omega)}\chi(X-R\Omega,g'\to g)\,\Sigma_{t_g}(X-R\Omega)\Phi_{g',n-1}(X-R\Omega,\Omega')\frac{d\Omega'}{4\pi}$$

is the first collision density of neutrons in group g per unit solid angle about Ω resulting from the fission source produced by the $(n-1)$*th* generation, normalized to the system multiplication.

$$\sum_{g'} \int_{\Omega'} \frac{\Sigma_S(X,g'\rightarrow g\ \Omega'\cdot\Omega)}{\Sigma_{t_g}(X)} \Sigma_{t_g}(X)\Phi_{g\ n}(X,\Omega')d\Omega'$$ is the scattering source at position X emerging in group g and direction Ω resulting from previous collisions in the same generation

$$\Sigma_{t_g}(X) \int_0^{\infty} dR\ e^{-\int_0^R \Sigma_{t_g}(X\ \ R\ \Omega)dR}$$

$$\sum_{g'} \int_{\Omega} \frac{\Sigma_S(X\ \ R\Omega,g'\rightarrow g,\Omega'\cdot\Omega)}{\Sigma_{t_g}(X-R\Omega)} \Sigma_{t_g}(X-R\Omega)\Phi_{g\ n}(X-R\Omega,\Omega')d\Omega'$$ is the collision density in group g, per solid angle about Ω and is the relationship used by KENO to process collisions

The total collision density times $\frac{\nu_g(X)\ \Sigma_{f_g}(X)}{\Sigma_{t_g}(X)}$ is the relationship from which KENO IV picks the source points for the next generation

2 Weighting

The purpose of weighting is to improve the statistical accuracy of k effective per unit tracking time [4] The values of the average weight, WTAVG, the weight cutoff, WTLOW, and the weight at which splitting occurs, WTHIGH, which should be used depend on the importance of neutrons in a region and the relative cost of tracking a low weight neutron compared to the cost of starting a new neutron The default options used in KENO IV are as follows

WTAVG = 0 5
WTLOW = WTAVG*FWTL
WTHIGH = WTAVG*FWTH

where FWTH = 3 0 and FWTL = 1 0/FWTH These values[1] were chosen after studying a system where neutrons engaged in a large number of collisions before being absorbed or escaping from the system Figure 1 illustrates the estimated standard deviation as a function of statistical weight cut off WTLOW given a fixed amount of computer time

To reduce the computing time for a reflected system, a judgment is made about the relative importance of a neutron in the reflector to the average neutron in the system The importance of a neutron in the reflector usually varies as a function of energy and distance from the core Therefore a space or region and energy dependent weighting function is used to reduce the amount of time spent tracking neutrons in the reflector One means of obtaining this weighting function for a given core material and reflector material is to use the adjoint solution from the S_n type programs for a similar (usually simplified) problem This adjoint flux gives the relative contribution of a neutron at a given energy and position to the total fissions in the system The weighting function for KENO is thus proportional to the reciprocal of the adjoint flux Although such a function can be difficult to obtain, the savings gained usually makes the effort worthwhile The use of weighting to minimize the error in k effective per unit computer time will usually increase the error in other parameters such as leakage or absorption in the reflector

Examples of the 16 group and 123 group weighting functions for some reflector materials can be found in, "16 and 123 Group Weighting Functions for KENO "[5]

3 Collision and Scattering

When a neutron being tracked has not moved into a different geometrical region as determined by the subroutines POSIT or CROS, it has undergone a collision in the material comprising that region The absorption weight and the fission weight are calculated by multiplying the weight of the neutron by the absorption and nu fission probabilities of the material, respectively The neutron weight, WT, is then multiplied by the non absorption probability of that material and the new weight is checked against WTHIGH (the weight at which splitting occurs) If WT is larger than WTHIGH, the neutron is split and stored until WT is less than WTHIGH If WT is less than the statistical weight cutoff, WTLOW, Russian roulette is applied If the neutron loses a game of Russian roulette, it exits from the collision processing section and the fission weight and absorption weight are summed into the accumulators for that generation If the neutron survives Russian roulette, its weight is set to WTAVG and it undergoes scattering If WT is greater than WTLOW and less than WTHIGH, the neutron scatters Scattering from any energy group to any other energy group is allowed by proper selection from the transfer or downscatter matrix The energy group after the collision (the energy group the neutron scatters to) is found by picking from the normalized cumulative transfer probability matrix, FSP KENO IV accounts for anisotropic scattering by using a P_1 Legendre polynomial expansion of the differential scattering cross section, Σ_s

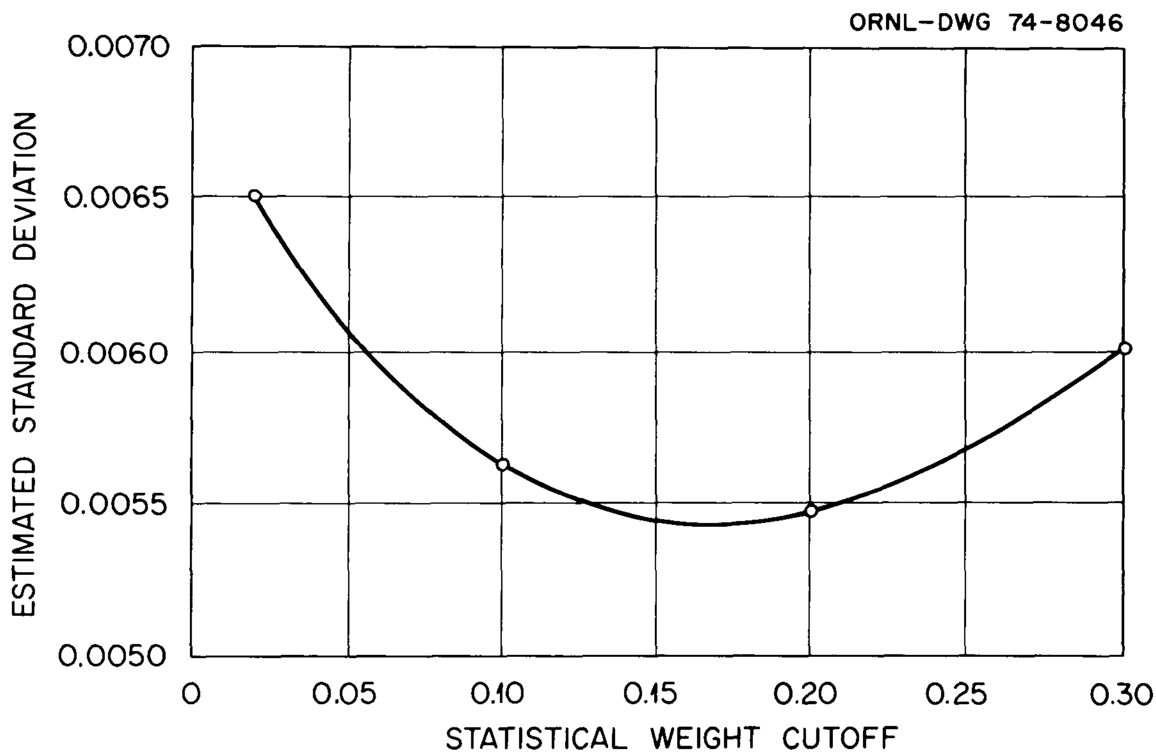
ORNL-DWG 74-8046
0.0070
0.0065
0.0060
0.0055
0.0050
ESTIMATED STANDARD DEVIATION
0
0.05
0.10
0.15
0.20
0.25
0.30
STATISTICAL WEIGHT CUTOFF

Figure 1.

For $\Sigma_s(\mu)$ where $(-1 \leqslant \mu \leqslant 1)$ the P_1 expansion gives

$$\Sigma_s(\mu) = \sum_{n=0}^{1} C_n P_n(\mu) = C_0 + C_1 \mu \qquad [11]$$

where Σ_s is the macroscopic scattering cross section, C_n are coefficients of Legendre polynomials and $P_n(\mu)$ are Legendre polynomials.

The zero and first order coefficients are defined as

$$C_n = \frac{2n+1}{2} \int_{-1}^{1} \Sigma_S(\mu) P_n(\mu) d\mu \quad . \qquad [12]$$

Because a P_1 representation can be negative over part of the angular range, making sampling difficult, a MUBAR or $\bar{\mu}_{j,i,k}$ is defined as

$$\bar{\mu}_{j,i,k} = \frac{\int_{-1}^{1} \mu \, \Sigma_{S_{j,i,k}}(\mu) \, d\mu}{\int_{-1}^{1} \Sigma_{S_{j,i,k}}(\mu) \, d\mu} \quad , \qquad [13]$$

where $\bar{\mu}_{j,i,k}$ is the average scattering angle for a neutron in mixture k scattering from energy group i to j. $\Sigma_{S_{j,i,k}}(\mu)$ is the macroscopic transfer cross section of mixture k for scattering from group i to j while scattering through an angle $\cos^{-1}(\mu)$.

Substituting equation [11] into [13] yields

$$\bar{\mu}_{j,i,k} = \frac{C_1}{3C_0} = \frac{\sum_{n=1}^{N_k} \rho_n \sigma^1_{j,i,n}}{\sum_{n=1}^{N_k} \rho_n \sigma^0_{j,i,n}} \quad , \qquad [14]$$

where σ^0 and σ^1 are the P_0 and P_1 coefficients of the transfer cross section and ρ_n is the number density of the *nth* scatterer in mixture k. N_k is the number of scatterers in mixture k.

If the anisotropic scattering data, MUBAR($\bar{\mu}$) is zero, the new direction cosines are chosen from an isotropic distribution If the scattering data are nonzero, the direction cosines are calculated according to the following relationship where u, v, and w are the initial direction cosines and u′, v′, and w′ are the direction cosines after the collision

$$u' = u \cos\psi - \sqrt{1-u^2} \sin\psi \cos\eta \qquad [15]$$

$$v' = v \cos\psi + \frac{uv}{\sqrt{1-u^2}} \cos\eta \sin\psi - \frac{w}{\sqrt{1-u^2}} \sin\psi \sin\eta \qquad [16]$$

$$w' = w \cos\psi + \frac{uw}{\sqrt{1-u^2}} \cos\eta \sin\psi + \frac{v}{\sqrt{1-u^2}} \sin\psi \sin\eta \qquad [17]$$

where

$\sin\psi = \sqrt{1-\bar{\mu}^2}$

$\cos\psi = \bar{\mu}$ = cosine of the scattering angle

η = a random azimuthal angle between 0 and 2π

4 Fission

In order for a fission to occur, a neutron must first have a collision The fission weight, FISW, is defined as the neutron weight WT times the ν-fission probability, FNFP(KR,IG) of the material KR in which the collision occurred, at the energy of the incident neutron, IG

FISW = WT*FNFP(KR,IG)

Two important variables that are used in the processing of fission points are FWR which is defined as the fission weight, FISW, divided by a random number, and RAKBAR which is defined as 0 85 times the running average value of k-effective, AKBAR The 0 85 is an arbitrary factor and was chosen because it appears to produce an adequate number of independent fission points and does not produce so many that an excessive amount of time is spent choosing from the fission points that are produced If experience proves that enough independent fission points are not produced for more than a relatively few generations, it may be necessary to use a reduction factor somewhat lower than 0 85

A fission point is generated only if FWR is greater than RAKBAR Multiple fissions at the same point are allowed only if FISW is greater than RAKBAR If FISW is greater than RAKBAR, a fission point is stored with FWR set equal to RAKBAR divided by a random number and FISW is decremented by RAKBAR The above procedure is repeated until FISW is less than RAKBAR, at which time a point is selected with FWR equal to the remaining FISW divided by a random number The x, y, and z position, the location of the box within the array, the region number and the value of FWR are the quantities that are stored in the appropriate arrays if a fission occurs However, only NPB (the number per generation) fission points are kept to be used as fission positions for the next generation Therefore, if a fission occurs and the fission counter, NN, is less than the number per generation, the fission point information is stored If a fission occurs and NN is equal to the number per generation, a table search is made to find the smallest stored value of FWR If FWR of the newly fissioned neutron is less than the smallest FWR in the table, it is discarded Otherwise, the information from the newly fissioned neutron replaces that associated with the smallest value of FWR found in the table

When the next generation is ready to be processed, subroutine NSTART transfers the fission positions into another array to be used as starting positions for the fission neutrons If too few fission positions were stored (less than the number per generation), a message to that effect is printed and additional fission points are randomly chosen from those that were stored until the number of fission starting points is equal to the number of neutrons per generation The energy of each fission neutron is chosen randomly from the fission spectrum of the mixture in which the fission occurred

LOGICAL PROGRAM FLOW

1. Read Parameter Input and Allocate Storage

In the solution of a KENO IV problem, MAIN calls subroutine MESAGE to print a header page. The information contained thereon is the program name, "KENO", followed by the date the problem was run and the time execution was begun. MESAGE is called with two arguments, an eight character hollerith argument and an output unit. Subroutine FHLPR is called from MESAGE to print the hollerith argument in block letters (eight characters is the maximum number of block characters that can be printed across a page). MESAGE then calls DATIM which returns the date and time of day (each eight characters). FHLPR is then called twice to print out the date and the time execution was begun in block letters. The first card is read and checked to determine whether it is an "END CASE", "END KENO", or a title card. If the card is an "END KENO" or an end of file was encountered, execution is terminated. If it is an "END CASE" card, it reads the next card and checks in the same manner. When a card is encountered that is not an "END CASE" or "END KENO" card, it is assumed to be the title card. The next card that is read is the parameter card(s). The parameter information is used to determine which input and output units will be used and buffer space is allocated for them.

Subroutine ALOCAT is called to determine the maximum available space for running the problem, based on the amount of core requested for the job, the size of the program and the amount of space required for the buffers. At this point the starting storage location determined by ALOCAT is passed to KENO, which prints the title card and parameters. If albedos are to be used and the problem is not a restart problem, subroutine RDREF is called to read the reflector constants. Then KENO computes the starting indices for the arrays based on data already read in. The number of storage locations required for the problem and the number of remaining available locations are calculated and printed. If the latter number is negative, the problem is too large for the amount of core requested and execution is terminated by executing a STOP. If the problem fits in the available space, subroutine CLEAR is called and certain of the arrays are zeroed.

If velocity, cross-section or albedo data from the previous case is to be used, subroutine SAVE is called to restore the appropriate data.

2. Read Cross Section and Velocity Input Data

Subroutine INPUT is called and reads velocities from cards if they are expected. If cross sections are to be read, INPUT calls subroutine XSTAPE which in turn prints the title, reads the mixing table cards, prints the mixing table and reads the appropriate microscopic cross section data (including fission spectra, energy levels and lethargy) from the appropriate unit (disc, tape, or cards) in whatever format the parameters indicate (KENO IV, AMPX', or ANISN). If KENO IV or AMPX format is specified, velocities are calculated from the energy bounds. If AMPX format is used, subroutine STID is called to store the AMPX 1-dimensional cross section arrays in the proper positions. REA is called to store the AMPX P and P_1 transfer arrays in the appropriate positions. If ANISN format is used, READSG is used to read the cross section data and STORE is used to store them. Depending on the input parameters, the microscopic cross sections will be printed, or a list of their titles will be printed. The macroscopic cross sections are then computed for each mixture. If any mixing table errors are recognized, an error message is printed. Upon returning to subroutine INPUT, subroutine AJOINT may be called to create adjoint cross sections from the forward cross sections created in XSTAPE if an adjoint problem is to be run. The macroscopic cross sections are then used to create cumulative probabilities for use in the calculation. At this point, options are available to (1) print only the one-dimensional probability tables for each mixture, (2) print both the one-dimensional and two-dimensional probabilities for each mixture, or (3) bypass printing mixture probability tables. The one-dimensional part of the probabilities is printed in INPUT and the two-dimensional part is printed in WARR. If a fissionable mixture does not have a fission spectrum associated with it, an error message is printed.

3 Read Geometry Input Data

If the parameters specify that new geometry data is to be read, subroutine KENOG is called. KENOG prints the problem title and the words "GEOMETRY DESCRIPTION". It then reads the geometry data and the group dependent weight average for each geometry region, numbers the regions inside each box type, writes out the geometry data and stores the geometry data in the proper arrays. WTHIGH and WTLOW are calculated from WTAVG as each geometry card is read, and all three arrays are stored.

If the automatic reflector option is to be used, subroutine MAKREF is called. If the problem involves more than one box type, subroutine FILBOX is called from MAKREF to read the mixed box orientation data. At this point, MAKREF calculates a reflector of the desired material and applies the designated thicknesses to the appropriate faces. It automatically supplies the weight averages for the reflector material or can read them from cards. At the conclusion of the automatic reflector operation, the program returns to KENOG. After all the geometry cards have been read, KENOG calls FILBOX if more than one box type exists and the automatic reflector option has not been invoked. FILBOX reads the mixed box orientation data and loads the array that stores the arrangement of the box types. If any errors are recognized while reading the mixed box data, error messages are printed. Control is then returned to the calling subroutine. KENOG prints the geometry information and then prints weight low, weight average, and weight high for each geometry region and energy group.

Checks are made to be sure the mixture designation for each geometry region does not fall outside the allowable range and to be sure that certain simple rules governing geometry dimensions or specifications are not violated.

If KENOG encountered the geometry word "GENERAL" when reading the geometry description, INPUT calls JOMIN to read the generalized geometry (05R)[8] input data. The dimensions on the last "GENERAL" card read by KENOG are automatically set equal to the outer zone boundaries from the generalized geometry data.

FILBOX is called from INPUT only if geometry from the previous case is expected and the problem involves more than one box type.

If the problem involves more than one box type, subroutine BOX is then called from INPUT. BOX prints the problem title and the words "ARRAY DESCRIPTION". The box type arrangement is printed for each Z layer with the X-position increasing from left to right across the page and the Y-position increasing from bottom to top. If any position in the array contains a box type value less than or equal to zero or greater than NBOX, an error message is printed. At this point, control is returned to INPUT and all the geometry data except generalized geometry data from the previous case is restored, if desired. This is done by calling subroutine SAVE. If an adjoint problem is to be run, the velocities are inverted unless they came from the previous case.

Subroutine CORSIZE is called by INPUT to calculate the overall array dimensions and check to see that adjacent faces of neighboring box types are the same size. If they are not, an appropriate error message is written INPUT then checks to be sure the mixture number for each geometry region is within the allowable range and the core boundary card, if any, exactly encloses the array Control is then returned to KENO. If geometry from the previous case is to be used, KENO calls SAVE to reload the generalized geometry data

4 Read Albedo Data

If albedo data is to be read, KENO calls subroutine ALBIN which in turn reads the expected albedo data from the proper unit and converts it into the probability tables necessary for a differential albedo calculation If any input errors or inconsistencies are encountered, an error message is printed. After returning to subroutine KENO, the program checks to see if enough space is available to calculate the desired number of k-effectives If there is not enough room, the number of k-effectives to be calculated is reduced to fit in the available space and a message indicating this fact is printed If the number of k-effectives that can be calculated was reduced to less than 25, the problem will not be executed Space is now allocated for the arrays that depend on the number of generations that are to be run If the problem is a generalized geometry problem, subroutine LOKSET is called to initialize the generalized geometry subroutines Then KENO calls CLEAR to zero some arrays preceding the generalized geometry data, calculates the array length for the k-effective data and calls CLEAR to zero that array If the restart option is to be used and the number of generations between writing restart data is greater than zero, subroutine RESTRT is called If the problem is not to be restarted from an older run, control is returned immediately to KENO If this is a restart problem, the necessary restart data is read, the starting batch is incremented by 1 and control is returned to KENO At this point SAVE is called to save data on the scratch unit for any subsequent case that may need it Velocity data, macroscopic cross sections, albedo data and geometry data are included in the saved arrays After rewinding the scratch unit, subroutine JOMCHK is called

5 Check Geometry Data

JOMCHK is the geometry checking routine for KENO IV Its function is to make sure that no intersecting regions exist within a given box type or the reflector. Concentric or nested geometry regions may be tangent and may have faces in common, but they CANNOT intersect Conceptually, JOMCHK simply checks the *ith* region against the (i + 1)th region for each box type and the reflector. If intersecting regions are encountered, an error message is written, and the program continues with its checking until all geometry regions have been checked, then control returns to KENO

KENO immediately calls subroutine VOLUME which checks to be sure the positive dimension of a given geometry region is greater than the corresponding negative dimension It then prints the title and the word "volumes", calculates and prints the incremental and cumulative volumes for each region in each box type and the reflector and checks to be sure that no incremental volume is negative. It also calculates and prints the total volume occupied by each geometry region in the entire array This is simply the product of the volume of a given region and the number of times that box type appears in the array The result is printed under the heading "total volumes". If a nonallowable geometry type (the geometry data was incorrect or destroyed) is encountered for the last geometry region, an error message is printed Otherwise, the parameter BIG is set A check is also made to be sure the last geometry card in every box type is a cube or cuboid If it is not, an error message is printed.

6 Read Start Data and Pick Starting Points

As soon as control returns to KENO, ITIME is called to determine the time at which subroutine START is called, then control goes to START which prints the start type to be used in this problem If the type of start specified requires more data, it is read using FREAD, IREAD, or both Checks are made to be sure a proper start type was specified for single unit and mixed box problems The starting points are determined in terms of the x, y, and z coordinates of a point, the X, Y, and Z index of the box position in the array, and the region number Neutrons are allowed to start only in fissionable material, unless x, y, and z are specified, in which case the neutron is started at that point It is required that the same number of neutrons be started as are to be followed for each generation If too few are started in the maximum number of tries, (the maximum of (100 times the number of neutrons per generation) or (three times the number of neutrons per generation/volume fraction of fissionable material)), the remaining starting points are randomly picked from those already determined A message is printed pertaining to the type of start used and another message tells how many neutrons were started

7 Read Search Data

If a search has been specified and it is the first time through START, the search constants are read for each geometry region

After returning to KENO, ITIME is again called and the amount of time spent in subroutine START is printed At this point KENO checks to see if any errors were encountered in all the operations already completed If errors were found, a message is printed stating that the problem will not be run, and control returns to MAIN, where the entire procedure is begun again If no input errors were encountered, KENO calls subroutine BEGIN

8 Neutron Tracking Loop

8 1 General Loop Flow

Subroutine BEGIN comprises the main body of the program In essence, it consists of two concentric DO loops (the outer one being over the number of generations to be run and the inner one being over the number of neutrons in each generation) inside of which all the neutron tracking takes place The neutron is tracked until it has a collision or escapes from the system The general flow of the tracking procedure is illustrated in Figs 2 and 3 The starting point, region, material, energy and direction cosines for a neutron are determined in the fission starting section, FSTART The path length and end point of the path are then determined in PATH If the neutron is in a generalized geometry region, GEOM is called to return the fraction of the path used If all the path was used without changing regions, a collision occurred, and the section called XSEC is entered to process the collision If the neutron changed media internal to the generalized geometry region, then x, y, and z are updated and PATH is entered as before If the neutron crossed out of the generalized geometry region and into a KENO geometry region, then x, y, and z are set and PATH picks new end points If the last crossing was in the outward direction, POSIT determines if the end point is within the same region If it is, a collision occurred and is processed in the XSEC section of BEGIN Fission neutrons are created as described in the FISSION section of THEORY Russian roulette is played and if the neutron survives, a new path is chosen and tracking continues If the neutron fails Russian roulette, it is removed from the tracking procedure and any previously stored split neutrons are tracked

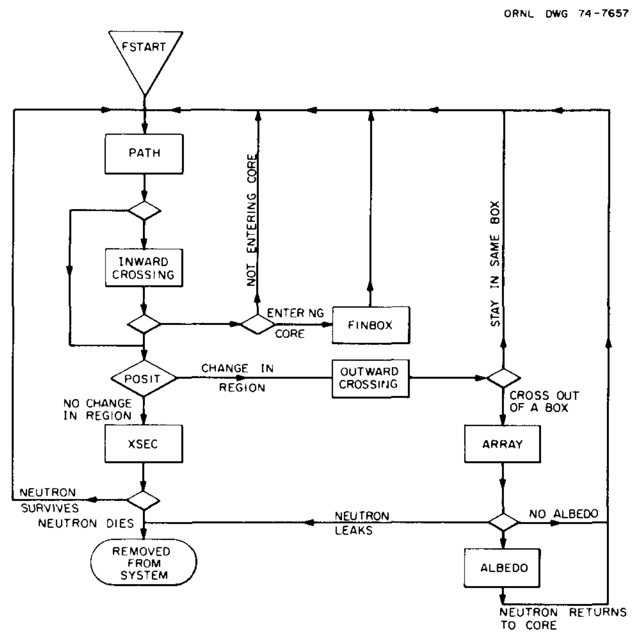

Figure 2. Neutron tracking loop internal to subroutine BEGIN.

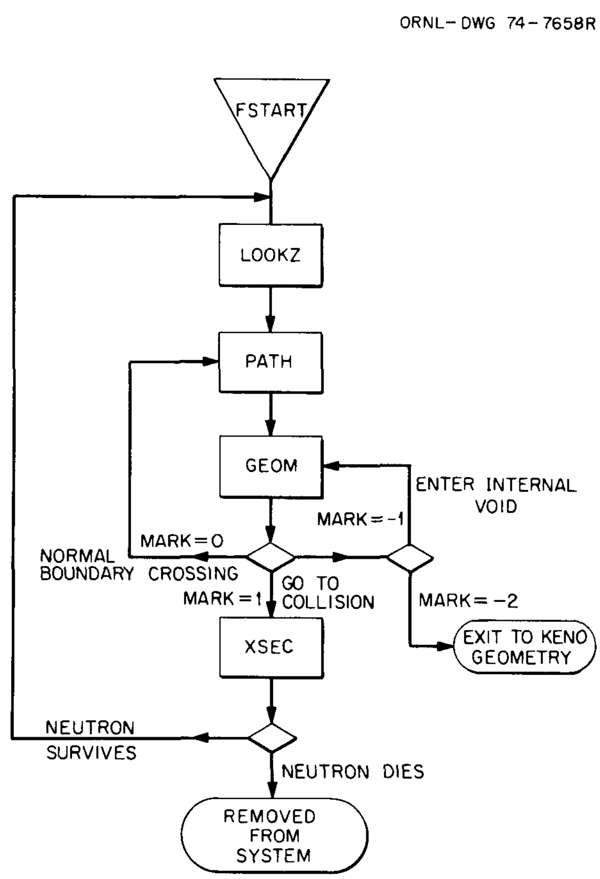

Figure 3. Neutron tracking loop in subroutine BEGIN for Generalized Geometry

If POSIT determines that the neutron's end point is external to the region it was in, subroutine CROS is called CROS determines the point at which a boundary crossing occurred After an outward crossing has taken place, the ARRAY section of BEGIN checks to see if the boundary crossing just indicated by CROS took place on a box boundary Tracking returns to PATH if the crossing was not on a box boundary If the crossing was on a box boundary, the new box type is determined and a transformation of coordinates is made to determine the neutron's position relative to the origin of the new box If the new region number is less than or equal to the maximum for the problem, tracking returns to PATH If the new region number is larger than the maximum, the neutron has left the core through that face A check is made to determine if an albedo reflector was specified on that face, and, if not, the neutron has leaked and is removed from the system The presence of an albedo reflector on that face causes tracking to proceed through the ALBEDO TREATMENT portion of BEGIN This section determines if the neutron has leaked or returns the neutron to the system at the same point that it exited The returning energy and angle are determined by ALBEDO If the neutron did not leak, tracking returns to PATH and a new path is chosen

At the time a neutron leaves PATH, if its last crossing was inward and it has moved into another region, a check is made for an inward crossing If an inward crossing did not occur, control goes to POSIT to check for a collision If an inward crossing occurred within a box, tracking returns to PATH If an inward crossing occurred into the core from the reflector, the FINBOX section determines the box coordinates, transforms the coordinates according to the "new" origin, and determines the box type and the new x, y, and z position Tracking then returns to PATH and proceeds as before

8 2 PULL - Prevent Looping

Immediately after entering the number of generations loop, subroutine PULL is called from BEGIN at the beginning of each generation to generate a maximum time interval for that generation If this time interval is exceeded, PULL seizes control, writes a message and terminates the problem This helps eliminate the possibility of a problem getting into a loop and wasting large amounts of time

8 3 FSTART - Start Fission Neutron

The first identifiable area inside the number per generation loop is the fission starting section, FSTART Here the neutron starting point, region and material are obtained from the data generated by the previous generation (or subroutine START for the first generation) The starting energy is chosen using FLTRN and the fission distribution The direction cosines are returned from GTISO which picks from an isotropic distribution

8 4 Generalized Geometry`

Immediately following the fission start section is an area involving operations undertaken if a neutron is in a generalized geometry region Subroutines LOOKZ and GEOM are called to determine the media, the fraction of the path used, whether a collision occurred, and the end point of the path If the starting coordinate and end coordinate of the path are identical in any direction, the end point is changed by a small amount in the proper direction to prevent computational difficulties in the code

8 5 PATH - Pick a Path

In the section called PATH, if all the path length has been used up, EXPRN chooses a new number of mean free paths from an exponential distribution If the neutron is in a void, the distance traveled is set equal to three times the maximum chord length of the system (BIG) If the neutron is not in a void, the distance traveled is equal to the path length remaining, divided by the total cross section The ending coordinates are determined from the starting coordinates, the distance traveled and the direction cosines Again, if the starting and ending coordinates are identical in any given direction the end point is changed by a very small amount in the proper direction

8 6 FINBOX - Determine Box Position

During the tracking procedure, BEGIN utilizes a section called FINBOX that performs the transformation of coordinates that is necessary when a neutron crosses from the reflector into the core It also determines the X, Y and Z indices of the box the neutron is in and uses this information to determine the box type and the region numbers defining the box type

The section called POSIT determines whether the end point of the path stays within the same geometry region (has a collision) or attempts to cross the boundary into another region

8 7 CROS - Boundary Crossing

Subroutine CROS is called if a boundary crossing is indicated CROS is used for both inward and outward crossings It determines whether a neutron actually crossed into the next region If a crossing occurred, the x, y, and z coordinates are upgraded to reflect the crossing point, and the fraction of the path length that was used is determined

8 8 ARRAY - Cross a Box Boundary

Another section of BEGIN, entitled ARRAY, is utilized whenever a neutron crosses a box boundary This can occur only when a neutron is moving in an outward direction Each face of the box is checked in order to assure proper positioning for face, edge and corner crossings The X, Y, and or Z index of the box is updated, a logical flag is set to indicate if the neutron is exiting from the core, and the x, y, and or z coordinate of the crossing is set equal to the proper face dimension of the box If the neutron remains within the core, the box type is determined The code then goes through a transformation of coordinates to correct for crossing into a new box type or crossing out of the core

8 9 ALBEDO - Albedo Reflector Treatment

If an albedo reflector was present on any face of the array, a section entitled "PSEUDO REFLECTOR TREATMENT" is entered The logic employed in this section is very similar to that in "ARRAY" where each face is checked in sequence If the neutron crossed any given face, subroutine ALBEDO is called to supply the energy group, weight and direction cosines for the neutron returning from the albedo reflector The box index in that direction is reset to the proper value If the weight of the neutron is less than WTLOW (weight low) from the last collision, Russian roulette is used to determine if the neutron survives If it does, its weight is set equal to WTAVG (weight average) and tracking continues

8.10 LEAK - Remove Neutron from System

If the neutron crosses out of the core and no reflector, either real or albedo, is present, the neutron leaks from the system. A neutron also leaks from the system if it passes out of the outer-most region of the reflector in an outward direction. If a neutron leaks, its weight is summed into an energy-dependent variable called FLEAK.

Whenever a neutron undergoes a boundary crossing or has a collision, flux and lifetime information is collected based on the path length of the neutron in the region.

8.11 XSEC - Collision

If a neutron has a collision, the section called "XSEC" is entered. If fluxes are to be calculated, the new flux contribution is added in. The absorption weight and fission weight are calculated based on macroscopic cross section data and weight, WT. WT is then redefined as WT times the nonabsorption probability. If matrix k-effective information is desired, the fission weight is summed into the proper arrays. If WT is greater than WTHIGH (weight high), the neutron is split and the necessary information is stored for later use (This information includes weight, energy, region, box position, neutron position and lifetime). This splitting procedure is continued until the neutron's weight is less than or equal to WTHIGH. If the neutron's weight is less than WTLOW, Russian roulette is played. If the neutron is killed, the fission weight, absorption weight and lifetime information are added into the appropriate banks. If it survives, the group to which the neutron scatters is determined. If that group is larger than the number of energy groups, an upscatter has taken place and the energy group must be redefined properly. If the anisotropic scattering data (P_1 data) is zero, the neutron direction after collision is chosen from an isotropic distribution using GEISO. If anisotropic scattering occurred (P_1 data was nonzero) the azimuthal angle is chosen randomly using AZIRN and the sine and cosine of that angle are returned to BEGIN to use in calculating the new direction cosines. Now the collision mechanism has been completed and the fission weight, absorption weight and lifetime information are added into the appropriate banks.

8.12 Store Fission Points for the Next Generation

If the fission weight divided by a random number is greater than RAKBAR, 0.85 times the average k-effective determined to this point, the collision position is stored to be used as the fission source for the next generation. The fission weight is then decremented by RAKBAR. The same test is applied to the remaining fission weight to allow for the possibility of storing multiple fission neutrons at the same point. If the number of fission points generated exceeds the needed number (number per generation), a test is made to determine whether to save that fission position. If it is to be saved, it is stored over the point having the lowest existing value of FWR (fission weight divided by a random number).

If by this time the neutron has not escaped from the system or has not been killed, tracking continues by picking a new path and continuing as before. If the neutron tracking has been followed to completion, any neutrons that were produced as the result of splitting are followed, one at a time, until they have all been processed in the same manner as the original neutron.

8.13 Compute Results for Generation

After all neutrons in a given generation have been followed to completion, k-effective for that generation is calculated, lifetime and generation time information is collected, matrix k-effective information is generated if it was desired, the running average of k-effective is generated (AKBAR), and a test is made to determine if any fission neutrons were generated. If not, a message is written and control is returned to subroutine KENO.

8.14 NSTART - Fission Source for Next Generation

If no fission neutrons were generated, an error message is printed and execution of the problem is terminated. If fission neutrons were generated, subroutine NSTART checks to see that the proper number of fission source points to run the next generation were provided If too few fission source points were generated in BEGIN, a message to that effect is printed and the remaining positions are filled by randomly picking from those that were generated until "number per generation" starting positions are available.

8 15 Print Generation Results

If flux and fission density information was requested, the appropriate information is summed into the proper banks. The amount of time required to process the generation of neutrons is computed and the generation number, k-effective, elapsed time, average k-effective, deviation, and matrix k-effective are printed

8.16 WRTRST - Save Restart Data

If restart information is to be saved and a multiple of NRSTRT generations (the number of generations between the writing of restart data) have been processed, WRTRST is called to write the necessary restart information on the proper input-output unit

8 17 Complete Number of Generations

A test is then made to determine if the maximum time for the problem has been exceeded If not, the next generation of neutrons is processed just like the previous generation If time was exceeded, the problem is considered completed, the number of generations is redefined as the number completed, and subroutine PULL is called to cancel the last time interval that was set. Control is returned to subroutine KENO, which immediately calls subroutine KEDIT to do the final analysis and printing.

9. Edit and Print Average K-Effective Results

KEDIT executes a loop to calculate the average value of k-effective and its associated deviation, the range of k-effective for the 67, 95, and 99% confidence intervals and the number of histories that were run On the first pass through the loop, it prints the problem title at the top of the page, calculates and prints the generation time, lifetime, and their associated deviations, and prints a heading for the k-effective data. The title and heading are printed at the top of each subsequent page of k-effective data that is printed. The loop runs from the number of generations to be skipped to the number of generations that were run. The results of the first 10 times through the loop are printed followed by the results of every fifth pass after that. When the printing is finished, control is returned to KENO.

10 Execute Search

If a search is to be made, subroutine XXMOD is called XXMOD will not execute if a recognized error has occurred or if less than 10 generations were run A table search is made to determine where the minimum deviation occurred and the k-effective corresponding to it is used in the calculations done by XXMOD. A check is made to determine if the calculated k-effective is within the specified number of deviations of the desired value of k-effective If it is, the search is considered complete, and the converged search data is printed and control is returned to KENO If a coarse-fine search is being made (search type 3), the number of allowable iterations is updated, the convergence flag is set true, the search type and number of generations to be executed are updated, the converged dimensions are stored in the OLDXX array and control is returned to KENO If the calculated k-effective did not conform to the convergence criteria, the iteration number is incremented, a message stating the iteration number and maximum allowed iterations is printed, and delta k is determined At this point, a check is made to determine whether to do an array search or a dimension search An explanation of both kinds of searches follows

If the search data specified an array search, subroutine ARAMOD is called to calculate the new array size Upon entering ARAMOD, a check is made on the number of box types If it is a mixed box problem, an error message is printed, the search type is set to zero and control returns to XXMOD If only one box type exists, ARAMOD calculates the number of units in the array, stores it in the proper position, and calculates delta k If it is the first iteration, the number of units in the X, Y, and Z directions are stored in the OLDXX array The multiplier is set to +1 if the calculated k is less than the desired k and to -1 if the calculated k is greater than the desired k If all the search constants are zero, a message is printed, the search parameter is set to zero, and control is returned to XXMOD

If iteration (INTRTN) is the second or any subsequent iteration and the search has not converged, the coefficients necessary for the solution of a linear, quadratic or cubic equation are calculated based on the number of directions in which the array is to be altered The type of equation to be solved is determined on the basis of which coefficients are zero and nonzero (A zero coefficient in a given direction indicates that the number of units stacked in that direction shall remain unchanged.) If the search has converged, the coefficient calculations and linear, quadratic or cubic equation solution are skipped The new array size is calculated, checks are made to be sure the results fall within the allowable range (an error message is printed if they do not), and the search constants and updated array size information are printed The new array information is stored in OLDXX, and checks are made to be sure the new array size is different from all previous iteration results. (If they are not, a message is printed, the search type is set to zero, and control is returned to XXMOD.) If the maximum allowable number of iterations has been exceeded, the search type is set to zero and control is returned to XXMOD Otherwise, the last value of k-effective is stored for use in the next iteration and control returns to XXMOD At this point, the iteration is complete. If convergence was achieved, control is returned to KENO Otherwise, subroutine CORSIZE is called to redefine certain geometry data If no reflector is present or the reflector thickness is not to be maintained, control is returned to KENO If reflector thickness is to be maintained, the new reflector dimensions are calculated before returning to KENO

If the search data specified a dimension search, a loop is executed over the number of geometry regions. The number of dimensions involved for each region is determined. If it is the first iteration, the key governing whether the reflector is to be altered is set, and the key indicating convergence for the search type 3 is set. The original dimensions are stored in the OLDXX array. The region number is written out, the new dimensions for that region are calculated based on delta k (the change in k-effective) and the search constants, the new dimensions are stored in the OLDXX array, a check is made to be sure these exact dimensions have not been calculated in a previous iteration, and the new geometry data for that region is printed If the dimensions for the region are the same as those for a previous iteration, a message is printed, the search type is set to zero to terminate the search and control is returned to KENO. (Regions having a zero search constant are exempt from this condition Therefore, a search should never be made with all search constants set to zero) If the same dimensions had not been calculated previously, the search constants for that region are printed The new value of k-effective is stored for use in the next iteration If the iteration number is equal to the maximum allowed, the search type is set to zero, CORSIZE is called to redefine certain geometry information, and if reflector thickness is to be maintained, the proper operations are executed. Control is then returned to subroutine KENO

If the iteration is the second or a subsequent iteration, the same operations are carried out except the search constants are redefined based on a linear extrapolation using the two previous dimensions and k-effectives and the desired value of k-effective before calculating the new dimensions

When XXMOD returns control to KENO, a check is made to be sure no recognizable errors were encountered If errors were encountered, the search type is set to zero, an error message is written, and subroutine AREAD is called to read cards until it encounters an END KENO, END CASE or "end of file" card If an END KENO card is found, a STOP is executed If an END CASE card is encountered, control is returned to MAIN and the program attempts to execute the next problem

If the error flag is zero, subroutine FINALE is called to do the final printing and editing for the problem

11 Final Editing

Upon entering FINALE, control is immediately returned to KENO if the number of generations executed is less than or equal to the number of generations to be skipped The number of groups that will be written on a page is determined (the maximum is 27) and the title and heading are printed at the top of each page Fissions and absorptions by energy group and region are calculated and the totals are collected If a search is being made and has not converged, only the total leakages, absorptions and fissions are printed. If no search is being made or the search has converged, the leakage, absorptions and fissions are printed for each energy group If region-dependent fissions and absorptions were specified, they are printed for each energy group If albedo reflection was specified, a message is printed stating that leakages and absorptions occurring in the albedo portion of the problem are not included in the totals. The total elapsed time is printed.

If a search is being made and has not converged, the calculation and printing of matrix k-effective, fission density, and flux are bypassed. Otherwise, if matrix k-effective by unit was specified, the problem title is printed at the top of a page followed by a heading for the unit number, the x, y, and z position, box type, and cofactor k-effective Then three concentric loops running from 1 to NBZMAX, 1 to NBYMAX and 1 to NBXMAX are executed and the unit number, position, box type and cofactor k-effective are printed for each position in the mixed box orientation array. If the unit interaction matrix is to be printed, the heading "FISSION PROBABILITY MATRIX by UNIT" is printed followed by the interaction matrix The problem title is printed at the top of the page followed by the source vector by unit. The average unit self-multiplication and its associated deviation are calculated and printed

If matrix k-effective by box type was specified, the necessary calculations are done inside two nested loops running from 1 to the number of box types The problem title, the box type k-effective, and the fission probability matrix by box type are printed If the number of box types is greater than one, the headings "BOX TYPE" and "SOURCE" are printed, followed by each box type and its associated source The problem title is printed, and the headings "BOX TYPE" and "COFACTOR K-EFFECTIVE" are printed, followed by all the box types and their associated cofactor k-effectives The matrix k-effective, cofactor k-effective and source vectors are calculated in subroutine MATK, which uses an iterative method of solving for the principal eigenvalue and eigenvector of a matrix The source vectors are printed in subroutine TABI

The fission densities and their associated deviations are calculated for each geometry region If they are to be printed, the problem title is printed, followed by the heading "FISSION DENSITIES" Each box type is printed, each region within a box is numbered and the fission density, its deviation, and the total fissions are printed for each region in every box type and for each region in the reflector If a generalized geometry region was encountered a warning message is printed regarding the volume used in the calculation If fluxes are to be calculated, they are calculated and printed in a manner parallel to that used for fission densities The arrays used in the calculation of the flux and fission densities are zeroed, and subroutine FREAK is called to print a histogram of the frequency distribution of k-effective

In FREAK, the interval width is set to 4 divided by the number of generations run Half of this value is added to the average value of k-effective to get the upper interval boundary and half of it is subtracted from the average value of k-effective to get the lower interval boundary The number of k-effectives falling within this range is counted and the highest and lowest values of k-effective in the range are stored Some calculations are made to prevent the frequency distribution from exceeding the width of a page by dividing up the storage bins The title is printed at the top of the page A total of four frequency distributions is printed The number of k-effectives falling in each interval is tallied and printed The first frequency distribution contains the k-effectives for all the generations, the second one contains the last three-fourths of the generations, the third contains the last half of the generations, and the fourth one contains the last one-fourth of the generations

Control is returned to FINALE, which in turn returns to KENO If no further search passes are expected, an error message is written if any recognizable errors were found If no errors were found, control returns to MAIN, otherwise, AREAD is called as it was after returning from XXMOD

If a coarse-fine search (search type 3) was being made and the coarse pass converged, the indices used for the number of generation loops in BEGIN are altered and KENO transfers to the point where it calls BEGIN This enables the code to do the first fine pass without wasting the calculations that were done on the coarse pass that converged Otherwise KENO transfers to the point where JOMCHK is called and proceeds as before

ALPHABETICAL SUBROUTINE SUMMARY

ADJOINT

This subroutine is called from INPUT only if an adjoint problem was specified It inverts the cross-section data, the fission spectrum, the energy bounds and the lethargy bounds in the proper manner

ALBIN

If albedo data is expected for a given problem, subroutine ALBIN is called from KENO to read in the necessary data from cards or tape It then converts the data to usable probability tables

ALBEDO is an entry point in ALBIN ALBEDO returns the weight, direction cosines and returning energy to subroutine BEGIN whenever a neutron enters a face having an albedo reflector

ALOCAT

This subroutine is called from MAIN It determines the maximum storage available for a KENO problem based on the amount of core requested and passes this information to subroutine KENO

ARAMOD

ARAMOD is the subroutine that calculates the new array size for an array search problem It is called from XXMOD

AREAD

Subroutine AREAD is used to read card input data for KENO IV AREAD reads alphanumeric character data It is called from KENO, KENOG and MAKREF

IREAD is an entry point in AREAD It reads free-form fixed point (integer) data IREAD is called from FILBOX, KENO KENOG, MAIN, MAKREF, START and XSTAPE

FREAD is an entry point in AREAD It reads free-form floating point (decimal) data FREAD is called from INPUT, KENO, KENOG MAIN, MAKREF RDREF START and XSTAPE

BEGIN

Subroutine BEGIN is the main tracking routine for KENO IV It consists of two concentric DO loops, the outer one running over the number of generations and the inner one running over the number of neutrons per generation BEGIN is called from KENO

BOX

This subroutine prints out the box type arrangement for each z-layer in the box orientation array It also checks the box orientation for errors and prints out error messages for any errors it finds BOX is called from INPUT

CLEAR

Subroutine CLEAR is called from KENO It's function is to zero an array "A" that is of length "L".

CORSIZ

Subroutine CORSIZ calculates the overall array dimensions and checks to assure that the tangent faces of adjacent boxes are the same size CORSIZE is called from INPUT and XXMOD

CROS

This subroutine is called from BEGIN and calculates all the boundary crossing information needed by BEGIN in tracking a neutron. It does both inward and outward boundary crossings

DATIM

A machine language subroutine that determines the date and time and returns them as eight character alphanumeric data. DATIM is called from subroutine MESAGE

FHLPR

This subroutine is called from MESAGE to print eight block letter characters across a page

FILBOX

Subroutine FILBOX reads the mixed box orientation data and stores the three-dimensional arrangement of the box types used in a problem. It is called from INPUT, KENOG, and MAKREF

FINALE

This subroutine collects and prints fissions, absorptions and leakages by region and energy group if so desired. It also prints the matrix k-effective, cofactor k-effectives, source vectors, the unit interaction matrix and the interaction matrix by box type if requested. Fluxes and fission densities are also calculated and printed FINALE is called from KENO.

FREAK

Subroutine FREAK is called by FINALE to print four frequency distributions for each problem. All k-effectives, the last three-fourths, the last one-half and the last one-fourth of the k-effectives calculated are used in the plots. The plots are scaled so they do not exceed the page width

INPUT

This subroutine reads velocities from cards if they are expected It calls XSTAPE to read cross sections and AJOINT to invert cross sections for an adjoint problem INPUT creates and stores the macroscopic cross sections and probabilities used in the problem solution. It sets the dimensions of the last general region equal to the outer zone boundaries. It also checks to be sure the mixture numbers on the geometry cards fall within the allowable range, and if a reflector is present, it makes sure the core boundary exactly encloses the array Input is called from KENO

JOMCHK

Subroutine JOMCHK is called by KENO to be sure that the regions within a given box type or the reflector do not contain intersecting surfaces Each successive geometry region must completely enclose the one before it They can have common faces or be tangent, but they must not intersect

KEDIT

Subroutine KEDIT is called from KENO after all the generations have been calculated for a given pass KEDIT calculates and prints the average k-effectives and their associated deviation for the 67, 95 and 99% confidence intervals It also calculates and prints the number of histories used in calculating each k-effective that is printed

KENO

Subroutine KENO computes the starting indices for the data arrays, prints the title and input parameters, calculates the amount of storage locations required for the problem and the amount of storage left over It also directs the calling of the basic subroutines governing the flow used in the solution of a problem

KENOG

This subroutine reads and prints the geometry description of a problem If the automatic reflector option is invoked, it calls MAKREF It checks to be sure each geometry type encountered is a valid one It also reads in the energy-dependent weight average for each geometry region and calculates and stores the values of weight high and weight low The weights are printed out after all the geometry data has been printed KENOG is called from INPUT

LABL

Subroutine LABL is a printing subroutine It prints from one to a maximum of five sets of headings (two per set) across the page Under each heading is a column of up to 50 numbers Each set of numbers consists of an integer number and a floating point number LABL is called from subroutine FINALE to print the source vector by unit and the source vector by box type

MAIN

This subroutine prints the KENO IV header page, reads the title card and parameters, sets up buffer space for the necessary input and output units, and calls subroutine ALOCAT

MAKREF

Subroutine MAKREF is called from KENOG to calculate a reflector of the desired material and thickness on the designated faces It supplies the energy-dependent weights and weighting intervals, calculates all the necessary regions in the reflector and applies the appropriate weights to each region

MATK

MATK solves for the principal eigenvalue and eigenvector of a matrix using an iterative technique It is called from BEGIN to calculate matrix k-effective and from FINALE to provide cofactor k-effective and source vectors

MESAGE

Subroutine MESAGE is called from MAIN to print the header page It in turn calls FHLPR and DATIM

NSTART

NSTART is called from BEGIN at the end of each generation to provide neutron starting positions for the next generation This is accomplished by adjusting the number of fission neutrons to be equal to the number per generation by randomly repeating existing fission positions if too few were stored in BEGIN

POSIT

Subroutine POSIT is called from START to determine which region in a box a neutron at position x, y, z is in

PULL

Subroutine PULL is an assembly language subroutine that interfaces the program with the system clock routines It sets the time interval supplied in the calling sequence When the interval expires, the program execution is interrupted and control is returned to the statement number supplied in the calling sequence as a nonstandard return This is done to prevent excessive time loss due to looping

Subroutine ITIME is an entry point in PULL It returns the current execution time in units of hundredths of a second

RANDNUM

RANDNUM is a random number package, written in machine language, containing many entry points Entry points utilized in the solution of a KENO IV problem are listed and summarized below

AZIRN randomly picks an azimuthal angle and returns the sine and cosine of that angle to the calling program AZIRN is called from START, BEGIN and ALBIN

EXPRN randomly picks from an exponential distribution EXPRN is called from BEGIN

FLTRN picks a random number between zero and 1 FLTRN is called from ALBIN, BEGIN, NSTART, and START

GTISO picks direction cosines from an isotropic distribution, and is called from BEGIN and START

RDREF

Subroutine RDREF reads the reflector constants for an albedo problem, stores the kind of albedo to be used on each face, and determines how many different albedos are involved. It also checks to be certain that the albedo key NXX is consistent with the reflector constants read in. A message is printed stating how many differential albedos will be read, whether albedos were used from the previous case, and the albedo ID number of the albedo that will be used on each face RDREF is called from KENO.

REA

Subroutine REA reorders the coefficients of the AMPX P_0 and P_1 transfer arrays to be compatible with KENO and is called from XSTAPE

READSG

READSG is called from XSTAPE to read ANISN cross-section data from cards.

RESTRT

Subroutine RESTRT is responsible for reading and writing restart data The restart data is read if the start type is negative, the starting generation is incremented by 1 and control is returned to the calling program RESTRT is called from KENO.

WRTRST is an entry point in RESTRT. It is called from BEGIN to write out and save restart data at given generation intervals so a problem can be restarted at the desired point without losing the advantage of calculations that were already completed

FINRST is an entry point in RESTRT It is called from KENO if restart data is to be read It reads through the sets of saved restart data until it finds the designated starting point, reads and stores that data and checks to be sure the saved data is compatible with that specified in the problem to be restarted If discrepancies are encountered, error messages are written.

SAVE

This subroutine is used to write out data that may be used in a subsequent case and to read in data from the previous case for use in the current problem It is called from INPUT and KENO.

START

Subroutine START is called from KENO to provide the starting positions for the first generation of neutrons Neutrons are allowed to start only in fissionable material unless x, y, and z are specified, in which case the neutron is started at that point. The starting positions are chosen from the desired starting distribution The allowable distributions include flat over the array, cosine over the array, an arbitrary fraction started in unit N with the remainder started in a cosine distribution about unit N, all started at position x, y, z in unit N, all started at position x, y, z in box type M with a flat distribution over units of box type M, a flat distribution in fissile material in units of box type M, and an arbitrary starting distribution in which all starting points are read from cards.

STORE

This subroutine is called from XSTAPE to store the ANISN one-dimensional cross-section data

STORE1 is an entry point in STORE It is called from XSTAPE to store the ANISN two-dimensional cross-section data

STID

This subroutine is called from XSTAPE to store the AMPX one-dimensional cross-section data in the proper arrays

TIMFAC

This subroutine is called from KENO It is used specifically at ORNL to return a variable called FACTOR that is dependent on which local computer is being utilized FACTOR is then used to modify TMAX in subroutine KENO The non-ORNL KENO IV user should write a dummy TIMFAC that returns a FACTOR of 1 0

VOLUME

Subroutine VOLUME is called from KENO to calculate and print the incremental and cumulative volumes for each region in each box type and the reflector It also calculates the total volume in the entire array that is occupied by each region VOLUME also makes simple checks to be sure the input dimensions are not "wrong side out", that volumes do not become negative, that each box type contains at least one region, and that the last geometry region in every box type is a cube or cuboid

WARR

This subroutine is called from INPUT and XSTAPE to print the two-dimensional part of the input cross section data (microscopic cross sections) and the two-dimensional probabilities for each mixture (macroscopic cross sections that have been summed and normalized to supply probabilities)

XSTAPE

Subroutine XSTAPE is called from INPUT to read and print the mixing table and to read the appropriate microscopic cross-section data, fission spectra, energy levels and lethargies from disc, tape or cards in the desired format (KENO IV, AMPX, or ANISN)

XXMOD

Subroutine XXMOD is called from KENO It calculates new dimensions for specified geometry regions in a dimension search problem

KENO-GENERALIZED GEOMETRY INTERFACES

The following subroutines are called from KENO if a generalized geometry region is encountered

GEOM - determines track length and boundary crossing information

JOMIN - reads generalized geometry input data

LOKSET - initializes the generalized geometry routines with array addresses

LOOKZ - locates x, y, and z in generalized geometry

KENO ERROR MESSAGES

KENO IV prints error messages whenever an error is recognized If a severe error is encountered, an error flag, MFLAG, is incremented and data reading continues When all the data has been read, MFLAG is checked and if a severe error was encountered, the code will not execute the problem There are a few errors that will cause termination of the data input at the time they occur rather than continuing on until all input data has been read The following table lists the subroutines and the type of data they process.

Table 1 Directory of the type of data processed by each subroutine

Subroutine	Type of Data
KENO	Parameters
AREAD	All data
RDREF	Parameters
INPUT	Cross sections
XSTAPE	Cross sections
KENOG	Geometry
MAKREF	Geometry
CORSIZ	Geometry
FILBOX	Geometry
BOX	Geometry
ALBIN	Albedo
VOLUME	Geometry
RESTART	Restart data
START	Start
POSIT	Start
BEGIN	Execution
MATK	Execution
CROS	Execution
KEDIT	Summarization
XXMOD	Search execution
ARAMOD	Search execution
FINALE	Summarization

The error messages are more or less arranged in the order in which the subroutines are called, and within each subroutine, in the order the messages appear Error messages for errors encountered in processing the input parameters are printed by KENO, AREAD, and RDREF after printing the parameters and before the following messages

STORAGE LOCATIONS REQUIRED FOR THIS JOB = _____

REMAINING AVAILABLE LOCATIONS = _____

If the above messages are written but none of the geometry data is printed, an error occurred in processing the input cross-section data in AREAD, INPUT, or XSTAPE

If the heading GEOMETRY DESCRIPTION is printed but START TYPE = ____ has not been printed, an error occurred in processing the geometry data in AREAD, KENOG, MAKREF, CORSIZ, FILBOX, BOX, or VOLUME

If the above message is printed but _____ MINUTES WERE REQUIRED FOR STARTING. was not printed, an error was encountered in using the start data or search data in subroutines AREAD, START, or POSIT. If the problem is a search problem, the heading READ SEARCH DATA is printed before an attempt is made read the search data.

At this point, all the input data has been read in. If the following message is written, a careful search through the printout prior to this message will reveal at least one other error message

*********K-EFFECTIVES WERE NOT CALCULATED FOR THIS PROBLEM BECAUSE ERRORS WERE ENCOUNTERED IN THE INPUT DATA*********

Even if the input data has been read in without triggering a fatal error flag, some error messages may be printed during execution if certain conditions are violated. These messages will appear somewhere after the following heading

GENERATION, K-EFFECTIVE, ELAPSED TIME (MIN), AVG K-EFF, DEVIATION, MATRIX, K-EFF

These messages will originate in BEGIN, MATK or CROS. At completion of a problem a heading stating

LIFETIME = ____ ± ____ GENERATION TIME = ____ ± ____

is printed unless the following message is printed

NUMBER OF BATCHES RUN IS INSUFFICIENT TO EDIT

Any messages appearing after either of these messages originate in KEDIT, XXMOD, ARAMOD, or FINALE.

Always check through the computer printout to make sure no error messages were printed and the input data was entered correctly.

Error messages as printed by each subroutine are listed as follows.

The following error messages are found in subroutine KENO

1. THE SEARCH TYPE WAS INCORRECTLY SPECIFIED, NO SEARCH WILL BE MADE

The search parameter NSCH was less than zero or greater than 3

2. **WARNING***WARNING***WARNING***WARNING***WARNING***WARNING** MATRIX CALCULATIONS CANNOT BE MADE FOR A SINGLE UNIT, A 1X1X1 ARRAY OR AN ARRAY SEARCH. THE MATRIX FLAG HAS BEEN SET TO ZERO **WARNING***WARNING***WARNING***WARNING***WARNING***WARNING**

   A matrix calculation was specified for a single-unit problem, a one-unit array, or an array search problem.

3. **THIS PROBLEM SPECIFIED DATA FROM A PREVIOUS CASE WHICH CONTAINED ERRORS, DID NOT EXIST, OR TERMINATED WITH AN END CASE CARD.**

   The error flag MFLAG is greater than 1, indicating that an "END CASE" card was encountered when attempting to read input data or an error was found in a case from which data was to be used for the present case. Often this error simply indicates that the input parameters are out of order.

4 *****ALBEDOS CANNOT BE USED WITH A SINGLE UNIT PROBLEM. THIS PROBLEM WILL NOT BE RUN.*****

The parameter NXX was not zero and the input parameter NBOX was zero If albedo is truly desired for a single-unit problem, the last geometry region must be a cube or cuboid, NBOX must be one, and NBXMAX=NBYMAX=NBZMAX=1.

5. *****AN ARRAY SEARCH CANNOT BE SPECIFIED FOR A SINGLE UNIT PROBLEM THIS PROBLEM WILL NOT BE RUN *****

NSCH was 2 and NBOX was zero on the parameter card (Beware· NBOX prints as one on the computer printout because the single unit logical flag is set true if NBOX = 0. Then NBOX is set to 1). The parameters are out of order or the problem was incorrectly specified

6. $$$NUMBER OF GEOMETRY CARDS ( ) DOES NOT AGREE WITH THE NUMBER ( ) SPECIFIED FOR THE PREVIOUS CASE$$$.

The problem specified geometry from the preceding case, but the number of geometry regions, KREFM, specified on the parameter cards of the two cases does not agree The parameters may be out of order or the problem was incorrectly specified

7. $$$THE NUMBER OF BOX TYPES ( ) DOES NOT AGREE WITH THE NUMBER( ) SPECIFIED FOR THE PREVIOUS CASE$$$

The problem specified geometry from the preceding case, but the number of box types, NBOX, does not agree for the two cases. The parameters are out of order or the problem was incorrectly specified.

8 $$$ALBEDOS FROM THE PREVIOUS CASE WERE SPECIFIED BUT NO ALBEDOS WERE USED IN THE PREVIOUS CASE$$$

The parameters are out of order or the problem was incorrectly specified.

9. $$$THE NUMBER OF ENERGY GROUPS ( ) DOES NOT AGREE WITH THE NUMBER ( ) SPECIFIED FOR THE PREVIOUS CASE$$$.

The number of energy groups, NGP, does not agree for the two cases. The parameters are out of order or the problem was incorrectly specified. The number of groups must always be the same as the previous case when using data from the previous case

10. $$$THE NUMBER OF DOWNSCATTERS ( ) DOES NOT AGREE WITH THE NUMBER ( ) SPECIFIED FOR THE PREVIOUS CASE$$$

The number of downscatters, NDS, does not agree for the two cases. The parameters are out of order or the problem was incorrectly specified

11. **WARNING***WARNING***WARNING***WARNING***WARNING***WARNING** DATA FROM THE PREVIOUS CASE WAS SPECIFIED BUT INCONSISTENCIES WERE ENCOUNTERED. EXECUTION HAS BEEN CANCELED.

WARNING*WARNING***WARNING***WARNING***WARNING***WARNING**

The necessary parameters did not agree between the two cases when data from the preceding case was specified.

12. *****CROSS SECTIONS FROM THE PREVIOUS CASE CANNOT BE USED UNLESS BOTH PROBLEMS ARE FORWARD OR BOTH ARE ADJOINT.*****

The units digit of the parameter NADJ must agree if cross sections from the preceding case are specified.

13 *****DIFFERENTIAL ALBEDOS CANNOT BE USED IN AN ADJOINT PROBLEM *****

The parameter NXX was incorrectly specified or the data was out of order Specular reflection (NXX = 1) can be used in an adjoint problem but differential albedos (NXX = 2) cannot

14 TOO MANY STORAGE LOCATIONS REQUIRED, THE PROBLEM IS TOO LARGE TO FIT IN THE AVAILABLE SPACE

Increase the region allocated for this step sufficiently to contain the problem For IBM users increase the region allocated for this step by four times the absolute value of the REMAINING AVAILABLE LOCATIONS which is printed out immediately preceding this message

15 *WARNING***WARNING****WARNING****WARNING****WARNING***WARNING*
NUMBER OF GENERATIONS WAS REDUCED FROM TO TO FIT IN AVAILABLE STORAGE
IF THIS REDUCTION ALLOWS LESS THAN 25 GENERATIONS THE EXECUTION PHASE HAS BEEN CANCELED
*WARNING***WARNING****WARNING****WARNING****WARNING***WARNING*

To eliminate this problem, increase the region allocated for this step See KENO core size requirements

16 **********K-EFFECTIVES WERE NOT CALCULATED FOR THIS PROBLEM BECAUSE ERRORS WERE ENCOUNTERED IN THE INPUT DATA **********

Check through the printout prior to this message At least one other error message will be printed Correct the input errors and this message will go away

The following error messages are printed in subroutine AREAD

1 *****ERROR IN INPUT CARD IMAGE PRINTED ON NEXT LINE *****

An invalid character was encountered in the printed card Either a key punch error was found or the data is out of order

2 ON THE ABOVE CARD, CHARACTER NUMBER, , (IMAGE =) IS NOT VALID IN AN INTEGER FIELD

The card is mispunched or out of order

3 ON THE ABOVE CARD, CHARACTER NUMBER, , (IMAGE =) IS NOT VALID IN A FLOATING FIELD

The card is incorrectly punched or out of order

Subroutine RDREF prints the following error message

1 *****NXX DID NOT SPECIFY DIFFERENTIAL ALBEDOS BUT THE SURFACE DID THE PROBLEM WILL NOT BE EXECUTED *****

The parameter NXX was one but at least one reflector constant, REFCST, was positive The problem is incorrectly specified or the cards are out of order

The following error messages are printed in subroutine INPUT

1 MIXTURE ( ) CONTAINS A FISSIONABLE MATERIAL BUT NO FISSION SPECTRUM WAS SPECIFIED THE PROBLEM WILL NOT BE EXECUTED

A fission cross section existed for the mixture specified but no material in that mixture was preceded by a minus sign

2. THE MIXTURE NUMBER ON GEOMETRY CARD ( ) DOES NOT FALL IN THE SPECIFIED RANGE
   MAT(I), the entry following the geometry word on the specified geometry card was negative or was larger than the number of mixtures (MATT) specified in the parameters
3. THE INSIDE REFLECTOR DIMENSION DOES NOT EQUAL THE NUMBER OF UNITS TIMES THE UNIT DIMENSIONS
   The core boundary is calculated by summing the dimensions of each unit in the array in each direction If the dimensions thus computed do not agree with those specified on the CORE card, this message is printed Either the array size (NBXMAX, NBYMAX, NBZMAX) was incorrectly specified, a box dimension was incorrectly specified, the mixed box orientation is incorrect or the CORE card is incorrect

The following error messages occur in subroutine XSTAPE

1. ***THE NUMBER OF NUCLIDES REQUESTED FROM TAPE IS INCONSISTENT WITH THE TOTAL NUMBER SPECIFIED FOR THE PROBLEM ***
   The parameter NTAPE, the number of cross sections to be read from tape, is larger than the parameter NMAT, the number of input nuclides The data is mispunched or out of order
2. THE MIXTURE NUMBER DOES NOT FALL IN THE SPECIFIED RANGE.
   When reading the mixing table, one of the mixtures, KKA(I), was zero or negative or was larger than the number of mixtures, MATT, specified in the parameters Either the data is mispunched or is out of order
3. CHECK INPUT DATA AND TAPE FOR CONSISTENCY EITHER THE NUMBER OF GROUPS OR THE NUMBER OF DOWNSCATTERS ARE IMPROPERLY STATED
   NDS = NDS1 = NGP = NGP1 =
   The wrong tape was mounted or the parameters are incorrectly specified NDS and NGP are parameters stated in the problem NDS1 and NGP1 are read from the tape
4. AT LEAST ONE NUCLIDE WAS NOT FOUND ON THE LIBRARY TAPE
   A LIST OF THOSE REQUESTED FOLLOWS
   The number of nuclides found on the tape is less than the parameter NTAPE (the number of nuclides to be read from tape) Either NTAPE is incorrectly specified, one of the ID numbers was incorrectly specified, the wrong tape was mounted, or one of the nuclides requested was not on the tape
5. THE MIXING TABLE CONTAINS MORE NUCLIDES THAN REQUESTED IN THE PARAMETERS
   A LIST OF THOSE REQUESTED FOLLOWS
   The number of requested nuclides is more than NMAT (the number of input nuclides) Either NMAT was incorrectly specified, or one or more of the input nuclide ID's were incorrectly specified

The following error messages are found in subroutine KFNOG

1. *****A SINGLE UNIT PROBLEM CANNOT HAVE A CORE BOUNDARY REGION *****
   If a reflector exists, simply include those regions in KREFM and remove the core boundary card An alternative is to change NBOX from 0 to 1 and set NBXMAX = NBYMAX = NBZMAX = 1 and leave the core boundary card in

2. WARNING . . . A CORE BOUNDARY CARD IS REQUIRED ONLY IF AN EXTERNAL REFLECTOR IS PRESENT.
   NOTE . . A CORE BOUNDARY CARD IS NOT REQUIRED FOR ALBEDO REFLECTION.
   This is just a warning messsage and does not cause termination of the problem. It does cause the problem to run less efficiently.
3. UNRECOGNIZABLE GEOMETRY WORD______ MATERIAL _____ .
   The geometry word is not one of those specified in the data guide. Either the card was mispunched or the data is out of order. Check to be sure the proper number of dimensions, the mixture number and the proper number of weights are on the preceding geometry region
4. AN ERROR WAS FOUND IN THE HEMISPHERE DESIGNATION.
   The geometry word did not correctly specify the direction in which the hemisphere exists
5. **********ERROR . . . . NHCYL = **********.
   The hemicylinder geometry word was incorrectly specified.
6. MIXTURE IS NOT SPECIFIED IN THE MIXING TABLE
   The mixture number MAT(I) specified on the previous geometry card is less than zero or greater than the parameter MATT (the number of mixtures in the problem). The data was mispunched or is out of order
7. **********NEGATIVE WEIGHTS ARE NOT ALLOWED. THE PROBLEM WILL NOT BE RUN **********
   One of the input values of weight average was negative. The data was mispunched or out of order.
8. **
   ALBEDOS CANNOT BE USED UNLESS THE OUTERMOST GEOMETRY REGION IS A CUBE, CUBOID, OR GENERAL REGION.
   ****
   Either the albedo key NXX was incorrectly specified or the outermost geometry region was not a cube, cuboid, or general region
9. NUMBER OF BOXES ON PARAMETER CARD DOES NOT AGREE WITH BOX DATA READ IN
   NBOX = ITP =
   NBOX is the parameter stating how many box types are in the problem ITP is the number of box types that were encountered when reading the geometry data. Either NBOX was incorrectly specified, the geometry data was incorrectly entered, or the parameter KREFM (the number of geometry cards to be read) was too small.
10. END OF CASE FLAG READ IN GEOMETRY DATA.
    More geometry data was specified than was found. Either the parameter KREFM (the number of geometry cards to be read) was too large, too few geometry cards were included, or too few entries were made for the material, dimensions, or weights. The data may be incorrectly punched or improperly arranged.
11. END OF KENO FLAG READ IN GEOMETRY DATA.
    The explanation is the same as 10 above.

The following error messages appear in subroutine MAKREF

1 *****KREFM WAS NOT LARGE ENOUGH TO ALLOW ANY REFLECTOR REGIONS THE PROBLEM WILL NOT BE RUN *****

The geometry word REFLECTOR has been encountered, invoking the automatic reflector option However the parameter KREFM the number of geometry cards to be read, is too small KREFM must include the number of regions you wish to be made in the reflector, just as though the cards were actually punched See the data guide for full details

2 *****A WEIGHTING ID OF ___ WAS SPECIFIED USING ___ ENERGY GROUPS BUT IT WAS NOT FOUND ON TAPE *****

The weighting ID, IDWT was greater than 10 but was not found on the tape with the specified energy group structure Either IDWT or NGP was incorrectly specified or the wrong tape was mounted

3 *****A WEIGHTING ID OF ___ WAS SPECIFIED USING ___ ENERGY GROUPS BUT IT WAS NOT FOUND ON CARDS *****

The weighting ID, IDWT was less than 10 but was not found on the input cards with the specified energy group structure Either IDWT, NGP or the weights from cards are incorrect Check the data guide for more details

The following error message appears in subroutine CORSIZ

1 *****THE ___ DIMENSIONS OF BOX TYPE ___ AT (__, __, __) DO NOT MATCH THOSE OF BOX TYPE ___ AT (__ __ __) *****
FOR BOX TYPE ___ + ___ = ___ AND - ___ = ___ WHILE FOR BOX TYPE ___ + ___ = ___ AND - ___ = ___

This message appears because the common faces of adjacent boxes are not the same size One or more of the dimensions of one of the box types specified in the message may be incorrect or the mixed box orientation data may be incorrect

The following error messages appear in subroutine FILBOX

1 ARRAY DESCRIPTION ERROR MESSAGES

This message appears only if errors were encountered in the mixed box orientation data One of the following messages will also be printed

2 MIXED BOX ORIENTATION CARD NUMBER ___ CONTAINS ___ ERROR(S)

This message can appear no more than 10 times It tells which card is in error and occurs only if some of the conditions explained in 3 , below, exist

3 LTYPE = ___ IX1 = ___ IX2 = ___ INCX = ___ IY1 = ___ IY2 = ___
INCY = ___ IZ1 = ___ IZ2 = ___ INCZ = ___

This message appears in conjunction with error message 2 , above, and is written if

(a) LTYPE (the box type) is less than or equal to zero or if LTYPE is greater than the parameter NBOX, the number of box types,

(b) if IX1, IY1, or IZ1 is less than one,

(c) if IX2 is less than IX1 or greater than NBXMAX, if IY2 is less than IY1 or greater than NBYMAX, or if IZ2 is less than IZ1 or greater than NBZMAX,

(d) if INCX, INCY, or INCZ is not positive

Any of the above may result from data being mispunched or out of order Further clarification may be derived from the data guide

4 THE ABOVE MIXED BOX ORIENTATION CARD(S) CONTAIN(S) AT LEAST ONE OF THE FOLLOWING ERRORS

This message follows message 3 , above, if any errors were found The messages listed in 5 , below, then follow

5 1 IX1, IY1, IZ1, INCX, INCY, or INCZ IS LESS THAN OR EQUAL TO ZERO

2 IX2 IS LESS THAN IX1, IY2 IS LESS THAN IY1, OR IZ2 IS LESS THAN IZ1

3 IX2 IS GREATER THAN NBXMAX, IY2 IS GREATER THAN NBYMAX, OR IZ2 IS GREATER THAN NBZMAX

4 LTYPE IS LESS THAN 1 OR GREATER THAN NBOX

These error messages are printed if errors are found in the mixed box orientation data The parameters NBOX, NBXMAX, NBYMAX, or NBZMAX may be incorrectly specified, but more than likely the mixed box orientation cards are incorrectly punched

The following error messages appear in subroutine BOX

1 ***AN ERROR EXISTS IN THE ARRAY DESCRIPTION ***

X INDEX = ____ Y INDEX = ____ Z INDEX = ____

This message occurs if the box type stored in the mixed box orientation array, the array showing the position of each box type in the array is less than or equal to zero, or greater than NBOX, the number of box types in the problem This error usually results from leaving some positions in the array unfilled or from mispunching the mixed box orientation data Check the mixed box orientation array printout at the position indicated in the message and correct the input data

The following error messages appear in subroutine ALBIN

1 *****WARNING THE NXX PARAMETER INDICATED DIFFERENTIAL ALBEDOS BUT NONE WERE SPECIFIED ON THE REFLECTED FACES *****

This error occurs if NXX = 2 or 3 and the reflector constants are all entered as zero or negative (i e , none of the reflector constants (card 4) are positive)

2 ***** ____ DIFFERENTIAL ALBEDOS WERE SPECIFIED, BUT ONLY ____ COULD BE FOUND *****

THE ALBEDOS SPECIFIED WERE ___, ___, ___, ___, ___, ___

One of the albedo ID's was incorrectly specified or too few sets of albedo data were available

3 *****DIFFERENTIAL ALBEDO ____ WAS SPECIFIED TO BE USED FROM THE PREVIOUS CASE, BUT COULD NOT BE FOUND *****

THE FOLLOWING DIFFERENTIAL ALBEDOS ARE SAVED FROM THE PREVIOUS CASE

ID = ____, ID = ____, ID = ____, ID = ____, etc

This message occurs if the specified albedo was not found in the saved data The data is mispunched, incorrect or out of order

The following error messages appear in subroutine VOLUME

1 REGION NUMBER ___ CONTAINS AN ERROR IN THE DIMENSIONS

This message occurs if the positive x, y, or z dimension is smaller than the negative x, y, or z dimension The data is mispunched or out of order The positive dimension in a given direction must always be more positive than the negative dimension in that direction

2 THE VOLUME DEFINED BY GEOMETRY CARD ___ IS NEGATIVE

This message occurs if the volume of any region becomes negative This usually results from incorrect nesting of the regions

3 A BOX VOLUME MUST BE GREATER THAN ZERO

This message occurs if the cumulative volume over a given box type is negative, data is incorrectly punched, the data is out of order, or a box is specified with no geometry regions

4 INVALID GEOMETRY ENCOUNTERED FOR THE LAST GEOMETRY REGION IGEO = ___

The last geometry card was not one of the allowed types The data was entered incorrectly or the storage arrays have been destroyed

5 THE LAST GEOMETRY CARD IN THE UNIT MUST BE A CUBE OR CUBOID

This message occurs if the last region in a given box type is not a cube or cuboid The data is incorrectly punched or out of order

The following error messages occur in subroutine RESTRT

1 THE NUMBER OF GENERATIONS SPECIFIED IN THE RESTART PROBLEM ( ) IS LESS THAN THE NUMBER OF GENERATIONS ALREADY CALCULATED ( )

In order to run a restart problem, you must ask for more generations (NBA) than were run when generating restart information

2 *****RESTART ERROR*****

	INPUT SPECIFICATIONS	OLD SPECIFICATIONS
RESTART COUNT	______	______
NUMBER PER GENERATION	______	______
NUMBER OF GROUPS	______	______
NUMBER OF DOWNSCATTERS	______	______
NUMBER OF MIXTURES	______	______
NUMBER OF GEOMETRY CARDS	______	______
NUMBER OF BOX TYPES	______	______
NUMBER OF X UNITS	______	______
NUMBER OF Y UNITS	______	______
NUMBER OF Z UNITS	______	______
ALBEDO TYPE	______	______
SEARCH TYPE	______	______
FLUX FLAG	______	______
FISSION DENSITY FLAG	______	______
ADJOINT FLAG	______	______
MATRIX FLAG	______	______
KMAX	______	______

Check the input specifications and the old specifications They do not agree for one or more of the parameters listed

The following error messages occur in subroutine START

1 AN ERROR HAS BEEN DETECTED IN THE DATA FOR START TYPE ___.

An error was encountered when reading in the data for the specified start type For example, the box indices may fall outside the allowable range, the point where the neutron is to be started may not be within the specified box type, etc.

2 START TYPE ___ IS NOT APPLICABLE FOR A SINGLE UNIT PROBLEM START TYPE 0 WILL BE USED

Only start type 0, 3, or 6 can be used with a single unit problem If a start type 0 was not acceptable, resubmit the problem with a start type 3 or 6

3 *****INVALID GEOMETRY TYPE IN START. IGEO = ___ *****

An unrecognizable geometry type was encountered The storage arrays may have been destroyed

4 NO NEUTRON STARTING POSITIONS WERE FOUND YOU SHOULD SELECT ANOTHER STARTING OPTION

If after trying the allowed number of tries (the maximum of (3 times the number per generation/volume fraction of fissionable material) or (100 times the number per generation)), no starting positions were found, this message is printed Carefully check the input data to be sure fissionable material exists where it is expected and to be sure the starting information was correctly specified

5 THE CHOSEN START TYPE MAY NOT BE ADEQUATE TOO MANY ATTEMPTS MAY BE NEEDED TO START THE NEUTRONS

This message appears for start type 0, 1, or 5 if (3 times the number per generation)/(volume fraction of fissionable material) is greater than (100 times the number per generation) Look at the problem carefully and choose a better starting distribution.

6 ___ NEUTRONS WERE INITIALLY STARTED HOWEVER, ONLY ___ WERE STARTED FROM INDEPENDENT POSITIONS

This message indicates that the code encountered some difficulty starting the necessary number of neutrons and was forced to fill the remaining starting positions from those already found Try to pick a better starting distribution

The following error messages occur in subroutine POSIT

1 POSIT ERROR — ILLEGAL GEOMETRY TYPE

X = ___ Y = ___ Z = ___ K1 = ___ K2 = ___ K = ___ IGEO = ___

This message is printed if the geometry type, IGEO, is outside the allowable range It indicates that some of the storage array has been destroyed

2 POSIT ERROR

X = ___ Y = ___ Z = ___ K1 = ___ K2 = ___

An error has been encountered in processing the neutrons Some of the storage arrays have probably been destroyed.

The following error messages appear in subroutine BEGIN

1 $$$ MARK = ___ IS NOT ALLOWED, K = ___, KOLD = ___, KR = ___$$$

X = ___ Y = ___ Z = ___ X1 = ___ Y1 = ___ Z1 = ___

This message is printed only if the generalized geometry portion of the problem returns an invalid value for MARK This message indicates that the program contains an error.

2 SPLITTING BINS FULL
This message indicates that a neutron was split more than 25 times After printing the message 10 times, execution will be terminated Check the weighting values associated with the geometry regions

3 $$$$$ERROR IN DOWNSCATTERS, KR = ____ IG = ____ IGKR = ____
NDS = ____ FSP = ____ R = ____
This error occurs only if the storage arrays have been destroyed FSP should be 1

4 JOB PULLED BATCH = ____ NEUTRON = ____
This message is printed when subroutine PULL has determined that the time interval for a generation has been exceeded It usually means the program has gone into a loop Check the printed time intervals to determine whether this time interval is out of range If it is not, increase TMAX and resubmit the problem If it is looping, put in diagnostic print to locate the error if it cannot be found by checking the input data

5 EXECUTION TERMINATED DUE TO EXCESSIVE SPLITTING
This message is printed if the SPLITTING BINS FULL message was encountered more than 10 times

The following error messages are printed in subroutine NSTART

1 NO FISSIONS
This message occurs if an entire generation was tracked without causing fission Check to be sure fissionable materials exist where they are supposed to be

2 WARNING - ONLY ____ INDEPENDENT FISSION POINTS WERE GENERATED
This message indicates that less than NPB (number per generation) fission points were generated It may become necessary to lower the value of RAKBAR in subroutine BEGIN if this message occurs frequently and the number of independent fission points is very different from NPB

The following error message may originate from subroutine MATK

1 The calculations done in subroutine MATK may result in exponent underflows for large unit matrices These are considered to be of no significance and may be ignored

The following error messages are printed in subroutine CROS

1 *****CROSS ERROR __ __ __ __ __ __ __ __
IGEO, K, X, Y, Z, X1, Y1, Z1 are printed in that order This error indicates that the geometry type, IGEO, has been destroyed in the storage array

2 *********ERROR NHCYL = ____ *********
This message is printed if NHCYL is outside the allowable range Either the input data for hemicylinders was incorrect or the storage array has been destroyed

The following error messages are printed in subroutine KEDIT

1 *****WARNING*** NO VELOCITIES WERE READ VELOCITIES WERE SET TO 1 0*****
The lifetime and generation time were calculated using velocities of 1 0 because the input data specified cross sections from cards but did not specify velocities from cards See the units digit of Parameter 26 of card 2 in the data guide

2 * ** *
THE START TYPE WAS NOT ADEQUATE FOR THIS PROBLEM CHOOSE A BETTER STARTING DISTRIBUTION FOR ANY SIMILAR PROBLEM
* ** *
This message indicates that subroutine START was unable to provide NPB, number per generation, independent starting positions For any similar problem, a different choice of start type, NTYPST, or a different choice of starting positions for the specified start type is recommended

3 NUMBER OF BATCHES RUN WAS INSUFFICIENT TO EDIT
This message is printed if the number of generations run was less than or equal to the parameter NSKIP + 1 Either increase the allowed time, TMAX, increase the parameter NBA, the number of generations to be run, or decrease the number of generations to be skipped, NSKIP

The following error messages occur in subroutine XXMOD

1 ***A SEARCH WILL NOT BE PERFORMED BECAUSE LESS THAN 10 + NSKIP GENERATIONS WERE CALCULATED ***
In the calculation just completed, too few generations were calculated so the search option has been canceled If the parameter NBA is less than or equal to the parameter NSKIP + 10, increase the value of NBA Otherwise, increase the value of TMAX

2 UNRECOGNIZABLE GEOMETRY WORD ______
This error occurs if the storage array was destroyed

3 **********ERROR NHCYL = ___ **********
This error occurs if the storage array has been destroyed

4 THE SEARCH TYPE HAS BEEN INCORRECTLY SPECIFIED AS _____
The search type parameter, NSCH, was not 1, 2, or 3 Correct the data and resubmit

5 GEOMETRY ERROR IN SEARCH PACKAGE
This error occurs if the geometry type, IGEO, is outside the allowable range It indicates that some of the storage array has been destroyed

6 A GENERALIZED REGION CAN NOT BE ALTERED
Nonzero search constants have been supplied for a generalized geometry region *This is not allowed* Either the problem was incorrectly specified, the data was mispunched, or cards are out of order

7 THIS DIMENSION HAS ALREADY BEEN CALCULATED FOR REGION ______
If this message occurs, the search has returned to a point it has already calculated and the problem is terminated Check input data and if it is correct, the search may be restarted with a different first guess or different search constants

8 THE GEOMETRY TYPE IS UNDEFINED OR A SEARCH WAS ATTEMPTED ON A GENERAL REGION
This error occurs if the geometry type, IGEO, is outside the allowable range, or if a search constant for a generalized geometry region is nonzero If IGEO is outside the allowable range, some of the storage array has been destroyed If the search constants are nonzero for a generalized geometry region, set them to zero

9 *****ILLEGAL GEOMETRY TYPE FOR REFLECTOR REGION ___ IN THE SEARCH PACKAGE *****
The geometry type, IGEO, is outside the allowable range or a generalized geometry region was specified in the reflector Either a general card was out of order or some of the storage array was destroyed

The following error messages occur in subroutine ARAMOD

1 THE SEARCH PACKAGE DOES NOT APPLY TO MIXED BOXES

This message is self-explanatory An array search cannot be made for a problem where NBOX is not 1

2 THE SEARCH TYPE FOR AN ARRAY SEARCH IS INCORRECT SEARCH TYPE ___ WAS SPECIFIED

Either the search parameter NSCH was incorrectly entered or some of the storage array has been destroyed

3 ALL SEARCH CONSTANTS ARE ZERO NO SEARCH WILL BE MADE

All the search constants were entered as zero The data was incorrect or out of order

4 THIS CASE HAS ALREADY BEEN CALCULATED

If this message occurs, the search has returned to a point that has already been calculated and the problem is terminated If the input data is correct, the search may be restarted with a different initial guess or different search constants if desired

5 ********FURTHER CONVERGENCE IS IMPOSSIBLE USING THE SEARCH CONSTANTS SPECIFIED IN THIS PROBLEM ********

THE NUMBER OF UNITS IN THE X DIRECTION WERE ___, IN THE Y DIRECTION WERE ___, AND IN THE Z DIRECTION WERE ___ FOR THE LAST SEARCH

The search cannot be converged with the data specified If the data is correct, nothing more can be accomplished

6 THERE IS NO FEASIBLE SOLUTION TO THE QUADRATIC EQUATION

Using the data supplied for this problem resulted in a negative discriminant when solving the quadratic equation Check input data carefully

The following error messages occur in subroutine FINALE

1 ********WARNING********WARNING********WARNING********WARNING********

THE FISSION DENSITY AND FLUX WERE COMPUTED USING ARBITRARY VOLUMES (LISTED UNDER - TOTAL VOLUMES-) IN THE REGIONS DESCRIBED BY GENERALIZED GEOM THEY MUST BE MULTIPLIED BY THE TRUE VOLUME OVER THE ARBITRARY VOLUME TO OBTAIN THE CORRECT VALUES

This is a warning message It appears because KENO does not know the volumes of regions internal to the generalized geometry portion If fluxes and fission densities are to be used, they must be multiplied as indicated in the message

KENO IV INPUT DATA PREPARATION

1 Free-Form Input

The free-form version of KENO allows data to be entered in an unformatted manner by separating each data item by one or more blanks All 80 columns of any card may be used, and data, with certain exceptions noted below, can start or end in any column Decimal data may be entered as in FORTRAN input, e g , 1.733-4, 1 733E-4 or 0001733, is the same as 1.733×10^{-4}. Note that no imbedded blanks are allowed within a given number representation Since blanks are ignored, all zeros must be entered

Geometry description words, such as CYLINDER, SPHERE, etc , must begin in column 1 of a card and be separated by two or more blanks from the rest of the free-form data on the card Additional card(s) following the geometry description word may be used, with the data in any columns 1-80 inclusive Each new geometry description word must start in column 1 of a new card

Free-form KENO has provisions for multiple entries of the same data value This is done by entering the number of repeats, followed by either R, *, or $, followed by the data value to be repeated For example, 5R2 or 5*2 enters five successive 2's in the input data There should be no blanks between the number of repeats and the repeat flag (R, *, or $), but each multiple entry must be separated from the rest of the data by 1 or more blanks Multiple zeros may be specified as NZ where N is the number of zeros to be repeated There should not be any blanks between the N and the Z but the NZ must be separated from the rest of the data by one or more blanks

Certain data items such as cross-section decks, fission spectra, and albedos are never entered in free form Proper formats for these items are given in the data guide The title card contains identification information only and no data The END CASE and END KENO cards must start in column 1 and cannot contain any data

An END CASE card is really a flag to signal the end of data for a given problem This is particularly useful if one problem in a set of stacked cases contains an error, because it helps prevent the code from reading into the next problem Once the END CASE card is encountered, the program knows it has finished with the problem, whether or not it encountered all the expected data, and it immediately prepares to read the data for a new problem It should be noted that, if one problem expects to utilize data from the preceding problem, they MUST NOT be separated by an END CASE card Most errors encountered during the tracking procedure are presumed to be programming errors and result in termination of execution rather than continuing on to the next problem

The END KENO card causes the program to cease execution

In KENO, the following unit numbers are used as stated in Table 2

2 KENO IV Logical Unit Numbers

Table 2 Function of KENO IV logical units

Unit Number	Function
4 or NXCUTE	AMPX working library
5	Input from cards
6	Printed output
18	Scratch unit
41 or NXCUTE	Master KENO cross section library
42	Master KENO albedo library
43	Master KENO WTAVG library for automatic reflector option
44	Read restart data for KENO
45	Write restart data for KENO

3 KENO IV Data Guide

Card 1 Title Card FORMAT(20A4) Contains title only

Card(s) 2 Parameter Card (Parameters are separated by one or more blanks A new card may be started after any parameter)

1	TMAX	Maximum computer time (in minutes) to be allowed for problem, or for each iteration if a search is to be made
2	NBA	Number of generations
3	NPB	Number of neutrons per generation
4	NSKIP	Number of generations to be skipped
5	NGP	Number of energy groups
6	NDS	Number of downscatters or energy transfers (includes inscatter)
7	NMAT	Number of input cross-section sets
8	MAT1	Number of mixtures
9	NMIX	Number of mixing table entries (see card(s) 6)
10	KREFM	Total number of geometry cards This includes the regions generated by the automatic reflector option, and the CORE BOUNDARY card, whether calculated by the automatic reflector option, or entered separately Do not count the REFLECTOR card from the automatic reflector option and do not count BOX TYPE cards All other geometry cards must be included
11	NBOX	The number of box types *NOTE NBOX must be zero for a single unit A single unit is a configuration that does not have to be enclosed in a cube or cuboid and cannot be stacked into an array*
12	NBXMAX	Number of units in the x direction of the array A value must be entered for a single unit problem, but it is not used
13	NBYMAX	Number of units in the y direction of the array A value must be entered for a single unit problem, but it is not used
14	NBZMAX	Number of units in the z direction of the array A value must be entered for a single unit problem, but it is not used

15 NTAPE — |NTAPE| is the number of input cross-section sets to be read from a library If NTAPE > 0, read a KENO cross-section library on logical unit 41 If NTAPE < 0, read an AMPX[6] working format cross-section library on logical unit 4

16 NXX — Specified albedo-k_∞ options *NOTE Albedo cannot be used for a single unit problem*

- NXX = 0 — No albedo or k_∞ to be used
- NXX = 1 — Uses specular reflection (k_∞) Note that this consists of mirror image reflection, multiplying the weight (WT) by the absolute value of the reflector constant (card 4) for that face, and leaving the energy unchanged NXX = 1 cannot be used for a problem that utilizes both specular reflection and differential albedos
- NXX = 2 — Read differential albedos from cards or tape If a combination of differential albedos and specular reflection are to be used NXX must be 2
- NXX = 3 — Use differential albedos from the previous case Cannot be used in the first case following an "END CASE" card
  NOTE Differential albedos cannot be used for an adjoint problem

17 NSCH — Search type

- NSCH = 0 — If no search
- NSCH = 1 — Search on dimensions
- NSCH = 2 — Search on the number of units (array search)
  Use only if NBOX = 1 (parameter 11 of card 2)
- NSCH = 3 — Search on dimensions using a small number of generations, NBAT (given as parameter 4 of card 3) Once convergence has been achieved, an additional search is made using the number of generations read in as NBA (parameter 2 of card 2) for NUMBRF (parameter 5 of card 3) iterations This option enables the user to minimize the hazards of a poor starting guess and yet still obtain a significant number of histories in a relatively shorter time interval than required if run using NSCH = 1

18 LIST — Supplies print flags to KENO (four-digit number)

THOUSANDS DIGIT
- = 0 PRINT ALL macroscopic cross sections
- = 1 PRINT ONLY macroscopic 1-D cross sections
- = 2, DO NOT PRINT any macroscopic cross sections

HUNDREDS DIGIT
- = 0 DO NOT print array unit interaction matrix (Fission probability matrix by unit)
- = 1, PRINT array unit interaction matrix Use only if MATRIX (parameter 26 of card 2) is 1 or 3

TENS DIGIT
- = 0, DO NOT print region-dependent fissions and absorptions
- = 1, PRINT region-dependent fissions and absorptions

	UNITS DIGIT	= 0, DO NOT print input cross sections from tape = 1, PRINT input cross sections *NOTE For example, assume you wish to print input cross sections, macroscopic cross sections, and the array unit interaction matrix but not region-dependent fissions and absorptions, then LIST = 0101*
19	NOXS	Specifies whether to reuse macro cross sections and or the geometry description from the preceding case (two-digit number) *NOTE NOXS must always be zero for the first case following an END CASE card*
	TENS DIGIT	= 0, read new geometry = 1, use geometry from the preceding case However, the mixed box orientation data *must* be read in again if NBOX (parameter 11, card 2) is greater than 1
	UNITS DIGIT	= 0, read new cross sections = 1, use cross sections from the preceding case If using cross sections from the preceding case, the units digit of NADJ (parameter 23, card 2) must be the same for both cases *NOTE For example, to use cross sections from the preceding case and new geometry, NOXS = 01 To read new cross sections and to use the geometry from the preceding case, NOXS = 10*
20	NTYPST	The type of starting distribution to be used NTYPST must be negative to read restart data If NTYPST is negative, the absolute value of it specifies which set of restart data is to be used The restart data is written sequentially on tape as described in NRSTRT, (parameter 25, card 2) Note that a problem that reads restart data consists only of a title card and parameter cards All other data is read in from the restart unit Restart data is written on unit 45 and is read in from unit 44 Note that, wherever X, Y, and Z are used in the start information, they are actually integer position indicators that define the position of the specified unit in the array $1 \leqslant X \leqslant NBXMAX$, $1 \leqslant Y \leqslant NBYMAX$, and $1 \leqslant Z \leqslant NBZMAX$
	NTYPST	= 0, flat over the overall array dimensions, in fissile material only
	NTYPST	= 1, cosine over the overall array dimensions, in fissile material only Not applicable for single-unit problems
	NTYPST	= 2, arbitrary fraction started in fissile material in unit (X, Y, Z), the rest started in fissile material with cosine distribution, over the array, about unit (X, Y, Z) Not applicable for single-unit problems
	NTYPST	= 3, all are started at position (x, y, z) in cm, in unit (X, Y, Z)
	NTYPST	= 4, all are started at position (x, y, z) in cm, with all units of box type NBOXST (card 13) being equally probable Not applicable for single-unit problems

	NTYPST	= 5, flat distribution in fissile material in units of box type NBOXST (card 13) Not applicable for single-unit problems
	NTYPST	= 6, starting distribution is arbitrarily input This is the only way neutrons can be started in the reflector of an array *NOTE NTYPST must be 0, 3, or 6 for a single-unit problem If any other value is specified, it will be run as a start type zero*
21	NFLX	Flux flag
	NFLX	= 0, fluxes will be calculated
	NFLX	≠ 0, fluxes will not be calculated
22	NFDEN	Fission density flag
	NFDEN	= 0, fission densities will be calculated
	NFDEN	≠ 0, fission densities will not be calculated
23	NADJ	
	UNITS DIGIT	= 0, a forward calculation will be done = 1, an adjoint calculation will be done
24	NXCUTE	= 0, the logical device number, XSECS is set to 41 for the KENO cross-section library and 4 for AMPX cross-section library ≠ 0, the logical device number for the input cross-section library, XSECS, is set equal to the absolute value of NXCUTE
25	NRSTRT	Specifies the number of generations between writing of restart data The sets of restart data for each problem are numbered sequentially starting with 1 If NRSTRT = 0, no restart data will be generated
26	MATRIX	Flag for input velocities and matrix calculations
	TENS DIGIT	= 0, read energy and lethargy from tape and calculate velocities = 1, read velocities from cards = 2, use velocities from the previous case Note that NADJ (parameter 23, card 2) must be the same for both cases Note that velocities are used to calculate lifetimes and generation times Lifetime and generation time are incorrect if a differential albedo reflector is used
	UNITS DIGIT	= 0, no matrix k_{eff} will be calculated = 1, matrix k_{eff} by array unit will be calculated = 2, matrix k_{eff} by box type will be calculated = 3, matrix k_{eff} by both array unit and box type will be calculated *NOTE The k_{eff} and co-factor k_{eff} will be printed If the unit interaction matrix is to be printed, LIST (parameter 18, card 2) must include a 1 in the hundreds digit*

27 NPST	Position of σ_7 if ANISN format cross sections* are read from cards NPST = 0 if cross sections other than ANISN format are to be used
28 NPSGG	Position of σ_{gg} if ANISN format cross sections are read from cards NPSGG = 0 if cross sections other than ANISN format are to be used

Card 3 Search Parameters *Enter only if NSCH > 0* (parameter 17, card 2)

1 CONSTK	The desired k_{eff} for a search problem
2 NSIG	The maximum number of standard deviations k_{eff} may be from CONSTK for search completion
3 NUMBR	If NSCH = 1 or 2 (parameter 17, card 2), NUMBR is the maximum number of iterations the search will run If NSCH = 3, NUMBR is the number of iterations allowed for coarse convergence
4 NBXMA	*Enter only if NSCH = 2* (parameter 17, card 2) The maximum number of units that will be allowed in the X direction during an array search
4(a) NBA1	*Enter only if NSCH = 3* (parameter 17, card 2) The number of batches to be run to achieve coarse convergence (See explanation for NSCH = 3)
5 NBYMA	*Enter only if NSCH = 2* (parameter 17, card 2) Maximum number of units that will be allowed in the Y direction during an array search
5(a) NUMBRF	*Enter only if NSCH = 3* (parameter 17, card 2) The number of iterations to be run to achieve fine convergence (See explanation for NSCH = 3) If coarse convergence was not achieved, fine convergence will not be attempted
6 NBZMA	*Enter only if NSCH = 2* (parameter 17, card 2) Maximum number of units that will be allowed in the Z direction during an array search

Card 4 Reflector Constants Enter only if NXX ≠ 0 (parameter 16, card 2)

NOTE Reflector constants should be the POSITIVE albedo ID for the faces using DIFFERENTIAL ALBEDOS, the NEGATIVE albedo ID for faces using SPECULAR ALBEDOS, and zero for faces having no albedo treatment SPECULAR ALBEDOS may be used on some faces and DIFFERENTIAL ALBEDOS on others in problems where the use of DIFFERENTIAL ALBEDOS has been indicated in NXX (parameter 26, card 2) The absolute value of the reflector constant entered for specular albedo is the fractional return for that face The value of the reflector constant is the albedo ID for differential albedo

*See Appendix I

1	REFCST(1)	Reflector constant for +x face of the array
2	REFCST(2)	Reflector constant for -x face of the array
3	REFCST(3)	Reflector constant for +y face of the array
4	REFCST(4)	Reflector constant for -y face of the array
5	REFCST(5)	Reflector constant for +z face of the array
6	REFCST(6)	Reflector constant for -z face of the array

Card(s) 5 Velocities *Enter only if the TENS DIGIT of MATRIX is equal to 1* NGP (parameter 5, card 2) entries will be read A velocity must be entered for each energy group The units on the velocity is cm/sec

Card(s) 6 Mixing Table *Enter only if the units digit of NOXS = 0* (parameter 19, card 2)

1	KKA	Mixture number It must lie between 1 and MA11 (parameter 8, card 2)
2	NMA	Nuclide ID number A negative nuclide ID number indicates that the fission spectrum for that nuclide will be used for mixture KKA A negative nuclide ID *MUST* be specified in each mixture that contains fissionable material *NOTE Nuclides read from cards are assigned sequential ID numbers starting with 1*
3	RHOA	Number density (atoms/barn-cm), must be greater than zero

Repeat starting with KKA, for each nuclide Each set of KKA, NMA RHOA is a mixing table entry

NOTE There must be NMIX (parameter 9, card 2) sets of entries

Card(s) 7 Cross Sections from Cards Enter only if units digit of NOXS = 0 (parameter 19, card 2) and |NTAPE| < NMAT (parameters 15 and 7, card 2) There will be NMAT-|NTAPE| cross-section decks entered Each cross-section deck consists of the card sequence 7(a), 7(b), and 7(c) described below

NOTE Cross sections must be formatted

Card(s) 7-a Title Card Format (17A4,A3,I1)

Cols 1-71 XST Nuclide identification

Cols 72 IORDER Enter 0 if P_0 component only, enter 1 if P_1 is present

Card(s) 7-b P_0 and P_1 cross-section sets

First enter the P_0 component for all energy groups *Next*, if IORDER = 1 (Card 7-a), enter the P_1 component for all energy groups

NOTE Both the P_0 and P_1 components must be entered in either KENO or ANISN format described under A and B below All cross-section sets from cards must be entered in the same format for a given problem

A KENO FORMAT, see next page

B ANISN FORMAT, enter only if NPST ≠ 0 (parameter 27, card 2)

For a detailed description of this format, see Appendix 1

A. **KENO Format (6E12.5) ENTER ONLY IF NPST = 0 (parameter 27 of card 2).**

Cols.→	1 → 12	13 → 24	25 → 36	37 → 48	49 → 60	61 → 72
GP ↓						
1	σ_a	$\nu\sigma_f$	σ_t	$\sigma_{1\to1}$	$\sigma_{1\to2}$	$\sigma_{1\to3}$
	$\sigma_{1\to4}$	...	$\sigma_{1\to1+NDS-1}$			
2	σ_a	$\nu\sigma_f$	σ_t	$\sigma_{2\to2}$	$\sigma_{2\to3}$	$\sigma_{2\to4}$
	$\sigma_{2\to5}$	...	$\sigma_{2\to2+NDS-1}$			
.						
.						
.						
J=NGP−NDS+1	σ_a	$\nu\sigma_f$	σ_t	$\sigma_{J\to J}$	$\sigma_{J\to J+1}$	$\sigma_{J\to J+2}$
	$\sigma_{J\to J+3}$	...	$\sigma_{J\to NGP}$			
J+1	σ_a	$\nu\sigma_f$	σ_t	$\sigma_{J+1\to J+1}$	$\sigma_{J+1\to J+2}$	$\sigma_{J+1\to J+3}$
	$\sigma_{J+1\to J+4}$	...	$\sigma_{J+1\to NGP}$	$\sigma_{J+1\to J}$		
J+2	σ_a	$\nu\sigma_f$	σ_t	$\sigma_{J+2\to J+2}$	$\sigma_{J+2\to J+3}$	$\sigma_{J+2\to J+4}$
	$\sigma_{J+2\to J+5}$	...	$\sigma_{J+2\to NGP}$	$\sigma_{J+2\to J+1}$	$\sigma_{J+2\to J}$	
.						
.						
.						
NGP−1	σ_a	$\nu\sigma_f$	σ_t	$\sigma_{NGP-1\to NGP-1}$	$\sigma_{NGP-1\to NGP}$	$\sigma_{NGP-1\to NGP-2}$
	...	$\sigma_{NGP-1\to J}$				
NGP	σ_a	$\nu\sigma_f$	σ_t	$\sigma_{NGP\to NGP}$	$\sigma_{NGP\to NGP-1}$	$\sigma_{NGP\to NGP-2}$
	...	$\sigma_{NGP\to J}$				

where the following table defines the terms

Table 3 Cross section symbol definitions

Symbol	Definition	KENO Variable Names
σ_a	absorption cross section (barns)	AC
ν	neutron/fission	
σ_f	fission cross section (barns)	
$\nu\sigma_f$	$\nu*\sigma_f$	F
σ_t	total cross section (barns)	T
$\sigma_{i\to j}$	scattering cross section from group i to group j	TSP
NGP	number of energy groups	NGP
NDS	number of downscatters	NDS
J	NGP−NDS+1	

NOTE For the P_1 component, σ_a, $\nu\sigma_f$, and σ_T are dummy variables whose value is ignored

Card(s) 7-c Fission Spectrum FORMAT (6E12 5) *Enter only if $\nu\sigma_f \neq 0$* for at least one energy group There must be NGP entries

WARNING Cross sections and fission spectrum cannot be read in free-form format

Card(s) 8 Geometry Cards and Weights *Enter only if the tens digit of NOXS = 0 (parameter 19 card 2)* Starting in column 1 on a new card, enter the geometry word, followed by at least two blanks Then the mixture number, dimensions and weights are entered, separated by one or more blanks This information may be carried over to a new card after any entry Note that the geometry type must *ALWAYS* start in column 1 A weight for each energy group must follow each geometry card (*except BOX TYPE or REFLECTOR cards which are not counted as geometry cards*) If NBOX = 1 (parameter 11, card 2), no BOX TYPE cards are needed, if NBOX > 1, start in column 1 and punch BOX or BOX TYPE, followed by two or more blanks Then enter the box type This card is followed by as many geometry cards and weights as are necessary to describe the box type Repeat this process until all box types have been described NOTE ALL REGIONS WITHIN A GIVEN BOX TYPE MUST BE DESCRIBED SO THAT EACH SUCCESSIVE REGION COMPLETELY ENCLOSES THE PREVIOUS REGION THE ADJACENT FACES OF BOXES IN CONTACT WITH EACH OTHER MUST BE THE SAME SIZE

If an external reflector to an array is present, enter a CORE BOUNDARY card The CORE BOUNDARY card starts in column 1 and the first four characters must be CORE followed by two or more blanks The word CORE may be followed by a blank and the word BDY or BOUND, which then must be followed by two or more blanks The mixture field contains a zero and the remainder of the field is punched with cuboid dimensions that fit tightly around the array Following the CORE card are weights for each energy group The remaining reflector regions are described as any appropriate geometry type, in the manner illustrated under Card(s) 8-b NOTE EACH SUCCESSIVE REFLECTOR REGION *MUST* COMPLETELY ENCLOSE THE PREVIOUS REGION A weight for each energy group must follow each reflector region card

The REFLECTOR card starts in column 1 and says REFLECTOR, followed by two or more blanks followed by a mixture number The next six entries indicate the desired reflector thickness on each face (+x, -x, +y, -y, +z, and -z, respectively) The reflector thickness must be either zero or positive They can*not* be negative Following the thicknesses is the ID number of the weights to be read from tape If the ID is less than 10, the weights will be read from cards as given in card(s) type 10 The REFLECTOR card may replace the CORE BOUNDARY card or be placed at any point external to it If it replaces the CORE BOUNDARY card, it calculates the core boundary, supplies the weights for it, and fills in the reflector regions and their associated weights until KREFM-1 (parameter 10, card 2) regions contain data It then fills the last region with the remaining reflector thickness and supplies the weights associated with it The thickness of each region is governed by data associated with the weights read from tape or cards (3 cm for water and paraffin, 5 cm for concrete, etc) If KREFM (parameter 10, card 2) is too large so the maximum reflector thickness is used up before reaching KREFM regions, it simply pads with zero thickness regions until it accumulates KREFM regions If the REFLECTOR card is external to the CORE BOUNDARY card, it follows the same procedure except it does not calculate the core boundary but starts creating regions at the point where the REFLECTOR card was read NOTE The first automatic reflector region *always* uses the weights for the first increment (i e , 0-3 cm for water and paraffin, 0-5 cm for concrete, etc) Therefore, exercise caution in choosing weights for any regions that occur between the CORE BOUNDARY card and the REFLECTOR card If the REFLECTOR card replaces the CORE BOUNDARY card, you need not be concerned

Card(s) 8-a Box Type Card If NBOX = 0, (parameter 11, card 2), do not enter a Box Type Card If NBOX = 1, a Box Type Card may be entered but is not necessary

Start in Col 1 "BOX TYPE" (left adjusted)
Starting two or more spaces after the geometry word, enter the box number (between 1 and NBOX)

Card(s) 8-b Geometry Cards *NOTE All geometry words start in Col 1*

FGEOM — FGEOM may be one of the following and must be left adjusted
CUBE, CUBOID, SPHERE, CYLINDER, XCYLINDER, YCYLINDER, HEMISPHERE, HEMISPHE+Z, HEMISPHE-Z, HEMISPHE+X, HEMISPHE-X, GENERAL, XHEMICYL+Y, XHEMICYL-Y, HEMISPHE+Y, HEMISPHE-Y, XHEMICYL+Z, XHEMICYL-Z, YHEMICYL+X, YHEMICYL-X, YHEMICYL+Z, YHEMICYL-Z, ZHEMICYL+X, ZHEMICYL-X, ZHEMICYL+Y, ZHEMICYL-Y, CORE BDY, REFLECTOR
NOTE. FGEOM may be no more than 12 characters long

CUBE has +X = +Y = +Z and -X = -Y = -Z Note that the +X dimension need not equal the -X dimension of the cube, i e , the origin need not be at the center of the cube

CUBOID is a rectangular parallelepiped and may be described anywhere relative to the origin

SPHERE must be centered about the origin

CYLINDER has its length described along the Z axis and its center line must lie on the Z axis

XCYLINDER has its length described along the X axis and its center line must lie on the X axis

YCYLINDER has its length described along the Y axis and its center line must lie on the Y axis

HEMISPHERE must have its flat portion centered about the origin at Z = 0 0 and exists only in the positive Z direction

HEMISPHE(B) (C) must have its flat portion centered about the origin at (C) = 0 0 and exists only in the BC direction (B = + or -, C = X, Y, or Z). For example, HEMISPHE+Z is the same as the previously described HEMISPHFRE and HEMISPHE-Z is the mirror image of HEMISPHE+Z, therefore existing only in the negative Z direction

(B)HEMICYL(C)(D) is a half cylinder whose axis is the B axis (B = X, Y, or Z) and exists only in the CD direction (C = + or -, D = X, Y, or Z) (Examples ZHEMICYL+X, YHEMICYL-Z, XHEMICYL+Y).

GENERAL refers to generalized geomery.[8] A GENERAL card must be entered for each generalized geometry media The purpose of the GENERAL card is to set up a correspondence between each medium number and a mixture. The first GENERAL card should contain the KENO mixture number corresponding to medium 1 as defined in GEOM, the second should contain the KENO mixture number for medium 2, etc. The dimension specification portion of the GENERAL cards may be set to zero KENO IV automatically inserts the outer ZONE boundaries from the generalized geometry data for the dimensions of the last GENERAL card. Note that for a single-unit problem (NBOX = 0, parameter 11, card 2) a GENERAL card can be the last card entered However, for an array problem the last card must be a cube or cuboid whose dimensions are as large or larger than the zone dimensions of the generalized geometry region

Starting two or more spaces after the geometry word, the following data is entered, separated by one or more blanks. A new card may be started after any entry

MAT	Mixture number (enter a zero for a void)
XX(1)	Radius for sphere, cylinders, hemispheres, hemicylinders, +x dimension for cube, cuboid, or general region
XX(2)	-x dimension for cube, cuboid, or general region, +z for cylinder, +x for x cylinder, +y for y cylinder, + length for hemicylinder, omit XX(2) for a sphere or hemisphere
XX(3)	+y dimension for cuboid or general region, -z for cylinder, -x for x cylinder, -y for y cylinder, - length for hemicylinder, omit XX(3) for a sphere, hemisphere, or cube
XX(4)	-y dimension for cuboid or general region } omit for all other geometry types except CORE BDY
XX(5)	+z dimension for cuboid or general region } omit for all other geometry types except CORE BDY
XX(6)	-z dimension for cuboid or general region } omit for all other geometry types except CORE BDY

Weights

WTAVG	The weight which is given a neutron that survives Russian roulette. Enter a value for each energy group. Enter a weight of 0.5 or 0.0 for all regions within the core. If a value of 0.0 is entered it is defaulted to 0.5 within the code. Weights for some commonly used reflector materials are given in ORNL-TM-4660 (see ref. 4)

Repeat the card(s) 8-a, 8-b sequence until NBOX box types have been described. Boxes must be numbered sequentially starting with 1.

NOTE. The last geometry card for each box type must be a cube or cuboid

Card(s) 8-b1 Core Boundary Card (must be cuboid). *Enter only if there are additional regions external to the core.* This card is needed only if one or more of cards 8-b2 are used.

Starting in Col 1

CORE BDY (left adjusted)

MAT	Enter a mixture number (usually zero), *leave two or more blanks between CORE BDY and MAT*
XX(1)	+x dimension for a cuboid or cube
XX(2)	-x dimension for a cuboid or cube
XX(3)	+y dimension for a cuboid, zero for a cube
XX(4)	-y dimension for a cuboid, zero for a cube
XX(5)	+z dimension for a cuboid, zero for a cube
XX(6)	-z dimension for a cuboid, zero for a cube. *NOTE. These dimensions must fit tightly around the array*
WTAVG	Enter a value for each energy group even though they are not used

Card(s) 8-b2 Reflector Geometry Cards See card(s) 8-b
FGEOM
MAT
XX(1) XX(6)
Weights

Repeat the above card sequence until all reflector regions have been described

Card(s) 8-b3 Automatic Reflector Card (must be cuboid) This card can be entered in the place of a core boundary card (in which case it calculates the core boundary and fills in any remaining regions) or it may be entered at any point external to the core boundary card (it then just fills in any remaining cuboidal regions) *It must never be internal to any other geometry type Use only one Automatic Reflector card per problem NOTE All regions generated by the automatic reflector option must be counted in KREFM (card 2 parameter 10)*

Starting in Col 1

REFLECTOR	(left adjusted) Enter only if the automatic reflector option is to be exercised for putting an external reflector around an array
MAT	Enter the mixture number of the material comprising the reflector, *leave two or more blanks between REFLECTOR and MAT*
XX(1)	The reflector thickness in the +x direction (Non-negative numbers only)
XX(2)	The reflector thickness in the -x direction (Non-negative numbers only)
XX(3)	The reflector thickness in the +y direction (Non-negative numbers only)
XX(4)	The reflector thickness in the -y direction (Non-negative numbers only)
XX(5)	The reflector thickness in the +z direction (Non-negative numbers only)
XX(6)	The reflector thickness in the -z direction (Non-negative numbers only)
IDWT	The ID of the appropriate set of WTs to be read from library* If IDWT is less than 10, the weights will be read from cards (See card(s) 10) *NOTE Do NOT enter weights for the REFLECTOR card They are automatically provided through reading IDWT*

Card(s) 9 Mixed Box Orientation Cards *Enter only if NBOX > 1* (parameter 11, card 2)

The first field contains the box type, followed by three sets of three fields that are treated like FORTRAN DO loops, followed by a field that indicates whether another set of mixed box data is to be read The arrangement of boxes may be considered as consisting of a three-dimensional matrix of box type numbers, with the box position increasing in the positive X, Y and Z directions respectively Each set of mixed box orientation data consists of the following parameters separated by one or more blanks

*See Table III 3

LTYPE	The box type LTYPE must be greater than zero and less than or equal to NBOX (parameter 11, card 2)
IX1	The starting point in the X direction IX1 must be at least 1 and less than or equal to NBXMAX (parameter 12, card 2)
IX2	The ending point in the X direction IX2 must be at least 1 and less than or equal to NBXMAX
INCX	The number of boxes by which increments are made in the positive X direction INCX must be greater than zero and less than or equal to NBXMAX
IY1	The starting point in the Y direction IY1 must be at least 1 and less than or equal to NBYMAX (parameter 13, card 2)
IY2	The ending point in the Y direction IY2 must be at least 1 and less than or equal to NBYMAX
INCY	The number of boxes by which increments are made in the positive Y direction INCY must be greater than zero and less than or equal to NBYMAX
IZ1	The starting point in the Z direction IZ1 must be at least 1 and less than or equal to NBZMAX (parameter 14, card 2)
IZ2	The ending point in the Z direction IZ2 must be at least 1 and less than or equal to NBZMAX
INCZ	The number of boxes by which increments are made in the positive Z direction INCZ must be greater than zero and less than or equal to NBZMAX
ISTP	Indicates whether to read another set of mixed box orientation data = 0, read another set of data, ≠ 0, do not read any more mixed box orientation data

An important feature of this type of data description is that if any portion of an array is defined in a conflicting manner, the last card to define that portion will be the one that determines the array's box type configuration To utilize this feature, one can fill an entire array with the most prevalent box type and then superimpose the other box types in their proper places to accurately describe the array *The last set of mixed box orientation data must have a nonzero entry in the last field*

Card(s) 10 Reflector Weights from Cards *Enter only if IDWT* (card 8-b3) is less than 10

WTTITL	Name of material being used for the reflector weights Enter in Cols 1-12
IDWTT	Weight ID number (usually the ID number that will be put on the library, but may be anything The code automatically sets it equal to the value of IDWT (card 8-b3))
ISUBST	Number of sets of weights associated with this IDWTT Usually one since you need read in only 1 set of weights
THICK	The thickness in cm of each weighting region or interval

NUMINC	The number of intervals in the set of weights (NUMINC*THICK = maximum thickness for which weights are given.)
NGPWT	The number of energy groups for this set of weights. It must be equal to NGP
WTAVG(I,J)	The weight average for each interval and energy group. I=1 to NUMINC and J=1 to NGPWT. There are NUMINC*NGPWT entries. *NOTE: If ISUBST is greater than 1, the data "THICK" through "WTAVG(I,J)" must be repeated ISUBST times.*

Card(s) 11 Generalized Geometry Description, if any, as described in Appendix II.

Card(s) 12 Albedo Deck. *Enter only if NXX = 2* (parameter 16, card 2)

NOTE. ALBEDO data must be *formatted*. It consists of the following data.
(1) ATITLE format (18A4) Title card for the albedo deck.
(2) (WTCOS(I),I=1,NANG) format (6E12.5). WTCOS is the product of the fractional solid angle and the cosine of the polar angle for each polar angle. NANG is the number of polar angles and for the existing KENO Albedos is 4.
(3) (PLIM(I),I=1,NANG) format (6E12.5). PLIM is the cosines of the angular bounds for each of the polar angles.
(4) (CPOL(I),I=1,NANG) format (6E12.5). CPOL is the cosines of the polar angles.
(5) (SPOL(I),I=1,NANG) format (6E12.5). SPOL is the sines of the polar angles.
(6) ((((A(I,J,K,L),L=1,NANG),J=1,NGP),K=1,NANG),I=1,NGP) format (18A4). A(I,J,K,L) is the albedo data in hexidecimal form and represents the relative angular return tables for each input angle and energy.

Card(s) 13 Data for special start options. Input if NTYPST $\geqslant$ 2 (parameter 20, card 2)
(Entered in free form.)

if NTYPST = 2	(parameter 20, card 2) Enter the X, Y, and Z coordinates (in terms of boxes) of the box about which the starting distribution is given.
NBXS	The X index of the box.
NBYS	The Y index of the box.
NBZS	The Z index of the box.
FX	The fraction of neutrons to be started as spike in box (NBXS, NBYS, NBZS) of the array.
if NTYPST = 3	(parameter 20, card 2) Enter the X, Y, and Z indices (in terms of boxes) of the box where the neutrons will be started as a spike at the coordinates x, y, and z in that box.
NBXS	The X index of the box.
NBYS	The Y index of the box.
NBZS	The Z index of the box.
TFX	The x coordinate of the spike in box (X, Y, and Z).
TFY	The y coordinate of the spike in box (X, Y, and Z).
TFZ	The z coordinate of the spike in box (X, Y, and Z).

if NTYPST = 4	(parameter 20, card 2) Enter the box type in which the neutrons will be started at the point (x, y, and z)
NBOXST	The box type in which the neutrons will be started
TFX	The x coordinate of the point at which the neutrons will be started in box type NBOXST
TFY	The y coordinate of the point at which the neutrons will be started in box type NBOXST
TFZ	The z coordinate of the point at which the neutrons will be started in box type NBOXST
if NTYPST = 5	(parameter 20, card 2) Enter the box type in which the neutrons will be started
NBOXST	The box type in which the neutrons will be started
if NTYPST = 6	(parameter 20, card 2)
LFIN	The final neutron to be started at this point The first LFIN must be $\geqslant 1$ (The first neutron at this point is the one following the previous LFIN) Points are read until LFIN = NPB (parameter 3, card 2), the number of neutrons per batch
NBXS	The X index of the box
NBYS	The Y index of the box
NBZS	The Z index of the box
TFX	The x coordinate of the point
TFY	The y coordinate of the point
TFZ	The z coordinate of the point

For example, assume there are 50 neutrons in a generation, and you wish to start the first five neutrons in box (1, 1, 1) at x = 1 0, y = 0 0, z = 0 0, the next 25 neutrons in box (1, 2, 1) at x = 1 0, y = 0 0, z = 2 0, and the remaining neutrons in box (1, 2, 2) at x = 1 5, y = 1 5, z = 1 5 Then the input card could be entered as follows

5 1 1 1 1 0 0 0 0 0 30 1 2 1 1 0 0 0 2 0 50 1 2 2 1 5 1 5 1 5

Card(s) 14 Search Constants *Enter only if NSCH = 1, 2, or 3*

The physical significance of a search constant may best be described as a proportionality constant For a dimension search, the search constant (CONS) is proportional to the relative change in dimension $(XX_{new}\text{-}XX_{old})/XX_{old}$ divided by the change in k-effective $(k_{new}\text{-}k_{old})$ where XX_{old} is the dimension that yielded a k-effective of k_{old} and XX_{new} is the dimension that yielded a k-effective of k_{new} The search constant is positive if k-effective increases as the dimension increases and negative if k-effective decreases as the dimension increases

If NSCH = 1 or 3 (parameter 17, card 2) Enter one set for each geometry region, and in corresponding order There will be one entry on a card for a sphere or hemisphere, three entries for a cylinder, xcylinder, or ycylinder, and six entries for a cube, cuboid or general region

Each entry corresponds to a dimension and tells how that dimension will be altered A value of zero means that dimension will be unchanged

NOTE Zeros should ALWAYS *be entered for a general region because a search cannot be made for a general region*

CONS(1) Search constant for the radius of a sphere, hemisphere, cylinder, xcylinder, ycylinder, hemicylinder, +x dimension of cube or cuboid

CONS(2) Search constant for +z of cylinder, +x of xcylinder, +y of ycylinder, +x of xhemicylinder, +y of yhemicylinder, +z of zhemicylinder, -x dimension of cube or cuboid

CONS(3) Search constant for -z of cylinder, -x of xcylinder, -y of ycylinder, -x of xhemicylinder, -y of yhemicylinder, -z of zhemicylinder, +y dimension of cube or cuboid

CONS(4) Search constant for -y dimension of cube or cuboid

CONS(5) Search constant for +z dimension of cube or cuboid

CONS(6) Search constant for -z dimension of cube or cuboid

NOTE If NSCH = 1 or 3 and the problem contains a reflector that is to maintain its thickness even if the unit spacing changes, simply enter zeros for all six search constant for each of the core boundary and reflector regions The code will automatically calculate the new core boundary and maintain proper reflector thickness and weightings

if NSCH = 2 (parameter 17, card 2) Enter only one set There will be three entries, one for each coordinate direction of the array The number of units in a given direction will be changed by an integer multiple of the search constant specified For any array search, the search constant for a given direction represents the minimum number of units by which the array size can be changed in that direction The change in the number of units in each direction maintains the proportionality of the search constants stated for those directions The search constant is positive if k-effective increases as the array size increases and negative if k-effective decreases as the array size increases

CONS(1) Search constant for changing the number of units in the X direction

CONS(2) Search constant for changing the number of units in the Y direction

CONS(3) Search constant for changing the number of units in the Z direction

Card 15 END CASE This card is optional It enables KENO to read to the end of a case that contains an error and to start on a new case

Card 16 END KENO This card is optional and comes after the last card of the last case No more data will be read after this card has been encountered

4. Determination of KENO Core Requirements

KREFM	= number of geometry regions (parameter 10 of card 2)
MATT	= number of mixtures (parameter 8 of card 2)
NALB	= number of albedos to be read (see card 4)
NBXMA	= maximum allowed units in x direction for an array search (parameter 4 of card 3)
NBYMA	= maximum allowed units in y direction for an array search (parameter 5 of card 3)
NBZMA	= maximum allowed units in z direction for an array search (parameter 6 of card 3)
NBXMAX	= number of units in X direction of the array (parameter 12 of card 2)
NBYMAX	= number of units in Y direction of the array (parameter 13 of card 2)
NBZMAX	= number of units in Z direction of the array (parameter 14 of card 2)
NDS	= number of downscatters or energy transfers (parameter 6 of card 2)
NDS1	= number of downscatters or energy transfers for the input cross sections (NDS1 is read from the input cross-section library)
NFDEN	= 1 if no fission densities = 0 if fission densities (parameter 22 of card 2)
NFLUX	= 1 if no flux = 0 if flux (parameter 21 of card 2)
NGP	= number of energy groups (parameter 5 of card 2)
NPSGG	= position of σ_{gg} in ANISN format cross sections (parameter 28 of card 2)
NSCH	= 0 no search = 1 dimension search = 2 array search = 3 coarse-fine search (parameter 17 of card 2)
NUMBR	= the number of iterations for NSCH = 1 or 2; or the number of coarse iterations for NSCH = 3 (parameter 3, card 3)
NUMBRF	= the number of fine iterations for NSCH = 3; otherwise, NUMBRF = 0 (parameter 5a, card 3)
NUMDIM	= NUMBR + NUMBRF
NXX	= 0 no albedo reflector = 1 spectral reflector = 2 albedo reflector (parameter 16 of card 2)

MATDIM = NBXMAX*NBYMAX*NBZMAX

NS = 1, if matrix k by unit
= 0, if not
NB = 1, if matrix k by box
= 0, if not
IAT = 1, if ANISN or AMPX cross sections input
= 0, if not
NFDENT = 1 - NFDEN
NFLXD = 1 - NFLUX
NSCHD = MINO (1,NSCH)
NGGM = Words of generalized geometry storage

A = NGP + MATT*NGP*(5 + NDS*2)

B = (34 + 20*NGP**2)*NALB if NXX = 2 or 3

= 0 if NXX ⩽ 0

C = [(MATDIM + 1)/2] if NBOX > 1

= 0 if NBOX ⩽ 1

D = KREFM*(11 + 3*NGP) + 2*NBOX + NBXMA + NBYMA + NBZMA
+ NSCHD*6*KREFM*(NUMDIM + 1) + 250 + (15*NGP) + NGP*(4*KREFM + 3)
+ 3*KREFM*(NFDENT + NFLXD*NGP)
+ NS*2*MATDIM*(MATDIM + 1) + NB*NBOX*(NBOX + 1) + [whichever is larger, (NS*MATDIM) or (NB*NBOX)]
+ 3*NBA + NGGM

E = NGP*(6 + 2*NDS1 + IAT*(NPSGG - 1 + NDS1)) + 3*NMIX + 20

SIZE = A + B + [whichever is larger, (C + D) or E] words of storage

REGION = ([SIZE/256] + 134)K bytes

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APPENDIX I ANISN Cross-Section Input

ANISN[7,] expects a table of cross sections for each group, g, of each material in the following format

Table I 1 ANISN cross section format

Position	Cross Section Type	
1	activity	
	activity	
.		
	activity	
NPST-2	absorption	
NPST-1	nu fission	
NPST	total	
NPST+1	$\sigma_{g+NUS\to g}$	upscatter[5]
NPSGG−1	$\sigma_{g+1\to g}$	
NPSGG	$\sigma_{g\to g}$	
NPSGG+1	$\sigma_{g-1\to g}$	downscatter[5]
IHM	$\sigma_{g-NDS\to g}$	

[5]NUS is the NPSGG NPST
NDS is the number of groups of downscatter
NPST is the position of σ_{Total}
NPSGG is the position of $\sigma_{g\to g}$
IHM is NPSGG + NDS 1

Thus the parameters NPST, NPSGG, and IHM completely describe the format of the cross sections If there are no activity cross sections, NPST = 3 If there is no upscatter NPSGG = NPST + 1 If there is no downscatter, IHM = NPSGG (i e , a one-group problem) If there is upscatter, ANISN will compute a total upscatter cross section for each group of each material and place that cross section in position IHM + 1 The activity cross sections are ignored by KENO

The P_L cross-section tables must correspond in format to the P tables even though the transfer coefficients are the only numbers used Note that the P_L cross sections must contain a (2L + 1) term Some previous S_r codes supplied this term internally (e g , DTF-II multiplied the P_1 cross sections by 3 0)

APPENDIX II Generalized Geometry Input

If a GENERAL card is present in the input, then generalized GEOM data must be entered The following GEOM input description is essentially the same as that found in ORNL-3622

The outstanding feature of GEOM is its ability to describe multiple media bounded by essentially arbitrary shapes As many as 33 distinct media may be included, while the permissible boundaries may be of any shape which can be described by quadric surfaces used singly or in combination

The initial step in the geometric description of a system for GEOM is to enclose the entire system in a cuboid whose faces are parallel with the xy, yx, and xz coordinate planes This cuboid is then divided into several smaller cuboids, called zones, by planes parallel to the coordinate planes and extending entirely across the system

The zones, in turn, are then divided into smaller cuboids, called blocks, by planes again parallel to the coordinate axes but extending only across individual zones The planes used as zone and block boundaries need not necessarily be boundaries between media, however, if a boundary between two media is a plane parallel to a coordinate plane, it is advantageous to make it a block or zone boundary The use of the zone-block scheme allows complicated parts of the system under study to be divided into smaller blocks than may be needed for simpler regions If the whole system is relatively simple or requires a similar description throughout, the system should be composed of one zone divided into many blocks rather than many zones of one block each

Boundaries between media which are not also block boundaries may be any quadric surface A quadric surface is defined by the zeros of a quadratic function, and divides all space into two regions In one region, the function defining the surface will be positive, in the other it will be negative Each block may contain a maximum of 32 such surfaces as medium boundaries The surfaces will divide the block into sectors A sector is defined as a volume positive to one set of quadric surfaces but negative to another set Each sector must contain only one medium which may be the same as the medium in another sector Spatial volumes containing a single medium which cannot be described by a single sector definition must be divided into two or more sectors It is not necessary to mention every surface in the block in defining a sector It is, in fact, more efficient to include in a sector definition only those surfaces which actually form the boundary of the sector In addition sectors containing the same medium may overlap without error

Care must be taken in the use of cones as quadric surfaces, since the quadratic equation describes a surface of two nappes If, as is usual, the described surface is but one nappe of the cone, a block boundary through the vertex must be used to cut off the surface

Input to GEOM (All alphabetic input must be left-adjusted)

Card A Format (I5)

a An index which is not used in KENO but must be specified as a 2

Card B Format [A11,5(E10 5,A1)]

This card lists the zone boundaries in increasing order along the X axis, including the boundaries of the parallelepiped enclosing the entire system Since the number of boundaries depends upon the problem, commas in the A1 fields separating the boundaries are used to indicate that the list continues, while the absence of a comma following the last boundary indicates that the list has ended The A11 field is for the programmer's convenience and will be ignored by the code

Card(s) B′ Format [6(E10.5,A1)]

If the number of boundaries exceeds the five allowed by the format of card B, the list is continued on as many cards B′ as are required

Card C Format [A11,5(E10.5,A1)]

Identical with card B except that the listing is of the zone boundaries in order along the Y axis

Card C′. Format [6(E10.5,A11)]

Identical with card B′ but continues the Y axis zone boundaries

Card D Format [A11,5(E10.5,A1)]

Identical with card B except that the listing is of the zone boundaries in order along the Z axis

Card D′ Format [6(E10.5,A1)]

Identical with card B′ but continues the Z axis zone boundaries

Cards E through P Constitute a complete zone description This set of cards must be included once for each zone

a *l* m n

Card E. Format (A6,I5,I5,I5)

a The word ZONE.

l,m,n Each zone is located in the system by three integers *l*, m, and n. These specify the zone as being the *l*th in the X direction, the mth in the Y direction, and the nth in the Z direction The integers *l*, m, and n run from 1 to the maximum number of zones in each direction

Card F: Format [A11,5(E10.5,A1)]

This card lists the block boundaries in this zone in increasing order along the X axis, including the boundaries of the zone

Card(s) F′. Format [6(E10.5,A1)]

This is a block list continuation card similar to card B′ of the zone listing

Cards G,G′

The same as cards F and F′ except that the block boundaries along the Y axis are listed.

Cards H,H′.

The same as cards F and F′ except that the block boundaries along the Z axis are listed

Cards J through P· Constitute a complete block description. This set of cards must be included once for each block in the zone.

a *l* m n

Card J. Format (A6,I5,I5,I5)

a. The word BLOCK.

l,m,n: Each block is located in the zone by three integers. *l*, m, and n These specify the block as being the *l*th in the X direction, the mth in the Y direction, and the nth in the Z direction, within the given zone. The integers *l*, m, and n run from 1 to the maximum number of blocks in each direction

a b

Card K Format [A12,10(I5,A1)]

a The word MEDIA

b A list of the media, sector by sector, in the block As with other lists, a comma in the A1 field indicates that the list continues; its termination is indicated by the absence of the comma A media number of 1000 signifies an internal void, while a media number of 0 signifies an external void

Card(s) K′ Format [12(I5,A1)]

The continuation, if required, of the medium list

a b

Card L Format [A12,10(I5,A1)]

a. The word SURFACES.

b A list of the quadric surfaces appearing in the block Commas in the A1 field indicate that the list continues, a blank indicates the end of the list The numbers appearing in this list derive from the order in which the surfaces are mathematically described on card R, which will be described later in the input

Card L′ Format [8(I5,A1)]

The continuation, if needed, of the list begun on card L

a b

Card M Format (A6,18I3)

a The word SECTOR

b The designation of each sector with reference to its position relative to the quadric surfaces. For every sector in the block there must be a card M, which will have as many references as there are surfaces in the block. The status of the sector is listed according to the following key

+1 The sector is on the positive side of the surface

−1 The sector is on the negative side of the surface.

0 The surface is not needed in the definition of the sector The order in which each reference to a quadric surface appears on each card M must correspond to the order in which the quadric surfaces are listed on card L

If there is only one sector in a block, cards L and M should be omitted

a
Card Q Format (I5,11A6)

a The total number of quadric surfaces in *the entire system* The alphabetic data in the A6 fields is ignored by the code

a b c
Card R Format [4(E10 5,A5,A1)]

Each quadric surface is described by writing the quadratic function whose zeros define the surface, in a fixed field format resembling the normal manner of writing functions Each term in the function is specified by

a The coefficient of the term

b May be XSQ, YSQ, ZSQ (used for x , y , and z),
XZ, YX, YZ, XY, ZX, YZ, X, Y, Z, or blank

c A nonblank character in this field indicates the end of the function The next function must start on a new card

APPENDIX III Standard KFNO Libraries

Table III-1 Differential albedo ID's for differential albedo option

12 in water	Differential albedo, 4 incident angles	DP_0 (30 48 cm)	1112
12 in water	Differential albedo, 4 incident angles	(30 48 cm)	1012
12 in paraffin	Differential albedo, 4 incident angles	(30 48 cm)	2012
78 74 in carbon	Differential albedo, 4 incident angles	(200 00 cm)	3080
12 in polyethylene	Differential albedo, 4 incident angles	(30 48 cm)	4012
4 in concrete	Differential albedo, 4 incident angles	(10 16 cm)	5004
8 in concrete	Differential albedo, 4 incident angles	(20 32 cm)	5008
12 in concrete	Differential albedo, 4 incident angles	(30 48 cm)	5012
16 in concrete	Differential albedo, 4 incident angles	(40 64 cm)	5016
24 in concrete	Differential albedo, 4 incident angles	(60 96 cm)	5024

Table III 2 Weighting ID's for automatic reflector option

Refl Matl	ID	Groups	Thickness	Increments
Concrete	301	16	5 cm	20
		123	5 cm	20
Paraffin	400	16	3 cm	10
		123	5 cm	10
Water	500	16	3 cm	10
		123	3 cm	10
Graphite	6100	16	20 cm	6
		123	20 cm	6

The following mixtures are premixed on the KENO 16 group cross-section library They are materials that are frequently used in KENO calculations at Oak Ridge National Laboratory It is recommended that, rather than using the premixed concrete and vermiculite on this data set, their number densities be recalculated by the user because the composition of these materials varies widely, depending upon the geographical location and the application for which they are intended

Table III 3 Mixtures on KENO xsec tape

Mixture	Density	Number Density (atoms/barn-cm)	ID Number
Carbon Steel	7 82 g/cc	C= 003921,Fe= 083491	00100
304 Stainless Steel	7 9 g/cc	C=3 1691-4,Cr=1 6471-2, Mn=1 7321-3,Fe=6 036 2, Ni=6 4834-3,Si=1 694-3	00200
Oak Ridge Concrete	2 3 g/cc	H= 0085,C= 0202, O= 0355,Ca= 0111, Si= 0017,Mg= 00186, Fe=1 93-4,Al=5 56-4, K=4 03,Na=1 63 5	00300
Ordinary Concrete	2 37 g/cc	H= 014868,C= 003814, O= 041519,Ca= 011588, Si= 006037,Mg= 000587, Fe= 0001968,Al= 000735, Na= 000304	00301
Magnuson Concrete	2 15 g/cc	H= 004240,C= 011300 O= 040200,Ca= 007270, Si= 001930,Mg= 004990, Fe= 000129,Al= 000375, K= 00311,Na= 000079, S= 000100,Cl= 000019, Ti= 000040,Zn= 000089, Mn= 000012	00302
x(L) Polyethylene	0 92 g/cc	H= 079433,C= 039716	00401
dE/E Polyethylene	0 92 g/cc	H= 079433,C= 039716	00402
x(E) Polyethylene	9982 g/cc	H= 066743,O= 033372	00501
dE/E Water	9982 g/cc	H= 066743,O= 033372	00502
x(E) Plexiglas	1 182 g/cc	H= 056884,C= 035552, O= 014221	00601
dE/E Plexiglas	1 182 g/cc	H= 056884,C= 035552, O= 014221	00602
Magnuson Vermiculite		H=5 86-3,C=2 67-3 N=1 77-3,O=6 23-3 Al=2 5-4,Ca=2 0-5 Cl=5 8 6,Si=5 8-4 Mg=4 0-4,Fe=7 9-5 K=5 5-5,Cr=3 1-6 Mn=1 9-6,Ti=3 4-5	00701

Table III-4 KENO 16 group cross-section library

Mixture Title	ID
CARBON STEEL 7.82g/cc C= 003921, FE=.083491	100
TYPE 304 STAINLESS STEEL 7.9g/cc CONTAINS C, CR, MN, FE, NI, SI	200
OAK RIDGE CONCRETE 2.3g/cc	300
ORDINARY CONCRETE 2.37g/cc	301
MAGNUSUN CONCRETE 2.15g/cc	302
x(E)POLYETHYLENE 0 92g/cc H=.079433,C= 039716	401
DE/E POLYETHYLENE 0.92g/cc H=.079433, C=.039716	402
x(E)WATER 0.9982g/cc H=.066742, O=.033371	501
DE/E WATER 0.9982g/cc H=.066742, O=.033371	502
x(E)PLEXIGLAS 1 182g/cc H=.056884, C=.035552, O= 014221	601
DE/E PLEXIGLAS 1 182g/cc H=.056884, C= 035552, O= 014221	602
MAGNUSON VERMICULITE	701

Element Title	Source	ID
HYDROGEN x(E)	Hansen Roach	1101
HYDROGEN DE/E	Hansen Roach	1102
DEUTERIUM x(E)	Hansen Roach	1201
LITHIUM-6	Hansen, Roach	3100
LITHIUM-7	Hansen Roach	3200
BERYLLIUM	Hansen Roach	4100
BORON	Hansen Roach	5100
CARBON	Hansen Roach	6100
NITROGEN	Hansen Roach	7100
OXYGEN	Hansen Roach	8100
FLUORINE	Hansen Roach	9100
SODIUM	Hansen Roach	11100
MAGNESIUM	XSDRN	12100
ALUMINUM	Hansen Roach	13100
SILICON	XSDRN	14100
SULFUR	XSDRN	16100
CHLORINE	Hansen Roach	17100
POTASSIUM	Hansen Roach	19100
CALCIUM	GAM-2	20100
TITANIUM	GAM-2	22100
VANADIUM	GAM-2	23100
CHROMIUM	AEROJET	24100
MAGNANESE	XSDRN	25100
IRON	Hansen Roach	26100
COBALT	Hansen Roach	27100
NICKEL	Hansen Roach	28100
COPPER	XSDRN	29100
ZINC	GAM-2	30100
ZIRCONIUM	Hansen Roach	40100
NIOBIUM	Hansen Roach	41100
MOLYBDENUM	Hansen Roach	42100
CADMIUM	GAM-2	48100
INDIUM	GAM-2	49100
CERIUM	Hansen Roach	58100
SAMARIUM	GAM-2	62100
EUROPIUM	GAM-2	63100
GADOLINIUM	GAM-2	64100
TANTALUM	Hansen Roach	73100
TUNGSTEN	GAM-2	74100
LEAD	XSDRN	82100
TH-232 SIG P = 50	Hansen Roach	90104
TH-232 SIG P = 1000	Hansen Roach	90108
TH-232 SIG P = 1250	Hansen Roach	90109
TH-232 SIG P = 1500	Hansen Roach	90110

Table III-4 (continued)

Element Title		Source	ID
TH-232	SIG P = 1750	Hansen Roach	90111
TH-232	SIG P = 2000	Hansen Roach	90112
TH-232	SIG P = 2500	Hansen Roach	90113
TH-232	SIG P = 3000	Hansen Roach	90114
TH-232	SIG P = 3500	Hansen Roach	90115
TH-232	INFINITE DILUTION	Hansen Roach	90200
TH-232	SIG P = 20	Hansen Roach	90202
TH-232	SIG P = 40	Hansen Roach	90204
TH-232	SIG P = 60	Hansen Roach	90206
TH-232	SIG P = 80	Hansen Roach	90208
TH-232	SIG P = 100	Hansen Roach	90210
TH-232	SIG P = 150	Hansen Roach	90212
TH-232	SIG P = 200	Hansen Roach	90214
TH-232	SIG P = 300	Hansen Roach	90216
TH-232	SIG P = 400	Hansen Roach	90218
TH-232	SIG P = 600	Hansen Roach	90220
TH-232	SIG P = 800	Hansen Roach	90222
TH-232	SIG P = 1000	Hansen Roach	90224
TH-232	SIG P = 1500	Hansen Roach	90226
TH-232	SIG P = 2000	Hansen Roach	90228
TH-232	SIG P = 3000	Hansen Roach	90230
TH-232	SIG P = 4000	Hansen Roach	90232
TH-232	SIG P = 6000	Hansen Roach	90234
TH-232	SIG P = 10K	Hansen Roach	90236
TH-232	SIG P = 20K	Hansen Roach	90238
U-233		Hansen Roach	92300
U-233-1	SIG P = 20	Hansen Roach	92301
U-233-2	SIG P = 40	Hansen Roach	92302
U-233-3	SIG P = 60	Hansen Roach	92303
U-233-4	SIG P = 100	Hansen Roach	92304
U-233-5	SIG P = 200	Hansen Roach	92305
U-233-6	SIG P = 400	Hansen Roach	92306
U-233-7	SIG P = 600	Hansen Roach	92307
U-233-8	SIG P = 1000	Hansen Roach	92308
U 233-9	SIG P = 2000	Hansen Roach	92309
U-233-10	SIG P = 4000	Hansen Roach	92310
U-233-11	SIG P = 6000	Hansen Roach	92311
U-233-12	SIG P = 10000	Hansen Roach	92312
U-234		Mihalczo Mod of H-R U-238	92400
U-235 YR		Hansen Roach	92500
U-235-1R	SIG P = 20	Hansen Roach	92501
U-235-2R	SIG P = 40	Hansen Roach	92502
U-235-3R	SIG P = 60	Hansen Roach	92503
U-235-4R	SIG P = 100	Hansen Roach	92504
U-235-5R	SIG P = 200	Hansen Roach	92505
U-235-6R	SIG P = 400	Hansen Roach	92506
U-235-7R	SIG P = 600	Hansen Roach	92507
U-235-8R	SIG P = 1000	Hansen Roach	92508
U-235-9R	SIG P = 2000	Hansen Roach	92509
U-235-10R	SIG P = 4000	Hansen Roach	92510
U-235-11R	SIG P = 6000	Hansen Roach	92511
U-235-12R	SIG P = 10000	Hansen Roach	92512
U-236		Mihalczo Mod of H-R U-238	92600
U-238 Y		Hansen Roach	92800
U-238	SIG P = 12	Hansen Roach JRK Mod	92801
U-238	SIG P = 15	Hansen Roach JRK Mod	92802
U-238	SIG P = 20	Hansen Roach JRK Mod	92803
U-238	SIG P = 25	Hansen Roach JRK Mod	92804

Table III-4 (continued)

Element Title		Source	ID
U-238	SIG P = 30	Hansen Roach JRK Mod	92805
U-238	SIG P = 35	Hansen Roach JRK Mod	92806
U 238	SIG P = 40	Hansen Roach JRK Mod	92807
U-238	SIG P = 45	Hansen Roach JRK Mod	92808
U-238	SIG P = 50	Hansen Roach JRK Mod	92809
U-238	SIG P = 55	Hansen Roach JRK Mod	92810
U-238	SIG P = 60	Hansen Roach JRK Mod	92811
U-238	SIG P = 65	Hansen Roach JRK Mod	92812
U-238	SIG P = 70	Hansen Roach JRK Mod	92813
U-238	SIG P = 75	Hansen Roach JRK Mod	92814
U-238	SIG P = 80	Hansen Roach JRK Mod	92815
U-238	SIG P = 85	Hansen Roach JRK Mod	92816
U 238	SIG P = 90	Hansen Roach JRK Mod	92817
U-238	SIG P = 95	Hansen Roach JRK Mod	92818
U-238	SIG P = 100	Hansen Roach JRK Mod	92819
U-238	SIG P = 110	Hansen Roach JRK Mod	92820
U-238	SIG P = 120	Hansen Roach JRK Mod	92821
U-238	SIG P = 130	Hansen Roach JRK Mod	92822
U-238	SIG P = 140	Hansen Roach JRK Mod	92823
U-238	SIG P = 160	Hansen Roach JRK Mod	92824
U-238	SIG P = 180	Hansen Roach JRK Mod	92825
U-238	SIG P = 200	Hansen Roach JRK Mod	92826
U-238	SIG P = 220	Hansen Roach JRK Mod	92827
U 238	SIG P = 240	Hansen Roach JRK Mod	92828
U-238	SIG P = 260	Hansen Roach JRK Mod	92829
U-238	SIG P = 280	Hansen Roach JRK Mod	92830
U-238	SIG P = 300	Hansen Roach JRK Mod	92831
U-238	SIG P = 330	Hansen Roach JRK Mod	92832
U-238	SIG P = 360	Hansen Roach	92833
U-238	SIG P = 400	Hansen Roach	92834
U-238	SIG P = 450	Hansen Roach	92835
U-238	SIG P = 500	Hansen Roach	92836
U-238	SIG P = 550	Hansen Roach	92837
U-238	SIG P = 600	Hansen Roach	92838
U-238	SIG P = 650	Hansen Roach	92839
U-238	SIG P = 700	Hansen Roach	92840
U-238	SIG P = 800	Hansen Roach	92841
U-238	SIG P = 900	Hansen Roach	92842
U-238	SIG P = 1000	Hansen Roach	92843
U-238	SIG P = 1500	Hansen Roach	92844
U-238	SIG P = 2000	Hansen Roach	92845
U-238	SIG P = 3000	Hansen Roach	92846
U-238	SIG P = 4000	Hansen Roach	92847
U-238	SIG P = 5000	Hansen Roach	92848
U-238	SIG P = 6000	Hansen Roach	92849
U-238	SIG P = 8000	Hansen Roach	92850
U-238	SIG P = 10000	Hansen Roach	92851
U-238	SIG P = 20000	Hansen Roach	92852
U-238	SIG P = 40000	Hansen Roach	92853
U-238	SIG P = 60000	Hansen Roach	92854
U-238	SIG P = 100000	Hansen Roach	92855
U-238-1R	SIG P = 20	Hansen Roach	92856
U-238-2R	SIG P = 40	Hansen Roach	92857
U-238-3R	SIG P = 60	Hansen Roach	92858
U-238-4R	SIG P = 100	Hansen Roach	92859
U-238-5R	SIG P = 200	Hansen Roach	92860
U-238-6R	SIG P = 400	Hansen Roach	92861
U-238-7R	SIG P = 600	Hansen Roach	92862

Table III-4 (continued)

Element Title		Source	ID
PU-240		Hansen Roach	94000
PU-240-1	SIG P = 50	Hansen Roach	94001
PU-240-2	SIG P = 100	Hansen Roach	94002
PU-240-3	SIG P = 200	Hansen Roach	94003
PU-240-4	SIG P = 400	Hansen Roach	94004
PU-240-5	SIG P = 600	Hansen Roach	94005
PU-240-6	SIG P = 1000	Hansen Roach	94006
PU-240-7	SIG P = 2000	Hansen Roach	94007
PU-240-8	SIG P = 4000	Hansen Roach	94008
PU-240-9	SIG P - 6000	Hansen Roach	94009
PU-240-10	SIG P = 10000	Hansen Roach	94010
PU-240-11	SIG P = 20000	Hansen Roach	94011
PU-240-12	SIG P = 40000	Hansen Roach	94012
PU-240-13	SIG P = 60000	Hansen Roach	94013
PU-240-14	SIG P = 100000	Hansen Roach	94014
PU-240-15	SIG P = 200000	Hansen Roach	94015
PU-240-16	SIG P = 400000	Hansen Roach	94016
PU-240-17	SIG P = 600000	Hansen Roach	94017
PU-240-18	SIG P = 1000000	Hansen Roach	94018
PU-241		GAM-2	94100
PU-242		GAM-2	94200
PU-238		Hansen Roach	94800
PU-238-1	SIG P = 100	Persimmon	94801
PU-238-2	SIG P = 1000	Persimmon	94802
PU-238-3	SIG P = 10000	Persimmon	94803
PU-238 Y		Persimmon	94804
PU-239		Hansen Roach	94900
PU-239-1	SIG P = 20	Hansen Roach	94901
PU-239-2	SIG P = 40	Hansen Roach	94902
PU-239-3	SIG P = 60	Hansen Roach	94903
PU-239-4	SIG P = 100	Hansen Roach	94904
PU-239-5	SIG P = 200	Hansen Roach	94905
PU-239-6	SIG P = 400	Hansen Roach	94906
PU-239-7	SIG P = 600	Hansen Roach	94907
PU-239-8	SIG P = 1000	Hansen Roach	94908
PU-239-9	SIG P = 2000	Hansen Roach	94909
PU-239-10	SIG P = 4000	Hansen Roach	94910
PU-239-11	SIG P = 6000	Hansen Roach	94911
PU-239-12	SIG P = 10000	Hansen Roach	94912
PU-239-13	SIG P = 20000	Hansen Roach	94913
PU-239-14	SIG P = 40000	Hansen Roach	94914
PU-239-15	SIG P = 60000	Hansen Roach	94915
PU-239-16	SIG P = 100000	Hansen Roach	94916

APPENDIX IV Comments for KENO Users

1 Random Sequence

The random number package utilized in KENO IV always starts at the same place when a problem is run Therefore, if the same problem is run as the first problem, it will give identical results each time The random sequence can be changed by increasing or decreasing the number of neutrons per generation by at least one, or by changing a problem's position if stacked cases were run For example, if a problem is the third problem in a set of stacked problems, it will have a different random sequence than if it were the first or second problem in the stack

RNDOUT is an entry point in the random number package that loads the current random number in a double-precision argument as a right-adjusted, six-byte integer

RNDIN is an entry point in the random number package that uses its double-precision argument (a right-adjusted six byte integer) to set the current random number

RNDIN and RNDOUT are not utilized by KENO IV but are available to be used as desired

2 Matrix K-effective

Matrix k calculations in KENO IV provide an alternate method of estimating k-effective in addition to providing such information as cofactor k-effective, source vector, and fission probability matrix Subroutine MATK solves for the principal eigenvalue and eigenvector of a matrix by using an iterative technique If a matrix calculation has been specified, the necessary source and fission weight data is collected in subroutine BEGIN during the regular neutron tracking procedure Matrix information can be collected by box type, by array unit, or both The fission weights are summed in a fission weight matrix as they are generated Their location in the matrix is determined by the position where the neutron was born and the position where it caused a fission A source vector is generated by summing the weight, WT, when a fission neutron is born in an array unit At the end of each generation, the fission weight matrix by array unit is normalized by the source vector by array unit This normalized matrix, T(i,j) is called the "FISSION PROBABILITY MATRIX BY UNIT" and gives the probability that a neutron born in unit i will cause a fission in unit j The principal eigenvalue of this matrix is determined by subroutine MATK and is printed as the "MATRIX K-EFF" for each generation

The fission probability matrix information by box type is collected in the same manner but is not normalized by the source vector until the entire tracking procedure has been completed This normalized matrix STMAT(i,j) gives the probability that a neutron born in box type i will cause a fission in box type j

The information that can be obtained from a matrix calculation includes the following

1 The average value of the matrix k-effective by array unit This is the largest eigenvalue of the "FISSION PROBABILITY MATRIX BY UNIT" The result is printed in subroutine BEGIN for each generation

The remaining matrix information is printed in subroutine FINALE except the source vectors, which are printed in subroutine LABL

2 COFACTOR K-EFFECTIVE by unit This is the eigenvalue of the "FISSION PROBABILITY MATRIX BY UNIT", reduced by the row and column that references that unit The difference between the k-effective of the system and the cofactor k-effective of a unit is a

measure of the *in situ* k-effective of that unit or the contribution that unit makes to the k-effective of the system It should be noted that the cofactor k-effective of units composed entirely of nonfissionable material should be the same as the k-effective of the system The cofactor k-effectives printed for such units in KENO IV may not be identical to the k-effective of the system but may be different by some small amount due to roundoff

3 FISSION PROBABILITY MATRIX BY UNIT This square matrix is composed of the probability that a neutron born in unit i causes a fission in unit j The principal eigenvalue of this matrix is the k-effective of the system The print flag LIST makes it possible to avoid printing this matrix

4 SOURCE VECTOR BY UNIT This is the eigenvector of the "FISSION PROBABILITY MATRIX BY UNIT" The sum of the components of this vector should be near 1

5 AVERAGE UNIT SELF MULTIPLICATION This is the probability that a neutron born in a unit produces a fission in that same unit

6 BOX TYPE K-EFFECTIVE This is the largest eigenvalue of the "FISSION PROBABILITY MATRIX BY BOX TYPE" This calculation is done only once in the solution of a problem and then only if matrix k-effective by box type was specified in the parameters

7 FISSION PROBABILITY MATRIX BY BOX TYPE This is the matrix that is solved to determine the BOX TYPE K-EFFECTIVE It gives the probability that a neutron born in box type i causes a fission in box type j

8 SOURCE VECTOR BY BOX TYPE is the eigenvector of the "FISSION PROBABILITY MATRIX BY BOX TYPE" The components of this vector should sum to 1 000

9 COFACTOR K-EFFECTIVE BY BOX TYPE The cofactor k-effective for each box type is found by solving the FISSION PROBABILITY MATRIX by box type, striking out the row and column that pertain to that box type This gives an estimate of the k-effective of the array, neglecting the contribution of that box type The cofactor k-effective of box types without fissionable material is very near the k-effective by box type

3 Lifetime and Generation Time

In KENO IV the velocity data can be read in from cards or calculated from the energy and lethargy information stored on the cross-section library If velocities are expected from cards, the velocities must be entered in units of cm/sec If velocities are to be calculated from the energy and lethargy information on the library tape, the following relationships are used

$$V = \sqrt{\frac{2\overline{E}}{M}}$$

where

V is velocity in cm sec
$\overline{E}$ is the average energy in electron volts at the midpoint of the lethargy interval
M is the mass of a neutron in grams = 1 67 10 ^{4} g

There are 1 602 × 10 $^{-12}$ erg/ev or 1 602 × 10 $^{-12}$ g cm^2/sec^2/ev

therefore $\quad v = 1\ 3859 \times 10^6\sqrt{E}$

where $\quad \bar{E} = \sqrt{(E_{i+1})(E_i)}$

E_{i+1} and E_i are in units of ev and are the energies at the bounds of the group interval

Lifetime and generation time calculations utilize an elapsed time, TME, defined as distance traveled multiplied by 1/velocity This time is collected at boundary crossings and utilized whenever a collision occurs The generation time, TIMG, is defined as follows

$$\text{TIMG} = \frac{\sum\limits_{\text{NBA}} \left(\dfrac{\sum\limits_{\text{NPB}} \text{FISW*TME}}{\sum\limits_{\text{NPB}} \text{FISW}} \right)}{\text{FNBA}}$$

where

FISW is the fission weight,

TME is elapsed time as defined above,

FNBA = NBA = the number of generations that were run, and

NPB is the number of neutrons per generation

Thus generation time is the average time between successive neutron generations in the system The neutron lifetime, TIML, is defined as follows

$$\text{TIML} = \frac{\sum\limits_{\text{NBA}} \left(\dfrac{\sum\limits_{\text{NPB}} (\text{AB*TME} + \text{WT * TME})}{\text{FNPB}} \right)}{\text{FNBA}}$$

where

AB is the absorption weight,

WT is the weight associated with a neutron that leaks from the system,

TME is the elapsed time,

FNFB = NPB = number of neutrons per generation, and

FNBA = NBA = number of generations

Thus the lifetime is the average life span of a neutron in the system (i e , until it escapes from the system or is absorbed)

4 Albedo

The major advantage of using the albedo reflector option as opposed to actual tracking in the reflector is a significant decrease in the computing time For criticality calculations, it should be noted that for small arrays (small edge or face size), the result should tend to be conservative due to corner effects For large arrays (large edge or face size) the k-effective should agree better with actual tracking results as the face size of the array approaches an infinite slab

To generate a set of albedos for a given reflector material, the ANISN code is used to generate the angular flux for a source inserted at a given angle and energy This angular flux must be generated for all input polar angles and energy groups The presently used albedos use four polar angles, corresponding to a S_8 quadrature set in ANISN

Subroutine ALBIN integrates and normalizes the angular current to form the probability distribution tables Entry point ALBEDO utilizes these probability tables to determine from the input angle and energy of a neutron, its probability of return, and if the neutron is returned, its returning angle and energy

5 σ_p or Resonance Corrected Cross Sections for Homogeneous Systems

"σ_p" is a resonance correction that is made to compensate for the self-shielding of incident neutrons due to the nature of the material

A σ_p correction is generally used for resonance nuclides The σ_p correction is usually much more important for U-238 than for U-235 If a σ_p should have been used for U-238 but infinite dilution cross sections were used instead, the k-effective calculated by KENO may be too low

The σ_p of a resonance nuclide in a homogeneous system is calculated according to the following equation

$$\sigma_{p_D} = \frac{\sum_{i=1}^{M} \sigma_{scatt_i} N_i}{N_D}$$

where

σ_{scatt} is the scattering cross section in the resonance energy range for the *ith* component of the mixture,
ith component of the mixture,
N_i is **the number density** of the ith component of the mixture in atoms/barn-cm,
M is the number of components in the mixture, and
N_D is the number density of the isotope for which σ_{p_D} is being calculated

A table of approximate σ_{scatt} for several nuclides is given below

Table IV-1 Approximate scattering cross section for frequently used elements

Element	σ_{scatt}
Al	1 4
B	4 0
C	4 6
F	3 4
Fe	11 4
H	21 0
K	2 2
Mo	6 0
N	10 0
Na	3 1
O	3 7
Si	2 2
Th	12 0
All U	12 0
Cl	6 0
Pu	12 0
Cu	7 5
Li 7	1 0
Nb	6 3
Ni	17 5
Zr	6 2
Cr	4 3
M	6 5

APPENDIX V Interpretation of KENO IV Results

Results printed by KENO IV generation-by-generation as they are calculated, include GENERATION, K-EFFECTIVE, ELAPSED TIME (MIN), AVG K-EFF, DEVIATION, and MATRIX K-EFF The k-effective is calculated and printed for each generation The elapsed time is the amount of time spent in executing the program to the end of that generation The AVG K-EFF, AKBAR, is the running average of the k-effectives (note that it is set to 1 0 for the first two batches) The deviation is the deviation associated with the average k-effective If matrix k calculations by unit were specified, the result is printed under the heading MATRIX K-EFF This result is the principal eigenvalue of the "FISSION PROBABILITY MATRIX BY UNIT" and should tend to converge as more and more generations are run If matrix k calculations were not specified, zeros will be printed The printout associated with the matrix k options is described in the matrix k-effective section of TIPS FOR USING KENO

The individual k-effectives and the running average k-effectives are printed to provide information about how rapidly the code is running and how stable k-effective is When interpreting KENO IV results, it is suggested that the k-effective of the problem be determined from the page or pages where the lifetime and generation times are printed These k-effectives, printed under the heading AVERAGE K-EFFECTIVE is simply the average of the individual k-effectives when the k-effectives of the first N generations have been excluded from the averaging process N is printed under the heading NO OF INITIAL GENERATIONS SKIPPED The deviation from the mean is printed under the heading DEVIATION For convenience, the 67, 95, and 99% confidence intervals are printed for each average k-effective The NUMBER OF HISTORIES is the number of neutron histories that were utilized in determining the average k-effective It is worthwhile to verify that the average k-effectives do not drift significantly as more and more generations are skipped Naturally the last few average k-effectives should be excluded from this condition because so few histories are involved in averaging them If a drift in the average k-effectives is apparent, it could indicate a poorly converged source A more accurate representation of the source through a different starting distribution may correct the problem It is usually advisable to run at least 50 generations in order to be sure the problem has converged

The leakage, absorptions, and fissions are printed by energy group and may be further divided by geometry region The fissions by energy group give an indication of where the fission activity has occurred A well-moderated or thermal system should have a "soft spectrum" with most of the fissions occurring in the thermal energy groups A "fast" system should have most of the fissions occurring in the upper energy groups The sum of the total leakage and absorption should be very close to 1 0 if albedos are not utilized and severe weighting is not imposed The total fissions should be very nearly equal to the average k-effective for skipping NSKIP generations

The fission density, percent deviation and total fissions are printed for each region in the problem The summation of the total fissions over all geometry regions is equal to the total fissions (i e , the one printed with the leakages and absorptions), which in turn is the k-effective of the system The fission density for a given region is simply the total fissions for that region divided by the volume of that region and is in units of fissions per cubic centimeter

KENO IV calculates a volume averaged track length flux in units of neutrons per square centimeter per source neutron These fluxes are printed with their associated deviations for each geometry region and energy group

The frequency distributions are printed last These are plots of the frequency with which the individual generation k-effectives fall within a certain range in k-effective The range is scaled such that the plots do not exceed the width of a page One asterisk is printed for each k-effective that is calculated This does exclude the first NSKIP (number of generations to be skipped) generations for the first plot A total of four plots is made, (1) All generations, (2) the last three-quarters of the generations, (3) the last one-half of the generations and (4) the last one-fourth of the generations These plots can be used to estimate the normality of the distribution of the k-effectives and can sometimes show a trend indicative of source convergence difficulties

APPENDIX VI

1 Sample Problem Input

This appendix contains a set of 19 sample problems that demonstrate some of the options available in KENO IV Included for each sample problem is a brief problem description followed by the card input data necessary to execute the problem Selected printouts are included in Section 2 of this appendix

SAMPLE PROBLEM 1 2C8 BARE

This problem is a simple 2x2x2 array of uranium metal cylinders as described in the article, "Critical Three-Dimensional Arrays of U(93 2)-Metal Cylinders"[10], by J T Thomas This critical experiment is designated in Table II of that article as cylinder index 11 and reflector index 1

CARD INPUT

```
SAMPLE PROBLEM 1  CASE 2C8 BARE
0.5 103 300 3 16 6 4 1 4 2 1 3*2 4 2*0 2000 10*0
1 -92500 4.48006-2 1 92800 2.6578-3 1 92400 4.827-4 1 92600 9.57-5
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID  0 6.87 -6.87 6.87 -6.87 6.505 -6.505 16*0.5
```

SAMPLE PROBLEM 2 2C8 BARE WITH 8 BOX TYPES MATRIX CALCULATION

This problem is the same as sample problem 1 except it is set up as a mixed box problem with each unit of the array defined as a different box type Matrix k-effective will be calculated for this problem by both unit and box type The print flag is set to print all cross section data A cosine start is used

CARD INPUT

```
SAMPLE PROBLEM 2  CASE 2C8 BARE WITH 8 BOX TYPES MATRIX CALCULATION
.35 103 300 3 16 6 4 1 4 16 8 3*2 4 2*0 101 0 1 5*0 3 2*0
1 -92500 4.48006-2 1 92800 2.6578-3 1 92400 4.827-4 1 92600 9.57-5
BOX TYPE  1
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID  0 6.87 -6.87 6.87 -6.87 6.505 -6.505 16*0.5
BOX TYPE  2
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID  0 6.87 -6.87 6.87 -6.87 6.505 -6.505 16*0.5
BOX TYPE  3
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID  0 6.87 -6.87 6.87 -6.87 6.505 -6.505 16*0.5
BOX TYPE  4
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID  0 6.87 -6.87 6.87 -6.87 6.505 -6.505 16*0.5
BOX TYPE  5
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID  0 6.87 -6.87 6.87 -6.87 6.505 -6.505 16*0.5
```

```
BOX TYPE  6
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID  0 6.87 -6.87 6.87 -6.87 6.505 -6.505 16*0.5
BOX TYPE  7
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID  0 6.87 -6.87 6.87 -6.87 6.505 -6.505 16*0.5
BOX TYPE  8
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID  0 6.87 -6.87 6.87 -6.87 6.505 -6.505 16*0.5
10*1 0 3*2 7*1 0 3 1 1 1 2 2 1 1 1 1 0 4 2 2 1 2 2 1 1 1 1 0 5 6*1 2 2 1 0
6 2 2 1 1 1 1 2 2 1 0 7 1 1 1 2 2 1 2 2 1 0 8 2 2 1 2 2 1 2 2 1 1
```

SAMPLE PROBLEM 3 2C8 BARE MIXED BOX WITH 2 BOX TYPES (XSECS FROM PRIOR CASE)

Same as sample problem 2 except (1) use cross sections from case 2 (the preceding case), (2) set up as 2 box types with the bottom layer being box type 1 and the top layer being box type 2

CARD INPUT

```
SAMPLE PROBLEM 3  CASE 2C8 BARE WITH 2 BOX TYPES (XSECS FROM PRIOR CASE)
0.35 103 300 3 16 6 4 1 4 4 2 3*2 4 2*0 1000 1 6*0 3*0
BOX TYPE  1
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID  0 6.87 -6.87 6.87 -6.87 6.505 -6.505 16*0.5
BOX TYPE  2
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID  0 6.87 -6.87 6.87 -6.87 6.505 -6.505 16*0.5
1 1 2 1 1 2 1 1 1 1 0 2 1 2 1 1 2 1 2 2 1 1
```

SAMPLE PROBLEM 4 2C8 BARE, MIXED BOX, SEARCH, XSEC, GEOMETRY FROM PRIOR CASE

Use cross sections and geometry from problem 3 (preceding case) It will do a search on the radius of the cylinders, maintaining the initial height, until it is within 1 standard deviation of a k-effective of 0 975, or until three passes have been made Search constants of 1.0 were entered for the radius of the cylinders and search constants of 0.0 were entered for the cylinder height and the cuboid dimensions

CARD INPUT

```
SAMPLE PROB 4 2C8 BARE, MIXED BOX, SEARCH, XSEC & GEOMETRY FROM PRIOR CASE
.35 103 300 3 16 6 4 1 4 4 2 3*2 4 0 1 2000 11 6*0 3 2*0
0.975 1 3
1 1 2 1 1 2 1 1 1 1 0 2 1 2 1 1 2 1 2 2 1 1
1 8*0.0 1 8*0.0
```

SAMPLE PROBLEM 5 2C8 15.24 CM PARAFFIN REFL

A 2x2x2 array of uranium metal cylinders reflected by six inches of paraffin on all faces. This critical experiment[10] is designated as cylinder index 11 and reflector index 5 in Table II of reference 10

CARD INPUT

```
SAMPLE PROBLEM 5  2C8  15.24 CM PARAFFIN REFL
4.0 103 300 3 16 6 6 2 6 8 1 3*2 6 13*0
1 -92500 4.48006-2 1 92800 2.6578-3 1 92400 4.827-4 1 92600 9.57-5
2 1101 8.2581-2  2 6100 3.9702-2
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID  0 11.74 -11.74 11.74 -11.74 11.375 -11.375 16*0.5
CORE BDY        0 23.48  -23.48  23.48  -23.48  22.75  -22.75   16*0.5
CUBOID  2 26.48 -26.48 26.48 -26.48 25.75 -25.75
.596 .589 .583 .577 .594 .64 .671 .684 .687 .673 .648 .631 .768 .818 .824 .891
CUBOID  2 29.48 -29.48 29.48 -29.48 28.75 -28.75
.846 .873 .915 .972 1.14 1.44 1.63 1.75 1.84 1.88 1.89 1.95 2.65 2.97 3.05 3.52
CUBOID  2 32.48 -32.48 32.48 -32.48 31.75 -31.75
1.28 1.5 1.8 2.17 2.99 4.46 5.38 6.02 6.57 6.95 7.12 7.48 10.3 11.6 11.9 13.9
CUBOID  2 35.48 -35.48 35.48 -35.48 34.75 -34.75
2.08 2.87 4.17 5.8 9.42 16.1 20.2 23. 25.4 27.1 27.9 29.4 40.5 45.6 47. 54.6
CUBOID  2 38.72 -38.72 38.72 -38.72 37.99 -37.99
3.51 5.88 10.7 17.3 32.8 61.9 78.6 90.1 99.7 107. 110. 116. 159. 180. 185. 215.
```

SAMPLE PROBLEM 6 2C8 15.24 CM PARAFFIN REFL AUTOMATIC REFL

This problem is the same as sample problem 5 except it is set up using the automatic reflector option instead of describing the reflector manually. Computer output for this problem is included in Section 2 of this appendix

CARD INPUT

```
SAMPLF PROB 6  2C8  15.24 CM PARAFFIN REFL AUTOMATIC REFL
10. 103 300 3 16 6 6 2 6 8 1 3*2 6   13*0
1 -92500 4.48006-2 1 92800 2.6578-3 1 92400 4.827-4 1 92600 9.57-5
2 1101 8.2581-2  2 6100 3.9702-2
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID  0 11.74 -11.74 11.74 -11.74 11.375 -11.375 16*0.5
REFLECTOR       2 6*15.24   400
```

SAMPLE PROBLEM 7 2C8 12 INCH PARAFFIN ALBEDO REFLECTOR

This problem is the same as sample problems 5 and 6 except the reflector is represented by a 12-inch paraffin albedo Note the decrease in execution time when using albedo reflector instead of doing actual tracking Note also that k-effective is somewhat higher for this system, probably due to the small edge size of the system [11]

CARD INPUT

```
SAMPLE PROBLEM 7  2C8 12 INCH PARAFFIN ALBEDO REFLECTOR
0.5 103 300 3 16 6 4 1 4 2 1 3*2 4 2 12*0
6*2012
1 -92500 4.48006-2 1 92800 2.6578-3 1 92400 4.827-4 1 92600 9.57-5
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID  0 11.74 -11.74 11.74 -11.74 11.375 -11.375 16*0.5
```

SAMPLE PROBLEM 8 2C8 SPACING SEARCH

This problem is set up with an initial spacing of ±7 557 cm in the x and y directions and ±7 1555 cm in the z direction The search option is activated to search for a k-effective within two standard deviations of 1 000 The experimentally correct result[10] is ±6 87 cm in the x and y directions and ±6 505 cm in the z direction Computer printout for this problem is included in Section 2 of this appendix

CARD INPUT

```
SAMPLE PROBLEM    8  2C8 SPACING SEARCH
2.0  90 300 3 16 6 4 1 4 2 1 3*2 4 0 1 11*0
1.000 1 3
1 -92500 4.48006-2 1 92800 2.6578-3 1 92400 4.827-4 1 92600 9.57-5
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID  0 7.557 -7.557 7.557 -7.557 7.1555 -7.1555 16*0.5
3*0.0  6*-1.0
```

SAMPLE PROBLEM 9 2C8 REFLECTOR THICKNESS SEARCH

This problem is initially described with a 0 5 cm thick paraffin reflector A search will be made for the reflector thickness of paraffin that is necessary to make the system critical This occurs experimentally at a reflector thickness of 1 3 cm[10]

CARD INPUT

```
SAMPLE PROBLEM  9 2C8 REFLECTOR THICKNESS SEARCH
2.0  80 300 3 16 6 6 2 6 4 1 3*2 6 0 1 11*0
1.000 2 3
1 -92500 4.48006-2 1 92800 2.6578-3 1 92400 4.827-4 1 92600 9.57-5
2 1101 8.2581-2  2 6100 3.9702-2
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID  0 7.585 -7.585 7.585 -7.585 7.22 -7.22 16*0.5
CORE BDY  0 15.17 -15.17 15.17 -15.17 14.44 -14.44 16*0.5
CUBOID  2 15.67 -15.67 15.67 -15.67 14.94 -14.94 16*0.5
15*0.0  4*1.0  2*1.048862
```

SAMPLE PROBLEM 10 ONE 2C8 UNIT (SINGLE UNIT)

One of the 2C units is described and run as a single-unit problem (NBOX=0) and its k-effective is calculated

CARD INPUT

```
SAMPLE PROBLEM  10 ONE  2C8  UNIT  (SINGLE UNIT)
0.3 103 300 3 16 6 4 1 4 1 0 3*1 4 13*0
1 -92500 4.48006-2 1 92800 2.6578-3 1 92400 4.827-4 1 92600 9.57-5
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
```

SAMPLE PROBLEM 11 BARE 2C8 USING SPECULAR REFLECTION

One of the 2C8 units is described and the 2x2x2 array is simulated by using specular reflection on the positive x, y, and z faces of the unit This is a simulation of sample problem 1

CARD INPUT

```
SAMPLE PROBLEM  11 BARE 2C8 USING SPECULAR REFLECTION
0.3 103 300 3 16 6 4 1 4 2 1 3*1 4 1 12*0
-1.0 0.0 -1.0 0.0 -1.0 0.0
1 -92500 4.48006-2 1 92800 2.6578-3 1 92400 4.827-4 1 92600 9.57-5
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID  0 6.87 -6.87 6.87 -6.87 6.505 -6.505 16*0.5
```

SAMPLE PROBLEM 12 INFINITELY LONG CYLINDER FROM 2C8 UNIT

The fuel and cylinder radius from sample problem 1 is used The length of the cylinder is arbitrarily chosen to be 20 cm and the unit is specularly reflected on the top and bottom to create an infinitely long cylinder

CARD INPUT

```
SAMPLE PROBLEM  12 INFINITELY LONG CYLINDER FROM 2C8 UNIT
0.3 103 300 3 16 6 4 1 4 2 1 3*1 4 1 12*0
4*0.0 2*-1.0
1 -92500 4.48006-2 1 92800 2.6578-3 1 92400 4.827-4 1 92600 9.57-5
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID  0 6.87 -6.87 6.87 -6.87 6.505 -6.505 16*0.5
```

SAMPLE PROBLEM 13 INFINITE ARRAY OF 2C8 UNITS

The geometry description from sample problem 1 is used and the cuboid is specularly reflected on all faces to create an infinite array of units having an edge spacing of 2.244 cm in the x and y directions and 2.245 cm in the z direction.

CARD INPUT

```
SAMPLE PROBLEM  13 INFINITE ARRAY OF 2C8 UNITS
0.3 103 300 3 16 6 4 1 4 2 1 3*1 4 1 12*0
6*-1.0
1 -92500 4.48006-2 1 92800 2.6578-3 1 92400 4.827-4 1 92600 9.57-5
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID  0 6.87 -6.87 6.87 -6.87 6.505 -6.505 16*0.5
```

SAMPLE PROBLEM 14 93% UO_2F_2 SOLUTION SPHERE FORWARD CALCULATION

A single uranyl fluoride sphere is described as a single unit and run as a forward (regular k-effective) problem

CARD INPUT

```
SAMPLE PROB 14 93% UO2F2 SOLUTION SPHERE    FORWARD CALCULATION
2.5 103 300 3 16 6 5 1 5 1 0 3*1 5 13*0
1 -92500 3.206-4  1 92800 2.339-5  1 1102 6.5236-2  1 8100 3.3306-2
1 9100 6.879-4
SPHERE  1 16.0 16*0.5
```

SAMPLE PROBLEM 15 93% UO_2F_2 SOLUTION SPHERE ADJOINT CALCULATION

The uranyl fluoride sphere from sample problem 14 is described and run as an adjoint calculation Note that the forward and adjoint k-effectives should be the same within statistical error when a problem is run both ways

CARD INPUT

```
SAMPLE PROB 15 93% UO2F2 SOLUTION SPHERE    ADJOINT CALCULATION
2.5 103 300 3 16 6 5 1 5 1 0 3*1 5 7*0 1 5*0
1 -92500 3.206-4  1 92800 2.339-5  1 1102 6.5236-2  1 8100 3.3306-2
1 9100 6.879-4
SPHERE  1 16.0 16*0.5
```

SAMPLE PROBLEM 16 GENERALIZED GEOMETRY GROTESQUE

This is a generalized geometry description of a critical assembly[12,13] of eight enriched uranium units placed on a diaphragm, with an irregularly shaped centerpiece positioned in the center hole of the diaphragm. The assembly and centerpiece are shown in Figure 4. The eight units consist of an approximate parallelepiped with an irregular top, a parallelepiped, and six cylinders of assorted sizes. The centerpiece, which penetrated the hole in the support diaphragm consists of a cylinder topped by a parallelepiped topped by a hemisphere. The computer printout for this problem is included in Section 2 of this appendix.

CARD INPUT

```
SAMPLE PROB 16 GENERALIZED GEOMETRY GAOTESQUE
1.0 103 300 3 16 6 2 1 2 1 0 3*1 2  13*0
1 -92500 .0450792    1 92800 .0029695
GENERAL   1 6*0.0 16*0.5
   2       MALE
X BOUNDS       -23.319,     24.353
Y BOUNDS       -22.841,     21.686
Z BOUNDS        -1.755,      15.24
ZONE       1      1     1                                                                  5
X BLOCKS       -23.319,    -5.7569,     6.9433,     24.353
Y BLOCKS       -22.841,    -6.9433,     5.7569,     21.686
Z BLOCKS        -1.755,      15.24
BLOCK      1      1     1                                                                  9
MEDIA                1,  1000,  1000,  1000                                               10
SURFACES            26,     27,     28                                                    11
SECTOR -1 &1 -1                                                                           12
SECTOR  0  0 &1                                                                           13
SECTOR &1  0  0                                                                           14
SECTOR  0 -1  0                                                                           15
BLOCK      2      1     1                                                                 16
MEDIA                1,     1,     1, 1000,  1000,  1000,  1000,  1000,  1000,  1000     17
SURFACES            20,     21,     22,    23,    24,    25,    26,    27,    28          18
SECTOR -1 &1 -1  0  0  0  0  0  0                                                         19
SECTOR  0  0  0 -1 &1 -1  0  0  0                                                         20
SECTOR  0  0  0  0  0  0 -1 &1 -1                                                         21
SECTOR  0  0 &1  0  0 &1  0  0 &1                                                         22
SECTOR  0 -1  0  0  0 &1  0  0 &1                                                         23
SECTOR &1  0  0  0  0 &1  0  0 &1                                                         24
SECTOR  0  0 &1  0 -1  0  0  0 &1                                                         25
SECTOR  0  0 &1 &1  0  0  0  0 &1                                                         26
SECTOR  0  0 &1  0  0 &1  0 -1  0                                                         27
SECTOR  0  0 &1  0  0 &1 &1  0  0                                                         28
BLOCK      3      1     1                                                                 29
MEDIA                1,     1,  1000,  1000,  1000,  1000,  1000                          30
SURFACES            20,     21,     22,    23,    24,    25                               31
SECTOR -1 &1 -1  0  0  0                                                                  32
SECTOR  0  0  0 -1 &1 -1                                                                  33
SECTOR  0  0 &1  0  0 &1                                                                  34
SECTOR &1  0  0  0  0 &1                                                                  35
SECTOR  0 -1  0  0  0 &1                                                                  36
SECTOR  0  0 &1 &1  0  0                                                                  37
SECTOR  0  0 &1  0 -1  0                                                                  38
BLOCK      1      2     1                                                                 39
MEDIA                1,     1,     1, 1000,  1000,  1000,  1000,  1000,  1000             40
SURFACES             1,     2,     3,     4,    36,    37,    38,    39                   41
SECTOR  0  0 -1 &1 -1  0  0 &1                                                            42
SECTOR -1  0  0 &1  0 -1 &1  0                                                            43
SECTOR  0 -1  0 &1 -1  0 &1  0                                                            44
SECTOR &1  0  0  0  0  0  0  0                                                            45
SECTOR  0  0  0 -1  0  0  0  0                                                            46
SECTOR  0  0  0  0 &1  0  0  0                                                            47
```

```
SECTOR   0  0  0  0  0  0  0 -1                                                     48
SECTOR   0 &1  0  0  0 &1  0  0                                                     49
SECTOR   0  0 &1  0  0  0 -1  0                                                     50
BLOCK      1     3     1                                                            51
MEDIA              1, 1000, 1000, 1000                                              52
SURFACES           5,     6,     7                                                  53
SECTOR -1 &1 -1                                                                     54
SECTOR   0  0 &1                                                                    55
SECTOR &1  0  0                                                                     56
SECTOR   0 -1  0                                                                    57
BLOCK      2     3     1                                                            58
MEDIA              1,     1, 1000, 1000, 1000, 1000, 1000                           59
SURFACES           5,     6,     7,     8,     9,    10                             60
SECTOR -1 &1 -1  0  0  0                                                            61
SECTOR   0  0  0 -1 &1 -1                                                           62
SECTOR   0  0 &1  0  0 &1                                                           63
SECTOR &1  0  0  0  0 &1                                                            64
SECTOR   0 -1  0  0  0 &1                                                           65
SECTOR   0  0 &1 &1  0  0                                                           66
SECTOR   0  0 &1  0 -1  0                                                           67
BLOCK      3     3     1                                                            68
MEDIA              1,     1, 1000, 1000, 1000, 1000, 1000                           69
SURFACES           8,     9,    10,    11,    12,    13                             70
SECTOR -1 &1 -1  0  0  0                                                            71
SECTOR   0  0  0 -1 &1 -1                                                           72
SECTOR   0  0 &1  0  0 &1                                                           73
SECTOR &1  0  0  0  0 &1                                                            74
SECTOR   0 -1  0  0  0 &1                                                           75
SECTOR   0  0 &1 &1  0  0                                                           76
SECTOR   0  0 &1  0 -1  0                                                           77
BLOCK      3     2     1                                                            78
MEDIA              1,     1,     1,     1, 1000, 1000, 1000, 1000, 1000, 1000,      79
  1000, 1000, 1000, 1000, 1000                                                      80
SURFACES          11,    12,    13,    20,    21,    22,    34,    14,    35,    15, 81
    16,    17,    18,    19                                                         82
SECTOR -1 &1 -1  0  0  0  0  0  0  0  0  0  0  0                                    92
SECTOR   0  0  0 -1 &1 -1  0  0  0  0  0  0  0  0                                   93
SECTOR   0  0  0  0  0  0 -1 &1 -1  0  0  0  0  0                                   94
SECTOR   0  0  0  0  0  0  0 -1  0 &1 -1 &1 -1 &1                                   95
SECTOR   0  0 &1  0  0 &1 &1  0  0  0  0  0  0  0                                   96
SECTOR   0  0 &1  0  0 &1  0 &1 &1  0  0  0  0  0                                   97
SECTOR   0  0 &1  0  0 &1  0 -1  0  0 &1  0  0  0                                   98
SECTOR   0  0 &1  0  0 &1  0 -1  0  0  0 -1  0  0                                   99
SECTOR   0  0 &1  0  0 &1  0 -1  0  0  0  0 &1  0                                  100
SECTOR   0  0 &1  0  0 &1  0 -1  0  0  0  0  0 -1                                  101
SECTOR   0  0 &1  0  0 &1  0  0  0 -1  0  0  0  0                                  102
SECTOR &1  0 -1  0  0  0  0  0  0  0  0  0  0  0                                   103
SECTOR   0 -1 -1  0  0  0  0  0  0  0  0  0  0  0                                  104
SECTOR   0  0  0  0 -1 -1  0  0  0  0  0  0  0  0                                  105
SECTOR   0  0  0 &1  0 -1  0  0  0  0  0  0  0  0                                  106
BLOCK      2     2     1                                                            83
MEDIA           1000,     1,     1,     1, 1000, 1000                               84
SURFACES          31,    32,    33,    29,    30                                    85
SECTOR   0 -1 &1  0  0                                                              86
SECTOR -1 &1  0  0  0                                                               87
SECTOR   0  0 -1 &1  0                                                              88
SECTOR   0  0  0 -1 -1                                                              89
SECTOR &1  0 &1  0  0                                                               90
SECTOR   0  0  0 -1 &1                                                              91
    39 QUADRIC  SURFACES IN GEOMETRY                                               107
      .02356X         &.99972Z        -13.1339      $
      .02356X         &.99972Z        -12.8151      $
      .02356X         &.99972Z        -10.9048      $
      .02356X         &.99972Z         &.25011      $
  1.487E-02X      -1.938E-02Y      9.997E-01Z      -1.262E&01      $
  1.487E-02X      -1.938E-02Y      9.997E-01Z       3.557E-01      $
  9.998E-01XSQ     9.996E-01YSQ    5.963E-04ZSQ     5.766E-04XY
```

```
-2.974E-02XZ     3.876E-02YZ     1.772E&01X      -2.309E&01Y
-7.112E-01Z      1.911E&02      $
-3.424E-03X     -3.005E-02Y      9.995E-01Z      -1.299E&01     $
-3.424E-03X     -3.005E-02Y      9.995E-01Z       4.817E-01     $
 1.000E&00XSQ    9.991E-01YSQ    9.149E-04ZSQ    -2.058E-04XY
 6.845E-03XZ     6.008E-02YZ    -3.602E&00X      -3.162E&01Y
-9.629E-01Z      2.202E&02      $
-2.610E-02X     -2.229E-02Y      9.994E-01Z      -1.246E&01     $
-2.610E-02X     -2.229E-02Y      9.994E-01Z       5.056E-01     $
 9.993E-01XSQ    9.995E-01YSQ    1.173E-03ZSQ    -1.163E-03XY
 5.216E-02XZ     4.455E-02YZ    -2.233E&01X      -1.911E&01Y
-1.011E&00Z      1.960E&02      $
   -.04507X        &.99898Z        -8.3852     $
   -.04507X        &.99898Z         &.5252     $
    .99898X        &.04507Z        -24.34      $
    .99898X        &.04507Z        -11.64      $
       1.0Y        -3.2168      $
       1.0Y        &4.4032      $
-2.183E-02X      1.966E-02Y      9.996E-01Z      -1.252E&01     $
-2.183E-02X      1.966E-02Y      9.996E-01Z       4.557E-01     $
 9.995E-01XSQ    9.996E-01YSQ    8.629E-04ZSQ     8.582E-04XY
 4.364E-02XZ    -3.929E-02YZ    -2.304E&01X       2.074E&01Y
-9.110E-01Z      2.197E&02      $
-2.129E-03X      2.434E-02Y      9.997E-01Z      -1.306E&01     $
-2.129E-03X      2.434E-02Y      9.997E-01Z       4.176E-01     $
 1.000E&00XSQ    9.994E-01YSQ    5.963E-04ZSQ     1.037E-04XY
 4.258E-03XZ    -4.866E-02YZ    -2.977E&00X       3.403E&01Y
-8.349E-01Z      2.589E&02      $
 1.182E-02X      1.513E-02Y      9.998E-01Z      -1.266E&01     $
 1.182E-02X      1.513E-02Y      9.998E-01Z       2.966E-01     $
 9.999E-01XSQ    9.998E-01YSQ    3.685E-04ZSQ    -3.576E-04XY
-2.363E-02XZ    -3.025E-02YZ     1.902E&01X       2.434E&01Y
-5.932E-01Z      2.179E&02      $
       1.0Z         -.9374      $
       1.0XSQ        &1.0YSQ       -33.142     $
       1.0XSQ        &1.0YSQ          &1.0ZSQ      -1.7226X
    &.6502Y      -13.3122Z         &8.1601     $
       1.0XSQ        &1.0YSQ          &1.0ZSQ      -1.7226X
    &.6502Y      -13.3122Z        &45.0945     $
       1.0Z        -6.6562      $
-4.507E-02X      9.990E-01Z     -1.270E&01     $                              34
 9.980E-01XSQ    1.000E&00YSQ    2.032E-03ZSQ     9.005E-02XZ
-3.239E&01X      1.186E&00Y     -1.461E&00Z       2.422E&02     $
    .99972X       -.02356Z        &10.613      $
    .99972X       -.02356Z        &15.693      $
    .99972X       -.02356Z        &20.773      $
    .99972X       -.02356Z        &23.316      $
```

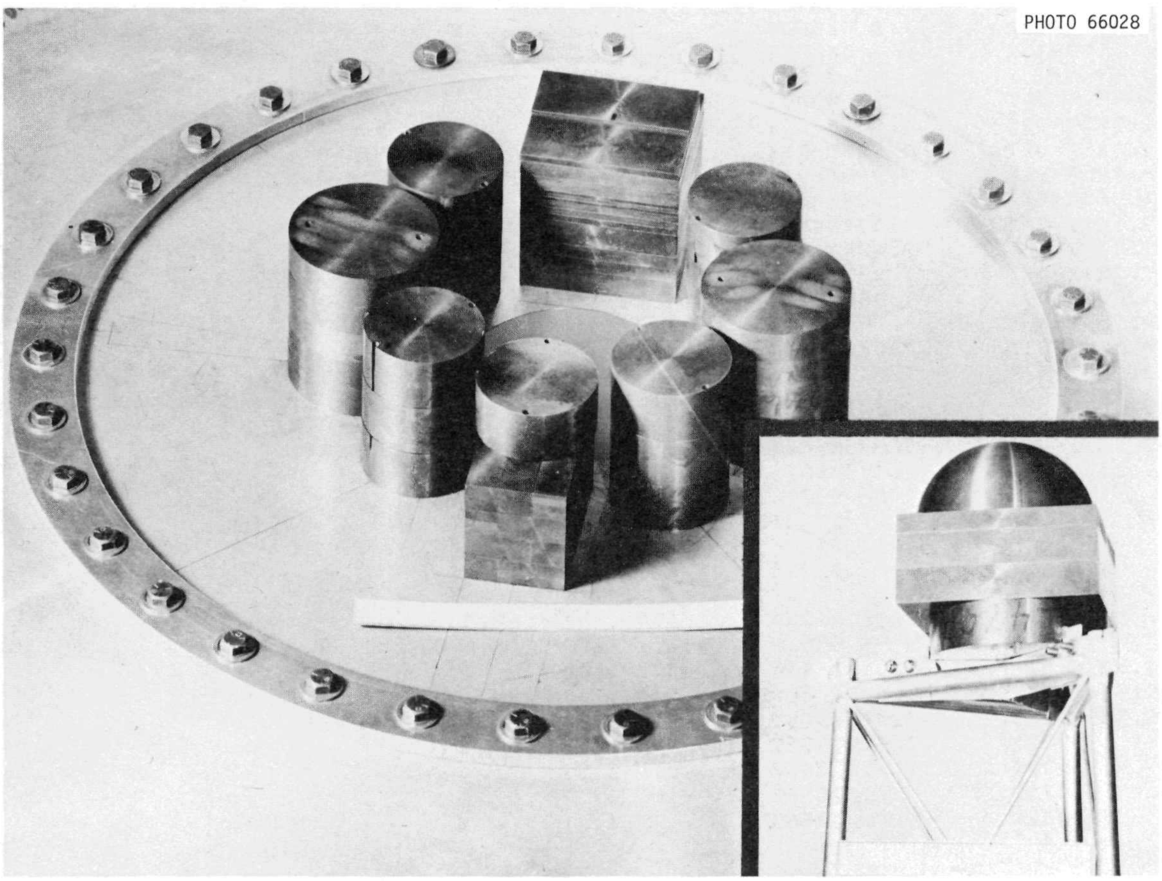

Figure 4.

SAMPLE PROBLEM 17 2C8 BARE WRITE RESTART

This problem is the same as sample problem 1, a 2x2x2 array of metal cylinders. Restart information is written out after the completion of every fifth generation The computer printout for this problem is included in Section 2 of this appendix

CARD INPUT

```
SAMPLE PROBLEM 17  CASE 2C8 BARE WRITE RESTART
0.5 103 300 3 16 6 4 1 4 2 1 3*2 4  2*0 2000 6*0 5 3*0
1 -92500 4.48006-2 1 92800 2.6578-3 1 92400 4.827-4 1 92600 9.57-5
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID   0 6.87 -6.87 6.87 -6.87 6.505 -6.505 16*0.5
```

SAMPLE PROBLEM 18 2C8 BARE READ RESTART DATA

This problem is a restart of sample problem 17 The problem is restarted from the tenth set of restart data that was written by sample problem 17 The computer printout for this problem is included in Section 2 of this appendix

CARD INPUT

```
SAMPLE PROBLEM 18  CASE 2C8 BARE  READ RESTART DATA
0.5 103 300 3 16 6 4 1 4 2 1 3*2 4 2*0 2000 0 -10  8*0
```

SAMPLE PROBLEM 19 4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

This problem is a critical experiment consisting of a composite array[10,14] of four highly enriched uranium metal cylinders and four cylindrical plexiglas containers filled with uranyl nitrate solution The metal units in this experiment are designated in Table II of ref 10 as cylinder index 11 and reflector index 1 This system is illustrated in Fig. 5. The computer printout for this problem is included in Section 2 of this appendix.

CARD INPUT

```
SAMPLE PROBLEM 19   4 AQUEOUS 4 METAL  MIXED BOX MATRIX CALCULATION
2.5 103 300 3 16 6 6 3 10 11 5 3*2 6  2*0 2110 7*0 3 2*0
1 92860 3.2275-3 1 -92501 4.4802-2 2 1102 5.81-2 2 7100 1.9753-3
 2 8100 3.6927-2 2 -92501 9.8471-4 2 92860 7.7697-5 3 6100 3.5552-2
3 1102 5.6884-2 3 8100 1.4221-2
BOX TYPE  1
CYLINDEP  2 9.525 8.89 -8.89 16*0.5
CYLINDER  3 10.16 9.525 -9.525 16*0.5
CUBOID    0 10.875 -10.875 10.875 -10.875 10.24 -10.24 16*0.5
BOX TYPE  2
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID    0 6.59 -15.16 6.59 -15.16 6.225 -14.255  16*0.5
BOX TYPE  3
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID    0 6.59 -15.16 15.16 -6.59 6.225 -14.255 16*0.5
BOX TYPE  4
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID    0 6.59 -15.16 6.59 -15.16 14.255 -6.225 16*0.5
BOX TYPE  5
CYLINDER  1 5.748 5.3825 -5.3825 16*0.5
CUBOID    0 6.59 -15.16 15.16 -6.59 14.255 -6.225 16*0.5
1 3R2 1 2 1 1 2 1 0 2 9R1 0  3 3R1 2 2 1 3R1 0  4 6R1 2 2 1 0
5 3R1 2 2 1 2 2 1 1
```

The metal units in this experiment are designated in Table II of reference 10 as cylinder index 11 and reflector index 1.

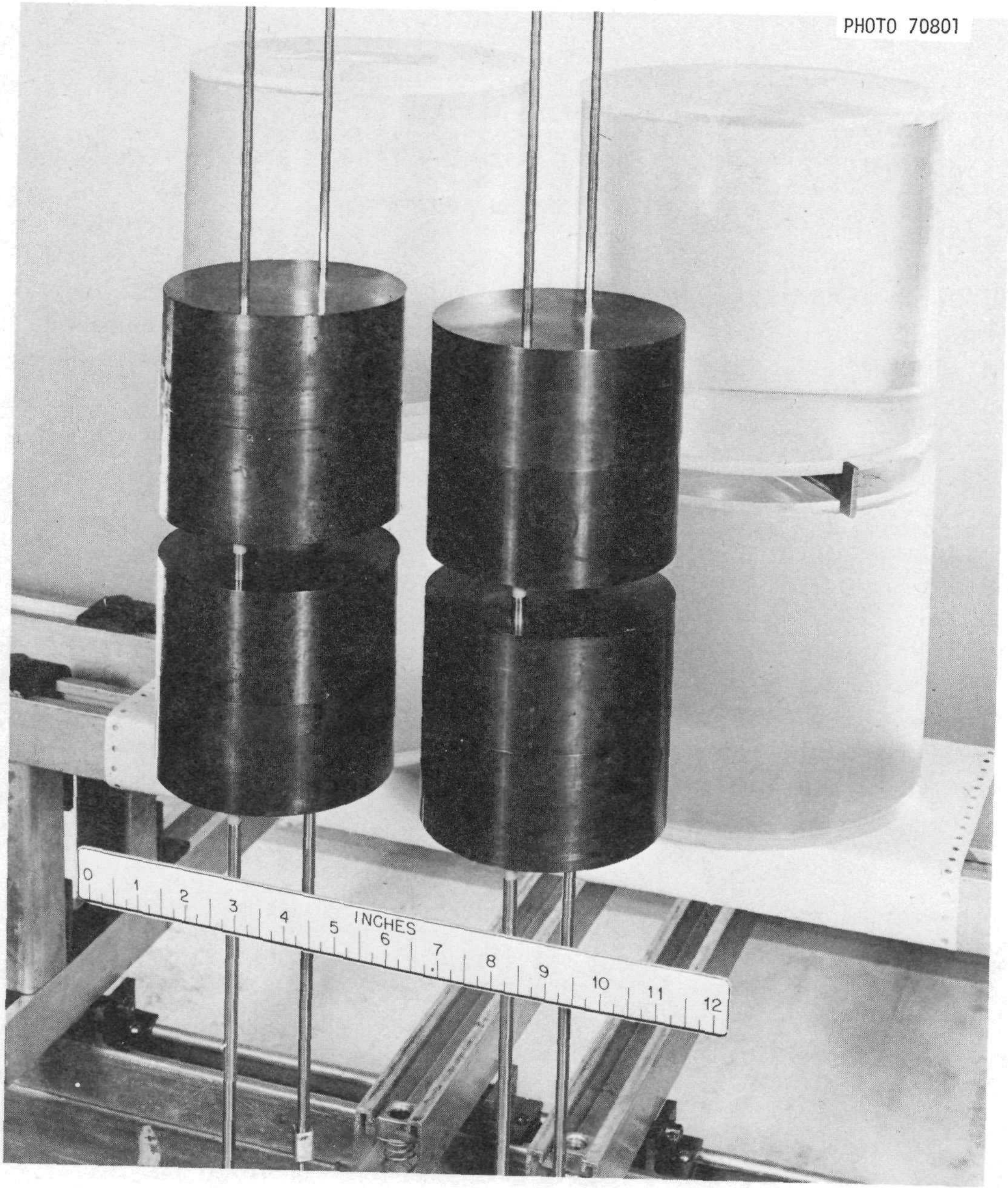

Figure 5.

2. Sample Problem Output

The computer printout for sample problems 6, 8, 16, 17, 18, and 19 are included in this section.

SAMPLE PROB 6 2C8 15.24 CM PARAFFIN REFL AUTOMATIC REFL

NUMBER OF GENERATIONS	103	START TYPE	0
NUMBER PER GENERATION	300	GENERATIONS BETWEEN CHECKPOINTS	0
NUMBER OF GENERATIONS TO BE SKIPPED	3	LIST INPUT X-SECTIONS READ FROM TAPE	NO
NUMBER OF ENERGY GROUPS	16	LIST 1-D MIXTURE X SECTIONS	YES
MAX. NUMBER OF ENERGY TRANSFERS	6	LIST 2-D MIXTURE X-SECTIONS	YES
NUMBER OF INPUT NUCLIDES	6	LIST FISS. AND ABS. BY REGION	NO
NUMBER OF MIXTURES	2	USE X-SECTIONS FROM PREVIOUS CASE	NO
NUMBER OF MIXING TABLE ENTRIES	6	USE GEOMETRY FROM PREVIOUS CASE	NO
NUMBER OF GEOMETRY CARDS	8	USE VELOCITIES FROM PREVIOUS CASE	NO
NUMBER OF BOX TYPES	1	COMPUTE MATRIX K-EFFECTIVE BY UNIT	NO
NUMBER OF UNITS IN X DIRECTION	2	COMPUTE MATRIX K-EFFECTIVE BY BOX TYPE	NO
NUMBER OF UNITS IN Y DIRECTION	2	LIST FISS PROB MATRIX BY UNIT	NO
NUMBER OF UNITS IN Z DIRECTION	2	ADJOINT CALCULATION	NO
NUMBER OF NUCLIDES READ FROM TAPE	6	USE EXPONENTIAL TRANSFORM	NO
ALBEDO TYPE	0	CALCULATE FLUX	YES
SEARCH TYPE	0	CALCULATE FISSION DENSITIES	YES

MAXIMUM TIME = 10.0000 MINUTES

STORAGE LOCATIONS REQUIRED FOR THIS JOB = 6834
REMAINING AVAILABLE LOCATIONS= 27982

SAMPLE PROB 6 2C8 15.24 CM PARAFFIN REFL AUTOMATIC REFL

MIXTURE	NUCLIDE	DENSITY
1	-92500	4.48006E-02
1	92800	2.65780E-03
1	92400	4.82700E-04
1	92600	9.57000E-05
2	1101	8.25810E-02
2	6100	3.97020E-02

CROSS SECTIONS READ FROM TAPE

NUCLIDE =	1101	HYDROGEN X(E)	HANSEN ROACH
NUCLIDE =	6100	CARBON	HANSEN ROACH
NUCLIDE =	92400	U-234	MIHALCZO MOD OF H-R U-238
NUCLIDE =	92500	U-235 YR	HANSEN ROACH
NUCLIDE =	92600	U-236	MIHALCZO MOD OF H-R U-238
NUCLIDE =	92800	U-238 Y	HANSEN ROACH

SAMPLE PROB 6 2C8 15.24 CM PARAFFIN REFL AUTOMATIC REFL

MIXTURE = 1

GP.	ABSORPTION PROBABILITY	NU*FISSION PROBABILITY	NON-ABSORPTION PROBABILITY	TOTAL CROSS-SECTION	FISSION SPECTRUM
1	2.88282E-01	8.16362E-01	7.11718E-01	2.03826E-01	2.04000E-01
2	2.79495E-01	6.86119E-01	7.20504E-01	2.16334E-01	5.48000E-01
3	2.71457E-01	6.27380E-01	7.28542E-01	2.23507E-01	7.16000E-01
4	2.45009E-01	5.38731E-01	7.54990E-01	2.50360E-01	8.96000E-01
5	1.96930E-01	4.14508E-01	8.03070E-01	3.80508E-01	9.86000E-01
6	2.39931E-01	4.61768E-01	7.60215E-01	5.94246E-01	1.00000E 00
7	3.44514E-01	6.38682E-01	6.55486E-01	7.21796E-01	1.00000E 00
8	5.06884E-01	8.72719E-01	4.93116E-01	9.93835E-01	1.00000E 00
9	7.21710E-01	1.18113E 00	2.78289E-01	1.73778E 00	1.00000E 00
10	8.52618E-01	1.28837E 00	1.47382E-01	3.23737E 00	1.00000E 00
11	8.86332E-01	1.14093E 00	1.13668E-01	4.19760E 00	1.00000E 00
12	8.84983E-01	8.92047E-01	1.15017E-01	4.14836E 00	1.00000E 00
13	7.85621E-01	1.47950E 00	2.14379E-01	2.22565E 00	1.00000E 00
14	8.82566E-01	1.89106E 00	1.17435E-01	4.06296E 00	1.00000E 00
15	9.54627E-01	1.93100E 00	4.53733E-02	1.05157E 01	1.00000E 00
16	9.82873E-01	2.03304E 00	1.71272E-02	2.78582E 01	1.00000E 00

CUMULATIVE TRANSFER PROBABILITIES

FROM I	TO I+ 0	I+ 1	I+ 2	I+ 3	I+ 4	I+ 5
1	3.9857E-01	4.8931E-01	6.1384E-01	8.3220E-01	9.7991E-01	1.0000E 00
2	5.4663E-01	6.2288E-01	8.3538E-01	9.7801E-01	1.0000E 00	1.0000E 00
3	6.9055E-01	8.5777E-01	9.7875E-01	1.0000E 00	1.0000E 00	1.0000E 00
4	8.8815E-01	9.7967E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
5	9.8742E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
6	9.9433E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
7	9.9486E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
8	9.9503E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
9	9.9503E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
10	9.9490E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
I = 11 THRU I= 14 SAME AS ABOVE						
15	9.9591E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
16	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00

MUBAR

FROM I	TO I+ 0	I+ 1	I+ 2	I+ 3	I+ 4	I+ 5
1	0.0	0.0	0.0	0.0	0.0	0.0
I = 2 THRU I= 16 SAME AS ABOVE						

SAMPLE PROB 6 2C8 15.24 CM PARAFFIN REFL AUTOMATIC REFL

MIXTURE = 2

GP.	ABSORPTION PROBABILITY	NU*FISSION PROBABILITY	NON-ABSORPTION PROBABILITY	TOTAL CROSS-SECTION	FISSION SPECTRUM
1	0.0	0.0	1.00000E 00	1.67254E-01	0.0
2	0.0	0.0	9.99999E-01	2.33100E-01	0.0
3	0.0	0.0	9.99999E-01	3.68355E-01	0.0
4	0.0	0.0	1.00000E 00	4.55157E-01	0.0
5	0.0	0.0	1.00000E 00	6.85995E-01	0.0
6	0.0	0.0	1.00003E 00	1.13493E 00	0.0
7	0.0	0.0	9.99999E-01	1.35306E 00	0.0
8	5.85257E-05	0.0	9.99941E-01	1.41102E 00	0.0
9	2.34103E-04	0.0	9.99764E-01	1.41102E 00	0.0
10	4.68205E-04	0.0	9.99531E-01	1.41102E 00	0.0
11	8.19360E-04	0.0	9.99179E-01	1.41102E 00	0.0
12	1.45904E-03	0.0	9.98541E-01	1.41499E 00	0.0
13	2.62627E-03	0.0	9.97373E-01	1.41499E 00	0.0
14	3.47661E-03	0.0	9.96523E-01	1.66273E 00	0.0
15	4.80345E-03	0.0	9.95197E-01	2.24075E 00	0.0
16	6.18326E-03	0.0	9.93817E-01	3.89238E 00	0.0

CUMULATIVE TRANSFER PROBABILITIES

FROM I	TO I+ 0	I+ 1	I+ 2	I+ 3	I+ 4	I+ 5
1	1.9342E-01	6.8055E-01	7.9460E-01	9.0866E-01	9.7729E-01	1.0000E 00
2	2.2132E-01	5.3378E-01	7.9275E-01	9.4828E-01	9.9114E-01	1.0000E 00
3	1.9459E-01	6.8300E-01	9.2064E-01	9.8655E-01	9.9753E-01	1.0000E 00
4	2.8980E-01	8.3562E-01	9.7206E-01	9.9510E-01	9.9909E-01	1.0000E 00
5	4.8378E-01	9.1658E-01	9.8531E-01	9.9735E-01	9.9952E-01	1.0000E 00
6	4.5508E-01	9.0727E-01	9.8330E-01	9.9691E-01	9.9909E-01	1.0000E 00
7	4.3686E-01	8.9936E-01	9.8169E-01	9.9445E-01	9.9817E-01	1.0000E 00
8	4.2409E-01	8.9734E-01	9.6875E-01	9.8982E-01	9.9696E-01	1.0000E 00
9	4.2557E-01	8.3094E-01	9.4334E-01	9.8314E-01	9.9438E-01	1.0000E 00
10	3.0123E-01	7.7240E-01	9.3161E-01	9.7728E-01	9.9087E-01	1.0000E 00
11	2.7197E-01	7.8814E-01	9.2977E-01	9.7188E-01	9.9297E-01	1.0000E 00
12	2.9074E-01	7.7013E-01	9.0830E-01	9.7738E-01	1.0000E 00	1.0000E 00
13	2.5917E-01	7.1175E-01	9.2732E-01	1.0000E 00	1.0000E 00	1.0000E 00
14	3.2264E-01	8.3553E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
15	8.0530E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
16	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00

MUBAR

FROM I	TO I+ 0	I+ 1	I+ 2	I+ 3	I+ 4	I+ 5
1	1.0211E-02	5.6558E-01	5.4578E-01	4.1126E-01	2.5180E-01	1.0870E-01
2	2.4011E-02	6.4515E-01	5.8276E-01	3.5763E-01	1.7355E-01	8.0000E-02
3	1.6129E-01	6.1831E-01	4.6792E-01	2.2449E-01	1.0204E-01	0.0
4	1.7467E-01	5.8304E-01	3.0984E-01	1.2598E-01	4.5455E-02	0.0
5	4.2127E-01	5.0651E-01	2.2242E-01	9.0000E-02	5.5556E-02	0.0
6	4.5727E-01	5.4258E-01	2.3732E-01	1.0160E-01	3.3333E-02	0.0
7	4.7738E-01	5.4765E-01	2.4092E-01	1.1005E-01	6.5574E-02	3.3333E-02

8	4.8539E-01	5.4961E-01	2.5410E-01	1.4167E-01	8.1967E-02	3.8462E-02
9	4.8722E-01	5.7735E-01	3.3177E-01	1.8824E-01	1.0417E-01	6.2500E-02
10	4.2374E-01	6.1688E-01	3.6300E-01	2.0256E-01	1.2069E-01	7.0513E-02
11	3.9067E-01	6.1789E-01	3.5691E-01	2.1140E-01	1.2500E-01	4.1667E-02
12	3.8497E-01	6.1886E-C1	3.7902E-01	2.2673E-01	7.2351E-02	0.0
13	3.5989E-01	6.3896E-01	4.0C11E-01	1.2882E-01	0.0	0.0
14	6.1788E-01	6.2191E-01	1.8182E-01	0.0	0.0	0.0
15	4.5986E-01	3.8040E-01	0.0	0.0	0.0	0.0
16	2.5618E-01	0.C	0.0	0.0	0.0	0.0

```
SAMPLE PROB 6  2C8 15.24 CM PARAFFIN REFL AUTOMATIC REFL

GEOMETRY DESCRIPTION

REGION

  1  CYLINDER     1  RADIUS = 5.7480E 00    +Z = 5.3825E 00    -Z =-5.3825E 00

  2  CUBOID       0       +X = 1.1740E 01    -X =-1.1740E 01    +Y = 1.1740E 01    -Y =-1.1740E 01    +Z = 1.1375E 01    -Z =-1.1375E 01

REFLECTOR         2       +X = 1.5240E 01    -X = 1.5240E 01    +Y = 1.5240E 01    -Y = 1.5240E 01    +Z = 1.5240E 01    -Z = 1.5240E 01

                     WT. ID =  40C
                      16 GROUP WEIGHTS FOR PARAFFIN    , HAVING 10 INTERVALS, EACH  3.0 CM THICK WERE USED.

  1  CORE BDY     0       +X = 2.3480E 01    -X =-2.3480E 01 +Y = 2.3480E 01    -Y =-2.3480E 01    +Z = 2.2750E 01    -Z =-2.2750E 01

  2  CUBOID       2       +X = 2.6480E 01    -X =-2.6480E 01 +Y = 2.6480E 01    -Y =-2.6480E 01    +Z = 2.5750E 01    -Z =-2.5750E 01

  3  CUBOID       2       +X = 2.9480E 01    -X =-2.9480E 01 +Y = 2.9480E 01    -Y =-2.9480E 01    +Z = 2.8750E C1    -Z =-2.8750E 01

  4  CUBOID       2       +X = 3.2480E 01    -X =-3.2480E 01 +Y = 3.2480E 01    -Y =-3.2480E 01    +Z = 3.1750E C1    -Z =-3.1750E 01

  5  CUBOID       2       +X = 3.5480E 01    -X =-3.5480E 01 +Y = 3.5480E 01    -Y =-3.5480E 01    +Z = 3.4750E 01    -Z =-3.4750E 01

  6  CUBOID       2       +X = 3.8720E 01    -X =-3.8720E 01 +Y = 3.8720E 01    -Y =-3.8720E 01    +Z = 3.7990E 01    -Z =-3.7990E 01
```

SAMPLE PROB 6 2C8 15.24 CM PARAFFIN REFL AUTOMATIC REFL

WEIGHTING FUNCTION

BOX TYPE 1

REGION 1 DEFINED BY GEOMETRY CARD 1

GROUP	WTLOW	WT AVG	WT HI
1	0.167	0.500	1.500

GROUPS 2 TO 16 SAME AS ABOVE

REGION 2 DEFINED BY GEOMETRY CARD 2

GROUP	WTLOW	WT AVG	WT HI
1	0.167	0.500	1.500

GROUPS 2 TO 16 SAME AS ABOVE

REFLECTOR

REGION 1 DEFINED BY GEOMETRY CARD 3

GROUP	WTLOW	WT AVG	WT HI
1	0.199	0.596	1.788
2	0.196	0.589	1.767
3	0.194	0.583	1.749
4	0.192	0.577	1.731
5	0.198	0.594	1.782
6	0.213	0.640	1.920
7	0.224	0.671	2.013
8	0.228	0.684	2.052
9	0.229	0.687	2.061
10	0.224	0.673	2.019
11	0.216	0.648	1.944
12	0.210	0.631	1.893
13	0.256	0.768	2.304
14	0.273	0.818	2.454
15	0.275	0.824	2.472
16	0.297	0.891	2.673

REGION 2 DEFINED BY GEOMETRY CARD 4

GROUP	WTLOW	WT AVG	WT HI
1	0.199	0.596	1.788
2	0.196	0.589	1.767
3	0.194	0.583	1.749
4	0.192	0.577	1.731
5	0.198	0.594	1.782
6	0.213	0.640	1.920
7	0.224	0.671	2.013
8	0.228	0.684	2.052
9	0.229	0.687	2.061
10	0.224	0.673	2.019
11	0.216	0.648	1.944
12	0.210	0.631	1.893
13	0.256	0.768	2.304
14	0.273	0.818	2.454
15	0.275	0.824	2.472
16	0.297	0.891	2.673

REGION 3 DEFINED BY GEOMETRY CARD 5

GROUP	WTLOW	WT AVG	WT HI
1	0.282	0.846	2.538
2	0.291	0.873	2.619
3	0.305	0.915	2.745
4	0.324	0.972	2.916
5	0.380	1.140	3.420
6	0.480	1.440	4.320
7	0.543	1.630	4.890
8	0.583	1.750	5.250
9	0.613	1.840	5.520
10	0.627	1.880	5.640

11	0.630	1.890	5.670
12	0.650	1.950	5.850
13	0.883	2.650	7.950
14	0.990	2.970	8.910
15	1.017	3.050	9.150
16	1.173	3.520	10.560

REGION 4 DEFINED BY GEOMETRY CARD 6

1	0.427	1.280	3.840
2	0.500	1.500	4.500
3	0.600	1.800	5.400
4	0.723	2.170	6.510
5	0.997	2.990	8.970
6	1.487	4.460	13.380
7	1.793	5.380	16.140
8	2.007	6.020	18.060
9	2.190	6.570	19.710
10	2.317	6.950	20.850
11	2.373	7.120	21.360
12	2.493	7.480	22.440
13	3.433	10.300	30.900
14	3.867	11.600	34.800
15	3.967	11.900	35.700
16	4.633	13.900	41.700

REGION 5 DEFINED BY GEOMETRY CARD 7

1	0.693	2.080	6.240
2	0.957	2.870	8.610
3	1.390	4.170	12.510
4	1.933	5.800	17.400
5	3.140	9.420	28.260
6	5.367	16.100	48.300
7	6.733	20.200	60.600
8	7.667	23.000	69.000
9	8.467	25.400	76.200
10	9.033	27.100	81.300
11	9.300	27.900	83.700
12	9.800	29.400	88.200
13	13.500	40.500	121.500
14	15.200	45.600	136.800
15	15.667	47.000	141.000
16	18.200	54.600	163.800

REGION 6 DEFINED BY GEOMETRY CARD 8

1	1.170	3.510	10.530
2	1.960	5.880	17.640
3	3.567	10.700	32.100
4	5.767	17.300	51.900
5	10.933	32.800	98.400
6	20.633	61.900	185.700
7	26.200	78.600	235.800
8	30.033	90.100	270.300
9	33.233	99.700	299.100
10	35.667	107.000	321.000
11	36.667	110.000	330.000
12	38.667	116.000	348.000
13	53.000	159.000	477.000
14	60.000	180.000	540.000
15	61.667	185.000	555.000
16	71.667	215.000	645.000

SAMPLE PROB 6 2C8 15.24 CM PARAFFIN REFL AUTOMATIC REFL

VOLUMES

BOX TYPE 1

REGION DEFINED BY GEOMETRY CARD	1	VOLUME =	1.11737E 03 CM**3	CUMULATIVE VOLUME =	1.11737E 03 CM**3
REGION DEFINED BY GEOMETRY CARD	2	VOLUME =	1.14249E 04 CM**3	CUMULATIVE VOLUME =	1.25423E 04 CM**3

REFLECTOR VOLUMES - GEOMETRY CARD 3 IS THE CORE BOUNCARY CARD

REGION DEFINED BY GEOMETRY CARD	4	VOLUME =	4.41067E 04 CM**3	CUMULATIVE VOLUME =	1.44445E 05 CM**3
REGION DEFINED BY GEOMETRY CARD	5	VOLUME =	5.54410E 04 CM**3	CUMULATIVE VOLUME =	1.99886E 05 CM**3
REGION DEFINED BY GEOMETRY CARD	6	VOLUME =	6.80709E 04 CM**3	CUMULATIVE VOLUME =	2.67957E 05 CM**3
REGION DEFINED BY GEOMETRY CARD	7	VOLUME =	8.19977E 04 CM**3	CUMULATIVE VOLUME =	3.49955E 05 CM**3
REGION DEFINED BY GEOMETRY CARD	8	VOLUME =	1.05693E 05 CM**3	CUMULATIVE VOLUME =	4.55648E 05 CM**3

TOTAL VOLUMES

1	8.93896E 03
2	9.13994E 04

VOLUME FRACTION OF THE CORE CCNTAINING FISSILE MATERIAL= 0.89088E-01

START TYPE = 0

THE NEUTRONS WERE STARTED IN THE ARRAY WITH A FLAT DISTRIBUTION.

300 NEUTRONS WERE INITIALLY STARTED
0.00917 MINUTES WERE REQUIRED FOR STARTING.

SAMPLE PROB 6 2C8 15.24 CM PARAFFIN REFL AUTOMATIC REFL

GENFRATION	K-EFFECTIVE	ELAPSED TIME(MIN)	AVG. K-EFF	DEVIATICN	MATRIX K-EFF
1	9.45726E-01	6.25000E-02	1.00000E 00	0.0	0.0
2	1.C5210E 00	1.18833E-01	1.00000E 00	0.0	0.0
3	1.C8601E 00	1.86333E-01	1.08601E 00	0.0	0.0
4	9.24630E-01	2.51000E-01	1.00532E 00	8.06950E-02	0.0
5	1.02742E 00	3.23000E-01	1.01269E 00	4.71741E-02	0.0
6	9.26417E-01	3.95833E-01	9.91119E-01	3.97155E-02	0.0
7	1.00347E 00	4.61667E-01	9.93589E-01	3.08621E-02	0.0
8	1.00645E 00	5.18000E-01	9.95732E-01	2.52897E-02	0.0
9	1.05197E 00	5.90833E-01	1.00377E 00	2.28364E-02	0.0
10	1.05893E 00	6.53000E-01	1.01066E 00	2.09482E-02	0.0
11	8.93213E-01	7.25833E-01	9.97612E-01	2.26143E-02	0.0
12	9.72167E-01	7.83000E-01	9.95068E-01	2.03860E-02	0.0
13	9.57243E-01	8.47667E-01	9.91629E-01	1.87577E-02	0.0
14	1.04421E 00	9.08833E-01	9.96011E-01	1.76750E-02	0.0
15	1.05846E 00	9.75500E-01	1.00081E 00	1.69544E-02	0.0
16	9.81207E-01	1.04133E 00	9.99414E-01	1.57563E-02	0.0
17	9.17930E-01	1.10217E 00	9.93982E-01	1.56438E-02	0.0
18	9.21897E-01	1.17100E 00	9.89477E-01	1.53112E-02	0.0
19	1.07425E 00	1.22767E 00	9.94463E-01	1.52229E-02	0.0
20	1.04953E 00	1.29550E 00	9.97521E-01	1.46768E-02	0.0
21	9.76105E-01	1.35050E 00	9.96393E-01	1.39311E-02	0.0
22	1.01519E 00	1.41550E 00	9.97333E-01	1.32493E-02	0.0
23	9.93914E-01	1.47000E 00	9.97170E-01	1.26031E-02	0.0
24	1.C7258E 00	1.54050E 00	1.00060E 00	1.24970E-02	0.0
25	9.93325E-01	1.59100E 00	1.00028E 00	1.19459E-02	0.0
26	1.03956E 00	1.65850E 00	1.00192E 00	1.15548E-02	0.0
27	9.70045E-01	1.72500E 00	1.00064E 00	1.11595E-02	0.0
28	9.78354E-01	1.78833E 00	9.99784E-01	1.07528E-02	0.0
29	1.00652E 00	1.83967E 00	1.00003E 00	1.03527E-02	0.0
30	1.00871E 00	1.90350E 00	1.00034E 00	9.98028E-03	0.0
31	9.47363E-01	1.96467E 00	9.98516E-01	9.80207E-03	0.0
32	9.79976E-01	2.02967E 00	9.97897E-01	9.49035E-03	0.0
33	1.03385E 00	2.08750E 00	9.99057E-01	9.25075E-03	0.0
34	9.48662E-01	2.15217E 00	9.97482E-01	9.09588E-03	0.0
35	9.87758E-01	2.21850E 00	9.97187E-01	8.82206E-03	0.0
36	9.91036E-01	2.28083E 00	9.97006E-01	8.56107E-03	0.0
37	1.C2732E 00	2.34550E 00	9.97872E-01	8.35866E-03	0.0
38	1.03650E 00	2.41933E 00	9.98945E-01	8.19257E-03	0.0
39	1.13133E 00	2.49717E 00	1.00252E 00	8.73616E-03	0.0
40	9.60205E-01	2.55883E 00	1.00141E 00	8.57531E-03	0.0
41	9.56283E-01	2.61517E 00	1.00025E 00	8.43351E-C3	0.0
42	1.04959E 00	2.70100E 00	1.00148E 00	8.31145E-03	0.0
43	8.46409E-01	2.75933E 00	9.97703E-01	8.94460E-03	0.0
44	9.83936E-01	2.82217E 00	9.97375E-01	8.73531E-03	0.0
45	9.82837E-01	2.88833E 00	9.97037E-01	8.53620E-03	0.0
46	1.01057E 00	2.95467E 00	9.97344E-01	8.34600E-03	0.0
47	9.81127E-01	3.02550E 00	9.96983E-01	8.16620E-03	0.0
48	9.45773E-01	3.09300E 00	9.95870E-01	8.06395E-03	0.0
49	1.01336E 00	3.15917E 00	9.96242E-01	7.89950E-03	0.0
50	1.01587E 00	3.21550E 00	9.96651E-01	7.74369E-03	0.0
51	9.63092E-01	3.27350E 00	9.95966E-01	7.61490E-03	0.0
52	9.09364E-01	3.35267E 00	9.94234E-01	7.65926E-03	0.0
53	9.77089E-01	3.43050E 00	9.93898E-01	7.51525E-03	0.0
54	9.29639E-01	3.50183E 00	9.92662E-01	7.47287E-03	0.0
55	1.03947E 00	3.56350E 00	9.93545E-01	7.38384E-03	0.0
56	1.00164E 00	3.63267E 00	9.93694E-01	7.24758E-03	0.0
57	9.48836E-01	3.69933E 00	9.92879E-01	7.16184E-03	0.0
58	1.01426E 00	3.75433E 00	9.93260E-01	7.04332E-03	0.0
59	9.30564E-01	3.81083E 00	9.92160E-01	7.00557E-03	0.0
60	1.00169E 00	3.87250E 00	9.92325E-01	6.88563E-03	0.0

61	1.03940E 00	3.96100E 00	9.93122E-01	6.81486E-03	0.0

WARNING - ONLY 293 INDEPENDENT FISSION POINTS WERE GENERATED.

62	8.67492E-01	4.01800E 00	9.91028E-01	7.02025E-03	0.0
63	9.55540E-01	4.08600E 00	9.90446E-01	6.92882E-03	0.0
64	9.17188E-01	4.14300E 00	9.89265E-01	6.91827E-03	0.0
65	1.06024E 00	4.20083E 00	9.90391E-01	6.89991E-03	0.0
66	8.90958E-01	4.25433E 00	9.88837E-01	6.96686E-03	0.0
67	9.57537E-01	4.31500E 00	9.88356E-01	6.87574E-03	0.0
68	1.05342E 00	4.38167E 00	9.89342E-01	6.84211E-03	0.0
69	1.04736E 00	4.44667E 00	9.90207E-01	6.79459E-03	0.0
70	9.01017E-01	4.50333E 00	9.88896E-01	6.82122E-03	0.0
71	1.11682E 00	4.56750E 00	9.90750E-01	6.97254E-03	0.0
72	1.11554E 00	4.63767E 00	9.92532E-01	7.09994E-03	0.0
73	1.03963E 00	4.70717E 00	9.93196E-01	7.03054E-03	0.0
74	9.93715E-01	4.77883E 00	9.93203E-01	6.93215E-03	0.0
75	9.17950E-01	4.83967E 00	9.92172E-01	6.91402E-03	0.0
76	1.07025E 00	4.90267E 00	9.93227E-01	6.90120E-03	0.0
77	1.09361E 00	4.96933E 00	9.94565E-01	6.93879E-03	0.0
78	9.63181E-01	5.03800E 00	9.94152E-01	6.85915E-03	0.0
79	1.09738E 00	5.10833E 00	9.95493E-01	6.90091E-03	0.0
80	9.77637E-01	5.18300E 00	9.95264E-01	6.81569E-03	0.0
81	1.00009E 00	5.24667E 00	9.95325E-01	6.72936E-03	0.0
82	1.01225E 00	5.30833E 00	9.95536E-01	6.64827E-03	0.0
83	9.31811E-01	5.37500E 00	9.94749E-01	6.61273E-03	0.0
84	1.00469E 00	5.44600E 00	9.94871E-01	6.53276E-03	0.0
85	1.06184E 00	5.53467E 00	9.95677E-01	6.50393E-03	0.0
86	9.29541E-01	5.60000E 00	9.94890E-01	6.47412E-03	0.0
87	1.06247E 00	5.65933E 00	9.95685E-01	6.44693E-03	0.0
88	1.03556E 00	5.72683E 00	9.96148E-01	6.38868E-03	0.0
89	9.85426E-01	5.79100E 00	9.96025E-01	6.31608E-03	0.0
90	1.08290E 00	5.86967E 00	9.97012E-01	6.32143E-03	0.0
91	9.41111E-01	5.93133E 00	9.96384E-01	6.28158E-03	0.0
92	1.08299E 00	6.01333E 00	9.97346E-01	6.28563E-03	0.0
93	9.58043E-01	6.08383E 00	9.96914E-01	6.23114E-03	0.0
94	9.38136E-01	6.14583E 00	9.96275E-01	6.19612E-03	0.0
95	1.00217E 00	6.23000E 00	9.96339E-01	6.12941E-03	0.0
96	1.01512E 00	6.28467E 00	9.96538E-01	6.06734E-03	0.0
97	9.96578E-01	6.35517E 00	9.96538E-01	6.00332E-03	0.0
98	1.02434E 00	6.42583E 00	9.96828E-01	5.94737E-03	0.0
99	1.06051E 00	6.48050E 00	9.97484E-01	5.92246E-03	0.0
100	1.03393E 00	6.55583E 00	9.97856E-01	5.87362E-03	0.0
101	9.31787E-01	6.61633E 00	9.97189E-01	5.85236E-03	0.0
102	9.83258E-01	6.68883E 00	9.97049E-01	5.79521E-03	0.0
103	9.80156E-01	6.75967E 00	9.96882E-01	5.74011E-03	0.0

THE MATRIX K-EFF IS THE LARGEST EIGENVALUE OF THE MATRIX OF FISSION PROBABILITIES BY UNIT.
THERE ARE NBXMAX * NBYMAX * NBZMAX UNITS IN AN ARRAY.

SAMPLE PROB 6 2C8 15.24 CM PARAFFIN REFL AUTOMATIC REFL

LIFETIME = 1.36387E-04 + OR - 7.03527E-06   GENERATION TIME = 4.52127E-05 + OR - 1.03802E-06

NO. OF INITIAL GENERATIONS SKIPPED	AVERAGE K-EFFECTIVE	DEVIATION	67 PER CENT CONFIDENCE INTERVAL	95 PER CENT CONFIDENCE INTERVAL	99 PER CENT CONFIDENCE INTERVAL	NUMBER OF HISTORIES
3	0.99599	+ OR - 0.00572	0.99027 TO 1.00171	0.98455 TO 1.00744	0.97882 TO 1.01316	30000
4	0.99671	+ OR - 0.00573	0.99098 TO 1.00245	0.98524 TO 1.00818	0.97951 TO 1.01392	29700
5	0.99640	+ OR - 0.00579	0.99061 TO 1.00218	0.98483 TO 1.00797	0.97904 TO 1.01375	29400
6	0.99712	+ OR - 0.00580	0.99132 TO 1.00292	0.98552 TO 1.00872	0.97972 TO 1.01452	29100
7	0.99705	+ OR - 0.00586	0.99119 TO 1.00291	0.98533 TO 1.00877	0.97948 TO 1.01463	28800
8	0.99696	+ OR - 0.00592	0.99103 TO 1.00288	0.98511 TO 1.00880	0.97919 TO 1.01472	28500
9	0.99637	+ OR - 0.00595	0.99042 TO 1.00232	0.98446 TO 1.00828	0.97851 TO 1.01423	28200
10	0.99570	+ OR - 0.00598	0.98972 TO 1.00168	0.98374 TO 1.00766	0.97776 TO 1.01364	27900
11	0.99681	+ OR - 0.00594	0.99087 TO 1.00275	0.98493 TO 1.00869	0.97899 TO 1.01463	27600
12	0.99708	+ OR - 0.00600	0.99108 TO 1.00308	0.98508 TO 1.00908	0.97908 TO 1.01508	27300
17	0.99739	+ OR - 0.00620	0.99119 TO 1.00359	0.98500 TO 1.00978	0.97880 TO 1.01598	25800
22	0.99677	+ OR - 0.00640	0.99037 TO 1.00317	0.98397 TO 1.00958	0.97757 TO 1.01598	24300
27	0.99565	+ OR - 0.00672	0.98893 TO 1.00236	0.98221 TO 1.00908	0.97550 TO 1.01580	22800
32	0.99645	+ OR - 0.00715	0.98931 TO 1.00360	0.98216 TO 1.01075	0.97501 TO 1.01790	21300
37	0.99636	+ OR - 0.00762	0.98874 TO 1.00398	0.98111 TO 1.01160	0.97349 TO 1.01922	19800
42	0.99387	+ OR - 0.00781	0.98606 TO 1.00168	0.97824 TO 1.00949	0.97043 TO 1.01730	18300
47	0.99680	+ OR - 0.00807	0.98874 TO 1.00487	0.98067 TO 1.01293	0.97260 TO 1.02100	16800
52	0.99948	+ OR - 0.00859	0.99089 TO 1.00807	0.98231 TO 1.01665	0.97372 TO 1.02524	15300
57	1.00167	+ OR - 0.00928	0.99239 TO 1.01095	0.98311 TO 1.02023	0.97383 TO 1.02951	13800
62	1.00545	+ OR - 0.00966	0.99579 TO 1.01511	0.98613 TO 1.02477	0.97647 TO 1.03442	12300
67	1.01228	+ OR - 0.00986	1.00241 TO 1.02214	0.99255 TO 1.03201	0.98268 TO 1.04187	10800
72	1.00671	+ OR - 0.00955	0.99716 TO 1.01625	0.98761 TO 1.02580	0.97807 TO 1.03535	9300
77	1.00357	+ OR - 0.00991	0.99366 TO 1.01347	0.98376 TO 1.02338	0.97385 TO 1.03329	7800
82	1.00201	+ OR - 0.01119	0.99083 TO 1.01320	0.97964 TO 1.02438	0.96846 TO 1.03557	6300
87	1.00325	+ OR - 0.01209	0.99116 TO 1.01534	0.97906 TO 1.02744	0.96697 TO 1.03953	4800
92	0.99309	+ OR - 0.01208	0.98102 TO 1.00517	0.96894 TO 1.01724	0.95687 TO 1.02932	3300

SAMPLE PROB 6 2C8 15.24 CM PARAFFIN REFL AUTOMATIC REFL

NO. OF INITIAL GENERATIONS SKIPPED	AVERAGE K-EFFECTIVE	DEVIATION	67 PER CENT CONFIDENCE INTERVAL	95 PER CENT CONFIDENCE INTERVAL	99 PER CENT CONFIDENCE INTERVAL	NUMBER OF HISTORIES
97	1.00233	+ OR - 0.01889	0.98344 TO 1.02122	0.96456 TO 1.04010	0.94567 TO 1.05899	1800

SAMPLE PROB 6 2C8 15.24 CM PARAFFIN REFL AUTOMATIC REFL

GROUP	REGION	LEAKAGE	ABSORPTIONS	FISSIONS	WITH 3 GENERATIONS SKIPPED
1		4.89309D-03	3.84388D-02	1.08852D-01	
2		6.49403D-03	7.32299D-02	1.79769D-01	
3		2.38573D-03	4.39184D-02	1.01502D-01	
4		3.84796D-03	7.01251D-02	1.54192D-01	
5		2.03650D-03	6.30274D-02	1.32663D-01	
6		1.86600D-03	2.23375D-02	4.29903D-02	
7		3.15670D-03	6.50325D-03	1.20562D-02	
8		0.0	6.53001D-03	1.11522D-02	
9		2.18679D-03	8.24198D-03	1.31477D-02	
10		0.0	5.79673D-03	8.31976D-03	
11		0.0	5.68401D-03	6.72037D-03	
12		3.31865D-03	5.64227D-03	4.78832D-03	
13		0.0	5.39888D-03	7.36918D-03	
14		0.0	4.96781D-03	6.53905D-03	
15		0.0	2.03058D-02	1.83930D-02	
16		7.54884D-03	5.31591D-01	1.87543D-01	
TOTAL =		3.77343D-02	9.11739D-01	9.95997D-01	

ELAPSED TIME   6.75967MINUTES

SAMPLE PROB 6 2C8 15.24 CM PARAFFIN REFL AUTOMATIC REFL

**** FISSION DENSITIES ****

	REGION	FISSION DENSITY	PERCENT DEVIATION	TOTAL FISSICNS
BOX TYPE 1				
	1	1.114E-C4	0.58	9.959E-01
	2	0.0	0.0	0.0
REFLECTOR				
	1	0.0	0.0	0.0
	2	0.0	0.0	0.0
	3	0.0	0.0	0.0
	4	0.0	0.0	0.0
	5	0.0	0.0	0.0
	6	0.0	0.0	0.0

SAMPLE PROB 6 2C8 15.24 CM PARAFFIN REFL AUTOMATIC REFL

FLUXES FOR BOX TYPE 1

	REGION 1		REGION 2	
GROUP	FLUX	PERCENT DEVIATION	FLUX	PERCENT DEVIATION
1	7.511E-05	1.66	2.337E-05	1.98
2	1.350E-04	1.20	4.257E-05	1.48
3	8.161F-05	1.73	2.458E-05	2.06
4	1.287E-04	1.27	4.063E-05	1.32
5	9.180E-05	1.53	3.164E-05	1.43
6	1.824E-05	3.08	1.184E-05	2.93
7	2.914E-06	7.26	7.571E-06	3.96
8	1.536E-06	7.83	6.965E-06	4.21
9	7.040E-07	7.46	6.294E-06	3.58
10	2.414E-07	10.34	3.883E-06	5.05
11	1.600E-07	10.51	3.545E-06	5.30
12	1.609E-07	10.93	3.655E-06	4.82
13	2.473E-07	10.99	3.037E-06	5.72
14	8.903E-08	11.78	2.744E-06	6.48
15	9.004E-08	7.23	6.839E-06	3.95
16	3.758E-07	2.98	6.740E-05	2.13

SAMPLE PROB 6 208 15.24 CM PARAFFIN REFL AUTOMATIC REFL

FLUXES FOR REFLECTOR

	REGION 1		REGION 2		REGION 3		REGION 4		REGION 5		REGION 6	
GROUP	FLUX	PERCENT DEVIATION	FLUX	PERCENT DEVIATION	FLUX	PERCENT DEVIATION	FLUX	PERCENT DEVIATION	FLUX	PERCENT DEVIATION	FLUX	PERCENT DEVIATION
1	0.0	0.0	9.054E-06	2.01	3.631E-06	2.83	1.574E-06	4.33	6.889E-07	5.86	3.006E-07	8.59
2	0.0	0.0	1.638E-05	1.38	6.206E-06	2.08	2.511E-06	2.79	1.114E-06	4.43	4.378E-07	8.67
3	0.0	0.0	9.675E-06	1.63	3.236E-06	2.54	1.314E-06	4.25	5.699E-07	9.21	1.747E-07	13.76
4	0.0	0.0	1.599E-05	1.08	5.289E-06	1.66	1.886E-06	3.56	7.437E-07	6.71	2.893E-07	14.01
5	0.0	0.0	1.830E-05	0.96	6.898E-06	1.78	2.571E-06	2.85	8.413E-07	9.34	3.225E-07	19.41
6	0.0	0.0	1.056E-05	1.22	4.442E-06	1.73	1.707E-06	4.91	6.778E-07	11.00	2.046E-07	24.79
7	0.0	0.0	7.986E-06	1.17	3.565E-06	1.95	1.390E-06	5.04	4.685E-07	15.18	9.757E-08	48.94
8	0.0	0.0	6.977E-06	1.13	3.473E-06	2.13	1.411E-06	6.20	4.273E-07	16.47	5.704E-08	43.32
9	0.0	0.0	6.605E-06	1.25	3.563E-06	2.21	1.429E-06	5.61	3.892E-07	15.11	1.333E-07	52.07
10	0.0	0.0	4.434E-06	1.41	2.592E-06	2.33	1.042E-06	6.45	3.374E-07	16.51	5.081E-08	54.73
11	0.0	0.0	3.936E-06	1.55	2.327E-06	2.79	9.315E-07	7.28	3.970E-07	17.64	2.687E-08	73.66
12	0.0	0.0	4.174E-06	1.70	2.510E-06	2.61	9.500E-07	6.84	4.779E-07	17.53	5.275E-08	81.71
13	0.0	0.0	3.586E-06	1.52	2.279E-06	2.72	1.025E-06	8.49	3.561E-07	20.41	1.066E-07	78.94
14	0.0	0.0	2.991E-06	1.66	1.910E-06	3.31	8.212E-07	7.59	3.196E-07	22.78	4.223E-08	55.78
15	0.0	0.0	8.726E-06	1.60	6.187E-06	3.45	2.840E-06	7.82	1.068E-06	18.14	1.451E-07	46.97
16	0.0	0.0	1.217E-04	1.76	1.147E-04	2.91	6.109E-05	6.41	2.601E-05	15.62	2.036E-06	46.99

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SAMPLE PROB 6  2C8 15.24 CM PARAFFIN REFL AUTOMATIC REFL

                                      FREQUENCY FOR GENERATICNS    4 TO  103
0.8459 TO 0.8690     **
0.8690 TO 0.8921     *
0.8921 TO 0.9152     ***
0.9152 TO 0.9383     ************
0.9383 TO 0.9613     ***********
0.9613 TO 0.9844     ***************
0.9844 TO 1.0075     ***************
1.0075 TO 1.0306     ***********
1.0306 TO 1.0537     **************
1.0537 TO 1.0768     *********
1.0768 TO 1.0999     ****
1.0999 TO 1.1230     **
1.1230 TO 1.1461     *

                                      FREQUENCY FOR GENERATICNS   29 TO  103
0.8459 TO 0.8690     **
0.8690 TO 0.8921     *
0.8921 TO 0.9152     **
0.9152 TO 0.9383     ********
0.9383 TO 0.9613     **********
0.9613 TO 0.9844     **********
0.9844 TO 1.0075     ***********
1.0075 TO 1.0306     *********
1.0306 TO 1.0537     **********
1.0537 TO 1.0768     *****
1.0768 TO 1.0999     ****
1.0999 TO 1.1230     **
1.1230 TO 1.1461     *

                                      FREQUENCY FOR GENERATICNS   54 TO  103
0.8459 TO 0.8690     *
0.8690 TO 0.8921     *
0.8921 TO 0.9152     *
0.9152 TO 0.9383     ********
0.9383 TO 0.9613     *****
0.9613 TO 0.9844     ****
0.9844 TO 1.0075     ********
1.0075 TO 1.0306     ****
1.0306 TO 1.0537     *******
1.0537 TO 1.0768     *****
1.0768 TO 1.0999     ****
1.0999 TO 1.1230     **
1.1230 TO 1.1461

                                      FREQUENCY FOR GENERATICNS   79 TO  103
0.8459 TO 0.8690
0.8690 TO 0.8921
0.8921 TO 0.9152
0.9152 TO 0.9383     ****
0.9383 TO 0.9613     **
0.9613 TO 0.9844     ***
0.9844 TO 1.0075     *****
1.0075 TO 1.0306     ***
1.0306 TO 1.0537     **
1.0537 TO 1.0768     ***
1.0768 TO 1.0999     ***
1.0999 TO 1.1230
1.1230 TO 1.1461

********** END OF FILE ON UNIT    5 **********
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SAMPLE PROBLEM 8 2C8 SPACING SEARCH

NUMBER OF GENERATIONS	90
NUMBER PER GENERATION	300
NUMBER OF GENERATIONS TO BE SKIPPED	3
NUMBER OF ENERGY GROUPS	16
MAX. NUMBER OF ENERGY TRANSFERS	6
NUMBER OF INPUT NUCLIDES	4
NUMBER OF MIXTURES	1
NUMBER OF MIXING TABLE ENTRIFS	4
NUMBER OF GEOMETRY CARDS	2
NUMBER OF BOX TYPES	1
NUMBER OF UNITS IN X DIRECTION	2
NUMBER OF UNITS IN Y DIRECTION	2
NUMBER OF UNITS IN Z DIRECTICN	2
NUMBER OF NUCLIDES READ FROM TAPE	4
ALBEDO TYPE	0
SEARCH TYPE	1

MAXIMUM TIME = 2.COOO MINLTES

STORAGE LOCATIONS REQUIRED FOR THIS JOB = 5566
REMAINING AVAILABLE LOCATIONS= 29250

START TYPE	C
GENERATIONS BETWEEN CHECKPOINTS	0
LIST INPUT X-SECTIONS READ FROM TAPE	NO
LIST 1-D MIXTURE X SECTIONS	YES
LIST 2-D MIXTURE X-SECTIONS	YES
LIST FISS. AND ABS. BY REGION	NC
USE X-SECTICNS FROM PREVIOUS CASE	NO
USE GEOMETRY FROM PREVIOUS CASE	NO
USE VELOCITIES FROM PREVIOUS CASE	NO
COMPUTE MATRIX K-EFFECTIVE BY UNIT	NC
COMPUTE MATRIX K-EFFECTIVE BY BOX TYPE	NO
LIST FISS PROB MATRIX BY UNIT	NO
ADJOINT CALCULATION	NO
USE EXPONENTIAL TRANSFORM	NO
CALCULATE FLUX	YES
CALCULATE FISSION DENSITIES	YES

SAMPLE PROBLEM 8 2C8 SPACING SEARCH

MIXTURE	NUCLIDE	DENSITY
1	-92500	4.48006E-02
1	92800	2.65780E-03
1	92400	4.8270CE-04
1	92600	9.5700CE-C5

CROSS SECTIONS READ FROM TAPE

NUCLIDE =	92400	U-234	MIHALCZO MOD OF H-R U-238
NUCLIDE =	92500	U-235 YR	HANSEN ROACH
NUCLIDE =	92600	U-236	MIHALCZC MOD OF H-R U-238
NUCLIDE =	92800	U-238 Y	HANSEN ROACH

SAMPLE PROBLEM 8 2C8 SPACING SEARCH

MIXTURE = 1

GP.	ABSORPTION PROBABILITY	NU*FISSION PROBABILITY	NON-ABSORPTION PROBABILITY	TOTAL CROSS-SECTION	FISSION SPECTRUM
1	2.88282E-01	8.16362E-01	7.11718E-01	2.03826E-01	2.04000E-01
2	2.79495E-01	6.86119E-01	7.20504E-01	2.16334E-01	5.48000E-01
3	2.71457E-01	6.27380E-01	7.28542E-01	2.23507E-01	7.16000E-01
4	2.45009E-01	5.38731E-01	7.54990E-01	2.50360E-01	8.96000E-01
5	1.96930E-01	4.14508E-01	8.03070E-01	3.80508E-01	9.86000E-01
6	2.39931E-01	4.61768E-01	7.60215E-01	5.94246E-01	1.00000E 00
7	3.44514E-01	6.38682E-01	6.55486E-01	7.21796E-01	1.00000E 00
8	5.06884E-01	8.72719E-01	4.93116E-01	9.93835E-01	1.00000E 00
9	7.21710E-01	1.18113E 00	2.78289E-01	1.73778E 00	1.00000E 00
10	8.52618E-01	1.28837E 00	1.47382E-01	3.23737E 00	1.00000E 00
11	8.86332E-01	1.14093E 00	1.13668E-01	4.19760E 00	1.00000E 00
12	8.84983E-01	8.92047E-01	1.15017E-01	4.14836E 00	1.00000E 00
13	7.85621E-01	1.47950E 00	2.14379E-01	2.22565E 00	1.00000E 00
14	8.82566E-01	1.89106E 00	1.17435E-01	4.06296E 00	1.00000E 00
15	9.54627E-01	1.93100E 00	4.53733E-02	1.05157E 01	1.00000E 00
16	9.82873E-01	2.03304E 00	1.71272E-02	2.78582E 01	1.00000E 00

CUMULATIVE TRANSFER PROBABILITIES

FROM I	TO I+ 0	I+ 1	I+ 2	I+ 3	I+ 4	I+ 5
1	3.9857E-01	4.8931E-01	6.1384E-01	8.3220E-01	9.7991E-01	1.0000E 00
2	5.4663E-01	6.2288E-C1	8.3538E-01	9.7801E-01	1.0000E 00	1.0000E 00
3	6.9055E-01	8.5777E-01	S.7875E-01	1.0000E 00	1.0000E 00	1.0000E 00
4	8.8815E-01	9.7967E-01	1.0C00E 00	1.0000E 00	1.0000E 00	1.0000E 00
5	9.8742E-01	1.0000E 00	1.0C00E 00	1.0000E 00	1.0000E 00	1.0000E 00
6	9.9433E-01	1.0000E 00	1.0C00E 00	1.0000E 00	1.0000E 00	1.0000E 00
7	9.9486E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
8	9.9503E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
9	9.9503E-01	1.0000E 00	1.0C00E 00	1.0000E 00	1.0000E 00	1.0000E 00
10	9.9490E-01	1.0000E 00	1.0C00E 00	1.0000E 00	1.0000E 00	1.0000E 00
I = 11 THRU I= 14 SAME AS ABOVE						
15	9.9591E-01	1.C000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
16	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00

MUBAR

FROM I	TO I+ 0	I+ 1	I+ 2	I+ 3	I+ 4	I+ 5
1	0.0	0.0	0.0	0.0	0.0	0.0
I = 2 THRU I= 16 SAME AS ABOVE						

SAMPLE PROBLEM 8 2C8 SPACING SEARCH

GEOMETRY DESCRIPTION

REGION

1	CYLINDER	1	RADIUS = 5.7480E 00	+Z = 5.3825E 00	-Z =-5.3825E 00			
2	CUBOID	0	+X = 7.5570E 00	-X =-7.5570E 00	+Y = 7.5570E 00	-Y =-7.5570E 00	+Z = 7.1555E 00	-Z =-7.1555E 00

SAMPLE PROBLEM 8 2C8 SPACING SEARCH

WEIGHTING FUNCTION

BOX TYPE 1	GROUP	WTLOW	WT AVG	WT HI
REGION 1 DEFINED BY GEOMETRY CARD 1				
	1	0.167	0.500	1.500
	GROUPS 2 TO 16 SAME AS ABOVE			
REGION 2 DEFINED BY GEOMETRY CARD 2				
	1	0.167	0.500	1.500
	GROUPS 2 TO 16 SAME AS ABOVE			

SAMPLE PROBLEM 8 2C8 SPACING SEARCH

VOLUMES

```
BOX TYPE      1
         REGION DEFINED BY GECMETRY CARD    1   VCLUME =   1.11737E 03 CM**3      CUMULATIVE VOLUME =   1.11737E 03 CM**3
         REGION DEFINED BY GECMETRY CARD    2   VOLUME =   2.15173E 03 CM**3      CUMULATIVE VOLUME =   3.26910E 03 CM**3
```

```
TOTAL VOLUMES
   1        8.93896E 03
   2        1.72139E 04
```

VOLUME FRACTION OF THE CORE CCNTAINING FISSILE MATERIAL= 0.34180E 00

START TYPE = 0

THE NEUTRONS WERE STARTED IN THE ARRAY WITH A FLAT DISTRIBUTION.

300 NEUTRONS WERE INITIALLY STARTED

READ SEARCH DATA
0.00217 MINUTES WERE REQUIRED FOR STARTING.

SAMPLE PROBLEM 8 2C8 SPACING SEARCH

WARNING - ONLY 293 INDEPENDENT FISSION POINTS WERE GENERATED.

GENERATION	K-EFFECTIVE	ELAPSED TIME(MIN)	AVG. K-EFF	DEVIATICN	MATRIX K-EFF
1	8.25274E-01	6.83333E-03	1.00000E 00	0.0	0.0
2	9.03134E-01	1.21667E-02	1.00000E 00	0.0	0.0
3	8.59577E-01	1.75000E-02	8.59577E-01	0.0	0.0
4	9.66195E-01	2.60000E-02	9.12886E-01	5.33055E-02	0.0
5	9.49888E-01	3.41667E-02	9.25220E-01	3.31551E-02	0.0
6	9.68434E-01	4.13333E-02	9.36023E-01	2.58139E-02	0.0
7	9.49882E-01	4.80000E-02	9.38795E-01	2.01871E-02	0.0
8	9.26781E-01	5.55000E-02	9.36792E-01	1.66044E-02	0.0
9	9.25062E-01	6.21667E-02	9.35117E-01	1.41342E-02	0.0
10	8.73986E-01	6.76666E-02	9.27475E-01	1.44303E-02	0.0
11	9.78998E-01	7.60000E-02	9.33200E-01	1.39545E-02	0.0
12	9.96002E-01	8.38333E-02	9.39480E-01	1.39728E-02	0.0
13	8.88199E-01	9.01666E-02	9.34818E-01	1.34714E-02	0.0
14	1.02059F 00	9.80000E-02	9.41966E-01	1.42239E-02	0.0
15	9.03838E-01	1.04333E-01	9.39033E-01	1.34089E-02	0.0
16	9.54782E-01	1.12500E-01	9.40158E-01	1.24652E-02	0.0
17	9.84242E-01	1.20500E-01	9.43097E-01	1.19707E-02	0.0
18	9.39344E-01	1.27167E-01	9.42862E-01	1.12000E-02	0.0
19	8.77059E-01	1.32667E-01	9.38991E-01	1.12102E-02	0.0
20	8.87153E-01	1.38500E-01	9.36111E-01	1.09577E-02	0.0
21	8.97903E-01	1.45167E-01	9.34099E-01	1.05620E-02	0.0
22	9.42993E-01	1.51833E-01	9.34543E-01	1.00315E-02	0.0
23	9.53350E-01	1.59167E-01	9.35438E-01	9.58637E-03	0.0
24	9.42191E-01	1.66333E-01	9.35745E-01	9.14515E-03	0.0
25	9.40668E-01	1.73500E-01	9.35958E-01	8.74162E-03	0.0
26	9.27922E-01	1.80833E-01	9.35623E-01	8.37677E-03	0.0
27	9.40616E-01	1.88500E-01	9.35823E-01	8.03720E-03	0.0
28	9.70689E-01	1.95167E-01	9.37164E-01	7.83672E-03	0.0
29	8.92884E-01	2.01000E-01	9.35524E-01	7.71729E-03	0.0
30	9.10282E-C1	2.08000E-01	9.34622E-01	7.49037E-03	0.0
31	9.20734E-01	2.14667E-01	9.34143E-01	7.24341E-03	0.0
32	9.70186E-01	2.21833E-01	9.35344E-01	7.10008E-03	0.0
33	9.77310E-01	2.29167E-01	9.36698E-01	6.99851E-03	0.0
34	9.18911E-01	2.35167E-01	9.36142E-01	6.80012E-03	0.0
35	9.79603E-01	2.43000E-01	9.37459E-01	6.72080E-03	0.0
36	9.55138E-01	2.50167E-01	9.37978E-01	6.54187E-03	0.0
37	9.16220E-01	2.56667E-01	9.37357E-01	6.38250E-03	0.0
38	9.96674E-01	2.64333E-01	9.39004E-01	6.41703E-03	0.0
39	9.29095E-01	2.70833E-01	9.38736E-01	6.24669E-03	0.0
40	9.43160E-01	2.77167E-01	9.38852E-01	6.08223E-03	0.0
41	9.70202E-01	2.84667E-01	9.39656E-01	5.97823E-03	0.0
42	8.37832E-01	2.90500E-01	9.37110E-01	6.35824E-03	0.0
43	8.95768E-01	2.96667E-01	9.36102E-01	6.28277E-03	0.0
44	8.87213E-01	3.03833E-01	9.34938E-01	6.24095E-03	0.0
45	9.87986E-01	3.11833E-01	9.36171E-01	6.21800E-03	0.0
46	9.97082E-01	3.20000E-01	9.37555E-01	6.23184E-03	0.0
47	9.21852E-01	3.25500E-01	9.37206E-01	6.10196E-03	0.0
48	9.41177E-01	3.32167E-01	9.37293E-01	5.96812E-03	0.0
49	8.67363E-01	3.38000E-01	9.35805E-01	6.02639E-03	0.0
50	9.51818E-01	3.45000E-01	9.36138E-01	5.90862E-03	0.0
51	9.28585E-01	3.51833E-01	9.35984E-01	5.78934E-03	0.0
52	9.73013E-01	3.59667E-01	9.36724E-01	5.72061E-03	0.0
53	9.05999E-01	3.65500E-01	9.36122E-01	5.64002E-03	0.0
54	9.37279E-01	3.73000E-01	9.36144E-01	5.53061E-03	0.0
55	8.94740E-01	3.79167E-01	9.35362E-01	5.48168E-03	0.0
56	9.19820E-01	3.85500E-01	9.35074E-01	5.38667E-03	0.0
57	9.62928E-01	3.93333E-01	9.35581E-01	5.31210E-03	0.0
58	1.C0385E 00	4.00833E-01	9.36800E-01	5.35685E-03	0.0
59	9.23351E-01	4.06667E-01	9.36564E-01	5.26775E-03	0.0

60	9.49840E-01	4.13000E-01	9.36792E-01	5.18163E-03	0.0
61	8.92048E-01	4.19333E-01	9.36034E-01	5.14925E-03	0.0
62	9.56534E-01	4.26333E-01	9.36375E-01	5.07437E-03	0.0
63	9.33243E-01	4.33833E-01	9.36324E-01	4.99057E-03	0.0
64	9.71819E-01	4.41000E-01	9.36897E-01	4.94278E-03	0.0
65	9.98736E-01	4.49333E-01	9.37878E-01	4.96152E-03	0.0
66	8.75902E-01	4.55833E-01	9.36910E-01	4.97847E-03	0.0
67	8.54151E-01	4.61000E-01	9.35636E-01	5.06426E-03	0.0
68	9.21401E-01	4.68333E-01	9.35420E-01	4.99193E-03	0.0
69	8.74640E-01	4.74167E-01	9.34513E-01	4.99996E-03	0.0
70	9.25732E-01	4.80833E-01	9.34384E-01	4.92797E-03	0.0
71	9.67717E-01	4.88333E-01	9.34867E-01	4.87985E-03	0.0
72	9.77433E-01	4.96333E-01	9.35475E-01	4.84784E-03	0.0
73	9.66022E-01	5.04167E-01	9.35905E-01	4.79855E-03	0.0
74	9.06166E-01	5.11333E-01	9.35492E-01	4.74964E-03	0.0
75	9.46073E-01	5.19167E-01	9.35637E-01	4.68687E-03	0.0
76	9.02238E-01	5.25833E-01	9.35185E-01	4.64492E-03	0.0
77	8.97658E-01	5.31667E-01	9.34685E-01	4.61028E-03	0.0
78	9.14743E-01	5.38500E-01	9.34422E-01	4.55691E-03	0.0
79	8.70791E-01	5.44667E-01	9.33596E-01	4.57260E-03	0.0
80	8.62886E-01	5.50500E-01	9.32689E-01	4.60366E-03	0.0
81	9.34002E-01	5.58833E-01	9.32706E-01	4.54523E-03	0.0
82	9.23164E-01	5.66667E-01	9.32586E-01	4.48965E-03	0.0
83	8.96902E-01	5.73500E-01	9.32146E-01	4.45573E-03	0.0
84	9.94820E-01	5.81667E-01	9.32910E-01	4.46702E-03	0.0
85	9.63124E-01	5.89333E-01	9.33274E-01	4.42773E-03	0.0
86	9.86756E-01	5.97500E-01	9.33911E-01	4.42068E-03	0.0
87	9.47050E-01	6.05000E-01	9.34065E-01	4.37146E-03	0.0
88	9.29918E-01	6.12500E-01	9.34017E-01	4.32059E-03	0.0
89	9.33280E-01	6.18333E-01	9.34008E-01	4.27064E-03	0.0
90	9.19460E-01	6.25167E-01	9.33843E-01	4.22532E-03	0.0

THE MATRIX K-EFF IS THE LARGEST EIGENVALUE OF THE MATRIX OF FISSION PROBABILITIES BY UNIT.
THERE ARE NBXMAX * NBYMAX * NBZMAX UNITS IN AN ARRAY.

SAMPLE PROBLEM 8 2C8 SPACING SEARCH

LIFETIME = 1.09773E-08 + OR - 6.59320E-11 GENERATION TIME = 7.01510E-09 + OR - 7.94819E-11

NO. OF INITIAL GENERATIONS SKIPPED	AVERAGE K-EFFECTIVE	DEVIATION	67 PER CENT CONFIDENCE INTERVAL	95 PER CENT CONFIDENCE INTERVAL	99 PER CENT CONFIDENCE INTERVAL	NUMBER OF HISTORIES
3	0.93470	+ OR - 0.00418	0.93052 TO 0.93888	0.92633 TO 0.94306	0.92215 TO 0.94724	26100
4	0.93433	+ OR - 0.00421	0.93012 TO 0.93854	0.92590 TO 0.94276	0.92169 TO 0.94697	25800
5	0.93415	+ OR - 0.00426	0.92989 TO 0.93841	0.92563 TO 0.94267	0.92137 TO 0.94693	25500
6	0.93374	+ OR - 0.00429	0.92945 TO 0.93803	0.92516 TO 0.94232	0.92087 TO 0.94661	25200
7	0.93355	+ OR - 0.00434	0.92921 TO 0.93788	0.92487 TO 0.94222	0.92053 TO 0.94656	24900
8	0.93363	+ OR - 0.00439	0.92924 TO 0.93802	0.92485 TO 0.94241	0.92046 TO 0.94680	24600
9	0.93373	+ OR - 0.00444	0.92929 TO 0.93818	0.92485 TO 0.94262	0.92040 TO 0.94707	24300
10	0.93448	+ OR - 0.00444	0.93004 TO 0.93892	0.92561 TO 0.94335	0.92117 TO 0.94779	24000
11	0.93392	+ OR - 0.00446	0.92946 TO 0.93837	0.92501 TO 0.94283	0.92055 TO 0.94728	23700
12	0.93312	+ OR - 0.00444	0.92868 TO 0.93756	0.92424 TO 0.94200	0.91980 TO 0.94644	23400
17	0.93194	+ OR - 0.00446	0.92748 TO 0.93641	0.92301 TO 0.94087	0.91855 TO 0.94533	21900
22	0.93364	+ OR - 0.00464	0.92900 TO 0.93828	0.92435 TO 0.94292	0.91971 TO 0.94757	20400
27	0.93306	+ OR - 0.00500	0.92806 TO 0.93806	0.92306 TO 0.94305	0.91806 TO 0.94805	18900
32	0.93307	+ OR - 0.00529	0.92778 TO 0.93836	0.92249 TO 0.94365	0.91720 TO 0.94894	17400
37	0.93152	+ OR - 0.00563	0.92590 TO 0.93715	0.92027 TO 0.94278	0.91464 TO 0.94841	15900
42	0.93112	+ OR - 0.00567	0.92545 TO 0.93680	0.91978 TO 0.94247	0.91410 TO 0.94814	14400
47	0.93033	+ OR - 0.00585	0.92448 TO 0.93617	0.91863 TO 0.94202	0.91279 TO 0.94787	12900
52	0.93005	+ OR - 0.00628	0.92378 TO 0.93633	0.91750 TO 0.94260	0.91123 TO 0.94888	11400
57	0.93095	+ OR - 0.00704	0.92391 TO 0.93799	0.91688 TO 0.94502	0.90984 TO 0.95206	9900
62	0.92842	+ OR - 0.00765	0.92077 TO 0.93607	0.91313 TO 0.94371	0.90548 TO 0.95136	8400
67	0.92878	+ OR - 0.00758	0.92120 TO 0.93636	0.91362 TO 0.94394	0.90604 TO 0.95152	6900
72	0.92750	+ OR - 0.00851	0.91899 TO 0.93601	0.91048 TO 0.94452	0.90197 TO 0.95303	5400
77	0.92899	+ OR - 0.01084	0.91815 TO 0.93983	0.90732 TO 0.95067	0.89648 TO 0.96150	3900
82	0.94641	+ OR - 0.01186	0.93456 TO 0.95827	0.92270 TO 0.97013	0.91084 TO 0.98198	2400
87	0.92755	+ OR - 0.00416	0.92339 TO 0.93171	0.91923 TO 0.93587	0.91507 TO 0.94004	900

```
SAMPLE PROBLEM    8  2C8 SPACING SEARCH

THE MINIMUM DEVIATION OF    0.00418 OCCURS AFTER SKIPPING   3 GENERATIONS.  THE CORRESPONDING K-EFFECTIVE IS    0.93470

THE DESIRED VALUE OF K-EFFECTIVE IS    1.00000   + CR -     1 STANDARD DEVIATIONS

ITERATION NO.     1  OF A MAXIMUM OF    3  ITERATICNS.


REGION NUMBER      1  WILL NOT BE ALTERED.
***  CYLINDER      1  RADIUS = 5.7480E 00, +Z = 5.3825E 00, -Z =-5.3825E 00                                                         ***
SEARCH CONSTANTS              0.0                0.0                0.0


REGION NUMBER      2  WILL BE ALTERED.
***  CUBOID        0       +X = 7.0635E 00, -X =-7.0635E 00, +Y = 7.0635E 00, -Y =-7.0635E 00, +Z = 6.6882E 00, -Z =-6.6882E 00   ***
SEARCH CONSTANTS                 -1.0000E 00       -1.0000E 00       -1.0000E 00       -1.0000E 00       -1.0000E 00       -1.0000E 00
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SAMPLE PROBLEM    8  2C8 SPACING SEARCH

AFTER SKIPPING   3 GENERATIONS. THE TOTAL LEAKAGE =  5.95276D-01   TOTAL ABSCRPTIONS =  4.03760D-01   TOTAL FISSIONS =  9.34702D-01

ELAPSED TIME   0.62517MINUTES
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SAMPLE PROBLEM    8  2C8 SPACING SEARCH

                                FREQUENCY FOR GENERATICNS    4 TO   87
0.8224 TO 0.8455     *
0.8455 TO 0.8686     ***
0.8686 TO 0.8917     ********
0.8917 TO 0.9148     *************
0.9148 TO 0.9379     *****************
0.9379 TO 0.9610     *****************
0.9610 TO 0.9841     ***************
0.9841 TO 1.0072     *********
1.0072 TO 1.0303     *

                                FREQUENCY FOR GENERATICNS   25 TO   87
0.8224 TO 0.8455     *
0.8455 TO 0.8686     ***
0.8686 TO 0.8917     ****
0.8917 TO 0.9148     ***********
0.9148 TO 0.9379     ***************
0.9379 TO 0.9610     **********
0.9610 TO 0.9841     ************
0.9841 TO 1.0072     *******
1.0072 TO 1.0303

                                FREQUENCY FOR GENERATICNS   46 TO   87
0.8224 TO 0.8455
0.8455 TO 0.8686     ***
0.8686 TO 0.8917     ***
0.8917 TO 0.9148     ********
0.9148 TO 0.9379     **********
0.9379 TO 0.9610     ******
0.9610 TO 0.9841     *******
0.9841 TO 1.0072     *****
1.0072 TO 1.0303

                                FREQUENCY FOR GENERATICNS   67 TO   87
0.8224 TO 0.8455
0.8455 TO 0.8686     **
0.8686 TO 0.8917     **
0.8917 TO 0.9148     *****
0.9148 TO 0.9379     ****
0.9379 TO 0.9610     **
0.9610 TO 0.9841     ****
0.9841 TO 1.0072     **
1.0072 TO 1.0303
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SAMPLE PROBLEM    8  2C8 SPACING SEARCH

 VOLUMES

 BOX TYPE      1
         REGION DEFINED BY GEOMETRY CARD      1    VOLUME =    1.11737E 03 CM**3       CUMULATIVE VOLUME =    1.11737E 03 CM**3
         REGION DEFINED BY GEOMETRY CARD      2    VOLUME =    1.55220E 03 CM**3       CUMULATIVE VOLUME =    2.66957E 03 CM**3

 TOTAL VOLUMES
    1        8.93896E 03
    2        1.24176E 04

VOLUME FRACTION OF THE CORE CONTAINING FISSILE MATERIAL= 0.41856E 00

START TYPE =     0

  300 NEUTRONS WERE INITIALLY STARTED
0.00200 MINUTES WERE REQUIRED FOR STARTING.
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SAMPLE PROBLEM 8 2C8 SPACING SEARCH

WARNING - ONLY 290 INDEPENDENT FISSION POINTS WERE GENERATED.

GENERATION	K-EFFECTIVE	ELAPSED TIME(MIN)	AVG. K-EFF	DEVIATION	MATRIX K-EFF
1	8.65193E-01	7.50000E-03	1.00000E 00	0.0	0.0
2	9.87538E-01	1.36667E-02	1.00000E 00	0.0	0.0
3	9.91086E-01	2.11667E-02	9.91086E-01	0.0	0.0
4	1.00331E 00	2.78333E-02	9.97198E-01	6.16183E-03	0.0
5	9.22805E-01	3.41667E-02	9.72400E-01	2.50539E-02	0.0
6	1.02644E 00	4.25000E-02	9.85909E-01	2.22766E-02	0.0
7	1.05132E 00	5.23333E-02	9.98991E-01	2.16533E-02	0.0
8	1.03439E 00	6.00000E-02	1.00489E 00	1.86470E-02	0.0
9	8.99668E-01	6.58333E-02	9.89858E-01	2.17735E-02	0.0
10	1.02828E 00	7.41667E-02	9.94661E-01	1.94579E-02	0.0
11	9.00489E-01	7.98333E-02	9.84198E-01	2.00992E-02	0.0
12	9.75938E-01	8.86666E-02	9.83372E-01	1.79964E-02	0.0
13	9.55818E-01	9.58333E-02	9.80867E-01	1.64700E-02	0.0
14	1.03329E 00	1.03333E-01	9.85235E-01	1.56567E-02	0.0
15	1.00716E 00	1.11500E-01	9.86922E-01	1.45005E-02	0.0
16	9.71764E-01	1.18167E-01	9.85839E-01	1.34683E-02	0.0
17	9.74173E-01	1.24833E-01	9.85062E-01	1.25625E-02	0.0
18	9.37354E-01	1.31167E-01	9.82080E-01	1.21237E-02	0.0
19	9.77828E-01	1.37833E-01	9.81829E-01	1.13915E-02	0.0
20	1.01219E 00	1.44167E-01	9.83515E-01	1.08745E-02	0.0
21	9.07180E-01	1.49500E-01	9.79497E-01	1.10458E-02	0.0
22	1.00626E 00	1.56667E-01	9.80835E-01	1.05646E-02	0.0
23	1.02364E 00	1.64833E-01	9.82873E-01	1.02526E-02	0.0
24	9.64448E-01	1.70833E-01	9.82036E-01	9.80999E-03	0.0
25	9.48737E-01	1.77833E-01	9.80587E-01	9.48614E-03	0.0
26	9.81827E-01	1.84500E-01	9.80639E-01	9.08427E-03	0.0
27	1.01630E 00	1.92333E-01	9.82065E-01	8.82896E-03	0.0
28	1.03690E 00	2.00667E-01	9.84174E-01	8.74187E-03	0.0
29	9.49191E-01	2.07833E-01	9.82878E-01	8.51078E-03	0.0
30	1.03200E 00	2.15833E-01	9.84632E-01	8.38769E-03	0.0
31	1.03755E 00	2.25000E-01	9.86456E-01	8.29821E-03	0.0
32	8.81952E-01	2.30667E-01	9.82972E-01	8.74158E-03	0.0
33	1.00551E 00	2.37333E-01	9.83699E-01	8.48624E-03	0.0
34	9.52963E-01	2.44167E-01	9.82738E-01	8.27270E-03	0.0
35	9.09560E-01	2.50000E-01	9.80520E-01	8.31994E-03	0.0
36	9.81010E-01	2.57333E-01	9.80535E-01	8.07187E-03	0.0
37	9.45678E-01	2.63667E-01	9.79538E-01	7.90197E-03	0.0
38	9.75448E-01	2.71167E-01	9.79424E-01	7.68137E-03	0.0
39	9.50773E-01	2.78167E-01	9.78650E-01	7.51192E-03	0.0
40	9.92579E-01	2.85667E-01	9.79016E-01	7.32092E-03	0.0
41	9.45137E-01	2.92333E-01	9.78147E-01	7.18410E-03	0.0
42	9.91162E-01	3.00333E-01	9.78472E-01	7.01023E-03	0.0
43	1.00964E 00	3.08667E-01	9.79232E-01	6.87983E-03	0.0
44	9.19839E-01	3.15000E-01	9.77818E-01	6.86183E-03	0.0
45	9.82724E-01	3.22833E-01	9.77931E-01	6.70239E-03	0.0
46	1.03698E 00	3.32333E-01	9.79273E-01	6.68451E-03	0.0
47	9.35088E-01	3.39167E-01	9.78291E-01	6.60822E-03	0.0
48	1.05160E 00	3.46667E-01	9.79885E-01	6.65678E-03	0.0
49	1.06686E 00	3.56167E-01	9.81735E-01	6.77185E-03	0.0
50	1.03105E 00	3.64167E-01	9.82762E-01	6.70888E-03	0.0
51	1.00537E 00	3.71667E-01	9.83223E-01	6.58718E-03	0.0
52	8.55318E-01	3.77000E-01	9.80665E-01	6.94259E-03	0.0
53	9.70221E-01	3.84167E-01	9.80460E-01	6.80815E-03	0.0
54	1.02313E 00	3.92333E-01	9.81280E-01	6.72650E-03	0.0
55	8.74031E-01	3.98167E-01	9.79257E-01	6.90185E-03	0.0
56	1.00845E 00	4.05833E-01	9.79797E-01	6.79477E-03	0.0
57	9.99521E-01	4.13667E-01	9.80156E-01	6.68012E-03	0.0
58	1.01310E 00	4.21667E-01	9.80744E-01	6.58637E-03	0.0
59	9.72997E-01	4.28667E-01	9.80608E-01	6.47137E-03	0.0

60	9.71305E-01	4.35333E-01	9.80447E-01	6.36066E-03	0.0
61	9.52872E-01	4.43167E-01	9.80658E-01	6.25617E-03	0.0
62	9.68557E-01	4.50667E-01	9.80456E-01	6.15437E-03	0.0
63	9.76670E-01	4.58333E-01	9.80394E-01	6.05277E-03	0.0
64	9.38465E-01	4.65000E-01	9.79717E-01	5.99252E-03	0.0
65	9.58309E-01	4.71667E-01	9.79377E-01	5.90685E-03	0.0
66	9.56670E-01	4.78333E-01	9.79023E-01	5.82455E-03	0.0
67	1.01035E 00	4.86167E-01	9.79504E-01	5.75449E-03	0.0
68	1.01133E 00	4.94000E-01	9.79986E-01	5.68736E-03	0.0
69	9.41916E-01	5.01167E-01	9.79418E-01	5.63033E-03	0.0
70	9.57673E-01	5.07500E-01	9.79098E-01	5.55623E-03	0.0
71	9.18929E-01	5.13667E-01	9.78226E-01	5.54430E-03	0.0
72	9.72441E-01	5.20667E-01	9.78143E-01	5.46556E-03	0.0
73	9.24686E-01	5.26667E-01	9.77390E-01	5.44048E-03	0.0
74	9.99361E-01	5.33667E-01	9.77695E-01	5.37297E-03	0.0
75	1.09964E 00	5.43167E-01	9.79366E-01	5.55632E-03	0.0
76	9.69500E-01	5.50000E-01	9.79232E-01	5.48236E-03	0.0
77	1.01055E 00	5.56500E-01	9.79650E-01	5.42481E-03	0.0
78	1.06433E 00	5.65000E-01	9.80764E-01	5.46773E-03	0.0
79	9.80770E-01	5.72000E-01	9.80764E-01	5.39637E-03	0.0
80	9.67755E-01	5.79167E-01	9.80597E-01	5.32942E-03	0.0
81	1.01289E 00	5.87000E-01	9.81006E-01	5.27773E-03	0.0
82	9.41482E-01	5.93333E-01	9.80511E-01	5.23508E-03	0.0
83	9.64275E-01	6.00667E-01	9.80311E-01	5.17418E-03	0.0
84	9.89204E-01	6.07333E-01	9.80419E-01	5.11193E-03	0.0
85	1.06833E 00	6.16500E-01	9.81478E-01	5.16002E-03	0.0
86	9.54606E-01	6.23333E-01	9.81158E-01	5.10829E-03	0.0
87	1.00799E 00	6.30833E-01	9.81474E-01	5.05812E-03	0.0
88	9.94458E-01	6.37833E-01	9.81625E-01	5.00143E-03	0.0
89	1.01450E 00	6.47000E-01	9.82002E-01	4.95796E-03	0.0
90	1.00119E 00	6.55667E-01	9.82220E-01	4.90640E-03	0.0

THE MATRIX K-EFF IS THE LARGEST EIGENVALUE OF THE MATRIX OF FISSION PROBABILITIES BY UNIT.
THERE ARE NBXMAX * NBYMAX * NBZMAX UNITS IN AN ARRAY.

SAMPLE PROBLEM 8 2C8 SPACING SEARCH

LIFETIME = 1.06801E-08 + OR - 6.81662E-11 GENERATION TIME = 7.32666E-09 + OR - 7.20140E-11

NO. OF INITIAL GENERATIONS SKIPPED	AVERAGE K-EFFECTIVE	DEVIATION	67 PER CENT CONFIDENCE INTERVAL	95 PER CENT CONFIDENCE INTERVAL	99 PER CENT CONFIDENCE INTERVAL	NUMBER OF HISTORIES
3	0.98212	+ OR - 0.00495	0.97717 TO 0.98707	0.97221 TO 0.99202	0.96726 TO 0.99698	26100
4	0.98187	+ OR - 0.00500	0.97687 TO 0.98688	0.97186 TO 0.99188	0.96686 TO 0.99689	25800
5	0.98257	+ OR - 0.00502	0.97755 TO 0.98758	0.97254 TO 0.99260	0.96752 TO 0.99761	25500
6	0.98205	+ OR - 0.00505	0.97700 TO 0.98709	0.97195 TO 0.99214	0.96690 TO 0.99719	25200
7	0.98121	+ OR - 0.00504	0.97617 TO 0.98625	0.97113 TO 0.99129	0.96610 TO 0.99633	24900
8	0.98056	+ OR - 0.00506	0.97550 TO 0.98562	0.97045 TO 0.99068	0.96539 TO 0.99574	24600
9	0.98156	+ OR - 0.00502	0.97654 TO 0.98658	0.97152 TO 0.99160	0.96650 TO 0.99662	24300
10	0.98098	+ OR - 0.00505	0.97593 TO 0.98603	0.97088 TO 0.99107	0.96583 TO 0.99612	24000
11	0.98200	+ OR - 0.00501	0.97699 TO 0.98700	0.97198 TO 0.99201	0.96697 TO 0.99702	23700
12	0.98207	+ OR - 0.00507	0.97700 TO 0.98715	0.97193 TO 0.99222	0.96686 TO 0.99729	23400
17	0.98164	+ OR - 0.00535	0.97629 TO 0.98699	0.97094 TO 0.99233	0.96559 TO 0.99768	21900
22	0.98263	+ OR - 0.00557	0.97706 TO 0.98820	0.97149 TO 0.99377	0.96593 TO 0.99933	20400
27	0.98228	+ OR - 0.00592	0.97636 TO 0.98821	0.97044 TO 0.99413	0.96452 TO 1.00005	18900
32	0.98183	+ OR - 0.00596	0.97588 TO 0.98779	0.96992 TO 0.99374	0.96397 TO 0.99970	17400
37	0.98399	+ OR - 0.00629	0.97770 TO 0.99029	0.97141 TO 0.99658	0.96512 TO 1.00287	15900
42	0.98535	+ OR - 0.00686	0.97849 TO 0.99221	0.97163 TO 0.99907	0.96477 TO 1.00593	14400
47	0.98634	+ OR - 0.00729	0.97904 TO 0.99363	0.97175 TO 1.00092	0.96446 TO 1.00821	12900
52	0.98427	+ OR - 0.00683	0.97744 TO 0.99110	0.97061 TO 0.99793	0.96378 TO 1.00476	11400
57	0.98566	+ OR - 0.00694	0.97872 TO 0.99261	0.97178 TO 0.99955	0.96484 TO 1.00649	9900
62	0.98600	+ OR - 0.00808	0.97792 TO 0.99409	0.96984 TO 1.00217	0.96175 TO 1.01026	8400
67	0.98990	+ OR - 0.00938	0.98052 TO 0.99928	0.97115 TO 1.00865	0.96177 TO 1.01803	6900
72	0.99808	+ OR - 0.01056	0.98752 TO 1.00865	0.97696 TO 1.01921	0.96639 TO 1.02977	5400
77	0.99706	+ OR - 0.01058	0.98648 TO 1.00764	0.97590 TO 1.01821	0.96533 TO 1.02879	3900
82	0.99932	+ OR - 0.01227	0.98705 TO 1.01158	0.97479 TO 1.02385	0.96252 TO 1.03611	2400
87	1.00338	+ OR - 0.00589	0.99749 TO 1.00927	0.99160 TO 1.01516	0.98571 TO 1.02105	900

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SAMPLE PROBLEM    8  2C8 SPACING SEARCH

THE MINIMUM DEVIATION OF    0.00495 OCCURS AFTER SKIPPING   3 GENERATIONS.  THE CORRESPONDING K-EFFECTIVE IS    0.98212

THE DESIRED VALUE OF K-EFFECTIVE IS     1.00000    + OR -     1 STANDARD DEVIATIONS

ITERATION NO.     2  OF A MAXIMUM OF    3  ITERATIONS.

REGION NUMBER      1  WILL NOT BE ALTERED.
***  CYLINDER      1  RADIUS = 5.7480E 00, +Z = 5.3825E 00, -Z =-5.3825E 00                                                      ***
SEARCH CONSTANTS               0.0               0.0               0.0

REGION NUMBER      2  WILL BE ALTERED.
***  CUBOID        0      +X = 6.8774E 00, -X =-6.8774E 00, +Y = 6.8774E 00, -Y =-6.8774E 00, +Z = 6.5120E 00, -Z =-6.5120E 00   ***
SEARCH CONSTANTS            -1.4733E 00       -1.4733E 00       -1.4733E 00       -1.4733E 00       -1.4733E 00       -1.4733E 00
```

SAMPLE PROBLEM 8 2C8 SPACING SEARCH

AFTER SKIPPING 3 GENERATIONS, THE TOTAL LEAKAGE = 5.75147D-01 TOTAL ABSCRPTIONS = 4.24941D-01 TOTAL FISSIONS = 9.82126D-01

ELAPSED TIMF 0.65567MINUTES

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SAMPLE PROBLEM     8  2C8 SPACING SEARCH

                                   FREQUENCY FOR GENERATICNS    4 TO   87
0.8346 TO 0.8577     *
0.8577 TO 0.8808     *
0.8808 TO 0.9039     ***
0.9039 TO 0.9270     ******
0.9270 TO 0.9501     *********
0.9501 TO 0.9732     *****************
0.9732 TO 0.9963     *************
0.9963 TO 1.0194     *****************
1.0194 TO 1.0425     ***********
1.0425 TO 1.0656     ***
1.0656 TO 1.0887     **
1.0887 TO 1.1118     *

                                   FREQUENCY FOR GENERATICNS   25 TO   87
0.8346 TO 0.8577     *
0.8577 TO 0.8808     *
0.8808 TO 0.9039     *
0.9039 TO 0.9270     ****
0.9270 TO 0.9501     ********
0.9501 TO 0.9732     **************
0.9732 TO 0.9963     **********
0.9963 TO 1.0194     *************
1.0194 TO 1.0425     ******
1.0425 TO 1.0656     **
1.0656 TO 1.0887     **
1.0887 TO 1.1118     *

                                   FREQUENCY FOR GENERATICNS   46 TO   87
0.8346 TO 0.8577     *
0.8577 TO 0.8808     *
0.8808 TO 0.9039
0.9039 TO 0.9270     **
0.9270 TO 0.9501     ****
0.9501 TO 0.9732     ************
0.9732 TO 0.9963     ****
0.9963 TO 1.0194     **********
1.0194 TO 1.0425     ***
1.0425 TO 1.0656     **
1.0656 TO 1.0887     **
1.0887 TO 1.1118     *

                                   FREQUENCY FOR GENERATICNS   67 TO   87
0.8346 TO 0.8577
0.8577 TO 0.8808
0.8808 TO 0.9039
0.9039 TO 0.9270     **
0.9270 TO 0.9501     **
0.9501 TO 0.9732     ******
0.9732 TO 0.9963     **
0.9963 TO 1.0194     ******
1.0194 TO 1.0425
1.0425 TO 1.0656     *
1.0656 TO 1.0887     *
1.0887 TO 1.1118     *
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SAMPLE PROBLEM    8  2C8 SPACING SEARCH

 VOLUMES

 BOX TYPE      1
          REGION DEFINED BY GEOMETRY CARD      1    VOLUME =     1.11737E 03 CM**3        CUMULATIVE VOLUME =     1.11737E 03 CM**3
          REGION DEFINED BY GEOMETRY CARD      2    VOLUME =     1.34672E 03 CM**3        CUMULATIVE VOLUME =     2.46409E 03 CM**3

 TOTAL VOLUMES
    1       8.93896E 03
    2       1.07738E 04

VOLUME FRACTION OF THE CORE CONTAINING FISSILE MATERIAL= 0.45346E 00

START TYPE =    0

  300 NEUTRONS WERE INITIALLY STARTED
0.00217 MINUTES WERE REQUIRED FOR STARTING.
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SAMPLE PROBLEM 8 2C8 SPACING SEARCH

GENFRATION	K-EFFECTIVE	ELAPSED TIME(MIN)	AVG. K-EFF	CEVIATICN	MATRIX K-EFF
1	9.49329E-01	8.50000E-03	1.00000E 00	0.0	0.0
2	9.67207E-01	1.50000E-02	1.00000E 00	0.0	0.0
3	1.C9156E 00	2.41667E-02	1.09156E 00	0.0	0.0
4	1.06761E 00	3.21667E-02	1.07959E 00	1.20002E-02	0.0
5	1.02057E C0	3.96667E-02	1.05992E 00	2.08422E-02	0.0
6	1.03386E C0	4.63333E-02	1.05340E 00	1.61157E-02	0.0
7	1.04634E 00	5.35000E-02	1.05199E 00	1.25632E-02	0.0
8	9.80797E-01	6.00000E-02	1.04012E 00	1.56859E-02	0.0
9	8.88414E-01	6.58333E-02	1.01845E 00	2.54094E-02	0.0
10	1.08887E 00	7.38333E-02	1.02725E 00	2.37034E-02	0.0
11	9.47517E-01	7.88333E-02	1.01839E 00	2.27038E-02	0.0
12	9.S4675E-01	8.54999E-02	1.01602E 00	2.04431E-02	0.0
13	1.02844E 00	9.26666E-02	1.01715E 00	1.85290E-02	0.0
14	9.44549E-C1	1.00000E-01	1.01110E 00	1.79635E-02	0.0
15	9.68742E-01	1.06833E-01	1.00784E 00	1.68392E-02	0.0
16	1.04425E 00	1.15000E-01	1.01044E 00	1.58094E-02	0.0
17	1.02068E 00	1.21833E-01	1.01112E 00	1.47342E-02	0.0
18	1.06448E 00	1.31000E-01	1.01446E 00	1.41764E-02	0.0
19	1.C5550E C0	1.38833E-01	1.01687E 00	1.35338E-02	0.0
20	1.08462E 00	1.47500E-01	1.02064E 00	1.33038E-02	0.0
21	9.66366E-01	1.53333E-01	1.01778E 00	1.29064E-02	0.0
22	9.43585E-01	1.59167E-01	1.01407E 00	1.27977E-02	0.0
23	1.01564E 00	1.66667E-01	1.01414E 00	1.21718E-02	0.0
24	9.46838E-01	1.73333E-01	1.01108E 00	1.20059E-02	0.0
25	9.55788E-01	1.80833E-01	1.00868E 00	1.17206E-02	0.0
26	9.40199E-01	1.85833E-01	1.00583E 00	1.15817E-02	0.0
27	1.C9208E 00	1.95167E-01	1.00928E 00	1.16303E-02	0.0
28	1.03401E 00	2.03833E-01	1.01023E 00	1.12181E-02	0.0
29	9.92529E-C1	2.10500E-01	1.00957E 00	1.08120E-02	0.0
30	1.04455E 00	2.18333E-01	1.01082E 00	1.04977E-02	0.0
31	9.80443E-01	2.25500E-01	1.00977E 00	1.01789E-02	0.0
32	1.10413E 00	2.32667E-01	1.01292E 00	1.03270E-02	0.0
33	1.04526E C0	2.40833E-01	1.01396E 00	1.00433E-02	0.0
34	1.00929E 00	2.48000E-01	1.01381E 00	9.72617E-03	0.0
35	1.03164E 00	2.55167E-01	1.01435E 00	9.44291E-03	0.0
36	9.42140E-01	2.61333E-01	1.01223E 00	9.40381E-03	0.0
37	8.S3321E-01	2.66833E-01	1.00883E 00	9.74550E-03	0.0
38	1.00453E 00	2.74167E-01	1.00871E 00	9.46957E-03	0.0
39	9.74946E-01	2.81000E-01	1.00780E 00	9.25447E-03	0.0
40	1.01529E 00	2.88000E-01	1.00800E 00	9.01062E-03	0.0
41	1.01436E 00	2.96000E-01	1.00816E 00	8.77906E-03	0.0
42	9.14951E-01	3.01833E-01	1.00583E 00	8.86938E-03	0.0
43	1.03582E 00	3.09667E-01	1.00656E 00	8.67988E-03	0.0
44	1.05308E 00	3.18000E-01	1.00767E 00	8.54484E-03	0.0
45	9.91416E-01	3.25167E-01	1.00729E 00	8.35055E-03	0.0
46	1.C1183E 00	3.31667E-01	1.00739E 00	8.15964E-03	0.0
47	1.C1786E C0	3.40000E-01	1.00763E 00	7.97994E-03	0.0
48	1.05996E 00	3.48000E-01	1.00876E 00	7.88943E-03	0.0
49	1.06174E C0	3.56333E-01	1.00989E 00	7.80055E-03	0.0
50	1.02320E 00	3.63000E-01	1.01017E 00	7.64048E-03	0.0
51	1.C8488E 00	3.71000E-01	1.01169E 00	7.63891E-03	0.0
52	9.75512E-01	3.77167E-01	1.01097E 00	7.51667E-03	0.0
53	8.78216E-01	3.82500E-01	1.00836E 00	7.81616E-03	0.0
54	9.68784E-01	3.90000E-01	1.00760E 00	7.70161E-03	0.0
55	1.00335E 00	3.97500E-01	1.00752E 00	7.55714E-03	0.0
56	1.02252E 00	4.05000E-01	1.00780E 00	7.41911E-03	0.0
57	9.20273E-01	4.11333E-01	1.00621E 00	7.45507E-03	0.0
58	9.S0819E-01	4.18833E-01	1.00593E 00	7.32688E-03	0.0
59	9.88417E-01	4.26333E-01	1.00563E 00	7.20348E-03	0.0
60	9.81806E-01	4.33500E-01	1.00522E 00	7.09181E-03	0.0

61	1.04511E 00	4.41333E-01	1.00589E 00	7.00229E-03	0.0
62	1.00681E 00	4.48333E-01	1.00591E 00	6.88541E-03	0.0
63	9.41917E-01	4.54333E-01	1.00486E 00	6.85219E-03	0.0
64	1.00340E 00	4.61833E-01	1.00483E 00	6.74152E-03	0.0
65	1.01583E 00	4.69333E-01	1.00501E 00	6.63497E-03	0.0
66	1.06365E 00	4.78000E-01	1.00593E 00	6.59474E-03	0.0
67	9.81059E-01	4.86000E-01	1.00554E 00	6.50304E-03	0.0
68	9.83415E-01	4.93500E-01	1.00521E 00	6.41290E-03	0.0
69	1.07946E 00	5.01833E-01	1.00632E 00	6.41389E-03	0.0
70	9.98253E-01	5.10000E-01	1.00620E 00	6.31872E-03	0.0
71	1.03925E 00	5.16833E-01	1.00668E 00	6.24520E-03	0.0
72	9.81228E-01	5.24167E-01	1.00631E 00	6.16848E-03	0.0
73	9.67029E-01	5.30500E-01	1.00576E 00	6.10533E-03	0.0
74	9.65258E-01	5.36833E-01	1.00520E 00	6.04554E-03	0.0
75	9.43908E-01	5.43333E-01	1.00436E 00	6.02103E-03	0.0
76	1.02167E 00	5.50000E-01	1.00459E 00	5.94350E-03	0.0
77	1.01699E 00	5.56833E-01	1.00476E 00	5.86707E-03	0.0
78	9.76686E-01	5.63333E-01	1.00439E 00	5.80049E-03	0.0
79	1.06227E 00	5.71000E-01	1.00514E 00	5.77416E-03	0.0
80	1.01561E 00	5.79667E-01	1.00527E 00	5.69972E-03	0.0
81	9.47208E-01	5.86000E-01	1.00454E 00	5.67601E-03	0.0
82	1.02682E 00	5.93333E-01	1.00482E 00	5.61208E-03	0.0
83	1.02671E 00	6.01000E-01	1.00508E 00	5.54903E-03	0.0
84	9.78720E-01	6.08333E-01	1.00476E 00	5.49114E-03	0.0
85	9.99624E-01	6.15500E-01	1.00470E 00	5.42442E-03	0.0
86	1.01833E 00	6.22667E-01	1.00486E 00	5.36280E-03	0.0
87	1.04805E 00	6.30000E-01	1.00537E 00	5.32226E-03	0.0
88	1.01404E 00	6.37500E-01	1.00547E 00	5.26215E-03	0.0
89	1.05724E 00	6.45167E-01	1.00607E 00	5.23570E-03	0.0
90	9.74901E-01	6.52500E-01	1.00571E 00	5.18654E-03	0.0

THE MATRIX K-EFF IS THE LARGEST EIGENVALUE OF THE MATRIX OF FISSION PROBABILITIES BY UNIT.
THERE ARE NBXMAX * NBYMAX * NBZMAX UNITS IN AN ARRAY.

SAMPLE PROBLEM 8 2C8 SPACING SEARCH

LIFETIME = 1.05710E-08 + OR - 6.70534E-11 GENERATION TIME = 7.49980E-09 + OR - 7.35570E-11

NO. OF INITIAL GENERATIONS SKIPPED	AVERAGE K-EFFECTIVE	DEVIATION	67 PER CENT CONFIDENCE INTERVAL	95 PER CENT CONFIDENCE INTERVAL	99 PER CENT CONFIDENCE INTERVAL	NUMBER OF HISTORIES
3	1.00473	+ OR - 0.00514	0.99958 TO 1.00987	0.99444 TO 1.01501	0.98929 TO 1.02016	26100
4	1.00399	+ OR - 0.00515	0.99884 TO 1.00915	0.99369 TO 1.01430	0.98854 TO 1.01945	25800
5	1.00380	+ OR - 0.00521	0.99859 TO 1.00901	0.99338 TO 1.01422	0.98817 TO 1.01943	25500
6	1.00344	+ OR - 0.00526	0.99818 TO 1.00870	0.99293 TO 1.01396	0.98767 TO 1.01922	25200
7	1.00293	+ OR - 0.00530	0.99763 TO 1.00822	0.99233 TO 1.01352	0.98704 TO 1.01882	24900
8	1.00320	+ OR - 0.00535	0.99784 TO 1.00855	0.99249 TO 1.01390	0.98713 TO 1.01926	24600
9	1.00461	+ OR - 0.00523	0.99938 TO 1.00984	0.99416 TO 1.01507	0.98893 TO 1.02030	24300
10	1.00356	+ OR - 0.00519	0.99837 TO 1.00875	0.99319 TO 1.01393	0.98800 TO 1.01912	24000
11	1.00427	+ OR - 0.00520	0.99907 TO 1.00947	0.99387 TO 1.01467	0.98866 TO 1.01987	23700
12	1.00439	+ OR - 0.00527	0.99913 TO 1.00966	0.99386 TO 1.01493	0.98859 TO 1.02020	23400
17	1.00460	+ OR - 0.00551	0.99910 TO 1.01011	0.99359 TO 1.01561	0.98808 TO 1.02112	21900
22	1.00326	+ OR - 0.00557	0.99769 TO 1.00883	0.99211 TO 1.01440	0.98654 TO 1.01997	20400
27	1.00430	+ OR - 0.00563	0.99867 TO 1.00993	0.99303 TO 1.01557	0.98740 TO 1.02120	18900
32	1.00199	+ OR - 0.00578	0.99621 TO 1.00777	0.99043 TO 1.01355	0.98465 TO 1.01933	17400
37	1.00366	+ OR - 0.00578	0.99787 TO 1.00944	0.99209 TO 1.01522	0.98631 TO 1.02100	15900
42	1.00562	+ OR - 0.00607	0.99955 TO 1.01168	0.99349 TO 1.01775	0.98742 TO 1.02381	14400
47	1.00371	+ OR - 0.00663	0.99709 TO 1.01034	0.99046 TO 1.01696	0.98384 TO 1.02359	12900
52	0.99880	+ OR - 0.00675	0.99205 TO 1.00555	0.98530 TO 1.01230	0.97855 TO 1.01905	11400
57	1.00489	+ OR - 0.00620	0.99868 TO 1.01109	0.99248 TO 1.01730	0.98628 TO 1.02350	9900
62	1.00530	+ OR - 0.00709	0.99821 TO 1.01239	0.99112 TO 1.01948	0.98402 TO 1.02658	8400
67	1.00620	+ OR - 0.00768	0.99851 TO 1.01388	0.99083 TO 1.02157	0.98314 TO 1.02925	6900
72	1.00339	+ OR - 0.00849	0.99490 TO 1.01188	0.98640 TO 1.02038	0.97791 TO 1.02887	5400
77	1.01125	+ OR - 0.00962	1.00162 TO 1.02087	0.99200 TO 1.03049	0.98238 TO 1.04011	3900
82	1.01470	+ OR - 0.01051	1.00419 TO 1.02521	0.99368 TO 1.03572	0.98317 TO 1.04623	2400
87	1.01540	+ OR - 0.02378	0.99162 TO 1.03917	0.96784 TO 1.06295	0.94406 TO 1.08673	900

SAMPLE PROBLEM 8 2C8 SPACING SEARCH

THE MINIMUM DEVIATION OF 0.00514 OCCURS AFTER SKIPPING 3 GENERATIONS. THE CORRESPONDING K-EFFECTIVE IS 1.00473

THE DESIRED VALUE OF K-EFFECTIVE IS 1.00000 + OR - 1 STANDARD DEVIATIONS

*** SEARCH COMPLETED ***

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SAMPLE PROBLEM    8  2C8 SPACING SEARCH

                    THE SEARCH WAS COMPLETED AFTER  3 PASSES

                THE ELAPSED TIME FCR THE LAST PASS WAS   0.65250 MINUTES

          THE DESIRED VALUE OF K-EFFECTIVE WAS   1.00000   + OR -    1  STANDARD DEVIATIONS

        THE CALCULATED VALUE OF K-EFFECTIVE WAS   1.00473   + OR -   0.00514  AFTER     26100 HISTORIES

THE FINAL GEOMETRY CONFIGURATION WAS AS FOLLOWS

CYLINDER      1  RADIUS = 5.7480E 00, +Z = 5.3825E 00, -Z =-5.3825E 00

CUBOID        0      +X = 6.8774E 00, -X =-6.8774E 00, +Y = 6.8774E 00, -Y =-6.8774E 00, +Z = 6.5120E 00, -Z =-6.5120E 00
```

SAMPLE PROBLEM 8 2C8 SPACING SEARCH

GROUP	REGION	LEAKAGE	ABSORPTIONS	FISSIONS	WITH 3 GENERATIONS SKIPPED
1		7.767000D-02	5.027020D-02	1.423560D-01	
2		1.432260D-01	9.832770D-02	2.413800D-01	
3		8.588830D-02	6.140600D-02	1.419190D-01	
4		1.451980D-01	1.049150D-01	2.306900D-01	
5		9.820180D-02	9.466820D-02	1.992620D-01	
6		1.100950D-02	2.504350D-02	4.819830D-02	
7		5.297380D-05	4.999730D-04	9.268830D-04	
8		0.0	0.0	0.0	
9		0.0	0.0	0.0	
10		0.0	0.0	0.0	
11		0.0	0.0	0.0	
12		0.0	0.0	0.0	
13		0.0	0.0	0.0	
14		0.0	0.0	0.0	
15		0.0	0.0	0.0	
16		0.0	0.0	0.0	
TOTAL =		5.652470D-01	4.351310-01	1.004730D 00	

ELAPSED TIME 0.65250MINUTES

SAMPLE PROBLEM 8 2C8 SPACING SEARCH

**** FISSION DENSITIES ****

	REGION	FISSION DENSITY	PERCENT DEVIATION	TOTAL FISSICNS
BOX TYPE 1				
	1	1.124E-C4	0.51	1.005E 00
	2	0.0	0.0	0.0

SAMPLE PROBLEM 8 2C8 SPACING SEARCH

FLUXES FOR BOX TYPE 1

GROUP	REGION 1 FLUX	REGION 1 PERCENT DEVIATION	REGION 2 FLUX	REGION 2 PERCENT DEVIATION
1	9.431E-05	1.86	5.261E-05	2.30
2	1.813E-04	1.00	1.021E-04	1.56
3	1.128E-04	1.75	6.344E-05	2.39
4	1.901E-04	1.08	1.048E-04	1.29
5	1.420E-04	1.32	7.531E-05	1.62
6	1.918E-05	3.29	9.259E-06	4.59
7	1.971E-07	24.23	5.896E-08	59.95
8	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0

```
SAMPLE PROBLEM     8  2C8 SPACING SEARCH

                                   FREQUENCY FOR GENERATICNS    4 TO    87
0.8777 TO 0.9008     ***
0.9008 TO 0.9239     **
0.9239 TO 0.9470     *******
0.9470 TO 0.9701     ********
0.9701 TO 0.9932     **************
0.9932 TO 1.0163     **************
1.0163 TO 1.0394     ****************
1.0394 TO 1.0625     ***********
1.0625 TO 1.0856     ******
1.0856 TO 1.1086     ***

                                   FREQUENCY FOR GENERATICNS   25 TO    87
0.8777 TO 0.9008     **
0.9008 TO 0.9239     **
0.9239 TO 0.9470     ****
0.9470 TO 0.9701     *****
0.9701 TO 0.9932     *************
0.9932 TO 1.0163     ************
1.0163 TO 1.0394     ************
1.0394 TO 1.0625     ********
1.0625 TO 1.0856     ***
1.0856 TO 1.1086     **

                                   FREQUENCY FOR GENERATICNS   46 TO    87
0.8777 TO 0.9008     *
0.9008 TO 0.9239     *
0.9239 TO 0.9470     **
0.9470 TO 0.9701     ****
0.9701 TO 0.9932     *********
0.9932 TO 1.0163     ********
1.0163 TO 1.0394     *********
1.0394 TO 1.0625     *****
1.0625 TO 1.0856     ***
1.0856 TO 1.1086

                                   FREQUENCY FOR GENERATICNS   67 TO    87
0.8777 TO 0.9008
0.9008 TO 0.9239
0.9239 TO 0.9470     *
0.9470 TO 0.9701     ***
0.9701 TO 0.9932     *****
0.9932 TO 1.0163     ***
1.0163 TO 1.0394     ******
1.0394 TO 1.0625     **
1.0625 TO 1.0856     *
1.0856 TO 1.1086

********** END OF FILE ON UNIT    5 **********
```

SAMPLE PROB 16 GENERALIZED GECMETRY GROTESQUE

NUMBER OF GENERATIONS	103
NUMBER PFR GENERATION	300
NUMBER OF GENERATIONS TO BE SKIPPED	3
NUMBER OF ENERGY GROUPS	16
MAX. NUMBER OF ENERGY TRANSFERS	6
NUMBER OF INPUT NUCLIDES	2
NUMBER OF MIXTURES	1
NUMBER OF MIXING TABLE ENTRIES	2
NUMBER OF GEOMETRY CARDS	1
NUMBER OF BOX TYPES	1
NUMBER OF UNITS IN X DIRECTION	1
NUMBER OF UNITS IN Y DIRECTION	1
NUMBER OF UNITS IN Z DIRECTION	1
NUMBER OF NUCLIDES READ FROM TAPE	2
ALBEDO TYPE	0
SEARCH TYPE	0

START TYPE	0
GENERATIONS BETWEEN CHECKPOINTS	0
LIST INPUT X-SECTIONS READ FROM TAPE	NC
LIST 1-D MIXTURE X SECTIONS	YES
LIST 2-D MIXTURE X-SECTIONS	YES
LIST FISS. AND ABS. BY REGION	NO
USE X-SECTIONS FROM PREVIOUS CASE	NC
USE GEOMETRY FROM PREVIOUS CASE	NO
USE VELOCITIES FROM PREVIOUS CASE	NO
COMPUTE MATRIX K-EFFECTIVE BY UNIT	NO
COMPUTE MATRIX K-EFFECTIVE BY BOX TYPE	NO
LIST FISS PROB MATRIX BY UNIT	NO
ADJOINT CALCULATION	NO
USE EXPONENTIAL TRANSFORM	NC
CALCULATE FLUX	YES
CALCULATE FISSION DENSITIES	YES

THIS PROBLEM WAS RUN AS A SINGLE UNIT.

MAXIMUM TIME = 1.C000 MINUTES

STORAGE LOCATIONS REQUIRED FOR THIS JOB = 5341
REMAINING AVAILABLE LOCATIONS= 29475

```
SAMPLE PROB 16 GENERALIZED GECMETRY GROTESQUE

     MIXTURE  NUCLIDE   DENSITY
        1     -92500   4.50792E-C2
        1      92800   2.96950E-C3



CROSS SFCTIONS READ FROM TAPE

NUCLIDF =       92500   U-235 YR                             HANSEN ROACH
NUCLIDE =       92800   U-238 Y                              HANSEN ROACH
```

SAMPLE PROB 16 GENERALIZED GEOMETRY GROTESQUE

MIXTURE = 1

GP.	ABSORPTION PROBABILITY	NU*FISSION PROBABILITY	NON-ABSORPTION PROBABILITY	TOTAL CROSS-SECTION	FISSION SPECTRUM
1	2.87423E-01	8.13257E-01	7.12576E-01	2.03465E-01	2.04000E-01
2	2.78765E-01	6.83927E-01	7.21234E-01	2.15922E-01	5.48000E-01
3	2.70799E-01	6.25525E-01	7.29201E-01	2.22981E-01	7.16000E-01
4	2.45089E-01	5.38783E-01	7.54911E-01	2.50002E-01	8.96000E-01
5	1.97927E-01	4.16817E-01	8.02072E-01	3.80475E-01	9.86000E-01
6	2.41056E-01	4.64350E-01	7.58944E-01	5.94616E-01	1.00000E 00
7	3.46151E-01	6.42233E-01	6.53849E-01	7.22269E-01	1.00000E 00
8	5.08498E-01	8.76490E-01	4.91502E-01	9.95713E-01	1.00000E 00
9	7.22514E-01	1.18541E 00	2.77486E-01	1.74227E 00	1.00000E 00
10	8.52644E-01	1.29510E 00	1.47355E-01	3.24059E 00	1.00000E 00
11	8.86442E-01	1.14599E 00	1.13558E-01	4.20506E 00	1.00000E 00
12	8.84658E-01	8.99401E-01	1.15342E-01	4.14002E 00	1.00000E 00
13	7.86517E-01	1.48128E 00	2.13483E-01	2.23679E 00	1.00000E 00
14	8.83119E-01	1.89233E 00	1.16881E-01	4.08549E 00	1.00000E 00
15	9.54858E-01	1.93153E 00	4.51415E-02	1.05782E 01	1.00000E 00
16	9.82963E-01	2.03328E 00	1.70371E-02	2.80281E 01	1.00000E 00

CUMULATIVE TRANSFER PROBABILITIES

FROM I	TO I+ 0	I+ 1	I+ 2	I+ 3	I+ 4	I+ 5
1	3.9879E-01	4.8950E-01	6.1397E-01	8.3225E-01	9.7991E-01	1.0000E 00
2	5.4716E-01	6.2331E-01	8.3556E-01	9.7802E-01	1.0000E 00	1.0000E 00
3	6.9073E-01	8.5782E-01	9.7877E-01	1.0000E 00	1.0000E 00	1.0000E 00
4	8.8817E-01	9.7963E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
5	9.8740E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
6	9.9435E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
7	9.9485E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
8	9.9503E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
9	9.9503E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
10	9.9491E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
I = 11 THRU I= 14 SAME AS ABOVE						
15	9.9591E-01	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00
16	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00

MUBAR

FROM I	TO I+ 0	I+ 1	I+ 2	I+ 3	I+ 4	I+ 5
1	0.0	0.0	0.0	0.0	0.0	0.0
I = 2 THRU I= 16 SAME AS ABOVE						

SAMPLE PROB 16 GENERALIZED GECMETRY GROTESQUE

GEOMETRY DESCRIPTION

REGION

1	GENERAL	1	+X = C.0	-X = 0.0	+Y = 0.0	-Y = 0.0	+Z = 0.0	-Z = 0.0

SAMPLE PROB 16 GENERALIZED GEOMETRY GROTESQUE

WEIGHTING FUNCTION

BOX TYPE 1

REGION 1 DEFINED BY GEOMETRY CARD 1

GROUP	WTLOW	WT AVG	WT HI
1	0.167	0.500	1.500

GROUPS 2 TO 16 SAME AS ABOVE

```
    2      MALE
X BOUNDS    -0.23319E 02,  0.24353E 02
Y BOUNDS    -0.22841E 02,  0.21686E 02
Z BOUNDS    -0.17550E 01,  0.15240E 02

ZONE        1     1     1
X BLOCKS    -0.23319E 02, -0.57569E 01,  0.69433E 01,  0.24353E 02
Y BLOCKS    -0.22841E 02, -0.69433E 01,  0.57569E 01,  0.21686E 02
Z BLOCKS    -0.17550E 01,  0.15240E 02

BLOCK       1     1     1
MEDIA              1, 1000, 1000, 1000
SURFACES          26,   27,   28
SECTOR -1  1 -1
SECTOR  0  0  1
SECTOR  1  0  0
SECTOR  0 -1  0

BLOCK       2     1     1
MEDIA              1,    1,    1, 1000, 1000, 1000, 1000, 1000, 1000, 1000
SURFACES          20,   21,   22,   23,   24,   25,   26,   27,   28
SECTOR -1  1 -1  0  0  0  0  0  0
SECTOR  0  0  0 -1  1 -1  0  0  0
SECTOR  0  0  0  0  0  0 -1  1 -1
SECTOR  0  0  1  0  0  1  0  0  1
SECTOR  0 -1  0  0  0  1  0  0  1
SECTOR  1  0  0  0  0  1  0  0  1
SECTOR  0  0  1  0 -1  0  0  0  1
SECTOR  0  0  1  1  0  0  0  0  1
SECTOR  0  0  1  0  0  1  0 -1  0
SECTOR  0  0  1  0  0  1  1  0  0

BLOCK       3     1     1
MEDIA              1,    1, 1000, 1000, 1000, 1000, 1000
SURFACES          20,   21,   22,   23,   24,   25
SECTOR -1  1 -1  0  0  0
SECTOR  0  0  0 -1  1 -1
SECTOR  0  0  1  0  0  1
SECTOR  1  0  0  0  0  1
SECTOR  0 -1  0  0  0  1
SECTOR  0  0  1  1  0  0
SECTOR  0  0  1  0 -1  0

BLOCK       1     2     1
MEDIA              1,    1,    1, 1000, 1000, 1000, 1000, 1000, 1000
SURFACES           1,    2,    3,    4,   36,   37,   38,   39
SECTOR  0  0 -1  1 -1  0  0  1
SECTOR -1  0  0  1  0 -1  1  0
SECTOR  0 -1  0  1 -1  0  1  0
SECTOR  1  0  0  0  0  0  0  0
SECTOR  0  0  0 -1  0  0  0  0
SECTOR  0  0  0  0  1  0  0  0
SECTOR  0  0  0  0  0  0  0 -1
SECTOR  0  1  0  0  0  1  0  0
SECTOR  0  0  1  0  0  0 -1  0

BLOCK       1     3     1
MEDIA              1, 1000, 1000, 1000
SURFACES           5,    6,    7
SECTOR -1  1 -1
SECTOR  0  0  1
SECTOR  1  0  0
SECTOR  0 -1  0
```

```
BLOCK       2     3     1
MEDIA              1.      1. 1000. 1000. 1000. 1000. 1000
SURFACES           5.      6.     7.     8.     9.    10
SECTOR -1  1 -1  0  0  0
SECTOR  0  0  0 -1  1 -1
SECTOR  0  0  1  0  0  1
SECTOR  1  0  0  0  0  1
SECTOR  0 -1  0  0  0  1
SECTOR  0  0  1  1  0  0
SECTOR  0  0  1  0 -1  0

BLOCK       3     3     1
MEDIA              1.      1. 1000. 1000. 1000. 1000. 1000
SURFACES           8.      9.    10.    11.    12.    13
SECTOR -1  1 -1  0  0  0
SECTOR  0  0  0 -1  1 -1
SECTOR  0  C  1  0  0  1
SECTOR  1  0  0  0  0  1
SECTOR  0 -1  0  0  0  1
SECTOR  0  0  1  1  0  0
SECTOR  0  0  1  0 -1  0

BLOCK       3     2     1
MEDIA              1.      1.     1.     1. 1000. 1000. 1000. 1000. 1000. 1000.
 1000. 1000. 1000. 1000. 1000
SURFACES          11.     12.    13.    20.    21.    22.    34.    14.    35.    15.
   16.    17.    18.    19
SECTOR -1  1 -1  0  0  0  0  0  0  0  0  0  0  0
SECTOR  0  0  0 -1  1 -1  0  0  C  0  0  0  0  0
SECTOR  0  0  0  0  0  0 -1  1 -1  0  0  0  0  0
SECTOR  0  0  0  0  0  0  0 -1  C  1 -1  1 -1  1
SECTOR  0  0  1  0  0  1  1  0  0  0  0  0  0  0
SECTOR  0  0  1  0  0  1  0  1  1  0  0  0  0  0
SECTOR  0  0  1  0  0  1  0 -1  C  0  1  0  0  0
SECTOR  0  0  1  0  0  1  0 -1  C  0  0 -1  0  0
SECTOR  0  0  1  0  0  1  0 -1  C  0  0  0  1  0
SECTOR  0  0  1  0  0  1  0 -1  C  0  0  0  0 -1
SECTOR  0  0  1  0  0  1  0  0  C -1  0  0  0  0
SECTOR  1  0 -1  0  0  0  0  C  C  0  0  0  0  0
SECTOR  0 -1 -1  0  0  0  0  0  C  0  0  0  0  0
SECTOR  0  0  0  0 -1 -1  0  C  C  0  0  0  0  0
SECTOR  0  0  0  1  0 -1  0  0  0  0  0  0  0  0

BLOCK       2     2     1
MEDIA          1000.      1.     1.     1. 1000. 1000
SURFACES          31.     32.    33.    29.    30
SECTOR  0 -1  1  0  0
SECTOR -1  1  0  0  0
SECTOR  0  0 -1  1  0
SECTOR  0  0  0 -1 -1
SECTOR  1  0  1  0  0
SECTOR  0  0  0 -1  1

   39 QUADRIC  SURFACES IN GECMETRY
  0.23560E-01X       0.99572E 00Z       -0.13134E 02      $
  0.23560E-01X       0.99572E 00Z       -0.12815E 02      $
  0.23560E-01X       0.99572E C0Z       -0.10905E 02      $
  0.23560E-01X       0.99572E 00Z        0.25011E 00      $
  0.14870F-01X      -0.19380E-01Y        0.99970E 00Z       -0.12620E 02      $
  0.14870E-01X      -0.19380E-01Y        0.99970E 00Z        0.35570E 00      $
  0.99980E 00XSQ     0.99960E 00YSQ      0.59690E-03ZSQ      0.57660E-03XY
 -0.29740E-01XZ      0.38760E-01YZ       0.17720E 02X       -0.23090E 02Y
 -0.71120E 00Z       0.19110E 03      $
 -0.34240E-02X      -0.30C50E-01Y        0.99950E 00Z       -0.12990E 02      $
 -0.34240E-02X      -0.30050E-C1Y        0.99950E 00Z        0.48170E 00      $
```

0.10000E 01XSQ	0.99910E 00YSQ	0.91490E-03ZSQ	-0.20580E-03XY	
0.68450E-02XZ	0.60080E-01YZ	-0.36020E 01X	-0.31620E 02Y	
-0.96290E 00Z	0.22020E 03	$		
-0.26100E-01X	-0.22290E-01Y	0.99940E 00Z	-0.12460E 02	$
-0.26100E-01X	-0.22290E-01Y	0.99940E 00Z	0.50560E 00	$
0.99930E 00XSQ	0.99550E 00YSQ	0.11780E-02ZSQ	-0.11630E-02XY	
0.52160E-01XZ	0.44550E-01YZ	-0.22380E 02X	-0.19110E 02Y	
-0.10110E 01Z	0.19600E 03	$		
-0.45070E-01X	0.99898E 00Z	-0.83852E 01	$	
-0.45070E-01X	0.99898E 00Z	0.52520E 00	$	
0.99898E 00X	0.45070E-01Z	-0.24340E 02	$	
0.99898E 00X	0.45070E-01Z	-0.11640E 02	$	
0.10000E 01Y	-0.32168E 01	$		
0.10000E 01Y	0.44032E 01	$		
-0.21830E-01X	0.19660E-01Y	0.99960E 00Z	-0.12520E 02	$
-0.21830E-01X	0.19660E-01Y	0.99960E 00Z	0.45570E 00	$
0.99950E 00XSQ	0.99960E 00YSQ	0.86290E-03ZSQ	0.85820E-03XY	
0.43640E-01XZ	-0.39290E-01YZ	-0.23040E 02X	0.20740E 02Y	
-0.91100E 00Z	0.21970E 03	$		
-0.21290E-02X	0.24340E-01Y	0.99970E 00Z	-0.13060E 02	$
-0.21290E-02X	0.24340E-01Y	0.99970E 00Z	0.41760E 00	$
0.10000E 01XSQ	0.99940E 00YSQ	0.59690E-03ZSQ	0.10370E-03XY	
0.42580E-02XZ	-0.48660E-01YZ	-0.29770E 01X	0.34030E 02Y	
-0.83490E 00Z	0.25890E 03	$		
0.11820E-01X	0.15130E-01Y	0.99980E 00Z	-0.12660E 02	$
0.11820E-01X	0.15130E-01Y	0.99980E 00Z	0.29660E 00	$
0.99990E 00XSQ	0.99980E 00YSQ	0.36850E-03ZSQ	-0.35760E-03XY	
-0.23630E-01XZ	-0.30250E-01YZ	0.19020E 02X	0.24340E 02Y	
-0.59320E 00Z	0.21790E 03	$		
0.10000E 01Z	-0.93740E 00	$		
0.10000E 01XSQ	0.10000E 01YSQ	-0.33142E 02	$	
0.10000E 01XSQ	0.10000E 01YSQ	0.10000E 01ZSQ	-0.17226E 01X	
0.65020E 00Y	-0.13312E 02Z	0.81601E 01	$	
0.10000E 01XSQ	0.10000E 01YSQ	0.10000E 01ZSQ	-0.17226E 01X	
0.65020E 00Y	-0.13312E 02Z	0.45094E 02	$	
0.10000E 01Z	-0.66562E 01	$		
-0.45070E-01X	0.99900E 00Z	-0.12700E 02	$	
0.99800E 00XSQ	0.10000E 01YSQ	0.20320E-02ZSQ	0.90050E-01XZ	
-0.32390E 02X	0.11860E 01Y	-0.14610E 01Z	0.24220E 03	$
0.99972E 00X	-0.23560E-01Z	0.10613E 02	$	
0.99972E 00X	-0.23560E-01Z	0.15693E 02	$	
0.99972E 00X	-0.23560E-01Z	0.20773E 02	$	
0.99972E 00X	-0.23560E-01Z	0.23316E 02	$	

```
SAMPLE PROB 16 GENERALIZED GECMETRY GROTESQUE

 VOLUMES

 BOX TYPE      1
          REGION DEFINED BY GEOMETRY CARD      1   VOLUME =    3.60751E 04 CM**3        CUMULATIVE VOLUME =    3.60751E 04 CM**3

 TOTAL VOLUMES
    1        3.60751E 04

VOLUME FRACTION OF THE CORE CCNTAINING FISSILE MATERIAL= 0.10000E 01

START TYPE =    0

 THE NEUTRONS WERE STARTED IN THE ARRAY WITH A FLAT DISTRIBUTION.

  300 NEUTRONS WERE INITIALLY STARTED
0.00883 MINUTES WERE REQUIRED FOR STARTING.
```

SAMPLE PROB 16 GENERALIZED GEOMETRY GROTESQUE

GENERATION	K-EFFECTIVE	ELAPSED TIME(MIN)	AVG. K-EFF	DEVIATION	MATRIX K-EFF
1	8.72581E-01	3.08333E-02	1.00000E 00	0.0	0.0
2	9.01470E-01	5.33333E-02	1.00000E 00	0.0	0.0
3	9.29230E-01	7.68333E-02	9.29230E-01	0.0	0.0
4	8.51639E-01	9.85000E-02	8.90434E-01	3.88022E-02	0.0
5	9.88196E-01	1.25500E-01	9.23021E-01	3.95444E-02	0.0
6	1.02334E 00	1.53000E-01	9.48100E-01	3.75609E-02	0.0
7	1.03137E 00	1.79167E-01	9.64753E-01	3.35231E-02	0.0
8	1.01251E 00	2.05167E-01	9.72713E-01	2.85053E-02	0.0
9	9.70096E-01	2.30000E-01	9.72339E-01	2.40942E-02	0.0
10	1.03442E 00	2.55833E-01	9.80100E-01	2.22622E-02	0.0
11	9.97580E-01	2.81000E-01	9.82042E-01	1.97296E-02	0.0
12	9.95473E-01	3.05167E-01	9.83385E-01	1.76981E-02	0.0
13	9.22024E-01	3.28500E-01	9.77807E-01	1.69524E-02	0.0
14	1.01999E 00	3.54667E-01	9.81322E-01	1.58695E-02	0.0
15	8.95723E-01	3.76833E-01	9.74737E-01	1.60142E-02	0.0
16	9.56894E-01	4.01667E-01	9.73463E-01	1.48810E-02	0.0
17	9.99876E-01	4.26833E-01	9.75224E-01	1.39649E-02	0.0
18	1.05211E 00	4.53500E-01	9.80029E-01	1.39187E-02	0.0
19	1.00636E 00	4.79167E-01	9.81577E-01	1.31659E-02	0.0
20	1.03973E 00	5.04333E-01	9.84807E-01	1.28275E-02	0.0
21	9.90795E-01	5.29167E-01	9.85122E-01	1.21404E-02	0.0
22	1.05161E 00	5.55500E-01	9.88446E-01	1.19883E-02	0.0
23	1.04593E 00	5.81000E-01	9.91183E-01	1.17266E-02	0.0
24	1.01630E 00	6.04667E-01	9.92325E-01	1.12398E-02	0.0
25	9.95562E-01	6.29333E-01	9.92465E-01	1.07407E-02	0.0
26	9.54012E-01	6.51667E-01	9.90863E-01	1.04067E-02	0.0
27	9.23793E-01	6.75000E-01	9.88180E-01	1.03363E-02	0.0
28	9.27173E-01	6.98500E-01	9.85833E-01	1.02037E-02	0.0
29	1.01951E 00	7.23833E-01	9.87080E-01	9.89749E-03	0.0
30	1.00870E 00	7.48333E-01	9.87852E-01	9.56867E-03	0.0
31	1.17670E 00	7.76833E-01	9.94364E-01	1.12981E-02	0.0
32	1.04433E 00	8.01333E-01	9.96030E-01	1.10407E-02	0.0
33	1.00510E 00	8.27167E-01	9.96322E-01	1.06822E-02	0.0
34	1.01283E 00	8.53333E-01	9.96838E-01	1.03566E-02	0.0
35	9.65980E-01	8.80000E-01	9.95900E-01	1.00814E-02	0.0
36	9.59780E-01	9.05000E-01	9.94838E-01	9.83786E-03	0.0
37	1.05439E 00	9.31833E-01	9.96539E-01	9.70395E-03	0.0
38	1.04151E 00	9.57500E-01	9.97788E-01	9.51272E-03	0.0
39	1.00669E 00	9.82500E-01	9.98028E-01	9.25536E-03	0.0
40	1.00717E 00	1.00683E 00	9.98268E-01	9.01267E-03	0.0

THE MATRIX K-EFF IS THE LARGEST EIGENVALUE OF THE MATRIX OF FISSION PROBABILITIES BY UNIT.
THERE ARE NBXMAX * NBYMAX * NBZMAX UNITS IN AN ARRAY.

SAMPLE PROB 16 GENERALIZED GECMETRY GROTESQUE

LIFETIME = 6.48759E-09 + OR - 8.42788E-11 GENERATION TIME = 5.71515E-09 + OR - 8.71827E-11

NO. OF INITIAL GENERATIONS SKIPPED	AVERAGE K-EFFECTIVE	DEVIATION	67 PER CENT CONFIDENCE INTERVAL	95 PER CENT CONFIDENCE INTERVAL	99 PER CENT CONFIDENCE INTERVAL	NUMBER OF HISTORIES
3	1.00013	+ OR - 0.00906	0.99108 TO 1.00919	0.98202 TO 1.01825	0.97296 TO 1.02730	11100
4	1.00426	+ OR - 0.00829	0.99597 TO 1.01255	0.98768 TO 1.02084	0.97939 TO 1.02913	10800
5	1.00472	+ CR - 0.00852	0.99620 TO 1.01324	0.98769 TO 1.02175	0.97917 TO 1.03027	10500
6	1.00417	+ OR - 0.00875	0.99542 TO 1.01292	0.98667 TO 1.02168	0.97791 TO 1.03043	10200
7	1.00335	+ OR - 0.00898	0.99437 TO 1.01233	0.98538 TO 1.02131	0.97640 TO 1.03029	9900
8	1.00306	+ OR - 0.00926	0.99380 TO 1.01232	0.98454 TO 1.02159	0.97527 TO 1.03085	9600
9	1.00412	+ OR - 0.00950	0.99462 TO 1.01363	0.98512 TO 1.02313	0.97561 TO 1.03263	9300
10	1.00311	+ OR - 0.00977	0.99334 TO 1.01288	0.98357 TO 1.02265	0.97380 TO 1.03242	9000
11	1.00331	+ OR - 0.01011	0.99319 TO 1.01342	0.98308 TO 1.02353	0.97297 TO 1.03364	8700
12	1.00359	+ OR - 0.01047	0.99311 TO 1.01406	0.98264 TO 1.02454	0.97216 TO 1.03501	8400
17	1.01330	+ OR - 0.01089	1.00241 TO 1.02419	0.99152 TO 1.03508	0.98062 TO 1.04597	6900
22	1.00919	+ OR - 0.01347	0.99572 TO 1.02265	0.98225 TO 1.03612	0.96879 TO 1.04959	5400
27	1.01767	+ OR - 0.01653	1.00114 TO 1.03421	0.98461 TO 1.05074	0.96808 TO 1.06727	3900
32	1.00667	+ OR - 0.01149	0.99518 TO 1.01816	0.98369 TO 1.02965	0.97220 TO 1.04114	2400
37	1.01845	+ OR - 0.01153	1.00693 TO 1.02998	0.99540 TO 1.04151	0.98387 TO 1.05304	900

SAMPLE PROB 16 GENERALIZED GEOMETRY GROTESQUE

GROUP	REGION	LEAKAGE	ABSORPTIONS	FISSIONS	WITH 3 GENERATIONS SKIPPED
1		7.97511D-02	5.17232D-02	1.46350D-01	
2		1.45052D-01	9.86704D-02	2.42079D-01	
3		8.94054D-02	5.92413D-02	1.36843D-01	
4		1.49070D-01	1.06364D-01	2.33822D-01	
5		9.39189D-02	9.14981D-02	1.92687D-01	
6		1.09209D-02	2.47556D-02	4.76871D-02	
7		1.60003D-05	3.29853D-04	6.11995D-04	
8		0.0	3.41633D-05	5.88868D-05	
9		0.0	0.0	0.0	
10		0.0	0.0	0.0	
11		0.0	0.0	0.0	
12		0.0	0.0	0.0	
13		0.0	0.0	0.0	
14		0.0	0.0	0.0	
15		0.0	0.0	0.0	
16		0.0	0.0	0.0	
TOTAL =		5.68134D-01	4.32616D-01	1.00014D 00	

ELAPSED TIME 1.08683MINUTES

SAMPLE PROB 16 GENERALIZED GECMETRY GROTESQUE

**** FISSION DENSITIES ****

	REGION	FISSION DENSITY	PERCENT DEVIATION	TOTAL FISSICNS
BOX TYPE 1				
	1	2.772E-05	C.91	1.000E 00

******** WARNING ************* WARNING **********
THE FISSION DENSITY AND FLUX WERE COMPUTED USING ARBITRARY VOLUMES (LISTED UNDER - TOTAL VOLUMES -) IN THE REGIONS DESCRIBED BY GENERALIZED GEOM. THEY MUST BE MULTIPLIED BY THE TRUE VOLUME OVER THE ARBITRARY VOLUME TO OBTAIN THE CORRECT VALUES.

SAMPLE PROB 16 GENERALIZED GECMETRY GROTESQUE

FLUXES FOR BOX TYPE 1
REGION 1

GROUP	FLUX	PERCENT DEVIATION
1	2.395E-05	2.13
2	4.535E-05	1.19
3	2.818E-05	2.48
4	4.789E-05	1.26
5	3.446E-05	2.49
6	4.795E-06	5.71
7	2.958E-08	43.00
8	4.043E-10	100.00
9	0.0	0.0
10	0.0	0.0
11	0.0	0.0
12	0.0	0.0
13	0.0	0.0
14	0.0	0.0
15	0.0	0.0
16	0.0	0.0

SAMPLE PROB 16 GENERALIZED GECMETRY GROTESQUE

```
                                      FREQUENCY FOR GENERATICNS    4 TO   40
0.8500 TO 0.8731      *
0.8731 TO 0.8962      *
0.8962 TO 0.9193
0.9193 TO 0.9424      ***
0.9424 TO 0.9655      ***
0.9655 TO 0.9886      ***
0.9886 TO 1.0117      **********
1.0117 TO 1.0348      ********
1.0348 TO 1.0579      *******
1.0579 TO 1.0810
1.0810 TO 1.1041
1.1041 TO 1.1271
1.1271 TO 1.1502
1.1502 TO 1.1733
1.1733 TO 1.1964      *

                                      FREQUENCY FOR GENERATICNS   13 TO   40
0.8500 TO 0.8731
0.8731 TO 0.8962      *
0.8962 TO 0.9193
0.9193 TO 0.9424      ***
0.9424 TO 0.9655      ***
0.9655 TO 0.9886      *
0.9886 TO 1.0117      ********
1.0117 TO 1.0348      ****
1.0348 TO 1.0579      *******
1.0579 TO 1.0810
1.0810 TO 1.1041
1.1041 TO 1.1271
1.1271 TO 1.1502
1.1502 TO 1.1733
1.1733 TO 1.1964      *

                                      FREQUENCY FOR GENERATICNS   22 TO   40
0.8500 TO 0.8731
0.8731 TO 0.8962
0.8962 TO 0.9193
0.9193 TO 0.9424      **
0.9424 TO 0.9655      **
0.9655 TO 0.9886      *
0.9886 TO 1.0117      *****
1.0117 TO 1.0348      ***
1.0348 TO 1.0579      *****
1.0579 TO 1.0810
1.0810 TO 1.1041
1.1041 TO 1.1271
1.1271 TO 1.1502
1.1502 TO 1.1733
1.1733 TO 1.1964      *
```

SAMPLE PROB 16 GENERALIZED GECMETRY GROTESQUE

```
                              FREQUENCY FOR GENERATICNS   31 TO   40
0.8500 TO 0.8731
0.8731 TO 0.8962
0.8962 TO 0.9193
0.9193 TO 0.9424
0.9424 TO 0.9655     *
0.9655 TO 0.9886     *
0.9886 TO 1.0117     ***
1.0117 TO 1.0348     *
1.0348 TO 1.0579     ***
1.0579 TO 1.0810
1.0810 TO 1.1041
1.1041 TO 1.1271
1.1271 TO 1.1502
1.1502 TO 1.1733
1.1733 TO 1.1964     *

********** END OF FILE ON UNIT    5 **********
```

SAMPLE PROBLEM 17 CASE 2C8 BARE WRITE RESTART

NUMBER OF GENERATIONS	103	START TYPE	0
NUMBER PER GENERATION	300	GENERATIONS BETWEEN CHECKPOINTS	5
NUMBER OF GENERATIONS TO BE SKIPPED	3	LIST INPUT X-SECTIONS READ FROM TAPE	NO
NUMBER OF ENERGY GROUPS	16	LIST 1-D MIXTURE X SECTIONS	NO
MAX. NUMBER OF ENERGY TRANSFERS	6	LIST 2-D MIXTURE X-SECTIONS	NO
NUMBER OF INPUT NUCLIDES	4	LIST FISS. AND ABS. BY REGION	NO
NUMBER OF MIXTURES	1	USE X-SECTIONS FROM PREVIOUS CASE	NO
NUMBER OF MIXING TABLE ENTRIES	4	USE GEOMETRY FROM PREVIOUS CASE	NO
NUMBER OF GEOMETRY CARDS	2	USE VELOCITIES FROM PREVIOUS CASE	NO
NUMBER OF BOX TYPES	1	COMPUTE MATRIX K-EFFECTIVE BY UNIT	NO
NUMBER OF UNITS IN X DIRECTION	2	COMPUTE MATRIX K-EFFECTIVE BY BOX TYPE	NO
NUMBER OF UNITS IN Y DIRECTION	2	LIST FISS PROB MATRIX BY UNIT	NO
NUMBER OF UNITS IN Z DIRECTION	2	ADJOINT CALCULATION	NO
NUMBER OF NUCLIDES READ FROM TAPE	4	USE EXPONENTIAL TRANSFORM	NO
ALBEDO TYPE	0	CALCULATE FLUX	YES
SEARCH TYPE	0	CALCULATE FISSION DENSITIES	YES

MAXIMUM TIME =   0.5000 MINUTES

STORAGE LOCATIONS REQUIRED FOR THIS JOB =   5518
REMAINING AVAILABLE LOCATIONS=   27250

SAMPLE PROBLEM 17 CASE 2C8 BARE WRITE RESTART

MIXTURE	NUCLIDE	DENSITY
1	-92500	4.48006E-02
1	92800	2.65780E-C3
1	92400	4.82700E-C4
1	92600	9.57000E-05

CROSS SECTIONS READ FROM TAPE

NUCLIDE =	92400	U-234	MIHALCZC MOD OF H-R U-238
NUCLIDE =	92500	U-235 YR	HANSEN RCACH
NUCLIDE =	92600	U-236	MIHALCZC MOD OF H-R U-238
NUCLIDE =	92800	U-238 Y	HANSEN RCACH

SAMPLE PROBLEM 17 CASE 2C8 EARE WRITE RESTART

GEOMETRY DESCRIPTION

REGION

```
  1  CYLINDER     1  RADIUS = 5.7480E 00   +Z = 5.3825E 00   -Z =-5.3825E 00
  2  CUBOID       0      +X = 6.8700E 00   -X =-6.8700E 00   +Y = 6.8700E 00   -Y =-6.8700E 00   +Z = 6.5050E 00   -Z =-6.5050E 00
```

SAMPLE PROBLEM 17 CASE 2C8 BARE WRITE RESTART

WEIGHTING FUNCTION

```
BOX TYPE   1                                          GROUP   WTLOW    WT AVG    WT HI

        REGION   1 DEFINED BY GEOMETRY CARD   1
                                                        1     0.167     0.500     1.500
                                                      GROUPS 2 TO   16 SAME AS ABOVE

        REGION   2 DEFINED BY GEOMETRY CARD   2
                                                        1     0.167     0.500     1.500
                                                      GROUPS 2 TO   16 SAME AS ABOVE
```

SAMPLE PROBLEM 17 CASE 2C8 BARE WRITE RESTART

VOLUMES

```
BOX TYPE      1
        REGION DEFINED BY GEOMETRY CARD      1   VOLUME =     1.11737E 03 CM**3        CUMULATIVE VOLUME =    1.11737E 03 CM**3
        REGION DEFINED BY GEOMETRY CARD      2   VOLUME =     1.33876E 03 CM**3        CUMULATIVE VOLUME =    2.45613E 03 CM**3

TOTAL VOLUMES
   1        8.93896E 03
   2        1.07100E 04
```

VOLUME FRACTION OF THE CORE CONTAINING FISSILE MATERIAL= 0.45493E 00

START TYPE =   0

THE NEUTRONS WERE STARTED IN THE ARRAY WITH A FLAT DISTRIBUTION.

300 NEUTRONS WERE INITIALLY STARTED
0.00183 MINUTES WERE REQUIRED FOR STARTING.

SAMPLE PROBLEM 17 CASE 2C8 BARE WRITE RESTART

GENERATION	K-EFFECTIVE	ELAPSED TIME(MIN)	AVG. K-EFF	DEVIATION	MATRIX K-EFF
1	9.48664E-01	8.33333E-03	1.00000E 00	0.0	0.0
2	9.26448E-01	1.55000E-02	1.00000E 00	0.0	0.0
3	9.32275E-01	2.10000E-02	9.32275E-01	0.0	0.0
4	1.00046E 00	2.93333E-02	9.66366E-01	3.40933E-02	0.0
5	1.03192E 00	3.80000E-02	9.88216E-01	2.94086E-02	0.0
				RESTART NUMBER	1 WRITTEN
6	1.06028E 00	4.80000E-02	1.00623E 00	2.75176E-02	0.0
7	1.11285E 00	5.63333E-02	1.02756E 00	3.01511E-02	0.0
8	1.04947E 00	6.51667E-02	1.03121E 00	2.48861E-02	0.0
9	9.69609E-01	7.25000E-02	1.02241E 00	2.27981E-02	0.0
10	1.04584E 00	7.96666E-02	1.02534E 00	1.99590E-02	0.0
				RESTART NUMBER	2 WRITTEN
11	9.65813E-01	8.60000E-02	1.01872E 00	1.88099E-02	0.0
12	1.05368E 00	9.43333E-02	1.02222E 00	1.71818E-02	0.0
13	1.03684E 00	1.02500E-01	1.02355E 00	1.56006E-02	0.0
14	9.47292E-01	1.08000E-01	1.01719E 00	1.55945E-02	0.0
15	9.89856E-01	1.16000E-01	1.01509E 00	1.44985E-02	0.0
				RESTART NUMBER	3 WRITTEN
16	1.01807E 00	1.25000E-01	1.01530E 00	1.34255E-02	0.0
17	1.01822E 00	1.32500E-01	1.01550E 00	1.25007E-02	0.0
18	1.00909E 00	1.39667E-01	1.01510E 00	1.17025E-02	0.0
19	1.00058E 00	1.46000E-01	1.01424E 00	1.10269E-02	0.0
20	1.00288E 00	1.53000E-01	1.01361E 00	1.04161E-02	0.0
				RESTART NUMBER	4 WRITTEN
21	1.07051E 00	1.60833E-01	1.01661E 00	1.02913E-02	0.0
22	9.60427E-01	1.67667E-01	1.01380E 00	1.01636E-02	0.0
23	9.56329E-01	1.75000E-01	1.01106E 00	1.00520E-02	0.0
24	1.00177E 00	1.82667E-01	1.01064E 00	9.59202E-03	0.0
25	1.04658E 00	1.91333E-01	1.01220E 00	9.29951E-03	0.0
				RESTART NUMBER	5 WRITTEN
26	9.92254E-01	1.98000E-01	1.01137E 00	8.94107E-03	0.0
27	1.05239E 00	2.06333E-01	1.01301E 00	8.73464E-03	0.0
28	9.68244E-01	2.13000E-01	1.01129E 00	8.56930E-03	0.0
29	9.69718E-01	2.20000E-01	1.00975E 00	8.38979E-03	0.0
30	9.96146E-01	2.27500E-01	1.00926E 00	8.09668E-03	0.0
				RESTART NUMBER	6 WRITTEN
31	9.94557E-01	2.34333E-01	1.00875E 00	7.82992E-03	0.0
32	9.56272E-01	2.41000E-01	1.00700E 00	7.76182E-03	0.0
33	1.00044E 00	2.48333E-01	1.00679E 00	7.51382E-03	0.0
34	1.02966E 00	2.56833E-01	1.00751E 00	7.30582E-03	0.0
35	9.83747E-01	2.63000E-01	1.00679E 00	7.12205E-03	0.0
				RESTART NUMBER	7 WRITTEN
36	9.53114E-01	2.69333E-01	1.00521E 00	7.08709E-03	0.0
37	9.39802E-01	2.74333E-01	1.00334E 00	7.13312E-03	0.0
38	8.83828E-01	2.81000E-01	1.00002E 00	7.68414E-03	0.0
39	9.63702E-01	2.87667E-01	9.99037E-01	7.53712E-03	0.0
40	1.00218E 00	2.96333E-01	9.99119E-01	7.33598E-03	0.0
				RESTART NUMBER	8 WRITTEN
41	1.05249E 00	3.05833E-01	1.00049E 00	7.27695E-03	0.0
42	9.94617E-01	3.12667E-01	1.00034E 00	7.09399E-03	0.0
43	9.64916E-01	3.20500E-01	9.99476E-01	6.97405E-03	0.0
44	1.01404E 00	3.27167E-01	9.99823E-01	6.81400E-03	0.0
45	1.00956E 00	3.34667E-01	1.00005E 00	6.65927E-03	0.0
				RESTART NUMBER	9 WRITTEN
46	1.05045E 00	3.45000E-01	1.00119E 00	6.60829E-03	0.0
47	9.96764E-01	3.51833E-01	1.00110E 00	6.45936E-03	0.0
48	9.39462E-01	3.58333E-01	9.99756E-01	6.45638E-03	0.0
49	1.03453E 00	3.65833E-01	1.00049E 00	6.36315E-03	0.0
50	1.00944E 00	3.72667E-01	1.00068E 00	6.23355E-03	0.0
				RESTART NUMBER	10 WRITTEN

51	1.11304E 00	3.83000E-01	1.00297E 00	6.52210E-03	0.0
52	9.26212E-01	3.88500E-01	1.00144E 00	6.57323E-03	0.0
53	1.02864E 00	3.96833E-01	1.00197E 00	6.46304E-03	0.0
54	9.51587E-01	4.02667E-01	1.00100E 00	6.40959E-03	0.0
55	1.03430E 00	4.10833E-01	1.00163E 00	6.32160E-03	0.0
				RESTART NUMBER	11 WRITTEN
56	1.04214E 00	4.18833E-01	1.00238E 00	6.25161E-03	0.0
57	9.84012E-01	4.26000E-01	1.00205E 00	6.14479E-03	0.0
58	9.26579E-01	4.32500E-01	1.00070E 00	6.18194E-03	0.0
59	1.07952E 00	4.43000E-01	1.00208E 00	6.22712E-03	0.0
60	1.05940E 00	4.51667E-01	1.00307E 00	6.19930E-03	0.0
				RESTART NUMBER	12 WRITTEN
61	1.02553E 00	4.60833E-01	1.00345E 00	6.10402E-03	0.0
62	1.06355E 00	4.69167E-01	1.00445E 00	6.08669E-03	0.0
63	9.80649E-01	4.76833E-01	1.00406E 00	5.99745E-03	0.0
64	1.00790E 00	4.85500E-01	1.00412E 00	5.90324E-03	0.0
65	9.59801E-01	4.92667E-01	1.00342E 00	5.84755E-03	0.0
				RESTART NUMBER	13 WRITTEN
66	9.82424E-01	5.00500E-01	1.00309E 00	5.76431E-03	0.0

THE MATRIX K-EFF IS THE LARGEST EIGENVALUE OF THE MATRIX OF FISSION PROBABILITIES BY UNIT.
THERE ARE NBXMAX * NBYMAX * NBZMAX UNITS IN AN ARRAY.

SAMPLE PROBLEM 17 CASE 2C8 BABE WRITE RESTART

LIFETIME = 1.03417E-08 + OR - 7.73495E-11 GENERATION TIME = 7.31301E-09 + OR - 7.44215E-11

NO. OF INITIAL GENERATIONS SKIPPED	AVERAGE K-EFFECTIVE	DEVIATION	67 PER CENT CONFIDENCE INTERVAL	95 PER CENT CONFIDENCE INTERVAL	99 PER CENT CONFIDENCE INTERVAL	NUMBER OF HISTORIES
3	1.00422	+ OR - 0.00574	0.99848 TO 1.00995	0.99274 TO 1.01569	0.98700 TO 1.02143	18900
4	1.00428	+ OR - 0.00583	0.99845 TO 1.01011	0.99262 TO 1.01594	0.98679 TO 1.02177	18600
5	1.00382	+ OR - 0.00591	0.99791 TO 1.00973	0.99201 TO 1.01564	0.98610 TO 1.02155	18300
6	1.00288	+ OR - 0.00593	0.99695 TO 1.00881	0.99102 TO 1.01474	0.98509 TO 1.02067	18000
7	1.00102	+ OR - 0.00573	0.99529 TO 1.00675	0.98956 TO 1.01247	0.98384 TO 1.01820	17700
8	1.00018	+ OR - 0.00576	0.99442 TO 1.00595	0.98865 TO 1.01171	0.98289 TO 1.01748	17400
9	1.00072	+ OR - 0.00584	0.99488 TO 1.00656	0.98904 TO 1.01240	0.98320 TO 1.01824	17100
10	0.99991	+ OR - 0.00589	0.99403 TO 1.00580	0.98814 TO 1.01169	0.98225 TO 1.01758	16800
11	1.00054	+ OR - 0.00596	0.99457 TO 1.00650	0.98861 TO 1.01246	0.98264 TO 1.01843	16500
12	0.99955	+ OR - 0.00599	0.99356 TO 1.00554	0.98757 TO 1.01153	0.98158 TO 1.01753	16200
17	0.99930	+ OR - 0.00645	0.99285 TO 1.00575	0.98640 TO 1.01220	0.97995 TO 1.01865	14700
22	0.99823	+ OR - 0.00694	0.99129 TO 1.00517	0.98435 TO 1.01211	0.97741 TO 1.01905	13200
27	0.99674	+ OR - 0.00753	0.98921 TO 1.00426	0.98169 TO 1.01179	0.97416 TO 1.01932	11700
32	0.99964	+ OR - 0.00847	0.99117 TO 1.00811	0.98271 TO 1.01658	0.97424 TO 1.02505	10200
37	1.00280	+ OR - 0.00950	0.99330 TO 1.01230	0.98380 TO 1.02180	0.97430 TO 1.03130	8700
42	1.00768	+ OR - 0.00994	0.99775 TO 1.01762	0.98781 TO 1.02755	0.97788 TO 1.03749	7200
47	1.00782	+ OR - 0.01217	0.99565 TO 1.02000	0.98348 TO 1.03217	0.97131 TO 1.04434	5700
52	1.00900	+ OR - 0.01230	0.99670 TO 1.02130	0.98440 TO 1.03360	0.97210 TO 1.04590	4200
57	1.00948	+ OR - 0.01727	0.99221 TO 1.02676	0.97493 TO 1.04403	0.95766 TO 1.06130	2700
62	0.98269	+ OR - 0.00985	0.97285 TO 0.99254	0.96300 TO 1.00239	0.95315 TO 1.01223	1200

SAMPLE PROBLEM 17 CASE 2C8 BARE WRITE RESTART

GROUP	REGION	LEAKAGE	ABSORPTIONS	FISSIONS	WITH 3 GENERATIONS SKIPPED
1		7.74640D-02	5.16425D-02	1.46242D-01	
2		1.45236D-01	9.57107D-02	2.34956D-01	
3		8.97487D-02	6.08006D-02	1.40520D-01	
4		1.47500D-01	1.05959D-01	2.32985D-01	
5		9.31690D-02	9.48936D-02	1.99737D-01	
6		1.16444D-02	2.56673D-02	4.93989D-02	
7		6.63445D-05	2.06982D-04	3.83717D-04	
8		0.0	0.0	0.0	
9		0.0	0.0	0.0	
10		0.0	0.0	0.0	
11		0.0	0.0	0.0	
12		0.0	0.0	0.0	
13		0.0	0.0	0.0	
14		0.0	0.0	0.0	
15		0.0	0.0	0.0	
16		0.0	0.0	0.0	
TOTAL =		5.64828D-01	4.34881D-01	1.00422D 00	

ELAPSED TIME 0.50050MINUTES

SAMPLE PROBLEM 17 CASE 2C8 BARE WRITE RESTART

**** FISSION DENSITIES ****

	REGION	FISSION DENSITY	PERCENT DEVIATION	TOTAL FISSIONS
BOX TYPE 1				
	1	1.123E-04	0.57	1.004E 00
	2	0.0	0.0	0.0

SAMPLE PROBLEM 17 CASE 2C8 BARE WRITE RESTART

FLUXES FOR BOX TYPE 1

GROUP	REGION 1 FLUX	REGION 1 PERCENT DEVIATION	REGION 2 FLUX	REGION 2 PERCENT DEVIATION
1	9.838E-05	1.87	5.247E-05	2.93
2	1.778E-04	1.13	9.740E-05	1.89
3	1.118E-04	1.95	5.922E-05	2.21
4	1.909E-04	1.14	1.044E-04	1.55
5	1.408E-04	1.60	7.144E-05	2.19
6	2.010E-05	4.26	9.057E-06	6.45
7	1.084E-07	39.15	5.064E-08	55.08
8	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0

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SAMPLE PROBLEM 17  CASE 2C8 BARE WRITE RESTART

                                 FREQUENCY FOR GENERATIONS    4 TO   66
0.8772 TO 0.9003     *
C.9003 TO 0.9234
0.9234 TO 0.9465     ****
0.9465 TO 0.9696     ***********
0.9696 TO 0.9927     ********
0.9927 TO 1.0158     ***************
1.0158 TO 1.0389     *********
1.0389 TO 1.0619     **********
1.0619 TO 1.0850     ***
1.0850 TO 1.1081
1.1081 TO 1.1312     **

                                 FREQUENCY FOR GENERATIONS   2C TO   66
0.8772 TO 0.9003     *
C.9003 TO 0.9234
0.9234 TO 0.9465     ****
0.9465 TO 0.9696     *********
0.9696 TO 0.9927     ******
0.9927 TO 1.0158     ************
1.0158 TO 1.0389     *****
1.0389 TO 1.0619     ******
1.0619 TO 1.0850     ***
1.0850 TO 1.1081
1.1081 TO 1.1312     *

                                 FREQUENCY FOR GENERATIONS   35 TO   66
0.8772 TO 0.9003     *
C.9003 TO 0.9234
0.9234 TO 0.9465     ****
0.9465 TO 0.9696     *****
0.9696 TO 0.9927     ****
0.9927 TO 1.0158     *******
1.0158 TO 1.0389     ****
1.0389 TO 1.0619     ****
1.0619 TO 1.0850     **
1.0850 TO 1.1081
1.1081 TO 1.1312     *

                                 FREQUENCY FOR GENERATIONS   51 TO   66
0.8772 TO 0.9003
C.9003 TO 0.9234
0.9234 TO 0.9465     **
0.9465 TO 0.9696     **
0.9696 TO 0.9927     ***
0.9927 TO 1.0158     *
1.0158 TO 1.0389     ***
1.0389 TO 1.0619     **
1.0619 TO 1.0850     **
1.0850 TO 1.1081
1.1081 TO 1.1312     *
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SAMPLE PROBLEM 18 CASE 2C8 BARE READ RESTART DATA

NUMBER OF GENERATIONS	103
NUMBER PER GENERATION	300
NUMBER OF GENERATIONS TO BE SKIPPED	3
NUMBER OF ENERGY GROUPS	16
MAX. NUMBER OF ENERGY TRANSFERS	6
NUMBER OF INPUT NUCLIDES	4
NUMBER OF MIXTURES	1
NUMBER OF MIXING TABLE ENTRIES	4
NUMBER OF GEOMETRY CARDS	2
NUMBER OF BOX TYPES	1
NUMBER OF UNITS IN X DIRECTION	2
NUMBER OF UNITS IN Y DIRECTION	2
NUMBER OF UNITS IN Z DIRECTION	2
NUMBER OF NUCLIDES READ FROM TAPE	4
ALBEDO TYPE	0
SEARCH TYPE	0

MAXIMUM TIME = 0.5000 MINUTES

STORAGE LOCATIONS REQUIRED FOR THIS JOB = 5518
REMAINING AVAILABLE LOCATIONS= 27250

START TYPE	-10
GENERATIONS BETWEEN CHECKPOINTS	0
LIST INPUT X-SECTIONS READ FROM TAPE	NO
LIST 1-D MIXTURE X SECTIONS	NO
LIST 2-D MIXTURE X-SECTIONS	NO
LIST FISS. AND ABS. BY REGION	NO
USE X-SECTIONS FROM PREVIOUS CASE	NO
USE GEOMETRY FROM PREVIOUS CASE	NO
USE VELOCITIES FROM PREVIOUS CASE	NO
COMPUTE MATRIX K-EFFECTIVE BY UNIT	NO
COMPUTE MATRIX K-EFFECTIVE BY BOX TYPE	NO
LIST FISS PROB MATRIX BY UNIT	NO
ADJOINT CALCULATION	NO
USE EXPONENTIAL TRANSFORM	NO
CALCULATE FLUX	YES
CALCULATE FISSION DENSITIES	YES

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SAMPLE PROBLEM 18  CASE 2C8 BARE  READ RESTART DATA

 VOLUMES

 BOX TYPE      1
          REGION DEFINED BY GEOMETRY CARD       1   VOLUME =     1.11737E 03 CM**3        CUMULATIVE VOLUME =    1.11737E 03 CM**3
          REGION DEFINED BY GEOMETRY CARD       2   VCLUME =     1.33876E 03 CM**3        CUMULATIVE VOLUME =    2.45613E 03 CM**3

 TOTAL VOLUMES
    1        8.93896E 03
    2        1.07100E 04

VOLUME FRACTION OF THE CORE CONTAINING FISSILE MATERIAL= 0.45493E 00

START TYPE =  -10
0.0     MINUTES WERE REQUIRED FOF STARTING.
```

SAMPLE PROBLEM 18 CASE 2C8 BARE READ RESTART DATA

GENERATION	K-EFFECTIVE	ELAPSED TIME(MIN)	AVG. K-EFF	DEVIATION	MATRIX K-EFF
51	9.81007E-01	7.16667E-03	1.00028E 00	6.11814E-03	0.0
52	9.57774E-01	1.50000E-02	9.99430E-01	6.05369E-03	0.0
53	9.74349E-01	2.25000E-02	9.98938E-01	5.95463E-03	0.0
54	9.37221E-01	2.91667E-02	9.97750E-01	5.95876E-03	0.0
55	1.03034E 00	3.71667E-02	9.98365E-01	5.87725E-03	0.0
56	1.04222E 00	4.58333E-02	9.99177E-01	5.82308E-03	0.0
57	1.03329E 00	5.50000E-02	9.99797E-01	5.74946E-03	0.0
58	9.79889E-01	6.21667E-02	9.99442E-01	5.65773E-03	0.0
59	1.00213E 00	6.86666E-02	9.99489E-01	5.55731E-03	0.0
60	1.06031E 00	7.86666E-02	1.00054E 00	5.56350E-03	0.0
61	9.64150E-01	8.54999E-02	9.99921E-01	5.50134E-03	0.0
62	9.93563E-01	9.19999E-02	9.99815E-01	5.40877E-03	0.0
63	9.50963E-01	9.80000E-02	9.99014E-01	5.38061E-03	0.0
64	9.84113E-01	1.05333E-01	9.98773E-01	5.29921E-03	0.0
65	9.40797E-01	1.12167E-01	9.97853E-01	5.29466E-03	0.0
66	9.11605E-01	1.17833E-01	9.96505E-01	5.38341E-03	0.0
67	1.06900E 00	1.27833E-01	9.97620E-01	5.41608E-03	0.0
68	9.11825E-01	1.32167E-01	9.96320E-01	5.48955E-03	0.0
69	1.02114E 00	1.41167E-01	9.96691E-01	5.41972E-03	0.0
70	1.03889E 00	1.49667E-01	9.97311E-01	5.37523E-03	0.0
71	9.16157E-01	1.57500E-01	9.96135E-01	5.42597E-03	0.0
72	9.38865E-01	1.65000E-01	9.95317E-01	5.41019E-03	0.0
73	1.01492E 00	1.72500E-01	9.95593E-01	5.34081E-03	0.0
74	9.69333E-01	1.80333E-01	9.95228E-01	5.27887E-03	0.0
75	1.05619E 00	1.89667E-01	9.96063E-01	5.27263E-03	0.0
76	9.82212E-01	1.97500E-01	9.95876E-01	5.20432E-03	0.0
77	9.66337E-01	2.04667E-01	9.95482E-01	5.15007E-03	0.0
78	9.56917E-01	2.11167E-01	9.94974E-01	5.10723E-03	0.0
79	1.03138E 00	2.19500E-01	9.95447E-01	5.06261E-03	0.0
80	1.04801E 00	2.28667E-01	9.96121E-01	5.04284E-03	0.0
81	9.10343E-01	2.34667E-01	9.95035E-01	5.09563E-03	0.0
82	1.00974E 00	2.43000E-01	9.95219E-01	5.03481E-03	0.0
83	1.01418E 00	2.52167E-01	9.95453E-01	4.97786E-03	0.0
84	1.10549E 00	2.60833E-01	9.96795E-01	5.09665E-03	0.0
85	1.00748E 00	2.68667E-01	9.96923E-01	5.03663E-03	0.0
86	1.05835E 00	2.77167E-01	9.97654E-01	5.02966E-03	0.0
87	1.04148E 00	2.85833E-01	9.98170E-01	4.99701E-03	0.0
88	9.94547E-01	2.93833E-01	9.98128E-01	4.93907E-03	0.0
89	1.00293E 00	3.02000E-01	9.98183E-01	4.88217E-03	0.0
90	9.93563E-01	3.10333E-01	9.98130E-01	4.82650E-03	0.0
91	1.04844E 00	3.19167E-01	9.98696E-01	4.80535E-03	0.0
92	9.58589E-01	3.27000E-01	9.98250E-01	4.77245E-03	0.0
93	1.03753E 00	3.35333E-01	9.98681E-01	4.73937E-03	0.0
94	1.03749E 00	3.42167E-01	9.99103E-01	4.70568E-03	0.0
95	1.00476E 00	3.48667E-01	9.99164E-01	4.65505E-03	0.0
96	1.02986E 00	3.56667E-01	9.99491E-01	4.61741E-03	0.0
97	9.72013E-01	3.63333E-01	9.99201E-01	4.57771E-03	0.0
98	1.00417E 00	3.71167E-01	9.99253E-01	4.53001E-03	0.0
99	1.00891E 00	3.80000E-01	9.99353E-01	4.48453E-03	0.0
100	1.01070E 00	3.88333E-01	9.99468E-01	4.44016E-03	0.0
101	9.62863E-01	3.94667E-01	9.99098E-01	4.41076E-03	0.0
102	1.00372E 00	4.02000E-01	9.99144E-01	4.36677E-03	0.0
103	9.54299E-01	4.09167E-01	9.98700E-01	4.34653E-03	0.0

THE MATRIX K-EFF IS THE LARGEST EIGENVALUE OF THE MATRIX OF FISSION PROBABILITIES BY UNIT.
THERE ARE NBXMAX * NBYMAX * NBZMAX UNITS IN AN ARRAY.

SAMPLE PROBLEM 18 CASE 2C8 BARE READ RESTART DATA

LIFETIME = 1.04263E-08 + OR - 6.29764E-11 GENERATION TIME = 7.41373E-09 + OR - 6.66802E-11

NO. OF INITIAL GENERATIONS SKIPPED	AVERAGE K-EFFECTIVE	DEVIATION	67 PER CENT CONFIDENCE INTERVAL	95 PER CENT CONFIDENCE INTERVAL	99 PER CENT CONFIDENCE INTERVAL	NUMBER OF HISTORIES
3	0.99936	+ OR - 0.00433	0.99503 TO 1.00370	0.99070 TO 1.00803	0.98637 TO 1.01236	30000
4	0.99935	+ OR - 0.00438	0.99498 TO 1.00373	0.99060 TO 1.00811	0.98622 TO 1.01248	29700
5	0.99902	+ OR - 0.00441	0.99461 TO 1.00343	0.99020 TO 1.00784	0.98580 TO 1.01225	29400
6	0.99839	+ OR - 0.00441	0.99398 TO 1.00280	0.98957 TO 1.00721	0.98517 TO 1.01161	29100
7	0.99720	+ OR - 0.00429	0.99291 TO 1.00149	0.98862 TO 1.00577	0.98433 TO 1.01006	28800
8	0.99665	+ OR - 0.00430	0.99235 TO 1.00095	0.98805 TO 1.00524	0.98375 TO 1.00954	28500
9	0.99694	+ OR - 0.00433	0.99260 TO 1.00127	0.98827 TO 1.00560	0.98393 TO 1.00994	28200
10	0.99641	+ OR - 0.00435	0.99206 TO 1.00076	0.98771 TO 1.00511	0.98336 TO 1.00946	27900
11	0.99674	+ OR - 0.00438	0.99236 TO 1.00113	0.98798 TO 1.00551	0.98359 TO 1.00989	27600
12	0.99612	+ OR - 0.00439	0.99173 TO 1.00050	0.98734 TO 1.00489	0.98296 TO 1.00928	27300
17	0.99577	+ OR - 0.00457	0.99120 TO 1.00034	0.98664 TO 1.00491	0.98207 TO 1.00947	25800
22	0.99497	+ OR - 0.00474	0.99024 TO 0.99971	0.98550 TO 1.00445	0.98076 TO 1.00918	24300
27	0.99400	+ OR - 0.00492	0.98908 TO 0.99891	0.98416 TO 1.00383	0.97924 TO 1.00875	22800
32	0.99519	+ OR - 0.00521	0.98998 TO 1.00041	0.98477 TO 1.00562	0.97956 TO 1.01083	21300
37	0.99624	+ OR - 0.00548	0.99076 TO 1.00172	0.98529 TO 1.00720	0.97981 TO 1.01268	19800
42	0.99763	+ OR - 0.00553	0.99210 TO 1.00315	0.98658 TO 1.00868	0.98105 TO 1.01420	18300
47	0.99678	+ OR - 0.00591	0.99087 TO 1.00268	0.98496 TO 1.00859	0.97906 TO 1.01449	16800
52	0.99799	+ OR - 0.00628	0.99170 TO 1.00427	0.98542 TO 1.01056	0.97913 TO 1.01684	15300
57	0.99739	+ OR - 0.00667	0.99072 TO 1.00406	0.98404 TO 1.01074	0.97737 TO 1.01741	13800
62	0.99707	+ OR - 0.00727	0.98980 TO 1.00435	0.98252 TO 1.01162	0.97525 TO 1.01890	12300
67	1.00065	+ OR - 0.00737	0.99328 TO 1.00802	0.98592 TO 1.01539	0.97855 TO 1.02275	10800
72	1.00634	+ OR - 0.00708	0.99926 TO 1.01343	0.99218 TO 1.02051	0.98509 TO 1.02759	9300
77	1.00799	+ OR - 0.00789	1.00010 TO 1.01588	0.99220 TO 1.02377	0.98431 TO 1.03166	7800
82	1.01197	+ OR - 0.00784	1.00412 TO 1.01981	0.99628 TO 1.02766	0.98843 TO 1.03550	6300
87	1.00152	+ OR - 0.00716	0.99436 TO 1.00869	0.98720 TO 1.01585	0.98004 TO 1.02301	4800
92	1.00239	+ OR - 0.00860	0.99379 TO 1.01099	0.98519 TO 1.01960	0.97658 TO 1.02820	3300

SAMPLE PROBLEM 18 CASE 2C8 BARE READ RESTART DATA

NO. OF INITIAL GENERATIONS SKIPPED	AVERAGE K-EFFECTIVE	DEVIATION	67 PER CENT CONFIDENCE INTERVAL	95 PER CENT CONFIDENCE INTERVAL	99 PER CENT CONFIDENCE INTERVAL	NUMBER OF HISTORIES
97	0.99078	+ OR - 0.01030	0.98048 TO 1.00108	0.97018 TO 1.01138	0.95988 TO 1.02168	1800

SAMPLE PROBLEM 18 CASE 2C8 BARE READ RESTART DATA

GROUP	REGION	LEAKAGE	ABSORPTIONS	FISSIONS	WITH 3 GENERATIONS SKIPPED
1		7.91213D-02	5.13373D-02	1.45378D-01	
2		1.46367D-01	9.63799D-02	2.36599D-01	
3		8.99233D-02	6.14222D-02	1.41956D-01	
4		1.48535D-01	1.03456D-01	2.27481D-01	
5		9.33108D-02	9.43695D-02	1.98634D-01	
6		1.09062D-02	2.52736D-02	4.86412D-02	
7		1.03079D-04	3.50939D-04	6.50593D-04	
8		0.0	1.81515D-05	3.12521D-05	
9		0.0	0.0	0.0	
10		0.0	0.0	0.0	
11		0.0	0.0	0.0	
12		0.0	0.0	0.0	
13		0.0	0.0	0.0	
14		0.0	0.0	0.0	
15		0.0	0.0	0.0	
16		0.0	0.0	0.0	
TOTAL =		5.68266D-01	4.32608D-01	9.99371D-01	

ELAPSED TIME 0.40917MINUTES

SAMPLE PROBLEM 18 CASE 2C8 BARE READ RESTART DATA

**** FISSION DENSITIES ****

	REGION	FISSION DENSITY	PERCENT DEVIATION	TOTAL FISSIONS
BOX TYPE 1				
	1	1.118E-04	0.43	9.993E-01
	2	0.0	0.0	0.0

SAMPLE PROBLEM 18 CASE 2C8 BARE READ RESTART DATA

FLUXES FOR BOX TYPE 1

	REGION 1		REGION 2	
GROUP	FLUX	PERCENT DEVIATION	FLUX	PERCENT DEVIATION
1	9.867E-05	1.44	5.424E-05	2.11
2	1.784E-04	0.99	9.888E-05	1.45
3	1.120E-04	1.49	6.023E-05	1.88
4	1.902E-04	0.92	1.052E-04	1.19
5	1.408E-04	1.24	7.257E-05	1.63
6	1.973E-05	3.31	8.845E-06	4.64
7	1.685E-07	22.14	6.331E-08	40.67
8	3.671E-09	100.00	0.0	0.0
9	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0

```
SAMPLE PROBLEM 18  CASE 2C8 EARE  READ RESTART DATA

                                     FREQUENCY FOR GENERATICNS    4 TC  103
0.8723 TO 0.8954     *
0.8954 TO 0.9185     ****
0.9185 TC 0.9416     *****
0.9416 TO 0.9647     *************
0.9647 TO 0.9878     **************
0.9878 TO 1.0109     ***************************
1.0109 TC 1.0340     ************
1.0340 TO 1.0571     *****************
1.0571 TO 1.0802     *****
1.0802 TO 1.1033
1.1033 TO 1.1264     **

                                     FREQUENCY FOR GENERATIONS   29 TC  103
0.8723 TO 0.8954     *
0.8954 TC 0.9185     ****
0.9185 TO 0.9416     *****
0.9416 TO 0.9647     **********
0.9647 TO 0.9878     ***********
0.9878 TC 1.0109     ********************
1.0109 TO 1.0340     *********
1.0340 TO 1.0571     ***********
1.0571 TO 1.0802     ***
1.0802 TC 1.1033
1.1033 TO 1.1264     *

                                     FREQUENCY FOR GENERATIONS   54 TC  103
0.8723 TO 0.8954
0.8954 TO 0.9185     ****
0.9185 TO 0.9416     ***
0.9416 TO 0.9647     ******
0.9647 TO 0.9878     ******
0.9878 TC 1.0109     ************
1.0109 TO 1.0340     *******
1.0340 TC 1.0571     ********
1.0571 TO 1.0802     ***
1.0802 TO 1.1033
1.1033 TO 1.1264     *

                                     FREQUENCY FOR GENERATIONS   79 TC  103
0.8723 TO 0.8954
0.8954 TO 0.9185     *
0.9185 TO 0.9416
0.9416 TO 0.9647     ***
0.9647 TO 0.9878     *
0.9878 TC 1.0109     **********
1.0109 TO 1.0340     ***
1.0340 TO 1.0571     *****
1.0571 TO 1.0802     *
1.0802 TO 1.1033
1.1033 TO 1.1264     *

********** END OF FILE ON UNIT    5 **********
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SAMPLE PROBLEM 19 4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

NUMBER OF GENERATIONS	103	START TYPE	0
NUMBER PER GENERATION	300	GENERATIONS BETWEEN CHECKPOINTS	0
NUMBER OF GENERATIONS TO BE SKIPPED	3	LIST INPUT X-SECTIONS READ FROM TAPE	NO
NUMBER OF ENERGY GROUPS	16	LIST 1-D MIXTURE X SECTIONS	NO
MAX. NUMBER OF ENERGY TRANSFERS	6	LIST 2-D MIXTURE X-SECTIONS	NO
NUMBER OF INPUT NUCLIDES	6	LIST FISS. AND ABS. BY REGION	YES
NUMBER OF MIXTURES	3	USE X-SECTIONS FROM PREVIOUS CASE	NO
NUMBER OF MIXING TABLE ENTRIES	10	USE GEOMETRY FROM PREVIOUS CASE	NO
NUMBER OF GEOMETRY CARDS	11	USE VELOCITIES FROM PREVIOUS CASE	NO
NUMBER OF BOX TYPES	5	COMPUTE MATRIX K-EFFECTIVE BY UNIT	YES
NUMBER OF UNITS IN X DIRECTION	2	COMPUTE MATRIX K-EFFECTIVE BY BOX TYPE	YES
NUMBER OF UNITS IN Y DIRECTION	2	LIST FISS PROB MATRIX BY UNIT	YES
NUMBER OF UNITS IN Z DIRECTION	2	ADJOINT CALCULATION	NO
NUMBER OF NUCLIDES READ FROM TAPE	6	USE EXPONENTIAL TRANSFORM	NO
ALBEDO TYPE	0	CALCULATE FLUX	YES
SEARCH TYPE	0	CALCULATE FISSION DENSITIES	YES

MAXIMUM TIME = 2.5000 MINUTES

STORAGE LOCATIONS REQUIRED FOR THIS JOB = 7823
REMAINING AVAILABLE LOCATIONS= 9073

SAMPLE PROBLEM 19 4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

MIXTURE	NUCLIDE	DENSITY
1	92860	3.22750E-03
1	-92501	4.48020E-02
2	1102	5.81000E-02
2	7100	1.97530E-03
2	8100	3.69270E-02
2	-92501	9.84710E-04
2	92860	7.76970E-05
3	6100	3.55520E-02
3	1102	5.68840E-02
3	8100	1.42210E-02

CROSS SECTIONS READ FROM TAPE

NUCLIDE =	1102	HYDROGEN CE/E		HANSEN ROACH
NUCLIDE =	6100	CARBON		HANSEN ROACH
NUCLIDE =	7100	NITROGEN		HANSEN ROACH
NUCLIDE =	8100	OXYGEN		HANSEN ROACH
NUCLIDE =	92501	U-235-1R	SIG P = 20	HANSEN ROACH
NUCLIDE =	92860	U-238-5R	SIG P = 200	HANSEN ROACH

```
SAMPLE PROBLEM 19   4 AQUEOUS 4 METAL  MIXED BOX MATRIX CALCULATION

GEOMETRY DESCRIPTION


BOX TYPE   1

REGION

  1  CYLINDER    2  RADIUS = 9.5250E 00   +Z = 8.8900E 00   -Z =-8.8900E 00

  2  CYLINDER    3  RADIUS = 1.0160E 01   +Z = 9.5250E 00   -Z =-9.5250E 00

  3  CUBOID      0      +X = 1.0875E 01   -X =-1.0875E 01   +Y = 1.0875E 01   -Y =-1.0875E 01   +Z = 1.0240E 01   -Z =-1.0240E 01


BOX TYPE   2

REGION

  1  CYLINDER    1  RADIUS = 5.7480E 00   +Z = 5.3825E 00   -Z =-5.3825E 00

  2  CUBOID      0      +X = 6.5900E 00   -X =-1.5160E 01   +Y = 6.5900E 00   -Y =-1.5160E 01   +Z = 6.2250E 00   -Z =-1.4255E 01


BOX TYPE   3

REGION

  1  CYLINDER    1  RADIUS = 5.7480E 00   +Z = 5.3825E 00   -Z =-5.3825E 00

  2  CUBOID      0      +X = 6.5900E 00   -X =-1.5160E 01   +Y = 1.5160E 01   -Y =-6.5900E 00   +Z = 6.2250E 00   -Z =-1.4255E 01


BOX TYPE   4

REGION

  1  CYLINDER    1  RADIUS = 5.7480E 00   +Z = 5.3825E 00   -Z =-5.3825E 00

  2  CUBOID      0      +X = 6.5900E 00   -X =-1.5160E 01   +Y = 6.5900E 00   -Y =-1.5160E 01   +Z = 1.4255E 01   -Z =-6.2250E 00


BOX TYPE   5

REGION

  1  CYLINDER    1  RADIUS = 5.7480E 00   +Z = 5.3825E 00   -Z =-5.3825E 00

  2  CUBOID      0      +X = 6.5900E 00   -X =-1.5160E 01   +Y = 1.5160E 01   -Y =-6.5900E 00   +Z = 1.4255E 01   -Z =-6.2250E 00
```

SAMPLE PROBLEM 19   4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

WEIGHTING FUNCTION

```
BOX TYPE   1                                              GROUP   WTLOW    WT AVG    WT HI
       REGION   1 DEFINED BY GEOMETRY CARD   1
                                                            1     0.167     0.500     1.500
                                                          GROUPS 2 TO   16 SAME AS ABOVE
       REGION   2 DEFINED BY GEOMETRY CARD   2
                                                            1     0.167     0.500     1.500
                                                          GROUPS 2 TO   16 SAME AS ABOVE
       REGION   3 DEFINED BY GEOMETRY CARD   3
                                                            1     0.167     0.500     1.500
                                                          GROUPS 2 TO   16 SAME AS ABOVE
BOX TYPE   2                                              GROUP   WTLOW    WT AVG    WT HI
       REGION   1 DEFINED BY GEOMETRY CARD   4
                                                            1     0.167     0.500     1.500
                                                          GROUPS 2 TO   16 SAME AS ABOVE
       REGION   2 DEFINED BY GEOMETRY CARD   5
                                                            1     0.167     0.500     1.500
                                                          GROUPS 2 TO   16 SAME AS ABOVE
BOX TYPE   3                                              GROUP   WTLOW    WT AVG    WT HI
       REGION   1 DEFINED BY GEOMETRY CARD   6
                                                            1     0.167     0.500     1.500
                                                          GROUPS 2 TO   16 SAME AS ABOVE
       REGION   2 DEFINED BY GEOMETRY CARD   7
                                                            1     0.167     0.500     1.500
                                                          GROUPS 2 TO   16 SAME AS ABOVE
BOX TYPE   4                                              GROUP   WTLOW    WT AVG    WT HI
       REGION   1 DEFINED BY GEOMETRY CARD   8
                                                            1     0.167     0.500     1.500
                                                          GROUPS 2 TO   16 SAME AS ABOVE
       REGION   2 DEFINED BY GEOMETRY CARD   9
                                                            1     0.167     0.500     1.500
                                                          GROUPS 2 TO   16 SAME AS ABOVE
BOX TYPE   5                                              GROUP   WTLOW    WT AVG    WT HI
       REGION   1 DEFINED BY GEOMETRY CARD  10
                                                            1     0.167     0.500     1.500
                                                          GROUPS 2 TO   16 SAME AS ABOVE
       REGION   2 DEFINED BY GEOMETRY CARD  11
                                                            1     0.167     0.500     1.500
                                                          GROUPS 2 TO   16 SAME AS ABOVE
```

SAMPLE PROBLEM 19   4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

ARRAY DESCRIPTION

```
Z =      1
  3   1
  2   1

Z =      2
  5   1
  4   1
```

SAMPLE PROBLEM 19   4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

```
 VOLUMES

 BOX TYPE      1
          REGION DEFINED BY GEOMETRY CARD      1    VOLUME =     5.06770E 03 CM**3       CUMULATIVE VOLUME =     5.06770E 03 CM**3
          REGION DEFINED BY GEOMETRY CARD      2    VOLUME =     1.11006E 03 CM**3       CUMULATIVE VOLUME =     6.17777E 03 CM**3
          REGION DEFINED BY GEOMETRY CARD      3    VOLUME =     3.51055E 03 CM**3       CUMULATIVE VOLUME =     9.68832E 03 CM**3

 BOX TYPE      2
          REGION DEFINED BY GEOMETRY CARD      4    VOLUME =     1.11737E 03 CM**3       CUMULATIVE VOLUME =     1.11737E 03 CM**3
          REGION DEFINED BY GEOMETRY CARD      5    VOLUME =     8.57093E 03 CM**3       CUMULATIVE VOLUME =     9.68830E 03 CM**3

 BOX TYPE      3
          REGION DEFINED BY GEOMETRY CARD      6    VOLUME =     1.11737E 03 CM**3       CUMULATIVE VOLUME =     1.11737E 03 CM**3
          REGION DEFINED BY GEOMETRY CARD      7    VOLUME =     8.57093E 03 CM**3       CUMULATIVE VOLUME =     9.68830E 03 CM**3

 BOX TYPE      4
          REGION DEFINED BY GEOMETRY CARD      8    VOLUME =     1.11737E 03 CM**3       CUMULATIVE VOLUME =     1.11737E 03 CM**3
          REGION DEFINED BY GEOMETRY CARD      9    VOLUME =     8.57093E 03 CM**3       CUMULATIVE VOLUME =     9.68830E 03 CM**3

 BOX TYPE      5
          REGION DEFINED BY GEOMETRY CARD     10    VOLUME =     1.11737E 03 CM**3       CUMULATIVE VOLUME =     1.11737E 03 CM**3
          REGION DEFINED BY GEOMETRY CARD     11    VOLUME =     8.57093E 03 CM**3       CUMULATIVE VOLUME =     9.68830E 03 CM**3

 TOTAL VOLUMES
    1       2.02708E 04
    2       4.44025E 03
    3       1.40422E 04
    4       1.11737E 03
    5       8.57093E 03
    6       1.11737E 03
    7       8.57093E 03
    8       1.11737E 03
    9       8.57093E 03
   10       1.11737E 03
   11       8.57093E 03

VOLUME FRACTION OF THE CORE CONTAINING FISSILE MATERIAL= 0.31920E 00

START TYPE =    0

 THE NEUTRONS WERE STARTED IN THE ARRAY WITH A FLAT DISTRIBUTION.

  300 NEUTRONS WERE INITIALLY STARTED
0.00250 MINUTES WERE REQUIRED FOR STARTING.
```

SAMPLE PROBLEM 19   4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

WARNING - ONLY 294 INDEPENDENT FISSION POINTS WERE GENERATED.

GENERATION	K-EFFECTIVE	ELAPSED TIME(MIN)	AVG. K-EFF	DEVIATION	MATRIX K-EFF
1	8.27109E-01	1.58333E-02	1.00000E 00	0.0	9.39234E-01
2	9.40043E-01	3.16667E-02	1.00000E 00	0.0	9.92507E-01
3	9.73342E-01	4.71667E-02	9.73342E-01	0.0	9.65725E-01
4	9.42672E-01	6.41667E-02	9.58007E-01	1.53459E-02	9.72408E-01
5	9.99765E-01	8.21666E-02	9.71926E-01	1.65007E-02	9.69194E-01
6	9.19819E-01	9.75000E-02	9.58859E-01	1.74892E-02	9.51676E-01
7	9.28839E-01	1.11333E-01	9.52887E-01	1.48219E-02	9.62113E-01
8	9.34989E-01	1.25500E-01	9.49904E-01	1.24631E-02	9.56578E-01
9	9.51273E-01	1.40167E-01	9.50100E-01	1.05363E-02	9.62521E-01
10	1.04127E 00	1.56833E-01	9.61496E-01	1.45987E-02	9.69135E-01
11	9.41320E-01	1.72500E-01	9.59254E-01	1.30684E-02	9.67853E-01
12	9.67263E-01	1.88000E-01	9.60055E-01	1.17168E-02	9.69735E-01
13	8.88465E-01	2.02500E-01	9.53547E-01	1.24370E-02	9.64624E-01
14	9.61500E-01	2.18500E-01	9.54209E-01	1.13724E-02	9.64352E-01
15	1.03400E 00	2.35500E-01	9.60347E-01	1.21287E-02	9.69508E-01
16	9.54658E-01	2.50167E-01	9.59940E-01	1.12366E-02	9.67049E-01
17	1.09019E 00	2.66000E-01	9.68623E-01	1.35947E-02	9.76544E-01
18	1.06108E 00	2.84167E-01	9.74402E-01	1.39679E-02	9.78848E-01
19	1.09506E 00	3.01333E-01	9.81499E-01	1.49173E-02	9.85794E-01
20	1.06478E 00	3.20167E-01	9.86125E-01	1.48075E-02	9.89196E-01
21	9.75386E-01	3.35167E-01	9.85560E-01	1.40199E-02	9.87646E-01
22	8.94098E-01	3.50000E-01	9.80986E-01	1.40659E-02	9.83209E-01
23	9.57938E-01	3.66667E-01	9.79888E-01	1.34244E-02	9.82470E-01
24	9.70337E-01	3.81667E-01	9.79453E-01	1.28087E-02	9.80564E-01
25	1.05390E 00	4.00167E-01	9.82690E-01	1.26606E-02	9.83466E-01
26	1.07233E 00	4.20500E-01	9.86425E-01	1.26842E-02	9.86333E-01
27	1.09465E 00	4.39167E-01	9.90754E-01	1.29132E-02	9.90496E-01
28	1.06547E 00	4.58333E-01	9.93627E-01	1.27362E-02	9.92991E-01
29	1.00459E 00	4.75000E-01	9.94033E-01	1.22626E-02	9.93296E-01
30	9.44996E-01	4.91000E-01	9.92281E-01	1.19454E-02	9.91683E-01
31	9.23596E-01	5.06333E-01	9.89912E-01	1.17681E-02	9.89765E-01
32	9.66310E-01	5.21833E-01	9.89126E-01	1.13960E-02	9.89743E-01
33	1.03612E 00	5.38833E-01	9.90641E-01	1.11263E-02	9.91637E-01
34	9.95530E-01	5.54333E-01	9.90794E-01	1.07739E-02	9.92665E-01
35	1.04370E 00	5.70167E-01	9.92397E-01	1.05647E-02	9.93561E-01
36	1.01538E 00	5.86667E-01	9.93073E-01	1.02717E-02	9.93878E-01
37	1.00727E 00	6.02667E-01	9.93478E-01	9.98258E-03	9.94012E-01
38	9.74707E-01	6.18833E-01	9.92957E-01	9.71536E-03	9.93127E-01
39	1.04085E 00	6.35167E-01	9.94251E-01	9.53773E-03	9.94376E-01
40	1.02916E 00	6.52500E-01	9.95169E-01	9.32946E-03	9.95291E-01
41	1.02669E 00	6.69167E-01	9.95978E-01	9.12314E-03	9.96755E-01
42	1.08517E 00	6.86000E-01	9.98207E-01	9.16772E-03	9.98602E-01
43	9.20872E-01	7.00167E-01	9.96321E-01	9.13800E-03	9.96364E-01
44	1.11865E 00	7.20000E-01	9.99233E-01	9.38058E-03	9.98755E-01
45	9.60186E-01	7.35000E-01	9.98325E-01	9.20509E-03	9.98062E-01
46	1.09799E 00	7.53833E-01	1.00059E 00	9.27645E-03	1.00019E 00
47	9.50193E-01	7.68500E-01	9.99470E-01	9.13520E-03	9.99465E-01
48	1.09539E 00	7.87167E-01	1.00155E 00	9.17715E-03	1.00128E 00
49	8.87401E-01	8.01000E-01	9.99126E-01	9.30036E-03	9.98965E-01
50	1.07377E 00	8.17500E-01	1.00068E 00	9.23816E-03	1.00082E 00
51	1.04579E 00	8.34167E-01	1.00160E 00	9.09458E-03	1.00171E 00
52	9.01669E-01	8.46667E-01	9.99602E-01	9.13211E-03	9.99753E-01
53	1.04510E 00	8.64167E-01	1.00049E 00	8.99711E-03	1.00073E 00
54	9.84622E-01	8.80167E-01	1.00019E 00	8.82621E-03	1.00047E 00
55	9.52017E-01	8.95000E-01	9.99280E-01	8.70585E-03	9.99476E-01
56	1.01036E 00	9.10167E-01	9.99485E-01	8.54564E-03	9.99677E-01
57	9.22323E-01	9.23500E-01	9.98082E-01	8.50550E-03	9.98222E-01
58	1.07793E 00	9.40500E-01	9.99508E-01	8.47239E-03	9.99411E-01
59	9.58086E-01	9.53000E-01	9.98781E-01	8.35459E-03	9.98630E-01

60	1.02921E 00	9.66833E-01	9.99306E-01	8.22612E-03	9.99089E-01
61	1.01395E 00	9.82667E-01	9.99554E-01	8.08904E-03	9.99240E-01
62	1.02812E 00	9.99167E-01	1.00003E 00	7.96819E-03	9.99642E-01
63	1.00757E 00	1.01467E 00	1.00015E 00	7.83687E-03	9.99805E-01
64	9.29862E-01	1.02917E 00	9.99020E-01	7.79221E-03	9.98706E-01
65	1.12910E 00	1.04833E 00	1.00108E 00	7.94138E-03	1.00062E 00
66	1.03928E 00	1.06467E 00	1.00168E 00	7.84151E-03	1.00098E 00
67	1.04074E 00	1.08250E 00	1.00228E 00	7.74257E-03	1.00138E 00
68	9.67696E-01	1.09800E 00	1.00176E 00	7.64353E-03	1.00105E 00
69	9.97595E-01	1.11717E 00	1.00169E 00	7.52804E-03	1.00109E 00
70	9.15400E-01	1.13133E 00	1.00043E 00	7.52480E-03	9.99942E-01

WARNING - ONLY 283 INDEPENDENT FISSION POINTS WERE GENERATED.

71	3.38099E-01	1.14467E 00	9.98073E-01	7.77787E-03	9.97704E-01
72	9.57619E-01	1.15917E 00	9.97495E-01	7.68828E-03	9.97059E-01
73	1.01200E 00	1.17417E 00	9.97700E-01	7.58207E-03	9.97283E-01
74	9.99665E-01	1.18767E 00	9.97727E-01	7.47606E-03	9.97478E-01
75	1.00535E 00	1.20250E 00	9.97831E-01	7.37378E-03	9.97454E-01
76	9.51288E-01	1.21750E 00	9.97202E-01	7.30066E-03	9.96701E-01
77	9.50677E-01	1.23217E 00	9.96582E-01	7.22936E-03	9.96015E-01
78	9.92980E-01	1.24917E 00	9.96534E-01	7.13420E-03	9.95956E-01
79	9.97849E-01	1.26550E 00	9.96551E-01	7.04081E-03	9.95969E-01
80	9.70942E-01	1.28183E 00	9.96223E-01	6.95788E-03	9.95652E-01
81	1.02024E 00	1.30000E 00	9.96527E-01	6.87601E-03	9.95968E-01
82	1.03598E 00	1.31833E 00	9.97020E-01	6.80713E-03	9.96390E-01
83	9.46282E-01	1.33417E 00	9.96393E-01	6.75188E-03	9.95920E-01
84	1.00451E 00	1.35017E 00	9.96492E-01	6.67003E-03	9.96134E-01
85	1.03590E 00	1.37017E 00	9.96967E-01	6.60645E-03	9.96602E-01
86	9.97147E-01	1.38517E 00	9.96969E-01	6.52720E-03	9.96662E-01
87	8.94114E-01	1.39967E 00	9.95759E-01	6.56267E-03	9.95560E-01
88	1.01991E 00	1.41667E 00	9.96039E-01	6.49211E-03	9.96057E-01
89	9.99144E-01	1.43217E 00	9.96075E-01	6.41732E-03	9.96172E-01
90	1.00324E 00	1.44750E 00	9.96156E-01	6.34458E-03	9.96259E-01
91	1.02294E 00	1.46417E 00	9.96457E-01	6.28023E-03	9.96578E-01
92	1.02598E 00	1.48100E 00	9.96785E-01	6.21879E-03	9.96929E-01
93	1.00346E 00	1.49683E 00	9.96858E-01	6.15048E-03	9.97039E-01
94	9.93435E-01	1.51350E 00	9.96821E-01	6.08347E-03	9.97087E-01
95	1.01991E 00	1.52933E 00	9.97069E-01	6.02295E-03	9.97403E-01
96	1.03280E 00	1.54667E 00	9.97449E-01	5.97071E-03	9.97750E-01
97	9.42863E-01	1.56083E 00	9.96875E-01	5.93550E-03	9.97191E-01
98	1.00042E 00	1.57633E 00	9.96912E-01	5.87333E-03	9.97147E-01
99	9.96061E-01	1.59167E 00	9.96903E-01	5.81272E-03	9.97013E-01
100	9.57447E-01	1.60550E 00	9.96500E-01	5.76715E-03	9.96564E-01
101	1.02913E 00	1.62133E 00	9.96829E-01	5.71832E-03	9.96862E-01
102	1.00057E 00	1.63667E 00	9.96867E-01	5.66104E-03	9.96872E-01
103	1.07187E 00	1.65517E 00	9.97609E-01	5.65374E-03	9.97538E-01

THE MATRIX K-EFF IS THE LARGEST EIGENVALUE OF THE MATRIX OF FISSION PROBABILITIES BY UNIT.
THERE ARE NBXMAX * NBYMAX * NBZMAX UNITS IN AN ARRAY.

SAMPLE PROBLEM 19   4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

LIFETIME = 3.19221E-06 + OR - 4.66543E-08   GENERATION TIME = 3.91343E-06 + OR - 6.31336E-08

NO. OF INITIAL GENERATIONS SKIPPED	AVERAGE K-EFFECTIVE	DEVIATION	67 PER CENT CONFIDENCE INTERVAL	95 PER CENT CONFIDENCE INTERVAL	99 PER CENT CONFIDENCE INTERVAL	NUMBER OF HISTORIES
3	0.99785	+ OR - 0.00570	0.99215 TO 1.00355	0.98645 TO 1.00925	0.98075 TO 1.01495	30000
4	0.99841	+ OR - 0.00573	0.99268 TO 1.00414	0.98695 TO 1.00987	0.98122 TO 1.01560	29700
5	0.99840	+ OR - 0.00579	0.99261 TO 1.00418	0.98682 TO 1.00997	0.98103 TO 1.01576	29400
6	0.99921	+ OR - 0.00579	0.99342 TO 1.00500	0.98762 TO 1.01079	0.98183 TO 1.01658	29100
7	0.99994	+ OR - 0.00580	0.99413 TO 1.00574	0.98833 TO 1.01155	0.98253 TO 1.01735	28800
8	1.00062	+ OR - 0.00582	0.99480 TO 1.00645	0.98897 TO 1.01227	0.98315 TO 1.01810	28500
9	1.00115	+ OR - 0.00586	0.99528 TO 1.00701	0.98942 TO 1.01287	0.98356 TO 1.01874	28200
10	1.00072	+ OR - 0.00591	0.99481 TO 1.00663	0.98890 TO 1.01254	0.98298 TO 1.01845	27900
11	1.00136	+ OR - 0.00594	0.99542 TO 1.00730	0.98948 TO 1.01324	0.98354 TO 1.01918	27600
12	1.00174	+ OR - 0.00599	0.99574 TO 1.00773	0.98975 TO 1.01372	0.98376 TO 1.01972	27300
17	1.00267	+ OR - 0.00606	0.99660 TO 1.00873	0.99054 TO 1.01479	0.98448 TO 1.02085	25800
22	1.00171	+ OR - 0.00609	0.99563 TO 1.00780	0.98954 TO 1.01389	0.98345 TO 1.01998	24300
27	0.99987	+ OR - 0.00622	0.99364 TO 1.00609	0.98742 TO 1.01231	0.98120 TO 1.01853	22800
32	1.00119	+ OR - 0.00644	0.99475 TO 1.00764	0.98831 TO 1.01408	0.98187 TO 1.02052	21300
37	0.99980	+ OR - 0.00688	0.99293 TO 1.00668	0.98605 TO 1.01355	0.97918 TO 1.02043	19800
42	0.99722	+ OR - 0.00723	0.98999 TO 1.00445	0.98276 TO 1.01167	0.97554 TO 1.01890	18300
47	0.99612	+ OR - 0.00714	0.98898 TO 1.00325	0.98184 TO 1.01039	0.97471 TO 1.01752	16800
52	0.99566	+ OR - 0.00679	0.98886 TO 1.00245	0.98207 TO 1.00924	0.97527 TO 1.01604	15300
57	0.99705	+ OR - 0.00721	0.98984 TO 1.00425	0.98263 TO 1.01146	0.97542 TO 1.01867	13800
62	0.99407	+ OR - 0.00769	0.98638 TO 1.00175	0.97870 TO 1.00944	0.97101 TO 1.01712	12300
67	0.98918	+ OR - 0.00741	0.98176 TO 0.99659	0.97435 TO 1.00400	0.96694 TO 1.01141	10800
72	0.99787	+ OR - 0.00632	0.99155 TO 1.00419	0.98524 TO 1.01050	0.97892 TO 1.01682	9300
77	1.00058	+ OR - 0.00704	0.99353 TO 1.00762	0.98649 TO 1.01466	0.97945 TO 1.02171	7800
82	0.99986	+ OR - 0.00840	0.99146 TO 1.00826	0.98306 TO 1.01667	0.97465 TO 1.02507	6300
87	1.00745	+ OR - 0.00746	0.99999 TO 1.01491	0.99253 TO 1.02237	0.98507 TO 1.02983	4800
92	1.00436	+ OR - 0.01063	0.99373 TO 1.01499	0.98311 TO 1.02561	0.97248 TO 1.03624	3300

SAMPLE PROBLEM 19   4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

NO. OF INITIAL GENERATIONS SKIPPED	AVERAGE K-EFFECTIVE	DEVIATION	67 PER CENT CONFICENCE INTERVAL	95 PER CENT CONFIDENCE INTERVAL	99 PER CENT CONFIDENCE INTERVAL	NUMBER OF HISTORIES
97	1.00925	+ OR - 0.01563	0.99362 TO 1.02488	0.97799 TO 1.04051	0.96236 TO 1.05613	1800

SAMPLE PROBLEM 19   4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

GROUP	REGION	LEAKAGE	ABSORPTICNS	FISSIONS	WITH 3 GENFRATIONS SKIPPED
1		6.40643D-02	2.51146D-02	6.70441D-02	
	1		2.25877D-03	2.52312D-03	
	2		5.73427D-05	0.0	
	3		0.0	0.0	
	4		5.90535D-03	1.67125D-02	
	5		0.0	0.0	
	6		5.57095D-03	1.57661D-02	
	7		0.0	0.0	
	8		5.89728D-03	1.66897D-02	
	9		0.0	0.0	
	10		5.42489D-03	1.53528D-02	
	11		0.0	0.0	
2		1.16601D-01	4.59771D-02	1.12095D-01	
	1		1.97428D-03	4.15822D-03	
	2		0.0	0.0	
	3		0.0	0.0	
	4		1.16753D-02	2.86391D-02	
	5		0.0	0.0	
	6		1.10662D-02	2.71450D-02	
	7		0.0	0.0	
	8		1.06359D-02	2.60893D-02	
	9		0.0	0.0	
	10		1.06254D-02	2.60637D-02	
	11		0.0	0.0	
3		5.95828D-02	2.81050D-02	6.47758D-02	
	1		8.80352D-04	1.91696D-03	
	2		0.0	0.0	
	3		0.0	0.0	
	4		7.01102D-03	1.61877D-02	
	5		0.0	0.0	
	6		6.81073D-03	1.57253D-02	
	7		0.0	0.0	
	8		6.85328D-03	1.58235D-02	
	9		0.0	0.0	
	10		6.54962D-03	1.51224D-02	
	11		0.0	0.0	

SAMPLE PROBLEM 19 4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

GROUP	REGION	LEAKAGE	ABSORPTIONS	FISSIONS	WITH 3 GENERATIONS SKIPPED
4		9.07835D-02	4.67363D-02	1.02520D-01	
	1		1.25741D-03	2.60680D-03	
	2		0.0	0.0	
	3		0.0	0.0	
	4		1.20693D-02	2.65154D-02	
	5		0.0	0.0	
	6		1.12312D-02	2.46741D-02	
	7		0.0	0.0	
	8		1.09534D-02	2.40638D-02	
	9		0.0	0.0	
	10		1.12249D-02	2.46603D-02	
	11		0.0	0.0	
5		6.95589D-02	4.40052D-02	9.26068D-02	
	1		1.45976D-03	3.06293D-03	
	2		0.0	0.0	
	3		0.0	0.0	
	4		1.07827D-02	2.26940D-02	
	5		0.0	0.0	
	6		1.06489D-02	2.24124D-02	
	7		0.0	0.0	
	8		1.08722D-02	2.28824D-02	
	9		0.0	0.0	
	10		1.02415D-02	2.15550D-02	
	11		0.0	0.0	
6		2.76098D-02	1.51974D-02	2.92412D-02	
	1		1.93324D-03	3.71249D-03	
	2		0.0	0.0	
	3		0.0	0.0	
	4		3.46462D-03	6.66813D-03	
	5		0.0	0.0	
	6		3.07062D-03	5.90983D-03	
	7		0.0	0.0	
	8		3.58033D-03	6.89084D-03	
	9		0.0	0.0	
	10		3.14858D-03	6.05987D-03	
	11		0.0	0.0	

SAMPLE PROBLEM 19 4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

GROUP REGION LEAKAGE ABSORPTIONS FISSIONS WITH 3 GENERATIONS SKIPPED

GROUP	REGION	LEAKAGE	ABSORPTIONS	FISSIONS
7		1.63434D-02	5.96885D-03	1.10548D-02
	1		2.54817D-03	4.71320D-03
	2		0.0	0.0
	3		0.0	0.0
	4		8.89728D-04	1.64948D-03
	5		0.0	0.0
	6		9.59427D-04	1.77869D-03
	7		0.0	0.0
	8		7.84496D-04	1.45439D-03
	9		0.0	0.0
	10		7.87022D-04	1.45907D-03
	11		0.0	0.0
8		1.30448D-02	7.98730D-03	1.37327D-02
	1		4.51778D-03	7.74471D-03
	2		2.87943D-06	0.0
	3		0.0	0.0
	4		8.05607D-04	1.39155D-03
	5		0.0	0.0
	6		8.10328D-04	1.39970D-03
	7		0.0	0.0
	8		9.67876D-04	1.67184D-03
	9		0.0	0.0
	10		8.82832D-04	1.52494D-03
	11		0.0	0.0
9		1.11451D-02	1.33607D-02	2.20690D-02
	1		1.03572D-02	1.70801D-02
	2		1.10153D-05	0.0
	3		0.0	0.0
	4		5.47001D-04	9.11936D-04
	5		0.0	0.0
	6		8.27793D-04	1.38006D-03
	7		0.0	0.0
	8		9.02773D-04	1.50506D-03
	9		0.0	0.C
	10		7.14932D-04	1.19190D-03
	11		0.0	0.0

SAMPLE PROBLEM 19 4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

GROUP	REGION	LEAKAGE	ABSORPTIONS	FISSIONS	WITH 3 GENERATIONS SKIPPED
10		6.88144D-03	1.49860D-02	2.35795D-02	
	1		1.29307D-02	2.03333D-02	
	2		1.40560D-05	0.0	
	3		0.0	0.0	
	4		4.21613D-04	6.70481D-04	
	5		0.0	0.0	
	6		4.42491D-04	7.03683D-04	
	7		0.0	0.0	
	8		6.42795D-04	1.02222D-03	
	9		0.0	0.0	
	10		5.34412D-04	8.49862D-04	
	11		0.0	0.0	
11		6.06417D-03	7.23840D-03	1.06838D-02	
	1		5.69014D-03	8.35692D-03	
	2		2.20625D-05	0.0	
	3		0.0	0.0	
	4		3.86527D-04	5.89319D-04	
	5		0.0	0.0	
	6		3.94559D-04	6.01566D-04	
	7		0.0	0.0	
	8		3.58278D-04	5.46249D-04	
	9		0.0	0.0	
	10		3.86832D-04	5.89785D-04	
	11		0.0	0.0	
12		6.41426D-03	7.83010D-03	8.13215D-03	
	1		6.29114D-03	6.48516D-03	
	2		3.93262D-05	0.0	
	3		0.0	0.0	
	4		4.31955D-04	4.74402D-04	
	5		0.0	0.0	
	6		4.48475D-04	4.92545D-04	
	7		0.0	0.0	
	8		3.57970D-04	3.93146D-04	
	9		0.0	0.0	
	10		2.61229D-04	2.86899D-04	
	11		0.0	0.0	

SAMPLE PROBLEM 19   4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

GROUP	REGION	LEAKAGE	ABSORPTIONS	FISSIONS	WITH 3 GENERATIONS SKIPPED
13		6.20843D-03	6.63203D-03	1.15205D-02	
	1		5.35220D-03	9.17465D-03	
	2		5.89829D-05	0.0	
	3		0.0	0.0	
	4		4.11298D-04	7.90296D-04	
	5		0.0	0.0	
	6		3.13689D-04	6.02744D-04	
	7		0.0	0.0	
	8		3.65858D-04	7.02984D-04	
	9		0.0	0.0	
	10		1.30006D-04	2.49802D-04	
	11		0.0	0.0	
14		4.50419D-03	1.28460D-02	2.59164D-02	
	1		1.18189D-02	2.38756D-02	
	2		7.46388D-05	0.0	
	3		0.0	0.0	
	4		1.81660D-04	3.89241D-04	
	5		0.0	0.0	
	6		3.34856D-04	7.17493D-04	
	7		0.0	0.0	
	8		2.48724D-04	5.32939D-04	
	9		0.0	0.0	
	10		1.87224D-04	4.01163D-04	
	11		0.0	0.0	
15		7.34613D-03	6.37414D-02	1.23567D-01	
	1		6.15273D-02	1.19671D-01	
	2		2.87908D-04	0.0	
	3		0.0	0.0	
	4		5.53998D-04	1.12062D-03	
	5		0.0	0.0	
	6		5.08245D-04	1.02807D-03	
	7		0.0	0.0	
	8		5.47810D-04	1.10810D-03	
	9		0.0	0.0	
	10		3.16175D-04	6.39554D-04	
	11		0.0	0.0	

SAMPLE PROBLEM 19   4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

GROUP	REGION	LEAKAGE	ABSORPTIONS	FISSIONS	WITH 3 GENERATIONS SKIPPED
16		7.35365D-03	1.40409D-01	2.79319D-01	
	1		1.37083D-01	2.74357D-01	
	2		9.27313D-04	0.0	
	3		0.0	0.0	
	4		4.95798D-04	1.02554D-03	
	5		0.0	0.0	
	6		4.84318D-04	1.00180D-03	
	7		0.0	0.0	
	8		7.39279D-04	1.52918D-03	
	9		0.0	0.0	
	10		6.79374D-04	1.40527D-03	
	11		0.0	0.0	
TOTAL =		5.13506D-01	4.86136D-01	9.57859D-01	

ELAPSED TIME   1.65517MINUTES

SAMPLE PROBLEM 19 4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

UNIT NUMBER	POSITION X	Y	Z	BOX TYPE	COFACTOR K-EFFECTIVE
1	1	1	1	2	9.44449E-01
2	2	1	1	1	9.61593E-01
3	1	2	1	3	9.48397E-01
4	2	2	1	1	9.61444E-01
5	1	1	2	4	9.46371E-01
6	2	1	2	1	9.64612E-01
7	1	2	2	5	9.51019E-01
8	2	2	2	1	9.61632E-01

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SAMPLE PROBLEM 19   4 AQUEOUS 4 METAL  MIXED BOX MATRIX CALCULATION

FISSION PROBABILITY MATRIX BY UNIT
  (  I.   J) P IS THE PROBABILITY THAT A NEUTRON BORN IN UNIT I CAUSES A NEXT GENERATION FISSION IN UNIT J.

   (  1.   1) 7.38F-01  (  1.   2) 7.28E-02  (  1.   3) 6.22E-02  (  1.   4) 4.46E-02  (  1.   5) 7.76E-02  (  1.   6) 3.20E-02
   (  1.   7) 3.15F-02  (  1.   8) 2.92E-02

   (  2.   1) 4.63E-02  (  2.   2) 6.35E-01  (  2.   3) 2.30E-02  (  2.   4) 6.52E-02  (  2.   5) 1.64E-02  (  2.   6) 9.48F-02
   (  2.   7) 1.51E-02  (  2.   8) 3.11E-02

   (  3.   1) 6.40E-02  (  3.   2) 4.03E-02  (  3.   3) 7.08E-01  (  3.   4) 7.84E-02  (  3.   5) 3.05E-02  (  3.   6) 2.67E-02
   (  3.   7) 8.11E-02  (  3.   8) 3.69E-02

   (  4.   1) 2.35E-02  (  4.   2) 6.46E-02  (  4.   3) 4.11E-02  (  4.   4) 6.76E-01  (  4.   5) 1.52E-02  (  4.   6) 1.64E-02
   (  4.   7) 1.53E-02  (  4.   8) 9.64E-02

   (  5.   1) 7.64F-02  (  5.   2) 3.72E-02  (  5.   3) 2.71E-02  (  5.   4) 2.42E-02  (  5.   5) 7.21E-01  (  5.   6) 7.47E-02
   (  5.   7) 6.93F-02  (  5.   8) 4.47E-02

   (  6.   1) 1.88E-02  (  6.   2) 1.05E-01  (  6.   3) 1.61E-02  (  6.   4) 1.95E-02  (  6.   5) 5.09E-02  (  6.   6) 6.17E-01
   (  6.   7) 2.29E-02  (  6.   8) 5.97E-02

   (  7.   1) 3.14F-02  (  7.   2) 2.70E-02  (  7.   3) 8.44E-02  (  7.   4) 2.80E-02  (  7.   5) 6.11E-02  (  7.   6) 4.26F-02
   (  7.   7) 7.06E-01  (  7.   8) 7.20E-02

   (  8.   1) 1.17E-02  (  8.   2) 1.77E-02  (  8.   3) 2.50E-02  (  8.   4) 8.94E-02  (  8.   5) 3.21E-02  (  8.   6) 5.90E-02
   (  8.   7) 4.34F-02  (  8.   8) 6.34E-01
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SAMPLE PROBLEM 19   4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

SOURCE VECTOR BY UNIT

UNIT	VECTOR
1	1.65533E-01
2	1.49830E-01
3	1.43115E-01
4	1.34681E-01
5	1.49637E-01
6	1.23401E-01
7	1.33803E-01
8	1.36990E-01

AVERAGE UNIT SELF MULTIPLICATION = 6.79370E-01 +OR- 1.61587E-02 (THE PROBABILITY THAT A NEUTRON BORN IN A UNIT PRODUCES A FISSION IN THAT SAME UNIT.)

SAMPLE PROBLEM 19 4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

BOX TYPE K-EFFECTIVE = 9.9C990E-01
THE BOX TYPE K-EFFECTIVE IS THE LARGEST EIGENVALUE OF THE MATRIX OF FISSION PROBABILITIES BY BOX TYPE.

FISSION PROBABILITY MATRIX BY BOX TYPE
(I. J) P IS THE PROBABILITY THAT A NEUTRON BORN IN BOX TYPE I CAUSES A NEXT GENERATION FISSION IN BOX TYPE J.

(1. 1) 8.04E-01	(1. 2) 2.51E-02	(1. 3) 2.68E-02	(1. 4) 2.79E-02	(1. 5) 2.41E-02
(2. 1) 1.78E-01	(2. 2) 7.38E-01	(2. 3) 6.22E-02	(2. 4) 7.76E-02	(2. 5) 3.15E-02
(3. 1) 1.82E-01	(3. 2) 6.40E-02	(3. 3) 7.08E-01	(3. 4) 3.05E-02	(3. 5) 8.11E-02
(4. 1) 1.81E-01	(4. 2) 7.64E-02	(4. 3) 2.71E-02	(4. 4) 7.21E-01	(4. 5) 6.93E-02
(5. 1) 1.69E-01	(5. 2) 3.14E-02	(5. 3) 8.44E-02	(5. 4) 6.11E-02	(5. 5) 7.06E-01

SAMPLE PROBLEM 19 4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

SOURCE VECTOR BY BOX TYPE

BOX TYPE	VECTOR
1	4.88506E-01
2	1.34042E-01
3	1.24418E-01
4	1.30431E-01
5	1.22603E-01

SAMPLE PROBLEM 19   4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

BOX TYPE	COFACTOR K-EFFECTIVE
1	8.92911E-01
2	9.36202E-01
3	9.40733E-01
4	9.37133E-01
5	9.42324E-01

SAMPLE PROBLEM 19   4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

**** FISSION DENSITIES ****

	REGION	FISSION DENSITY	PERCENT DEVIATION	TOTAL FISSIONS
BOX TYPE 1				
	1	2.515E-05	1.16	5.097E-01
	2	0.0	0.0	0.0
	3	0.0	0.0	0.0
BOX TYPE 2				
	1	1.131E-04	1.98	1.264E-01
	2	0.0	0.0	0.0
BOX TYPE 3				
	1	1.086E-04	2.35	1.213E-01
	2	0.0	0.0	0.0
BOX TYPE 4				
	1	1.100E-04	2.38	1.229E-01
	2	0.0	0.0	0.0
BOX TYPE 5				
	1	1.051E-04	2.44	1.174E-01
	2	0.0	0.0	0.0

SAMPLE PROBLEM 19   4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

FLUXES FOR BOX TYPE   1

	REGION 1		REGION 2		REGION 3	
GROUP	FLUX	PERCENT DEVIATION	FLUX	PERCENT DEVIATION	FLUX	PERCENT DEVIATION
1	3.408E-05	2.09	2.353E-05	2.98	2.000E-05	3.33
2	6.310E-05	1.80	4.255E-05	2.19	3.916E-05	2.19
3	3.116E-05	1.85	2.209E-05	3.04	2.060E-05	3.02
4	4.414E-05	1.57	3.225E-05	2.08	3.064E-05	2.35
5	4.410E-05	1.55	3.140E-05	1.98	2.631E-05	2.40
6	3.072E-05	1.51	1.985E-05	2.54	1.375E-05	4.02
7	2.289E-05	1.59	1.422E-05	2.58	9.606E-06	4.01
8	1.984E-05	1.51	1.174E-05	2.89	7.741E-06	4.79
9	1.873E-05	1.58	1.076E-05	3.16	6.486E-06	4.48
10	1.205E-05	2.17	7.037E-06	3.68	4.065E-06	5.63
11	1.058E-05	2.23	6.231E-06	3.40	3.834E-06	5.81
12	1.111E-05	2.01	5.994E-06	3.59	3.906E-06	5.62
13	9.397E-06	1.82	5.149E-06	3.94	3.158E-06	6.48
14	7.040E-06	2.04	4.414E-06	4.45	2.425E-06	7.93
15	1.326E-05	1.52	8.833E-06	3.42	5.012E-06	4.72
16	1.092E-05	1.44	1.248E-05	3.34	6.548E-06	4.45

SAMPLE PROBLEM 19 4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

FLUXES FOR BOX TYPE 2

	REGION 1		REGION 2	
GROUP	FLUX	PERCENT DEVIATION	FLUX	PERCENT DEVIATION
1	9.129E-05	4.11	1.787E-05	4.85
2	1.660E-04	3.08	3.243E-05	3.96
3	1.073E-04	4.20	2.015E-05	4.24
4	1.712E-04	3.64	3.267E-05	3.16
5	1.277E-04	3.90	2.224E-05	4.15
6	2.244E-05	8.15	7.378E-06	8.49
7	3.183E-06	16.34	2.673E-06	12.16
8	1.447E-06	19.97	1.924E-06	15.05
9	3.217E-07	26.04	1.825E-06	16.14
10	2.157E-07	32.74	7.958E-07	25.00
11	2.618E-07	33.23	9.970E-07	22.08
12	3.305E-07	33.98	8.169E-07	26.31
13	3.342E-07	35.69	9.263E-07	19.87
14	3.374E-08	40.58	5.846E-07	25.95
15	6.395E-08	28.12	1.188E-06	17.61
16	2.185E-08	26.89	1.180E-06	18.74

SAMPLE PROBLEM 19 4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

FLUXES FOR BOX TYPE 3

	REGION 1		REGION 2	
GROUP	FLUX	PERCENT DEVIATION	FLUX	PERCENT DEVIATION
1	8.585E-05	4.84	1.844E-05	4.76
2	1.666E-04	3.37	3.334E-05	3.51
3	1.026E-04	4.32	2.093E-05	4.51
4	1.593E-04	3.53	2.995E-05	3.82
5	1.236E-04	3.48	2.339E-05	3.95
6	1.872E-05	8.64	6.450E-06	8.31
7	3.296E-06	16.46	2.804E-06	14.55
8	1.445E-06	19.73	1.713E-06	15.80
9	5.926E-07	20.08	1.724E-06	17.00
10	1.125E-07	30.34	1.354E-06	23.36
11	3.104E-07	31.03	6.229E-07	31.67
12	3.311E-07	32.29	8.613E-07	24.35
13	2.885E-07	36.37	8.976E-07	23.07
14	7.518E-08	33.25	7.994E-07	24.16
15	4.537E-08	32.09	1.209E-06	17.97
16	1.584E-08	26.01	8.713E-07	18.18

SAMPLE PROBLEM 19 4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

FLUXES FOR BOX TYPE 4

	REGION 1		REGION 2	
GROUP	FLUX	PERCENT DEVIATION	FLUX	PERCENT DEVIATION
1	9.097E-05	4.56	1.922E-05	4.80
2	1.632E-04	3.59	3.576E-05	3.52
3	1.002E-04	4.88	1.859E-05	4.79
4	1.606E-04	3.70	2.998E-05	3.46
5	1.280E-04	4.11	2.296E-05	4.35
6	2.187E-05	7.99	5.722E-06	8.73
7	2.742E-06	20.51	2.468E-06	16.52
8	1.797E-06	18.42	2.047E-06	15.90
9	6.102E-07	19.65	2.088E-06	16.43
10	2.627E-07	22.20	1.185E-06	18.08
11	3.126E-07	33.93	1.141E-06	22.72
12	1.877E-07	31.67	1.182E-06	23.32
13	2.182E-07	31.45	1.383E-06	18.85
14	4.921E-08	39.02	5.644E-07	28.85
15	3.718E-08	26.02	1.260E-06	18.76
16	1.970E-08	22.58	1.184E-06	16.65

SAMPLE PROBLEM 19 4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

FLUXES FOR BOX TYPE 5

	REGION 1		REGION 2	
GROUP	FLUX	PERCENT DEVIATION	FLUX	PERCENT DEVIATION
1	8.563E-05	4.31	1.887E-05	4.85
2	1.587E-04	3.57	3.266E-05	3.49
3	1.038E-04	3.93	2.059E-05	4.63
4	1.664E-04	3.66	3.209E-05	3.38
5	1.230E-04	3.76	2.235E-05	4.12
6	2.065E-05	7.91	6.425E-06	8.70
7	2.927E-06	19.94	3.706E-06	12.36
8	1.808E-06	19.91	2.568E-06	13.55
9	5.597E-07	23.78	2.318E-06	13.46
10	2.057E-07	28.95	1.227E-06	21.45
11	3.163E-07	34.44	1.203E-06	19.81
12	1.551E-07	33.50	9.552E-07	22.50
13	9.113E-08	42.20	8.686E-07	21.79
14	7.387E-08	42.99	6.146E-07	28.72
15	2.685E-08	34.90	9.755E-07	20.25
16	1.994E-08	25.23	1.018E-06	16.27

```
SAMPLE PROBLEM 19   4 AQUEOUS 4 METAL  MIXED BOX MATRIX CALCULATION

                               FREQUENCY FOR GENERATIONS    4 TO  103
0.8246 TO 0.8477     *
0.8477 TO 0.8708
0.8708 TO 0.8939     **
0.8939 TO 0.9170     ****
0.9170 TO 0.9401     *******
0.9401 TO 0.9632     *****************
0.9632 TO 0.9863     ********
0.9863 TO 1.0094     *******************
1.0094 TO 1.0325     **************
1.0325 TO 1.0556     *************
1.0556 TO 1.0787     *******
1.0787 TO 1.1018     ******
1.1018 TO 1.1249     *
1.1249 TO 1.1480     *

                               FREQUENCY FOR GENERATIONS   29 TO  103
0.8246 TO 0.8477     *
0.8477 TO 0.8708
0.8708 TO 0.8939     *
0.8939 TO 0.9170     ***
0.9170 TO 0.9401     ****
0.9401 TO 0.9632     ***********
0.9632 TO 0.9863     *****
0.9863 TO 1.0094     ******************
1.0094 TO 1.0325     **************
1.0325 TO 1.0556     **********
1.0556 TO 1.0787     ***
1.0787 TO 1.1018     ***
1.1018 TO 1.1249     *
1.1249 TO 1.1480     *

                               FREQUENCY FOR GENERATIONS   54 TO  103
0.8246 TO 0.8477     *
0.8477 TO 0.8708
0.8708 TO 0.8939
0.8939 TO 0.9170     **
0.9170 TO 0.9401     **
0.9401 TO 0.9632     ********
0.9632 TO 0.9863     ***
0.9863 TO 1.0094     ***************
1.0094 TO 1.0325     ***********
1.0325 TO 1.0556     *****
1.0556 TO 1.0787     **
1.0787 TO 1.1018
1.1018 TO 1.1249
1.1249 TO 1.1480     *
```

SAMPLE PROBLEM 19   4 AQUEOUS 4 METAL MIXED BOX MATRIX CALCULATION

FREQUENCY FOR GENERATIONS   79 TO 103

```
0.8246 TO 0.8477
0.8477 TO 0.8708
0.8708 TO 0.8939
0.8939 TO 0.9170     *
0.9170 TO 0.9401
0.9401 TO 0.9632     ***
0.9632 TO 0.9863     *
0.9863 TO 1.0094     **********
1.0094 TO 1.0325     ******
1.0325 TO 1.0556     ***
1.0556 TO 1.0787     *
1.0787 TO 1.1018
1.1018 TO 1.1249
1.1249 TO 1.1480
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********** END OF FILE ON UNIT   5 **********

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