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PACIFIC NORTHWEST LABORATORY

RICHLAND, WASHINGTON

operated by

BATTELLE MEMORIAL INSTITUTE

for the

UNITED STATES ATOMIC ENERGY COMMISSION UNDER CONTRACT AT(45-1)-1830

PRINTED BY/ FOR THE U. S. ATOMIC ENERGY COMMISSION

BNWL-450
UC-80, Reactor Technology

FCC-IV, A REVISED VERSION
OF THE FCC FUNDAMENTAL
MODE FAST REACTOR CODE

by

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FFTF Reactor Physics Section
FFTF Project

August 1967

FIRST UNRESTRICTED
DISTRIBUTION MADE OCT 17 1967

PACIFIC NORTHWEST LABORATORY
RICHLAND, WASHINGTON

Printed in the United States of America
Available from
Clearinghouse for Federal Scientific and Technical Information
National Bureau of Standards, U.S. Department of Commerce
Springfield, Virginia 22151
Price: Printed Copy \$3.00; Microfiche \$0.65

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ABSTRACT

FCC-IV is a multipurpose fundamental mode code for use in fast reactor neutronics analysis. The code can be used to:

- (1) Compute resonance shielded cross sections using data in the Russian format,
- (2) Compute the fundamental mode flux and adjoint flux,
- (3) Compute and punch collapsed microscopic, macroscopic, and perturbation cross sections,
- (4) Compute fuel burnup at constant flux or power density.

In a 65 K memory, the code can handle 14 isotopes with 40 energy groups and 10 downscattering terms. Running time on a UNIVAC 1108 is about 15 sec.

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I. INTRODUCTION

This report describes a computer code, FCC-IV, that will rapidly compute resonance shielded cross sections, collapsed group cross sections, and fuel burnup for fast reactor design analysis. FCC-IV is an extensive revision of the FCC code.^(1,2)

The principal revisions are:

- (1) Extension from 26 to 40 energy groups (maximum),
- (2) Inclusion of a feedback loop on flux to recompute removal cross sections,
- (3) Incorporation of a more complete scattering matrix (to handle hydrogen),
- (4) Adoption of a logarithmic interpolation scheme on temperature to compute shielded cross sections,
- (5) Option to compute and punch collapsed perturbation cross sections,
- (6) Cleaner code logic, input, and output,
- (7) Option to read input cross sections from tape. The cross section tape is prepared by the PUP-IV code.

A general description of the FCC-IV code is given in Chapters II and III. The mathematical models for computing flux, collapsed cross sections, burnup, and shielded cross sections are shown in Chapters IV through VIII. A FORTRAN IV source deck listing, input information, and a sample case are given in the appendices.

II. OUTLINE OF CODE LOGIC

Before presenting the details of the code, it is perhaps helpful to the reader to see a birds-eye view of the code logic. Such a sketch--with numerous details omitted--is shown in Figure 2.1. Although this figure is almost self-explanatory, one complete cycle will be traced.

Discussion of Schematic Diagram

After reading the preliminary data cards, the code reads and prints the input cross sections (in the DTK, DTF, or Russian format). A rather extensive cross check of the cross sections is then performed. If anomalies are encountered, appropriate error flags are printed.

If the input cross sections are in the Russian format,⁽³⁾ numerous interpolations and iterations--involving the total cross section, temperature, and flux--are performed to compute resonance shielded cross sections.

After reading parameters (e.g., atom densities) for the new case, the code computes and prints the fundamental mode energy spectrum. This spectrum is then used to compute spectrum averaged cross sections.

If no group collapsing or fuel burnup is desired, the code proceeds to the next case. If the current case includes group collapsing, the code computes, prints, and punches the collapsed cross sections. A neutron balance using the collapsed cross sections is also computed and printed.

If a burnup calculation is called for after a group collapsing computation, the code performs the burnup using the collapsed cross sections.

After the last operation (collapsing or burnup), the code reads parameters for a new case. Any number of cases can be run in series.

FIGURE 2.1. Schematic Diagram of FCC-IV

III. DISCUSSION OF PRINCIPAL OPTIONS

Format of Input Cross Sections

Three formats can be used for input cross sections. The first two formats, called DTK and DTF, contain data in a form directly applicable to transport and diffusion calculations. The only distinction between the DTK and DTF formats is the word placement on the data cards.

The third input format, the Russian format,⁽³⁾ contains infinite dilution cross sections and shielding factors. Shielding factors are tabulated as a function of energy, temperature, and total cross section per atom. Interpolation schemes are used to compute resonance shielded cross sections from the infinite dilution values and shielding factors. Shielded cross sections are recomputed at the beginning of each new case, but not during burnup.

Flux and Adjoint Flux Calculation

Only two significant options are possible in the flux calculation:

- The computation of k_{eff} for a specified buckling, B^2 ,
- The computation of B^2 for a specified k_{eff} .

As a variation of the first option, k_{eff} can be computed using the buckling from the previous case.

An input flux spectrum can also be used in FCC-IV. In this instance, of course, the flux calculation is bypassed.

Options Pertaining to Collapsing and Punching Cross Sections

If desired, FCC-IV will collapse, print, and punch microscopic, macroscopic, and perturbation cross sections. All collapsed cross sections are computed using the flux and adjoint spectrum corresponding to the current case.

Burnup Options

A number of options are available for computing fuel burnup. The principal choices are:

(1) Neutronics format

- k_{eff} as a function of time for a given initial k_{eff} (adjusting B^2)
- k_{eff} as a function of time for a specified buckling (B^2)
- B^2 as a function of time for a specified k_{eff} ,

(2) Burnup can be computed at constant power or constant flux,

(3) Fission products can be burned out or simply accumulated.

It should be mentioned that the code recomputes the spectrum and spectrum averaged cross sections at each time step. Although this continuous recalculation is unnecessary in many fast reactor studies, the running time for a typical burnup is still quite small (~ 30 sec).

IV. FUNDAMENTAL MODE EQUATIONS

At the start of each case, after each time step, and after each group collapsing calculation, the code computes the fundamental mode flux and adjoint flux. The equations used for the fundamental mode flux calculations are described below.

Algorithm for Flux

If ϕ_i is the flux in group i ($i = 1$ denotes highest energy group), it is easy to show that

$$\phi_i = \frac{\lambda_i S_0 + \sum_{k=1}^{i-1} \sum (k \rightarrow i) \phi_k}{\frac{B^2}{3 \sum_{\text{tr}}^i} + \sum_a^i + \sum_{j=i+1}^N \sum (i \rightarrow j)} \quad (4.1)$$

where:

N = number of energy groups,

B^2 = buckling,

S_0 = arbitrary constant,

χ_i = fission spectrum contribution to group i,

$\sum_{tr}^i$ = transport cross section for group i,

$\sum_a^i$ = absorption cross section for group i,

$\sum(i \rightarrow j)$ = cross section for scattering from group i to group j.

If the buckling, B^2 , is known, Equation (4.1) can be solved explicitly for ϕ_i by commencing in the first group and proceeding down in energy. If B^2 is not known, one must iterate between the flux algorithm, [i.e., Equation (4.1)] and the criticality relationship,

$$k_{eff} = \frac{\sum_{i=1}^N (\nu \Sigma_f)^i \phi_i}{S_0} \quad , \quad (4.2)$$

to obtain both B^2 and ϕ_i .

Algorithm for Adjoint Flux

Let ϕ_i^+ be the neutron worth, or adjoint flux, in group i. It is clear that

$$\phi_i^+ = \frac{(\nu \Sigma_f)^i S_1 + \sum_{j=i+1}^N \sum(i \rightarrow j) \phi_j^+}{\frac{B^2}{3 \sum_{tr}^i} + \sum_a^i + \sum_{j=i+1}^N \sum(i \rightarrow j)} \quad . \quad (4.3)$$

In contrast to Equation (4.1), observe that Equation (4.3) can be most easily solved by starting in the lowest energy group and proceeding up in energy.

The effective multiplication constant can also be expressed in terms of the adjoint flux by the relationship

$$k_{\text{eff}} = \frac{\sum_{i=1}^N \chi_i \phi_i^+}{S_1} \quad , \quad (4.4)$$

which, clearly, is similar in construction to Equation (4.2).

V. ALGORITHMS FOR COMPUTING COLLAPSED CROSS SECTIONS

As previously mentioned, the code will collapse an N group data set to an n group set, where $N > n \geq 1$. Any regrouping is permissible as long as the bounds of the new groups correspond to those of the original set. For example, a 26 group set could be collapsed to two groups: the first comprising the top 25 groups and the second equivalent to the original 26th group.

Two collapsing schemes are available: one conserves reaction rates and the other conserves first order reactivity coefficients. The former is applicable to general use; the latter can be used in calculating reactivity coefficients.

Averaging Procedure to Conserve Activity Rates

For convenience, let

K = index for new collapsed energy group,

ψ_K = total flux in group K,

$\bar{\sigma}_K$ = average microscopic cross section for the K^{th} collapsed group.

We now define ψ_K by the equation

$$\psi_K = \sum_{i=1}^K \phi_i \quad , \quad (5.1)$$

where the symbol $\sum^K$ denotes a sum over the initial energy groups comprising the K^{th} collapsed group.

For each isotope and collapsed energy group, the fission, capture, and neutron source ($\nu \sigma_f$) cross sections are obtained using the recipe

$$\bar{\sigma}_K = \frac{\sum^K \sigma_i^i \phi_i}{\psi_K} \quad (5.2)$$

Observe that the rate of fission, capture, and neutron emission is unaltered by this averaging procedure.

Unfortunately, the neutron leakage rate will not be conserved if the collapsed transport cross sections are computed by Equation (5.2). This difficulty arises, of course, from the inverse dependence of leakage on atom density.

For convenience, four options are available in the code for computing the average transport cross sections. These options are:

- (1) Reciprocal weighting, defined to be

$$\bar{\sigma}_{\text{tr}}^K = \frac{\psi_K}{\sum^K \left(\frac{\phi_i}{\sigma_{\text{tr}}^i} \right)} \quad (5.3)$$

(2) Normalized reciprocal weighting, defined by

$$\bar{\sigma}_{tr}^K = \gamma_K \left[\frac{\psi_K}{\sum_{i=1}^K \left(\frac{\phi_i}{\sigma_{tr}^i} \right)} \right] , \quad (5.4)$$

where γ_K is determined such that the fundamental mode leakage rate $\left(\frac{B^2}{3\sum_{tr}} \right) \phi$ is conserved for each coarse group.

(3) Linear weighting, defined by

$$\bar{\sigma}_{tr}^K = \frac{\sum_{i=1}^K \sigma_{tr}^i \phi_i}{\psi_K} , \quad (5.5)$$

(4) Normalized linear weighting, defined as

$$\bar{\sigma}_{tr}^K = \gamma_K \left[\frac{\sum_{i=1}^K \sigma_{tr}^i \phi_i}{\psi_K} \right] , \quad (5.6)$$

where, as before, the normalization factor, γ_K , is chosen such that the leakage rate is conserved for each coarse group.

Observe that since the neutron leakage rate is conserved in the normalized options, the total neutron balance using the initial and few group cross sections will be identical.

The collapsed downscattering cross sections are computed by matching the slowing down currents. If we define $\bar{\sigma}(K \rightarrow J)$ as the collapsed scattering probability from group K to group J, a current balance gives the algorithm

$$\bar{\sigma}(K \rightarrow J) = \frac{\sum_{i \in \psi_K}^K \sum_j^J \sigma(i \rightarrow j) \phi_i}{\psi_K} \quad (5.7)$$

The final cross section computed is the in-group scattering probability, σ_{gg} . For each isotope and energy group, σ_{gg} is calculated using the expression

$$\bar{\sigma}_{gg}^K = \bar{\sigma}_{tr}^K - \bar{\sigma}_a^K - \sum_J \bar{\sigma}(K \rightarrow J) \quad (5.8)$$

It should be mentioned that $\bar{\sigma}_{gg}$, as defined and used in this paper, is actually superfluous information. It is carried along as a dummy in the FCC-IV code because it is required input in neutron transport codes.

Collapsing Procedure for Perturbation Cross Sections

Since the applicability and merits of importance-weighting have been discussed at length in the literature,⁽⁴⁾ we will restrict ourselves to simply tabulating the particular importance-weighting scheme available in FCC-IV.

First, the collapsed fission (σ_f), neutron source ($\nu\sigma_f$), and moderation [$\sigma(I \rightarrow J)$] cross sections are identical to those described in the previous section. The microscopic neutron transport cross section is defined by the equation

$$\bar{\sigma}_{tr}^K = \frac{\left(\sum_{tr}^K\right)^2 \sum \phi_i \phi_i^\dagger \frac{\sigma_{tr}^i}{\left(\sum_{tr}^i\right)^2}}{\psi_K \psi_K^\dagger}, \quad (5.9)$$

where $\psi_K^\dagger$ is the adjoint flux in the K^{th} collapsed group.

The (pseudo) absorption cross section is computed from the rather complex expression

$$\bar{\sigma}_a^K = \frac{\sum \phi_i \phi_i^\dagger \sigma_a^i + \sum_{j=i+1}^K \sum_N \sigma(i \rightarrow j) \phi_i (\phi_i^\dagger - \phi_j^\dagger) - \sum_{J=K+1}^n \sigma(I \rightarrow J) (\psi_K^\dagger - \psi_J^\dagger) \psi_K}{\psi_K \psi_K^\dagger} \quad (5.10)$$

Finally, the in-group scattering cross section, $\bar{\sigma}_{gg}^K$, is obtained by subtracting $[\bar{\sigma}_a + \sum_{J \neq I} \bar{\sigma}(I \rightarrow J)]$ from $\bar{\sigma}_{tr}$.

Although not immediately obvious, it can be shown that the above collapsing scheme conserves first order reactivity coefficients in the fundamental mode, diffusion theory approximation.

Parenthetically, it should be mentioned that the familiar central perturbation cross section, σ_p , is simply

$$\sigma_p = \frac{1}{\bar{\sigma}_f} - \frac{1}{\bar{\sigma}_a}, \quad (5.11)$$

where $\bar{\sigma}^1$ denotes one-group collapsed cross sections (i.e., collapsed down to one group).

VI. BURNUP EQUATIONS

Burnup Model

The basic burnup equation has the form

$$\begin{aligned} \frac{dN^i}{dt} = & -\lambda^i N^i - \bar{\sigma}_a^i \bar{\phi} N^i + \lambda^k N^k + S^i \\ & + \sum_j \bar{\sigma}_c^j \bar{\phi} N^j + \sum_m \bar{\sigma}_f^m \bar{\phi} N^m \end{aligned} \quad (6.1)$$

where:

- N^i = density of nuclide i ,
- λ^i = decay constant of nuclide i ,
- $\bar{\sigma}_a^i$ = spectrum averaged absorption cross section for nuclide i ,
- $\bar{\phi}$ = total flux,
- S^i = external source for nuclide i ,
- $\lambda^k N^k$ = decay source from nuclide k .

The last two sum terms in Equation (6.1) allow provision for four capture and seven fission sources. The latter option, for example, could be used to compute the fission product buildup.

Equation (6.1) is solved using the improved Euler algorithm. If we rewrite Equation (6.1) in the form

$$\frac{d\vec{N}}{dt} = \vec{f}(\vec{N}, t) \quad , \quad (6.2)$$

the improved Euler algorithm can be written as

$$\vec{N}_{J+1} = \vec{N}_J + \frac{\delta t}{2}(\vec{f}_J + \vec{f}_{J+1}) \quad , \quad (6.3)$$

where J is the index on time and δt is the time step.

Observe that Equation (6.3) is implicit in the sense that $\vec{N}_{J+1}$ must be known in order to compute $\vec{f}_{J+1}$. One must therefore iterate on $\vec{N}$ at each time point. This procedure leads to the algorithm

$$\vec{N}_{J+1}^{\nu+1} = \vec{N}_J + \frac{\delta t}{2} (\vec{f}_J + \vec{f}_{J+1}^{\nu}) \quad , \quad (6.4)$$

where ν is the iteration index.

The iteration is continued until the convergence criterion,

$$\frac{\left| N_{J+1}^{\nu+1} - N_{J+1}^{\nu} \right|}{N_{J+1}^{\nu}} \leq \epsilon \quad , \quad (6.5)$$

is satisfied for all nuclides.

Remarks of Burnup Equations

It is perhaps important to emphasize that the fundamental mode flux and spectrum averaged cross sections appearing in Equation (6.1) are recomputed after each time step. Resonance shielded cross sections, however, are not recomputed during burnup.

It should be clear from the mathematical model presented that relatively short time steps should be employed to minimize the discretization error. This error will grow roughly as the square of the time step. It has been found that typical fast reactor burnup calculations require less than 100 time steps. For 16 energy groups, this corresponds to about 30 sec of UNIVAC 1108 time.

VII. CALCULATION OF RESONANCE SHIELDED CROSS SECTIONS USING DATA IN THE RUSSIAN FORMAT

The nuclear parameters in the Russian data compilation are arranged in three sections: infinite dilution cross sections, inelastic scattering matrix, and resonance self-shielding factors. A brief description of the format and treatment of these cross sections is given in the following paragraphs. For a complete description, the reader is referred to the Russian text. (3)

Infinite Dilution Cross Sections

For each energy group of each isotope, nine parameters are given. These are defined below.

- σ_t = total cross section ($\sigma_f + \sigma_c + \sigma_e + \sigma_{in}$),
- σ_f = fission cross section,
- ν = neutrons released per fission,
- σ_c = capture cross section,
- σ_{in} = total inelastic scattering cross section [includes (n, 2n) reaction],
- σ_e = total elastic scattering cross section,
- μ_e = average cosine of elastic scattering angle,
- ξ = average lethargy change by elastic scattering,
- $\sigma_{d,e}$ = elastic slowing-down cross section (in FCC-IV, elastic removal is always to next energy group).

The second data block contains the inelastic scattering matrix, $\sigma_{in}(i \rightarrow j)$. This matrix contains 11 terms for each energy group: one for in-group scattering and 10 for scattering to the first 10 lower groups.

The code cross checks a substantial portion of the above data by using the equations

$$\sigma_t = \sigma_f + \sigma_c + \sigma_e + \sigma_{in} \quad , \quad (7.1)$$

$$\sigma_{in,i} = \sum_j \sigma_{in}(i \rightarrow j) \quad , \quad (7.2)$$

and

$$\sigma_{d,e} = \frac{\xi \sigma_e}{\delta u} \quad , \quad (7.3)$$

where δu is the lethargy width of the group in question.

Resonance Self-Shielding Factors

Self-shielding factors are used to account for flux depression in the vicinity of large resonances. For each energy group of each isotope, self-shielding factors are listed for fission, capture, transport (total), and elastic scattering. In crude terms,

$$\bar{\sigma}_k = f_k \sigma_k^0 \quad , \quad (7.4)$$

where:

$\bar{\sigma}_k$ = resonance shielded cross section for k^{th} process,
 f_k = self-shielding factor,
 σ_k^0 = infinite dilution cross section.

The resonance self-shielding factors are compiled for discrete values of temperature and total cross section. The format of the input data is pictured in Table 7.I.

TABLE 7.1. Format for Resonance Self-Shielding Factors

Temperature, °K	Total Cross Section		
	σ_1	σ_2	σ_3
300	$^1f_{300}$	$^2f_{300}$	$^3f_{300}$
900	$^1f_{900}$	$^2f_{900}$	$^3f_{900}$
2100	$^1f_{2100}$	$^2f_{2100}$	$^3f_{2100}$

Although three rows of shielding factors are always listed (if f factors are temperature dependent), the number of columns (discrete total cross sections) varies from 1 to 6.

The next two sections describe the interpolation equations employed to compute shielding factors for any temperature and total cross section.

Temperature Interpolation Equation

For each column (discrete total cross section), the shielding factor corresponding to the current temperature is computed by the equation (suggested by Dr. Robert Schenter)

$$f(T) = A + B \ln T \quad (7.5)$$

where:

B is determined using the two end points, f_{300} and f_{2100} ,

A is chosen so that $f(900) \equiv f_{900}$.

It goes without saying that other interpolation equations could be used in place of Equation (7.5). In particular, second order curves in terms of $\ln T$ and $1/T$ may be preferable to Equation (7.5) for many studies. However, for most FBR analyses, Equation (7.5) appears to be quite satisfactory.

Interpolation on Total Cross Section

If σ_T , the total cross section of all other isotopes, lies between any two tabulated total cross sections, say σ_1 and σ_2 , the shielding factor is computed using the expression

$$f(\sigma_T) = f_1 + \frac{f_2 - f_1}{\ln(\sigma_2/\sigma_1)} \ln(\sigma_T/\sigma_1) \quad (7.6)$$

If σ_T is greater than the largest tabulated total cross section, σ_L , or less than the smallest cross section, σ_S , the following approximations are employed:

$$1) \quad \sigma_T \geq 10^7, \quad f = 1.0, \quad (7.7)$$

$$2) \quad 10^7 > \sigma_T > \sigma_L, \quad f = 1.0 + \frac{L_f - 1.0}{\ln(\sigma_L/10^7)} \ln(\sigma_T/10^7), \quad (7.8)$$

$$3) \quad \sigma_T < \sigma_S, \quad f = S_f. \quad (7.9)$$

Iteration to Obtain Total Cross Sections

Since the total cross section of each isotope cannot be obtained until the total cross section of all other isotopes is known, one must iterate to obtain both the shielding factors and the total cross sections.

An initial estimate of the total cross section per atom for each energy group of the k^{th} isotope is

$$\sigma_{T,k}^0 = \frac{1}{N_k} \sum_{j \neq k} N_j \sigma_{t,j}^0 \quad (7.10)$$

where:

$\sigma_{T,k}$ = total cross section seen (excluding itself) by each atom of the k^{th} isotope,

$\sigma_{t,k}$ = total cross section of k^{th} isotope,

N_k = atom density of k^{th} isotope.

For simplicity, the group index is suppressed.

Subsequent approximations to the total cross section are obtained using the algorithm

$$\sigma_{T,k}^{\nu+1} = \frac{1}{N_k} \sum_{j \neq k} N_j \left[f_{c,j}^{\nu} \sigma_{c,j} + f_{f,j}^{\nu} \sigma_{f,j} + f_{e,j}^{\nu} \sigma_{e,j} + \sigma_{in,j} \right] , \quad (7.11)$$

where ν is the iteration index. The symbol f^{ν} indicates that f has been evaluated using the ν^{th} value of σ_T .

The number of iterations, ν , is an input parameter. For any case, convergence on the total cross section is easy to check since the code prints $\sigma_{T,k}^{\nu}$ after each iteration. It has been found that typical problems converge very well in three or four iterations.

Heterogeneity Correction to σ_T

If desired, FCC-IV will compute the total cross section for each fuel isotope using the Bell modification⁽⁵⁾ to the rational approximation. That is,

$$\sigma_{T,k} = \frac{\sum_o}{N_o^k} + \frac{\sum_1 V_1}{N_o^k V_o} \cdot \frac{1}{1 + \frac{4V_1}{S_o} \sum_1} \quad (7.12)$$

$$\sigma_{T,k} = \frac{\sum_o}{N_o^k} + \frac{\sum_1 V_1}{N_o^k V_o} \cdot \frac{1}{1 + X \sum_1'} \quad (7.13)$$

where:

$$X = 4(V_o + V_1)/S_o$$

$$\sum_1' = V_1 \sum_1 / (V_o + V_1)$$

$\sigma_{T,k}$ = total (potential) cross section per atom for isotope k ,

N_o^k = atom density of isotope k in fuel region ,

$\sum_o$ = macroscopic total cross section in fuel excluding isotope k ,

V_o = volume of fuel region,

V_1 = volume of moderator region,

S_o = area of fuel region,

$\sum_1$ = macroscopic total cross section in moderator region.

X, in units of centimeters, is the only input parameter. Note that X = 0 corresponds to a homogeneous mixture of fuel and moderator.

Specification of Total Cross Sections per Atom

As discussed above, the code can compute the resonance shielding factors for each group of each isotope using a calculated total cross section of all other isotopes. If desired, however, the user can specify the total cross section (i.e., the total cross section to be used in computing the shielding factors) for each isotope. This value is then used for all energy groups--in contrast to the group dependent total cross sections computed by the code. If a value greater than 10^7 barns is specified, the code automatically assumes an infinite dilution.

Correction to Elastic Removal Using Current Flux Spectrum

By necessity, the infinite dilution cross sections and shielding factors were formulated without reference to a particular reactor system. Consequently, group cross sections were calculated using an assumed in-group flux spectrum. The Russian cross sections were computed using a fission spectrum weighting in the top 3 groups, and a constant flux [$\phi(u) = C$] weighting in the remaining groups.

For most cross sections, the above procedure is probably adequate. For elastic moderation, however, appreciable errors can be encountered if the flux that contributes to elastic moderation departs significantly from the group averaged flux.

Since elastic moderation (group transfer) usually originates near the lower group boundary ($\xi < u$), it is clearly more logical to use the lower boundary flux than the group averaged flux for computing elastic moderation.

As an option, the FCC-IV code will recompute the elastic moderation cross section, $\bar{\sigma}_{d,e}$, using the multigroup fluxes of the particular case at hand. For group i (except for $i = 1$), the elastic moderation rate for each isotope is computed using the flux at lethargy point u_i' , where

$$u_i' = u_i - c \xi, \quad (7.14)$$

and c is an input parameter (see Figure 7.1). Using linear interpolation on $\xi \bar{\sigma}_e \phi(u)$, $\bar{\sigma}_{d,e}$ is then computed using the expression

$$\bar{\sigma}_{d,e}^i = \frac{1}{\delta u_i} \left\{ (\xi \bar{\sigma}_e)^i + \frac{u_i' - \bar{u}_i}{\bar{u}_{i+1} - \bar{u}_i} \left[\frac{\phi(\bar{u}_{i+1})}{\phi(\bar{u}_i)} (\xi \bar{\sigma}_e)^{i+1} - (\xi \bar{\sigma}_e)^i \right] \right\}, \quad (7.15)$$

for $i = 2, \dots, N$. Although any number of iterations on $\bar{\sigma}_{d,e}$ (i.e., spectrum recalculations) can be made, it has been found that $\bar{\sigma}_{d,e}$ converges well in a few iterations (< 5).

FIGURE 7.1. Schematic Diagram of Elastic Removal Model

Equations for Multigroup Cross Sections

The FCC-IV code uses and punches cross sections in the format:

$$\bar{\sigma}_f^i \quad \bar{\sigma}_a^i \quad \bar{\nu}\sigma_f^i \quad \bar{\sigma}_{tr}^i \quad \bar{\sigma}(i \rightarrow i) \quad \bar{\sigma}(i-1 \rightarrow i) \quad \dots$$

The bar indicates that the cross sections include resonance self-shielding.

The above cross sections are computed from the Russian data using the following equations:

$$\bar{\sigma}_f^i = f_f^i \sigma_f^i \quad , \quad (7.16)$$

$$\bar{\sigma}_a^i = f_f^i \sigma_f^i + f_c^i \sigma_c^i - \left[\sum_j \sigma_{in} (i \rightarrow j) - \sigma_{in}^i \right] \quad , \quad (7.17)$$

$$(\bar{\nu} \sigma_f)^i = \nu^i f_f^i \sigma_f^i \quad , \quad (7.18)$$

$$* \left\{ \begin{aligned} \bar{\sigma}_{tr}^i &= \left[f_t^i \sigma_t^i - \left(f_f^i \sigma_f^i + f_c^i \sigma_c^i + \sigma_{in}^i \right) \right] (1 - \mu_e^i) \\ &+ f_f^i \sigma_f^i + f_c^i \sigma_c^i + \sigma_{in}^i \quad , \end{aligned} \right. \quad (7.19)$$

$$\bar{\sigma}_{tr}^i = f_e^i \sigma_e^i (1 - \mu_e^i) + f_f^i \sigma_f^i + f_c^i \sigma_c^i + \sigma_{in}^i \quad , \quad (7.20)$$

$$\bar{\sigma} (i - 1 \rightarrow i) = \bar{\sigma}_{d,e}^{i-1} + \sigma_{in} (i - 1 \rightarrow i) \quad , \quad (7.21)$$

$$\bar{\sigma} (i - 2 \rightarrow i) = \sigma_{in} (i - 2 \rightarrow i) \quad , \quad (7.22)$$

. . .

$$\bar{\sigma} (i - 10 \rightarrow i) = \sigma_{in} (i - 10 \rightarrow i) \quad , \quad (7.23)$$

* Optional

$$\bar{\sigma}(i \rightarrow i) = \bar{\sigma}_{tr}^i - \bar{\sigma}_a^i - \sum_{j \neq i} \bar{\sigma}(i \rightarrow j) \quad (7.24)$$

A few words should be given to the treatment of $\sigma(n, 2n)$. Since most codes do not handle $\sigma(n, 2n)$ directly, it must be incorporated in the above cross section format. This is customarily accomplished by adding $2 \times \sigma(n, 2n)$ to the inelastic scattering matrix and subtracting $\sigma(n, 2n)$ from the capture cross section. This approach was convenient to follow in FCC-IV since the Russian inelastic scattering matrix includes the $(n, 2n)$ reaction.

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APPENDIX A

DTK AND DTF CROSS SECTION FORMATS

In both the DTK and DTF formats, the cross sections for each energy group are arranged in the sequence

$$\sigma_f \quad \sigma_a \quad v\sigma_f \quad \sigma_{tr} \quad \sigma_{gg} \quad \sigma_{g-1 \rightarrow g} \quad \sigma_{g-2 \rightarrow g} \quad \cdot \quad \cdot \quad \cdot \quad ,$$

where:

$$\begin{aligned} \sigma_f &= \text{fission cross section in group } g, \\ \sigma_a &= \text{absorption cross section in group } g, \\ \sigma_{tr} &= \text{transport cross section in group } g, \\ \sigma_{gg} &= \text{in-group scattering (inelastic plus elastic) cross section,} \\ \sigma_{g-1 \rightarrow g} &= \text{cross section for scattering from group } g-1 \text{ to } g, \\ \sigma_{g-2 \rightarrow g} &= \text{cross section for scattering from group } g-2 \text{ to } g, \\ &\cdot \quad \cdot \quad \cdot \end{aligned}$$

In the DTK format, all terms are in decimal form. Each word, with the exception of the first, occupies a 9 column field. The first word occupies columns 2 through 9; a 9 is always punched in column 1. If there are more than 8 terms in each group, a second card with a 9 punch in column 1 is used. The next energy group is always started on a new card.

The DTF cross sections are arranged in the FORTRAN format 6E12.6, i.e., 6 floating point words to each card. Again, each new energy group is started on a new card.

APPENDIX B
INPUT INSTRUCTIONS

Preliminary Data

Card	Column	Format	Remarks
1	1-6	Integer	Number of energy groups (≤ 40).
1	7-12	Integer	Number of groups in original down-scattering matrix (≤ 10), (e.g., 5 for Hansen-Roach set, 6 for YOM set).
1	13-18	Integer	Number of burnable isotopes ($1 \leq N \leq 10$).
1	19-24	Integer	Number of nonburnable isotopes (burnable + nonburnable ≤ 14).
1	25-30	Integer	= 0; cross section data is in Russian format. = 1; cross section data is in DTK format. = 2; cross section data is in DTF format.
1	31-36	Integer	= 0; read cross section from cards. = 1; read cross section from tape.
1	37-42	Integer	= 0; full print. = 1; partial print.
2	1-6	Hollerith	Name of burnable isotope No. 1.
2	7-12	Floating	Atomic weight (amu).
2	13-18	Floating	Decay constant (days ⁻¹).
2	19-24	Floating	Energy release per fission (MeV/fission).
2	25-27	Integer	= 0; no decay source. = n; where n is the isotope number of the decay source.
2	28-30	Integer	Number of capture sources (≤ 4).
2	31-33	Integer	Capture source number (if any).
2	34-36	Integer	Capture source number.
2	37-39	Integer	Capture source number.
2	40-42	Integer	Capture source number.

Card	Column	Format	Remarks
2	43-45	Integer	Number of fission product sources (≤ 7).
2	46-48	Integer	Fission product source number (if any).
2	49-51	Integer	Fission product source number.
2	52-54	Integer	Fission product source number.
2	55-57	Integer	Fission product source number.
2	58-60	Integer	Fission product source number.
2	61-63	Integer	Fission product source number.
2	64-66	Integer	Fission product source number.
2+	Same as above for burnable isotope No. 2. Repeat for all burnable isotopes.		
3	1-6	Hollerith	Name of nonburnable isotope No. 1.
3	7-12	Floating	Atomic weight (amu).
3+	Same as above for nonburnable isotope No. 2. Repeat for all nonburnable isotopes.		
4	1-12	Floating	Fission source in energy group 1.
4	13-24	Floating	Fission source in group 2.
. . .			
5	1-12	Floating	Lower energy bound for group 1.
5	13-24	Floating	Lower energy bound for group 2.
. . .			
6	1-12	Floating	Lethargy width (δu) of group 1.
6	13-24	Floating	Lethargy width of group 2.
. . .			

Cross Section Data

If cross sections are in Russian format:

Card	Column	Format	Remarks
7	1-6	Hollerith	Name of isotope No. 1.
7	7-12	Integer	= 0; the f-factors are not temperature dependent for isotope No. 1. = 1; the f-factors are temperature dependent for isotope No. 1.
7	13-18	Integer	Group number for initial f-factors.
7	19-24	Integer	Group number for final f-factors.
7	25-30	Integer	Number of different types of f-factors (e.g., f_c , f_f , f_t).
7	31-36	Integer	Number of column of f_f 's.
7	37-42	Integer	Number of columns of f_c 's.
7	43-48	Integer	Number of columns of f_t 's.
7	49-54	Integer	Number of columns of f_e 's.
8	1-6	Floating	Total cross section per atom corresponding to first column of f-factors.
8	7-12	Floating	Total cross section corresponding to the second column of f-factors.
. . . .			
9	1-2	Integer	Group number for initial f-factors.
9	3-7	Floating	First f-factor for above group.
9	8-12	Floating	Second f-factor for above group.
. . . .			
9+	Same as above for next group of isotope No. 1. Repeat through all energy groups containing f-factors.		
10'	1-2	Integer	Group number.
10'	3-11	Floating	Cross section data for first group of first isotope; σ_t (barns).

Card	Column	Format	Remarks
10'	12-20	Floating	σ_f
10'	21-26	Floating	ν
10'	27-35	Floating	σ_c
10'	36-43	Floating	σ_{in}
10'	44-51	Floating	σ_e
10'	52-59	Floating	μ_e
10'	60-65	Floating	ξ
10'	66-72	Floating	$\sigma_{d,e}$
10'+	Same as above for second group of isotope No. 1. Repeat for all energy groups.		
11'	1-3	Integer	Group number.
11'	4-9	Floating	Inelastic scattering cross sections for first groups of first isotope; σ_{gg} .
11'	10-15	Floating	$\sigma_{g \rightarrow g+1}$
11'	16-21	Floating	$\sigma_{g \rightarrow g+2}$
11'	22-27	Floating	$\sigma_{g \rightarrow g+3}$
11'	28-33	Floating	$\sigma_{g \rightarrow g+4}$
11'	34-39	Floating	$\sigma_{g \rightarrow g+5}$
11'	40-45	Floating	$\sigma_{g \rightarrow g+6}$
11'	46-51	Floating	$\sigma_{g \rightarrow g+7}$
11'	52-57	Floating	$\sigma_{g \rightarrow g+8}$
11'	58-63	Floating	$\sigma_{g \rightarrow g+9}$
11'	64-69	Floating	$\sigma_{g \rightarrow g+10}$
11'+	Same as above for second group of isotope No. 1. Give data for <u>all</u> groups. Repeat entire cycle for all isotopes.		

Card	Column	Format	Remarks
------	--------	--------	---------

If cross sections are in DTK format:

7	1-6	Hollerith	Cross section identification
8	1	Integer	9
8	2-9	Floating	Cross section data for first group of first isotope; σ_f (barns).
8	10-18	Floating	σ_a
8	19-27	Floating	$\sqrt{\sigma_f}$
8	28-36	Floating	σ_{tr}
8	37-45	Floating	σ_{gg}
8	46-54	Floating	$\sigma_{g-1 \rightarrow g}$
8	55-63	Floating	$\sigma_{g-2 \rightarrow g}$
8	64-72	Floating	$\sigma_{g-3 \rightarrow g}$
9	1	Integer	9
9	2-9	Floating	$\sigma_{g-4 \rightarrow g}$
9	10-18	Floating	$\sigma_{g-5 \rightarrow g}$
. . . .			
9+	Same as above for second group of isotope No. 1. Repeat for all energy groups and isotopes.		

If cross sections are in DTF format:

7	1-6	Hollerith	Cross section identification.
8	1-12	Floating	Cross section data for first group of first isotope; σ_f (barns).
8	13-24	Floating	σ_a
8	25-36	Floating	$\sqrt{\sigma_f}$
8	37-48	Floating	σ_{tr}
8	49-60	Floating	σ_{gg}

Card	Column	Format	Remarks
8	61-72	Floating	$\sigma_{g-1 \rightarrow g}$
9	1-12	Floating	$\sigma_{g-2 \rightarrow g}$
9	13-24	Floating	$\sigma_{g-3 \rightarrow g}$
9	25-36	Floating	$\sigma_{g-4 \rightarrow g}$

. . .

9+ Same as above for second group of isotope No. 1. Repeat for all energy groups and isotopes.

If cross sections* are from tape:

7	1-6	Integer	No. on tape of 1st isotope.
7	7-12	Integer	No. on tape of 2nd isotope.

. . .

Change Case Data

10**	2-72	Hollerith	Identification card.
11	1-6	Integer	= 0; the code calculates the effective multiplication constant as a function of time for a given initial k_{eff} . = 1; the code calculates the effective multiplication constant as a function of time for a given buckling. = 2; the code calculates the buckling as a function of time for a specified k_{eff} .
11	7-12	Integer	= 0; calculation is performed for a constant power. = 1; calculation is performed for a constant flux.
11	13-18	Integer	= 0; code computes ϕ_i and $\phi_i^\dagger$. = 1; ϕ_i and $\phi_i^\dagger$ are provided in input data (see cards 22 and 23).

* In the current version, only data in the Russian Format can be read from tape.

** To run a series of cases, repeat from card 10.

Card	Column	Format	Remarks
11	19-24	Integer	Number of time steps.
11	25-30	Integer	Number of intervals between prints (e.g., = 1; print after each time step; = 10; print after each tenth time step).
11	31-36	Integer	Control used in calculating shielded cross sections: = 1; total cross section per atom assumed constant for each isotope. See card 17. = N(N ≥ 0); total cross section per atom is calculated using atom densities. N is the number of iterations on σ_t in the calculation of the resonance shielded cross sections.
11	37-42	Integer	Control used in calculating shielded transport cross sections: = 0; σ_{tr} calculated using $[(\bar{\sigma}_t - \bar{\sigma}_a - \bar{\sigma}_{in}) \cdot (1 - \bar{\mu})]$ This option is recommended. = 1; σ_{tr} calculated using $\bar{\sigma}_e(1 - \bar{\mu})$.
11	43-48	Integer	Number of iterations on spectrum for computing $\sigma_{d,e}$ (N ≥ 0).
12	1-6	Integer	Number of collapsed groups. If N ≥ number of initial groups, the collapsing calculation is bypassed.
12	7-12	Integer	Type weighting for collapsed σ_{tr} : = 1; reciprocal weighting, = 2; normalized reciprocal weighting, = 3; linear weighting, = 4; normalized linear weighting.
12	13-18	Integer	Perturbation cross section option: = 0; no effect. = 1; calculate, print, and punch perturbation cross sections.
12	19-24	Integer	Punch option: = 0; no effect, = 1; punch cross sections in DTK format, = 2; punch cross sections in DTF format, = 3; punch cross section mixes in DTK format, = 4; punch cross section mixes in DTF format.

Card	Column	Format	Remarks
12	25-30	Integer	Punch option for collapsed cross sections--same choices as above.
12	31-36	Integer	Number of cross section mixes calculated and punched: See cards 19-24. (Note: Leakage cross sections ($1/3 \Sigma_{tr}$) for the current composition can be obtained by calling for a mix with zero mix components.)
13	1-12	Floating	Length of time steps (days).
13	13-24	Floating	Volume of core (liters). This number is only used to compute material inventory.
13	25-36	Floating	Power (MWt) or flux (n/cm^2 -sec).
13	37-48	Floating	Buckling or effective multiplication constant. (If $B^2 = 0.0$, code uses buckling from previous case.)
13	49-60	Floating	Coefficient of ξ in Equation (7.14).
13	61-72	Floating	Heterogeneity constant used in calculating shielded cross sections. See Equation (7.13). If zero, heterogeneity calculation is ignored.
14	1-6	Integer	Number of fertile isotopes (≤ 5). The data on this card is used to compute the breeding ratio only.
14	7-12	Integer	Nuclide number of fertile isotope No. 1.
14	13-18	Integer	Nuclide number of fertile isotope No. 2.
14	19-24	Integer	Nuclide number of fertile isotope No. 3.
14	25-30	Integer	Nuclide number of fertile isotope No. 4.
14	31-36	Integer	Nuclide number of fertile isotope No. 5.
14	37-42	Integer	Number of fissile isotopes (≤ 5).
14	43-48	Integer	Nuclide number of fissile isotope No. 1.
14	49-54	Integer	Nuclide number of fissile isotope No. 2.
14	55-60	Integer	Nuclide number of fissile isotope No. 3.

Card	Column	Format	Remarks
14	61-66	Integer	Nuclide number of fissile isotope No. 4.
14	67-72	Integer	Nuclide number of fissile isotope No. 5.
15	1-12	Floating	Atom density for isotope No. 1 (atoms/barn-cm).
15	13-24	Floating	Atom density for isotope No. 2.
. . . .			
16	1-12 (optional)	Floating	Temperature of isotope Number 1 ($^{\circ}\text{K}$). This card is included only if the cross sections are in the Russian format.
16	13-24	Floating	Temperature of isotope No. 2.
. . . .			
17	1-12 (optional)	Floating	Total cross section per atom for isotope No. 1. (If greater than 10^7 , code assumes infinite dilution.) See Card 11, word 6.
17	13-24	Floating	Total cross section per atom for isotope No. 2.
. . . .			
18	1-6 (optional)	Integer	Number of original groups in first crunched group.
18	7-12	Integer	Number of original groups in second crunched group.
. . . .			
19	1-6 (optional)	Integer	Number of isotopes in mix No. 1. If zero code computes leakage cross sections ($1/3 \Sigma_{tr}$) for current composition.
19	7-12	Integer	Number of isotopes in mix No. 2.
. . . .			
20	1-6 (optional)	Integer	Nuclide number of first isotope in mix No. 1.
20	7-12	Integer	Nuclide number of second isotope in mix No. 1.
. . . .			
Continue for all isotopes in mix No. 1, then repeat cycle for all mixes.			

Card	Column	Format	Remarks
21	1-12 (optional)	Floating	Atom density for isotope No. 1 in mix No. 1. (atoms/barn-cm).
21	13-24	Floating	Atom density for isotope No. 2 in mix No. 1.
. . . .			
Continue for all isotopes in mix No. 1, then repeat cycle for all mixes.			
22	1-12 (optional)	Floating	Flux (ϕ_i) in group 1. See Card 11, word 3.
22	13-24	Floating	Flux in group 2.
. . . .			
23	1-12 (optional)	Floating	Adjoint flux (ϕ_i^+) in group 1. See Card 11, word 3.
23	13-24	Floating	Adjoint flux in group 2.
. . . .			
24	1-12	Floating	External source. Rate at which isotope No. 1 is added to reactor (kg/day). List data for burnable isotopes only.
24	13-24	Floating	Rate at which isotope No. 2 is added to reactor.
. . . .			

FCC-IV

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
No. of Groups (S40)						No. Down-Scattering Terms (S50)						No. Burnable Isotopes (S14) (S15)						No. Nonburnable Isotopes (Burnable = Nonburnable S 14)						X-sect Format - 0, Russian - 1, DTN - 2, DTF						- 0, Read X-sects from Cards - 1, Read X-sect from Tape						- 0, Full Print - 1, Partial Print																																			
Name of First Burnable Isotope						Atomic Wt.						Decay Constant (days ⁻¹)						Energy Released per Fission (Mev/f)						- 0, No Decay Source - n, Decay Source from Isotope n						No. of Capture Sources		Capture Source No.		Capture Source No.		Capture Source No.		Capture Source No.		No. of F. P. Sources		F. P. Source No.		F. P. Source No.		F. P. Source No.		F. P. Source No.		F. P. Source No.		F. P. Source No.																			
Name of First Nonburnable Isotope						Atomic Wt.																																																																	
Fission Source in Group No. 1						Fission Source in Group No. 2																																																																	
Lower Energy Bound of Group No. 1						Lower Energy Bound of Group No. 2																																																																	
Lethargy Width of Group No. 1						Lethargy Width of Group No. 2																																																																	
Cross Sections from Cards or																																																																							
Sequence No. on Tape of 1st Isotope						Sequence No. on Tape of 2nd Isotope																																																																	
Identification Card**																																																																							
Type Calculation - 0, k vs 1 for k_{eff} - 1, k vs 1 for β_{eff} - 2, β^2 vs 1 for k_{eff}						- 0, Constant Power - 1, Constant Flux						- 0, Calculate ϕ_1/s - 1, Read ϕ_1/s						No. Time Steps						No. Intervals Between Prints						- 1, Read σ_{eff} - n, No. Iterations in Calculation of σ_{eff}						- 0, No Effect - 1, σ_{eff} Calculated Using $\sigma_{eff}(1-\alpha)$						No. Iterations on Flux in Calculation of σ_{eff}																													
No. Crunched Groups (If Equal to No. Original Groups, No Crunch Calculation)						Type Weighting for Crunched or						- 0, No Effect - 1, Calculate and Punch PERT X-sects						Punch Option: - 0, No Punch - 1, DTK Format - 2, DTF Format - 3, Punch Mixes (DTN) - 4, Punch Mixes (DTF)						Same as Previous Option for Crunched X-sects						No. of Cross Section Mixes Calculated and Punched																																									

**To Run a Series of Cases, Repeat from this Card

APPENDIX C

SAMPLE CASE

A listing of the input data and computer print-out for a sample case is given on the following pages. The sample case is a one-step burnup calculation using the full print option. Twenty-six group Russian cross sections are used as input. The initial 26 groups are collapsed to 4 groups for the burnup calculation. To minimize printout, only two isotopes are used; the input cross sections for only one isotope, ^{239}Pu , are listed.

* * * * F C C * * * *

INPUT DATA LISTED BELOW

NUCLIDE NUMBER	NAME	ATM WEIGHT	LAMBDA(DAYS-1)	MEV/FISSION	SOURCE ELEMENT FOR DECAY	CAPTURE	FISSION
----------------	------	------------	----------------	-------------	--------------------------	---------	---------

1	PU239	2.3905+02	0.0000	2.0700+02	0 -0 -0		
---	-------	-----------	--------	-----------	---------	--	--

NON-BURNABLE NUCLIDES

2	OXYGEN	1.6000+01					
---	--------	-----------	--	--	--	--	--

C-2

GROUP	FISSION SOURCE	ENERGY LIMIT	VELOCITY	DELTA U
1	2.0000-02	6.5000+00	3.5311+09	4.8000-01
2	9.8000-02	4.0000+00	2.7700+09	4.8000-01
3	1.9000-01	2.5000+00	2.1899+09	4.8000-01
4	2.6800-01	1.4000+00	1.6388+09	5.7000-01
5	1.9600-01	8.0000-01	1.2388+09	5.7000-01
6	1.3500-01	4.0000-01	8.7595+08	6.9000-01
7	5.8000-02	2.0000-01	6.1939+08	6.9000-01
8	2.2000-02	1.0000-01	4.3798+08	6.9000-01
9	9.0000-03	4.6500-02	2.9866+08	7.7000-01
10	3.0000-03	2.1500-02	2.0308+08	7.7000-01
11	1.0000-03	1.0000-02	1.3850+08	7.7000-01
12	0.0000	4.6500-03	9.4444+07	7.7000-01
13	0.0000	2.1500-03	6.4220+07	7.7000-01
14	0.0000	1.0000-03	4.3798+07	7.7000-01
15	0.0000	4.6500-04	2.9866+07	7.7000-01
16	0.0000	2.1500-04	2.0308+07	7.7000-01
17	0.0000	1.0000-04	1.3850+07	7.7000-01
18	0.0000	4.6500-05	9.4444+06	7.7000-01
19	0.0000	2.1500-05	6.4220+06	7.7000-01
20	0.0000	1.0000-05	4.3798+06	7.7000-01
21	0.0000	4.6500-06	2.9866+06	7.7000-01
22	0.0000	2.1500-06	2.0308+06	7.7000-01
23	0.0000	1.0000-06	1.3850+06	7.7000-01
24	0.0000	4.6500-07	9.4444+05	7.7000-01
25	0.0000	2.1500-07	6.4220+05	7.7000-01
26	0.0000	2.5200-08	2.1986+05	1.0000+00
SUM	1.00000+00			

MICROSCOPIC CROSS SECTIONS FOR M2PU49

NUCLIDE NUMBER 1

GROUP	SIGT	SIGF	SIG	SIGC	SIGIN	SIGEL	MUEL	XI	SIGDEL
1	6.700	2.200	3.320	.010	.640	3.850	.840	.001	.026
2	7.751	1.900	3.470	.021	1.280	4.550	.800	.002	.026
3	7.900	1.970	3.240	.030	1.250	4.650	.710	.002	.028
4	7.351	2.000	3.090	.041	1.160	4.150	.550	.004	.027
5	7.248	1.750	2.980	.058	1.140	4.300	.450	.005	.035
6	8.257	1.640	2.920	.107	1.160	5.350	.350	.005	.042
7	9.867	1.630	2.880	.167	.950	7.120	.230	.006	.066
8	11.300	1.680	2.860	.240	.750	8.630	.130	.007	.090
9	12.239	1.700	2.850	.289	.550	9.700	.070	.008	.097
10	13.451	1.750	2.840	.561	.250	10.890	.040	.008	.113
11	14.130	1.800	2.840	.810	.100	11.420	.020	.008	.120
12	16.500	2.500	2.840	1.250	-.000	12.750	.010	.008	.136
13	18.000	3.400	2.840	1.900	-.000	12.700	.000	.008	.137
14	19.500	4.200	2.840	2.600	-.000	12.700	.000	.008	.137
15	26.000	7.600	2.840	5.000	-.000	13.400	.000	.008	.144
16	36.500	13.000	2.840	9.100	-.000	14.400	.000	.008	.155
17	48.000	19.000	2.840	14.000	-.000	15.000	.000	.008	.162
18	102.000	41.000	2.840	41.000	-.000	20.000	.000	.008	.216
19	68.000	22.000	2.840	31.000	-.000	15.000	.000	.008	.162
20	184.000	100.000	2.840	72.000	-.000	12.000	.000	.008	.129
21	90.500	45.000	2.840	35.000	-.000	10.500	.000	.008	.113
22	23.000	12.000	2.840	1.000	-.000	10.000	.000	.008	.108
23	38.000	24.000	2.840	3.000	-.000	11.000	.000	.008	.119
24	189.000	103.000	2.840	73.000	-.000	13.300	.000	.008	.143
25	2896.000	1670.000	2.840	1210.000	-.000	15.700	.000	.008	.169
26	1038.000	742.000	2.840	286.000	-.000	9.500	.000	.000	-.000

INELASTIC SCATTERING MATRIX FOR M2PU49

GROUP	GXG	GXG+1	GXG+2	GXG+3	GXG+4	GXG+5	GXG+6	GXG+7	GXG+8	GXG+9	GXG+10
1	.000	.000	.040	.150	.260	.320	.180	.070	.030	.010	-.000
2	.010	.050	.200	.360	.360	.180	.080	.030	.010	-.000	-.000
3	.040	.150	.310	.400	.220	.090	.030	.010	-.000	-.000	-.000
4	.100	.200	.420	.270	.120	.040	.010	-.000	-.000	-.000	-.000
5	.300	.430	.230	.130	.040	.010	-.000	-.000	-.000	-.000	-.000
6	.590	.440	.090	.030	.010	-.000	-.000	-.000	-.000	-.000	-.000
7	.760	.160	.020	.010	-.000	-.000	-.000	-.000	-.000	-.000	-.000
8	.600	.150	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
9	.430	.120	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
10	.110	.140	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
11	.100	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
12	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
13	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
14	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
15	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
16	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
17	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
18	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
19	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
20	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
21	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
22	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
23	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
24	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
25	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
26	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

RESONANCE SELF-SHIELDING COEFFICIENTS FOR M2PU49

SIG0		1000.	100.	10.	0.	1000.	100.	10.	0.	100.	10.	0.	100.	10.	0.
GROUP	TEMP	FF	FF	FF	FF	FC	FC	FC	FC	FT	FT	FT	FE	FE	FE
10	300.0	1.000	.990	.970	.940	1.000	1.000	.980	.960	1.000	.990	.980	1.000	1.000	1.000
10	900.0	1.000	1.000	.980	.970	1.000	1.000	.990	.980	1.000	1.000	1.000	1.000	1.000	1.000
10	2100.0	1.000	1.000	.990	.960	1.000	1.000	.990	.990	1.000	1.000	1.000	1.000	1.000	1.000
11	300.0	1.000	.980	.930	.880	1.000	.990	.950	.910	1.000	.970	.930	1.000	1.000	.990
11	900.0	1.000	.990	.970	.930	1.000	1.000	.980	.950	1.000	1.000	.990	1.000	1.000	1.000
11	2100.0	1.000	.990	.980	.950	1.000	1.000	.990	.970	1.000	1.000	1.000	1.000	1.000	1.000
12	300.0	1.000	.960	.870	.800	1.000	.960	.870	.800	.980	.920	.860	.990	.970	.960
12	900.0	1.000	.980	.930	.870	1.000	.980	.940	.880	1.000	.990	.960	1.000	.990	.980
12	2100.0	1.000	.990	.950	.910	1.000	.990	.960	.920	1.000	1.000	.990	1.000	1.000	1.000
13	300.0	.990	.920	.790	.690	.990	.920	.770	.670	.950	.850	.800	.960	.930	.910
13	900.0	1.000	.960	.870	.790	1.000	.960	.870	.780	.990	.960	.910	.990	.960	.940
13	2100.0	1.000	.980	.910	.880	1.000	.980	.910	.870	1.000	.980	.960	1.000	.980	.960
14	300.0	.980	.880	.670	.560	.980	.870	.620	.510	.890	.790	.690	.870	.850	.840
14	900.0	.990	.920	.780	.690	.990	.910	.760	.660	.950	.900	.820	.910	.870	.850
14	2100.0	1.000	.950	.860	.820	1.000	.950	.840	.790	.970	.940	.900	.930	.900	.870
15	300.0	.970	.800	.530	.420	.960	.760	.460	.360	.800	.680	.600	.800	.780	.760
15	900.0	.960	.860	.640	.530	.970	.820	.580	.470	.870	.810	.740	.830	.800	.780
15	2100.0	.990	.900	.770	.710	.990	.890	.720	.640	.920	.890	.870	.860	.820	.810
16	300.0	.930	.700	.410	.300	.910	.620	.330	.240	.660	.550	.510	.750	.720	.700
16	900.0	.960	.780	.500	.380	.940	.720	.420	.310	.730	.650	.600	.780	.740	.720
16	2100.0	.960	.830	.580	.520	.960	.800	.530	.450	.830	.790	.750	.810	.770	.750
17	300.0	.910	.630	.340	.250	.890	.580	.280	.200	.520	.430	.420	.720	.670	.650
17	900.0	.940	.690	.410	.320	.920	.640	.340	.260	.590	.510	.480	.740	.690	.670
17	2100.0	.970	.750	.490	.390	.950	.700	.410	.320	.700	.640	.610	.770	.710	.700
18	300.0	.760	.500	.370	.340	.750	.440	.300	.270	.410	.370	.340	.610	.550	.550
18	900.0	.830	.590	.450	.420	.800	.520	.380	.350	.450	.410	.390	.630	.560	.550
18	2100.0	.870	.660	.540	.520	.850	.610	.470	.440	.540	.500	.470	.650	.570	.560
19	300.0	.700	.330	.190	.160	.650	.280	.150	.130	.330	.210	.190	.760	.720	.710
19	900.0	.770	.370	.210	.180	.720	.320	.170	.150	.360	.230	.210	.770	.720	.720
19	2100.0	.850	.410	.220	.200	.810	.360	.190	.170	.390	.250	.230	.790	.730	.720
20	300.0	.660	.330	.190	.170	.650	.290	.180	.160	.180	.110	.100	.890	.860	.860
20	900.0	.730	.360	.200	.180	.700	.330	.190	.170	.230	.130	.110	.890	.870	.860
20	2100.0	.800	.390	.210	.190	.770	.360	.200	.180	.270	.150	.120	.890	.870	.860
21	300.0	.670	.330	.200	.180	.650	.310	.190	.170	.200	.180	.170	.960	.960	.960
21	900.0	.710	.350	.210	.190	.690	.330	.200	.180	.230	.190	.180	.970	.960	.960
21	2100.0	.760	.370	.220	.200	.740	.350	.210	.190	.250	.200	.190	.970	.960	.960
22	300.0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
22	900.0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
22	2100.0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

23	300.0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
23	900.0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
23	2100.0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
24	300.0	.940	.790	.700	.690	.770	.620	.530	.520	.540	.470	.450	.940	.890	.880	
24	900.0	.940	.790	.700	.690	.770	.620	.530	.520	.540	.470	.450	.940	.890	.880	
24	2100.0	.940	.790	.700	.690	.770	.620	.530	.520	.540	.470	.450	.940	.890	.880	
25	300.0	.660	.610	.590	.590	.680	.570	.560	.560	.330	.300	.300	.850	.840	.840	
25	900.0	.680	.610	.590	.590	.680	.570	.560	.560	.330	.300	.300	.850	.840	.840	
25	2100.0	.680	.610	.590	.590	.680	.570	.560	.560	.330	.300	.300	.850	.840	.840	

1 CHECK M2PU49 GROUP 1 PRESUMABLY SIGMA (N,2N) = 4.200000-01

MICROSCOPIC CROSS SECTIONS FOR

0

NUCLIDE NUMBER 2

GROUP	SIGT	SIGF	NU	SIGC	SIGIN	SIGEL	MUEL	XI	SIGDEL
1	1.150	.000	.000	.230	.160	.760	.350	.081	.252
2	1.450	.000	.000	.075	.000	1.380	.260	.092	.385
3	1.900	.000	.000	.003	-.000	1.900	.260	.092	.419
4	1.750	.000	.000	.000	-.000	1.750	.150	.106	.325
5	4.300	.000	.000	.000	-.000	4.300	.080	.115	.868
6	5.600	.000	.000	.000	-.000	5.600	.230	.096	.779
7	3.800	.000	.000	.000	-.000	3.800	.140	.142	.780
8	3.500	.000	.000	.000	-.000	3.500	.040	.120	.609
9	3.550	.000	.000	.000	-.000	3.550	.040	.120	.553
10	3.600	.000	.000	.000	-.000	3.600	.040	.120	.561
11	3.650	.000	.000	.000	-.000	3.650	.040	.120	.569
12	3.700	.000	.000	.000	-.000	3.700	.040	.120	.577
13	3.750	.000	.000	.000	-.000	3.750	.040	.120	.584
14	3.750	.000	.000	.000	-.000	3.750	.040	.120	.584
15	3.750	.000	.000	.000	-.000	3.750	.040	.120	.584
16	3.750	.000	.000	.000	-.000	3.750	.040	.120	.584
17	3.750	.000	.000	.000	-.000	3.750	.040	.120	.584
18	3.750	.000	.000	.000	-.000	3.750	.040	.120	.584
19	3.750	.000	.000	.000	-.000	3.750	.040	.120	.584
20	3.750	.000	.000	.000	-.000	3.750	.040	.120	.584
21	3.750	.000	.000	.000	-.000	3.750	.040	.120	.584
22	3.750	.000	.000	.000	-.000	3.750	.040	.120	.584
23	3.750	.000	.000	.000	-.000	3.750	.040	.120	.584
24	3.750	.000	.000	.000	-.000	3.750	.040	.120	.584
25	3.750	.000	.000	.000	-.000	3.750	.040	.120	.584
26	3.750	.000	.000	.000	-.000	3.750	.040	.120	-.000

INELASTIC SCATTERING MATRIX FOR 0

GROUP	GXG	GXG+1	GXG+2	GXG+3	GXG+4	GXG+5	GXG+6	GXG+7	GXG+8	GXG+9	GXG+10
1	.000	.000	.020	.050	.050	.030	.010	-.000	-.000	-.000	-.000
2	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
3	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
4	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
5	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
6	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
7	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
8	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
9	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
10	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
11	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
12	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
13	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
14	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
15	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
16	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
17	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
18	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
19	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
20	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
21	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
22	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
23	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
24	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
25	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
26	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

RESONANCE SELF-SHIELDING COEFFICIENTS FOR 0

THE F FACTORS FOR THIS ISOTOPE ARE NOT TEMPERATURE DEPENDENT

SIG0	10.	1.	0.	10.	1.	0.	10.	1.	0.
GROUP	FC	FC	FC	FT	FT	FT	FE	FE	FE
1	.990	.900	.850	.970	.900	.840	.980	.950	.900
2	.980	.880	.800	.960	.860	.780	.980	.930	.890
3	1.000	1.000	1.000	.940	.820	.700	.970	.880	.820
4	1.000	1.000	1.000	.930	.740	.300	.980	.890	.720
5	1.000	1.000	1.000	.940	.890	.860	.980	.940	.920
6	1.000	1.000	1.000	.830	.750	.700	.890	.810	.780
7	1.000	1.000	1.000	1.300	1.000	1.000	1.000	1.000	1.000

**** CROSS SECTION CHECK REVEALED 1 ERRORS OR INCONSISTENCIES

* * * * F C C * * * *

SAMPLE CASE FOR F C C

RESONANCE SHIELDED CROSS SECTIONS ARE COMPUTED FOR THIS CASE USING THE RUSSIAN DATA

NUMBER OF ITERATIONS IN CALCULATING THE ELASTIC DOWNSCATTERING CROSS SECTION = 3 (XI COEFF. = .6600)

HETEROGENEITY CORRECTION FACTOR(CM) = 2.0000+00

GROUP AVERAGED TOTAL CROSS SECTIONS PER ATOM (EXCLUDING ISOTOPE MENTIONED) ARE LISTED BELOW FOR EACH ITERATION

ITERATION	M2PU49	O
0	5.6266+00	8.4794+01
1	5.5819+00	5.7623+01
2	5.5819+00	5.7623+01
3	5.5819+00	5.7623+01
4	5.5819+00	5.7623+01
5	5.5819+00	5.7623+01
6	5.5819+00	5.7623+01

CALCULATED RESONANCE SELF-SHIELDING COEFFICIENTS ARE LISTED BELOW FOR M2PU49

GROUP	SIG0	FF	FC	FT	FE
1	.2223+01	1.00000	1.00000	1.00000	1.00000
2	.2720+01	1.00000	1.00000	1.00000	1.00000
3	.3356+01	1.00000	1.00000	1.00000	1.00000
4	.3169+01	1.00000	1.00000	1.00000	1.00000
5	.6552+01	1.00000	1.00000	1.00000	1.00000
6	.7325+01	1.00000	1.00000	1.00000	1.00000
7	.6089+01	1.00000	1.00000	1.00000	1.00000
8	.5734+01	1.00000	1.00000	1.00000	1.00000
9	.5794+01	1.00000	1.00000	1.00000	1.00000
10	.5854+01	.97884	.99116	.99834	1.00000
11	.5913+01	.96544	.98228	.99772	1.00000
12	.5972+01	.92328	.94672	.98440	.98888
13	.6031+01	.86121	.88428	.95012	.95780
14	.6031+01	.77012	.78636	.88463	.86780
15	.6031+01	.62792	.62612	.78474	.79780
16	.6031+01	.48682	.48370	.62474	.73780
17	.6031+01	.40012	.41248	.49133	.68780
18	.6031+01	.44671	.44809	.40671	.55890
19	.6031+01	.20671	.26115	.22341	.72000
20	.6031+01	.19780	.27895	.13659	.86890
21	.6031+01	.20780	.28786	.19110	.96000
22	.6031+01	1.00000	1.00000	1.00000	1.00000
23	.6031+01	1.00000	1.00000	1.00000	1.00000
24	.6031+01	.69890	.58162	.47659	.88890
25	.6031+01	.59000	.60632	.32855	.84000
26	.6031+01	1.00000	1.00000	1.00000	1.00000

CALCULATED RESONANCE SELF-SHIELDING COEFFICIENTS ARE LISTED BELOW FOR 0

GROUP	SIG0	FF	FC	FT	FE
1	.3015+01	1.00000	.94314	.93355	.96438
2	.3486+01	1.00000	.93426	.92341	.95713
3	.3555+01	1.00000	1.00000	.88610	.92958
4	.3308+01	1.00000	1.00000	.83872	.93676
5	.3262+01	1.00000	1.00000	.91567	.96054
6	.3716+01	1.00000	1.00000	.79560	.85560
7	.4440+01	1.00000	1.00000	1.00000	1.00000
8	.5085+01	1.00000	1.00000	1.00000	1.00000
9	.5508+01	1.00000	1.00000	1.00000	1.00000
10	.6034+01	1.00000	1.00000	1.00000	1.00000
11	.6324+01	1.00000	1.00000	1.00000	1.00000
12	.7245+01	1.00000	1.00000	1.00000	1.00000
13	.7548+01	1.00000	1.00000	1.00000	1.00000
14	.7335+01	1.00000	1.00000	1.00000	1.00000
15	.8367+01	1.00000	1.00000	1.00000	1.00000
16	.9610+01	1.00000	1.00000	1.00000	1.00000
17	.1066+02	1.00000	1.00000	1.00000	1.00000
18	.2154+02	1.00000	1.00000	1.00000	1.00000
19	.1055+02	1.00000	1.00000	1.00000	1.00000
20	.2263+02	1.00000	1.00000	1.00000	1.00000
21	.1328+02	1.00000	1.00000	1.00000	1.00000
22	.1035+02	1.00000	1.00000	1.00000	1.00000
23	.1710+02	1.00000	1.00000	1.00000	1.00000
24	.5682+02	1.00000	1.00000	1.00000	1.00000
25	.7805+03	1.00000	1.00000	1.00000	1.00000
26	.4669+03	1.00000	1.00000	1.00000	1.00000

ELASTIC DOWNSCATTERING CROSS SECTION FOR ITERATION 1

GROUP	M2PU49	O
1	2.6000-02	2.4302-01
2	3.3590-02	4.3720-01
3	3.2023-02	3.8743-01
4	2.9801-02	4.8620-01
5	4.0410-02	8.0751-01
6	4.3452-02	6.1236-01
7	6.0753-02	6.3345-01
8	6.9499-02	4.8250-01
9	7.0199-02	4.1758-01
10	7.7115-02	4.1361-01
11	7.5255-02	3.9258-01
12	8.0371-02	3.9176-01
13	7.6823-02	3.9327-01
14	6.7862-02	3.8344-01
15	6.4436-02	3.7698-01
16	6.2942-02	3.7292-01
17	5.8552-02	3.6074-01
18	6.6325-02	3.7344-01
19	6.0886-02	3.6007-01
20	6.0392-02	3.6704-01
21	5.9905-02	3.7331-01
22	5.7478-02	3.6350-01
23	6.0895-02	3.5515-01
24	6.4683-02	3.5251-01
25	8.1194-02	3.8270-01
26	0.0000	0.0000

ELASTIC DOWNSCATTERING CROSS SECTION FOR ITERATION 2

GROUP	M2PU49	0
1	2.6000-02	2.4302-01
2	3.4198-02	4.4385-01
3	3.0996-02	3.7869-01
4	3.1589-02	5.1389-01
5	3.9774-02	7.9999-01
6	4.3722-02	6.1499-01
7	5.9080-02	6.2510-01
8	6.8395-02	4.7758-01
9	6.8692-02	4.1156-01
10	7.5257-02	4.0652-01
11	7.1492-02	3.7956-01
12	7.6891-02	3.7926-01
13	7.3811-02	3.8133-01
14	6.5440-02	3.7355-01
15	6.2424-02	3.6871-01
16	6.1257-02	3.6579-01
17	5.7730-02	3.5753-01
18	6.4522-02	3.6615-01
19	6.0177-02	3.5710-01
20	5.9156-02	3.6168-01
21	5.8248-02	3.6607-01
22	5.6430-02	3.5934-01
23	6.0591-02	3.5402-01
24	6.4659-02	3.5243-01
25	8.1194-02	3.8262-01
26	0.0000	0.0000

ELASTIC DOWNSCATTERING CROSS SECTION FOR ITERATION 3

GROUP	M2PU49	O
1	2.6000-02	2.4302-01
2	3.4316-02	4.4514-01
3	3.0764-02	3.7671-01
4	3.1961-02	5.2569-01
5	3.9545-02	7.9729-01
6	4.3842-02	6.1617-01
7	5.8911-02	6.2426-01
8	6.8362-02	4.7744-01
9	6.8623-02	4.1129-01
10	7.5199-02	4.0630-01
11	7.1179-02	3.7348-01
12	7.6636-02	3.7835-01
13	7.3606-02	3.8051-01
14	6.5313-02	3.7303-01
15	6.2339-02	3.6836-01
16	6.1196-02	3.6553-01
17	5.7718-02	3.5749-01
18	6.4455-02	3.6588-01
19	6.0167-02	3.5706-01
20	5.9125-02	3.6155-01
21	5.8187-02	3.6581-01
22	5.6409-02	3.5925-01
23	6.0589-02	3.5402-01
24	6.4659-02	3.5243-01
25	8.1194-02	3.8262-01
26	0.0000	0.0000

MICROSCOPIC CROSS SECTIONS FOR M2PU49

NUCLIDE NUMBER 1

GROUP	SIGF	SIGA	NUSIGF	SIGTR	SIGXG	G-1XG	G-2XG	G-3XG	G-4XG	G-5XG	G-6XG
1	2.200	1.790	8.404	3.466	.590	.000	.000	.000	.000	.000	.000
2	1.900	1.921	6.593	4.111	.886	.026	.000	.000	.000	.000	.000
3	1.970	2.000	6.383	4.598	1.358	.084	.040	.000	.000	.000	.000
4	2.000	2.041	6.180	5.068	1.936	.181	.200	.150	.000	.000	.000
5	1.750	1.808	5.215	5.313	2.625	.232	.310	.360	.260	.000	.000
6	1.640	1.747	4.789	6.384	4.024	.470	.420	.400	.360	.320	.000
7	1.630	1.797	4.694	8.229	6.183	.484	.230	.270	.220	.180	.180
8	1.680	1.920	4.605	10.175	8.040	.219	.090	.130	.120	.090	.080
9	1.700	1.989	4.345	11.560	9.382	.218	.020	.030	.040	.040	.030
10	1.713	2.269	4.865	12.999	10.515	.189	-.000	.010	.010	.010	.010
11	1.738	2.533	4.935	13.868	11.264	.215	-.000	-.000	-.000	-.000	-.000
12	2.308	3.492	6.555	16.115	12.547	.071	-.000	-.000	-.000	-.000	-.000
13	2.928	4.608	8.316	17.102	12.420	.077	-.000	-.000	-.000	-.000	-.000
14	3.234	5.279	9.186	17.250	11.906	.074	-.000	-.000	-.000	-.000	-.000
15	4.772	7.903	13.553	20.403	12.438	.065	.000	-.000	-.000	-.000	-.000
16	6.329	10.730	17.973	22.803	12.012	.062	.000	.000	-.000	-.000	-.000
17	7.602	13.377	21.590	23.584	10.149	.061	.000	.000	.000	-.000	-.000
18	18.315	36.687	52.014	41.484	4.733	.058	.000	.000	.000	.000	-.000
19	4.548	12.643	12.915	15.192	2.489	.064	.000	.000	.000	.000	.000
20	19.760	39.865	56.176	25.132	-14.792	.060	.000	.000	.000	.000	.000
21	9.351	19.426	26.557	17.294	-2.190	.059	.000	.000	.000	.000	.000
22	12.000	13.000	34.080	23.000	9.944	.058	.000	.000	.000	.000	.000
23	24.000	27.000	68.160	38.000	10.939	.056	.000	.000	.000	.000	.000
24	71.987	114.445	204.443	90.075	-24.434	.061	.000	.000	.000	.000	.000
25	985.300	1721.368	2798.252	951.490	-769.959	.065	.000	.000	.000	.000	.000
26	742.000	1028.000	2107.280	1038.000	10.000	.061	.000	.000	.000	.000	.000

GROUP	G-7XG	G-8XG	G-9XG	G-10XG
1	.000	.000	.000	.000
2	.000	.000	.000	.000
3	.000	.000	.000	.000
4	.000	.000	.000	.000
5	.000	.000	.000	.000
6	.000	.000	.000	.000
7	.000	.000	.000	.000
8	.070	.000	.000	.000
9	.030	.030	.000	.000
10	.010	.010	.010	.000
11	-.000	-.000	-.000	-.000
12	-.000	-.000	-.000	-.000
13	-.000	-.000	-.000	-.000
14	-.000	-.000	-.000	-.000
15	-.000	-.000	-.000	-.000
16	-.000	-.000	-.000	-.000
17	-.000	-.000	-.000	-.000
18	-.000	-.000	-.000	-.000
19	-.000	-.000	-.000	-.000
20	.000	-.000	-.000	-.000
21	.000	.000	-.000	-.000
22	.000	.000	.000	-.000
23	.000	.000	.000	.000
24	.000	.000	.000	.000
25	.000	.000	.000	.000
26	.000	.000	.000	.000

MICROSCOPIC CROSS SECTIONS FOR

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NUCLIDE NUMBER 2

GROUP	SIGF	SIGA	NUSIGF	SIGTR	SIGXG	G-1XG	G-2XG	G-3XG	G-4XG	G-5XG	G-6XG
1	.000	.217	.000	.830	.210	.000	.000	.000	.000	.000	.000
2	.000	.070	.000	1.009	.494	.243	.000	.000	.000	.000	.000
3	.000	.003	.000	1.247	.867	.445	.020	.000	.000	.000	.000
4	.000	-.000	.000	1.248	.722	.377	-.000	.050	.000	.000	.000
5	.000	-.000	.000	3.622	2.825	.526	-.000	-.000	.050	.000	.000
6	.000	-.000	.000	3.431	2.814	.797	-.000	-.000	-.000	.030	.000
7	.000	-.000	.000	3.268	2.644	.616	-.000	-.000	-.000	-.000	.010
8	.000	-.000	.000	3.360	2.683	.624	-.000	-.000	-.000	-.000	.000
9	.000	-.000	.000	3.409	2.997	.477	-.000	-.000	-.000	-.000	.000
10	.000	-.000	.000	3.456	3.050	.411	-.000	-.000	-.000	-.000	.000
11	.000	-.000	.000	3.504	3.126	.406	-.000	-.000	-.000	-.000	.000
12	.000	-.000	.000	3.552	3.174	.378	-.000	-.000	-.000	-.000	.000
13	.000	-.000	.000	3.600	3.219	.378	-.000	-.000	-.000	-.000	.000
14	.000	-.000	.000	3.600	3.227	.381	-.000	-.000	-.000	-.000	.000
15	.000	-.000	.000	3.600	3.232	.373	.000	-.000	-.000	-.000	.000
16	.000	-.000	.000	3.600	3.234	.368	.000	.000	-.000	-.000	.000
17	.000	-.000	.000	3.600	3.243	.366	.000	.000	.000	-.000	.000
18	.000	-.000	.000	3.600	3.234	.357	.000	.000	.000	.000	.000
19	.000	-.000	.000	3.600	3.243	.366	.000	.000	.000	.000	.000
20	.000	-.000	.000	3.600	3.238	.357	.000	.000	.000	.000	.000
21	.000	-.000	.000	3.600	3.234	.362	.000	.000	.000	.000	.000
22	.000	-.000	.000	3.600	3.241	.366	.000	.000	.000	.000	.000
23	.000	-.000	.000	3.600	3.246	.359	.000	.000	.000	.000	.000
24	.000	-.000	.000	3.600	3.248	.354	.000	.000	.000	.000	.000
25	.000	-.000	.000	3.600	3.217	.352	.000	.000	.000	.000	.000
26	.000	-.000	.000	3.600	3.600	.383	.000	.000	.000	.000	.000

GROUP	G-7XG	G-8XG	G-9XG	G-10XG
1	.000	.000	.000	.000
2	.000	.000	.000	.000
3	.000	.000	.000	.000
4	.000	.000	.000	.000
5	.000	.000	.000	.000
6	.000	.000	.000	.000
7	.000	.000	.000	.000
8	-.000	.000	.000	.000
9	-.000	-.000	.000	.000
10	-.000	-.000	-.000	.000
11	-.000	-.000	-.000	-.000
12	-.000	-.000	-.000	-.000
13	-.000	-.000	-.000	-.000
14	-.000	-.000	-.000	-.000
15	-.000	-.000	-.000	-.000
16	-.000	-.000	-.000	-.000
17	-.000	-.000	-.000	-.000
18	-.000	-.000	-.000	-.000
19	-.000	-.000	-.000	-.000
20	.000	-.000	-.000	-.000
21	.000	.000	-.000	-.000
22	.000	.000	.000	-.000
23	.000	.000	.000	.000
24	.000	.000	.000	.000
25	.000	.000	.000	.000
26	.000	.000	.000	.000

THIS IS A REACTIVITY VERSUS TIME CALCULATION FOR A CONSTANT GEOMETRIC BUCKLING

THE INITIAL MULTIPLICATION CONSTANT IS EQUAL TO 1.050000

THE BURNUP WILL BE COMPUTED USING A CONSTANT FLUX OF 1.00000+00 N/CM2-SEC.

THE CONVERGENCE CRITERION ON THE MARCH-OUT ALGORITHM IS 1.00000-06

TOTAL NUMBER OF TIME STEPS IS 1

EACH STEP IS 1.000+01 DAYS

TOTAL BURNUP TIME IS 1.000+01 DAYS

OUTPUT WILL BE GIVEN EVERY 1 STEPS

SAMPLE CASE FOR F C C

THE INITIAL CORE LOADING IS GIVEN BELOW FOR A CORE VOLUME OF 600.000 LITERS

NUCLIDE	NAME	ATOM DENSITY(CM-3)	KG/LITER	KILOGRAMS	SOURCE(KG/DAY)	TEMPERATURE
1	M2PU49	2.29103-02	9.0930+00	5.4558+03	0.0000	9.0000+02
2	O	5.09118-02	1.3525+00	8.1148+02	0.0000	9.0000+02

SAMPLE CASE FOR F C C

T I M E = .00 D A Y S

K EFFECTIVE = 1.050000+00

TOTAL POWER = 8.123582-13 MWT

NEUTRON FLUX = 1.000000+00 N/CM2-SEC

BREEDING RATIO = 0.000000

GEOMETRIC BUCKLING = 5.601541-02 CM-2

SPHERICAL RADIUS = 1.327382+01 CM

*** F U E L I N V E N T O R Y ***

NUCLIDE	NAME	ATOM DENSITY(CM-3)	CURRENT LOAD(KG)	INITIAL LOAD(KG)	CHANGE(KG)
1	M2PU49	2.29103-02	5.45579+03	5.45579+03	0.00000

* * * N U C L E A R D A T A * * *

NEUTRON SOURCE RATE(PER CC PER SEC) = 1.23930-01
 NEUTRON FISSION RATE(PER CC PER SEC) = 4.08795-02
 NEUTRON ABSORPTION RATE(PER CC PER SEC) = 4.35370-02
 NEUTRON LEAKAGE RATE(PER CC PER SEC) = 7.44920-02
 NEUTRON GENERATION TIME(SECONDS) = 1.03968-08
 TOTAL NEUTRON LEAKAGE FROM CORE = 0.00000

GROUP	FLUX	NU*SIGF*FLUX	SIGF*FLUX	INTG FLUX	INTG F.R.	ADJOINT	CHI*ADJOINT	DENSITY	PHI(U)
1	9.40699-03	1.81121-03	4.74137-04	9.40699-03	1.15984-02	9.58527-01	1.91705-02	2.66406-12	1.95979-02
2	5.11765-02	7.73009-03	2.22769-03	6.05835-02	6.60925-02	9.04335-01	8.86248-02	1.84753-11	1.06618-01
3	1.16086-01	1.69755-02	5.23934-03	1.76669-01	1.94258-01	9.68073-01	1.83934-01	5.30103-11	2.41846-01
4	1.71026-01	2.42148-02	7.83652-03	3.47696-01	3.85956-01	9.96178-01	2.66976-01	1.04364-10	3.00046-01
5	1.83547-01	2.19297-02	7.35894-03	5.31242-01	5.65971-01	1.15850+00	2.27066-01	1.48167-10	3.22012-01
6	1.98929-01	2.18251-02	7.47434-03	7.30171-01	7.48809-01	1.13519+00	1.53250-01	2.27101-10	2.88303-01
7	1.38318-01	1.48761-02	5.16531-03	8.68489-01	8.75164-01	1.17003+00	6.78615-02	2.23313-10	2.00460-01
8	7.91860-02	8.71675-03	3.04781-03	9.47675-01	9.49720-01	1.22781+00	2.70117-02	1.80800-10	1.14762-01
9	3.55270-02	3.94351-03	1.38369-03	9.83202-01	9.83568-01	1.24965+00	1.12469-02	1.18955-10	4.61390-02
10	1.23963-02	1.38162-03	4.86486-04	9.95599-01	9.95468-01	1.21695+00	3.65086-03	6.10410-11	1.60990-02
11	3.73632-03	4.22463-04	1.48755-04	9.99335-01	9.99107-01	1.20798+00	1.20798-03	2.69770-11	4.85236-03
12	5.78613-04	8.68985-05	3.05981-05	9.99913-01	9.99855-01	1.32789+00	0.00000	6.12649-12	7.51445-04
13	7.64377-05	1.45629-05	5.12777-06	9.99990-01	9.99981-01	1.38097+00	0.00000	1.19025-12	9.92697-05
14	9.26668-06	1.95020-06	6.86689-07	9.99999-01	9.99998-01	1.38644+00	0.00000	2.11580-13	1.20346-05
15	8.25700-07	2.56383-07	9.02757-08	1.00000+00	1.00000+00	1.48298+00	0.00000	2.76469-14	1.07234-06
16	5.70100-08	2.34754-08	8.26600-09	1.00000+00	1.00000+00	1.51023+00	0.00000	2.80726-15	7.40390-08
17	3.24301-09	1.60412-09	5.64831-10	1.00000+00	1.00000+00	1.48263+00	0.00000	2.34152-16	4.21170-09
18	7.21854-11	8.60208-11	3.02890-11	1.00000+00	1.00000+00	1.38016+00	0.00000	7.64316-18	9.37472-11
19	4.21433-12	1.24696-12	4.39070-13	1.00000+00	1.00000+00	9.37111-01	0.00000	6.56235-19	5.47316-12
20	8.60618-14	1.10763-13	3.90010-14	1.00000+00	1.00000+00	1.37113+00	0.00000	1.96499-20	1.11769-13
21	3.42035-15	2.08106-15	7.32768-16	1.00000+00	1.00000+00	1.32038+00	0.00000	1.14523-21	4.44201-15
22	1.98598-16	1.55062-16	5.45993-17	1.00000+00	1.00000+00	2.41034+00	0.00000	9.77927-23	2.57920-16
23	5.93108-18	9.26177-18	3.26119-18	1.00000+00	1.00000+00	2.43418+00	0.00000	4.28237-24	7.70270-18
24	4.34515-20	2.03520-19	7.16620-20	1.00000+00	1.00000+00	1.77961+00	0.00000	4.60075-26	5.64306-20
25	2.13896-23	1.37126-21	4.82839-22	1.00000+00	1.00000+00	1.62579+00	0.00000	3.33069-29	2.77787-23
26	1.93803-26	9.35649-25	3.29454-25	1.00000+00	1.00000+00	2.04982+00	0.00000	8.81474-32	1.93803-26
SUM	1.00000+00	1.23930-01	4.08795-02			3.60729+01	1.05000+00	1.17243-09	

SAMPLE CASE FOR F C C

THE MACROSCOPIC CROSS SECTIONS ARE GIVEN IN THE TABLE BELOW

GROUP	SIGF	SIGA	NUSIGF	SIGTR	SIGXG	G-1XG	G-2XG	G-3XG	G-4XG	G-5XG	G-6XG
1	5.04-02	5.21-02	1.93-01	1.22-01	2.42-02	0.00	0.00	0.00	0.00	0.00	0.00
2	4.35-02	4.76-02	1.51-01	1.46-01	4.54-02	1.30-02	0.00	0.00	0.00	0.00	0.00
3	4.51-02	4.60-02	1.46-01	1.69-01	7.52-02	2.46-02	1.93-03	0.00	0.00	0.00	0.00
4	4.58-02	4.68-02	1.42-01	1.80-01	8.11-02	2.33-02	4.58-03	5.98-03	0.00	0.00	0.00
5	4.01-02	4.14-02	1.19-01	3.06-01	2.04-01	3.21-02	7.10-03	8.25-03	8.50-03	0.00	0.00
6	3.76-02	4.00-02	1.10-01	3.21-01	2.35-01	5.13-02	9.62-03	9.16-03	8.25-03	8.86-03	0.00
7	3.73-02	4.12-02	1.03-01	3.55-01	2.76-01	4.25-02	5.27-03	6.19-03	5.04-03	4.12-03	4.63-03
8	3.85-02	4.40-02	1.10-01	4.04-01	3.31-01	3.68-02	2.06-03	2.98-03	2.75-03	2.06-03	1.83-03
9	3.89-02	4.56-02	1.11-01	4.38-01	3.66-01	2.93-02	4.58-04	6.87-04	9.16-04	9.16-04	6.87-04
10	3.92-02	5.20-02	1.11-01	4.74-01	3.96-01	2.53-02	0.00	2.29-04	2.29-04	2.29-04	2.29-04
11	3.98-02	5.80-02	1.13-01	4.96-01	4.17-01	2.56-02	0.00	0.00	0.00	0.00	0.00
12	5.29-02	8.00-02	1.50-01	5.50-01	4.49-01	2.09-02	0.00	0.00	0.00	0.00	0.00
13	6.71-02	1.06-01	1.91-01	5.75-01	4.48-01	2.10-02	0.00	0.00	0.00	0.00	0.00
14	7.41-02	1.21-01	2.10-01	5.78-01	4.37-01	2.11-02	0.00	0.00	0.00	0.00	0.00
15	1.09-01	1.81-01	3.11-01	6.51-01	4.49-01	2.05-02	0.00	0.00	0.00	0.00	0.00
16	1.45-01	2.46-01	4.12-01	7.06-01	4.40-01	2.02-02	0.00	0.00	0.00	0.00	0.00
17	1.74-01	3.06-01	4.95-01	7.24-01	3.98-01	2.00-02	0.00	0.00	0.00	0.00	0.00
18	4.20-01	8.40-01	1.13+00	1.13+00	2.73-01	1.95-02	0.00	0.00	0.00	0.00	0.00
19	1.04-01	2.90-01	2.96-01	5.31-01	2.22-01	2.01-02	0.00	0.00	0.00	0.00	0.00
20	4.53-01	9.13-01	1.29+00	7.59-01	-1.74-01	1.96-02	0.00	0.00	0.00	0.00	0.00
21	2.14-01	4.45-01	6.03-01	5.80-01	1.14-01	1.98-02	0.00	0.00	0.00	0.00	0.00
22	2.75-01	2.98-01	7.81-01	7.10-01	3.93-01	2.00-02	0.00	0.00	0.00	0.00	0.00
23	5.50-01	6.19-01	1.55+00	1.05+00	4.16-01	1.96-02	0.00	0.00	0.00	0.00	0.00
24	1.65+00	2.62+00	4.68+00	2.25+00	-3.94-01	1.94-02	0.00	0.00	0.00	0.00	0.00
25	2.26+01	3.94+01	6.41+01	2.20+01	-1.75+01	1.94-02	0.00	0.00	0.00	0.00	0.00
26	1.70+01	2.36+01	4.83+01	2.40+01	4.12-01	2.13-02	0.00	0.00	0.00	0.00	0.00

GROUP	G-7X6	G-8X6	G-9X6	G-10X6
1	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00
8	1.60-03	0.00	0.00	0.00
9	6.87-04	6.87-04	0.00	0.00
10	2.29-04	2.29-04	2.29-04	0.00
11	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00

SAMPLE CASE FOR F C C

*** SPECTRUM AVERAGED CROSS SECTIONS ***

NUMBER	NAME	SIGMA F	SIGMA ABS	NU SIGMA F	SIGMA CAP
1	M2PU49	1.7843+00	1.8870+00	5.4094+00	1.0272-01
2	0	0.0000	5.9747-03	0.0000	5.9747-03

SAMPLE CASE FOR F C C

DATA FOR CROSS SECTION AVERAGING LISTED BELOW

THE NUMBER OF ENLARGED ENERGY GROUPS IS 4

SIGMA TRANSPORT IS CALCULATED USING NORMALIZED RECIPROCAL WEIGHTING

NEW GROUP	OLD GROUPS PER NEW GROUP	FISSION SOURCE FOR NEW GROUP	FLUX	VELOCITY	DENSITY
1	4	5.76000-01	3.47696-01	1.94773+09	1.78513-10
2	4	4.11000-01	5.99980-01	7.69816+08	7.79381-10
3	5	1.30000-02	5.23146-02	2.44130+08	2.14290-10
4	13	0.00000	1.01527-05	4.19055+07	2.42276-13

GROUP NORMALIZATION FACTOR FOR TRANSPORT CROSS SECTIONS

1	1.00051+00
2	1.01578+00
3	1.00084+00
4	1.00049+00

SAMPLE CASE FOR F C C

CRUNCHED MICROSCOPIC CROSS SECTIONS FOR M2PU49 NUCLIDE NUMBER 1

GROUP	SIGF	SIGA	NUSIGF	SIGTR	SIGXG	G-1XG	G-2XG	G-3XG	G-4XG	G-5XG	G-6XG
1	1.981	2.003	6.369	4.691	1.624	.000	.000	.000			
2	1.677	1.800	4.900	6.750	4.885	1.020	.000	.000			
3	1.714	2.115	4.880	12.073	9.959	.064	.045	.000			
4	3.378	5.526	9.595	17.504	11.978	.000	.000	.000			

SAMPLE CASE FOR F C C

CRUNCHED MICROSCOPIC CROSS SECTIONS FOR 0 NUCLIDE NUMBER 2

GROUP	SIGF	SIGA	NUSIGF	SIGTR	SIGXG	G-1XG	G-2XG	G-3XG	G-4XG	G-5XG	G-6XG
1	.000	.017	.000	1.190	.912	.000	.000	.000			
2	.000	.000	.000	3.492	3.429	.261	.000	.000			
3	.000	.000	.000	3.431	3.430	.063	.000	.000			
4	.000	.000	.000	3.602	3.602	.001	.000	.000			

SAMPLE CASE FOR F C C

T I M E = .00 D A Y S

K EFFECTIVE = 1.050000+00

TOTAL POWER = 8.123582-13 MWT

NEUTRON FLUX = 1.000000+00 N/CM2-SEC

BREEDING RATIO = 0.000000

GEOMETRIC BUCKLING = 5.601541-02 CM-2

SPHERICAL RADIUS = 1.327382+01 CM

*** F U E L I N V E N T O R Y ***

NUCLIDE	NAME	ATOM DENSITY(CM-3)	CURRENT LOAD(KG)	INITIAL LOAD(KG)	CHANGE(KG)
1	M2PU49	2.29103-02	5.45579+03	5.45579+03	0.00000

*** N U C L E A R D A T A ***

NEUTRON SOURCE RATE(PER CC PER SEC) = 1.23930-01
 NEUTRON FISSION RATE(PER CC PER SEC) = 4.08795-02
 NEUTRON ABSORPTION RATE(PER CC PER SEC) = 4.35370-02
 NEUTRON LEAKAGE RATE(PER CC PER SEC) = 7.44920-02
 NEUTRON GENERATION TIME(SECONDS) = 1.03096-08
 TOTAL NEUTRON LEAKAGE FROM CORE = 0.00000

GROUP	FLUX	NU*SIGF*FLUX	SIGF*FLUX	INTG FLUX	INTG F.R.	ADJOINT	CHI*ADJOINT	DENSITY	PHI(U)
1	3.47696-01	5.07316-02	1.57777-02	3.47696-01	3.85956-01	9.69569-01	5.58472-01	1.78513-10	1.72983-01
2	5.99980-01	6.73476-02	2.30464-02	9.47675-01	9.49720-01	1.15656+00	4.75346-01	7.79381-10	2.27265-01
3	5.23147-02	5.84906-03	2.05466-03	9.99990-01	9.99981-01	1.24476+00	1.61818-02	2.14290-10	1.35882-02
4	1.01527-05	2.23175-06	7.85827-07	1.00000+00	1.00000+00	1.38644+00	0.00000	2.42276-13	9.91475-07
SUM	1.00000+00	1.23930-01	4.08795-02			4.75732+00	1.05000+00	1.17243-09	

SAMPLE CASE FOR F C C

THE MACROSCOPIC CROSS SECTIONS ARE GIVEN IN THE TABLE BELOW

GROUP	SIGF	SIGA	NUSIGF	SIGTR	SIGXG	G-1XG	G-2XG	G-3XG	G-4XG	G-5XG	G-6XG
1	4.54-02	4.68-02	1.46-01	1.68-01	8.36-02	0.00	0.00	0.00			
2	3.84-02	4.12-02	1.12-01	3.32-01	2.86-01	3.67-02	0.00	0.00			
3	3.93-02	4.84-02	1.12-01	4.51-01	4.03-01	4.68-03	1.03-03	0.00			
4	7.74-02	1.27-01	2.20-01	5.84-01	4.58-01	3.08-05	0.00	0.00			

SAMPLE CASE FOR F C C

*** SPECTRUM AVERAGED CROSS SECTIONS ***

NUMBER	NAME	SIGMA F	SIGMA ABS	NU SIGMA F	SIGMA CAP
1	M2PU49	1.7843+00	1.8870+00	5.4094+00	1.0272-01
2	0	0.0000	5.9747-03	0.0000	5.9747-03

SAMPLE CASE FOR F C C

T I M E = 10.00 D A Y S

K EFFECTIVE = 1.050000+00

TOTAL POWER = 8.123582-13 MWT

NEUTRON FLUX = 1.000000+00 N/CM2-SEC

BREEDING RATIO = 0.000000

GEOMETRIC BUCKLING = 5.601541-02 CM-2

SPHERICAL RADIUS = 1.327382+01 CM

*** FUEL I N V E N T O R Y ***

NUCLIDE	NAME	ATOM DENSITY(CM-3)	CURRENT LOAD(KG)	INITIAL LOAD(KG)	CHANGE(KG)
1	M2PU49	2.29103-02	5.45579+03	5.45579+03	0.00000

*** N U C L E A R D A T A ***

NEUTRON SOURCE RATE(PER CC PER SEC) = 1.23930-01
 NEUTRON FISSION RATE(PER CC PER SEC) = 4.08795-02
 NEUTRON ABSORPTION RATE(PER CC PER SEC) = 4.35370-02
 NEUTRON LEAKAGE RATE(PER CC PER SEC) = 7.44920-02
 NEUTRON GENERATION TIME(SECONDS) = 1.03096-08
 TOTAL NEUTRON LEAKAGE FROM CORE = 3.86167+10

GROUP	FLUX	NU*SIGF*FLUX	SIGF*FLUX	INTG FLUX	INTG F.R.	ADJOINT	CHI*ADJOINT	DENSITY	PHI(U)
1	3.47696-01	5.07316-02	1.57777-02	3.47696-01	3.85956-01	9.69569-01	5.58472-01	1.78513-10	1.72983-01
2	5.99980-01	6.73476-02	2.30464-02	9.47675-01	9.49720-01	1.15656+00	4.75346-01	7.79381-10	2.27265-01
3	5.23146-02	5.84906-03	2.05466-03	9.99990-01	9.99981-01	1.24476+00	1.61818-02	2.14290-10	1.35882-02
4	1.01527-05	2.23175-06	7.85827-07	1.00000+00	1.00000+00	1.38644+00	0.00000	2.42276-13	9.91475-07
SUM	1.00000+00	1.23930-01	4.08795-02			4.75732+00	1.05000+00	1.17243-09	

SAMPLE CASE FOR F C C

THE MACROSCOPIC CROSS SECTIONS ARE GIVEN IN THE TABLE BELOW

GROUP	SIGF	SIGA	NUSIGF	SIGTR	SIGXG	G-1XG	G-2XG	G-3XG	G-4XG	G-5XG	G-6XG
1	4.54-02	4.66-02	1.46-01	1.68-01	8.36-02	0.00	0.00	0.00			
2	3.84-02	4.12-02	1.12-01	3.32-01	2.86-01	3.67-02	0.00	0.00			
3	3.93-02	4.84-02	1.12-01	4.51-01	4.03-01	4.68-03	1.03-03	0.00			
4	7.74-02	1.27-01	2.20-01	5.84-01	4.58-01	3.08-05	0.00	0.00			

SAMPLE CASE FOR F C C

*** S P E C T R U M A V E R A G E D C R O S S S E C T I O N S ***

NUMBER	NAME	SIGMA F	SIGMA ABS	NU SIGMA F	SIGMA CAP
1	M2PU49	1.7843+00	1.8870+00	5.4094+00	1.0272-01
2	0	0.0000	5.9747-03	0.0000	5.9747-03

MACROSCOPIC CROSS SECTIONS ARE PUNCHED OUT FOR 1 MIXED ISOTOPES

MIX 1

ISOTOPE	DENSITY
M2PU49	2.291030-02
0	5.091180-02

THE MACROSCOPIC CROSS SECTIONS FOR MIX 1 ARE LISTED BELOW

GROUP	SIGF	SIGA	NUSIGF	SIGTR	SIGXG	G-1XG	G-2XG	G-3XG	G-4XG	G-5XG	G-6XG
1	5.04-02	5.21-02	1.93-01	1.22-01	2.42-02	0.00	0.00	0.00	0.00	0.00	0.00
2	4.35-02	4.76-02	1.51-01	1.46-01	4.54-02	1.30-02	0.00	0.00	0.00	0.00	0.00
3	4.51-02	4.60-02	1.46-01	1.69-01	7.52-02	2.46-02	1.93-03	0.00	0.00	0.00	0.00
4	4.58-02	4.68-02	1.42-01	1.80-01	8.11-02	2.33-02	4.58-03	5.98-03	0.00	0.00	0.00
5	4.01-02	4.14-02	1.19-01	3.06-01	2.04-01	3.21-02	7.10-03	8.25-03	8.50-03	0.00	0.00
6	3.76-02	4.00-02	1.10-01	3.21-01	2.35-01	5.13-02	9.62-03	9.16-03	8.25-03	8.86-03	0.00
7	3.73-02	4.12-02	1.08-01	3.55-01	2.76-01	4.25-02	5.27-03	6.19-03	5.04-03	4.12-03	4.63-03
8	3.85-02	4.40-02	1.10-01	4.04-01	3.31-01	3.68-02	2.06-03	2.98-03	2.75-03	2.06-03	1.83-03
9	3.89-02	4.56-02	1.11-01	4.38-01	3.68-01	2.93-02	4.58-04	6.87-04	9.16-04	9.16-04	6.87-04
10	3.92-02	5.20-02	1.11-01	4.74-01	3.96-01	2.53-02	0.00	2.29-04	2.29-04	2.29-04	2.29-04
11	3.98-02	5.80-02	1.13-01	4.96-01	4.17-01	2.56-02	0.00	0.00	0.00	0.00	0.00
12	5.29-02	8.00-02	1.50-01	5.50-01	4.49-01	2.09-02	0.00	0.00	0.00	0.00	0.00
13	6.71-02	1.06-01	1.91-01	5.75-01	4.48-01	2.10-02	0.00	0.00	0.00	0.00	0.00
14	7.41-02	1.21-01	2.10-01	5.78-01	4.37-01	2.11-02	0.00	0.00	0.00	0.00	0.00
15	1.09-01	1.81-01	3.11-01	6.51-01	4.49-01	2.05-02	0.00	0.00	0.00	0.00	0.00
16	1.45-01	2.46-01	4.12-01	7.06-01	4.40-01	2.02-02	0.00	0.00	0.00	0.00	0.00
17	1.74-01	3.06-01	4.95-01	7.24-01	3.98-01	2.00-02	0.00	0.00	0.00	0.00	0.00
18	4.20-01	8.40-01	1.19+00	1.13+00	2.73-01	1.95-02	0.00	0.00	0.00	0.00	0.00
19	1.04-01	2.90-01	2.96-01	5.31-01	2.22-01	2.01-02	0.00	0.00	0.00	0.00	0.00
20	4.53-01	9.13-01	1.29+00	7.59-01	-1.74-01	1.96-02	0.00	0.00	0.00	0.00	0.00
21	2.14-01	4.45-01	6.08-01	5.80-01	1.14-01	1.98-02	0.00	0.00	0.00	0.00	0.00
22	2.75-01	2.98-01	7.81-01	7.10-01	3.93-01	2.00-02	0.00	0.00	0.00	0.00	0.00
23	5.50-01	6.19-01	1.56+00	1.05+00	4.16-01	1.96-02	0.00	0.00	0.00	0.00	0.00
24	1.65+00	2.62+00	4.68+00	2.25+00	-3.94-01	1.94-02	0.00	0.00	0.00	0.00	0.00
25	2.26+01	3.94+01	6.41+01	2.20+01	-1.75+01	1.94-02	0.00	0.00	0.00	0.00	0.00
26	1.70+01	2.36+01	4.83+01	2.40+01	4.12-01	2.13-02	0.00	0.00	0.00	0.00	0.00

GROUP	G-7XG	G-8XG	G-9XG	G-10XG
1	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00
8	1.60-03	0.00	0.00	0.00
9	6.87-04	6.87-04	0.00	0.00
10	2.29-04	2.29-04	2.29-04	0.00
11	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00

26	10	1	1	0	0	0	0
PU239	239.05	0.0	207.0	0	0	0	0
OXYGEN	16.000						
	0.020	0.098	0.190	0.268	0.196	0.135	
	0.058	0.022	0.009	0.003	0.001	0.0	
	0.0	0.0	0.0	0.0	0.0	0.0	
	0.0	0.0	0.0	0.0	0.0	0.0	
	0.0	0.0	0.0	0.0	0.0	0.0	
	6.5	4.0	2.5	1.4	0.8	0.4	
	0.2	0.1	0.0465	0.0215	0.0100	0.00465	
	0.00215	0.001	0.000465	0.000215	0.0001	0.0000465	
	0.0000215	0.00001	0.00000465	0.00000215	0.000001	0.000000465	
	0.000000215	0.0000000252					
	.48	.48	.57	.57	.69		
	.69	.69	.77	.77	.77		
	.77	.77	.77	.77	.77		
	.77	.77	.77	.77	.77		
	.77	1.0					
M2PU49	1	10	25	4	4	4	3
	.1+04	.1+03	.1+02	.0	.1+04	.1+03	.1+02
	.1+02	.0		.1+04	.1+03	.1+02	.0
	.1+02	.0		.1+04	.1+03	.1+02	.0
10	1.00	.99	.97	.94	1.00	1.00	.98
10	1.00	1.00	.98	.97	1.00	1.00	.99
10	1.00	1.00	.99	.98	1.00	1.00	1.00
10	1.00	1.00	.99	.98	1.00	1.00	1.00
11	1.00	.98	.93	.88	1.00	.99	.95
11	1.00	.99	.97	.93	1.00	1.00	.98
11	1.00	.99	.98	.95	1.00	1.00	1.00
11	1.00	.99	.98	.95	1.00	1.00	1.00
12	1.00	.96	.87	.80	1.00	.96	.87
12	1.00	.98	.93	.87	1.00	.98	.94
12	1.00	.99	.95	.91	1.00	.99	.96
13	.99	.92	.79	.69	.99	.92	.77
13	1.00	.96	.87	.79	1.00	.96	.87
13	1.00	.98	.91	.88	1.00	.98	.91
14	.98	.88	.67	.56	.98	.87	.62
14	.99	.92	.78	.69	.99	.91	.76
14	1.00	.95	.86	.82	1.00	.95	.84
15	.97	.80	.53	.42	.96	.76	.46
15	.98	.86	.64	.53	.97	.82	.58
15	.99	.90	.77	.71	.99	.89	.72
16	.93	.70	.41	.30	.91	.62	.33
16	.96	.78	.50	.38	.94	.72	.42
16	.98	.83	.58	.52	.96	.80	.53
17	.91	.63	.34	.25	.89	.58	.28
17	.94	.69	.41	.32	.92	.64	.34
17	.97	.75	.49	.39	.95	.70	.41
18	.78	.50	.37	.34	.75	.44	.30
18	.83	.59	.45	.42	.80	.52	.38

18	.87	.66	.54	.52	.85	.61	.47	.44	.54	.50	.47	.65	.57	.56
19	.70	.33	.19	.16	.65	.28	.15	.13	.33	.21	.19	.76	.72	.71
19	.77	.37	.21	.18	.72	.32	.17	.15	.36	.23	.21	.77	.72	.72
19	.85	.41	.22	.20	.81	.36	.19	.17	.39	.25	.23	.79	.73	.72
20	.68	.33	.19	.17	.65	.29	.18	.16	.18	.11	.10	.88	.86	.86
20	.73	.36	.20	.18	.70	.33	.19	.17	.23	.13	.11	.89	.87	.86
20	.80	.39	.21	.19	.77	.36	.20	.18	.27	.15	.12	.89	.87	.86
21	.67	.33	.20	.18	.65	.31	.19	.17	.20	.18	.17	.96	.96	.96
21	.71	.35	.21	.19	.69	.33	.20	.18	.23	.19	.18	.97	.96	.96
21	.76	.37	.22	.20	.74	.35	.21	.19	.25	.20	.19	.97	.96	.96
22	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
22	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
22	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
23	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
23	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
23	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
24	.94	.79	.70	.69	.77	.62	.53	.52	.54	.47	.45	.94	.89	.88
24	.94	.79	.70	.69	.77	.62	.53	.52	.54	.47	.45	.94	.89	.88
24	.94	.79	.70	.69	.77	.62	.53	.52	.54	.47	.45	.94	.89	.88
25	.68	.61	.59	.59	.68	.57	.56	.56	.33	.30	.30	.85	.84	.84
25	.68	.61	.59	.59	.68	.57	.56	.56	.33	.30	.30	.85	.84	.84
25	.68	.61	.59	.59	.68	.57	.56	.56	.33	.30	.30	.85	.84	.84
1	6.700	2.200	3.82	.010				.640	3.850		.840	.0013	.026	
2	7.751	1.900	3.47	.021	1.280	4.550			.800	.0017	.026			
3	7.900	1.970	3.24	.030	1.250	4.650			.710	.0024	.028			
4	7.351	2.000	3.09	.041	1.160	4.150			.550	.0037	.027			
5	7.248	1.750	2.98	.058	1.140	4.300			.450	.0046	.035			
6	8.257	1.640	2.92	.107	1.160	5.350			.350	.0054	.042			
7	9.867	1.630	2.88	.167	.950	7.120			.230	.0064	.066			
8	11.300	1.680	2.86	.240	.750	8.630			.130	.0072	.090			
9	12.239	1.700	2.85	.289	.550	9.700			.070	.0077	.097			
10	13.451	1.750	2.84	.561	.250	10.890			.040	.0080	.113			
11	14.130	1.800	2.84	.810	.100	11.420			.020	.0081	.120			
12	16.500	2.500	2.84	1.250	-.000	12.750			.010	.0082	.136			
13	18.000	3.400	2.84	1.900	-.000	12.700			.000	.0083	.137			
14	19.500	4.200	2.84	2.600	-.000	12.700			.000	.0083	.137			
15	26.000	7.600	2.84	5.000	-.000	13.400			.000	.0083	.144			
16	36.500	13.000	2.84	9.100	-.000	14.400			.000	.0083	.155			
17	48.000	19.000	2.84	14.000	-.000	15.000			.000	.0083	.162			
18	102.000	41.000	2.84	41.000	-.000	20.000			.000	.0083	.216			
19	68.000	22.000	2.84	31.000	-.000	15.000			.000	.0083	.162			
20	184.000	100.000	2.84	72.000	-.000	12.000			.000	.0083	.129			
21	90.500	45.000	2.84	35.000	-.000	10.500			.000	.0083	.113			
22	23.000	12.000	2.84	1.000	-.000	10.000			.000	.0083	.108			
23	38.000	24.000	2.84	3.000	-.000	11.000			.000	.0083	.119			
24	189.000	103.000	2.84	73.000	-.000	13.300			.000	.0083	.143			
25	2896.000	1670.000	2.84	1210.000	-.000	15.700			.000	.0083	.169			

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APPENDIX D

LISTING OF CODE

-IL PDP INCL

ABC* FCOPY

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    DIMENSION HOLN(14), ATW(14), ALAM(10), FEF(10), FSSF(14,40),
    1FSSC(14,40), FSST(14,40), CHI(40), EL(40), PHI(40), VEL(40),
    2FSSE(14,40), FC( 120,6), FF( 120,6), FT( 120,6), FE( 120,6),
    3SF(14,6), SC(14,6), ST(14,6), SF(14,6), SR(14,9,40), SM(14,40,11),
    4HF(6), HC(6), HT(6), HE(6), TEMP(14), HOL(12), DN(14), SOGO(14),
    5SIGO(14,40), SORCE(14), AVSIG(14), SN(15,40), FPHI(40), S(14,15,40),
    6DNMI(14), DNM(14), ACS(14,4), TFX(40), DENP(40), CHIP(40),
    7SG(14,15,40), CX(40), DEN(40), SIGR(40), ADJ(40), AN(40,2),
    8, DNSO(14, 15), SL(15, 40), VELP(40), ANG(14,120)
    9 , ALETH(40), PHU(40), PPHI(40), ALETP(40), AZZ(40), SCD(14,40)
    DIMENSION LD(10), LC(10), LCN(10,4), LF(10), LFN(10,7), NT(14),
    1NGB(14), NGE(14), NFT(14), NPFF(14), NPFC(14), NPFT(14), NPFE(14),
    2LN(14), LBSN(5), LBLN(5), NG(14,120), NPN(40), NV(40)
    3, NBUN(14), NISO(14, 14), WLFL(40), WLAFL(40), NUT(14), NDV(9)
    4 , LLD(40), LLDL(40), MPUP(14)
    COMMON T, H, TOTL, VOL, EPSL, HS, AK, BSQ, POW, FLX, EPS, RS,
    1RL, RA, TAK, RF, BR, AN, HETC, DELU
    COMMON NRCF, NPRTG, NUMT, NOP, NCR, NGP, NXCM, NBE, NNE,
    1NP, NFD, NXS, NSOP, NTI, NFP, NSP, NPCS, NPRT, NAVX, NPUN,
    2NOPP, LBS, LBL, LSMFT, NCAL, NXCMP, NXX, NBN, NMG, LST, NPSS
    3, NPUP, NLAST, LLD
    4 , NE, NF, NC, NTP, NINP, NOUT, NSCRAT, NTAPE, NIFF, NTR, NDRUM
    COMMON LD, LC, LCN, LF, LFN, NT, NGB, NGE, NFT, NPFF, NPFC, NPFT,
    1NPFE, LN, LBSN, LBLN, NG, NPN, NV, NBUN, NISO, NUT, NDV, MPUP
    COMMON DN, PHI, S, HOLN, HOL, SN, FPHI, SG, CHI, ATW, ALAM, EL,
    1VEL, HF, HC, HT, HE, TEMP, AVSIG, DNMI, DNM, ACS, DENP, CHIP,
    2CX, DEN, SIGR, ADJ, DNSO, SL, VELP, FEF,
    3 SF, SC, ST, SE, SOGO, SIGO, SORCE, SR, SM
    4 , TFX, WLFL, WLAFL, ALETH, PHU, PPHI, ALETP, AZZ, SCD
    EQUIVALENCE (ANG(1,1), NG(1,1)), (LLD(1), LLDL(1))
    EQUIVALENCE (SG(1), FSSE), (SG(561), FC), (SG(1281), FF),
    1 (SG(2001), FT), (SG(2721), FE), (SG(3441), FSSF), (SG(4001), FSSC),
    2 (SG(4561), FSST)
    END

```

```

-ITC FOR MAIN,MAIN
  INCLUDE ABC
C   SET UP TAPE UNITS
    NINP = 5
    NOUT = 6
    DIMENSION JLPTAB(22)
    CALL SETDR(8,500000,100000,JLPTAB(1))
    CALL SETDR(7,600000,100000,JLPTAB(8))
    CALL SETDR(9,700000,100000,JLPTAB(15))
    NSCRAT = 8
    NTAPE = 7
    NDRUM = 9
    REWIND 8
    REWIND 7
    REWIND 9
C   LST=0/1=PROBLEM IS NOT FIRST CASE--OMIT READING CROSS SECTIONS
C   THIS CASE/PROBLEM IS FIRST CASE
    LST = 1
C   READ AND PRINT PRELIMINARY INPUT DATA
    CALL INPUT1
    CALL PRINT1
10  CONTINUE
C   LCR=0/1=CODE IS DOING FEW GROUP CALCULATION/MULTIGROUP CALCULATION
    LCR = 1
C   NRCF=0/1/2=INPUT CROSS SECTIONS ARE IN RUSSIAN FORMAT/DTK FORMAT/
C   DTF FORMAT
    IF(NRCF - 1) 20,30,30
C   READ CROSS SECTIONS IN RUSSIAN FORMAT AND DO SHIELDING CALCULATION
20  CALL REDXS
C   PRINT SHIELDED CROSS SECTIONS
    CALL INPUT2
    GO TO 50
30  CONTINUE
    IF(LST) 50, 50, 40
40  CONTINUE
C   READ CROSS SECTIONS IN DTF OR DTK FORMAT AND PRINT
    CALL INPUT2
50  CONTINUE
    IF(NRCF) 90, 90, 60
60  IF(LST) 80, 80, 70
70  CONTINUE
C   CHECK CROSS SECTIONS IN DTK OR DTF FORMAT
    CALL CHECK
80  CONTINUE
C   READ DATA FOR NEW CASE
    CALL RCINP2
90  CALL PRINT2
C   CALCULATE INITIAL INVENTORIES
    CALL START
    NPRTG = 10000
    T = .0
    NN = 1
C   CHECK FOR BURNUP CALCULATION
    IF(NUMT) 200, 200, 100
100 DO 190 NN = 1, NUMT
    NPRTG = NPRTG + 1
C   CALCULATE SPECTRUM AVERAGED CROSS SECTIONS--AVXS ALSO CALLS THE
C   SUBROUTINE THAT PERFORMS THE FUNDAMENTAL MODE CALCULATION (CALC)
    CALL AVXS
C   NORMALIZE FLUXES
    CALL NORM

```

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      IF(NN - 1) 110, 110, 130
110  CONTINUE
C    CHECK FOR CRUNCH CALCULATION
      IF(NCR - NGP) 120, 130, 130
C    PRINT RESULTS OF F-M CALCULATION
120  CALL PRINT3
C    PERFORM GROUP COLLAPSING CALCULATION
      CALL CRXS1
      LCR = 0
130  CONTINUE
      IF(NOP) 140, 140, 150
140  NOP = 1
150  IF(NPRTG - NPRT) 180, 160, 160
C    PRINT DATA AT TIME=T
160  CALL PRINT3
170  NPRTG = 0
180  T = T + H
C    COMPUTE NEW ISOTOPE CONCENTRATIONS
      CALL MARCH
190  CONTINUE
200  CONTINUE
C    DO F-M CALCULATION (FINAL CALCULATION IF THIS IS A BURNUP RUN)
      CALL AVXS
      CALL NORM
      CALL PRINT3
      IF(NN - 1) 210, 210, 240
210  CONTINUE
C    CHECK FOR CRUNCH CALCULATION
      IF(NCR - NGP) 220, 240, 240
220  CALL CRXS1
      IF(NPUN) 228, 228, 224
C    PUNCH FEW GROUP CROSS SECTIONS
224  CALL PUNCH
228  CONTINUE
      LCR = 0
C    PRINT RESULTS OF F-M CALCULATION FOR FEW GROUPS
      CALL PRINT3
      IF (NPCS - 1) 240, 230, 240
C    CALCULATE FEW GROUP PERTURBATION CROSS SECTIONS
230  CALL PERT
240  CONTINUE
      IF(LCR) 250, 250, 280
250  CONTINUE
C    SWITCH MULTIGROUP AND FEW GROUP VARIABLES
      JJ = NXX + 5
      NPUN = NPSS
      NGP = NMG
      NXCM = NXX
      DO 270 I = 1, NGP
      DO 260 K = 1, NXS
      DO 260 J = 1, JJ
260  S(K, J, I) = SG(K, J, I)
      VEL(I) = EL(I)
      PHI(I) = TFX(I)
      ALETH(I) = AZZ(I)
270  CHI(I) = CXX(I)
280  CONTINUE
      IF(NPUN) 300, 300, 290
C    PUNCH MULTIGROUP CROSS SECTIONS
290  CALL PUNCH
300  CONTINUE
      LST = 0
      GO TO 10
      END

```



```

-ITC FOR INPUT1,INPUT1
C   THIS SUBROUTINE READS PRELIMINARY INPUT DATA SUCH AS FISSION
C   SPECTRUM, LOWER ENERGY BOUNDS, ETC.
      SUBROUTINE INPUT1
      INCLUDE ABC
      READ(NINP,2)  NGP, NXCM, NBE, NNE, NRCF, NPUP, NP
2     FORMAT(12I6)
      NXS = NBE + NNE
      DO 4 J = 1,NBE
      READ (NINP,3)  HOLN(J),ATW(J),ALAM(J),FEF(J),LD(J),LC(J),
1(LCN(J,K),K=1,4), LF(J),(LFN(J,K),K=1,7)
3     FORMAT (A6,3E6.1,14I3)
4     CONTINUE
      IF(NNE) 61, 61, 42
42    CONTINUE
      KK = NBE + 1
      DO 6 J = KK, NXS
      READ (NINP,5) HOLN(J), ATW(J)
5     FORMAT (A6,E6.1)
6     CONTINUE
61    CONTINUE
      READ (NINP,9) (CHI(I), I=1,NGP)
      READ (NINP,9) (EL(I),I=1,NGP)
      READ(NINP, 9) (ALETH(I), I = 1, NGP)
      DO 12 I = 1, NGP
12    VEL(I) = 1.3850*10.**9*SQRT (EL(I))
9     FORMAT (6E12.4)
      RETURN
      END

```

```

-ITC FOR PRINT1,PRINT1
  SUBROUTINE PRINT1
  INCLUDE ABC
C   THIS SUBROUTINE PRINTS PRELIMINARY INPUT DATA
  WRITE(NOUT, 1)
1   FORMAT(1H1,43X,35H * * * * F C C * * * * //)
  WRITE(NOUT,2)
2   FORMAT(24H0INPUT DATA LISTED BELOW///
  117H NUCLIDE NUMBER   NAME   ATM WEIGHT   LAMBDA(DAYS-1)   MEV
4/FISSION SOURCE ELEMENT FOR DECAY   CAPTURE   FISSION///)
  GG = 24. * 3600.
  DO 6J = 1, NBE
  KK = LC(J)
  KKK = LF(J)
  WRITE(NOUT,4) J,HOLN(J),ATW(J),ALAM(J),FEF(J),LD(J),
1 (LCN(J,K),K=1,KK),(LFN(J,K),K=1,KKK)
4   FORMAT (I8,7H           ,A6,1P3E16.4,I7,11I3)
  WRITE(NOUT,5)
5   FORMAT (1H0)
  ALAM(J) = ALAM(J)/GG
6   CONTINUE
  IF(NNE) 15, 15, 9
9   CONTINUE
  WRITE(NOUT,8)
8   FORMAT (32H0           NON-BURNABLE NUCLIDES///)
  KK = NBE + 1
  DO 14 J = KK, NXS
  WRITE(NOUT,10) J,HOLN(J), ATW(J)
10  FORMAT (I8,7H           ,A6,1PE16.4)
  WRITE(NOUT,5)
14  CONTINUE
15  CONTINUE
  G = .0
  WRITE(NOUT, 20)
20  FORMAT (66H1 GROUP FISSION SOURCE ENERGY LIMIT VELOCITY
1    DELTA U///)
  DO 24 I = 1, NGP
  WRITE(NOUT, 22) I, CHI(I), EL(I), VEL(I), ALETH(I)
22  FORMAT(I8, 1P4E15.4)
24  G = G + CHI(I)
  WRITE(NOUT, 41) G
41  FORMAT (7H0 SUM 1PE16.5)
  WRITE(NOUT, 52)
52  FORMAT( 1H1)
  RETURN
  END

```

```

-ITC FOR REDXS,REDXS
  SUBROUTINE REDXS
    INCLUDE ABC
  C   THIS SUBROUTINE CALLS RED CROSS SUBROUTINES
  C   CHECK TO SEE IF THIS IS THE FIRST CASE
    IF(LST) 5, 5, 1
  1   CONTINUE
    IF(NPUP) 3, 3, 2
  C   READ CROSS SECTIONS FROM TAPE
  2   CALL RCPUP
    GO TO 5
  C   READ CROSS SECTIONS FROM CARDS
  3   CALL RCINP1
  5   CONTINUE
  C   READ DATA FOR NEW CASE
    CALL RCINP2
  C   CALCULATE F-FACTORS FOR TEMPERATURE DEPENDENT ISOTOPES
    CALL RCSTUP
    IF(NSOP) 9, 7, 7
  C   CALCULATE SIGOS USING UNSHIELDED CROSS SECTIONS
  7   CALL RCCAL1
    IF(NSOP) 9, 9, 77
  77  DO 8 M=1,NTI
  C   CALCULATE SHIELDING FACTORS USING THE SIGOS
    CALL RCCAL2
  C   RECALCULATE SIGOS USING SHIELDED CROSS SECTIONS
    CALL RCRECL(M)
  8   CONTINUE
  9   CONTINUE
  10  CALL RCCAL2
    IF(NP) 53, 53, 55
  C   PRINT SHIELDING FACTORS FOR EACH ISOTOPE
  53  CALL RCPRT2
  C   CALCULATE RESONANCE SHIELDED CROSS SECTIONS
  55  CALL RCCSS
    RETURN
  END

```

```

-ITC  FOR RCINP1,RCINP1
      SUBROUTINE RCINP1
      INCLUDE ABC
C      THIS SUBROUTINE READS RUSSIAN CROSS SECTIONS
      ME = 0
      NNN = 3*NGP
      DO 300 I = 1, NXS
      DO 312 N=1, NNN
      DO 312 K=1,6
      FC(N,K) = 1.0
      FF(N,K) = 1.0
      FT(N,K) = 1.0
      FE(N,K) = 1.0
312  CONTINUE
      READ(NINP, 4) HOLN(I), NT(I), NGB(I), NGE(I), NFT(I), NPFF(I),
1NPFC(I), NPFT(I), NPFE(I)
4      FORMAT(A6, 8I6)
      NF = NPFF(I)
      NC = NPFC(I)
      NTP = NPFT(I)
      NE = NPFE(I)
      IF (NFT(I)) 159,159,26
26     CONTINUE
      IF (NFT(I) - 3) 50, 45, 28
28     CONTINUE
40     READ(NINP,41) (SF(I, J), J = 1, NF), (SC(I,J), J = 1, NC),
1(ST(I,J), J = 1, NTP), (SE(I, J), J = 1, NE)
41     FORMAT (12E6.4)
      GO TO 60
45     READ(NINP,41) (SC(I,J), J = 1, NC), (ST(I, J), J = 1, NTP),
1(SE(I, J), J = 1, NE)
      GO TO 60
50     READ(NINP,41) (ST(I, J), J = 1, NTP), (SE(I, J), J = 1, NE)
60     CONTINUE
      IF (NT(I)) 69,69,67
67     LN(I) = 3 * (NGE(I) - NGB(I)) + 2
      JJ = 3* NGB(I)
      JJJ = JJ + LN(I)
      GO TO 111
69     JJJ = NGE(I)
      JJ = NGB(I)
111    IF(NFT(I) - 3) 150, 145, 140
140    DO 144 J = JJ, JJJ
      READ(NINP,141) NG(I,J), (FF( J, N), N = 1, NF), (FC( J, N),
1N = 1, NC), (FT( J, N), N = 1, NTP), (FE( J, N), N = 1, NE)
141    FORMAT (I2, 14E5.4)
144    CONTINUE
      WRITE(NSCRAT) ( (FF( J, N), N = 1, NF), (FC( J, N),
1N = 1, NC), (FT( J, N), N = 1, NTP), (FE( J, N), N = 1, NE)
2 , J = JJ, JJJ)
      GO TO 159
145    DO 149 J = JJ, JJJ
      READ(NINP, 141) NG(I, J), (FC( J, N), N = 1, NC),
1(FT( J, N), N = 1, NTP), (FE( J, N), N = 1, NE)
149    CONTINUE
      WRITE(NSCRAT) ((FC( J, N), N = 1, NC),
1(FT( J, N), N = 1, NTP), (FE( J, N), N = 1, NE), J = JJ, JJJ)
      GO TO 159
150    DO 156 J = JJ, JJJ
      READ(NINP,141) NG(I, J), (FT( J, N), N = 1, NTP), (FE( J, N),
1N = 1, NE)

```

```

156  CONTINUE
      WRITE(NSCRAT)      ((FT(  J, N), N = 1, NTP),(FE(  J, N),
IN = 1, NE)      , J = JJ, JJJ)
159  CONTINUE
      DO 200 L = 1, NGP
      READ(NINP,190) LLD(L), (SR(I, K, L), K = 1, 9)
190  FORMAT(I2, 2F9.3,F6.2,F9.3,3F8.3,F6.4,F7.3)
      IF(L - LLD(L)) 192, 200, 192
192  CONTINUE
      WRITE (NOUT,193) HOLN(I), L
193  FORMAT(32H CHECK CROSS SECTION SEQUENCE  ,A6,6H GROUP I3///)
200  CONTINUE
      DO 280 L = 1, NGP
230  FORMAT (I3, 11E6.1)
280  READ(NINP,230) LLD(L), (SM(I, L, K), K = 1, 11)
      IF(NP) 294, 294, 296
294  CALL RCPRT1(I)
296  CALL RCCHK(I, I)
300  CONTINUE
      REWIND NSCRAT
C    AT THIS POINT, THE F-FACTORS ARE ON NSCRAT IN SAME FORM AS THEY
C    WERE ON CARDS
      RETURN
      END

```

```

-ITC FOR RCPUP,RCPUP
  SUBROUTINE RCPUP
    INCLUDE ABC
  C   THIS SUBROUTINE READS CROSS SECTIONS FROM A TAPE MADE BY THE
  C   PROGRAM P U P
    REAL LLD
    READ(NINP,1) (NUT(I), I = 1, NXS)
1    FORMAT(12I6)
    NLAST = 0
    DO 19 I = 1, NXS
      IF(NUT(I) - NLAST) 19, 19, 18
18   NLAST = NUT(I)
19   CONTINUE
    REWIND 15
    ME = 0
    NNN = 3*NGP
    JK = 0
    DO 400 K = 1, NLAST
      DO 3 II = 1, NXS
        I = II
        DO 312 N=1, NNN
          IF(N - NGP) 308, 308, 309
308   FSSF(I,N) = 1.0
          FSSC(I,N) = 1.0
          FSST(I,N) = 1.0
          FSSE(I,N) = 1.0
309   DO 312 J=1,6
          FC(N,J) = 1.0
          FF(N,J) = 1.0
          FT(N,J) = 1.0
          FE(N,J) = 1.0
312   CONTINUE
          IF(K - NUT(I)) 3, 30, 3
3    CONTINUE
          READ(15) (NDV(L), L = 1, 9)
          M = NDV(6) + NDV(7) + NDV(8) + NDV(9)
          IF(M) 8, 8, 7
7     READ(15)
          READ(15)
8     READ(15)
          READ(15)
          GO TO 400
30    CONTINUE
          JK = JK + 1
          MPUP(JK) = I
          READ(15) (HOLN(I), NT(I), NGB(I), NGE(I), NFT(I), NPFF(I),
1NPFC(I), NPFT(I), NPFE(I)
          IF(NP) 38, 38, 36
36    WRITE(NOUT, 41) HOLN(I), I, NUT(I)
41    FORMAT(/6X, A6, 16X, 8H ISOTOPE, I3, 16H IS SEQUENCE NO., I3,
1 8H ON TAPE/)
38    CONTINUE
          NF = NPFF(I)
          NC = NPFC(I)
          NTP = NPFT(I)
          NE = NPFE(I)
          IF (NFT(I)) 159,159,26
26    CONTINUE
          IF (NFT(I) - 3) 50, 45, 28
28    CONTINUE
40    READ(15) (SF(I, J), J = 1, NF), (SC(I,J), J = 1, NC),

```

```

1(ST(I,J), J = 1, NTP), (SE(I, J), J = 1, NE)
GO TO 60
45 READ(15) (SC(I,J), J = 1, NC), (ST(I, J), J = 1, NTP),
1(SE(I, J), J = 1, NE)
GO TO 60
50 READ(15) (ST(I, J), J = 1, NTP), (SE(I, J), J = 1, NE)
60 CONTINUE
IF (NT(I)) 69,69,67
67 LN(I) = 3 * (NGE(I) - NGB(I)) + 2
JJ = 3* NGB(I)
JJJ = JJ + LN(I)
GO TO 111
69 JJJ = NGE(I)
JJ = NGB(I)
111 IF(NFT(I) - 3) 150, 145, 140
140 READ(15) (ANG(I,J), (FF( J, N), N = 1, NF), (FC( J, N),
1N = 1, NC), (FT( J, N), N = 1, NTP), (FE( J, N), N = 1, NE)
2 , J = JJ, JJJ)
WRITE(NDRUM) ((FF( J, N), N = 1, NF), (FC( J, N),
1N = 1, NC), (FT( J, N), N = 1, NTP), (FE( J, N), N = 1, NE)
2 , J = JJ, JJJ)
GO TO 159
145 READ(15) (ANG(I, J), (FC( J, N), N = 1, NC),
1(FT( J, N), N = 1, NTP), (FE( J, N), N = 1, NE), J = JJ, JJJ)
WRITE(NDRUM) ((FC( J, N), N = 1, NC),
1(FT( J, N), N = 1, NTP), (FE( J, N), N = 1, NE), J = JJ, JJJ)
GO TO 159
150 READ(15) (ANG(I, J), (FT( J, N), N = 1, NTP), (FE( J, N),
1N = 1, NE) , J = JJ, JJJ)
WRITE(NDRUM) ((FT( J, N), N = 1, NTP), (FE( J, N),
1N = 1, NE) , J = JJ, JJJ)
159 CONTINUE
READ(15) (LLD(L), (SR(I, KK, L), KK = 1, 9), L = 1, NGP)
DO 200 L = NGP
LLDL(L) = LLD(L)
IF(L - LLDL(L)) 192, 200, 192
192 CONTINUE
WRITE (NOUT,193) HOLN(I), L
193 FORMAT(32H CHECK CROSS SECTION SEQUENCE ,A6,6H GROUP I3///)
200 CONTINUE
READ(15) (LLD(L), (SM(I, L, KK), KK = 1, 11), L = 1, NGP)
IF(NP) 294, 294, 296
294 CALL RCPRT1(I)
296 CALL RCCHK(I, JK)
400 CONTINUE
DO 623 I = 1, NXS
DO 623 L = 1, NNN
623 NG(I, L) = ANG(I, L)
REWIND 15
REWIND NDRUM
CALL RCDRUM
RETURN
END

```

```

-ITC FOR RCPRT1, RCPRT1
  SUBROUTINE RCPRT1(I)
    INCLUDE ABC
    THIS SUBROUTINE PRINTS RUSSIAN DATA
    WRITE(NOUT, 46) HOLN(I), I
46   FORMAT (32H1MICROSCOPIC CROSS SECTIONS FOR A6,21H      NUCLIDE NUM
1BER I2////
293H GROUP SIGT      SIGF      NU      SIGC      SIGIN      SIGEL
3   MUEL      XI      SIGDEL//)
    DO 50 L=1, NGP
    WRITE(NOUT, 48) L, (SR(I,K,L), K = 1,9)
48   FORMAT(I3, 9F10.3)
50   CONTINUE
    WRITE(NOUT, 51) HOLN(I)
51   FORMAT (34H1INELASTIC SCATTERING MATRIX FOR A6,1H //)
1   114H GROUP GXG      GXG+1      GXG+2      GXG+3      GXG+4
1   GXG+5      GXG+6      GXG+7      GXG+8      GXG+9      GXG+10//)
    DO 54 L = 1, NGP
    WRITE(NOUT, 55) L, (SM(I,L,K), K = 1, 11)
55   FORMAT(I3, 11F10.3)
49   FORMAT(1H /)
54   CONTINUE
    WRITE(NOUT, 60) HOLN(I)
60   FORMAT (43H1RESONANCE SELF-SHIELDING COEFFICIENTS FOR A6//)
    IF (NFT(I)) 62, 62, 64
62   WRITE(NOUT, 63)
63   FORMAT(57H THE COEFFICIENTS FOR THIS ISOTOPE ARE ALL EQUAL TO UNIT
1Y//)
    GO TO 200
64   CONTINUE
    DATA(HF(J),J=1,6)/6*2HFF/, (HC(J),J=1,6)/6*2HFC/, (HT(J),J=1,6)/
16*2HFT/, (HE(J),J=1,6)/6*2HFE/
65   IF (NT(I)) 67,67,70
67   WRITE(NOUT,69)
69   FORMAT (61H THE F FACTORS FOR THIS ISOTOPE ARE NOT TEMPERATURE DEP
1ENDENT//)
    JJJ = NGE(I)
    JJ = NGB(I)
    IF (NFT(I) - 3) 170,165,180
70   JJ = 3*NGB(I)
    JJJ = JJ + LN(I)
    TEMP(1) = 300.
    TEMP(2) = 900.
    TEMP(3) = 2100.
    IF (NFT(I) - 3) 270,265,280
165  WRITE(NOUT,181) (SC(I,J), J=1,NC), (ST(I,J), J=1,
1NTP), (SE(I,J), J=1,NE)
    WRITE(NOUT,184) (HC(J),J=1,NC), (HT(J),J=1,NTP), (HE(J),J=1,NE)
    WRITE(NOUT,182)
    DO 169 J = JJ, JJJ
    WRITE(NOUT,167) J, (FC( J, N), N = 1, NC), (FT( J, N),
1N = 1, NTP), (FE( J, N), N = 1, NE)
167  FORMAT(I5, 14F7.3)
169  CONTINUE
    GO TO 200
170  WRITE (NOUT,181) (ST(I,J), J=1,NTP), (SE(I,J), J=1,NE)
    WRITE (NOUT,184) (HT(J),J=1,NTP), (HE(J), J=1,NE)
    WRITE (NOUT,182)
    DO 179 J = JJ, JJJ
    WRITE (NOUT, 167) J, (FT( J, N), N = 1, NTP),
1(FE( J, N), N = 1, NE)

```



```

179  CONTINUE
    GO TO 200
180  WRITE(NOUT,181) (SF(I,J),J=1,NF), (SC(I,J),J=1,NC), (ST(I,J), J=1,
1NTP), (SE(I,J), J=1,NE)
181  FORMAT (5H0SIG014F7.0)
182  FORMAT (1H )
    WRITE (NOUT,184) (HF(J),J=1,NF), (HC(J),J=1,NC), (HT(J),J=1,NTP),
1 (HE(J),J=1,NE)
184  FORMAT (9H0GROUP      ,14(A6,X))
    WRITE (NOUT,182)
    DO 189 J = JJ, JJJ
    WRITE( NOUT, 167) J,      (FF(  J, N), N = 1, NF), (FC(  J, N),
1N = 1, NC), (FT(  J, N), N = 1, NTP), (FE(  J, N), N = 1, NE)
189  CONTINUE
    GO TO 200
265  WRITE (NOUT,281)      (SC(I,J), J=1,NC), (ST(I,J), J=1,
1NTP), (SE(I,J), J=1,NE)
    WRITE(NOUT,284)(HC(J),J=1,NC), (HT(J),J=1,NTP), (HE(J),J=1,NE)
    WRITE (NOUT,182)
    DO 269 J = JJ, JJJ
    K = J/3
    KK = J + 1 - (J/3)*3
    WRITE(NOUT,267) K,TEMP(KK),      (FC(  J, N), N = 1, NC),
1(FT(  J, N), N = 1, NTP),(FE(  J, N), N = 1, NE)
267  FORMAT (15, F9.1, 14F7.3)
269  CONTINUE
    GO TO 200
270  WRITE (NOUT,281) (ST(I,J), J=1,NTP), (SE(I,J), J=1,NE)
    WRITE (NOUT,284) (HT(J),J=1,NTP), (HE(J), J=1,NE)
    WRITE (NOUT,182)
    DO 279 J = JJ, JJJ
    K = J/3
    KK = J + 1 - (J/3)*3
    WRITE (NOUT,267) K,TEMP(KK),      (FT(  J, N), N = 1, NTP),
1(FE(  J, N), N = 1, NE)
279  CONTINUE
    GO TO 200
280  WRITE (NOUT,281) (SF(I,J),J=1,NF), (SC(I,J),J=1,NC),(ST(I,J), J=1,
1NTP), (SE(I,J), J=1,NE)
281  FORMAT (5H0SIG08X,F8.0,13F7.0)
    WRITE (NOUT,284) (HF(J),J=1,NF), (HC(J),J=1,NC), (HT(J),J=1,NTP),
1 (HE(J),J=1,NE)
284  FORMAT (18H0GROUP      TEMP      ,14(A6,X))
    WRITE (NOUT,182)
    DO 289 J = JJ, JJJ
    K = J/3
    KK = J + 1 - (J/3)*3
    WRITE (NOUT,267) K,TEMP(KK),      (FF(  J, N), N = 1, NF),
1(FC(  J, N), N = 1, NC), (FT(  J, N), N = 1, NTP),
2(FE(  J, N), N = 1, NE)
289  CONTINUE
200  CONTINUE
    WRITE(NOUT, 297)
297  FORMAT(1H //)
    RETURN
    END

```

```

-ITC FOR RCCHK,RCCHK
      SUBROUTINE RCCHK(N, JK)
      INCLUDE ABC
C      THIS SUBROUTINE CHECKS RUSSIAN DATA FOR CONSISTENCY
      IF(NPUP) 3, 3, 9
      IF(N - 1) 4, 4, 9
      IF(NP) 9, 9, 5
      WRITE (NOUT,2)
      2   FORMAT (1H015X,47H * * * * RESULTS OF CROSS SECTION CHECK * * * */
1////10X,15H COMMENTS . . .////)
      9   CONTINUE
      DO 30 I = 1,NGP
      G = (SR(N,1,I) - ( SR(N,2,I) + SR(N,4,I) + SR(N,5,I) + SR(N,6,I))) /
1SR(N,1,I)
      IF ( ABS(G) - .005) 19,10,10
      10  ME = ME + 1
      IF (ME - 100) 12,85,85
      12  WRITE (NOUT,14) ME, HOLN(N), I
      14  FORMAT (I3,8H CHECK A6, 9H GROUP I2//)
      19  CONTINUE
      IF(I - 3) 560, 560, 539
      539 IF(I - NGP) 540, 560, 560
      540  G = (SR(N,9,I) - (SR(N,8,I)*SR(N,6,I)/ALETH(I))) / SR(N,9,I)
      IF(ABS(G) - .03 ) 560,550,550
      550  ME = ME + 1
      IF (ME - 100) 551,85,85
      551  WRITE(NOUT,514) ME, HOLN(N), I
      514  FORMAT(I3,7H CHECK A6, 9H GROUP I2,21H SIGMADEL LOOKS BAD //)
      560  CONTINUE
      G = .0
      DO 22 K = 1,11
      G = G + SM(N,I,K)
      22  IF (ABS(G - SR(N,5,I)) - .005) 30,24,24
      24  G = G - SR(N,5,I)
      ME = ME + 1
      IF (ME - 100) 25,85,85
      25  WRITE (NOUT,26) ME, HOLN(N), I, G
      26  FORMAT (I3,8H CHECK A6,9H GROUP I2,5X,26H PRESUMABLY SIGMA (N,2
1N) =1PE16.6//)
      30  CONTINUE
      IF (NT(N)) 31,31,32
      31  II = NGP
      GO TO 33
      32  II = 3*NGP
      33  DO 40 I = 1,II
      DO 40 K = 1,6
      IF (K-2) 300,202,202
      202  CONTINUE
C      CHECK OF F VS SIGO
      IF (K - NPFC(N)) 204,204,208
      204  IF ( FC( I,K) - FC( I,K-1) - .00001) 208,238,238
      208  IF (K - NPFF(N)) 210,210,212
      210  IF ( FF( I,K) - FF( I,K-1) - .00001) 212,238,238
      212  IF (K - NPFT(N)) 215,215,218
      215  IF ( FT( I,K) - FT( I,K-1) - .00001) 218,238,238
      218  IF (K - NPFE(N)) 225,225,300
      225  IF ( FE( I,K) - FE( I,K-1) - .00001) 300,238,238
      238  ME = ME + 1
      IF (ME - 100) 239,85,85
      239  WRITE (NOUT,240) ME, HOLN(N)
      240  FORMAT (I3,15H F FACTORS IN A6,27H EXHIBIT ANOMALOUS BEHAVIOR//)

```

```

300  CONTINUE
      IF (FC( I,K) - 1.001) 336, 336, 38
336  IF (FF( I,K) - 1.001) 34,38,38
34   IF (FT( I,K) - 1.001) 35,38,38
35   IF (FE( I,K) - 1.001) 40,38,38
38   ME = ME + 1
      IF (ME - 100) 39,85,85
39   WRITE (NOUT,139) ME, HOLN(N)
139  FORMAT(I3,15H F FACTORS IN A6,23H ARE GREATER THAN UNITY//)
40   CONTINUE
      IF(NT(N)) 41,41,42
41   JJJ = NGE(N)
      JJ = NGB(N) + 1
      GO TO 43
42   JJ = NGB(N)
      JJJ = NGE(N)
      DO 450 J = JJ, JJJ
      I = 3*J
      DO 445 K = 1,6
      IF ( FC( I ,K) - FC( I+1,K) - .00001) 405,439,439
405  IF ( FC( I+1,K) - FC( I+2,K) - .00001) 410,439,439
410  IF ( FF( I ,K) - FF( I+1,K) - .00001) 415,439,439
415  IF ( FF( I+1,K) - FF( I+2,K) - .00001) 420,439,439
420  IF ( FT( I ,K) - FT( I+1,K) - .00001) 425,439,439
425  IF ( FT( I+1,K) - FT( I+2,K) - .00001) 430,439,439
430  IF ( FE( I ,K) - FE( I+1,K) - .00001) 435,439,439
435  IF ( FE( I+1,K) - FE( I+2,K) - .00001) 445,439,439
439  ME = ME + 1
      IF(ME - 100) 440, 85, 85
440  WRITE (NOUT,240) ME, HOLN(N)
445  CONTINUE
450  CONTINUE
      JJ = 3*NGB(N) + 1
      JJJ = 3*NGE(N) + 2
43   CONTINUE
      DO 49 J = JJ, JJJ
      IF (NG(N,J) - NG(N,J-1)) 46,49,49
46   ME = ME + 1
      IF (ME - 100) 47,85,85
47   WRITE (NOUT,48) ME, HOLN(N)
48   FORMAT(I3,22H CHECK SEQUENCING OF A6,10H F FACTORS//)
49   CONTINUE
50   CONTINUE
      IF(JK - NXS) 99, 60, 60
60   IF(NP) 65, 65, 70
65   WRITE(NOUT, 67)
67   FORMAT(1H1////////////////////)
      WRITE(NOUT, 68) ME
68   FORMAT(34H **** CROSS SECTION CHECK REVEALED,I3,
1 26H ERRORS OR INCONSISTENCIES)
      GO TO 99
70   IF(ME) 80, 80, 99
80   WRITE (NOUT,81)
81   FORMAT (60H0THE INPUT DATA APPEARS TO BE CONSISTENT AND IN PROPER
1ORDER)
      GO TO 99
85   WRITE (NOUT,87)
87   FORMAT (33H0SHODDY DATA - CHECK DISCONTINUED)
99   CONTINUE
      RETURN
      END

```

```

-ITC FOR RCDRUM,RCDRUM
SUBROUTINE RCDRUM
  INCLUDE ABC
C   THIS SUBROUTINE PUTS THE F-FACTORS IN PROPER ORDER ON THE DRUM
  KLK = NSCRAT
  NSCRAT = NDRUM
  NDRUM = KLK
  DO 200 I = 1, NXS
  IF(NFT(I)) 200, 200, 10
10  DO 30 ML = 1, NXS
  LL = MPUP(ML)
  IF(NFT(LL)) 30, 30, 20
20  CONTINUE
  NF = NPFF(LL)
  NC = NPFC(LL)
  NTP = NPFT(LL)
  NE = NPFE(LL)
  CALL RCFF(LL)
  IF(I - LL) 30, 64, 30
30  CONTINUE
64  CONTINUE
  IF(NT(I)) 69, 69, 67
67  LN(I) = 3 * (NGE(I) - NGB(I)) + 2
  JJ = 3 * NGB(I)
  JJJ = JJ + LN(I)
  GO TO 111
69  JJJ = NGE(I)
  JJ = NGB(I)
111 IF(NFT(I) - 3) 150, 145, 140
140 WRITE(NDRUM) ((FF( J, N), N = 1, NF), (FC( J, N),
1N = 1, NC), (FT( J, N), N = 1, NTP), (FE( J, N), N = 1, NE)
2 , J=JJ, JJJ)
  GO TO 159
145 WRITE(NDRUM) ((FC( J, N), N = 1, NC),
1(FT( J, N), N = 1, NTP), (FE( J, N), N = 1, NE), J=JJ, JJJ)
  GO TO 159
150 WRITE(NDRUM) ((FT( J, N), N = 1, NTP), (FE( J, N),
1N = 1, NE), J=JJ, JJJ)
159 CONTINUE
  REWIND NSCRAT
200 CONTINUE
  NDRUM = NSCRAT
  NSCRAT = KLK
  REWIND NSCRAT
  REWIND NDRUM
  RETURN
  END

```

```

-ITC FOR RCFF,RCFF
  SUBROUTINE RCFF(I)
    INCLUDE ABC
  C  THIS SUBROUTINE READS F-FACTORS FROM TAPE
    IF(NT(I)) 69, 69, 67
67   LN(I) = 3 * (NGE(I) - NGB(I)) + 2
      JJ = 3* NGB(I)
      JJJ = JJ + LN(I)
      GO TO 111
69   JJJ = NGE(I)
      JJ = NGB(I)
111  IF(NFT(I) - 3) 150, 145, 140
140  READ(NSCRAT) ((FF( J, N), N = 1, NF), (FC( J, N),
1N = 1, NC), (FT( J, N), N = 1, NTP), (FE( J, N), N = 1, NE)
2 , J=JJ, JJJ)
      GO TO 159
145  READ (NSCRAT) ((FC( J, N), N = 1, NC),
1(FT( J, N), N= 1, NTP), (FE( J, N), N = 1, NE), J=JJ, JJJ)
      GO TO 159
150  READ (NSCRAT) ((FT( J, N), N = 1, NTP), (FE( J, N),
1N = 1, NE), J=JJ, JJJ)
159  CONTINUE
      RETURN
      END

```

```

-ITC FOR RCINP2,RCINP2
SUBROUTINE RCINP2
  INCLUDE ABC
C   THIS SUBROUTINE READS DATA FOR NEW CASE
  TOTL = .0
  READ(NINP,3)(HOL(I), I = 1, 12)
3   FORMAT(12A6)
5   FORMAT(12I6)
  READ(NINP, 5)  NOP, NFP, NFD, NUMT, NPRT, NSOP, NTR, NIFF
  READ(NINP, 5)  NCR, NAVX, NPCS, NPUN, NOPP, NBN
  READ(NINP,51)  H, VOL, G, GG, DELU, HETC
  EPSL = .000001
  NTI = NSOP
  HS = H*24.*3600.
  IF(NOP - 1) 10, 20, 10
10  AK = GG
  BSQ = .0001
  GO TO 32
20  IF(ABS(GG) - .000001) 22, 22, 21
21  BSQ = GG
22  CONTINUE
32  CONTINUE
  IF(NFP) 37, 37, 45
37  POW = G
  GO TO 49
45  FLX = G
49  CONTINUE
  READ(NINP,5 ) LBS, (LBSN(I), I = 1, 5), LBL, (LBLN(I), I=1, 5)
  READ(NINP,51)(DN(J), J = 1, NXS)
  IF(NRCF) 52, 52, 190
52  READ(NINP,51)(TEMP(J), J = 1, NXS)
51  FORMAT(6E12.4)
  IF(NSOP) 70, 190, 190
70  READ(NINP,51)(SOGO(J), J = 1, NXS)
  DO 170 I = 1, NXS
  DO 170 J = 1, NGP
  SIGO(I, J) = SOGO(I)
170 CONTINUE
190 CONTINUE
  IF(NCR - NGP) 180, 200, 200
180 READ(NINP,5) (NPN(K), K = 1, NCR)
200 CONTINUE
  IF(NBN) 121, 121, 14
14  READ(NINP,5) (NBUN(I), I = 1, NBN)
  DO 110 I = 1, NBN
  KK = NBUN(I)
  IF(KK) 110, 110, 108
108 READ(NINP,5) (NISO(I, K), K = 1, KK)
110 CONTINUE
  DO 120 I = 1, NBN
  KK = NBUN(I)
  IF(KK) 120, 120, 118
118 READ(NINP,51)(DNSO(I, K), K = 1, KK)
120 CONTINUE
121 CONTINUE
  IF (NFD) 123,123,122
122 READ(NINP,51) (PHI(I), I = 1,NGP)
  READ(NINP, 51) (ADJ(I), I=1, NGP)
123 CONTINUE
  READ (NINP,51) (SORCE(I), I = 1, NBE)
  RETURN
  END

```

```

-ITC FOR RCSTUP,RCSTUP
  SUBROUTINE RCSTUP
    INCLUDE ABC
    THIS SUBROUTINE COMPUTES F FACTORS FOR TEMP DEPENDENT ISOTOPES
    WRITE(NOUT,1)
    1   FORMAT(1H1,43X,35H * * * * F C C * * * * //)
    WRITE (NOUT,3) (HOL (I), I = 1, 12)
    3   FORMAT(12A6//)
    WRITE (NOUT,4)
    4   FORMAT(84H RESONANCE SHIELDED CROSS SECTIONS ARE COMPUTED FOR THIS
1 CASE USING THE RUSSIAN DATA )
    NNN = 3*NGP
    WRITE(NOUT, 5) NIFF, DELU
    5   FORMAT(79H0NUMBER OF ITERATIONS IN CALCULATING THE ELASTIC DOWNSCA
1TTERING CROSS SECTION = 12 ,14H (XI COEFF. = F6.4, 1H))
    IF(NTR) 209, 209, 205
    205 WRITE(NOUT, 7)
    7   FORMAT(55H0TRANSPORT CROSS SECTION CALCULATED USING SIGMA ELASTIC)
    209 CONTINUE
    DO 200 N = 1, NXS
    DO 6 L = 1, NNN
    DO 6 K = 1, 6
    FC(L,K) = 1.0
    FF(L,K) = 1.0
    FT(L,K) = 1.0
    FE(L,K) = 1.0
    6   CONTINUE
    JJ = NGB(N)
    JJJ = NGE(N)
    NF = NPFF(N)
    NC = NPFC(N)
    NTP = NPFT(N)
    NE = NPFE(N)
    IF(NFT(N)) 200, 200, 8
    8   CONTINUE
    CALL RCFF(N)
    IF(NT(N)) 190, 190, 9
    9   CONTINUE
    IF (TEMP(N) - 299.) 16, 16, 12
    12  IF (TEMP(N) - 2101.) 19, 19, 16
    16  WRITE (NOUT,17) HOLN(N)
    17  FORMAT (37H1PLEASE NOTE THAT THE TEMPERATURE OF A6.23H IS OUTSIDE
1SAFE LIMITS)
    IF (TEMP(N) - .0001) 18, 18, 19
    18  TEMP(N) = 1.0
    WRITE (NOUT,21)
    21  FORMAT(34H0TEMPERATURE HAS BEEN SET TO UNITY/)
    19  IF (NFT(N) - 3) 60, 40, 20
    20  DO 30 I = JJ, JJJ
    J = 3 * I
    DO 30 K = 1, NF
    A = FF( J, K)
    B = FF( J+1, K)
    C = FF( J+2, K)
    Y = (C-A)/1.9459
    30  FF( I, K) = B + Y*ALOG(TEMP(N)/900.)
    40  DO 50 I = JJ, JJJ
    J = 3 * I
    DO 50 K = 1, NC
    A = FC( J, K)
    B = FC( J+1, K)

```

```

      C = FC(   J+2, K)
      Y = (C-A)/1.9459
50    FC(   I, K) = B + Y*ALOG(TEMP(N)/900.)
60    DO 80  I = JJ, JJJ
      J = 3 * I
      DO 70  K = 1, NTP
      A = FT(   J, K)
      B = FT(   J+1, K)
      C = FT(   J+2, K)
      Y = (C-A)/1.9459
70    FT(   I, K) = B + Y*ALOG(TEMP(N)/900.)
      DO 80  K = 1, NE
      A = FE(   J, K)
      B = FE(   J+1, K)
      C = FE(   J+2, K)
      Y = (C-A)/1.9459
80    FE(   I, K) = B + Y*ALOG(TEMP(N)/900.)
190   WRITE(NTAPE) ((FF(I,K), K=1,NF), (FC(I,K), K=1,NC), (FT(I,K),
1    K=1,NTP), (FE(I,K), K=1,NE), I=JJ, JJJ)
200   CONTINUE
      REWIND NSCRAT
      REWIND NTAPE
      RETURN
      END

```



```

-ITC FOR RCCAL1,RCCAL1
SUBROUTINE RCCAL1
  INCLUDE ABC
C    CALCULATION OF SIGO
  DO 40 N = 1,NXS
    AVSIG(N) = .0
    IF (DN(N)) 5,5,10
5    DO 7 L = 1,NGP
7    SIGO(N,L) = .0
    GO TO 40
10   DO 30 L = 1,NGP
    G = .0
    DO 12 NN = 1, NNE
    JJ = NBE + NN
12   G = G + DN(JJ)*SR(JJ,1,L)
    SIGO(N,L) = .0
    DO 20 K = 1,NXS
    IF(K - NBE) 18, 18, 15
15   IF(N - NBE) 16, 16, 18
16   SIGO(N,L) = SIGO(N,L) + DN(K) * SR(K,1,L)/(DN(N)*(1. +HETC*G))
    GO TO 20
18   SIGO(N,L) = SIGO(N,L) + DN(K) * SR(K,1,L)/DN(N)
20   CONTINUE
    SIGO(N,L) = SIGO(N,L) - SR(N,1,L)
30   AVSIG(N) = AVSIG(N) + SIGO(N,L)
    AAA = NGP
40   AVSIG(N) = AVSIG(N)/AAA
    KK = NXS
    IF (NXS - 8) 46,46,44
44   KK = 8
46   CONTINUE
    WRITE (NOUT,48) HETC
48   FORMAT (39H0HETEROGENEITY CORRECTION FACTOR(CM) = 1PE12.4)
    WRITE (NOUT,50) (HOLN(I), I = 1,KK)
50   FORMAT (111H0GROUP AVERAGED TOTAL CROSS SECTIONS PER ATOM (EXCLUDI
1NG ISOTOPE MENTIONED) ARE LISTED BELOW FOR EACH ITERATION//
211H ITERATION 8(6X,A6))
    LK = 0
    WRITE (NOUT,51) LK, (AVSIG(I), I = 1,KK)
51   FORMAT (1H0/5X, I3, 5X, 1P8E12.4)
    RETURN
  END

```

```

-ITC FOR RCRECL,RCRECL
SUBROUTINE RCRECL(M)
  INCLUDE ABC
C   THIS SUBROUTINE RECOMPUTES SIGO USING FSSF, FSSC, AND FSSE
  M = M
  KK = NXS
  IF ( NXS - 8 ) 6,6,4
4   KK = 8
6   CONTINUE
  DO 40 N = 1,NXS
    AVSIG(N) = .0
    IF (DN(N)) 5,5,10
5   DO 7 L = NGP
7   SIGO(N,L) = .0
    GO TO 40
10  DO 30 L = 1,NGP
    G = .0
    DO 12 NN = 1, NNE
      JJ = NBE + NN
12  G = G + DN(JJ)*SR(JJ,1,L)*FSST(JJ,L)
      SIGO(N,L) = .0
      DO 20 K = 1,NXS
        IF(K - NBE) 18, 18, 15
15  IF(N - NBE) 16, 16, 18
16  SIGO(N,L) = SIGO(N,L) + DN(K)*(FSSC(K,L) *SR(K,4,L) + FSSF(K,L) *
1  SR(K,2,L) + FSSE(K,L) * SR(K,6,L) + SR(K,5,L))/(DN(N)*(1.+HETC*
2G))
      GO TO 20
18  SIGO(N,L) = SIGO(N,L) + DN(K)*(FSSC(K,L) *SR(K,4,L) + FSSF(K,L) *
1  SR(K,2,L) + FSSE(K,L) * SR(K,6,L) + SR(K,5,L))/DN(N)
20  CONTINUE
      SIGO(N,L) = SIGO(N,L) - (FSSC(N,L)*SR(N,4,L) + FSSF(N,L) *
1  SR(N,2,L) + FSSE(N,L) * SR(N,6,L) + SR(N,5,L))
30  AVSIG(N) = AVSIG(N) + SIGO(N,L)
    AAA = NGP
40  AVSIG(N) = AVSIG(N)/AAA
    WRITE (NOUT,51) M, (AVSIG(I), I = 1, KK)
51  FORMAT(5X, I3, 5X, 1P8E12.4)
    RETURN
  END

```

```

-ITC FOR RCCAL2,RCCAL2
  SUBROUTINE RCCAL2
    INCLUDE ABC
  C   THIS SUBROUTINE COMPUTES F FACTORS USING SIGO
    DO 500 N = 1, NXS
    DO 8 I = 1, NGP
      FSSF(N,I) = 1.0
      FSSC(N,I) = 1.0
      FSST(N,I) = 1.0
      FSSE(N,I) = 1.0
    8   CONTINUE
    IF(NFT(N)) 500, 500, 12
  12   CONTINUE
      JJ = NGB(N)
      JJJ = NGE(N)
      NF = NPFF(N)
      NC = NPFC(N)
      NTP = NPFT(N)
      NE = NPFE(N)
      READ(NTAPE) ((FF(I,K), K=1,NF), (FC(I,K), K=1,NC), (FT(I,K),
1 K=1,NTP), (FE(I,K), K=1,NE), I=JJ, JJJ)
      IF(DN(N)) 500, 500, 20
  20   DO 450 I = JJ, JJJ
      IF (SIGO(N,I) - 9.99E6) 40,40,450
  40   IF (NFT(N) - 3) 300,200,100
  100  IF (SIGO(N,I) - SF(N,1)) 110,102,102
  102  A = 1.0
      B = FF( I,1)
      C = 1.E7
      D = SF(N,1)
      FSSF(N,I) = A + (B - A) * (ALOG(SIGO(N,I)/C)/ALOG(D/C))
      GO TO 200
  110  DO 120 K = 2,NF
      KK = K
      IF (SIGO(N,I) - SF(N,K)) 120,120,125
  120  CONTINUE
      FSSF(N,I) = FF( I,KK)
      GO TO 200
  125  IF(KK - NF ) 140,130,130
  130  IF (SF(N,NF) - .01) 132,132,140
  132  CONTINUE
      A = FF( I,KK-1)
      B = FF( I,KK)
      C = SF(N,KK-1)
      D = .1
      FSSF(N,I) = A + (B - A) * (ALOG(SIGO(N,I)/C)/ALOG(D/C))
      GO TO 200
  140  CONTINUE
      A = FF( I,KK-1)
      B = FF( I,KK)
      C = SF(N,KK-1)
      D = SF(N,KK)
      FSSF(N,I) = A + (B - A) * (ALOG(SIGO(N,I)/C)/ALOG(D/C))
  200  IF (SIGO(N,I) - SC(N,1)) 210,202,202
  202  A = 1.0
      B = FC( I,1)
      C = 1.E7
      D = SC(N,1)
      FSSC(N,I) = A + (B - A) * (ALOG(SIGO(N,I)/C)/ALOG(D/C))
      GO TO 300
  210  DO 220 K = 2,NC

```

```

      KK = K
      IF (SIGO(N,I) - SC(N,K)) 220,220,225
220  CONTINUE
      FSSC(N,I) = FC( I,KK)
      GO TO 300
225  IF (KK - NC) 240,230,230
230  IF (SC(N,NC) - .01) 232,232,240
232  CONTINUE
      A = FC( I,KK-1)
      B = FT( I,KK)
      C = SC(N,KK-1)
      D = .1
      FSSC(N,I) = A + (B - A) * (ALOG(SIGO(N,I)/C)/ALOG(D/C))
      GO TO 300
240  CONTINUE
      A = FC( I,KK-1)
      B = FC( I,KK)
      C = SC(N,KK-1)
      D = SC(N,KK)
      FSSC(N,I) = A + (B - A) * (ALOG(SIGO(N,I)/C)/ALOG(D/C))
300  IF (SIGO(N,I) - ST(N,1)) 310,302,302
302  A = 1.0
      B = FT( I,1)
      C = 1.E7
      D = ST(N,1)
      FSST(N,I) = A + (B - A) * (ALOG(SIGO(N,I)/C)/ALOG(D/C))
      GO TO 400
310  DO 320 K = 2,NTP
      KK = K
      IF (SIGO(N,I) - ST(N,K)) 320,320,325
320  CONTINUE
      FSST(N,I) = FT( I,KK)
      GO TO 400
325  IF (KK - NTP) 340,330,330
330  IF (ST(N,NTP) - .01) 332,332,340
332  CONTINUE
      A = FT( I,KK-1)
      B = FC( I,KK)
      C = ST(N,KK-1)
      D = .1
      FSST(N,I) = A + (B - A) * (ALOG(SIGO(N,I)/C)/ALOG(D/C))
      GO TO 400
340  CONTINUE
      A = FT( I,KK-1)
      B = FT( I,KK)
      C = ST(N,KK-1)
      D = ST(N,KK)
      FSST(N,I) = A + (B - A) * (ALOG(SIGO(N,I)/C)/ALOG(D/C))
400  IF (SIGO(N,I) - SE(N,1)) 410,402,402
402  A = 1.0
      B = FE( I,1)
      C = 1.E7
      D = SE(N,1)
      FSSE(N,I) = A + (B - A) * (ALOG(SIGO(N,I)/C)/ALOG(D/C))
      GO TO 450
410  DO 420 K = 2,NE
      KK = K
      IF (SIGO(N,I) - SE(N,K)) 420,420,425
420  CONTINUE
      FSSE(N,I) = FE( I,KK)
      GO TO 450

```

```

425  IF (KK - NE) 440,430,430
430  IF ( SE(N,NE) - .01) 432,432,440
432  CONTINUE
      A = FE( I, KK-1)
      B = FE( I, KK)
      C = SE(N, KK-1)
      D = .1
      FSSE(N, I) = A + (B - A) * (ALOG(SIGO(N, I)/C)/ALOG(D/C))
      GO TO 450
440  CONTINUE
      A = FE( I, KK-1)
      B = FE( I, KK)
      C = SE(N, KK-1)
      D = SE(N, KK)
      FSSE(N, I) = A + (B - A) * (ALOG(SIGO(N, I)/C)/ALOG(D/C))
450  CONTINUE
500  CONTINUE
      REWIND NTAPE
      RETURN
      END

```

```

-ITC FOR RCCSS,RCCSS
SUBROUTINE RCCSS
INCLUDE ABC
C    CALCULATION OF RESONANCE SHIELDED CROSS SECTIONS
DO 10 J = 1,NGP
DO 10 K = 1,15
10  SN(K,J) = .0
DO 500 I = 1, NXS
DO 100 J = 1, NGP
FPHI(J) = .0
DO 25 K = 1,11
25  FPHI(J) = FPHI(J) + SM(I,J,K)
30  CONTINUE
S(I,1,J) = FSSF(I,J)*SR(I,2,J)
S(I,3,J) = SR(I,3,J)*S(I,1,J)
S(I,2,J) = S(I,1,J) + FSSC(I,J)*SR(I,4,J) - (FPHI(J) - SR(I,5,J))
IF(NTR) 40, 40, 50
40  CONTINUE
S(I,4,J) = (FSST(I,J)*SR(I,1,J) - S(I,2,J) - FPHI(J))
1 * (1. - SR(I,7,J)) + S(I,2,J)+FPHI(J)
GO TO 60
50  S(I,4,J) = S(I,2,J) + FPHI(J) + (1 - SR(I,7,J))*FSSE(I,J)*
1 SR(I,6,J)
60  CONTINUE
S(I,5,J) = S(I,4,J) - S(I,2,J) - FPHI(J) + SM(I,J,1)
1-FSSE(I,J)*SR(I,9,J)
IF (J-1) 65,65,66
65  S(I, 6, J) = .0
GO TO 100
66  S(I,6,J) = FSSE(I,J-1)*SR(I,9,J-1) + SM(I,J-1,2)
100 CONTINUE
DO 250 J = 1, NGP
DO 250 N = 2, 10
M = N + 5
S(I, M, J) = 0.0
JK = J - N
IF(JK) 250, 250, 240
240 JL = N + 1
S(I,M,J)=SM(I,JK,JL)
250 CONTINUE
500 CONTINUE
C    CHECK NUMBER OF ITERATIONS ON THE ELASTIC DOWNSCATTERING CROSS
C    SECTION
IF(NIFF) 1200, 1200, 550
550 DO 1000 NNN = 1, NIFF
CALL AVXS
DO 900 I = 1, NXS
U0 = 0.0
DO 850 J = 1, NGP
PPHI(J) = 0.0
DO 625 K=1, 11
625 PPHI(J) = PPHI(J) + SM(I, J, K)
IF(J - NGP) 600, 700, 700
600 U0 = ALETH(J) + U0
605 CONTINUE
U1 = U0 - .5*ALETH(J)
U2 = U0 + .5*ALETH(J+1)
UX = U0 - DELU*SR(I,8,J)
G = PHU(J+1)/PHU(J)
GG = (UX - U1) / (U2 - U1)
GWL = SR(I,8,J) * FSSE(I,J) * SR(I,6,J)

```

```

GGWL = SR(I,8,J+1) * FSSE(I,J+1) * SR(I,6,J+1)
SCD(I,J) = (GWL + GG*(GGWL*G - GWL))/ALETH(J)
IF(J - 1) 650, 650, 700
650 SCD(I,J) = SR(I,9,J)*FSSE(I,J)
GO TO 850
700 S(I,6,J) = SCD(I,J-1) + SM(I,J-1,2)
800 CONTINUE
S(I,5,J) = S(I,4,J) - S(I,2,J) - PPHI(J) + SM(I,J,1)
1 - SCD(I,J)
850 CONTINUE
900 CONTINUE
IF(NP) 910, 910, 1000
910 WRITE(NOUT, 920) NNN
920 FORMAT(51H1ELASTIC DOWNSCATTERING CROSS SECTION FOR ITERATION 13/)
KK = NXS
IF(NXS - 8) 926, 926, 924
924 KK = 8
926 CONTINUE
WRITE(NOUT, 930) (HOLN(I), I = 1, KK)
930 FORMAT(9H0GROUP ,8(6X,A6))
WRITE(NOUT, 932)
932 FORMAT(1H )
DO 950 J=1, NGP
950 WRITE(NOUT, 960) J, (SCD(I,J), I=1, KK)
960 FORMAT(I5, 7X, 1P8E12.4)
1000 CONTINUE
1200 CONTINUE
RETURN
END

```

```

-ITC FOR RCPRT2, RCPRT2
  SUBROUTINE RCPRT2
    INCLUDE ABC
  C    THIS SUBROUTINE PRINTS THE F-FACTORS
    DO 200 I = 1, NXS
      WRITE (NOUT,2) HOLN(I)
  2    FORMAT(71H1CALCULATED RESONANCE SELF-SHIELDING COEFFICIENTS ARE LI
1STED BELOW FOR A6///)
      IF(NFT(I)) 62, 62, 64
  62    WRITE (NOUT,63)
  63    FORMAT(57H THE COEFFICIENTS FOR THIS ISOTOPE ARE ALL EQUAL TO UNIT
1Y)
      GO TO 200
  64    CONTINUE
      WRITE (NOUT,66)
  66    FORMAT(76H GROUP SIGO FF FC
1 FT FE//)
      DO 80 J = 1, NGP
        WRITE (NOUT,70) J, SIGO(I, J), FSSF(I, J), FSSC(I, J), FSST(I, J)
1, FSSE(I, J)
  70    FORMAT (15, E12.4, F17.5, 3F15.5)
  80    CONTINUE
  200    CONTINUE
      RETURN
    END

```



```

-ITC FOR INPUT2,INPUT2
SUBROUTINE INPUT2
  INCLUDE ABC
  C   THIS SUBROUTINE READS THE CROSS SECTIONS IN THE DTK AND DTF FORMAT
  C   AND PRINTS THEM (IF CROSS SECTIONS ARE IN THE RUSSIAN FORMAT,
  C   RESONANCE SHIELDED CROSS SECTIONS ARE PRINTED)
  KK = NXCM + 5
  IF(NRCF - 1) 30, 4, 10
4   DO 9 J = 1, NXS
    READ(NINP,5) MUSTA
5   FORMAT (A6)
    DO 9 I = 1, NGP
      READ(NINP,6) KD, (S(J, K, I), K = 1, 8)
6   FORMAT(I1, E8.3, 7E9.4)
      IF(KK - 8) 9, 9, 7
7   CONTINUE
      READ(NINP,6) KD, (S(J, K, I), K = 9, KK)
9   CONTINUE
      GO TO 30
10  DO 16 J = 1, NXS
    READ(NINP,5) MUSTA
    DO 16 I = 1, NGP
      READ(NINP,12) (S(J, K, I), K = 1, KK)
12  FORMAT(6E12.6)
16  CONTINUE
30  IF(NP) 31, 31, 100
31  DO 38 K = 1, NXS
    WRITE (NOUT,35) HOLN(K),K
35  FORMAT (32H1MICROSCOPIC CROSS SECTIONS FOR A6,21H      NUCLIDE NUM
1BER I2///
2113H GROUP      SIGF      SIGA      NUSIGF      SIGTR      SIGXG      G-1X
3G      G-2XG      G-3XG      G-4XG      G-5XG      G-6XG//)
    KKK = NXCM + 5
    IF (NXCM - 6) 41, 41, 43
43  CONTINUE
    DO 44 I = 1,NGP
      WRITE (NOUT,36) I, (S(K,J,I), J = 1,11)
44  CONTINUE
      WRITE (NOUT,40)
40  FORMAT (44H1GROUP      G-7XG      G-8XG      G-9XG      G-10XG///)
      DO 49 I = 1,NGP
        WRITE (NOUT,42) I, (S(K,J,I), J = 12, KKK)
42  FORMAT (I3,4F10.3)
49  CONTINUE
      GO TO 38
41  CONTINUE
      DO 538 I = 1, NGP
        WRITE (NOUT,36) I, (S(K,J,I), J=1,KKK)
36  FORMAT (I3,11F10.3)
37  FORMAT (1H )
538 CONTINUE
38  CONTINUE
100 CONTINUE
    RETURN
    END

```

```

-ITC FOR CHECK,CHECK
  SUBROUTINE CHECK
    INCLUDE ABC
  C    CHECK CROSS SECTIONS IF THEY ARE IN THE DTF OR DTK FORMAT
    ME = 0
    WRITE (NOUT,1)
  1    FORMAT (49H1 * * * * RESULTS OF CROSS SECTION CHECK * * * *//////
112X,15H COMMENTS . . .//)
    DO 50 J=1,NXS
    DO 50 I=1,NGP
      G = S(J,2,I) + S(J,5,I)
      DO 8 K=1,NXCM
        KK = I + K
        M = K + 5
        IF (KK -NGP) 4,4,8
  4      G = G + S(J,M,KK)
  8      CONTINUE
      IF ( ABS(( G - S(J,4,I))/S(J,4,I)) - .01) 50,20,20
 20      ME = ME + 1
      IF (ME - 100) 26,22,22
 22      WRITE (NOUT,23)
 23      FORMAT (36H0 SHODDY DATA - CHECK DISCONTINUED)
      GO TO 99
 26      WRITE (NOUT,28) ME, HOLN(J), I
 28      FORMAT (1H / I6,10H CHECK A6,10H GROUP 12)
 50      CONTINUE
      IF (ME) 60,60,99
 60      WRITE (NOUT,62)
 62      FORMAT (69H0THE INPUT CROSS SECTIONS APPEAR TO BE CONSISTENT AND I
1N PROPER ORDER)
 99      CONTINUE
      RETURN
    END

```

```

-ITC FOR PRINT2,PRINT2
  SUBROUTINE PRINT2
    INCLUDE ABC
  C    PRINT DATA FOR NEW CASE
    WRITE (NOUT,1)
  1    FORMAT(1H1)
    IF(NOP -1) 10,20,30
  10   WRITE (NOUT,11) AK
  11   FORMAT (1H0///87H          THIS IS A REACTIVITY VERSUS TIME CALC
    1ULATION FOR A CONSTANT GEOMETRIC BUCKLING///
    249H THE INITIAL MULTIPLICATION CONSTANT IS EQUAL TO F8.6//)
    GO TO 35
  20   WRITE (NOUT,21) BSQ
  21   FORMAT (1H0///87H          THIS IS A REACTIVITY VERSUS TIME CALCUL
    1ATION FOR A CONSTANT GEOMETRIC BUCKLING///
    226H THE BUCKLING IS EQUAL TO 1PE16.4, 6H CM-2.//)
    GO TO 35
  30   WRITE (NOUT,31) AK
  31   FORMAT (1H0///78H          THIS IS A BUCKLING VERSUS TIME CALCULA
    1TION FOR A CONSTANT REACTIVITY///
    225H K EFFECTIVE IS EQUAL TO F8.6//)
  35   CONTINUE
    IF (NFP) 37,37,45
  37   WRITE (NOUT,39) POW
  39   FORMAT (55H THE BURNUP WILL BE COMPUTED USING A CONSTANT POWER OF
    11PE16.5,5H MWT.//)
    GO TO 50
  45   WRITE (NOUT,46) FLX
  46   FORMAT (54H THE BURNUP WILL BE COMPUTED USING A CONSTANT FLUX OF 1
    1PE16.5,11H N/CM2-SEC.//)
  50   CONTINUE
  65   WRITE (NOUT,67) EPSL
  67   FORMAT (57H THE CONVERGENCE CRITERION ON THE MARCH-OUT ALGORITHM I
    1S 1PE16.5//)
    G = NUMT
    G = G*H
    WRITE (NOUT,70) NUMT, H, G, NPRT
  70   FORMAT (31H TOTAL NUMBER OF TIME STEPS IS 15///
    114H EACH STEP IS 1PE16.3,5H DAYS///
    222H TOTAL BURNUP TIME IS 1PE16.3,5H DAYS///
    328H OUTPUT WILL BE GIVEN EVERY 14,6H STEPS//)
    IF(LBS) 170,170,141
  141  WRITE (NOUT,150) LBS, LBL,(LBSN(I),I=1,LBS)
  150  FORMAT (24H THE BREEDING RATIO HAS 12,18H SOURCE TERMS AND 12,11H
    1SINK TERMS///
    239H          NUCLIDE NUMBERS FOR SOURCE TERMS 516)
    WRITE (NOUT,160) (LBLN(I),I =1,LBL)
  160  FORMAT (39H0          NUCLIDE NUMBERS FOR SINK TERMS    516)
    WRITE(NOUT, 171)
  170  CONTINUE
  171  FORMAT(1H /)
    IF(NFD) 195, 195, 188
  188  WRITE(NOUT, 190)
  190  FORMAT(41H FLUXES AND ADJOINT FLUXES ARE INPUT DATA//)
  195  CONTINUE
    RETURN
  END

```

```

-ITC FOR START,START
  SUBROUTINE START
    INCLUDE ABC
    WRITE (NOUT,1)
1    FORMAT(1H1)
    WRITE (NOUT,82) (HOL(I),I=1,12)
82   FORMAT (12A6)
    IF(NRCF) 86, 86, 83
83   WRITE (NOUT,84) VOL
84   FORMAT (1H0///62H THE INITIAL CORE LOADING IS GIVEN BELOW FOR A CO
1RE VOLUME OF F9.3,7H LITERS////
281H NUCLIDE   NAME      ATOM DENSITY(CM-3)    KG/LITER    KILOGRAMS
3    SOURCE(KG/DAY)////)
    GO TO 89
86   WRITE (NOUT,87) VOL
87   FORMAT (1H0///62H THE INITIAL CORE LOADING IS GIVEN BELOW FOR A CO
1RE VOLUME OF F9.3,7H LITERS////
296H NUCLIDE   NAME      ATOM DENSITY(CM-3)    KG/LITER    KILOGRAMS
3    SOURCE(KG/DAY)    TEMPERATURE////)
89   CONTINUE
    KK = NBE + 1
    DO 90 J = KK,NXS
90   SORCE(J) = .0
    DO 120 J = 1,NXS
    DNMI(J) = VOL*DN(J)*ATW(J)/.6023
    G = DNMI(J)/VOL
    IF(NRCF) 95, 95, 92
92   WRITE (NOUT,101) J,HOLN(J), DN(J), G, DNMI(J),SORCE(J)
101  FORMAT (I7,5H      ,A6,1PE18.5,1P4E14.4)
    GO TO 102
95   WRITE (NOUT,101) J,HOLN(J), DN(J), G, DNMI(J),SORCE(J), TEMP(J)
102  WRITE (NOUT,103)
103  FORMAT (1H /)
120  CONTINUE
    G = .602/VOL
    GG = 24.*3600.
    DO 150 J = 1,NBE
    DNM(J) = DNMI(J)
    SORCE(J) = SORCE(J)*G/(GG*ATW(J))
150  CONTINUE
    LSMFT = 0
    RETURN
    END

```

```

-ITC FOR AVXS,AVXS
  SUBROUTINE AVXS
    INCLUDE ABC
  C   THIS ROUTINE CALCULATES SPECTRUM AVERAGED CROSS SECTIONS
    KK = NXCM + 5
    DO 999 I = 1,NGP
    DO 999 K = 1,KK
      SN(K,I) = .0
    DO 999 J = 1,NXS
999   SN(K,I) = SN(K,I) + DN(J)*S(J,K,I)
      IF(NOP-1)      220,210,220
210   NCAL = 0
      CALL CALC
      GO TO 1
220   NCAL = 1
      CALL CALC
1     CONTINUE
      SUM = .0
      DO 4 I = 1, NGP
4     SUM = SUM + PHI(I)
      DO 99 J = 1, NXS
      DO 11 K = 1, 4
11    ACS(J,K) = .0
      DO 21 I = 1, NGP
      DO 20 K = 1,3
20    ACS(J,K) = ACS(J,K) + PHI(I)*S(J,K,I)
21    ACS(J,4) = ACS(J,4) + PHI(I)*(S(J,2,I)-S(J,1,I))
      DO 99 K= 1, 4
      ACS(J,K) = ACS(J,K)/SUM
99    CONTINUE
      RETURN
      END

```

```

-ITC FOR CALC,CALC
SUBROUTINE CALC
  INCLUDE ABC
C   THIS ROUTINE COMPUTES THE NEUTRON SPECTRUM
  EPS = .000001
  IF (NCAL) 2,2,1
1   CONTINUE
  ITER = 0
2   CONTINUE
  KK = NXCM + 5
  DO 101 I = 1, NGP
    SIGR(I) = .0
    DO 100 K = 6, KK
      NN = I + K - 5
      IF (NN - NGP) 100,100,101
100   SIGR(I) = SIGR(I) + SN(K,NN)
101   CONTINUE
106   CONTINUE
      ITER = ITER + 1
      IF(NFD) 105, 105, 201
105   CONTINUE
      DO 199 I = 1,NGP
        SUM = .0
        DO 111 N=1,NXCM
          KKK = I - N
          KK = N + 5
          IF(KKK) 112,112,111
111   SUM = SUM + PHI(KKK)*SN(KK,I)
112   CONTINUE
199   PHI(I) = (.00.*CHI(I) + SUM)/(RSQ/(3.*SN(4,I)) + SN(2,I)+SIGR(I))
201   CONTINUE
      RS = 0.
      RL = 0.
      RA = 0.
      DO 412 I = 1,NGP
        FPHI(I) = PHI(I) * SN(3,I)
        PHU(I) = PHI(I)/ALETH(I)
        RS = RS + FPHI(I)
        RL = RL + BSQ * PHI(I)/(3.*SN(4,I))
412   RA = RA + PHI(I) * SN(2,I)
        IF(NCAL) 511,511,441
441   TAK = RS/(RL + RA)
        IF(ABS(AK - TAK) - EPS) 512,512,601
601   IF(ITER - 200) 605,605,602
602   WRITE (NOUT,603)
603   FORMAT (27H1NO CONVERGENCE ON SPECTRUM)
        GO TO 511
605   G = .0
        DO 611 I = 1,NGP
          G = G + PHI(I)/(3.*SN(4,I))
611   BSQ = (RS/AK - RA)/G
        GO TO 106
511   AK = RS/(RL + RA)
512   CONTINUE
      IF(NFD) 650, 650, 1000
650   CONTINUE
C   CALCULATION OF ADJOINT FLUX
  DO 899 I = 1, NGP
    SUM = .0
    II = NGP+ 1 - I
    KK = II + 1

```

```

      KKK = II + 10
      DO 811 K = KK, KKK
      N = K - II + 5
      IF (K - NGP) 811, 811, 812
811  SUM = SUM + ADJ(K) * SN(N,K)
812  CONTINUE
899  ADJ(II) = (SN(3,II) + SUM) / (.33333333*BSQ/SN(4,II)+SN(2,II)
      2 + SIGR(II))
1000 CONTINUE
      RETURN
      END

```

```

-ITC FOR NORM,NORM
  SUBROUTINE NORM
    INCLUDE ABC
  C    THIS SUBROUTINE NORMALIZES THE FLUX
    IF (NFP) 100,100,52
52   CONTINUE
    G = .0
    DO 54 I= 1,NGP
54   G = G + PHI(I)
    G = FLX/G
    RS = G * RS
    RA = G * RA
    RL = G * RL
    RF = 0.
    POW = 0.
    DO 60 I= 1,NGP
    PHI(I) = G*PHI(I)
    FPHI(I) = G * FPHI(I)
    PHU(I) = G*PHU(I)
    DO 60 J=1,NBE
    RF = RF + DN(J)*S(J,1,I)*PHI(I)
60   POW = POW + DN(J)*S(J,1,I)*PHI(I)*FEF(J)
    POW = POW * VOL * 1000.*1.6*10.**(-19)
    GO TO 200
100  CONTINUE
    G = 0.
    DO 110 I=1,NGP
    DO 110 J=1,NBE
110  G = G + DN(J)*S(J,1,I)*PHI(I)*FEF(J)
    G = G * VOL *1000.*1.6*10.**(-19)
    G = POW/G
    RS = G * RS
    RA = G * RA
    RL = G * RL
    RF= .0
    FLX = .0
    DO 130 I=1,NGP
    PHI(I) = G * PHI(I)
    FLX = FLX + PHI(I)
    FPHI(I) = G * FPHI(I)
    PHU(I) = G*PHU(I)
    DO 130 J= 1,NBE
130  RF = RF + DN(J)*S(J,1,I)*PHI(I)
200  CONTINUE
    G = .0
    GG = .0
    DO 210 K=1,LBS
    KK = LBSN(K)
210  G = G + DN(KK)*ACS(KK,4)
    DO 220 K=1,LBL
    KK = LBLN(K)
220  GG = GG + DN(KK)*ACS(KK,2)
    BR = G/GG
    RETURN
  END

```



```

-ITC FOR CRXS1,CRXS1
  SUBROUTINE CRXS1
    INCLUDE ABC
  C THIS SUBROUTINE AND CRXS2 PERFORM THE GROUP COLLAPSING CALCULATION
    NXCMP = NXCM
    IF(NXCM - NCR + 1) 130, 130, 110
110 NXCMP = NCR - 1
130 CONTINUE
    I = 0
    DO 160 K = 1, NCR
      DENP(K) = 0.0
      FPHI(K) = .0
      CHIP(K) = .0
      ALETP(K) = 0.0
      KK = NPN(K)
      DO 160 L = 1, KK
        I = I + 1
        CHIP(K) = CHIP(K) + CHI(I)
        ALETP(K) = ALETH(I) + ALETP(K)
        DENP(K) = DENP(K) + DEN(I)
160 FPHI(K) = FPHI(K) + PHI(I)
      DO 170 I = 1, NCR
        VELP(I) = FPHI(I)/DENP(I)
        WRITE (NOUT,1)
1      FORMAT(1H1)
        WRITE (NOUT,2) (HOL(I), I=1,12)
2      FORMAT(1H1,6F9.9)
699      FORMAT (1H //)
        WRITE (NOUT,6) NCR
6      FORMAT (50H0 DATA FOR CROSS SECTION AVERAGING LISTED BELOW///
2 41H0THE NUMBER OF ENLARGED ENERGY GROUPS IS I3/ )
        IF (NAVX-2) 3,12,23
3      WRITE(NOUT,4)
4      FORMAT (57H0SIGMA TRANSPORT IS CALCULATED USING RECIPROCAL WEIG
1HTING/ )
        GO TO 38
12      WRITE (NOUT,14)
14      FORMAT (68H0SIGMA TRANSPORT IS CALCULATED USING NORMALIZED RECIP
1ROCAL WEIGHTING/ )
        GO TO 38
23      IF (NAVX-3) 26,26,30
26      WRITE (NOUT,28)
28      FORMAT (53H0SIGMA TRANSPORT IS CALCULATED USING LINEAR WEIGHTIN
1G/ )
        GO TO 38
30      WRITE (NOUT,31)
31      FORMAT (64H0SIGMA TRANSPORT IS CALCULATED USING NORMALIZED LINE
1AR WEIGHTING/ )
38      CONTINUE
        WRITE (NOUT,91)
91      FORMAT(115H0NEW GROUP OLD GROUPS PER NEW GROUP FISSION SOURC
1E FOR NEW GROUP FLUX VELOCITY DENSITY //)
        DO 94 K = 1, NCR
          WRITE (NOUT,92) K, NPN(K), CHIP(K), FPHI(K), VELP(K), DENP(K)
92      FORMAT(I3,20H I3,20H 1PE16.5
1,5H 1P3E16.5/)
94      CONTINUE
  C CALCULATION OF LINEAR AVERAGES
    KK=0
    II= 0
    DO 260 K = 1, NCR

```

```

      II = II+KK
      KK = NPN(K)
      DO 260 M = 1,NXS
      DO 260 MM = 1,4
      SG(M,MM,K) = .0
      DO 260 L = 1, KK
      I = L + II
260  SG(M,MM,K) = SG(M,MM,K) + S(M,MM,I)*PHI(I)/FPHI(K)
C    CALCULATION OF SIGTR
      IF (NAVX - 3) 300,400,380
300  KK=0
      II = 0
      DO 360 K=1,NCR
      II = II + KK
      KK = NPN(K)
      DO 360 M=1,NXS
      SG(M,4,K) = .0
      DO 360 L= 1,KK
      I = L + II
360  SG(M,4,K) = SG(M,4,K) + PHI(I)/S(M,4,I)
      DO 370 K=1,NCR
      DO 370 M=1,NXS
370  SG(M,4,K) = FPHI(K)/SG(M,4,K)
      IF(NAVX -2) 400, 380,380
      WRITE (NOUT,2) (HOL(I), I = 1, 12)
      WRITE (NOUT,699)
380  I=0
      WRITE (NOUT,991)
991  FORMAT(58H1GROUP   NORMALIZATION FACTOR FOR TRANSPORT CROSS SECTIO
1NS// )
      DO 390 K = 1, NCR
      G = .0
      DO 381 N=1,NXS
381  G=G + DN(N)*SG(N,4,K)
      GGG =FPHI(K)/G
      KK = NPN(K)
      GG=0.
      DO 386 L=1,KK
      I=I+1
      G = .0
      DO 384 N=1,NXS
384  G = G + DN(N)*S (N,4,I)
386  GG = GG + PHI(I)/G
      DO 389 M =1,NXS
389  SG(M,4,K) = GGG*SG(M,4,K)/GG
      GXG = GGG/GG
      WRITE (NOUT,992) K, GXG
992  FORMAT(I6,16H           ,1PE16.5/)
993  FORMAT(1H /)
390  CONTINUE
400  CONTINUE
      CALL CRXS2
      RETURN
      END

```

```

-ITC FOR CRXS2,CRXS2
SUBROUTINE CRXS2
  INCLUDE ABC
C    CALCULATION OF SCATTERING MATRIX
      LL = NXCMP + 5
      DO 630 N=1,NXS
      DO 630 K=1,NCR
        JJ = K + 5
        IF (JJ - LL) 621, 621, 630
621    DO 619 L = JJ, LL
619    SG(N, L, K) = 0.
630    CONTINUE
        IF(NXCMP) 700,700,640
640    CONTINUE
        NV(1) = 1
        DO 650 I=2,NCR
650    NV(I) = NV(I-1) + NPN(I-1)
        IL = NCR - 1
        DO 690 N=1,NXS
        DO 690 I=1,IL
          JL = I+1
          DO 690 J=JL,NCR
            MN = 5 + J - I
            IF (J-I-NXCMP) 655,655,690
655    SG(N,MN,J) = .0
            I4 = NPN(I)
            DO 680 III=1,I4
              II = NV(I) + III - 1
              J4 = NPN(J)
              DO 680 JJJ = 1,J4
                JJ = NV(J) + JJJ - 1
                NN = 5 + JJ - II
                IF (JJ - II - NXCMP) 670,670,680
670    SG(N,MN,J) = SG(N,MN,J) + S(N,NN,JJ) * PHI(II) / FPHI(I)
680    CONTINUE
690    CONTINUE
700    CONTINUE
C    CALCULATION OF SIGG
      DO 760 N = 1, NXS
      DO 760 K = 1, NCR
        G = .0
        DO 740 L = 1, NXCMP
          M = L + 5
          KK = K + L
          IF(KK - NCR) 740, 740, 760
740    G = G + SG(N, M, KK)
760    SG(N, 5, K) = SG(N, 4, K) - SG(N, 2, K) - G
        DO 55 J=1, NXS
          WRITE (NOUT,20)
20    FORMAT(1H1)
          WRITE (NOUT,22) (HOL(I),I=1,12)
22    FORMAT(12A6)
          WRITE (NOUT,41) HOLN(J), J
41    FORMAT (41HUCRUNCHED MICROSCOPIC CROSS SECTIONS FOR A6,21H      NU
1CLIDE NUMBER I2////
2114H GROUP      SIGF      SIGA      NUSIGF      SIGTR      SIGXG      G-1X
3G      G-2XG      G-3XG      G-4XG      G-5XG      G-6XG ///)
          KK = NXCMP + 5
          IF (NXCMP - 6) 49, 49, 45
45    CONTINUE
          DO 48 I=1,NCR

```

```

        WRITE (NOUT,47) I, (SG(J,K,I),K=1,11)
        WRITE (NOUT,47) I, (SG(J,K,I),K=12,KK)
47      FORMAT (I3,11F10.3)
        WRITE (NOUT,56)
56      FORMAT(1H )
48      CONTINUE
        GO TO 855
49      CONTINUE
        DO 53 I=1,NCR
        WRITE (NOUT,47) I, (SG(J, K, I), K = 1, KK)
        WRITE (NOUT,56)
53      CONTINUE
855     CONTINUE
55      CONTINUE
        JJ = NXCM + 5
        DO 100 I = 1, NGP
        DO 90 K = 1, NXS
        DO 90 J = 1, JJ
        G = S(K, J, I)
        S(K, J, I) = SG(K, J, I)
90      SG(K, J, I) = G
        CXX(I) = CHI(I)
        CHI(I) = CHIP(I)
        AZZ(I) = ALETH(I)
        ALETH(I) = ALETP(I)
        EL(I) = VEL(I)
        VEL(I) = VELP(I)
        TFX(I) = PHI(I)
100     CONTINUE
        DO 110 I = 1, NGP
        WLFL(I) = PHI(I)
        PHI(I) = FPHI(I)
110     WLAFL(I) = ADJ(I)
        NMG = NGP
        NXX = NXCM
        NGP = NCR
        NXCM = NXCMP
        NPSS = NPUN
        NPUN = NOPP
        CALL AVXS
        CALL NORM
102     CONTINUE
        RETURN
        END

```

```

-ITC FOR PERT, PERT
SUBROUTINE PERT
  INCLUDE ABC
  THIS SUBROUTINE COMPUTES COLLAPSED PERTURBATION CROSS SECTIONS
  KK=0
  II=0
  DO 1 I=1, NMG
    SN(1,I)=.0
    DO 1 M=1, NXS
      1 SN(1,I)=SN(1,I)+DN(M)*SG(M,4,I)
      DO 10 K=1, NCR
        GGN=PHI(K)*ADJ(K)
        II=II+KK
        G=GGN/SN(4,K)
        KK=NPN(K)
        DO 10 M=1,NXS
          S(M,2,K)=.0
          S(M,4,K)=.0
          DO 10 L=1,KK
            I=L+II
            S(M,2,K)=S(M,2,K)+SG(M,2,I)*WLFL(I)*WLAFL(I)/GGN
            10 S(M,4,K) = S(M,4,K) + SG(M,4,I)*WLFL(I)*WLAFL(I)*SN(4,K)
            1 / (G*SN(1,I)**2)
  C CALCULATION OF PSEUDO ABSORPTION
  DO 22 N=1,NXS
    KKK=0
    II=0
    DO 22 K=1,NCR
      G=.0
      GT=.0
      DO 11 L=1,NXCM
        M=L+5
        KK=K+L
        IF(KK-NCR) 11,11,12
        11 G=G+S(N,M,KK)*(ADJ(K)-ADJ(KK))*PHI(K)
        12 CONTINUE
        II=II+KKK
        KKK=NPN(K)
        DO 21 LL=1,KKK
          I=LL+II
          DO 20 L=1,NXX
            M=L+5
            J=I+L
            IF (J-NMG) 20,20,21
            20 GT=GT+SG(N,M,J)*(WLAFL(I)-WLAFL(J))*WLFL(I)
            21 CONTINUE
            GT=(GT-G)/(PHI(K)*ADJ(K))
        22 S(N,2,K)=S(N,2,K)+GT
  C CALCULATION OF SIGG
  DO 25 N=1,NXS
    DO 25 K=1,NCR
      G=.0
      DO 23 L=1,NXCM
        M=L+5
        KK=K+L
        IF(KK-NCR) 23,23,25
        23 G=G+S(N,M,KK)
        25 S(N,5,K) = S(N,4,K) - S(N,2,K) - G
      DO 55 J=1, NXS
        WRITE (NOUT,30)
    30 FORMAT(1H1)

```

```

      WRITE (NOUT,32) (HOL(I),I=1,12      )
32     FORMAT(12A6)
40     WRITE (NOUT,41)  HOLN(J), J
41     FORMAT (42HUCRUNCHED PERTURBATION CROSS SECTIONS FOR A6,20H      NU
1CLIDE NUMBER I2////
2114H GROUP      SIGF      SIGA      NUSIGF      SIGTR      SIGXG      G-1X
3G      G-2XG      G-3XG      G-4XG      G-5XG      G-6XG ///)
      KK = NXCM + 5
      IF (NXCM - 6) 49, 49, 45
45     CONTINUE
      DO 48 I=1,NCR
      WRITE (NOUT,47) I, (S (J,K,I),K=1,11)
      WRITE (NOUT,47) I, (S (J,K,I),K=12,KK)
47     FORMAT (I3,11F10.3)
      WRITE (NOUT,56)
56     FORMAT(1H )
48     CONTINUE
      GO TO 60
49     CONTINUE
      DO 53 I=1,NCR
      WRITE (NOUT,47) I, (S (J, K, I), K = 1, KK)
      WRITE (NOUT,56)
53     CONTINUE
60     CONTINUE
55     CONTINUE
      DO 70 I = 1, NXS
      PUNCH 100, HOLN(I), ATW(I), NGP
100    FORMAT(      A6, F6.2, 10X, I3, 7H GROUPS, 10X,
120H PERT CROSS SECTIONS)
      DO 70 J = 1, NGP
      PUNCH 102, (S(I, K, J), K = 1, KK)
102    FORMAT(6E12.6)
70     CONTINUE
      RETURN
      END

```

```

-ITC FOR MARCH,MARCH
SUBROUTINE MARCH
  INCLUDE ABC
  THIS ROUTINE COMPUTES THE TIME DEPENDENT ISOTOPE CONCENTRATION
  NCOV = 0
  FLX = FLX * 10.**(-24)
  C ESTIMATE OF N(T+1) USING EULERS METHOD
  DO 20 J = 1, NBE
    G = -(ALAM(J) + ACS(J,2)*FLX)* DN(J) + SORCE(J)
    IF (LD(J)) 6,6,4
  4 KK = LD(J)
    G = G + ALAM(KK) *DN(KK)
  6 IF (LC(J)) 12,12,8
  8 KK= LC(J)
    DO 10 K = 1,KK
      JJ = LCN(J,K)
  10 G = G + DN(JJ)*ACS(JJ,4)*FLX
  12 IF (LF(J)) 18,18,14
  14 KK = LF(J)
    DO 16 K = 1,KK
      JJ = LFN(J,K)
  16 G = G + DN(JJ)*ACS(JJ,1)*FLX
  18 AN(J,1) = DN(J) +HS*G
  20 CONTINUE
  30 CONTINUE
  C ESTIMATE OF N(T+1) USING MODIFIED EULER EQUATION
  DO 40 J = 1, NBE
    GG=(AN(J,1) + DN(J) )*.5
    G = -(ALAM(J) + ACS(J,2)*FLX)*GG + SORCE(J)
    IF (LD(J)) 33,33, 32
  32 KK = LD(J)
    G = G + ALAM(KK)*(DN(KK)+AN(KK,1)) *.5
  33 IF (LC(J)) 36, 36, 34
  34 KK = LC(J)
    DO 35 K = 1, KK
      JJ = LCN(J,K)
  35 G = G + ACS(JJ,4)*FLX*(AN(JJ,1) + DN(JJ))/2.
  36 IF (LF(J)) 39,39,37
  37 KK = LF(J)
    DO 38 K = 1,KK
      JJ = LFN(J,K)
  38 G = G + ACS(JJ,1)*FLX*(AN(JJ,1) + DN(JJ))/2.
  39 AN(J,2) = DN(J) + HS * G
  40 CONTINUE
  C CHECK ON ACCURACY
  DO 50 J = 1,NBE
    IF(ABS((AN(J,2)-AN(J,1))/AN(J,1)) - EPSL) 50,50,60
  50 CONTINUE
    GO TO 100
  60 NCOV = NCOV + 1
    IF (NCOV - 100)80,80,65
  65 WRITE (NOUT,67)
  67 FORMAT (28H1NO CONVERGENCE ON MARCH-OUT///
150H0 NUCLIDE      DN(T)      AN(T+1,1)      AN(T+1,2)///)
    DO 69 J = 1, NBE
      WRITE (NOUT,68) J,DN(J),AN(J,1),AN(J,2)
  68 FORMAT (I7,1P3E16.5)
  69 CONTINUE
    CALL EXIT
    RETURN
  80 CONTINUE

```

```
      DO 85 J = 1,NBE
85     AN(J,1) = AN(J,2)
      GO TO 30
100    CONTINUE
      TOTL = TOTL + RL * HS * VOL * 1000.
      FLX=FLX* 10.**(24)
      DO 106 J = 1, NBE
      DN(J) = AN(J,2)
106    DNM(J) = VOL*DN(J)*ATW(J)/.6023
      RETURN
      END
```



```

-ITC FOR PRINT3,PRINT3
  SUBROUTINE PRINT3
    INCLUDE ABC
  C   THIS ROUTINE PRINTS ALL APPROPRIATE INFORMATION AT ANY TIME DURING
  C   THE PROGRAM
    WRITE (NOUT,2)
  2   FORMAT (1H1)
    WRITE (NOUT,4) (HOL(I),I=1,12)
  4   FORMAT (12A6)
    TLD = ABS(9.869597/BSQ)
    SREE = SQRT(TLD)
    WRITE (NOUT,6) T, AK, POW, FLX, BR, BSQ,SREE
  6   FORMAT (1H0////27H          T I M E = F8.2,9H D A Y S///
115H K EFFECTIVE = 1PE16.6//
215H TOTAL POWER = 1PE16.6,4H MWT//
315H NEUTRON FLUX = 1PE16.6,10H N/CM2-SEC//
418H BREEDING RATIO = 1PE16.6//
522H GEOMETRIC BUCKLING = 1PE16.6,5H CM-2//
620H SPHERICAL RADIUS = 1PE16.6,3H CM////)
  C   WE WILL NOW PRINT FUEL INVENTORY
    WRITE (NOUT,10)
 10  FORMAT (47H          * * * F U E L   I N V E N T O R Y * * *///
192H NUCLIDE      NAME      ATOM DENSITY(CM-3)      CURRENT LOAD(KG)      I
2NITIAL LOAD(KG)      CHANGE(KG)///)
    DO 20 J=1, NBE
      DNM(J) = VOL*DN(J)*ATW(J)/.6023
      G = DNM(J) - DNMI(J)
      WRITE (NOUT,12) J, HOLN(J), DN(J), DNM(J), DNMI(J), G
      WRITE (NOUT,14)
 12  FORMAT (16,5H          ,A6,1PE19.5,1PE20.5,1PE18.5,1PE16.5)
 14  FORMAT (1H /)
 20  CONTINUE
    WRITE (NOUT,30)
 30  FORMAT (1H1)
    RP = .0
    P = 0.0
    DO 33 I = 1, NGP
      DEN(I) = PHI(I)/VEL(I)
      RP = RP + DEN(I)
 33  P = P + DEN(I)*ADJ(I)
      P = P/(RS*AK)
      WRITE (NOUT,34) RS, RF, RA, RL, P, TOTL
 34  FORMAT (1H0      45H          * * * N U C L E A R   D A T A * * *///
140H NEUTRON SOURCE RATE(PER CC PER SEC) = 1PE16.5//
240H NEUTRON FISSION RATE(PER CC PER SEC) = 1PE16.5//
343H NEUTRON ABSORPTION RATE(PER CC PER SEC) = 1PE16.5//
440H NEUTRON LEAKAGE RATE(PER CC PER SEC) = 1PE16.5//
436H NEUTRON GENERATION TIME(SECONDS) = 1PE16.5//
535H TOTAL NEUTRON LEAKAGE FROM CORE = 1PE16.5//
7126H GROUP      FLUX      NU*SIGF*FLUX      SIGF*FLUX      INTG FLUX
8 INTG F.R.      ADJOINT      CHI*ADJOINT      DENSITY      PHI(U)/)
    SUMA = .0
    SUM = .0
    DO 40 I = 1, NGP
      SUMA = SUMA + ADJ(I)
 40  SUM = SUM + PHI(I)
    SUMCA = .0
    WWWL = 0.0
    PPI = .0
    DO 42 I = 1, NGP
      WWWL = WWWL + PHI(I)/ SUM

```

```

POWER      = PHI(I) * SN(1, I)
PPI = PPI + POWER/RF
G = CHI(1) * ADJ(I)
SUMCA = SUMCA + G
WRITE (NOUT,41) I, PHI(I), FPHI(I), POWER,WWWL,PPI,ADJ(I),G,DEN(I)
1, PHU(I)
41  FORMAT (I3, 1P9E14.5)
42  CONTINUE
    WRITE (NOUT,31) SUM, RS, RF, SUMA,SUMCA, RP
31  FORMAT (4H0SUM1PE13.5,1P2E14.5,28X,1P3E14.5)
    IF (NP) 300,300,399
300  CONTINUE
    WRITE (NOUT,301)
    WRITE (NOUT,302) (HOL(I),I=1,12)
301  FORMAT (1H1)
302  FORMAT (12A6)
    WRITE (NOUT,304)
304  FORMAT (1H0///60H THE MACROSCOPIC CROSS SECTIONS ARE GIVEN IN THE
1TABLE BELOW///
2112H GROUP SIGF      SIGA      NUSIGF      SIGTR      SIGXG      G-1XG
3      G-2XG      G-3XG      G-4XG      G-5XG      G-6XG///)
    KK = NXCM + 5
    IF(NXCM - 6) 341, 341, 343
343  CONTINUE
    DO 354 I = 1, NGP
    WRITE (NOUT,306) I, (SN(K,I), K = 1, 11)
354  CONTINUE
390  FORMAT (44H1GROUP G-7XG      G-8XG      G-9XG      G-10XG///)
    WRITE (NOUT,390)
    DO 349 I = 1, NGP
352  FORMAT (I4, 1P4E10.2)
    WRITE (NOUT,352) I, (SN(K,I), K = 12, KK)
349  CONTINUE
    GO TO 399
341  CONTINUE
    DO 310 I = 1, NGP
    WRITE (NOUT,306) I, (SN(K,I), K=1, KK)
306  FORMAT (I4,1P11E10.2)
308  FORMAT (1H /)
310  CONTINUE
399  CONTINUE
    WRITE (NOUT,320)
320  FORMAT (1H1)
    WRITE (NOUT,330) (HOL(I),I=1,12)
330  FORMAT (12A6)
    WRITE (NOUT,340)
340  FORMAT (1H0///83H      * * *      S P E C T R U M      A V E R A G E D
1C R O S S      S E C T I O N S      * * *///)
270H NUMBER      NAME      SIGMA F      SIGMA ABS      NU SIGMA F      SI
3GMA CAP//)
    DO 350 J=1,NXS
    WRITE (NOUT,342) J, HOLN(J),(ACS(J,K), K=1,4)
    WRITE (NOUT,344)
342  FORMAT (I5,4H      A6,1P4E14.4)
344  FORMAT (1H /)
350  CONTINUE
500  CONTINUE
    RETURN
    END

```

```

-ITC FOR PUNCH,PUNCH
SUBROUTINE PUNCH
INCLUDE ABC
C THIS SUBROUTINE PUNCHES THE CROSS SECTIONS
KK = NXCM + 5
KD = 9
IF(NPUN - 2) 200, 300, 401
200 DO 240 I = 1, NXS
PUNCH 100, HOLN(I), ATW(I), NGP
100 FORMAT(A6, F6.2, 10X, I3, 7H GROUPS)
DO 240 J = 1, NGP
PUNCH 202, KD, (S(I,K,J), K = 1, 8)
IF(KK - 9) 240, 204, 204
202 FORMAT(I1, F8.3, 7F9.3)
204 PUNCH 202, KD, (S(I,K,J), K = 9, KK)
240 CONTINUE
GO TO 999
300 DO 340 I = 1, NXS
PUNCH 100, HOLN(I), ATW(I), NGP
DO 340 J = 1, NGP
PUNCH 302, (S(I,K,J), K = 1, KK)
302 FORMAT (6E12.6)
340 CONTINUE
GO TO 999
401 WRITE (NOUT,402) NBN
402 FORMAT(48H1MACROSCOPIC CROSS SECTIONS ARE PUNCHED OUT FOR I3,15H M
1IXED ISOTOPES///)
DO 425 I = 1, NBN
WRITE (NOUT,405) I
405 FORMAT (4H MIXI3/ )
IF(NBUN(I)) 425, 425, 407
407 WRITE (NOUT,408)
408 FORMAT (27H ISOTOPE DENSITY/ )
JJ = NBUN(I)
DO 420 J = 1, JJ
L = NISO(I, J)
WRITE (NOUT,410) HOLN(L), DNSO(I, J)
410 FORMAT(5X,A6,1PE16.6)
420 CONTINUE
WRITE (NOUT,421)
421 FORMAT(1H //)
425 CONTINUE
DO 600 I = 1, NBN
451 WRITE (NOUT,453) I
453 FORMAT (41H1THE MACROSCOPIC CROSS SECTIONS FOR MIX I3,17H ARE LIS
1TED BELOW///)
2112H GROUP SIGF SIGA NUSIGF SIGTR SIGXG G-1XG
3 G-2XG G-3XG G-4XG G-5XG G-6XG///)
454 DO 475 J = 1, NGP
IF(NBUN(I)) 457, 457, 459
457 DO 458 K=1, KK
458 SL(K,J) = 0.0
SL(4,J) = 1./(3.*SN(4,J))
SL(2,J) = SL(4,J)
GO TO 475
459 CONTINUE
DO 474 K = 1, KK
SL(K, J) = .0
MM = NBUN(I)
DO 470 M = 1, MM
DO 460 L = 1, NXS

```

```

      IF(L - NISO(I,M)) 460, 455, 460
455  SL(K,J) = SL(K,J) + S(L,K,J)*DNSO(I,M)
      GO TO 470
460  CONTINUE
470  CONTINUE
474  CONTINUE
475  CONTINUE
      PUNCH 476, I
476  FORMAT(4H MIXI3)
      IF(NPUN - 3) 999, 478, 488
478  CONTINUE
      DO 485 J = 1, NGP
      PUNCH 480, KD, (SL(K,J), K = 1, 8)
480  FORMAT(I1, F8.3, 7F9.3)
      IF(KK - 9) 485, 482, 482
482  PUNCH 480, KD, (SL(K,J), K = 9, KK)
485  CONTINUE
      GO TO 500
488  CONTINUE
      DO 495 J = 1, NGP
      PUNCH 490, (SL(K,J), K = 1, KK)
490  FORMAT(6E12.6)
495  CONTINUE
500  CONTINUE
501  CONTINUE
      IF(NXCM - 6) 540, 540, 503
503  CONTINUE
      DO 508 J = 1, NGP
      WRITE (NOUT,506) J, (SL(K,J), K = 1, 11)
506  FORMAT(I3, 1P11E10.2)
507  FORMAT(1H )
508  CONTINUE
      WRITE (NOUT,510)
510  FORMAT (44H1GROUP  G-7XG      G-8XG      G-9XG      G-10XG///)
      DO 519 J = 1, NGP
      WRITE (NOUT,506) J, (SL(K,J), K = 12, KK)
519  CONTINUE
      GO TO 600
540  CONTINUE
      DO 565 J = 1, NGP
      WRITE (NOUT,506) J, (SL(K, J), K = 1, KK)
565  CONTINUE
600  CONTINUE
999  CONTINUE
      RETURN
      END

```

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