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FCC - A FUNDAMENTAL MODE CODE FOR FAST REACTOR ANALYSIS

W. W. LITTLE, JR.

R. W. HARDIE

MARCH, 1966

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FOR FAST REACTOR ANALYSIS

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ABSTRACT

This paper describes a multipurpose fundamental mode code for use in fast reactor analysis. The code can be used to:

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

In a 64 K memory, the code can handle 14 isotopes with 26 energy groups and 10 downscattering terms. Running time on a UNIVAC 1107 ($\approx$ IBM 7090) is about 20 sec.

A FORTRAN IV source deck listing, input information, and a sample case are given in the appendices.

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FCC - A FUNDAMENTAL MODE CODE FOR FAST REACTOR ANALYSIS

I. INTRODUCTION

Purpose and Use of FCC Code

This report describes a computer code, FCC, that will rapidly compute resonance shielded cross sections, collapsed group cross sections, and fuel burnup for fast reactor design analysis. Formed as a combination of the REDCROSS⁽¹⁾ cross section code, the CRUNCH⁽²⁾ group collapsing code, and the PYRE⁽³⁾ burnup code, the FCC code is designed to compute these fast reactor analysis items in a single computer run.

Contents of Report

A general description of the FCC code is given in Chapters II and III. The mathematical models for computing flux, collapsed cross sections, and burnup are shown in Chapters IV through VI.

The Russian data, together with the model used to compute resonance shielded cross sections, is discussed in Appendix B. The remaining appendices are devoted to the details of code operation.

II. OUTLINE OF CODE LOGIC

Introduction

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.

FIGURE 2-1. Schematic Diagram of ECC

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.

III. DISCUSSION OF PRINCIPLE 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, 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.

A detailed description of the DTK, DTF, and Russian formats is given in Appendices A and B.

Flux and Adjoint Flux Calculation

Only two significant options are possible in the flux calculation: (1) the computation of k_{eff} for a specified buckling, B^2 , or (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. In this instance, of course, the flux calculation is bypassed.

Options Pertaining to Collapsing and Punching Cross Sections

If desired, FCC will collapse, print, and punch microscopic or macroscopic cross sections. All collapsed cross sections are computed using the spectrum corresponding to the current case. Up to 14 macroscopic cross section mixes can be computed in a single case.

Burnup Options

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

- 1) Burnup can be computed at constant power or constant flux.
- 2) Spectrum averaged cross sections can be calculated using the spectrum in a critical reactor (adjusting B^2), or the spectrum at $k(t)$.
- 3) Neutronics format:
 - a) k_{eff} as a function of time for a given initial k_{eff} (adjusting B^2),
 - b) k_{eff} as a function of time for a specified buckling (B^2),
 - c) B^2 as a function of time for a specified k_{eff} .
- 4) 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

Introduction

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 these 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

$$\phi_i = \frac{\chi_i S_o + \sum_{k=1}^{i-1} \Sigma(k \rightarrow i) \phi_k}{\frac{B^2}{3\Sigma_{tr}^i} + \Sigma_a^i + \sum_{j=i+1}^N \Sigma(i \rightarrow j)} \quad (4.1)$$

where:

- N = number of energy groups,
- B^2 = buckling,
- S_o = arbitrary constant,
- χ_i = fission spectrum contribution to group i ,
- Σ_{tr}^i = transport cross section for group i ,
- Σ_a^i = absorption cross section for group i ,
- $\Sigma(i \rightarrow j)$ = 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,

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

in order to obtain both B^2 and ϕ_i .

Algorithm for Adjoint Flux

Let ϕ^+ be the neutron worth in group i . In this report, ϕ^+ is loosely called the adjoint flux. From physical intuition, it is clear that

$$\phi_i^+ = \frac{(\nu \Sigma_f)^i + \sum_{j=i+1}^N \Sigma(i \rightarrow j) \phi_j^+}{\frac{B^2}{3\Sigma_{tr}^i} + \Sigma_a^i + \sum_{j=i+1}^N \Sigma(i \rightarrow j)} \quad (4.3)$$

In contrast to Equation (4.1), observe that Equation (4.3) must be 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

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

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

It should be mentioned that the code uses Equation (4.2) rather than Equation (4.4) to compute k_{eff} . For most calculations, however, the expressions yield identical results.

V. ALGORITHMS FOR COMPUTING COLLAPSED CROSS SECTIONS

Introductory Remarks

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.

Cross Section Averaging Procedure

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 $\sum_{i=1}^K$ denotes a sum over the original microscopic 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

$$\bar{\sigma}^K = \frac{\sum_{i=1}^K \sigma^i \phi_i}{\psi_K} \quad . \quad (5.2)$$

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

$$\bar{\sigma}_{tr}^K = \frac{\psi_K}{\sum_{i=1}^K \frac{\phi_i}{\sigma_{tr}^i}} \quad (5.3)$$

- (2) Normalized reciprocal weighting, defined by

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

where

$$\gamma_K = \frac{\psi_K}{\sum_N (N \sigma_{tr}^K) \sum_K \left(\frac{\phi_i}{\sum_N \sigma_{tr}^i} \right)} \quad (5.5)$$

The symbol $\sum_N$ denotes a sum over the isotopes in the mixture.

(3) Linear weighting, defined by

$$\bar{\sigma}_{tr}^K = \frac{\sum_K \sigma_{tr}^i}{\psi_K} \quad (5.6)$$

(4) Normalized linear weighting, defined as

$$\bar{\sigma}_{tr}^K = \gamma_K \left[\frac{\sum_K \sigma_{tr}^i \phi_i}{\psi_K} \right] \quad (5.7)$$

where, as before, the normalization factor is obtained from Equation (5.5).

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

$$\bar{\sigma}(K \rightarrow J) \psi_K = \sum_K \sum_J \sigma(i \rightarrow j) \phi_i \quad (5.8)$$

or

$$\bar{\sigma}(K \rightarrow J) = \frac{\sum_K \sum_J \sigma(i \rightarrow j) \phi_i}{\psi_K} \quad (5.9)$$

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

$$\bar{\sigma}_{gg}^K = \bar{\sigma}_{tr}^K - \bar{\sigma}_a^K - \sum_J \bar{\sigma}(K \rightarrow J) \quad (5.10)$$

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 code because it is required input in many neutron transport codes.

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:

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

The last two sum terms in Equation (6.1) allow provision for four capture and seven fission sources. The latter option, for example, would 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

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

the improved Euler algorithm can be written as

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

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

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

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 on Burnup Equations

It is perhaps important to emphasize that the flux and spectrum averaged cross sections appearing in Equation (6.1) are recomputed at each time step. The cross sections can be evaluated using the current spectrum, or the spectrum corresponding to $k_{\text{eff}} = 1.0$ (adjusting leakage).

It should be clear from the mathematical model presented that relatively short time steps should be employed in order 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 1107 time.

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3. W. W. Little, Jr. and R. W. Hardie, PYRE - A Multigroup Burnup Code for Fast Reactors, BNWL-54, April, 1965.
4. I. I. Bondarenko et al., Group Constants for Nuclear Reactor Calculations, Consultants Bureau, New York, 1964.

APPENDIX A

DTK AND DTF CROSS SECTION FORMATS

CROSS SECTIONS

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

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

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 6E12.5; i.e., 6 floating point words to each card. Again, each new energy group is started on a new card.

A listing of DTK and DTF cards is given in the sample problem (Appendix D).

APPENDIX B

RUSSIAN INPUT DATA FORMAT AND TREATMENT

INTRODUCTORY REMARKS

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. More details are given in the sample problem in Appendix D. For a complete description, the reader is referred to the Russian text.⁽⁴⁾

INFINITE DILUTION CROSS SECTIONS

For each energy group of each isotope, eight parameters are listed. 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,
- $\sigma_{d,e}$ = elastic slowing-down cross section (in FCC, 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 part of the above data (for punching or printing errors) using the equations

$$\sigma_t = \sigma_f + \sigma_c + \sigma_e + \sigma_{in} \quad (B-1)$$

and

$$\sigma_{in,i} = \sum_j \sigma_{in}(i \rightarrow j) \quad (B-2)$$

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,

$$\bar{\sigma}_k = f_k^0 \sigma_k^0, \quad (B-3)$$

where:

- $\bar{\sigma}_k$ = resonance shielded cross section for kth 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 B-1.

TABLE B-1

FORMAT FOR RESONANCE SELF-SHIELDING FACTORS

Temperature, °K	<u>Total Cross Section</u>		
	<u>σ_1</u>	<u>σ_2</u>	<u>σ_3</u>
300	f_1	f_2	f_3
900	f_4	f_5	f_6
2100	f_7	f_8	f_9

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

$$f(T) = A + B/\sqrt{T}, \quad (B-4)$$

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 (B-4). In particular, second order curves in terms of T or 1/T may be preferable to Equation (B-4) for many studies. However, for analyses in the vicinity of 1000 °K, Equation (B-4) 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 discrete cross sections, say $\sigma_{t,1}$ and $\sigma_{t,2}$, the shielding factor is computed using the expression

$$f(\sigma_T) = f_1 + \frac{f_2 - f_1}{\ln(\sigma_2/\sigma_1)} \ln(\sigma_T/\sigma_1) \quad (B-5)$$

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

$$1) \sigma_T \geq 10^7, f = 1.0, \quad (B-6)$$

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

$$3) \sigma_T < \sigma_S, f = f_S \quad (B-8)$$

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

$$\sigma_{T,k}^0 = \frac{1}{N_k} \sum_{j \neq k} N_j \sigma_{t,j}^0, \quad (B-9)$$

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

$$\sigma_{T,k}^{\nu+1} = \frac{1}{N_k} \sum_{j \neq k} N_j \left(f_{e,j}^{\nu} \sigma_{c,j} + f_{f,j}^{\nu} \sigma_{f,j} + f_{e,j}^{\nu} \sigma_{e,j} + \sigma_{in,j} \right), \quad (B-10)$$

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.

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 b is specified, the code automatically assumes an infinite dilution.

EQUATIONS FOR MULTIGROUP CROSS SECTIONS

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

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

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:

$$\bar{\sigma}_f^i = f_f^i \sigma_f^i \quad (B-11)$$

$$\bar{\sigma}_a^i = f_f^i \sigma_f^i + f_c^i \sigma_c^i - \left[\sum_j \sigma_{in}(i \rightarrow j) - \sigma_{in}^i \right] \quad (B-12)$$

$$(\overline{\nu\sigma}_f)^i = \nu^i f_f^i \sigma_f^i \quad (B-13)$$

$$\begin{aligned} \bar{\sigma}_{tr}^i = & \left[f_t^i \sigma_t^i - \left(f_f^i \sigma_f^i + f_c^i \sigma_c^i + \sigma_{in}^i \right) \right] (1 - \mu_e^i) \\ & + f_f^i \sigma_f^i + f_c^i \sigma_c^i + \sigma_{in}^i \end{aligned} \quad (B-14)$$

$$\bar{\sigma}(i-1 \rightarrow i) = f_e^{i-1} \sigma_{d,e}^{i-1} + \sigma_{in}(i-1 \rightarrow i) \quad (B-15)$$

$$\bar{\sigma}(i-2 \rightarrow i) = \sigma_{in}(i-2 \rightarrow i) \quad (B-16)$$

$$\bar{\sigma}(i-10 \rightarrow i) = \sigma_{in}(i-10 \rightarrow i) \quad (B-17)$$

$$\bar{\sigma}(i \rightarrow i) = \bar{\sigma}_{tr}^i - \bar{\sigma}_a^i - \sum_{j \neq i} \bar{\sigma}(i \rightarrow j) \quad (B-18)$$

In passing, observe that if $\bar{\sigma}_{tr}^i$ and $\bar{\sigma}_a^i$ were approximately equal and large in magnitude, a small error in either would cause a large fractional error in $\bar{\sigma}(i \rightarrow i)$. However, these conditions are not serious since $\bar{\sigma}(i \rightarrow i)$ is unimportant when $\bar{\sigma}_a^i$ is large.

A few words should also 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 cross section format given on the previous page. 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 since the Russian inelastic scattering matrix includes the $(n, 2n)$ reaction.

APPENDIX C
INPUT INSTRUCTIONS

PRELIMINARY DATA

<u>Card</u>	<u>Column</u>	<u>Format</u>	<u>Remarks</u>
1	1-6	Integer	Number of energy groups (≤ 26).
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. (See Appendix B) = 1; cross section data is in DTK format. = 2; cross section data is in DTF format.
1	31-36	Integer	= 0; full print. = 1; partial print.
1	37-42	Integer	= 0; code computes flux. = 1; code reads flux as input. See card 8.
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.
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.

<u>Card</u>	<u>Column</u>	<u>Format</u>	<u>Remarks</u>
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.
3	Same as above for burnable isotope No. 2. Repeat for all burnable isotopes.		
4	1-6	Floating	Name of nonburnable isotope No. 1.
4	7-12	Floating	Atomic weight (amu).
5	Same as above for nonburnable isotope No. 2. Repeat for all nonburnable isotopes.		
6	1-12	Floating	Fission source in energy group 1.
6	13-24	Floating	Fission source in group 2.
...			
7	1-12	Floating	Lower energy bound for group 1.
7	13-24	Floating	Lower energy bound for group 2.
...			
8	1-12 (optional)	Floating	Flux in group 1 (optional - see card 1).
8	13-24	Floating	Flux in group 2.
...			

CROSS SECTION DATA

If cross sections are in Russian format:

<u>Card</u>	<u>Column</u>	<u>Format</u>	<u>Remarks</u>
9	1-6	Hollerith	Name of isotope No. 1.
9	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.
9	13-18	Integer	Group number of initial f-factors.
9	19-24	Integer	Group number of final f-factors.
9	25-30	Integer	Number of different types of f-factors (e.g., f_c , f_f , f_t).
9	31-36	Integer	Number of columns of f_f 's.
9	37-42	Integer	Number of columns of f_c 's.
9	43-48	Integer	Number of columns of f_t 's.
9	49-54	Integer	Number of columns of f_e 's.
10	1-6	Floating	Total cross section per atom corresponding to first column of f-factors.
10	7-12	Floating	Total cross section corresponding to the second column of f-factors.
...			
11	1-2	Integer	Group number of initial f-factors.
11	3-7	Floating	First f-factor for above group.
11	8-12	Floating	Second f-factor for above group.
12	Same as above for next group of isotope No. 1. Repeat through all energy groups containing f-factors.		
13	1-3	Integer	Group number.
13	4-12	Floating	Cross section data for first group of first isotope; σ_t (barns).
13	13-21	Floating	σ_f
13	22-30	Floating	ν
13	31-39	Floating	σ_c
13	40-47	Floating	σ_{in}
13	48-55	Floating	σ_e
13	56-63	Floating	μ_e
13	64-71	Floating	$\sigma_{d,e}$
14	Same as above for second group of isotope No. 1. Repeat for all energy groups.		

Card	Column	Format	Remarks
15	1-3	Integer	Group number.
15	4-8	Floating	Inelastic scattering cross sections for first groups of first isotope; σ_{gg} .
15	9-13	Floating	$\sigma_{g \rightarrow g+1}$
15	14-18	Floating	$\sigma_{g \rightarrow g+2}$
15	19-23	Floating	$\sigma_{g \rightarrow g+3}$
15	24-28	Floating	$\sigma_{g \rightarrow g+4}$
15	29-33	Floating	$\sigma_{g \rightarrow g+5}$
15	34-38	Floating	$\sigma_{g \rightarrow g+6}$
15	39-43	Floating	$\sigma_{g \rightarrow g+7}$
15	44-48	Floating	$\sigma_{g \rightarrow g+8}$
15	49-53	Floating	$\sigma_{g \rightarrow g+9}$
15	54-58	Floating	$\sigma_{g \rightarrow g+10}$
16	Same as above for second group of isotope No. 1. Give data for first 12 groups. Repeat cycle for all isotopes.		

If cross sections are in DTK format:

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

<u>Card</u>	<u>Column</u>	<u>Format</u>	<u>Remarks</u>
-------------	---------------	---------------	----------------

If cross sections are in DTF format:

9	1-12	Floating	Cross section data for first group of first isotope; σ_f (barns).
9	13-24	Floating	σ_a
9	25-36	Floating	$\nu\sigma_f$
9	37-48	Floating	σ_{tr}
9	49-60	Floating	σ_{gg}
9	61-72	Floating	$\sigma_{g-1 \rightarrow g}$
10	1-12	Floating	$\sigma_{g-2 \rightarrow g}$
10	13-24	Floating	$\sigma_{g-3 \rightarrow g}$
10	25-36	Floating	$\sigma_{g-4 \rightarrow g}$

...

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

CHANGE CASE DATA

12**	2-72	Hollerith	Identification card.
13	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 geometric buckling. = 2; the code calculates the geometric buckling as a function of time for a specified k_{eff} .
13	7-12	Integer	= 0; calculation is performed for a constant power. = 1; calculation is performed for a constant flux.
13	13-18	Integer	= 0; spectrum averaged cross sections calculated at $k_{eff} = 1$. = 1; spectrum averaged cross sections calculated at current k_{eff} .
13	19-24	Integer	Number of time steps.

** To run a series of cases, repeat from card 12.

Card	Column	Format	Remarks
13	25-30	Integer	Number of intervals between prints (e.g., = 1, print every time; = 2, print every other time).
13	31-36	Integer	Number of crunched energy groups (if equal to the number of original groups, the collapsing calculation is bypassed). See card 19.
13	37-42	Integer	= 1; $\bar{\sigma}_{tr}$ calculated using reciprocal weighting = 2; $\bar{\sigma}_{tr}$ calculated using normalized reciprocal weighting. = 3; $\bar{\sigma}_{tr}$ calculated using linear weighting. = 4; $\bar{\sigma}_{tr}$ calculated using normalized linear weighting.
13	43-48	Integer	= 0; total cross section per atom assumed constant for each isotope. See card 18. = 1; total cross section per atom is calcu- lated using atom densities.
13	49-54	Integer	Number of iterations in the calculation of the resonance shielded cross sections.
13	55-60	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.
13	61-66	Integer	Same as above punch option, except for crunched groups.
13	67-72	Integer	Number of cross section mixes to be punched. See cards 20-22.
14	1-12	Floating	Length of time steps (days).
14	13-24	Floating	Volume of core (liters).
14	25-36	Floating	Power (MW _t) or flux (n/cm ² -sec).
14	37-48	Floating	Buckling or effective multiplication constant.
14	49-60	Floating	Convergence criterion on march-out.
15	1-6	Integer	Number of fertile isotopes (≤ 5). The data on this card is used to compute the breeding ratio only.
15	7-12	Integer	Nuclide number of fertile isotope No. 1.
15	13-18	Integer	Nuclide number of fertile isotope No. 2.
15	19-24	Integer	Nuclide number of fertile isotope No. 3.
15	25-30	Integer	Nuclide number of fertile isotope No. 4.

Card	Column	Format	Remarks
15	31-36	Integer	Nuclide number of fertile isotope No. 5.
15	37-42	Integer	Number of fissile isotopes (≤ 5).
15	43-48	Integer	Nuclide number of fissile isotope No. 1.
15	49-54	Integer	Nuclide number of fissile isotope No. 2
15	55-60	Integer	Nuclide number of fissile isotope No. 3.
15	61-66	Integer	Nuclide number of fissile isotope No. 4.
15	67-72	Integer	Nuclide number of fissile isotope No. 5.
16	1-12	Floating	Atom density for isotope No. 1 ($\text{cm}^{-3} \times 10^{-24}$).
16	13-24	Floating	Atom density for isotope No. 2.
...			
17	1-12 (optional)	Floating	Temperature of isotope No. 1 ($^{\circ}\text{K}$). This card is included only if the cross sections are in the Russian format.
17	13-24	Floating	Temperature of isotope No. 2.
...			
18	1-12 (optional)	Floating	Total cross section per atom for isotope No. 1. (If greater than 10^7 , code assumes infinite dilution).
18	13-24	Floating	Total cross section per atom for isotope No. 2.
...			
19	1-6 (optional)	Integer	Number of original groups in first crunched group.
19	7-12	Integer	Number of original groups in second crunched group.
...			
20	1-6 (optional)	Integer	Number of isotopes in mix No. 1.
20	7-12	Integer	Number of isotopes in mix No. 2.
...			
21	1-6 (optional)	Integer	Nuclide number of first isotope in mix No. 1.
21	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.

<u>Card</u>	<u>Column</u>	<u>Format</u>	<u>Remarks</u>
22	1-12 (optional)	Floating	Atom density for isotope No. 1 in mix No. 1. ($\text{cm}^{-3} \times 10^{-24}$).
22	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.
23	1-12	Floating	Rate at which isotope No. 1 is being added to reactor (kg/day). List data for burnable isotopes only.
23	13-24	Floating	Rate at which isotope No. 2 is being added to reactor.
...			

** To run a series of cases, repeat from Card 12.

APPENDIX DSAMPLE CASE

The input data, computer print-out, and listing of the punched cross section output for a sample case are given on the following pages. The sample case is a one-step burnup calculation using four collapsed groups. To minimize print-out, only two isotopes are used. The input cross sections for only one isotope, Pu^{239} , are listed.

31

PU-239	1	10	25	4	4	4	3	3					
1.0E031.0E021.0E010.0	1.0E031.0E021.0E010.0	1.0E031.0E021.0E010.0	1.0E031.0E021.0E010.0	1.0E031.0E021.0E010.0	1.0E031.0E021.0E010.0	1.0E031.0E021.0E010.0	1.0E031.0E021.0E010.0	1.0E031.0E021.0E010.0	1.0E02				
101.00	0.99	0.97	0.94	1.00	1.00	0.98	0.96	1.00	0.99	0.98	1.00	1.00	1.00
101.00	1.00	0.98	0.97	1.00	1.00	0.99	0.98	1.00	1.00	1.00	1.00	1.00	1.00
101.00	1.00	0.99	0.98	1.00	1.00	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.00
111.00	0.98	0.93	0.88	1.00	0.99	0.95	0.91	1.00	0.97	0.93	1.00	1.00	0.99
111.00	0.99	0.97	0.93	1.00	1.00	0.98	0.95	1.00	1.00	0.99	1.00	1.00	1.00
111.00	0.99	0.98	0.95	1.00	1.00	0.99	0.97	1.00	1.00	1.00	1.00	1.00	1.00
121.00	0.96	0.87	0.80	1.00	0.96	0.87	0.80	0.98	0.92	0.86	0.99	0.97	0.96
121.00	0.98	0.93	0.87	1.00	0.98	0.94	0.88	1.00	0.99	0.96	1.00	0.99	0.98
121.00	0.99	0.95	0.91	1.00	0.99	0.96	0.92	1.00	1.00	0.99	1.00	1.00	1.00
130.99	0.92	0.79	0.69	0.99	0.92	0.77	0.67	0.95	0.85	0.80	0.96	0.93	0.91
131.00	0.96	0.87	0.79	1.00	0.96	0.87	0.78	0.99	0.96	0.91	0.99	0.96	0.94
131.00	0.98	0.91	0.88	1.00	0.98	0.91	0.87	1.00	0.98	0.96	1.00	0.98	0.96
140.98	0.88	0.67	0.56	0.98	0.87	0.62	0.51	0.89	0.79	0.69	0.87	0.85	0.84
140.99	0.92	0.78	0.69	0.99	0.91	0.76	0.66	0.95	0.90	0.82	0.91	0.87	0.85
141.00	0.95	0.86	0.82	1.00	0.95	0.84	0.79	0.97	0.94	0.90	0.93	0.90	0.87
150.97	0.80	0.53	0.42	0.96	0.76	0.46	0.36	0.80	0.68	0.60	0.80	0.78	0.76
150.98	0.86	0.64	0.53	0.97	0.82	0.58	0.47	0.87	0.81	0.74	0.83	0.80	0.78
150.99	0.90	0.77	0.71	0.99	0.89	0.72	0.64	0.92	0.89	0.87	0.86	0.82	0.81
160.93	0.70	0.41	0.30	0.91	0.62	0.33	0.24	0.66	0.55	0.51	0.75	0.72	0.70
160.96	0.78	0.50	0.38	0.94	0.72	0.42	0.31	0.73	0.65	0.60	0.78	0.74	0.72
160.98	0.83	0.58	0.52	0.96	0.80	0.53	0.45	0.83	0.79	0.75	0.81	0.77	0.75
170.91	0.63	0.34	0.25	0.89	0.58	0.28	0.20	0.52	0.43	0.42	0.72	0.67	0.65
170.94	0.69	0.41	0.32	0.92	0.64	0.34	0.26	0.59	0.51	0.48	0.74	0.69	0.67
170.97	0.75	0.49	0.39	0.95	0.70	0.41	0.32	0.70	0.64	0.61	0.77	0.71	0.70
180.78	0.50	0.37	0.34	0.75	0.44	0.30	0.27	0.41	0.37	0.34	0.61	0.55	0.55
180.83	0.59	0.45	0.42	0.80	0.52	0.38	0.35	0.45	0.41	0.39	0.63	0.56	0.55
180.87	0.66	0.54	0.52	0.85	0.61	0.47	0.44	0.54	0.50	0.47	0.65	0.57	0.56
190.70	0.33	0.19	0.16	0.65	0.28	0.15	0.13	0.33	0.21	0.19	0.76	0.72	0.71
190.77	0.37	0.21	0.18	0.72	0.32	0.17	0.15	0.36	0.23	0.21	0.77	0.72	0.72
190.85	0.41	0.22	0.20	0.81	0.36	0.19	0.17	0.39	0.25	0.23	0.79	0.73	0.72
200.68	0.33	0.19	0.17	0.65	0.29	0.18	0.16	0.18	0.11	0.10	0.88	0.86	0.86
200.73	0.36	0.20	0.18	0.70	0.33	0.19	0.17	0.23	0.13	0.11	0.89	0.87	0.86
200.80	0.39	0.21	0.19	0.77	0.36	0.20	0.18	0.27	0.15	0.12	0.89	0.87	0.86
210.67	0.33	0.20	0.18	0.65	0.31	0.19	0.17	0.20	0.18	0.17	0.96	0.96	0.96
210.71	0.35	0.21	0.19	0.69	0.33	0.20	0.18	0.23	0.19	0.18	0.97	0.96	0.96
210.76	0.37	0.22	0.20	0.74	0.35	0.21	0.19	0.25	0.20	0.19	0.97	0.96	0.96
221.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
221.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
221.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
231.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
231.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
240.94	0.79	0.70	0.69	0.77	0.62	0.53	0.52	0.54	0.47	0.45	0.94	0.89	0.88
240.94	0.79	0.70	0.69	0.77	0.62	0.53	0.52	0.54	0.47	0.45	0.94	0.89	0.88

24	0.94	0.79	0.70	0.69	0.77	0.62	0.53	0.52	0.54	0.47	0.45	0.94	0.89	0.88
25	0.68	0.61	0.59	0.59	0.68	0.57	0.56	0.56	0.33	0.30	0.30	0.85	0.84	0.84
25	0.68	0.61	0.59	0.59	0.68	0.57	0.56	0.56	0.33	0.30	0.30	0.85	0.84	0.84
25	0.68	0.61	0.59	0.59	0.68	0.57	0.56	0.56	0.33	0.30	0.30	0.85	0.84	0.84
1	6.700		2.200		3.860		0.010		0.640	3.850		0.840		0.026 00015622
2	7.751		1.900		3.510		0.021		1.280	4.550		0.800		0.026 00015722
3	7.900		1.970		3.270		0.030		1.250	4.650		0.710		0.028 00015822
4	7.351		2.000		3.120		0.041		1.160	4.150		0.550		0.027 00015922
5	7.248		1.750		3.010		0.058		1.140	4.300		0.450		0.035 00016022
6	8.257		1.640		2.950		0.107		1.160	5.350		0.350		0.042 00016122
7	9.867		1.630		2.910		0.167		0.950	7.120		0.230		0.066 00016222
8	11.300		1.680		2.890		0.240		0.750	8.630		0.130		0.090 00016322
9	12.239		1.700		2.880		0.289		0.550	9.700		0.070		0.097 00016422
10	13.451		1.750		2.870		0.561		0.250	10.890		0.040		0.113 00016522
11	14.130		1.800		2.870		0.810		0.100	11.420		0.020		0.120 00016622
12	16.500		2.500		2.870		1.250	-0.		12.750		0.010		0.137 00016722
13	18.000		3.400		2.870		1.900	-0.		12.700		0.		0.136 00016822
14	19.500		4.200		2.870		2.600	-0.		12.700		0.		0.137 00016922
15	26.000		7.600		2.870		5.000	-0.		13.400		0.		0.144 00017022
16	36.500		13.000		2.870		9.100	-0.		14.400		0.		0.155 00017122
17	48.000		19.000		2.870		14.000	-0.		15.000		0.		0.162 00017222
18	102.000		41.000		2.870		41.000	-0.		20.000		0.		0.216 00017322
19	68.000		22.000		2.870		31.000	-0.		15.000		0.		0.162 00017422
20	184.000		100.000		2.870		72.000	-0.		12.000		0.		0.129 00017522
21	90.500		45.000		2.870		35.000	-0.		10.500		0.		0.113 00017622
22	23.000		12.000		2.870		1.000	-0.		10.000		0.		0.108 00017722
23	38.000		24.000		2.870		3.000	-0.		11.000		0.		0.119 00017822
24	189.000		103.000		2.870		73.000	-0.		13.300		0.		0.143 00017922
25	2896.000		1670.000		2.870		1210.000	-0.		15.700		0.		0.169 00018022
26	1038.000		742.000		2.870		286.000	-0.		9.500		0.		-0. 00018122
1	0.00	0.00	0.04	0.15	0.26	0.37	0.18	0.07	0.03	0.01				
2	0.01	0.05	0.20	0.36	0.36	0.18	0.08	0.03	0.01					
3	0.04	0.15	0.31	0.40	0.22	0.09	0.03	0.01						
4	0.10	0.20	0.42	0.27	0.12	0.04	0.01							
5	0.30	0.43	0.23	0.13	0.04	0.01								
6	0.59	0.44	0.09	0.03	0.01									
7	0.76	0.16	0.02	0.01										
8	0.60	0.15												
9	0.43	0.12												
10	0.11	0.14												
11	0.10													
0														

SAMPLE CASE FOR F C C									
0	0	1	1	1	4	2	1	5	1
10.0	600.		400.		1.05			.0000001	
0					1		1		
.0229103	.0509118								
900.	900.								
4	4	5	13						
2									
1	2								
.0229103	.0509118								
.0

W. W. LITTLE, JR.
R. W. HARDIE

INPUT DATA LISTED BELOW

NUCLIDE NUMBER	NAME	ATM WEIGHT	LAMBDA(DAYS-1)	MEV/FISSION	SOURCE ELEMENT FOR DECAY	CAPTURE	FISSION
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1	PU239	2.3905+02	0.0000	2.0700+02	0 0 0		
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NON-BURNABLE NUCLIDES

2	OXYGEN	1.6000+01					
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GROUP	FISSION SOURCE	ENERGY LIMIT	VELOCITY
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1	2.0000-02	6.5000+00	3.5311+09
2	9.8000-02	4.0000+00	2.7700+09
3	1.9000-01	2.5000+00	2.1899+09
4	2.6800-01	1.4000+00	1.6388+09
5	1.9600-01	8.0000-01	1.2388+09
6	1.3500-01	4.0000-01	8.7595+08
7	5.8000-02	2.0000-01	6.1939+08
8	2.2000-02	1.0000-01	4.3798+08
9	9.0000-03	4.6500-02	2.9866+08
10	3.0000-03	2.1500-02	2.0308+08
11	1.0000-03	1.0000-02	1.3850+08
12	0.0000	4.6500-03	9.4444+07
13	0.0000	2.1500-03	6.4220+07
14	0.0000	1.0000-03	4.3798+07
15	0.0000	4.6500-04	2.9866+07
16	0.0000	2.1500-04	2.0308+07
17	0.0000	1.0000-04	1.3850+07
18	0.0000	4.6500-05	9.4444+06
19	0.0000	2.1500-05	6.4220+06
20	0.0000	1.0000-05	4.3798+06
21	0.0000	4.6500-06	2.9866+06
22	0.0000	2.1500-06	2.0308+06
23	0.0000	1.0000-06	1.3850+06
24	0.0000	4.6500-07	9.4444+05
25	0.0000	2.1500-07	6.4220+05
26	0.0000	2.5200-08	2.1986+05

SUM	1.00000+00		
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MICROSCOPIC CROSS SECTIONS FOR PU-239

NUCLIDE NUMBER 1

GROUP	SIGT	SIGF	NU	SIGC	SIGIN	SIGEL	MUEL	SIGDEL
1	6.700	2.200	3.860	.010	.640	3.850	.840	.026
2	7.751	1.900	3.510	.021	1.280	4.550	.800	.026
3	7.900	1.970	3.270	.030	1.250	4.650	.710	.028
4	7.351	2.000	3.120	.041	1.160	4.150	.550	.027
5	7.248	1.750	3.010	.058	1.140	4.300	.450	.035
6	8.257	1.640	2.950	.107	1.160	5.350	.350	.042
7	9.867	1.630	2.910	.167	.950	7.120	.230	.066
8	11.300	1.680	2.890	.240	.750	8.630	.130	.090
9	12.239	1.700	2.880	.289	.550	9.700	.070	.097
10	13.451	1.750	2.870	.561	.250	10.890	.040	.113
11	14.130	1.800	2.870	.810	.100	11.420	.020	.120
12	16.500	2.500	2.870	1.250	-.000	12.750	.010	.137
13	18.000	3.400	2.870	1.900	-.000	12.700	.000	.136
14	19.500	4.200	2.870	2.600	-.000	12.700	.000	.137
15	26.000	7.600	2.870	5.000	-.000	13.400	.000	.144
16	36.500	13.000	2.870	9.100	-.000	14.400	.000	.155
17	48.000	19.000	2.870	14.000	-.000	15.000	.000	.162
18	102.000	41.000	2.870	41.000	-.000	20.000	.000	.216
19	68.000	22.000	2.870	31.000	-.000	15.000	.000	.162
20	184.000	100.000	2.870	72.000	-.000	12.000	.000	.129
21	90.500	45.000	2.870	35.000	-.000	10.500	.000	.113
22	23.000	12.000	2.870	1.000	-.000	10.000	.000	.108
23	38.000	24.000	2.870	3.000	-.000	11.000	.000	.119
24	189.000	103.000	2.870	73.000	-.000	13.300	.000	.143
25	2896.000	1670.000	2.870	1210.000	-.000	15.700	.000	.169
26	1038.000	742.000	2.870	286.000	-.000	9.500	.000	-.000

INELASTIC SCATTERING MATRIX FOR PU-239

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

RESONANCE SELF-SHIELDING COEFFICIENTS FOR PU-239

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	.980	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	.980	.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	.980	.830	.530	.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	.780	.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	.680	.330	.190	.170	.650	.290	.180	.160	.180	.110	.100	.880	.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
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
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
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	.680	.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

MICROSCOPIC CROSS SECTIONS FOR 0 NUCLIDE NUMBER 2

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

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	.880	.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	1.000	1.000	1.000	1.000	1.000	1.000

* * * * RESULTS OF CROSS SECTION CHECK * * * *

COMMENTS . . .

1 CHECK PU-239 GROUP 1 PRESUMABLY SIGMA (N,2N) = 4.200000-01

SAMPLE CASE FOR F C C

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

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

ITERATION	PU-239	O
0	7.7308+00	8.4794+01
1	7.6180+00	5.6761+01
2	7.6180+00	5.6761+01
3	7.6180+00	5.6761+01
4	7.6180+00	5.6761+01
5	7.6180+00	5.6761+01

CALCULATED RESONANCE SELF-SHIELDING COEFFICIENTS ARE LISTED BELOW FOR PU-239

GROUP	SIG0	FF	FC	FT	FE
1	.2466+01	1.00000	1.00000	1.00000	1.00000
2	.3091+01	1.00000	1.00000	1.00000	1.00000
3	.3932+01	1.00000	1.00000	1.00000	1.00000
4	.3643+01	1.00000	1.00000	1.00000	1.00000
5	.9178+01	1.00000	1.00000	1.00000	1.00000
6	.1065+02	1.00000	1.00000	1.00000	1.00000
7	.8444+01	1.00000	1.00000	1.00000	1.00000
8	.7778+01	1.00000	1.00000	1.00000	1.00000
9	.7889+01	1.00000	1.00000	1.00000	1.00000
10	.8000+01	.97952	.99048	.99952	1.00000
11	.8111+01	.96818	.98091	.99909	1.00000
12	.8222+01	.92745	.94255	.98787	.98957
13	.8333+01	.86683	.87515	.95644	.95921
14	.8333+01	.77644	.76950	.89446	.86921
15	.8333+01	.63565	.59663	.80089	.79921
16	.8333+01	.49525	.44296	.64089	.73921
17	.8333+01	.40644	.36613	.50327	.68921
18	.8333+01	.44881	.40455	.40881	.55960
19	.8333+01	.20881	.20286	.22762	.72000
20	.8333+01	.19921	.22207	.13238	.86960
21	.8333+01	.20921	.23167	.19040	.96000
22	.8333+01	1.00000	1.00000	1.00000	1.00000
23	.8333+01	1.00000	1.00000	1.00000	1.00000
24	.8333+01	.69960	.54861	.47238	.88960
25	.8333+01	.59000	.57742	.31029	.84000
26	.8333+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	.3488+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	.6326+01	1.00000	1.00000	1.00000	1.00000
12	.7251+01	1.00000	1.00000	1.00000	1.00000
13	.7556+01	1.00000	1.00000	1.00000	1.00000
14	.7335+01	1.00000	1.00000	1.00000	1.00000
15	.8336+01	1.00000	1.00000	1.00000	1.00000
16	.9501+01	1.00000	1.00000	1.00000	1.00000
17	.1043+02	1.00000	1.00000	1.00000	1.00000
18	.2078+02	1.00000	1.00000	1.00000	1.00000
19	.9757+01	1.00000	1.00000	1.00000	1.00000
20	.2086+02	1.00000	1.00000	1.00000	1.00000
21	.1242+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	.5577+02	1.00000	1.00000	1.00000	1.00000
25	.7637+03	1.00000	1.00000	1.00000	1.00000
26	.4669+03	1.00000	1.00000	1.00000	1.00000

MICROSCOPIC CROSS SECTIONS FOR PU-239 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	8.492	3.466	.590	.000	.000	.000	.000	.000	.000
2	1.900	1.921	6.669	4.111	.894	.026	.000	.000	.000	.000	.000
3	1.970	2.000	6.442	4.598	1.361	.076	.040	.000	.000	.000	.000
4	2.000	2.041	6.240	5.068	1.940	.178	.200	.150	.000	.000	.000
5	1.750	1.808	5.267	5.313	2.630	.227	.310	.360	.260	.000	.000
6	1.640	1.747	4.838	6.384	4.026	.465	.420	.400	.360	.320	.000
7	1.630	1.797	4.743	8.229	6.176	.482	.230	.270	.220	.180	.180
8	1.680	1.920	4.855	10.178	8.018	.226	.090	.130	.120	.090	.080
9	1.700	1.989	4.896	11.560	9.354	.240	.020	.030	.040	.040	.030
10	1.714	2.270	4.920	13.007	10.485	.217	-.000	.010	.010	.010	.010
11	1.743	2.537	5.002	13.888	11.230	.253	-.000	-.000	-.000	-.000	-.000
12	2.319	3.497	6.654	16.172	12.540	.120	-.000	-.000	-.000	-.000	-.000
13	2.947	4.610	8.459	17.216	12.475	.136	-.000	-.000	-.000	-.000	-.000
14	3.261	5.262	9.359	17.442	12.061	.130	-.000	-.000	-.000	-.000	-.000
15	4.831	7.814	13.865	20.823	12.894	.119	.000	-.000	-.000	-.000	-.000
16	6.438	10.469	18.478	23.393	12.809	.115	.000	.000	-.000	-.000	-.000
17	7.722	12.848	22.163	24.157	11.197	.115	.000	.000	.000	-.000	-.000
18	18.401	34.988	52.812	41.699	6.590	.112	.000	.000	.000	.000	-.000
19	4.594	10.883	13.184	15.478	4.479	.121	.000	.000	.000	.000	.000
20	19.921	35.910	57.173	24.357	-11.665	.117	.000	.000	.000	.000	.000
21	9.414	17.523	27.019	17.231	-.401	.112	.000	.000	.000	.000	.000
22	12.000	13.000	34.440	23.000	9.892	.108	.000	.000	.000	.000	.000
23	24.000	27.000	63.880	38.000	10.881	.108	.000	.000	.000	.000	.000
24	72.059	112.108	206.810	89.279	-22.956	.119	.000	.000	.000	.000	.000
25	985.300	1683.978	2827.811	898.611	-785.510	.127	.000	.000	.000	.000	.000
26	742.000	1028.000	2129.540	1038.000	10.000	.142	.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 0 NUCLEIDE 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	.570	.243	.000	.000	.000	.000	.000
3	.000	.003	.000	1.247	.854	.368	.020	.000	.000	.000	.000
4	.000	-.000	.000	1.248	.943	.389	-.000	.050	.000	.000	.000
5	.000	-.000	.000	3.622	2.789	.304	-.000	-.000	.050	.000	.000
6	.000	-.000	.000	3.431	2.764	.834	-.000	-.000	-.000	.030	.000
7	.000	-.000	.000	3.268	2.488	.667	-.000	-.000	-.000	-.000	.010
8	.000	-.000	.000	3.360	2.751	.780	-.000	-.000	-.000	-.000	-.000
9	.000	-.000	.000	3.408	2.855	.609	-.000	-.000	-.000	-.000	-.000
10	.000	-.000	.000	3.456	2.895	.553	-.000	-.000	-.000	-.000	-.000
11	.000	-.000	.000	3.504	2.935	.561	-.000	-.000	-.000	-.000	-.000
12	.000	-.000	.000	3.552	2.975	.569	-.000	-.000	-.000	-.000	-.000
13	.000	-.000	.000	3.600	3.016	.577	-.000	-.000	-.000	-.000	-.000
14	.000	-.000	.000	3.600	3.016	.584	-.000	-.000	-.000	-.000	-.000
15	.000	-.000	.000	3.600	3.016	.584	.000	-.000	-.000	-.000	-.000
16	.000	-.000	.000	3.600	3.016	.584	.000	.000	-.000	-.000	-.000
17	.000	-.000	.000	3.600	3.016	.584	.000	.070	.000	-.000	-.000
18	.000	-.000	.000	3.600	3.016	.584	.000	.000	.000	.000	-.000
19	.000	-.000	.000	3.600	3.016	.584	.000	.000	.000	.000	.000
20	.000	-.000	.000	3.600	3.016	.584	.000	.000	.000	.000	.000
21	.000	-.000	.000	3.600	3.016	.584	.000	.000	.000	.000	.000
22	.000	-.000	.000	3.600	3.016	.584	.000	.000	.000	.000	.000
23	.000	-.000	.000	3.600	3.016	.584	.000	.000	.000	.000	.000
24	.000	-.000	.000	3.600	3.016	.584	.000	.000	.000	.000	.000
25	.000	-.000	.000	3.600	3.016	.584	.000	.000	.000	.000	.000
26	.000	-.000	.000	3.600	3.600	.584	.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 POWER OF 4.00000+02 MWt.

AVERAGE CROSS SECTIONS WILL BE EVALUATED AT K(T). NO ADJUSTMENT FOR CRITICALITY.

THE CONVERGENCE CRITERION ON THE MARCH-OUT ALGORITHM IS 1.00000-07

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	PU-239	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 = 4.000000+02 MWT

NEUTRON FLUX = 4.912440+14 N/CM2-SEC

BREEDING RATIO = 0.000000

GEOMETRIC BUCKLING = 5.671404-02 CM-2

SPHERICAL RADIUS = 1.319181+01 CM

55

* * * 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	PU-239	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) = 6.16678+13
 NEUTRON FISSION RATE(PER CC PER SEC) = 2.01288+13
 NEUTRON ABSORPTION RATE(PER CC PER SEC) = 2.14662+13
 NEUTRON LEAKAGE RATE(PER CC PER SEC) = 3.72650+13
 NEUTRON GENERATION TIME(SECONDS) = 9.53733-09
 TOTAL NEUTRON LEAKAGE FROM CORE = 0.00000

GROUP	FLUX	NU*SIGF*FLUX	SIGF*FLUX	INTG FLUX	ADJOINT	CHI*ADJOINT	DENSITY
1	4.64548+12	9.03798+11	2.34145+11	9.45656-03	9.59592-01	1.91918-02	1.31560+03
2	2.57444+13	3.93345+12	1.12064+12	6.18631-02	9.04853-01	8.86756-02	9.29400+03
3	5.67351+13	8.37330+12	2.56064+12	1.77356-01	9.67944-01	1.83909-01	2.59079+04
4	8.96155+13	1.28115+13	4.10624+12	3.59782-01	9.88054-01	2.64798-01	5.46852+04
5	3.46350+13	1.02138+13	3.39327+12	5.32069-01	1.16226+00	2.27804-01	6.33212+04
6	9.57120+13	1.06087+13	3.59618+12	7.26905-01	1.14039+00	1.53952-01	1.09266+05
7	6.51744+13	7.08253+12	2.43386+12	8.59577-01	1.17789+00	6.83178-02	1.05223+05
8	3.99595+13	4.44486+12	1.53801+12	9.40920-01	1.23397+00	2.71473-02	9.12369+04
9	1.89004+13	2.12003+12	7.36123+11	9.79395-01	1.25457+00	1.12911-02	6.32840+04
10	7.12116+12	8.02625+11	2.79660+11	9.93391-01	1.22758+00	3.68273-03	3.50657+04
11	2.37181+12	2.71783+11	9.46979+10	9.98719-01	1.23022+00	1.23022-03	1.71250+04
12	5.12169+11	7.80830+10	2.72066+10	9.99762-01	1.34875+00	0.00000	5.42297+03
13	9.72534+10	1.88465+10	6.56674+09	9.99960-01	1.40552+00	0.00000	1.51438+03
14	1.71603+10	3.67955+09	1.28207+09	9.99995-01	1.42544+00	0.00000	3.91611+02
15	2.32080+09	7.37188+08	2.56860+08	9.99999-01	1.53770+00	0.00000	7.77071+01
16	2.51670+08	1.06540+08	3.71218+07	1.00000+00	1.58900+00	0.00000	1.23926+01
17	2.31146+07	1.17367+07	4.08945+06	1.00000+00	1.57551+00	0.00000	1.66893+00
18	8.77391+05	1.06158+06	3.69890+05	1.00000+00	1.46475+00	0.00000	9.29003-02
19	8.99945+04	2.71836+04	9.47165+03	1.00000+00	1.11099+00	0.00000	1.40135-02
20	3.31201+03	4.33822+03	1.51157+03	1.00000+00	1.54246+00	0.00000	7.56209-04
21	2.29399+02	1.42002+02	4.94781+01	1.00000+00	1.49539+00	0.00000	7.68095-05
22	2.07221+01	1.63504+01	5.69700+00	1.00000+00	2.43335+00	0.00000	1.02032-05
23	9.97635-01	1.57433+00	5.48547-01	1.00000+00	2.44804+00	0.00000	7.20314-07
24	1.24091-02	5.87951-02	2.04861-02	1.00000+00	1.83668+00	0.00000	1.31390-08
25	1.04914-05	6.79696-04	2.36828-04	1.00000+00	1.67954+00	0.00000	1.63367-11
26	1.46930-08	7.16846-07	2.49772-07	1.00000+00	2.07147+00	0.00000	6.68282-14
SUM	4.91244+14	6.16678+13	2.01288+13		3.72119+01	1.05000+00	5.88146+05

SAMPLE CASE FOR F C C

THE MACROSCOPIC CROSS SECTIONS ARE GIVEN IN THE TABLE BELOW

GROUP	SIGF	SIGA	MUSIGF	SIGTR	SIGXG	G-1XG	G-2XG	G-3XG	G-4XG	G-5XG	G-6XG
1	5.04-02	5.21-02	1.95-01	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	1.53-01	1.46-01	4.95-02	1.30-02	0.00	0.00	0.00	0.00	0.00
3	4.51-02	4.60-02	1.48-01	1.69-01	7.47-02	2.05-02	1.93-03	0.00	0.00	0.00	0.00
4	4.58-02	4.68-02	1.43-01	1.80-01	9.25-02	2.39-02	4.58-03	5.98-03	0.00	0.00	0.00
5	4.01-02	4.14-02	1.21-01	3.06-01	2.02-01	2.07-02	7.10-03	8.25-03	8.50-03	0.00	0.00
6	3.76-02	4.00-02	1.11-01	3.21-01	2.33-01	5.31-02	9.62-03	9.16-03	8.25-03	8.86-03	0.00
7	3.73-02	4.12-02	1.09-01	3.55-01	2.68-01	4.50-02	5.27-03	6.19-03	5.04-03	4.12-03	4.63-03
8	3.85-02	4.40-02	1.11-01	4.04-01	3.24-01	4.49-02	2.06-03	2.98-03	2.75-03	2.06-03	1.83-03
9	3.89-02	4.56-02	1.12-01	4.38-01	3.60-01	3.65-02	4.58-04	6.87-04	9.16-04	9.16-04	6.87-04
10	3.93-02	5.20-02	1.13-01	4.74-01	3.88-01	3.31-02	0.00	2.29-04	2.29-04	2.29-04	2.29-04
11	3.99-02	5.51-02	1.15-01	4.97-01	4.07-01	3.44-02	0.00	0.00	0.00	0.00	0.00
12	5.31-02	8.01-02	1.52-01	5.51-01	4.39-01	3.17-02	0.00	0.00	0.00	0.00	0.00
13	6.75-02	1.06-01	1.94-01	5.78-01	4.39-01	3.25-02	0.00	0.00	0.00	0.00	0.00
14	7.47-02	1.21-01	2.14-01	5.83-01	4.30-01	3.27-02	0.00	0.00	0.00	0.00	0.00
15	1.11-01	1.79-01	3.18-01	6.60-01	4.49-01	3.25-02	0.00	0.00	0.00	0.00	0.00
16	1.48-01	2.40-01	4.23-01	7.19-01	4.47-01	3.24-02	0.00	0.00	0.00	0.00	0.00
17	1.77-01	2.94-01	5.06-01	7.37-01	4.10-01	3.24-02	0.00	0.00	0.00	0.00	0.00
18	4.22-01	6.02-01	1.21+00	1.14+00	3.05-01	3.23-02	0.00	0.00	0.00	0.00	0.00
19	1.05-01	2.49-01	3.02-01	5.38-01	2.56-01	3.25-02	0.00	0.00	0.00	0.00	0.00
20	4.56-01	8.23-01	1.31+00	7.41-01	-1.14-01	3.24-02	0.00	0.00	0.00	0.00	0.00
21	2.16-01	4.01-01	6.19-01	5.78-01	1.44-01	3.23-02	0.00	0.00	0.00	0.00	0.00
22	2.75-01	2.98-01	7.89-01	7.10-01	3.80-01	3.22-02	0.00	0.00	0.00	0.00	0.00
23	5.50-01	6.19-01	1.58+00	1.05+00	4.03-01	3.22-02	0.00	0.00	0.00	0.00	0.00
24	1.65+00	2.57+00	+7.74+00	2.23+00	-3.72-01	3.25-02	0.00	0.00	0.00	0.00	0.00
25	2.26+01	3.86+01	6.48+01	2.08+01	-1.78+01	3.26-02	0.00	0.00	0.00	0.00	0.00
26	1.70+01	2.35+01	4.62+01	2.40+01	4.12-01	3.30-02	0.00	0.00	0.00	0.00	0.00

GROUP	G-7XG	G-8XG	G-9XG	G-10XG
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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	PU-239	1.7885+00	1.8938+00	5.4794+00	1.0534-01
2	0	0.0000	6.0699-03	0.0000	6.0699-03

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	1.76741+14	1.93789+09	9.12027+04
2	4	4.11000-01	2.85481+14	7.63220+08	3.74048+05
3	5	1.30000-02	2.90028+13	2.36927+08	1.22412+05
4	13	0.00000	1.97569+10	4.08464+07	4.83687+02

GROUP NORMALIZATION FACTOR FOR TRANSPORT CROSS SECTIONS

1	1.00050+00
2	1.01591+00
3	1.00100+00
4	1.00082+00

SAMPLE CASE FOR F C C

CRUNCHED MICROSCOPIC CROSS SECTIONS FOR PU-239

NUCLIDE NUMBER 1

GROUP	SIGF	SIGA	NUSIGF	SIGTR	SIGXG	G-1XG	G-2XG	G-3XG	G-4XG	G-5XG	G-6XG
1	1.981	2.004	6.426	4.700	1.634	.000	.000	.000			
2	1.676	1.801	4.946	6.781	4.912	1.018	.000	.000			
3	1.722	2.138	4.953	12.144	10.006	.069	.045	.000			
4	3.492	5.638	10.022	17.861	12.223	.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	1.191	1.018	.000	.000	.000			
2	.000	.000	.000	3.490	3.405	.157	.000	.000			
3	.000	.000	.000	3.434	3.432	.085	.000	.000			
4	.000	.000	.000	3.603	3.603	.002	.000	.000			

MACROSCOPIC CROSS SECTIONS ARE PUNCHED OUT FOR 1 MIXED ISOTOPES

MIX 1

ISOTOPE	DENSITY
PU-239	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	4.54-02	4.68-02	1.47-01	1.68-01	3.92-02	0.00	0.00	0.00			
2	3.84-02	4.13-02	1.13-01	3.33-01	2.86-01	3.13-02	0.00	0.00			
3	3.95-02	4.90-02	1.13-01	4.53-01	4.04-01	5.91-03	1.03-03	0.00			
4	3.00-02	1.29-01	2.30-01	5.93-01	4.63-01	1.10-04	0.00	0.00			

SAMPLE CASE FOR F C C

T I M E = .00 D A Y S

K EFFECTIVE = 1.050000+00
TOTAL POWER = 4.000000+02 MW
NEUTRON FLUX = 4.912440+14 N/CM2-SEC
BREEDING RATIO = 0.000000
GEOMETRIC BUCKLING = 5.671404-02 CM-2
SPHERICAL RADIUS = 1.319181+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	PU-239	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) = 6.16678+13
 NEUTRON FISSION RATE(PER CC PER SEC) = 2.01288+13
 NEUTRON ABSORPTION RATE(PER CC PER SEC) = 2.14662+13
 NEUTRON LEAKAGE RATE(PER CC PER SEC) = 3.72650+13
 NEUTRON GENERATION TIME(SECONDS) = 9.53733-09
 TOTAL NEUTRON LEAKAGE FROM CORE = 0.00000

GROUP	FLUX	NU*SIGF*FLUX	SIGF*FLUX	INTG FLUX	ADJOINT	CHI*ADJOINT	DENSITY
1	1.76741+14	2.60220+13	8.02167+12	3.59782-01	9.65892-01	5.56354-01	9.12027+04
2	2.85481+14	3.23499+13	1.09613+13	9.40920-01	1.16151+00	4.77380-01	3.74048+05
3	2.90028+13	3.29137+12	1.14425+12	9.99960-01	1.25123+00	1.62660-02	1.22412+05
4	1.97569+10	4.53610+09	1.58052+09	1.00000+00	1.42544+00	0.00000	4.83687+02
SUM	4.91244+14	6.16678+13	2.01288+13		4.80407+00	1.05000+00	5.88146+05

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	1.47-01	1.68-01	8.92-02	0.00	0.00	0.00			
2	3.84-02	4.13-02	1.13-01	3.33-01	2.86-01	3.13-02	0.00	0.00			
3	3.95-02	4.90-02	1.13-01	4.53-01	4.04-01	5.91-03	1.03-03	0.00			
4	8.00-02	1.29-01	2.30-01	5.93-01	4.63-01	1.10-04	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	PU-239	1.7885+00	1.8938+00	5.4794+00	1.0534-01
2	0	0.0000	6.0699-03	0.0000	6.0699-03

SAMPLE CASE FOR F C C

T I M E = 10.00 D A Y S

K EFFECTIVE = 1.049162+00
TOTAL POWER = 4.000000+02 MWT
NEUTRON FLUX = 4.916394+14 N/CM2-SEC
BREEDING RATIO = 0.000000
GEOMETRIC BUCKLING = 5.671404-02 CM-2
SPHERICAL RADIUS = 1.319181+01 CM

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* * * 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	PU-239	2.28919-02	5.45141+03	5.45579+03	-4.38367+00

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

NEUTRON SOURCE RATE(PER CC PER SEC) = 6.16678+13
 NEUTRON FISSION RATE(PER CC PER SEC) = 2.01288+13
 NEUTRON ABSORPTION RATE(PER CC PER SEC) = 2.14663+13
 NEUTRON LEAKAGE RATE(PER CC PER SEC) = 3.73118+13
 NEUTRON GENERATION TIME(SECONDS) = 9.54507-09
 TOTAL NEUTRON LEAKAGE FROM CORE = 1.93182+25

GROUP	FLUX	NU*SIGF*FLUX	SIGF*FLUX	INTG FLUX	ADJOINT	CHI*ADJOINT	DENSITY
1	1.76880+14	2.60217+13	8.02157+12	3.59777-01	9.65015-01	5.55849-01	9.12749+04
2	2.85713+14	3.23501+13	1.09614+13	9.40919-01	1.16072+00	4.77057-01	3.74351+05
3	2.90266+13	3.29142+12	1.14427+12	9.99960-01	1.25048+00	1.62563-02	1.22512+05
4	1.97822+10	4.53827+09	1.58128+09	1.00000+00	1.42506+00	0.00000	4.84307+02
SUM	4.91639+14	6.16678+13	2.01288+13		4.80128+00	1.04916+00	5.88623+05

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	4.67-02	1.47-01	1.68-01	8.92-02	0.00	0.00	0.00			
2	3.84-02	4.12-02	1.13-01	3.33-01	2.86-01	3.13-02	0.00	0.00			
3	3.94-02	4.89-02	1.13-01	4.53-01	4.04-01	5.91-03	1.03-03	0.00			
4	7.99-02	1.29-01	2.29-01	5.92-01	4.63-01	1.10-04	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	PU-239	1.7885+00	1.8938+00	5.4794+00	1.0534-01
2	0	0.0000	6.0698-03	0.0000	6.0698-03

MIX 1

.453867-01	.467657-01	.147233-00	.168326-00	.892300-01	.000000
.000000	.000000				
.383960-01	.412549-01	.113317+00	.333051-00	.285883-00	.312977-01
.000000	.000000				
.394533-01	.489868-01	.113485+00	.453057-00	.403961-00	.591328-02
.103258-02	.000000				
.799986-01	.129171-00	.229596-00	.592637-00	.463466-00	.109722-03
.000000	.000000				

PU-239

26 GROUPS

9	2.200	1.790	8.492	3.466	.590	.000	.000	.000
9	.000	.000	.000	.000	.000	.000	.000	.000
9	1.900	1.921	6.669	4.111	.894	.026	.000	.000
9	.000	.000	.000	.000	.000	.000	.000	.000
9	1.970	2.000	6.442	4.598	1.361	.076	.040	.000
9	.000	.000	.000	.000	.000	.000	.000	.000
9	2.000	2.041	6.240	5.068	1.940	.178	.200	.150
9	.000	.000	.000	.000	.000	.000	.000	.000
9	1.750	1.808	5.267	5.313	2.630	.227	.310	.360
9	.260	.000	.000	.000	.000	.000	.000	.000
9	1.640	1.747	4.838	6.384	4.026	.465	.420	.400
9	.360	.370	.000	.000	.000	.000	.000	.000
9	1.630	1.797	4.743	8.229	6.176	.482	.230	.270
9	.270	.180	.180	.000	.000	.000	.000	.000
9	1.680	1.920	4.855	10.178	8.018	.226	.090	.130
9	.120	.090	.080	.070	.000	.000	.000	.000
9	1.700	1.989	4.896	11.560	9.354	.240	.020	.030
9	.040	.040	.030	.030	.030	.000	.000	.000
9	1.714	2.270	4.920	13.007	10.485	.217	-.000	.010
9	.010	.010	.010	.010	.010	.010	.000	.000
9	1.743	2.537	5.002	13.888	11.230	.253	-.000	-.000
9	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
9	2.319	3.497	6.654	16.172	12.540	.120	-.000	-.000
9	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
9	2.947	4.610	8.459	17.216	12.475	.136	-.000	-.000
9	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
9	3.261	5.262	9.359	17.442	12.061	.130	-.000	-.000
9	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
9	4.831	7.814	13.865	20.823	12.894	.119	.000	-.000
9	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
9	6.438	10.469	18.478	23.393	12.809	.115	.000	.000
9	-.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
9	7.722	12.848	22.163	24.157	11.197	.115	.000	.000
9	.000	-.000	-.000	-.000	-.000	-.000	-.000	-.000
9	18.401	34.988	52.812	41.699	6.590	.112	.000	.000
9	.000	.000	-.000	-.000	-.000	-.000	-.000	-.000
9	4.594	1.883	13.184	15.478	4.479	.121	.000	.000

9	19.921	35.910	57.173	24.357	-11.665	-	.000
9	.000	.000	.000	.000	-	.117	.000
9	9.414	17.523	27.019	17.231	-	.000	.000
9	.000	.000	.000	.000	-	.112	.000
9	12.000	13.000	34.440	23.000	9.892	-	.000
9	.000	.000	.000	.000	-	.108	.000
9	24.000	27.000	68.880	38.000	10.881	-	.000
9	.000	.000	.000	.000	-	.108	.000
9	72.059	112.108	206.810	89.279	-22.956	.000	.000
9	.000	.000	.000	.000	-	.119	.000
9	985.300	1683.978	2827.811	898.611	-785.510	.000	.000
9	.000	.000	.000	.000	-	.127	.000
9	742.000	1028.000	2129.540	1038.000	10.000	.000	.000
9	.000	.000	.000	.000	-	.142	.000
						.000	.000

APPENDIX E
FORTRAN IV SOURCE DECK LISTING

```

- TEL BNW    JOB U0547 TAPES U0352RI
-   RUN 500547,CUS485,5,50          R W HARDIE          RW HARDIE
-R ASG A=U0352
- XQT CUR
IN A
TRW A
- ABS MAIN,FCC
- XQT CUR
TOC
OUT A
TEF A
TRI A
-IL PDP INCL
ABC* FCOPY
  DIMENSION  HOLN(14), ATW(14), ALAM(10), FEF(10),FSSF(14,26),
1FSSC(14,26), FSST(14,26), CHI(26), EL(26), PHI(26), VEL(26),
2FSSE(14,26), FC(14,78,6), FF(14,78,4), FT(14,78,4), FE(14,78,4),
3SF(14,4), SC(14,6), ST(14,4), SE(14,4), SR(14,8,26), SM(14,12,11),
4HF(4), HC(6), HT(4), HE(4), TEMP(14), HOL(12), DN(14), SOGO(14),
5SIGO(14,26), SORCE(14),AVSIG(14),SN(15,26), FPHI(26), S(14,15,26),
6DNMI(14), DNM(14), ACS(14,4), TFX(26), DENP(26), CHIP(26),
7SG(14,15,26), CXX(26), DEN(26), SIGR(26), ADJ(26), AN(14,2)
3, DNSO(14, 15), SL(15, 26), VELP(26)
  DIMENSION  LD(10), LC(10), LCN(10,4), LF(10), LFN(10,7), NT(14),
1NGD(14), NGE(14), NFT(14), NPFF(14), NPFC(14), NPFT(14), NPFE(14),
2LN(14), LBSN(5), LBLN(5), NG(14,78), NPN(26), NV(26)
3, NBUN(14), NISO(14, 14)
  COMMON  T, H, TOTL, VOL, EPSL, HS, AK, BSQ, POW, FLX, FPS, RS,
1RL, RA, TAK, RF, BR, AN
  COMMON  NRCF, NPRTG, NUMT, NOP, NCR, NGP, NXCM, NBE, NNE,
1NP, NFD, NXS, NSOP, NTI, NFP, NSP, NPRT, NAVX, NPUN,
2NOPP, LBS, LBL, LSMFT, NCAL, NXCMP, NXX,NSN , NMG, LST, NPSS
  COMMON  LD, LC, LCN, LF, LFN, NT, NGD, NGE, NFT, NPFF, NPFC, NPFT,
1NPFE, LN, LBSN, LBLN, NG, NPN, NV, NBUN, NISO
  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,
2CXX, DEN, SIGR, ADJ, DNSO, SL, VELP, FEF, FSSF, FSSC, FSST,
3FSSE, FC, FF, FT, FE, SF, SC, ST, SE, SOGO, SIGO, SORCE, SR, SM
4,TFX
  END
-ITC FOR MAIN,MAIN
  INCLUDE ABC
  CALL SETIO (3, 2)
  CALL SETIO(2, 1)
  LST = 1
  CALL INPUT1
  CALL PRINT1
1  CONTINUE

```

```

      LCR = 1
      IF(NRCF - 1) 2, 4, 4
2     CALL REDXS
      CALL INPUT2
      GO TO 90
4     CONTINUE
      IF(LST) 90, 90, 89
89    CONTINUE
      CALL INPUT2
90    CONTINUE
      IF(NRCF) 6, 6, 5
5     IF(LST) 7, 7, 51
51    CONTINUE
      CALL CHECK
7     CONTINUE
      CALL RCINP2
6     CALL PRINT2
      CALL START
      NPRTG = 10000
      T = .0
      NN = 1
      IF(NUMT) 11, 11, 212
212   DO 8 NN = 1, NUMT
      NPRTG = NPRTG + 1
      CALL AVXS
      CALL NORM
      IF(NN - 1) 112, 112, 115
112   CONTINUE
      IF(NCR - NGP) 113, 115, 115
113   CALL PRINT3
      CALL CRXS1
      LCR = 0
115   CONTINUE
      IF(NOP) 100, 100, 101
100   NOP = 1
101   IF(NPRTG - NPRT) 16, 12, 12
12    CALL PRINT3
15    NPRTG = 0
16    T = T + H
      CALL MARCH
8     CONTINUE
11    CONTINUE
      CALL AVXS
      CALL NORM
      CALL PRINT3
      IF(NN - 1) 232, 232, 235
232   CONTINUE
      IF(NCR - NGP) 233, 235, 235

```

```

233 CALL CRXS1
    LCR = 0
    CALL PRINT3
235 CONTINUE
    IF(LCR) 401, 401, 450
401 CONTINUE
    JJ = NXCMP + 5
    NPUN = NPSS
    NGP = NMG
    NXCM = NXX
    DO 205 I = 1, NCR
    DO 202 K = 1, NXS
    DO 202 J = 1, JJ
202 S(K, J, I) = SG(K, J, I)
    VEL(I) = EL(I)
    PHI(I) = TFX(I)
205 CHI(I) = CXX(I)
450 CONTINUE
    IF(NPUN) 20, 20, 19
19 CALL PUNCH
20 CONTINUE
    LST = 0
    GO TO 1
END

```

```

1100 GO TO INP011,INP011
1101 DO UNTIL INP011
      INCLUDE SRC
      READ(2,2) NGP, NAC, NDE, NEE, NRCF, LP, LFD
1102   FORMAT(7I5)
      NXS = NDE + NEE
      DO 4 J = 1,NXS
      READ (2,3) FOLN(J),ATR(J),ALPH(J),FEF(J),LD(J),LL(J),
1103 1(LCH(J,1),K=1,4), LF(J),(LEN(J,K),K=1,7)
      FORMAT (A6,3E6.1,14I3)
1104   CONTINUE
      IF(NNE) 61, 61, 42
1105   CONTINUE
      KK = NDE + 1
      DO 6 J = KK, NXS
      READ (2,5) FOLN(J), ATR(J)
1106   FORMAT (A6,E6.1)
1107   CONTINUE
1108   CONTINUE
      READ (2,9) (CHI(I), I=1,NGP)
      READ (2,9) (LL(I), I=1,NGP)
      IF(NFD) 18, 18, 8
1109   READ(2,9) (PHI(I), I = 1, NGP)
1110   CONTINUE
      DO 12 I = 1, NGP
1111   VEL(I) = 1.385E10.**9*SQRT (EL(I))
1112   FORMAT (6E12.4)
1113   RETURN
1114   END

```

81


```

GG = 24. * 3600.
DO 6J = 1, NBE
KK = LC(J)
KKK = LF(J)
WRITE (3,4) J, HOLN(J), ATW(J), ALAM(J), FEF(J), LD(J),
1 (LCN(J,K), K=1, KK), (LEN(J,K), K=1, KKK)
4   FORMAT (I8, 7H          , A6, 1P3E16.4, I7, 11I3)
   WRITE (3,5)
5   FORMAT (1H0)
   ALAM(J) = ALAM(J)/GG
6   CONTINUE
   IF(NNE) 15, 15, 9
9   CONTINUE
   WRITE (3,8)
8   FORMAT (32H0          NON-BURNABLE NUCLIDES///)
   KK = NBE + 1
   DO 14 J = KK, NXS
   WRITE (3,10) J, HOLN(J), ATW(J)
10  FORMAT (I8, 7H          , A6, 1P3E16.4)
   WRITE (3,5)
14  CONTINUE
15  CONTINUE
   G = .0
   IF(NFD) 19, 19, 30
19  WRITE (3, 20)
20  FORMAT (52H1  GROUP FISSION SOURCE ENERGY LIMIT VELOCITY///
1/)
   DO 24 I = 1, NGP
   WRITE (3, 22) I, CHI(I), EL(I), VEL(I)
22  FORMAT(I8, 1P4E15.4)
24  G = G + CHI(I)
   GO TO 35
30  WRITE (3, 32)
32  FORMAT (67H1  GROUP FISSION SOURCE ENERGY LIMIT VELOCITY
1 INPUT FLUX///)
   DO 34 I = 1, NGP
   WRITE (3, 22) I, CHI(I), EL(I), VEL(I), PHI(I)
34  G = G + CHI(I)
35  WRITE (3, 41) G
41  FORMAT (7H0 SUM 1P3E16.5)
   RETURN
END

```

```

-ITC FOR REDXS,REDXS
  SUBROUTINE REDXS
    INCLUDE ABC
  C    THIS SUBROUTINE CALLS RED CROSS SUBROUTINES
    IF(LST) 5, 5, 1
  1    CONTINUE
    CALL RCINP1
    IF(NP) 4, 4, 6
  4    CALL RCPRT1
  6    CALL RCCHK
  5    CONTINUE
    CALL RCINP2
    CALL RCSTUP
    IF(NSOP) 9, 9, 7
  7    CALL RCCAL1
    DO 8 M = 1, NTI
    CALL RCCAL2
    CALL RCRECL(M)
  8    CONTINUE
  9    CONTINUE
 10    CALL RCCAL2
    IF(NP) 53, 53, 55
 53    CALL RCPRT2
 55    CALL RCCSS
    RETURN
  END

```

```

-ITC  FOR RCINP1,RCINP1
      SUBROUTINE RCINP1
      INCLUDE ABC
C      THIS SUBROUTINE READS RUSSIAN CROSS SECTIONS
      DO 312 N = 1,NXS
      DO 312 I = 1,78
      IF (I - 26) 308,308,309
308  CONTINUE
      FSSF (N,I) = 1.
      FSSC (N,I) = 1.
      FSST (N,I) = 1.
      FSSE (N,I) = 1.
309  CONTINUE
      DO 312 K = 1, 6
      FC(N, I, K) = 1.0
      IF(K - 4) 310, 310, 312
310  FF(N, I, K) = 1.0
      FT(N, I, K) = 1.0
      FE(N, I, K) = 1.0
312  CONTINUE
      DO 300 I = 1, NXS
      READ ( 2, 4) HOLN(I), NT(I), NGB(I), NGE(I), NFT(I), NPFF(I),
1NPFC(I), NPFT(I), NPFE(I)
4      FORMAT(A6, 9I6)
      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( 2, 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 (12F6.4)
      GO TO 60
45  READ( 2, 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(2 , 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 = NGE(I)

```

```

111 IF(NFT(I) - 3) 150, 145, 140
140 DO 144 J = JJ, JJJ
    READ( 2, 141) NG(I,J), (FF(I, J, N), N = 1, NF), (FC(I, J, N),
1N = 1, NC), (FT(I, J, N), N = 1, NTP), (FE(I, J, N), N = 1, NE)
141 FORMAT (I2, 14E5.4)
144 CONTINUE
    GO TO 159
145 DO 149 J = JJ, JJJ
    READ ( 2, 141) NG(I, J), (FC(I, J, N), N = 1, NC),
1(FT(I, J, N), N= 1, NTP), (FE(I, J, N), N = 1, NE)
149 CONTINUE
    GO TO 159
150 DO 156 J = JJ, JJJ
    READ( 2, 141) NG(I, J), (FT(I, J, N), N = 1, NTP), (FE(I, J, N),
1N = 1, NE)
156 CONTINUE
159 CONTINUE
    DO 200 L = 1, 26
    READ( 2, 190) LLD, (SR(I, K, L), K = 1, 8)
190 FORMAT (I3, 4E9.2, 4E8.2)
200 CONTINUE
    DO 300 L = 1, 12
    READ( 2, 230) LLD, (SM(I, L, K), K = 1, 11)
230 FORMAT (I3, 11E6.1)
300 CONTINUE
    RETURN
    END

```

```

-ITC FOR PCINP2,PCINP2
SUBROUTINE PCINP2
  INCLUDE ABC
  C   THIS SUBROUTINE READS DATA FOR NEW CASE
  TOTL = .0
  READ(2,3) (HOL(I), I = 1, 12)
  3   FORMAT(12A6)
  READ(2,5) NOP,NFP,NSP,NUMT,NPRT,NCR,NAVX,NSOP,NTI,NPUN,NOPP,NBN
  5   FORMAT(12I6)
  READ(2,6) H, VOL, G, GG, EPSL
  6   FORMAT(6E12.4)
  HS = H*24.*3600.
  IF(NOP - 1) 10, 20, 10
  10  AK = GG
  BSQ = .0001
  GO TO 32
  20  IF(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(2,140) LBS, (LBSN(I), I = 1, 5), LBL, (LBLN(I), I=1, 5)
  140 FORMAT(12I6)
  READ(2,51) (DN(J), J = 1, NXS)
  IF(NRCF) 52, 52, 190
  52  READ(2,51) (TEMP(J), J = 1, NXS)
  51  .FORMAT(6E12.4)
  IF(NSOP) 70, 70, 190
  70  READ(2,51) (SOGO(J), J = 1, NXS)
  DO 170 I = 1, NXS
  DO 170 J = 1, 26
  SIGO(I, J) = SOGO(I)
  170 CONTINUE
  190 CONTINUE
  IF(NCR - NGP) 180, 200, 200
  180 READ(2,184) (NPN(K), K = 1, NCR)
  184 FORMAT(12I6)
  200 CONTINUE
  IF(NBN) 121, 121, 14
  14  READ(2,15) (NBUN(I), I = 1, NBN)
  15  FORMAT(12I6)
  DO 110 I = 1, NBN
  KK = NBUN(I)
  READ(2,15) (NISO(I, K), K = 1, KK)

```

```
110  CONTINUE
      DO 120 I = 1, NBN
      KK = NBUN(I)
      READ(2, 118) (DNSO(I, K), K = 1, KK)
118  FORMAT(6E12.6)
120  CONTINUE
121  CONTINUE
      READ (2, 210) (SORCE(I), I = 1, NBE)
210  FORMAT(6E12.4)
      RETURN
      END
```

```

-ITC FOR RCPRT1, RCPRT1
SUBROUTINE RCPRT1
  INCLUDE ABC
  THIS SUBROUTINE PRINTS RUSSIAN DATA
  DO 200 I = 1, NXS
    WRITE ( 3, 46) HOLN(I), I
46    FORMAT (32H1MICROSCOPIC CROSS SECTIONS FOR A6,21H      NUCLEIDE NUM
1BER 12////
283H GROUP SIGT      SIGF      NU      SIGC      SIGIN      SIGEL
3      MUEL      SIGDEL//)
    DO 50 L = 1, 26
    WRITE ( 3, 48) L, (SR(I, K, L), K = 1, 8)
48    FORMAT(I3, 8F10.3)
50    CONTINUE
    WRITE ( 3, 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, 12
    WRITE ( 3, 55) L, (SM(I, L, K), K = 1, 11)
55    FORMAT(I3, 11F10.3)
49    FORMAT(1H /)
54    CONTINUE
    WRITE ( 3, 60) HOLN(I)
60    FORMAT (43H1RESONANCE SELF-SHIELDING COEFFICIENTS FOR A6//)
    IF (NFT(I)) 62, 62, 64
62    WRITE ( 3, 63)
63    FORMAT(57H THE COEFFICIENTS FOR THIS ISOTOPE ARE ALL EQUAL TO UNIT
1Y//)
    GO TO 200
64    CONTINUE
    NF = NPFF(I)
    NC = NPFC(I)
    NTP = NPFT(I)
    NE = NPFE(I)
    DATA (HF(J), J=1,4)/4*2HFF/, (HC(J), J=1,6)/6*2HFC/, (HT(J), J=1,4)/
14*2HFT/, (HF(J), J=1,4)/4*2HFE/
65    IF (NT(I)) 67, 67, 70
67    WRITE (3, 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.

```

```

-ITC FOR RCCHK,RCCHK
  SUBROUTINE RCCHK
    INCLUDE ABC
  C    THIS SUBROUTINE CHECKS RUSSIAN DATA FOR CONSISTENCY
    WRITE (3,2)
  2    FORMAT (1H115X,47H * * * * RESULTS OF CROSS SECTION CHECK * * * */
    1////10X,15H COMMENTS . . .////)
    MF = 0
    DO 50 N = 1,NXS
      DO 30 I = 1,26
        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    MF = ME + 1
        IF (MF - 100) 12,85,85
      12    WRITE (3,14) ME, HOLN(N), I
      14    FORMAT (13,8H CHECK A6, 9H GROUP I2//)
      19    CONTINUE
        IF (I - 12) 20,20,30
      20    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)
        MF = ME + 1
        IF (MF - 100) 25,85,85
      25    WRITE (3,26) ME, HOLN(N), I, G
      26    FORMAT (13,8H CHECK A6,9H GROUP I2,5X,26H PRESUMABLY SIGMA (N,2
        1N) =1PE16.6//)
      30    CONTINUE
        IF (NT(N)) 31,31,32
      31    II = 26
        GO TO 33
      32    II = 78
      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)) 204,204,205
  204    IF ( FC(N,I,K) - FC(N,I,K-1) - .00001) 205,238,238
  205    IF (K-5) 208,200,300
  208    IF (K - NPFF(N)) 210,210,212
  210    IF ( FF(N,I,K) - FF(N,I,K-1) - .00001) 212,238,238
  212    IF (K - NPFT(N)) 215,215,218
  215    IF ( FT(N,I,K) - FT(N,I,K-1) - .00001) 218,238,238
  218    IF (K - NPFE(N)) 225,225,300
  225    IF ( FE(N,I,K) - FE(N,I,K-1) - .00001) 300,238,238

```



```

238 ME = ME + 1
    IF (ME - 100) 239,85,85
239 WRITE (3,240) ME, HOLN(N)
240 FORMAT (I3,15H F FACTORS IN A6,27H EXHIBIT ANOMALOUS BEHAVIOR//)
300 CONTINUE
    IF (FC(N,I,K) - 1.001) 334, 334, 38
334 IF (K - 5) 336, 40, 40
336 IF (FF(N,I,K) - 1.001) 34,38,38
34 IF (FT(N,I,K) - 1.001) 35,38,38
35 IF (FE(N,I,K) - 1.001) 40,38,38
38 ME = ME + 1
    IF (ME - 100) 39,85,85
39 WRITE (3,139) 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 = NGF(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(N,I,K) - FC(N,I+1,K) - .00001) 405,439,439
405 IF (FC(N,I+1,K) - FC(N,I+2,K) - .00001) 408,439,439
408 IF (K-5) 410,445,445
410 IF (FF(N,I,K) - FF(N,I+1,K) - .00001) 415,439,439
415 IF (FF(N,I+1,K) - FF(N,I+2,K) - .00001) 420,439,439
420 IF (FT(N,I,K) - FT(N,I+1,K) - .00001) 425,439,439
425 IF (FT(N,I+1,K) - FT(N,I+2,K) - .00001) 430,439,439
430 IF (FE(N,I,K) - FE(N,I+1,K) - .00001) 435,439,439
435 IF (FE(N,I+1,K) - FE(N,I+2,K) - .00001) 445,439,439
439 ME = ME + 1
    IF (ME - 100) 440, 85, 85
440 WRITE (3, 240) ME, HOLN(N)
445 CONTINUE
450 CONTINUE
    JJ = 3 * NGB(N) + 1
    JJJ = 3 * NGF(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 (3,48) ME, HOLN(N)
48 FORMAT(I3,22H CHECK SEQUENCING OF A6,10H F FACTORS//)
49 CONTINUE

```

```
50  CONTINUE
    IF (MF) 80,80,99
80  WRITE (3,81)
81  FORMAT (60H"THE INPUT DATA APPEARS TO BE CONSISTENT AND IN PROPER
10PDER)
    GO TO 99
85  WRITE (3,87)
87  FORMAT (33H"SHODDY DATA - CHECK DISCONTINUED)
99  CONTINUE
    RETURN
    END
```

```

-ITC FOR RCSTUP,RCSTUP
  SUBROUTINE RCSTUP
    INCLUDE ABC
  C    THIS SUBROUTINE COMPUTES F FACTORS FOR TEMP DEPENDENT ISOTOPES
    WRITE (3, 2)
  2    FORMAT(1H1///)
    WRITE(3,3) (HOL (I), I = 1, 12)
  3    FORMAT(12A6//)
    WRITE(3, 4)
  4    FORMAT(64H RESONANCE SHIELDED CROSS SECTIONS ARE COMPUTED FOR THIS
1    CASE USING THE RUSSIAN DATA///)
    DO 200 N = 1, NXS
      IF (NT(N)) 200, 200, 10
  10    JJ = NGB(N)
      JJJ = NGE(N)
      NF = NPFF(N)
      NC = NPFC(N)
      NTP = NPFT(N)
      NE = NPFE(N)
      IF (TEMP(N) - 299.) 16, 16, 12
  12    IF (TEMP(N) - 2101.) 19, 19, 16
  16    WRITE (3, 17) HOLN(N)
  17    FORMAT (37H1PLEASE NOTE THAT THE TEMPERATURE OF A6,23H IS OUTSIDE
1    SAFE LIMITS)
      IF (TEMP(N) - .0001) 18, 18, 19
  18    TEMP(N) = 1.0
      WRITE(3, 21)
  21    FORMAT(34H1TEMPERATURE 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(N, J, K)
      B = FF(N, J+1, K)
      C = FF(N, J+2, K)
      Y = 350.*(A - C)
      X = B - Y/900.
  30    FF(N, I, K) = X + Y/TEMP(N)
  40    DO 50 I = JJ, JJJ
      J = 3 * I
      DO 50 K = 1, NC
      A = FC(N, J, K)
      B = FC(N, J+1, K)
      C = FC(N, J+2, K)
      Y = 350.*(A - C)
      X = B - Y/900.
  50    FC(N, I, K) = X + Y/TEMP(N)
  60    DO 80 I = JJ, JJJ

```

```

      J = 3 * I
      DO 70 K = 1, NTP
      A = FT(N, J, K)
      B = FT(N, J+1, K)
      C = FT(N, J+2, K)
      Y = 350.*(A - C)
      X = B - Y/900.
70    FT(N, I, K) = X + Y/TEMP(N)
      DO 80 K = 1, NE
      A = FE(N, J, K)
      B = FE(N, J+1, K)
      C = FE(N, J+2, K)
      Y = 350.*(A - C)
      X = B - Y/900.
80    FE(N, I, K) = X + Y/TEMP(N)
200  CONTINUE
      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 = 1,26
7    SIGO(N,L) = .0
    GO TO 40
10   DO 30 L = 1,26
    SIGO(N,L) = .0
    DO 20 K = 1,NXS
20   SIGO(N,L) = SIGO(N,L) + DN(K) * SR(K,1,L)/DN(N)
    SIGO(N,L) = SIGO(N,L) - SR(N,1,L)
30   AVSIG(N) = AVSIG(N) + SIGO(N,L)
40   AVSIG(N) = AVSIG(N)/26.
    KK = NXS
    IF (NXS - 8) 46,46,44
44   KK = 8
46   CONTINUE
    WRITE(3, 50) (HOLN(I), I = 1, KK)
50   FORMAT (11HUGROUP AVERAGED TOTAL CROSS SECTIONS PER ATOM (EXCLUDI
    ING ISOTOPE MENTIONED) ARE LISTED BELOW FOR EACH ITERATION///
    211H ITERATION 8(6X,A6))
    LK = 0
    WRITE(3, 51) LK, (AVSIG(I), I = 1, KK)
51   FORMAT (1H0/5X, 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
        IF (NFT(N)) 500,500,12
12       IF (DN(N)) 16,16,20
16       DO 18 I = 1,26
          FSSF(N,I) = 1.0
          FSSC(N,I) = 1.0
          FSST(N,I) = 1.0
          FSSE(N,I) = 1.0
18      CONTINUE
        GO TO 500
20      JJ = NGR(N)
        JJJ = NGE(N)
        NF = NPFF(N)
        NC = NPFC(N)
        NTP = NPFT(N)
        NE = NPFF(N)
        DO 450 I = JJ,JJJ
          IF (SIGO(N,I) - 9.99E6) 40,40,30
30         FSSF(N,I) = 1.0
          FSSC(N,I) = 1.0
          FSST(N,I) = 1.0
          FSSE(N,I) = 1.0
        GO TO 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(N,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(N,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(N,I,KK-1)
          B = FF(N,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(N,I,KK-1)
B = FF(N,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(N,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(N,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(N,I,KK-1)
B = FT(N,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(N,I,KK-1)
B = FC(N,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(N,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(N,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(N,I,KK-1)
      B = FC(N,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(N,I,KK-1)
      B = FT(N,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(N,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(N,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(N,I,KK-1)
      B = FE(N,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(N,I,KK-1)
      B = FE(N,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
      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 = 1,26
7   SIGO(N,L) = .0
  GO TO 40
10  DO 30 L = 1,26
  SIGO(N,L) = .0
  DO 20 K = 1,NXS
20  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)
  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)
40  AVSIG(N) = AVSIG(N)/26.
  WRITE(3, 51) M, (AVSIG(I), I = 1, KK)
51  FORMAT(5X, I3, 5X, 1P8E12.4)
  RETURN
  END

```

```

-IIC FOR RCPRT2, RCPRT2
SUBROUTINE RCPRT2
  INCLUDE ABC
  DO 200 I = 1, NXS
    WRITE ( 3, 2) HOLN(I)
2    FORMAT(71H1CALCULATED RESONANCE SELF-SHIELDING COEFFICIENTS ARE LI
1STED BELOW FOR A6///)
    IF(NFT(I)) 62, 62, 64
62   WRITE ( 3, 63)
63   FORMAT(57H THE COEFFICIENTS FOR THIS ISOTOPE ARE ALL EQUAL TO UNIT
1Y)
    GO TO 200
64   CONTINUE
    WRITE ( 3, 66)
66   FORMAT(76H GROUP SIGO FF FC
1 FT FF//)
    DO 80 J = 1, 26
    WRITE ( 3, 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 RCCSS,RCCSS
  SUBROUTINE RCCSS
    INCLUDE ABC
    CALCULATION OF SHIELDED CROSS SECTIONS IN DTK FORMAT
  C
    DO 10 J = 1,26
    DO 10 K = 1,15
  10  SN(K,J) = .0
    DO 500 I = 1, NXS
    DO 100 J = 1, 26
    FPHI(J) = .0
    IF (J - 12) 20,20,30
  20  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))
    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)
    IF (J - 12) 40,40,50
  40  S(I,5,J) = S(I,4,J) - S(I,2,J) - FPHI(J) + SM(I,J,1)
    1-FSSE(I,J)*SR(I,8,J)
    GO TO 60
  50  S(I,5,J) = S(I,4,J) - S(I,2,J) - FPHI(J) - FSSE(I,J)*SR(I,8,J)
  60  CONTINUE
    IF (J-1) 65,65,66
  65  S(I, 6, J) = .0
    GO TO 100
  66  IF(J - 13) 70,70,80
  70  S(I,6,J) = FSSE(I,J-1)*SR(I,8,J-1) + SM(I,J-1,2)
    GO TO 100
  80  S(I,6,J)=FSSE(I,J-1) * SR(I,8,J-1)
  100 CONTINUE
    DO 250 J = 1, 26
    DO 250 N = 2, 10
    M = N + 5
    S(I, M, J) = 0.0
    JK = J - N
    IF(JK) 230, 250, 230
  230 IF (JK - 12) 240,240,250
  240 JL = N + 1
    S(I,M,J)=SM(I,JK,JL)
  250 CONTINUE
  500 CONTINUE
    RETURN
  END

```

```

-ITC FOR INPUT2,INPUT2
SUBROUTINE INPUT2
  INCLUDE ABC
  KK = NXCM + 5
  IF(NRCF - 1) 30, 4, 10
4  DO 9 J = 1, NXS
  DO 9 I = 1, NGP
  READ(2, 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(2,6) KD,(S(J,K,I), K = 9, KK)
9  CONTINUE
  GO TO 30
10 DO 16 J = 1, NXS
  DO 16 I = 1, NGP
  READ(2, 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 (3,35) HOLN(K),K
35 FORMAT (32H1MICROSCOPIC CROSS SECTIONS FOR A6,21H      NUCLIDE NUM
18ER 12///
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 (3,36) I, (S(K,J,I), J = 1,11)
44 CONTINUE
  WRITE (3,40)
40 FORMAT (44H1GROUP G-7XG      G-8XG      G-9XG      G-10XG//)
  DO 49 I = 1,NGP
  WRITE (3,42) I, (S(K,J,I), J = 12, KKK)
42 FORMAT (13,4F10.3)
49 CONTINUE
  GO TO 38
41 CONTINUE
  DO 538 I = 1, NGP
  WRITE (3,36) I, (S(K,J,I),J=1,KKK)
36 FORMAT (13,11F10.3)
37 FORMAT (1H )
538 CONTINUE
38 CONTINUE
100 CONTINUE
RETURN

```

```

-ITC FOR CHECK,CHECK
SUBROUTINE CHECK
  INCLUDE ABC
  ME = 0
  WRITE (3,1)
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 (3,23)
23 FORMAT (36H SHODDY DATA - CHECK DISCONTINUED)
  GO TO 99
26 WRITE (3,28) ME, HOLN(J), I
28 FORMAT (1H / I6,10H CHECK A6,10H GROUP I2)
50 CONTINUE
  IF (ME) 60,60,99
60 WRITE (3,62)
62 FORMAT (69H THE INPUT CROSS SECTIONS APPEAR TO BE CONSISTENT AND I
IN PROPER ORDER)
99 CONTINUE
  RETURN
  END

```

```

-ITC FOR PRINT2,PRINT2
  SUBROUTINE PRINT2
    INCLUDE ABC
    WRITE(3, 1)
1    FORMAT(1H1)
    IF(NOP -1) 10,20,30
10   WRITE (3,11) AK
11   FORMAT (1HC///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 (3,21) BSQ
21   FORMAT (1HC///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 (3,31) AK
31   FORMAT (1HC///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 (3,39) POW
39   FORMAT (55H THE BURNUP WILL BE COMPUTED USING A CONSTANT POWER OF
    11PE16.5,5H MWT.//)
    GO TO 50
45   WRITE (3,46) FLX
46   FORMAT (54H THE BURNUP WILL BE COMPUTED USING A CONSTANT FLUX OF 1
    1PE16.5,11H N/CM2-SEC.//)
50   CONTINUE
    IF(NSP) 52,52,60
52   WRITE (3,53)
53   FORMAT (65H AVERAGE CROSS SECTIONS WILL BE EVALUATED AT K = 1 (ADJ
    1USTING B2)//)
    GO TO 65
60   WRITE (3,61)
61   FORMAT (82H AVERAGE CROSS SECTIONS WILL BE EVALUATED AT K(T). NO
    1ADJUSTMENT FOR CRITICALITY.//)
65   WRITE (3,67) EPSL
67   FORMAT (57H THE CONVERGENCE CRITERION ON THE MARCH-OUT ALGORITHM I
    1S 1PE16.5//)
    G = NUMT
    G = G*H
    WRITE (3,70) 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 (3,150) LBS, LBL,(LBSN(I),I=1,LBS)
150  FORMAT (24H THE BREEDING RATIO HAS I2,18H SOURCE TERMS AND I2,11H
      1SINK TERMS///
239H      NUCLIDE NUMBERS FOR SOURCE TERMS 5I6)
      WRITE (3,160) (LBLN(I),I =1,LBL)
160  FORMAT (39H      NUCLIDE NUMBERS FOR SINK TERMS 5I6)
170  CONTINUE
      RETURN
      END

```

```

-ITC FOR START, START
  SUBROUTINE START
    INCLUDE ABC
    WRITE(3, 1)
1    FORMAT(1H1)
    WRITE(3, 82) (HOL(I), I=1, 12)
82   FORMAT(12A6)
    IF(NRCF) 86, 86, 83
83   WRITE(3, 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(3, 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(3, 101) J, HOLN(J), DN(J), G, DNMI(J), SORCE(J)
101  FORMAT(17,5H    ,A6,1PE18.5,1P4E14.4)
    GO TO 102
95   WRITE(3, 101) J, HOLN(J), DN(J), G, DNMI(J), SORCE(J), TEMP(J)
102  WRITE(3, 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(NSP) 100,100,200
  100 TEMK = AK
  TEMB = BSQ
  AK = 1.0
  NCAL = 1
  CALL CALC
  AK = TEMK
  BSQ = TEMB
  GO TO 1
  200 CONTINUE
  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
  SUM = SUM + PHI(I)
  DO 99 J = 1, NX5
  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

```

```

1000 FOR CALC,CALC
1001 SUBROUTINE CALC
1002 INCLUDE ABC
1003 THIS ROUTINE COMPUTES THE NEUTRON SPECTRUM
1004 EPS = .000001
1005 IF (NCAL) 2,2,1
1006 CONTINUE
1007 ITER = 0
1008 CONTINUE
1009 KK = NXCM + 5
1010 DO 101 I = 1, NGP
1011 SIGR(I) = .0
1012 DO 100 K = 6, KK
1013 NM = I + K - 5
1014 IF (NM - NGP) 100,100,101
1015 SIGR(I) = SIGR(I) + SN(K,NM)
1016 CONTINUE
1017 ITER = ITER + 1
1018 IF (NFD) 105, 105, 201
1019 CONTINUE
1020 DO 109 I = 1,NGP
1021 SUM = .0
1022 DO 111 N=1,NXCM
1023 KKK = I - N
1024 KK = N + 5
1025 IF (KKK) 112,112,111
1026 SUM = SUM + PHI(KKK)*SN(KK,I)
1027 CONTINUE
1028 PHI(I) = (100*CHI(I) + SUM)/(BSO/(3.*SN(4,I)) + SN(2,I)+SIGR(I))
1029 CONTINUE
1030 RS = 0.
1031 RL = 0.
1032 RA = 0.
1033 DO 412 I = 1,NGP
1034 FPHI(I) = PHI(I) * SN(3,I)
1035 RS = RS + FPHI(I)
1036 RL = RL + BSG * PHI(I)/(3.*SN(4,I))
1037 RA = RA + PHI(I) * SN(2,I)
1038 IF (NCAL) 511,511,441
1039 TAK = RS/(RL + RA)
1040 IF (ABS(TAK - TAK) - EPS) 512,512,601
1041 IF (ITER - 200) 605,605,602
1042 - WRITE (3,603)
1043 FORMAT (27H1NO CONVERGENCE ON SPECTRUM)
1044 GO TO 511
1045 G = .0
1046 DO 611 I = 1,NGP

```

```

611  G = G + PHI(I)/(3.*SN(4,I))
      BSQ = (RS/AK - RA)/G
      GO TO 106
511  AK = RS/(RL + RA)
512  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))
      RETURN
      END

```

```

-ITC FOR NORM,NORM
SUBROUTINE NORM
  INCLUDE ABC
  IF (NSP) 2,2,50
2    CONTINUE
  IF(NOP - 1) 22,21,22
21   NCAL = 0
      CALL CALC
      GO TO 50
22   NCAL = 1
      CALL CALC
50   CONTINUE
      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)
      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)
      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)
      PR = G/GG
      RETURN
      END

```

```

-IIC FOR PRINT3,PRINT3
SUBROUTINE PRINT3
  INCLUDE ABC
  THIS ROUTINE PRINTS ALL APPROPRIATE INFORMATION AT ANY TIME DURING
  C THE PROGRAM
  WRITE (3,2)
  2  FORMAT (1H1)
  WRITE (3,4) (HOL(I),I=1,12)
  4  FORMAT (12A6)
  TLD = ABS(9.869597/BSQ)
  SREE = SQRT(TLD)
  WRITE (3,6) 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 DUCKLING = 1PE16.6,5H CM-2//
620H SPHERICAL RADIUS = 1PE16.6,3H CM////)
  C WE WILL NOW PRINT FUEL INVENTORY
  WRITE (3,10)
  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
2INITIAL LOAD(KG)      CHANGE(KG)////)
  DO 20 J=1, NBE
  DNM (J) = VOL*DN(J)*ATW(J)/.6023
  G = DNM(J) - DNMI(J)
  WRITE (3,12) J, HOLN(J), DN(J), DNM(J), DNMI(J), G
  WRITE (3,14)
  12  FORMAT (16,5H      ,A6,1PE19.5,1PE20.5,1PE18.5,1PE16.5)
  14  FORMAT (1H /)
  20  CONTINUE
  WRITE (3,30)
  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
  WRITE(3, 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//

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```

535H TOTAL NEUTRON LEAKAGE FROM CORE = 1PE16.5//
799H GROUP      FLUX      NU*SIGF*FLUX      SIGF*FLUX      INTG FLUX
8 ADJOINT      CHI*ADJOINT      DENSITY/ )
SUMA = .0
PP = .0
SUM = .0
DO 40 I = 1, NGP
SUMA = SUMA + ADJ(I)
40 SUM = SUM + PHI(I)
SUMCA = .0
WWWL = 0.0
DO 42 I = 1, NGP
WWWL = WWWL + PHI(I)/ SUM
POWER = PHI(I) * SN(1, I)
PP = PP + POWER
G = CHI(I) * ADJ(I)
SUMCA = SUMCA + G
WRITE(3, 41) I, PHI(I), FPHI(I), POWER, WWWL, ADJ(I), G, DEN(I)
41 FORMAT (I3, 1P7E14.5)
42 CONTINUE
WRITE(3, 31) SUM, RS, PP, SUMA, SUMCA, RP
31 FORMAT (4H0SUM1PE13.5, 1P2E14.5, 14X, 1P3E14.5)
IF (NP) 300, 300, 399
300 CONTINUE
WRITE (3, 301)
301 FORMAT (1H1)
WRITE (3, 302) (HOL(I), I=1, 12)
302 FORMAT (12A6)
WRITE (3, 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 (3, 306) I, (SN(K, I), K = 1, 11)
354 CONTINUE
390 FORMAT (44H1GROUP G-7XG G-8XG G-9XG G-10XG///)
WRITE (3, 390)
DO 349 I = 1, NGP
352 FORMAT (14, 1P4E10.2)
WRITE (3, 352) I, (SN(K, I), K = 12, KK)
349 CONTINUE
GO TO 399
341 CONTINUE
DO 310 I = 1, NGP

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```

      WRITE (3,306) I, (SN(K,I),K=1,KK)
306  FORMAT (14,1P11E10.2)
308  FORMAT (1H /)
310  CONTINUE
399  CONTINUE
      WRITE (3,320)
320  FORMAT (1H1)
      WRITE (3,330) (HOL(I),I=1,12)
330  FORMAT (12A6)
      WRITE (3,340)
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 (3,342) J, HOLN(J),(ACS(J,K), K=1,4)
      WRITE (3,344)
342  FORMAT (15,4H      A6,1P4E14.4)
344  FORMAT (1H /)
350  CONTINUE
500  CONTINUE
      RETURN
      END

```



```

-ITC FOR CRXS1,CRXS1
SUBROUTINE CRXS1
  INCLUDE ABC
  C MISCELLANEOUS DATA
  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
    KK = NPN(K)
    DO 160 L = 1,KK
      I = I + 1
      CHIP(K) = CHIP(K) + CHI(I)
      DENP(K) = DENP(K) + DEN(I)
160 FPHI(K) = FPHI(K) + PHI(I)
      DO 170 I = 1, NCR
170 VELP(I) = FPHI(I)/DENP(I)
      WRITE(3,1)
      FORMAT(1H1)
      WRITE(3,2) (HOL(I),I=1,12)
      FORMAT (12A6)
      WRITE (3, 699)
699 FORMAT (1H //)
      WRITE(3,6) NCR
      FORMAT (50H0 DATA FOR CROSS SECTION AVERAGING LISTED BELOW///
      2 41H0THE NUMBER OF ENLARGED ENERGY GROUPS IS 13/ )
      IF (NAVX-2) 3,12,23
      3 WRITE(3,4)
      4 FORMAT (57H0SIGMA TRANSPORT IS CALCULATED USING RECIPROCAL WEIG
      1HTING/ )
      GO TO 38
      12 WRITE (3,14)
      14 FORMAT (68H0SIGMA TRANSPORT IS CALCULATED USING NORMALIZED RECIP
      1ROCAL WEIGHTING/ )
      GO TO 38
      23 IF (NAVX-3) 26,26,30
      26 WRITE (3,28)
      28 FORMAT (53H0SIGMA TRANSPORT IS CALCULATED USING LINEAR WEIGHTIN
      1G/ )
      GO TO 38
      30 WRITE(3,31)
      31 FORMAT (64H0SIGMA TRANSPORT IS CALCULATED USING NORMALIZED LINE
      1AR WEIGHTING/ )
      38 CONTINUE

```

```

91      WRITE (3, 91)
      FORMAT(115HNEW GROUP      OLD GROUPS PER NEW GROUP      FISSION SOURC
1E FOR NEW GROUP      FLUX      VELOCITY      DENSITY      //)
      WRITE (3, 92) K, NPN(K), CHIP(K), FPHI(K), VELP(K), DENP(K)
      DO 94 K = 1, NCR
92      FORMAT(I3,20H      I3,20H      1PE16.5
1,5H      1PE16.5/)
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(3, 2) (HOL(I), I = 1, 12)
      WRITE(3, 699)
380      I=0
      WRITE (3, 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)
      GGC =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 (3, 992) K, GXG
992   FORMAT(16,16H                      ,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

```

```

20  WRITE (3,20)
    FORMAT(1H1)
    WRITE (3,22) (HOL(I),I=1,12      )
22  FORMAT(12A6)
40  WRITE(3, 41)  HOLN(J), J
41  FORMAT (41H0CRUNCHED 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 (3,47) I, (SG(J,K,I),K=1,11)
    WRITE (3,47) I, (SG(J,K,I),K=12,KK)
47  FORMAT (I3,11F10.3)
    WRITE (3, 56)
56  FORMAT(1H )
48  CONTINUE
    GO TO 855
49  CONTINUE
    DO 53 I=1,NCR
    WRITE (3, 47) I, (SG(J, K, I), K = 1, KK)
    WRITE (3, 56)
53  CONTINUE
855  CONTINUE
555  FORMAT (1H )
55  CONTINUE
    JJ = NXCMP + 5
    DO 100 I = 1, NCR
    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)
    EL(I) = VEL(I)
    VEL(I) = VELP(I)
    TFX(I) = PHI(I)
100 CONTINUE
    NMG = NGP
    NXX = NXCM
    NGP = NCR
    NXCM = NXCMP
    NPSS = NPUN
    NPUN = NOPP
    CALL AVXS

```

```
CALL NORM
IF(NPUN) 102, 102, 101
101 CALL PUNCH
102 CONTINUE
RETURN
END
```

```

-ITC FOR MARCH,MARCH
SUBROUTINE MARCH
  INCLUDE ABC
C   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 (3,67)
67      FORMAT (28H1NO CONVERGENCE ON MARCH-OUT///
150H1  NUCLIDE      DN(T)      AN(T+1,1)      AN(T+1,2)////)
        DO 69 J = 1, NBE
        WRITE (3,68) 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 PUNCH,PUNCH
SUBROUTINE PUNCH
  INCLUDE ABC
  KK = NXCM + 5
  KD = 9
  IF(NPUN - 2) 200, 300, 401
200  DO 240 I = 1, NXS
    PUNCH 100, HOLN(I), NGP
100  FORMAT(1X, A6, 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(11, 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), 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(3, 402) NBN
402  FORMAT(48H1MACROSCOPIC CROSS SECTIONS ARE PUNCHED OUT FOR 13,15H M
1IXED ISOTOPES///)
    DO 425 I = 1, NBN
    WRITE(3, 405) I
405  FORMAT (4H MIXI3/ )
    WRITE(3, 408)
408  FORMAT (27H ISOTOPE DENSITY/ )
    JJ = NBUN(I)
    DO 420 J = 1, JJ
    L = NISO(I, J)
    WRITE(3, 410) HOLN(L), DNSO(I, J)
410  FORMAT(5X,A6,1PE16.6)
420  CONTINUE
    WRITE(3, 421)
421  FORMAT(1H //)
425  CONTINUE
    DO 600 I = 1, NBN
451  WRITE(3, 453) I
453  FORMAT (41H1THE MACROSCOPIC CROSS SECTIONS FOR MIX 13,17H 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
    DO 475 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
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(3, 506) J, (SL(K,J), K = 1, 11)
506    FORMAT(I3, 1P11E10.2)
507    FORMAT(1H )
508    CONTINUE
      WRITE(3, 510)
510    FORMAT (44H1GROUP  G-7XG      G-8XG      G-9XG      G-10XG///)
      DO 519 J = 1, NGP
      WRITE(3, 506) J, (SL(K,J), K = 12, KK)
519    CONTINUE
      GO TO 600
540    CONTINUE
      DO 565 J = 1, NGP
      WRITE(3, 506) J, (SL(K, J), K = 1, KK)
565    CONTINUE
600    CONTINUE
999    CONTINUE
      RETURN

```

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