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R E D C R O S S-A CODE TO COMPUTE
RESONANCE SHIELDED, TEMPERATURE
DEPENDENT CROSS SECTIONS
FOR FAST REACTOR ANALYSIS

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August, 1965

RICHLAND, WASHINGTON

PACIFIC NORTHWEST LABORATORY operated by BATTELLE MEMORIAL INSTITUTE

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RED CROSS - A CODE TO COMPUTE RESONANCE
SHIELDED, TEMPERATURE DEPENDENT CROSS SECTIONS FOR
FAST REACTOR ANALYSIS

By

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Reactor Physics Section
Physics and Instruments Department

August 1965

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PACIFIC NORTHWEST LABORATORY
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SUMMARY

The code described in this paper uses the extensive Russian data compilation^(1,2) to compute resonance shielded, temperature dependent, 26-group cross sections. The output (printed or punched) is in a format suitable for fast reactor analyses using the corrected transport approximation.

I. INTRODUCTION

1.1 Synopsis of Code

This report describes a code, RED CROSS, which computes 26-group cross sections in the transport approximation from the data compiled by Bondarenko, et al.^(1,2) Cross sections can be computed at any temperature or atom concentration. To preclude punching errors, the code performs an exhaustive check of the input data. For the user's convenience, the code calculates the fundamental mode flux and adjoint flux using the computed cross sections.

The source deck is written in FORTRAN IV for a 32 K memory. A typical problem requires approximately five seconds on an IBM-7090.

1.2 Outline of Report

The essential features of RED CROSS are shown and discussed in Chapter II. A description of the format of the Russian data is shown in Chapter III.

Chapters IV-VI present the approximations used to compute the resonance shielded cross sections. Chapter VII discusses the equations comprising the fundamental mode flux and adjoint flux calculation.

A listing of the nuclides currently in the RED CROSS library is given in Appendix A. Input information, sample cases, and a FORTRAN IV source deck listing are shown in the remaining appendixes.

II. OUTLINE OF CODE

2.1 General Remarks

A bird's-eye view of the complete code is given in Figure 2.1. Needless to say, this diagram is presented only to give a rough indication of the items computed and their sequencing — the actual code logic is decidedly more complex.

2.2 Discussion of Schematic Diagram

Although Figure 2.1 is almost self-explanatory, one complete cycle will be traced and explained.

First, the code reads into memory the nuclear data for all isotopes involved in the calculation. If desired, the code will give a complete listing of the input data. A thorough check of the input data is then undertaken. If any anomalies are encountered, appropriate error flags are printed.

Next, the parameters for the specific case under study are read and printed. The principal items in this block are the nuclide temperatures and atom densities. The code then computes the nuclear data at the current temperature of each isotope using the interpolation equations described in Chapter IV.

An iteration is now performed to obtain the total resonance shielded cross sections per atom (summed over all other nuclides) for each nuclide. Using this information, the code then computes the multigroup cross sections in the transport approximation. Options are provided for both printing and punching the computed cross sections.

Figure 2.1 SCHEMATIC DIAGRAM OF RED CROSS

Finally, the fundamental mode flux and adjoint flux is computed and printed. These flux spectra permit the user to see the principal characteristics of the cross section sets before they are inserted in transport or diffusion codes.

III. RUSSIAN DATA FORMAT

3.1 Introductory Remarks

The nuclear parameters for each isotope are arranged in three sections: infinite dilution cross sections, inelastic scattering matrix, and resonance self-shielding factors. A brief description of the three sections is given in the following paragraphs. For detail information, the reader is referred to the Russian text. ⁽¹⁾

3.2 Infinite Dilution Cross Sections

For each energy group of each isotope, eight parameters are listed. These are defined below.

- 1) σ_t Total cross sections ($\sigma_f + \sigma_c + \sigma_e + \sigma_{in}$),
- 2) σ_f Fission cross section,
- 3) ν Neutrons released per fission,
- 4) σ_c Capture cross section,
- 5) σ_{in} Total inelastic scattering cross section
(includes $(n, 2n)$ reaction),
- 6) σ_e Total elastic scattering cross section,
- 7) μ_e Average cosine of elastic scattering angle,
- 8) $\sigma_{d,e}$ Elastic slowing-down cross section (in RED CROSS,
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.

Observe that a substantial part of the above data can be cross-checked (for punching or printing errors) using the equations

$$\sigma_t = \sigma_f + \sigma_c + \sigma_e + \sigma_{in}, \quad (3.1)$$

$$\sigma_{in,i} = \sum_j \sigma_{in}(i \rightarrow j). \quad (3.2)$$

3.3 Resonance Self-Shielding Factors

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

$$\bar{\sigma}_k = f_k \sigma_k^0, \quad (3.3)$$

where:

$\bar{\sigma}_k$ = resonance shielded cross section for kth process,

f_k = self-shielding factor,

σ_k^0 = infinite dilution cross section.

To preclude possible errors, the reader is warned that Eq. (3.3) is sometimes invalid. The precise meaning and use of the shielding factors is discussed in Chapter VI.

IV. INTERPOLATION EQUATIONS

4.1 Introduction

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 4.1.

TABLE 4.1:

FORMAT FOR RESONANCE SELF-SHIELDING FACTORS

Temperature (°K)	Total Cross Section		
	σ_1	σ_2	σ_3
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 (corresponding to temperatures of 300, 900, and 2100), 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.

4.2 Temperature Interpolation Equation

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

$$f(T) = A + B/\sqrt{T}, \quad (4.1)$$

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 Eq. 4.1. In particular, second order curves in terms of T or $1/T$ may be preferable to Eq. (4.1) for many studies. However, for analyses in the vicinity of 1000°K , Eq. (4.1) appears to be quite satisfactory.

4.3 Interpolation on Total Cross Section

If σ_t lies between any two discrete cross sections, say $\sigma_{t,1}$ and $\sigma_{t,2}$, the shielding factor is computed using the expression

$$f(\sigma) = f_1 + \frac{f_2 - f_1}{\ln(\sigma_2/\sigma_1)} \ln(\sigma/\sigma_1) . \quad (4.2)$$

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:

$$1) \quad \sigma_t \geq 10^7, \quad f = 1.0, \quad (4.3)$$

$$2) \quad 10^7 > \sigma_t > \sigma_L, \quad f = 1.0 + \frac{f_L - 1.0}{\ln(\sigma_L/10^7)} \ln(\sigma/10^7) \quad (4.4)$$

$$3) \quad \sigma_t < \sigma_S, \quad f = f_S . \quad (4.5)$$

V. ITERATION TO OBTAIN TOTAL CROSS SECTIONS

5.1 Introduction

As mentioned in the previous chapter, the Russian data gives the self-shielding factors as a function of the total cross section (of all other nuclides in the mixture). 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.

5.2 Iteration Algorithm

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

$$\sigma_{t,k}^0 = \frac{1}{N_k} \sum_{j \neq k} N_j \sigma_{t,j}^0, \quad (5.1)$$

where:

$\sigma_{t,k}$ = 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

$$\sigma_{t,k}^{v+1} = \frac{1}{N_k} \sum_{j \neq k} N_j \left[f_{e,j}^v \sigma_{c,j} + f_{f,j}^v \sigma_{f,j} + f_{e,j}^v \sigma_{e,j} + \sigma_{in,j} \right], \quad (5.2)$$

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

The number of iterations, v , is an input parameter. For any case, convergence on the total cross section is easy to check since the code prints $\sigma_{t,k}^v$ after each iteration. It has been found that typical problems converge very well in 3 or 4 iterations.

VI. COMPUTATION OF MULTIGROUP CROSS SECTIONS

6.1 Cross Section Format

For each energy group of each isotope, the cross sections are printed and punched in the format:

$\bar{\sigma}_f^i \quad \bar{\sigma}_a^i \quad \bar{\nu}\bar{\sigma}_f^i \quad \bar{\sigma}_{tr}^i \quad \bar{\sigma}(i \rightarrow i) \quad \bar{\sigma}(i-1 \rightarrow i) \quad \dots \quad \bar{\sigma}(i-10 \rightarrow i).$

The bar indicates that the cross section includes resonance self-shielding.

Two clarifications should be made at this point. First, the transport cross section in the corrected transport approximation is defined by the expression

$$\bar{\sigma}_{tr}^i = \bar{\sigma}_{es}^i (1 - \mu_e^i) + \bar{\sigma}_{in}^i + \bar{\sigma}_a^i, \quad (6.1)$$

where:

$\bar{\sigma}_{es}^i$ = total elastic scattering cross section,

$\bar{\sigma}_e^i$ = average cosine of scattering angle in laboratory coordinates,

$\bar{\sigma}_{in}^i$ = total inelastic scattering cross section.

The in-group scattering cross section, $\bar{\sigma}(i \rightarrow i)$, is then defined as the residue of the transport cross section and the removal cross section. Thus,

$$\bar{\sigma}(i \rightarrow i) = \bar{\sigma}_{tr}^i - \bar{\sigma}_a^i - \sum_{j \neq i} \bar{\sigma}(i \rightarrow j). \quad (6.2)$$

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.

The second clarification concerns 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 RED CROSS since the Russian inelastic scattering matrix includes the $(n, 2n)$ reaction.

6.2 Equations for Multigroup Cross Sections

The shielded multigroup cross sections in terms of the initial data are listed below. See Chapter III for a definition of the shielding factors and infinite dilution cross sections.

$$\bar{\sigma}_f^i = f_f^i \sigma_f^i \quad (6.3)$$

$$\bar{\sigma}_a^i = f_f^i \sigma_f^i + f_c^i \sigma_c^i - \sum_j \sigma_{in}(i \rightarrow j) - \sigma_{in}^i \quad (6.4)$$

$$(\bar{\nu} \sigma_f)^i = \nu^i f_f^i \sigma_f^i \quad (6.5)$$

$$\begin{aligned} \bar{\sigma}_{tr}^i = & \left\{ f_t^i \sigma_t^i - \left[f_f^i \sigma_f^i + f_c^i \sigma_c^i + \sigma_{in}^i \right] \right\} (1 - \mu_e^i) \\ & + f_f^i \sigma_f^i + f_c^i \sigma_c^i + \sigma_{in}^i \end{aligned} \quad (6.6)$$

$$\begin{aligned} \bar{\sigma}(i \rightarrow i) = & \left\{ f_t^i \sigma_t^i - \left[f_f \sigma_f + f_c^i \sigma_c^i + \sigma_{in}^i \right] \right\} (1 - \mu_e^i) \\ & - f_e^i \sigma_{d,e}^i + \sigma_{in}(i \rightarrow i) \end{aligned} \quad (6.7)$$

$$\bar{\sigma}(i-1 \rightarrow i) = f_e^{i-1} \sigma_{d,e}^{i-1} + \sigma_{in}(i-1 \rightarrow i) \quad (6.8)$$

$$\bar{\sigma}(i-2 \rightarrow i) = \sigma_{in}(i-2 \rightarrow i) \quad (6.9)$$

$$\bar{\sigma}(i-10 \rightarrow i) = \sigma_{in}(i-10 \rightarrow i) \quad (6.10)$$

VII. FUNDAMENTAL MODE FLUX AND ADJOINT FLUX CALCULATION

7.1 Introduction

In order to provide the user with some information on the characteristics of the computed cross sections, a fundamental mode calculation of the flux and adjoint flux is performed. The numerous options available in this calculation are described in Chapter VIII and Appendix B.

7.2 Algorithm for Flux

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

$$\phi_i = \frac{\chi_i S_0 + \sum_{k \neq i} \Sigma(k \rightarrow i) \phi_k}{\frac{B^2}{3\Sigma_{tr}^i} + \Sigma_a^i + \sum_{j \neq i} \Sigma(i \rightarrow j)}$$

where S_0 is an arbitrary constant. If the buckling, B^2 , is known, Eq. (7.1) 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, Eq. (7.1), and the criticality relationship,

$$k_{\text{eff}} = \frac{\sum_i (\nu \Sigma_f)^i \phi_i}{S_0}, \quad (7.2)$$

in order to obtain both B^2 and ϕ_i .

7.3 Algorithm for Adjoint Flux

Let ψ_i be the adjoint flux in group i . From physical intuition, it is clear that

$$\psi_i = \frac{(\nu \Sigma_f)^i + \sum_{j \neq i} \Sigma(i \rightarrow j) \psi_j}{\frac{B^2}{3\Sigma_{\text{tr}}^i} + \Sigma_a^i + \sum_{j \neq i} \Sigma(i \rightarrow j)}. \quad (7.3)$$

In contrast to Eq. (7.1), observe that Eq. (7.3) must be solved by starting in the lowest energy group and proceeding up in energy.

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

$$k_{\text{eff}} = \sum_i \chi_i \psi_i, \quad (7.4)$$

which, of course, is similar in construction to Eq. (7.2).

It should be mentioned that the code uses Eq. (7.2) rather than Eq. (7.4) to compute k_{eff} . For most calculations, however, the expressions yield identical results.

VIII. REMARKS ON CODE OPERATION

8.1 Introduction

A number of options are included in the RED CROSS code. Although the details of these options are described in Appendix B, perhaps a few preliminary words are in order.

8.2 Options Relating to the Fundamental Mode Flux Calculation

For a specified buckling, B^2 , the code computes k_{eff} using Eqs. (7.1) and (7.2); for a specified k_{eff} , the program computes the corresponding buckling. In either option, the flux spectrum can be read in as input data or computed by the code (Eq. 7.1).

Regardless of the above options, the code uses the current value of B^2 to compute the adjoint flux distribution. Note that the multiplication constant associated with the adjoint flux will not necessarily equal the k_{eff} obtained from Eq. (7.2) if the flux spectrum is specified as input.

8.3 Specification of Total Cross Sections per Atom

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

REFERENCES

1. Bondarenko, I.I., et al., Group Constants for Nuclear Reactor Calculations, Consultants Bureau, New York (1964).
2. Bondarenko, I.I., et al., "Experimental Studies on Fast Neutron Reactor Physics," A/Conf. 28/P/368 (1964).

APPENDIX A

NUCLIDES CURRENTLY IN USE

Cross section information for the nuclides listed below is available for use in the RED CROSS code. In addition to the nuclides listed, the Russian text⁽¹⁾ gives data for hydrogen and deuterium. However, these are not incorporated in RED CROSS since they are very poorly represented by the transport approximation. Indeed, the first few elements listed below should, in principle, be handled by a more precise angular representation.

<u>Number</u>	<u>Name</u>	<u>Number</u>	<u>Name</u>
1	Lithium-6	21	Zirconium
2	Lithium-7	22	Niobium
3	Beryllium	23	Molybdenum
4	Boron-10	24	Tantalum
5	Boron-11	25	Tungsten
6	Carbon	26	Rhenium
7	Nitrogen	27	Lead
8	Oxygen	28	Bismuth
9	Sodium	29	Thorium-232
10	Magnesium	30	Uranium-233
11	Aluminum	31	Uranium-234
12	Silicon	32	Uranium-235
13	Potassium	33	Uranium-236
14	Calcium	34	Uranium-238
15	Titanium	35	Plutonium-239
16	Vanadium	36	Plutonium-240
17	Chromium	37	Plutonium-241
18	Iron	38	Plutonium-242
19	Nickel	39	Fission Fragments of Uranium-233
20	Copper	40	Fission Fragments of Uranium-235
		41	Fission Fragments of Plutonium-239

APPENDIX B

OPERATION INSTRUCTIONS

<u>Card</u>	<u>Column</u>	<u>Format</u>	<u>Remarks</u>
1	1- 6	Integer	Number of isotopes (≤ 8).
1	1-12	Integer	Print option: = 0, full print; = 1, partial print.
1	13-18	Integer	Punch option: = 0, no effect; = 1, resonance shielded cross sections are punched in DTK format.
1	19-24	Integer	= 0, code computes flux; = 1, code reads flux as input (see card 3).
2	1-12	Floating	Fission source in group 1.
2	13-24	Floating	Fission source in group 2.
2	25-36	Floating	Fission source in group 3.
...			
3	1-12 (optional)	Floating	Flux in group 1 (optional - see card 1).
3	13-24	Floating	Flux in group 2.
4	1- 6	Hollerith	Name of Isotope #1.
4	7-12	Integer	= 0, the f-factors are not temperature dependent for isotope #1. = 1, the f-factors are temperature dependent for isotope #1.
4	13-18	Integer	Group number of initial f-factors.
4	19-24	Integer	Group number of final f-factors.
4	25-30	Integer	Number of different types of f-factors. (e.g., f_c , f_f , f_t).
4	31-36	Integer	Number of columns of f_f 's.
4	37-42	Integer	Number of columns of f_c 's.

<u>Card</u>	<u>Column</u>	<u>Format</u>	<u>Remarks</u>
4	43-48	Integer	Number of columns of f_t 's.
4	49-54	Integer	Number of columns of f_e 's.
5	1-6	Floating	Total cross section per atom corresponding to first column of f-factors.
5	7-12	Floating	Total cross section corresponding to the second column of f-factors.
...			
6	1-2	Integer	Group number of initial f-factors.
6	3-7	Floating	First f-factor for above group.
6	8-12	Floating	Second f-factor for above group.
...			
7	Same as above for next group of isotope #1. Repeat through all energy groups containing f-factors.		
8	1-3	Integer	Group number.
8	4-12	Floating	Cross section data for first group of first isotope. σ_t (barns).
8	13-21	Floating	σ_f
8	22-30	Floating	v
8	31-39	Floating	σ_c
8	40-47	Floating	σ_{in}
8	48-55	Floating	σ_e
8	56-63	Floating	μ_e
8	64-71	Floating	$\sigma_{d,e}$
9	Same as above for second group of isotope #1. Repeat for all energy groups.		
10	1-3	Integer	Group number.
10	4-8	Floating	Inelastic scattering cross sections for first group of first isotope. σ_{gg}

<u>Card</u>	<u>Column</u>	<u>Format</u>	<u>Remarks</u>
10	9-13	Floating	$\sigma_{g \rightarrow g+1}$
10	14-18	Floating	$\sigma_{g \rightarrow g+2}$
10	19-23	Floating	$\sigma_{g \rightarrow g+3}$
10	24-28	Floating	$\sigma_{g \rightarrow g+4}$
10	29-33	Floating	$\sigma_{g \rightarrow g+5}$
10	34-38	Floating	$\sigma_{g \rightarrow g+6}$
10	39-43	Floating	$\sigma_{g \rightarrow g+7}$
10	44-48	Floating	$\sigma_{g \rightarrow g+8}$
10	49-53	Floating	$\sigma_{g \rightarrow g+9}$
10	54-58	Floating	$\sigma_{g \rightarrow g+10}$
11	Same as above for second group of isotope #1. Give data for first 12 groups.		
Cards 4 to 11 are repeated for all isotopes.			
** 12	2-72	Hollerith	Identification card.
13	1-6	Integer	= 0; reactivity calculation. The code computes the reactivity corresponding to the buckling given on the fourth word of this card. =.1; buckling calculation. The code computes the buckling corresponding to the value of k_{eff} given on the fourth word of this card.
13	7-12	Integer	= 0; total cross section per atom assumed constant for each isotope. See card 16. = 1; total cross section per atom is calculated using atom densities.
13	13-18	Integer	Number of iterations in the calculation of the resonance shielded cross sections.

<u>Card</u>	<u>Column</u>	<u>Format</u>	<u>Remarks</u>
13	19-30	Floating	Effective multiplication constant if this is a buckling calculation. Buckling (B^2) if this is a reactivity calculation. (If zero is used for the buckling, the code will use the buckling from the previous case.)
14	1-12	Floating	Atom density for isotope #1 ($\text{cm}^{-3} \times 10^{-24}$).
14	13-24	Floating	Atom density for isotope #2.
...			
15	1-12	Floating	Temperature of isotope #1 ($^{\circ}\text{K}$).
15	13-25	Floating	Temperature of isotope #2.
...			
16	1-12 (optional)	Floating	Total cross section per atom for isotope #1. (If greater than 10^7 , code assumes infinite dilution.)
16	13-25	Floating	Total cross section per atom for isotope #2.
...			
**	To run a series of cases, repeat from card 12 (I.D. card).		

APPENDIX C

SAMPLE CASES

The input data and computer print-out for two sample cases are listed on the following pages. Case II is simply a rerun of Case I using the partial print option.

***** REID CROSS *****

CROSS SECTION CALCULATION USING RUSSIAN DATA

*** INPUT DATA LISTED ON FOLLOWING PAGES FOR 2 ISOTOPES ***

GROUP FISSION SOURCE

1	2.00000E-02
2	9.80000E-02
3	1.90000E-01
4	2.68000E-01
5	1.96000E-01
6	1.35000E-01
7	5.80000E-02
8	2.20000E-02
9	9.00000E-03
10	3.00000E-03
11	1.00000E-03
12	0.
13	0.
14	0.
15	0.
16	0.
17	0.
18	0.
19	0.
20	0.
21	0.
22	0.
23	0.
24	0.
25	0.
26	0.

SUM 1.00000E+00

MICROSCOPIC CROSS SECTIONS FOR PU-239

NUCLIDE NUMBER 1

GROUP	SIGT	SIGF	NU	SIGC	SIGTN	SIGEL	MUEL	SIGDEL
1	6,700	2,200	3,860	0,010	0,640	3,850	0,840	0,026
2	7,700	1,850	3,510	0,020	1,280	4,550	0,800	0,026
3	7,900	1,970	3,270	0,030	1,250	4,650	0,710	0,028
4	7,300	1,950	3,120	0,040	1,160	4,150	0,550	0,027
5	7,300	1,800	3,010	0,060	1,140	4,300	0,450	0,035
6	8,300	1,680	2,950	0,110	1,160	5,350	0,350	0,042
7	9,900	1,660	2,910	0,170	0,950	7,120	0,230	0,066
8	11,300	1,680	2,890	0,240	0,750	8,630	0,130	0,090
9	12,500	1,850	2,880	0,400	0,550	9,700	0,070	0,097
10	14,000	2,150	2,870	0,710	0,250	10,890	0,040	0,113
11	15,000	2,400	2,870	1,080	0,100	11,420	0,020	0,120
12	16,500	2,500	2,870	1,250	0,	12,750	0,010	0,137
13	18,000	3,400	2,870	1,900	0,	12,700	0,	0,136
14	19,500	4,200	2,870	2,600	0,	12,700	0,	0,137
15	26,000	7,600	2,870	5,000	0,	13,400	0,	0,144
16	36,500	13,000	2,870	9,100	0,	14,400	0,	0,155
17	48,000	19,000	2,870	14,000	0,	15,000	0,	0,162
18	102,000	41,000	2,870	41,000	0,	20,000	0,	0,216
19	68,000	22,000	2,870	31,000	0,	15,000	0,	0,162
20	184,000	100,000	2,870	72,000	0,	12,000	0,	0,129
21	90,500	45,000	2,870	35,000	0,	10,500	0,	0,113
22	23,000	12,000	2,870	1,000	0,	10,000	0,	0,108
23	38,000	24,000	2,870	3,000	0,	11,000	0,	0,119
24	189,000	103,000	2,870	73,000	0,	13,300	0,	0,143
25	2896,000	1670,000	2,870	1210,000	0,	15,700	0,	0,169
26	1038,000	742,000	2,870	286,000	0,	9,500	0,	0,

INELASTIC SCATTERING MATRIX FOR PU-239

[illegible]

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	0.990	0.970	0.940	1.000	1.000	0.980	0.960	1.000	0.990	0.980	1.000	1.000	1.000
10	900.0	1.000	1.000	0.980	0.970	1.000	1.000	0.990	0.980	1.000	1.000	1.000	1.000	1.000	1.000
10	2100.0	1.000	1.000	0.990	0.980	1.000	1.000	0.990	0.990	1.000	1.000	1.000	1.000	1.000	1.000
11	300.0	1.000	0.980	0.930	0.880	1.000	0.990	0.950	0.910	1.000	0.970	0.930	1.000	1.000	0.990
11	900.0	1.000	0.990	0.970	0.930	1.000	1.000	0.980	0.950	1.000	1.000	0.990	1.000	1.000	1.000
11	2100.0	1.000	0.990	0.980	0.950	1.000	1.000	0.990	0.970	1.000	1.000	1.000	1.000	1.000	1.000
12	300.0	1.000	0.960	0.870	0.800	1.000	0.960	0.870	0.800	0.980	0.920	0.860	0.990	0.970	0.960
12	900.0	1.000	0.980	0.930	0.870	1.000	0.980	0.940	0.880	1.000	0.990	0.960	1.000	0.990	0.980
12	2100.0	1.000	0.990	0.950	0.910	1.000	0.990	0.960	0.920	1.000	1.000	0.990	1.000	1.000	1.000
13	300.0	0.990	0.920	0.790	0.690	0.990	0.920	0.770	0.670	0.950	0.850	0.800	0.960	0.930	0.910
13	900.0	1.000	0.960	0.870	0.790	1.000	0.960	0.870	0.780	0.990	0.960	0.910	0.990	0.960	0.940
13	2100.0	1.000	0.980	0.910	0.880	1.000	0.980	0.910	0.870	1.000	0.980	0.960	1.000	0.980	0.960
14	300.0	0.980	0.880	0.670	0.560	0.980	0.870	0.620	0.510	0.890	0.790	0.690	0.870	0.850	0.840
14	900.0	0.990	0.920	0.780	0.690	0.990	0.910	0.760	0.660	0.950	0.900	0.820	0.910	0.870	0.850
14	2100.0	1.000	0.950	0.860	0.820	1.000	0.950	0.840	0.790	0.970	0.940	0.900	0.930	0.900	0.870
15	300.0	0.970	0.800	0.530	0.420	0.960	0.760	0.460	0.360	0.800	0.680	0.600	0.800	0.780	0.760
15	900.0	0.980	0.860	0.640	0.530	0.970	0.820	0.580	0.470	0.870	0.810	0.740	0.830	0.800	0.780
15	2100.0	0.990	0.900	0.770	0.710	0.990	0.890	0.720	0.640	0.920	0.890	0.870	0.860	0.820	0.810
16	300.0	0.930	0.700	0.410	0.300	0.910	0.620	0.330	0.240	0.660	0.550	0.510	0.750	0.720	0.700
16	900.0	0.960	0.780	0.500	0.380	0.940	0.720	0.420	0.310	0.730	0.650	0.600	0.780	0.740	0.720
16	2100.0	0.980	0.830	0.580	0.520	0.960	0.800	0.530	0.450	0.830	0.790	0.750	0.810	0.770	0.750
17	300.0	0.910	0.630	0.340	0.250	0.890	0.580	0.280	0.200	0.520	0.430	0.420	0.720	0.670	0.650
17	900.0	0.940	0.690	0.410	0.320	0.920	0.640	0.340	0.260	0.590	0.510	0.480	0.740	0.690	0.670
17	2100.0	0.970	0.750	0.490	0.390	0.950	0.700	0.410	0.320	0.700	0.640	0.610	0.770	0.710	0.700
18	300.0	0.780	0.500	0.370	0.340	0.750	0.440	0.300	0.270	0.410	0.370	0.340	0.610	0.550	0.550
18	900.0	0.830	0.590	0.450	0.420	0.800	0.520	0.380	0.350	0.450	0.410	0.390	0.630	0.580	0.550
18	2100.0	0.870	0.660	0.540	0.520	0.850	0.610	0.470	0.440	0.540	0.500	0.470	0.650	0.570	0.560
19	300.0	0.700	0.330	0.190	0.160	0.650	0.280	0.150	0.130	0.330	0.210	0.190	0.760	0.720	0.710
19	900.0	0.770	0.370	0.210	0.180	0.720	0.320	0.170	0.150	0.360	0.230	0.210	0.770	0.720	0.720
19	2100.0	0.850	0.410	0.220	0.200	0.810	0.360	0.190	0.170	0.390	0.250	0.230	0.790	0.730	0.720
20	300.0	0.680	0.330	0.190	0.170	0.650	0.290	0.180	0.160	0.180	0.110	0.100	0.880	0.860	0.860
20	900.0	0.730	0.360	0.200	0.180	0.700	0.330	0.190	0.170	0.230	0.130	0.110	0.890	0.870	0.860
20	2100.0	0.800	0.390	0.210	0.190	0.770	0.360	0.200	0.180	0.270	0.150	0.120	0.890	0.870	0.860
21	300.0	0.670	0.330	0.200	0.180	0.650	0.310	0.190	0.170	0.200	0.180	0.170	0.960	0.960	0.960
21	900.0	0.710	0.350	0.210	0.190	0.690	0.330	0.200	0.180	0.230	0.190	0.180	0.970	0.960	0.960
21	2100.0	0.760	0.370	0.220	0.200	0.740	0.350	0.210	0.190	0.250	0.200	0.190	0.970	0.960	0.960
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	0.940	0.790	0.700	0.690	0.770	0.620	0.530	0.520	0.540	0.470	0.450	0.940	0.890	0.880

24	900.0	0.940	0.790	0.700	0.690	0.770	0.620	0.530	0.520	0.540	0.470	0.450	0.940	0.890	0.880
24	2100.0	0.940	0.790	0.700	0.690	0.770	0.620	0.530	0.520	0.540	0.470	0.450	0.940	0.890	0.880
25	300.0	0.680	0.610	0.590	0.590	0.680	0.570	0.560	0.560	0.330	0.300	0.300	0.850	0.840	0.840
25	900.0	0.680	0.610	0.590	0.590	0.680	0.570	0.560	0.560	0.330	0.300	0.300	0.850	0.840	0.840
25	2100.0	0.680	0.610	0.590	0.590	0.680	0.570	0.560	0.560	0.330	0.300	0.300	0.850	0.840	0.840

MICROSCOPIC CROSS SECTIONS FOR

10

NUCLIDE NUMBER 2

GROUP	SIGT	SIGF	NU	SIGC	SIGN	SIGEL	MUEL	SIGDEL
1	1,150	0	0	0,230	0,160	0,760	0,350	0,252
2	1,450	0	0	0,075	0	1,380	0,260	0,385
3	1,900	0	0	0,003	0	1,900	0,260	0,419
4	1,750	0	0	0	0	1,750	0,150	0,325
5	4,300	0	0	0	0	4,300	0,080	0,868
6	5,600	0	0	0	0	5,600	0,230	0,779
7	3,800	0	0	0	0	3,800	0,140	0,780
8	3,500	0	0	0	0	3,500	0,040	0,609
9	3,550	0	0	0	0	3,550	0,040	0,553
10	3,600	0	0	0	0	3,600	0,040	0,561
11	3,650	0	0	0	0	3,650	0,040	0,569
12	3,700	0	0	0	0	3,700	0,040	0,577
13	3,750	0	0	0	0	3,750	0,040	0,584
14	3,750	0	0	0	0	3,750	0,040	0,584
15	3,750	0	0	0	0	3,750	0,040	0,584
16	3,750	0	0	0	0	3,750	0,040	0,584
17	3,750	0	0	0	0	3,750	0,040	0,584
18	3,750	0	0	0	0	3,750	0,040	0,584
19	3,750	0	0	0	0	3,750	0,040	0,584
20	3,750	0	0	0	0	3,750	0,040	0,584
21	3,750	0	0	0	0	3,750	0,040	0,584
22	3,750	0	0	0	0	3,750	0,040	0,584
23	3,750	0	0	0	0	3,750	0,040	0,584
24	3,750	0	0	0	0	3,750	0,040	0,584
25	3,750	0	0	0	0	3,750	0,040	0,584
26	3,750	0	0	0	0	3,750	0,040	0

0

[illegible]

THE F FACTORS FOR THIS ISOTOPE ARE NOT TEMPERATURE DEPENDENT.

[illegible]

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

COMMENTS:

1 CHECK PU-239 GROUP 1 PRESUMABLY SIGMA (N/2N) = 14.200000E-01

SAMPLE CASE FOR RED CROSS FULL PRINT

THIS IS A BUCKLING CALCULATION

K EFFECTIVE IS EQUAL TO 1.000000

THE CONVERGENCE CRITERION IS 1.000000E-06

NUCLIDE NUMBER	NAME	ATOMS/CC	TEMPERATURE
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1	PU-239	2.29103E+02	900.00
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2	0	5.09118E+02	900.00
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GROUP AVERAGED TOTAL CROSS SECTIONS PER ATOM (EXCLUDING ISOTOPE MENTIONED) ARE LISTED BELOW FOR EACH ITERATION

ITERATION PU-239 0

0	7.7308E 00	8.4823E 01
1	7.6181E 00	5.6790E 01
2	7.6181E 00	5.6790E 01
3	7.6181E 00	5.6790E 01
4	7.6181E 00	5.6790E 01
5	7.6181E 00	5.6790E 01

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

GROUP	SIG0	FF	FC	FT	FE
1	0.2466E 01	1.00000	1.00000	1.00000	1.00000
2	0.3090E 01	1.00000	1.00000	1.00000	1.00000
3	0.3932E 01	1.00000	1.00000	1.00000	1.00000
4	0.3642E 01	1.00000	1.00000	1.00000	1.00000
5	0.9180E 01	1.00000	1.00000	1.00000	1.00000
6	0.1065E 02	1.00000	1.00000	1.00000	1.00000
7	0.8444E 01	1.00000	1.00000	1.00000	1.00000
8	0.7778E 01	1.00000	1.00000	1.00000	1.00000
9	0.7889E 01	1.00000	1.00000	1.00000	1.00000
10	0.8000E 01	0.97952	0.99048	0.99952	1.00000
11	0.8111E 01	0.96818	0.98091	0.99909	1.00000
12	0.8222E 01	0.92745	0.94255	0.98787	0.99957
13	0.8333E 01	0.86683	0.87515	0.95644	0.95921
14	0.8333E 01	0.77644	0.76950	0.89446	0.86921
15	0.8333E 01	0.63565	0.59663	0.80089	0.79921
16	0.8333E 01	0.49525	0.44296	0.64089	0.73921
17	0.8333E 01	0.40644	0.36613	0.50327	0.68921
18	0.8333E 01	0.44881	0.40455	0.40881	0.55960
19	0.8333E 01	0.20881	0.20286	0.22762	0.72000
20	0.8333E 01	0.19921	0.22207	0.13238	0.86960
21	0.8333E 01	0.20921	0.23167	0.19040	0.96000
22	0.8333E 01	1.00000	1.00000	1.00000	1.00000
23	0.8333E 01	1.00000	1.00000	1.00000	1.00000
24	0.8333E 01	0.69960	0.54861	0.47238	0.88960
25	0.8333E 01	0.59000	0.57742	0.31029	0.84000
26	0.8333E 01	1.00000	1.00000	1.00000	1.00000

CALCULATED RESONANCE SELF-SHIELDING COEFFICIENTS ARE LISTED BELOW FOR 10

GROUP	SIG	FFI	FC	FT	FE
1	0.3015E 01	1.00000	0.94314	0.93355	0.96438
2	0.3465E 01	1.00000	0.93397	0.92318	0.95699
3	0.3555E 01	1.00000	1.00000	0.88610	0.92958
4	0.3285E 01	1.00000	1.00000	0.83814	0.93649
5	0.3285E 01	1.00000	1.00000	0.91583	0.96066
6	0.3735E 01	1.00000	1.00000	0.79578	0.85578
7	0.4455E 01	1.00000	1.00000	1.00000	1.00000
8	0.5085E 01	1.00000	1.00000	1.00000	1.00000
9	0.5625E 01	1.00000	1.00000	1.00000	1.00000
10	0.6277E 01	1.00000	1.00000	1.00000	1.00000
11	0.6706E 01	1.00000	1.00000	1.00000	1.00000
12	0.7251E 01	1.00000	1.00000	1.00000	1.00000
13	0.7556E 01	1.00000	1.00000	1.00000	1.00000
14	0.7335E 01	1.00000	1.00000	1.00000	1.00000
15	0.8336E 01	1.00000	1.00000	1.00000	1.00000
16	0.9501E 01	1.00000	1.00000	1.00000	1.00000
17	0.1043E 02	1.00000	1.00000	1.00000	1.00000
18	0.2078E 02	1.00000	1.00000	1.00000	1.00000
19	0.9757E 01	1.00000	1.00000	1.00000	1.00000
20	0.2086E 02	1.00000	1.00000	1.00000	1.00000
21	0.1242E 02	1.00000	1.00000	1.00000	1.00000
22	0.1035E 02	1.00000	1.00000	1.00000	1.00000
23	0.1710E 02	1.00000	1.00000	1.00000	1.00000
24	0.5577E 02	1.00000	1.00000	1.00000	1.00000
25	0.7637E 03	1.00000	1.00000	1.00000	1.00000
26	0.4669E 03	1.00000	1.00000	1.00000	1.00000

RESONANCE SHIELDED MICROSCOPIC CROSS SECTIONS FOR PU-239

GROUP	SIGF	SIGA	NUSIGF	SIGTR	SIGXG	G-1XG	G-2XG	G-3XG	G-4XG	G-5XG	G-6XG
1	2.2000	1.7900	8.4920	3.4660	0.5900	0.	0.	0.	0.	0.	0.
2	1.8500	1.8700	5.4935	4.0600	0.8940	0.0260	0.	0.	0.	0.	0.
3	1.9700	2.0000	5.4419	4.5985	1.3605	0.0760	0.0400	0.	0.	0.	0.
4	1.9500	1.9900	6.0840	5.0175	1.9405	0.1780	0.2000	0.1500	0.	0.	0.
5	1.8000	1.8600	5.4180	5.3650	2.6300	0.2270	0.3100	0.3600	0.2600	0.	0.
6	1.6800	1.7900	4.9560	6.4275	4.0255	0.4650	0.4200	0.4000	0.3600	0.3200	0.
7	1.6600	1.8300	4.8306	8.2624	6.1764	0.4820	0.2300	0.2700	0.2200	0.1800	0.1800
8	1.6800	1.9200	4.8552	10.1781	8.0181	0.2260	0.0900	0.1300	0.1200	0.0900	0.0800
9	1.8500	2.2500	5.3280	11.8210	9.3540	0.2400	0.0200	0.0300	0.0400	0.0400	0.0300
10	2.1060	2.8092	6.0441	13.5559	10.4937	0.2170	-0.	0.0100	0.0100	0.0100	0.0100
11	2.3236	3.3830	6.6688	14.7563	11.2533	0.2530	-0.	-0.	-0.	-0.	-0.
12	2.3186	3.4968	6.6545	16.1719	12.5395	0.1200	-0.	-0.	-0.	-0.	-0.
13	2.9472	4.6100	8.4586	17.2159	12.4754	0.1356	-0.	-0.	-0.	-0.	-0.
14	3.2610	5.2617	9.3592	17.4419	12.0611	0.1305	-0.	-0.	-0.	-0.	-0.
15	4.8309	7.8140	13.8647	20.8232	12.8941	0.1191	0.	-0.	-0.	-0.	-0.
16	6.4382	10.4692	18.4777	23.3926	12.8089	0.1151	0.	0.	-0.	-0.	-0.
17	7.7223	12.8481	22.1630	24.1569	11.1972	0.1146	0.	0.	0.	-0.	-0.
18	18.4013	34.9877	52.8117	41.6989	6.5903	0.1117	0.	0.	0.	0.	-0.
19	4.5939	10.8825	13.1844	15.4785	4.4793	0.1209	0.	0.	0.	0.	0.
20	19.9208	35.9097	57.1727	24.3571	-11.6648	0.1166	0.	0.	0.	0.	0.
21	9.4144	17.5229	27.0192	17.2308	-0.4006	0.1122	0.	0.	0.	0.	0.
22	12.0000	13.0000	34.4400	23.0000	9.8920	0.1085	0.	0.	0.	0.	0.
23	24.0000	27.0000	68.8800	38.0000	10.8810	0.1080	0.	0.	0.	0.	0.
24	72.0592	112.1076	206.8100	89.2790	-22.9558	0.1190	0.	0.	0.	0.	0.
25	985.3000	1683.9783	2827.8109	898.6105	-785.5097	0.1272	0.	0.	0.	0.	0.
26	742.0000	1028.0000	2129.5400	1038.0000	10.0000	0.1420	0.	0.	0.	0.	0.

GROUP G-7XG G-8XG G-9XG G-10XG

1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0
17	0	0	0	0
18	0	0	0	0
19	0	0	0	0
20	0	0	0	0
21	0	0	0	0
22	0	0	0	0
23	0	0	0	0
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0

RESONANCE SHIELDED MICROSCOPIC CROSS SECTIONS FOR

0

GROUP	SIGF	SIGA	NUSIGF	SIGTR	SIGXG	G-1XG	G-2XG	G-3XG	G-4XG	G-5XG	G-6XG
1	0.	0.2169	0.	0.8298	0.2098	0.	0.	0.	0.	0.	0.
2	0.	0.0700	0.	1.0088	0.5703	0.2430	0.	0.	0.	0.	0.
3	0.	0.0030	0.	1.2466	0.8541	0.3684	0.0200	0.	0.	0.	0.
4	0.	0.	0.	1.2467	0.9424	0.3895	0.	0.0500	0.	0.	0.
5	0.	0.	0.	3.6230	2.7892	0.3044	0.	0.	0.0500	0.	0.
6	0.	0.	0.	3.4314	2.7648	0.8339	0.	0.	0.	0.0300	0.
7	0.	0.	0.	3.2680	2.4880	0.6667	0.	0.	0.	0.	0.0100
8	0.	0.	0.	3.3600	2.7510	0.7800	0.	0.	0.	0.	0.
9	0.	0.	0.	3.4080	2.8550	0.6090	0.	0.	0.	0.	0.
10	0.	0.	0.	3.4560	2.8950	0.5530	0.	0.	0.	0.	0.
11	0.	0.	0.	3.5040	2.9350	0.5610	0.	0.	0.	0.	0.
12	0.	0.	0.	3.5520	2.9750	0.5690	0.	0.	0.	0.	0.
13	0.	0.	0.	3.6000	3.0160	0.5770	0.	0.	0.	0.	0.
14	0.	0.	0.	3.6000	3.0160	0.5840	0.	0.	0.	0.	0.
15	0.	0.	0.	3.6000	3.0160	0.5840	0.	0.	0.	0.	0.
16	0.	0.	0.	3.6000	3.0160	0.5840	0.	0.	0.	0.	0.
17	0.	0.	0.	3.6000	3.0160	0.5840	0.	0.	0.	0.	0.
18	0.	0.	0.	3.6000	3.0160	0.5840	0.	0.	0.	0.	0.
19	0.	0.	0.	3.6000	3.0160	0.5840	0.	0.	0.	0.	0.
20	0.	0.	0.	3.6000	3.0160	0.5840	0.	0.	0.	0.	0.
21	0.	0.	0.	3.6000	3.0160	0.5840	0.	0.	0.	0.	0.
22	0.	0.	0.	3.6000	3.0160	0.5840	0.	0.	0.	0.	0.
23	0.	0.	0.	3.6000	3.0160	0.5840	0.	0.	0.	0.	0.
24	0.	0.	0.	3.6000	3.0160	0.5840	0.	0.	0.	0.	0.
25	0.	0.	0.	3.6000	3.0160	0.5840	0.	0.	0.	0.	0.
26	0.	0.	0.	3.6000	3.6000	0.5840	0.	0.	0.	0.	0.

GROUP | G-7XG | G-8XG | G-9XG | G-10XG |

1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0
17	0	0	0	0
18	0	0	0	0
19	0	0	0	0
20	0	0	0	0
21	0	0	0	0
22	0	0	0	0
23	0	0	0	0
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0

THE MACROSCOPIC CROSS SECTIONS ARE GIVEN IN THE TABLE BELOW

GROUP	SIGF	SIGA	NUSIGF	SIGTR	SIGXG	G-1XG	G-2XG	G-3XG	G-4XG	G-5XG	G-6XG
1	5.04E-02	5.21E-02	1.95E+01	1.22E-01	2.42E-02	0.	0.	0.	0.	0.	0.
2	4.24E-02	4.64E-02	1.49E+01	1.44E-01	4.95E-02	1.30E-02	0.	0.	0.	0.	0.
3	4.51E-02	4.60E-02	1.48E+01	1.69E-01	7.47E-02	2.05E-02	1.93E-03	0.	0.	0.	0.
4	4.47E-02	4.56E-02	1.39E+01	1.78E-01	9.24E-02	2.39E-02	4.58E-03	5.98E-03	0.	0.	0.
5	4.12E-02	4.26E-02	1.24E+01	3.07E-01	2.02E-01	2.07E-02	7.10E-03	8.25E-03	8.50E-03	0.	0.
6	3.85E-02	4.10E-02	1.14E+01	3.22E-01	2.33E-01	5.31E-02	9.62E-03	9.16E-03	8.25E-03	8.86E-03	0.
7	3.80E-02	4.19E-02	1.11E+01	3.56E-01	2.68E-01	4.50E-02	5.27E-03	6.19E-03	5.04E-03	4.12E-03	4.63E-03
8	3.85E-02	4.40E-02	1.11E+01	4.04E-01	3.24E-01	4.49E-02	2.06E-03	2.98E-03	2.75E-03	2.06E-03	1.83E-03
9	4.24E-02	5.15E-02	1.22E+01	4.44E-01	3.60E-01	3.65E-02	4.58E-04	6.87E-04	9.16E-04	9.16E-04	6.87E-04
10	4.82E-02	6.44E-02	1.38E+01	4.87E-01	3.88E-01	3.31E-02	-0.	2.29E-04	2.29E-04	2.29E-04	2.29E-04
11	5.32E-02	7.75E-02	1.53E+01	5.16E-01	4.07E-01	3.44E-02	-0.	-0.	-0.	-0.	-0.
12	5.31E-02	8.01E-02	1.52E+01	5.51E-01	4.39E-01	3.17E-02	-0.	-0.	-0.	-0.	-0.
13	6.75E-02	1.06E-01	1.94E+01	5.78E-01	4.39E-01	3.25E-02	-0.	-0.	-0.	-0.	-0.
14	7.47E-02	1.21E-01	2.14E+01	5.83E-01	4.30E-01	3.27E-02	-0.	-0.	-0.	-0.	-0.
15	1.11E-01	1.79E-01	3.18E+01	6.60E-01	4.49E-01	3.25E-02	0.	-0.	-0.	-0.	-0.
16	1.48E-01	2.40E-01	4.23E+01	7.19E-01	4.47E-01	3.24E-02	0.	0.	-0.	-0.	-0.
17	1.77E-01	2.94E-01	5.08E+01	7.37E-01	4.10E-01	3.24E-02	0.	0.	0.	-0.	-0.
18	4.22E-01	8.02E-01	1.21E+00	1.14E+00	3.05E-01	3.23E-02	0.	0.	0.	0.	-0.
19	1.05E-01	2.49E-01	3.02E+01	5.38E-01	2.56E-01	3.25E-02	0.	0.	0.	0.	0.
20	4.56E-01	8.23E-01	1.31E+00	7.41E-01	-1.14E-01	3.24E-02	0.	0.	0.	0.	0.
21	2.16E-01	4.01E-01	6.19E+01	5.78E-01	1.44E-01	3.23E-02	0.	0.	0.	0.	0.
22	2.75E-01	2.98E-01	7.89E+01	7.10E-01	3.80E-01	3.22E-02	0.	0.	0.	0.	0.
23	5.50E-01	6.19E-01	1.58E+00	1.05E+00	4.03E-01	3.22E-02	0.	0.	0.	0.	0.
24	1.65E+00	2.57E+00	4.74E+00	2.23E+00	-3.72E-01	3.25E-02	0.	0.	0.	0.	0.
25	2.26E+01	3.86E+01	6.48E+01	2.08E+01	-1.78E+01	3.26E-02	0.	0.	0.	0.	0.
26	1.70E+01	2.36E+01	4.88E+01	2.40E+01	4.12E-01	3.30E-02	0.	0.	0.	0.	0.

THE MACROSCOPIC CROSS SECTIONS ARE GIVEN IN THE TABLE BELOW

GROUP G=7XG G=8XG G=9XG G=10XG

1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	1.60E-03	0	0	0
9	6.87E-04	6.87E-04	0	0
10	2.29E-04	2.29E-04	2.29E-04	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0
17	0	0	0	0
18	0	0	0	0
19	0	0	0	0
20	0	0	0	0
21	0	0	0	0
22	0	0	0	0
23	0	0	0	0
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0

***** FINAL RESULTS BELOW *****

SAMPLE CASE FOR RED CROSS: FULL PRINT

KI EFFECTIVE = 1.000000E 00

BUCKLING(B2) = 6.148746E 02

ABSORPTION RATE = 3.488399E 01

LEAKAGE RATE = 6.511665E 01

GROUP	FLUX	NU*SIGF*FLUX	SIGF*FLUX	INTG FLUX	ADJOINT	CHI*ADJOINT
1	7.52075E 00	1.46319E 00	3.79066E 01	9.55586E 03	9.04089E 01	1.80818E 02
2	4.17936E 01	6.21755E 00	1.77138E 00	6.26588E 02	8.36944E 01	8.20205E 02
3	9.21802E 01	1.36045E 01	4.16039E 00	1.79783E 01	9.14457E 01	1.73747E 01
4	1.45576E 02	2.02913E 01	6.50362E 00	3.64752E 01	9.21786E 01	2.47039E 01
5	1.37817E 02	1.71070E 01	5.68339E 00	5.39863E 01	1.12791E 00	2.21070E 01
6	1.53808E 02	1.74639E 01	5.91996E 00	7.35291E 01	1.10360E 00	1.48986E 01
7	1.03477E 02	1.14519E 01	3.93535E 00	8.66769E 01	1.13956E 00	6.60945E 02
8	6.28965E 01	6.99624E 00	2.42084E 00	9.46685E 01	1.19927E 00	2.63839E 02
9	2.83335E 01	3.45855E 00	1.20089E 00	9.82686E 01	1.26292E 00	1.13663E 02
10	9.90351E 00	1.37136E 00	4.77826E 01	9.95269E 01	1.30187E 00	3.90562E 03
11	2.95661E 00	4.51725E 01	1.57395E 01	9.99026E 01	1.30655E 00	1.30655E 03
12	6.26149E 01	9.54598E 02	3.32612E 02	9.99822E 01	1.31697E 00	0.
13	1.17013E 01	2.26756E 02	7.90092E 03	9.99970E 01	1.37880E 00	0.
14	2.03474E 02	4.36291E 03	1.52018E 03	9.99996E 01	1.40183E 00	0.
15	2.72447E 03	8.65412E 04	3.01537E 04	1.00000E 00	1.52072E 00	0.
16	2.93271E 04	1.24151E 04	4.32581E 05	1.00000E 00	1.57625E 00	0.
17	2.67714E 05	1.35935E 05	4.73641E 06	1.00000E 00	1.56565E 00	0.
18	1.01453E 06	1.22751E 06	4.27705E 07	1.00000E 00	1.46194E 00	0.
19	1.03099E 07	3.11418E 08	1.08508E 08	1.00000E 00	1.10030E 00	0.
20	3.78505E 09	4.95782E 09	1.72746E 09	1.00000E 00	1.53835E 00	0.
21	2.60625E 10	1.61331E 10	5.62131E 11	1.00000E 00	1.48554E 00	0.
22	2.33959E 11	1.84601E 11	6.43207E 12	1.00000E 00	2.41766E 00	0.
23	1.12382E 12	1.77346E 12	6.17931E 13	1.00000E 00	2.44250E 00	0.
24	1.39748E 14	6.62138E 14	2.30710E 14	1.00000E 00	1.83618E 00	0.
25	1.18152E 17	7.65458E 16	2.66710E 16	1.00000E 00	1.67954E 00	0.
26	1.65468E 20	8.07293E 19	2.81287E 19	1.00000E 00	2.07146E 00	0.
SUM	7.87030E 02	1.00001E 02	3.26531E 01		3.68126E 01	1.00000E 00

***** FINAL RESULTS BELOW *****

SAMPLE CASE FOR RED CROSS PARTIAL PRINT

KI EFFECTIVE = 1.000000E 00

BUCKLING(B2) = 6.148746E-02

ABSORPTION RATE = 3.488399E 01

LEAKAGE RATE = 6.511665E 01

GROUP	FLUX	NU SIG F FLUX	SIG F FLUX	INTG FLUX	ADJOINT	CHI ADJOINT
1	7.52075E 00	1.46319E 00	3.79066E 01	9.55586E 03	9.04089E 01	1.80818E 02
2	4.17936E 01	6.21755E 00	1.77138E 00	6.26588E 02	8.36944E 01	8.20205E 02
3	9.21802E 01	1.36045E 01	4.16039E 00	1.79783E 01	9.14457E 01	1.73747E 01
4	1.45576E 02	2.02913E 01	6.50362E 00	3.64752E 01	9.21786E 01	2.47039E 01
5	1.37817E 02	1.71070E 01	5.68339E 00	5.39863E 01	1.12791E 00	2.21070E 01
6	1.53808E 02	1.74639E 01	5.91996E 00	7.35291E 01	1.10360E 00	1.48986E 01
7	1.03477E 02	1.14519E 01	3.93535E 00	8.66769E 01	1.13956E 00	6.60945E 02
8	6.28965E 01	6.99624E 00	2.42084E 00	9.46685E 01	1.19927E 00	2.63339E 02
9	2.83335E 01	3.45855E 00	1.20089E 00	9.82686E 01	1.26292E 00	1.13563E 02
10	9.90351E 00	1.37136E 00	4.77826E 01	9.95269E 01	1.30187E 00	3.90562E 03
11	2.95661E 00	4.51725E 01	1.57395E 01	9.99026E 01	1.30655E 00	1.30655E 03
12	6.26149E 01	9.54598E 02	3.32612E 02	9.99822E 01	1.31697E 00	0.
13	1.17013E 01	2.26756E 02	7.90092E 03	9.99970E 01	1.37880E 00	0.
14	2.03474E 02	4.36291E 03	1.52018E 03	9.99996E 01	1.40183E 00	0.
15	2.72447E 03	8.65412E 04	3.01537E 04	1.00000E 00	1.52072E 00	0.
16	2.93271E 04	1.24151E 04	4.32581E 05	1.00000E 00	1.57625E 00	0.
17	2.67714E 05	1.35935E 05	4.73641E 06	1.00000E 00	1.56565E 00	0.
18	1.01453E 06	1.22751E 06	4.27705E 07	1.00000E 00	1.46194E 00	0.
19	1.03099E 07	3.11418E 08	1.08508E 08	1.00000E 00	1.10030E 00	0.
20	3.78505E 09	4.95782E 09	1.72746E 09	1.00000E 00	1.53835E 00	0.
21	2.60625E 10	1.61331E 10	5.62131E 11	1.00000E 00	1.48554E 00	0.
22	2.33959E 11	1.84601E 11	6.43207E 12	1.00000E 00	2.41766E 00	0.
23	1.12382E 12	1.77346E 12	6.17931E 13	1.00000E 00	2.44250E 00	0.
24	1.39748E 14	6.62138E 14	2.30710E 14	1.00000E 00	1.83618E 00	0.
25	1.18152E 17	7.65458E 16	2.66710E 16	1.00000E 00	1.67954E 00	0.
26	1.65468E 20	8.07293E 19	2.81287E 19	1.00000E 00	2.07146E 00	0.
SUM	7.87030E 02	1.00001E 02	3.26531E 01		3.68126E 01	1.00000E 00

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

ITERATION	PU-239	G
0	7.7308E 00	8.4823E 01
1	7.6181E 00	5.6790E 01
2	7.6181E 00	5.6790E 01
3	7.6181E 00	5.6790E 01
4	7.6181E 00	5.6790E 01
5	7.6181E 00	5.6790E 01

SAMPLE CASE FOR RED CROSS PARTIAL PRINT

THIS IS A BUCKLING CALCULATION

KIEFFECTIVE IS EQUAL TO 1.000000

THE CONVERGENCE CRITERION IS 1.000000E-06

NUCLIDE NUMBER	NAME	ATOMS/CC	TEMPERATURE
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1	PU-239	2.29103E+02	900.00
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2	O	5.09118E+02	900.00
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*****RESULTS OF CROSS SECTION CHECK*****

COMMENTS.....

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

***** RI ELD) C RI O SSS *****

CROSS SECTION CALCULATION USING RUSSIAN DATA

APPENDIX D

LISTING OF FORTRAN IV
SOURCE DECK

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$IBFTC MAIN LIST
  DIMENSION HOLN( 8), CHI(26), SF( 8,4), SC( 8,6), ST( 8,4),
1 SE( 8,4), FF( 8,78,4), FC( 8,78,6), FT( 8,78,4), FE( 8,78,4),
2 SR( 8,8,26), SM( 8,12,11), HOL(12), DN( 8), TEMP( 8), SOGO( 8),
3 SIGO(8,26), FSSF( 8,26), FSSC( 8,26), FSST( 8,26), FSSE( 8,26),
4 S(15,26), SN(15,26), SIGR(26), PHI(26), FPHI(26), AVSIG( 8),
5 HF(4), HC(6), HT(4), HE(4),ADJ(26)
  DIMENSION NT( 8), NGB( 8), NGE( 8), NFT( 8), NPFF( 8), NPFC( 8),
1 NPFT( 8), NPFE( 8), LN( 8), NG( 8,78)
  COMMON NXS, LTD, LTE, NOP, NFD, NSOP, NTI
  COMMON NT, NGB, NGE, NFT, NPFF, NPFC, NPFT, LN, NG, NPFE
  COMMON BSQ, EPS, AK, RS, RL, RA, TAK,ADJ
  COMMON HOLN, CHI, SF, SC, ST, SE, FF, FC, FE, SR, SM, HOL, DN,
1 TEMP, SOGO, SIGO, FSSF, FSSC, FSST, FSSE, S, SN, SIGR, PHI, FPHI, FT, AVSIG
C F M CALCULATION FOR RUSS CROSS SECTIONS WITH SHIELDING FACTORS
  CALL INPUT1
  CALL PRT1
  CALL CHECK
5 CONTINUE
  CALL INPUT2
  CALL SETUP
  IF(NSOP) 9,9,7
7 CALL CALC1
  DO 8 M = 1,NTI
  CALL CALC2
  CALL RECALC(M)
8 CONTINUE
9 CONTINUE
  CALL CALC2
  IF(LTD) 53, 53, 55
53 CALL PRT2
55 CONTINUE
  CALL CROSS
  CALL BUCK
  CALL CLIMAX
  GO TO 5
END
$IBFTC INPUT1 LIST
  SUBROUTINE INPUT1
  DIMENSION HOLN( 8), CHI(26), SF( 8,4), SC( 8,6), ST( 8,4),
1 SE( 8,4), FF( 8,78,4), FC( 8,78,6), FT( 8,78,4), FE( 8,78,4),
2 SR( 8,8,26), SM( 8,12,11), HOL(12), DN( 8), TEMP( 8), SOGO( 8),
3 SIGO(8,26), FSSF( 8,26), FSSC( 8,26), FSST( 8,26), FSSE( 8,26),
4 S(15,26), SN(15,26), SIGR(26), PHI(26), FPHI(26), AVSIG( 8),
5 HF(4), HC(6), HT(4), HE(4),ADJ(26)
  DIMENSION NT( 8), NGB( 8), NGE( 8), NFT( 8), NPFF( 8), NPFC( 8),
1 NPFT( 8), NPFE( 8), LN( 8), NG( 8,78)
  COMMON NXS, LTD, LTE, NOP, NFD, NSOP, NTI

```

```

COMMON  NT, NGB, NGE, NFT, NPFF, NPFC, NPFT, LN, NG, NPFE
COMMON  BSQ, EPS, AK, RS, RL, RA, TAK, ADJ
COMMON  HOLN, CHI, SF, SC, ST, SE, FF, FC, FE, SR, SM, HOL, DN,
1 TEMP, SOGO, SIGO, FSSF, FSSC, FSST, FSSE, S, SN, SIGR, PHI, FPHI, FT, AVSIG
WRITE (3,1000)
1000  FORMAT (1H1////////)
      WRITE (3,1)
1     FORMAT (1H032X,41H * * * * * R E D   C R O S S * * * * *////////
131X,45H CROSS SECTION CALCULATION USING RUSSIAN DATA///)
      READ( 2, 2)  NXS, LTD, LTE, NFD
2     FORMAT(4I6)
      READ( 2, 3)  (CHI(K), K = 1, 26)
3     FORMAT(6E12.4)
10    IF (NFD) 18,18,10
      READ(2,3) (PHI(I), I = 1,26)
18    CONTINUE
      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, 8I6)
      NF = NPFF(I)
      NC = NPFC(I)
      NTP = NPFT(I)
      NE = NPFE(I)
      IF (NFT(I)) 159, 159, 26
26    CONTINUE
      IF (NFT(I) - 3) 50, 45, 28
28    CONTINUE
40    READ( 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 (12E6.4)
      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
60 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 = NGB(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),
   1 N = 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),
   1 N = 1, NE)
156 CONTINUE
159 CONTINUE
   DO 200 L = 1, 26
   READ( 2, 190) LD, (SR(I, L, K), K = 1, 8)
190 FORMAT (I3, 4E9.2, 4E8.2)
200 CONTINUE
   DO 300 L = 1, 12
   READ( 2, 230) LD, (SM(I, L, K), K = 1, 11)
230 FORMAT (I3, 11E6.1)
300 CONTINUE
   RETURN
   END
$IBFTC PRT1 List

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```

SUBROUTINE PRT1
  DIMENSION HOLN( 8), CHI(26), SF( 8,4), SC( 8,6), ST( 8,4),
1 SE( 8,4), FF( 8,78,4), FC( 8,78,6), FT( 8,78,4), FE( 8,78,4),
2 SR( 8,8,26), SM( 8,12,11), HOL(12), DN( 8), TEMP( 8), SOGO( 8),
3 SIGO(8,26), FSSF( 8,26), FSSC( 8,26), FSST( 8,26), FSSE( 8,26),
4 S(15,26), SN(15,26), SIGR(26), PHI(26), FPHI(26), AVSIG( 8),
5 HF(4), HC(6), HT(4), HE(4),ADJ(26)
  DIMENSION NT( 8), NGB( 8), NGE( 8), NFT( 8), NPFF( 8), NPFC( 8),
1 NPFT( 8), NPFE( 8), LN( 8), NG( 8,78)
  COMMON NXS, LTD, LTE, NOP, NFD, NSOP, NTI
  COMMON NT, NGB, NGE, NFT, NPFF, NPFC, NPFT, LN, NG, NPFE
  COMMON BSG, EPS, AK, RS, RL, RA, TAK,ADJ
  COMMON HOLN, CHI, SF, SC, ST, SE, FF, FC, FE, SR, SM, HOL, DN,
1 TEMP,SOGO,SIGO,FSSF,FSSC,FSST,FSSE,S,SN,SIGR,PHI,FPHI,FT,AVSIG
  IF(LTD) 5, 5, 299
5  CONTINUE
  IF(NFD) 20, 20, 10
10 CONTINUE
  WRITE( 3, 14) NXS
14 FORMAT (49H1* * * INPUT DATA LISTED ON FOLLOWING PAGES FOR 12,16H
1 ISOTOPES * * *///
246H GROUP FISSION SOURCE INPUT FLUX ///)
  G = 0.
  DO 18 I = 1, 26
  WRITE (3,38) I,CHI(I),PHI(I)
18 G = G + CHI(I)
  GO TO 45
20 CONTINUE
  WRITE( 3, 32) NXS
32 FORMAT (49H1* * * INPUT DATA LISTED ON FOLLOWING PAGES FOR 12,16H
1 ISOTOPES * * *///
327H GROUP FISSION SOURCE///)
  G = 0.
  DO 44 I = 1, 26
  WRITE ( 3, 38) I, CHI(I)
  G = G + CHI(I)
38 FORMAT(18,1P2E16.5)
44 CONTINUE
45 CONTINUE
  WRITE ( 3, 41) G
41 FORMAT (8H0 SUM 1PE16.5)
  DO 200 I = 1, NXS
  WRITE ( 3, 46) HOLN(I), I
46 FORMAT (32H1MICROSCOPIC CROSS SECTIONS FOR A6,21H NUCLIDE 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)
WRITE( 3, 49)
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 ALLEQUAL 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/, (HE(J), J=1,4)/4*2HFE/
65  IF (NFT(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.
TEMP(3) = 2100.
IF (NFT(I) = 3) 270, 265, 280
165 WRITE (3, 181) (SC(I, J), J=1, NC), (ST(I, J), J=1,
1NTP), (SE(I, J), J=1, NE)
WRITE (3, 184) (HC(J), J=1, NC), (HT(J), J=1, NTP), (HE(J), J=1, NE)
WRITE (3, 182)
DO 169 J = JJ, JJJ
WRITE( 3, 167) J, (FC(I, J, N), N = 1, NC), (FT(I, J, N),
1N = 1, NTP), (FE(I, J, N), N = 1, NE)
167 FORMAT(I5, 14F7.3)

```

```

169  CONTINUE
    GO TO 200
170  WRITE (3,181) (ST(I,J), J=1,NTP), (SE(I,J), J=1,NE)
    WRITE (3,184) (HT(J),J=1,NTP), (HE(J), J=1,NE)
    WRITE (3,182)
    DO 179 J = JJ, JJJ
    WRITE ( 3, 167) J, (FT(I, J, N), N = 1, NTP),
1 (FE(I, J, N), N = 1, NE)
179  CONTINUE
    GO TO 200
180  WRITE (3,181) (SF(I,J), J=1,NF), (SC(I,J), J=1,NC), (ST(I,J), J=1,
1NTP), (SE(I,J), J=1,NE)
181  FORMAT (5HOSIG014F7.0)
182  FORMAT (1H )
    WRITE (3,184) (HF(J),J=1,NF), (HC(J),J=1,NC), (HT(J),J=1,NTP),
1 (HE(J),J=1,NE)
184  FORMAT (9HOGROUP 14(A6,X))
    WRITE (3,182)
    DO 189 J = JJ, JJJ
    WRITE( 3, 167) 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)
189  CONTINUE
    GO TO 200
265  WRITE (3,281) (SC(I,J), J=1,NC), (ST(I,J), J=1,
1NTP), (SE(I,J), J=1,NE)
    WRITE (3,284) (HC(J),J=1,NC), (HT(J),J=1,NTP), (HE(J),J=1,NE)
    WRITE (3,182)
    DO 269 J = JJ, JJJ
    K = J/3
    KK = J + 1 - (J/3)*3
    WRITE( 3, 267) K,TEMP(KK), (FC(I, J, N), N = 1, NC),
1(FT(I, J, N), N = 1, NTP),(FE(I, J, N), N = 1, NE)
267  FORMAT (I5, F9.1, 14F7.3)
269  CONTINUE
    GO TO 200
270  WRITE (3,281) (ST(I,J), J=1,NTP), (SE(I,J), J=1,NE)
    WRITE (3,284) (HT(J),J=1,NTP), (HE(J), J=1,NE)
    WRITE (3,182)
    DO 279 J = JJ, JJJ
    K = J/3
    KK = J + 1 - (J/3)*3
    WRITE ( 3, 267) K,TEMP(KK), (FT(I, J, N), N = 1, NTP),
1(FE(I, J, N), N = 1, NE)
279  CONTINUE
    GO TO 200
280  WRITE (3,281) (SF(I,J), J=1,NF), (SC(I,J), J=1,NC), (ST(I,J), J=1,
1NTP), (SE(I,J), J=1,NE)
281  FORMAT (5HOSIG08X,F8.0,13F7.0)

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```

WRITE(3,284) (HE(J),J=1,NF), (HC(J),J=1,NC), (HT(J),J=1,NTP),
1 (HE(U),U=1,NE)
284  FORMAT(18H0GROUP   TEMP   14(A6,X))
      WRITE(3,182)
      DO 289 J = JJ, JJJ
      K = J/3
      KK = J + 1 - (J/3)*3
      WRITE(3,267) K,TEMP(KK), (FF(I,J,N), N = 1, NF),
1 (FC(I,J,N), N = 1, NC), (FT(I,J,N), N = 1, NTP),
2 (FE(I,J,N), N = 1, NE)
289  CONTINUE
200  CONTINUE
299  CONTINUE
      RETURN
      END
$IBFIC INPUT2 LIST

```

```

SUBROUTINE INPUT2
  DIMENSION HOLN( 8), CHI(26), SF( 8,4), SC( 8,6), ST( 8,4),
1 SE( 8,4), FF( 8,78,4), FC( 8,78,6), FT( 8,78,4), FE( 8,78,4),
2 SR( 8,8,26), SM( 8,12,11), HOL(12), DN( 8), TEMP( 8), SOGO( 8),
3 SIGO(8,26), FSSF( 8,26), FSSC( 8,26), FSST( 8,26), FSSE( 8,26),
4 S(15,26), SN(15,26), SIGR(26), PHI(26), FPHI(26), AVSIG( 8),
5 HF(4), HC(6), HT(4), HE(4), ADJ(26)
  DIMENSION NT( 8), NGB( 8), NGE( 8), NFT( 8), NPFF( 8), NPFC( 8),
1 NPFT( 8), NPFE( 8), LN( 8), NG( 8,78)
  COMMON NXS, LTD, LTE, NOP, NFD, NSOP, NTI
  COMMON NT, NGB, NGE, NFT, NPFF, NPFC, NPFT, LN, NG, NPFE
  COMMON BSQ, EPS, AK, RS, RL, RA, TAK, ADJ
  COMMON HOLN, CHI, SF, SC, ST, SE, FF, FC, FE, SR, SM, HOL, DN,
1 TEMP, SOGO, SIGO, FSSF, FSSC, FSST, FSSE, S, SN, SIGR, PHI, FPHI, FT, AVSIG
  READ ( 2, 3) (HOL(I), I = 1, 12)
  WRITE( 3, 1)
1  FORMAT(1H1)
  WRITE( 3, 3) (HOL(I), I = 1, 12)
3  FORMAT (12A6)
  READ( 2, 5) NOP, NSOP, NTI, G
5  FORMAT(3I6, E12.4)
  EPS = .000001
  IF (NOP) 7, 7, 21
7  IF(G) 11, 11, 9
9  BSQ = G
11 CONTINUE
  WRITE ( 3, 13) BSQ, EPS
13  FORMAT (1H0//40H THIS IS A REACTIVITY CALCULATION///
117H THE BUCKLING IS 1PE16.6///
230H THE CONVERGENCE CRITERION IS 1PE16.6/////
253H NUCLIDE NUMBER NAME ATOMS/CC TEMPERATURE//)
  GO TO 49
21  AK = G
  WRITE ( 3, 23) AK, EPS
23  FORMAT (1H0//38H THIS IS A BUCKLING CALCULATION////
125H K EFFECTIVE IS EQUAL TO F8.6///
230H THE CONVERGENCE CRITERION IS 1PE16.6/////
253H NUCLIDE NUMBER NAME ATOMS/CC TEMPERATURE//)
49  CONTINUE
  READ ( 2, 51) (DN(J), J = 1, NXS)
51  FORMAT (6E12.4)
  READ ( 2, 51) (TEMP(J), J = 1, NXS)
  DO 54 J = 1, NXS
  WRITE (3,52)
52  FORMAT (1H0)
  WRITE ( 3, 55) J, HOLN(J), DN(J), TEMP(J)
55  FORMAT (18,10H ,A6,1PE14.5,0PF14.2)
54  CONTINUE

```

```

SUBROUTINE CALC2
  DIMENSION HOLN( 8), CHI(26), SF( 8,4), SC( 8,6), ST( 8,4),
1SE( 8,4), FF( 8,78,4), FC( 8,78,6), FT( 8,78,4), FE( 8,78,4),
2SR( 8,8,26), SM( 8,12,11), HOL(12), DN( 8), TEMP( 8), SOGO( 8),
3 SIGO(8,26), FSSF( 8,26), FSSC( 8,26), FSST( 8,26), FSSE( 8,26),
4 S(15,26), SN(15,26), SIGR(26), PHI(26), FPHI(26), AVSIG( 8),
5 HF(4), HC(6), HT(4), HE(4),ADJ(26)
  DIMENSION NT( 8), NGB( 8), NGE( 8), NFT( 8), NPFF( 8), NPFC( 8),
1NPFT( 8), NPFE( 8), LN( 8), NG( 8,78)
  COMMON NXS, LTD, LTE, NOP, NFD, NSOP, NTI
  COMMON NT, NGB, NGE, NFT, NPFF, NPFC, NPFT, LN, NG, NPFE
  COMMON BSQ, EPS, AK, RS, RL, RA, TAK,ADJ
  COMMON HOLN, CHI, SF, SC, ST, SE, FF, FC, FE, SR, SM, HOL, DN,
1 TEMP, SOGO, SIGO, FSSF, FSSC, FSST, FSSE, S, SN, SIGR, PHI, FPHI, FT, AVSIG
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 = NGB(N)
    JJJ = NGE(N)
    NF = NPFF(N)
    NC = NPFC(N)
    NTP= NPFT(N)
    NE = NPFE(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(NSOP) 70, 70, 190
70  READ( 2, 51) (SOGO(J), J = 1, NXS)
      WRITE( 3, 74)
74  FORMAT(42H1THE SIGOS FOR THIS CASE ARE THE FOLLOWING////
133H NUCLEIDE NUMBER      NAME      SIGO//)
      DO 76 J = 1, NXS
      WRITE( 3, 52)
      WRITE( 3, 75) J, HOLN(J), SOGO(J)
75  FORMAT (18,10H      ,A6,E14.5)
76  CONTINUE
      DO 170 I = 1, NXS
      DO 170 J = 1, 26
      SIGO(I, J) = SOGO(I)
170 CONTINUE
190 CONTINUE
      RETURN
      END
$IBFTC CALC1 LIST
      SUBROUTINE CALC1
      DIMENSION HOLN( 8), CHI(26), SF( 8,4), SC( 8,6), ST( 8,4),
1SE( 8,4), FF( 8,78,4), FC( 8,78,6), FT( 8,78,4), FE( 8,78,4),
2SR( 8,8,26), SM( 8,12,11), HOL(12), DN( 8), TEMP( 8), SOGO( 8),
3 SIGO(8,26), FSSF( 8,26), FSSC( 8,26), FSST( 8,26), FSSE( 8,26),
4 S(15,26), SN(15,26), SIGR(26), PHI(26), FPHI(26), AVSIG( 8),
5 HF(4), HC(6), HT(4), HE(4), ADJ(26)
      DIMENSION NT( 8), NGB( 8), NGE( 8), NFT( 8), NPFF( 8), NPFC( 8),
1NPFT( 8), NPFE( 8), LN( 8), NG( 8,78)
      COMMON NXS, LTD, LTE, NOP, NFD, NSOP, NTI
      COMMON NT, NGB, NGE, NFT, NPFF, NPFC, NPFT, LN, NG, NPFE
      COMMON BSQ, EPS, AK, RS, RL, RA, TAK, ADJ
      COMMON HOLN, CHI, SF, SC, ST, SE, FF, FC, FE, SR, SM, HOL, DN,
1 TEMP, SOGO, SIGO, FSSF, FSSC, FSST, FSSE, S, SN, SIGR, PHI, FPHI, FT, AVSIG
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 (111HIGROUP AVERAGED TOTAL CROSS SECTIONS PER ATOM (EXCLUDING 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
$IBFIC RECALC LIST

```

```

SUBROUTINE RECALC(M)
  DIMENSION HOLN( 8), CHI(26), SF( 8,4), SC( 8,6), ST( 8,4),
1 SE( 8,4), FF( 8,78,4), FC( 8,78,6), FT( 8,78,4), FE( 8,78,4),
2 SR( 8,8,26), SM( 8,12,11), HOL(12), DN( 8), TEMP( 8), SOGO( 8),
3 SIGO(8,26), FSSF( 8,26), FSSC( 8,26), FSST( 8,26), FSSE( 8,26),
4 S(15,26), SN(15,26), SIGR(26), PHI(26), FPHI(26), AVSIG( 8),
5 HF(4), HC(6), HT(4), HE(4), ADJ(26)
  DIMENSION NT( 8), NGB( 8), NGE( 8), NFT( 8), NPFF( 8), NPFC( 8),
1 NPFT( 8), NPFE( 8), LN( 8), NG( 8,78)
  COMMON NXS, LTD, LTE, NOP, NFD, NSOP, NTI
  COMMON NT, NGB, NGE, NFT, NPFF, NPFC, NPFT, LN, NG, NPFE
  COMMON BSQ, EPS, AK, RS, RL, RA, TAK, ADJ
  COMMON HOLN, CHI, SF, SC, ST, SE, FF, FC, FE, SR, SM, HOL, DN,
1 TEMP, SOGO, SIGO, FSSF, FSSC, FSST, FSSE, S, SN, SIGR, PHI, FPHI, FT, AVSIG
  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

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\$IBFTC CALC2 LIST

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      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
$IBFTC SETUP LIST
SUBROUTINE SETUP
    DIMENSION HOLN( 8), CHI(26), SF( 8,4), SC( 8,6), ST( 8,4),
    1SE( 8,4), FF( 8,78,4), FC( 8,78,6), FT( 8,78,4), FE( 8,78,4),
    2SR( 8,8,26), SM( 8,12,11), HOL(12), DN( 8), TEMP( 8), SOGO( 8),
    3 SIGO(8,26), FSSF( 8,26), FSSC( 8,26), FSST( 8,26), FSSE( 8,26),
    4 S(15,26), SN(15,26), SIGR(26), PHI(26), FPHI(26), AVSIG( 8),
    5 HF(4), HC(6), HT(4), HE(4), ADJ(26)
    DIMENSION NT( 8), NGB( 8), NGE( 8), NFT( 8), NPFF( 8), NPFC( 8),
    1NPFT( 8), NPFE( 8), LN( 8), NG( 8,78)
    COMMON NXS, LTD, LTE, NOP, NFD, NSOP, NTI
    COMMON NT, NGB, NGE, NFT, NPFF, NPFC, NPFT, LN, NG, NPFE
    COMMON BSQ, EPS, AK, RS, RL, RA, TAK, ADJ
    COMMON HOLN, CHI, SF, SC, ST, SE, FF, FC, FE, SR, SM, HOL, DN,
    1 TEMP, SOGO, SIGO, FSSF, FSSC, FSST, FSSE, S, SN, SIGR, PHI, FPHI, FT, AVSIG
C THIS SUBROUTINE COMPUTES F FACTORS FOR TEMP DEPENDENT ISOTOPES
    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
1SAFE LIMITS)
    IF (TEMP(N) - .0001) 18, 18, 19
18 TEMP(N) = 1.0
    WRITE(3, 21)
21 FORMAT(34H0TEMPERATURE HAS BEEN SET TO UNITY/)
19 IF (NFT(N) - 3) 60, 40, 20
20 DO 30 I = JJ, JJJ
    J = 3 * I
    DO 30 K = 1, NF

```

```

A = FF(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
$1BFTC PRT2 LIST

```

```

SUBROUTINE PRT2
  DIMENSION HOLN( 8), CHI(26), SF( 8,4), SC( 8,6), ST( 8,4),
1 SE( 8,4), FF( 8,78,4), FC( 8,78,6), FT( 8,78,4), FE( 8,78,4),
2 SR( 8,8,26), SM( 8,12,11), HOL(12), DN( 8), TEMP( 8), SOGO( 8),
3 SIGO(8,26), FSSF( 8,26), FSSC( 8,26), FSST( 8,26), FSSE( 8,26),
4 S(15,26), SN(15,26), SIGR(26), PHI(26), FPHI(26), AVSIG( 8),
5 HF(4), HC(6), HT(4), HE(4),ADJ(26)
  DIMENSION NT( 8), NGB( 8), NGE( 8), NFT( 8), NPFF( 8), NPFC( 8),
1 NPFT( 8), NPFE( 8), LN( 8), NG( 8,78)
  COMMON NXS, LTD, LTE, NOP, NFD, NSOP, NTI
  COMMON NT, NGB, NGE, NFT, NPFF, NPFC, NPFT, LN, NG, NPFE
  COMMON BSQ, EPS, AK, RS, RL, RA, TAK,ADJ
  COMMON HOLN, CHI, SF, SC, ST, SE, FF, FC, FE, SR, SM, HOL, DN,
1 TEMP, SOGO, SIGO, FSSF, FSSC, FSST, FSSE, S, SN, SIGR, PHI, FPHI, FT, AVSIG
  DO 200 I = 1, NXS
    WRITE( 3, 2) HOLN(I)
2  FORMAT(71H1CALCULATED RESONANCE SELF-SHIELDING COEFFICIENTS ARE LI
1STED BELOW FOR A6777)
    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          FE//)
    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
$IBFTC CROSS LIST

```

```

SUBROUTINE CROSS
  DIMENSION HOLN( 8), CHI(26), SF( 8,4), SC( 8,6), ST( 8,4),
  1SE( 8,4), FF( 8,78,4), FC( 8,78,6), FT( 8,78,4), FE( 8,78,4),
  2SR( 8,8,26), SM( 8,12,11), HOL(12), DN( 8), TEMP( 8), SOGO( 8),
  3 SIGO(8,26), FSSF( 8,26), FSSC( 8,26), FSST( 8,26), FSSE( 8,26),
  4 S(15,26), SN(15,26), SIGR(26), PHI(26), FPHI(26), AVSIG( 8),
  5 HF(4), HC(6), HT(4), HE(4), ADJ(26)
  DIMENSION NT( 8), NGB( 8), NGE( 8), NFT( 8), NPFF( 8), NPFC( 8),
  1NPFT( 8), NPFE( 8), LN( 8), NG( 8,78)
  COMMON NXS, LTD, LTE, NOP, NFD, NSOP, NTI
  COMMON NT, NGB, NGE, NFT, NPFF, NPFC, NPFT, LN, NG, NPFE
  COMMON BSQ, EPS, AK, RS, RL, RA, TAK, ADJ
  COMMON HOLN, CHI, SF, SC, ST, SE, FF, FC, FE, SR, SM, HOL, DN,
  1 TEMP, SOGO, SIGO, FSSF, FSSC, FSST, FSSE, S, SN, SIGR, PHI, FPHI, FT, AVSIG
C  CALCULATION OF SHIELDED CROSS SECTIONS IN DTK FORMAT
  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(1,J) = FSSF(I,J) * SR(I,2,J)
  S(3,J) = SR(I,3,J) * S(1,J)
  S(2,J) = S(1,J) + FSSC(I,J) * SR(I,4,J) - (FPHI(J) - SR(I,5,J))
  S(4,J) = (FSST(I,J)*SR(I,1,J) - S(2,J) - FPHI(J))
  1 * (1. - SR(I,7,J)) + S(2,J) + FPHI(J)
  IF (J - 12) 40,40,50
40  S(5,J) = S(4,J) - S(2,J) - FPHI(J) + SM(I,J,1) - FSSE(I,J)*SR(I,8,J)
  GO TO 60
50  S(5,J) = S(4,J) - S(2,J) - FPHI(J) - FSSE(I,J)*SR(I,8,J)
60  CONTINUE
  IF (J-1) 65,65,66
65  S(6,J) = .0
  GO TO 100
66  IF(J - 13) 70,70,80
70  S(6,J) = FSSE(I,J-1)*SR(I,8,J-1) + SM(I,J-1,2)
  GO TO 100
80  S(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( M, J) = 0.0
  JK = J - N

```

```

      IF(JK) 250, 250, 230
230  IF (JK - 12) 240, 240, 250
240  JL = N + 1
      S(M,J) = SM(I,JK,JL)
250  CONTINUE
      IF (LTE) 360, 360, 358
358  KD = 9
      DO 353 J = 1, 26
      PUNCH 354, KD, (S(K, J), K = 1, 8)
      PUNCH 354, KD, (S(K, J), K = 9, 15)
353  CONTINUE
354  FORMAT (I1, F8.3, 7F9.3)
360  CONTINUE
      IF (LTD) 370, 370, 460
370  CONTINUE
      WRITE ( 3, 435) HOLN(I)
435  FORMAT(51H1RESONANCE SHIELDED MICROSCOPIC CROSS SECTIONS FOR A6///
1//
2111H GROUP  SIGF  SIGA  NUSIGF  SIGTR  SIGXG  G-1X
3G  G-2XG  G-3XG  G-4XG  G-5XG  G-6XG///)
      DO 444 J = 1, 26
      WRITE (3, 436) J, (S(K, J), K = 1, 11)
436  FORMAT(I3, 11F10.4)
444  CONTINUE
      WRITE ( 3, 440)
440  FORMAT(44H1GROUP  G-7XG  G-8XG  G-9XG  G-10XG///)
      DO 449 J = 1, 26
      WRITE (3, 442) J, (S(K, J), K = 12, 15)
442  FORMAT(I3, 4F10.4)
449  CONTINUE
460  CONTINUE
      DO 480 J = 1, 26
      DO 480 K = 1, 15
480  SN(K, J) = SN(K, J) + DN(I)*S(K, J)
500  CONTINUE
      RETURN
      END
$IBFTC BUCK LIST

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```

SUBROUTINE BUCK
  DIMENSION HOLN( 8), CHI(26), SF( 8,4), SC( 8,6), ST( 8,4),
1SE( 8,4), FF( 8,78,4), FC( 8,78,6), FT( 8,78,4), FE( 8,78,4),
2SR( 8,8,26), SM( 8,12,11), HOL(12), DN( 8), TEMP( 8), SOGO( 8),
3 SIGO(8,26), FSSF( 8,26), FSSC( 8,26), FSST( 8,26), FSSE( 8,26),
4 S(15,26), SN(15,26), SIGR(26), PHI(26), FPHI(26), AVSIG( 8),
5 HF(4), HC(6), HT(4), HE(4),ADJ(26)
  DIMENSION NT( 8), NGB( 8), NGE( 8), NFT( 8), NPFF( 8), NPFC( 8),
1NPFT( 8), NPFE( 8), LN( 8), NG( 8,78)
  COMMON NXS, LTD, LTE, NOP, NFD, NSOP, NTI
  COMMON NT, NGB, NGE, NFT, NPFF, NPFC, NPFT, LN, NG, NPFE
  COMMON BSQ, EPS, AK, RS, RL, RA, TAK,ADJ
  COMMON HOLN, CHI, SF, SC, ST, SE, FF, FC, FE, SR, SM, HOL, DN,
1 TEMP, SOGO, SIGO, FSSF, FSSC, FSST, FSSE, S, SN, SIGR, PHI, FPHI, FT, AVSIG
  IF(LTD) 71, 71, 89
71 CONTINUE
  WRITE ( 3, 73)
73 FORMAT (60H)THE MACROSCOPIC CROSS SECTIONS ARE GIVEN IN THE TABLE
1BELOW///
2111H GROUP SIGF SIGA NUSIGF SIGTR SIGXG G-1X
3G G-2XG G-3XG G-4XG G-5XG G-6XG///)
  DO 78 I = 1, 26
  WRITE ( 3, 74) I, (SN(K, I), K = 1, 11)
74 FORMAT (14, 1P11E10.2)
78 CONTINUE
  WRITE (3,83)
83 FORMAT (60H)THE MACROSCOPIC CROSS SECTIONS ARE GIVEN IN THE TABLE
1BELOW///40H:GROUP G-7XG G-8XG G-9XG G-10XG///)
  DO 88 I = 1, 26
  WRITE (3,74) I, (SN(K,I), K = 12,15)
88 CONTINUE
89 CONTINUE
  IF(NOP) 99, 99,93
93 BSQ = .001
  ITER = 0
99 CONTINUE
  DO 101 I = 1, 26
  SIGR(I) = .0
  DO 100 K = 6, 15
  NN = I + K - 5
  IF(NN - 26) 100, 100, 101
100 SIGR(I) = SIGR(I) + SN(K, NN)
101 CONTINUE
106 CONTINUE
  ITER = ITER + 1
  IF(NFD) 105, 105, 201
105 CONTINUE
  DO 199 I = 1, 26

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```

SUM = .0
DO 111 N = 1, 10
KKK = I - N
KK = N + 5
IF(KKK) 112, 112, 111
111 SUM = SUM + PHI(KKK)*SN(KK, I)
112 CONTINUE
199 PHI(I) = (100.*CHI(I) + SUM)/(.33333*BSQ/SN(4, I) + SN(2, I) + SIG
1R(I))
201 CONTINUE
RS = 0.
RL = 0.
RA = 0.
DO 412 I = 1, 26
FPHI(I) = PHI(I) * SN(3, I)
RS = RS + FPHI(I)
RL = RL + BSQ*PHI(I)/(3.*SN(4, I))
412 RA = RA + PHI(I)*SN(2, I)
IF(NOP) 511, 511, 441
441 TAK = RS/(RL + RA)
IF (ABS(AK - TAK) - EPS) 511, 511, 601
601 IF(ITER - 200) 605, 605, 511
605 G = .0
DO 611 I = 1, 26
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, 26
SUM = .0
II = 27-I
KK = II + 1
KKK = II + 10
DO 811 K = KK, KKK
N = K - II + 5
IF (K - 26) 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
$IBFTC CLIMAX LIST

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SUBROUTINE CLIMAX
  DIMENSION HOLN( 8), CHI(26), SF( 8,4), SC( 8,6), ST( 8,4),
1 SE( 8,4), FF( 8,78,4), FC( 8,78,6), FT( 8,78,4), FE( 8,78,4),
2 SR( 8,8,26), SM( 8,12,11), HOL(12), DN( 8), TEMP( 8), SOGO( 8),
3 SIGO(8,26), FSSF( 8,26), FSSC( 8,26), FSST( 8,26), FSSE( 8,26),
4 S(15,26), SN(15,26), SIGR(26), PHI(26), FPHI(26), AVSIG( 8),
5 HF(4), HC(6), HT(4), HE(4),ADJ(26)
  DIMENSION NT( 8), NGB( 8), NGE( 8), NFT( 8), NPFF( 8), NPFC( 8),
1 NPFT( 8), NPFE( 8), LN( 8), NG( 8,78)
  COMMON NXS, LTD, LTE, NOP, NFD, NSOP, NTI
  COMMON NT, NGB, NGE, NFT, NPFF, NPFC, NPFT, LN, NG, NPFE
  COMMON BSQ, EPS, AK, RS, RL, RA, TAK,ADJ
  COMMON HOLN, CHI, SF, SC, ST, SE, FF, FC, FE, SR, SM, HOL, DN,
1 TEMP,SOGO,SIGO,FSSF,FSSC,FSST,FSSE,S,SN,SIGR,PHI,FPHI,FT,AVSIG
  WRITE (3,1)
1  FORMAT (1H120X,56H * * * * F I N A L   R E S U L T S   B E L O W
1 * * * *///)
  WRITE (3,2) (HOL(I), I = 1,12)
2  FORMAT (12A6)
  WRITE (3,3) AK,BSQ,RA,RL
3  FORMAT (1H0//14H K EFFECTIVE =1PE16.6,20X,15H BUCKLING(B2) =1PE16.
26//18H ABSORPTION RATE =1PE16.6,16X,15H LEAKAGE RATE =1PE16.6////
793H GROUP      FLUX      NU*SIGF*FLUX      SIGF*FLUX      INTG FLUX
8 ADJOINT      CHI*ADJOINT      //)
  SUMA = .0
  PP = .0
  SUM = .0
  DO 4      I = 1, 26
  SUMA = SUMA + ADJ(I)
4  SUM = SUM + PHI(I)
  SUMCA = .0
  WWWL = 0.0
  DO 11      I = 1, 26
  WWWL = WWWL + PHI(I)/ SUM
  POWER = PHI(I) * SN(1, I)
  PP = PP + PCWER
  G = CHI(I) * ADJ(I)
  SUMCA = SUMCA + G
  WRITE( 3, 5) I, PHI(I), FPHI(I), POWER , WWWL ,ADJ(I), G
5  FORMAT (I3, 1P6E14.5)
11  CONTINUE
  WRITE(3, 31) SUM, RS, PP, SUMA, SUMCA
31  FORMAT (4H0SUM1PE13.5,1P2E14.5,14X,1P2E14.5)
  RETURN
  END
$IBFTC CHECK LIST

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SUBROUTINE CHECK
  DIMENSION HOLN( 8), CHI(26), SF( 8,4), SC( 8,6), ST( 8,4),
1 SE( 8,4), FF( 8,78,4), FC( 8,78,6), FT( 8,78,4), FE( 8,78,4),
2 SR( 8,8,26), SM( 8,12,11), HOL(12), DN( 8), TEMP( 8), SOGO( 8),
3 SIGO(8,26), FSSF( 8,26), FSSC( 8,26), FSST( 8,26), FSSE( 8,26),
4 S(15,26), SN(15,26), SIGR(26), PHI(26), FPHI(26), AVSIG( 8),
5 HF(4), HC(6), HT(4), HE(4),ADJ(26)
  DIMENSION NT( 8), NGB( 8), NGE( 8), NFT( 8), NPFF( 8), NPFC( 8),
1 NPFT( 8), NPFE( 8), LN( 8), NG( 8,78)
  COMMON NXS, LTD, LTE, NOP, NFD, NSOP, NTI
  COMMON NT, NGB, NGE, NFT, NPFF, NPFC, NPFT, LN, NG, NPFE
  COMMON BSQ, EPS, AK, RS, RL, RA, TAK,ADJ
  COMMON HOLN, CHI, SF, SC, ST, SE, FF, FC, FE, SR, SM, HOL, DN,
1 TEMP,SOGO,SIGO,FSSF,FSSC,FSST,FSSE,S,SN,SIGR,PHI,FPHI,FT,AVSIG
  WRITE (3,2)
2  FORMAT (1H115X,47H * * * * RESULTS OF CROSS SECTION CHECK * * * */
17///10X,15H COMMENTS . . .//)
  ME = 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  ME = ME + 1
    IF (ME - 100) 12,85,85
12  WRITE (3,14) ME, HOLN(N), I
14  FORMAT (I3,8H CHECK A6, 9H GROUP I2//)
19  CONTINUE
    IF (I - 12) 20,20,30
20  G = .0
    DO 22 K = 1,11
22  G = G + SM(N,I,K)
    IF (ABS(G - SR(N,5,I)) - .005) 30,24,24
24  G = G - SR(N,5,I)
    ME = ME + 1
    IF (ME - 100) 25,85,85
25  WRITE (3,26) ME, HOLN(N), I, G
26  FORMAT (I3,8H CHECK A6,9H GROUP I2,5X,26H PRESUMABLY SIGMA (N,2
1N) =1PE16.6//)
30  CONTINUE
    IF (NT(N)) 31,31,32
31  II = 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

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```

C      CHECK OF F VS SIG
      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) 208,300,300
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 (13,15H 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 (13,15H F FACTORS IN A6,23H ARE GREATER THAN UNITY//)
40    CONTINUE
      IF (NT(N)) 41,41,42
41    JJJ = NGE(N)
      JJ = NGB(N) + 1
      GO TO 43
42    JJ = NGB(N)
      JJJ = NGE(N)
      DO 450 J = JJ, JJJ
      I = 3 * J
      DO 445 K = 1, 6
      IF (FC(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

```

```

      UJ = 3*NGB(N) + 1
      UJJE = 3*NGE(N) + 2
43      CONTINUE
      DO 49 J = UJ, UJJE
      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(13,22H CHECK SEQUENCING OF A6,10H F FACTORS//)
49      CONTINUE
50      CONTINUE
      IF (ME) 80,80,99
80      WRITE (3,81)
81      FORMAT (60H0THE INPUT DATA APPEARS TO BE CONSISTENT AND IN PROPER
1ORDER)
      GO TO 99
85      WRITE (3,87)
87      FORMAT (33H0SHODDY DATA - CHECK DISCONTINUED)
99      CONTINUE
      RETURN
      END

```

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