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MUFT-5-A FAST NEUTRON SPECTRUM PROGRAM FOR THE PHILCO 2000

February 1961

CONTRACT AT-11-1-GEN-14

BETTIS ATOMIC POWER LABORATORY
PITTSBURGH, PENNSYLVANIA

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A FAST NEUTRON SPECTRUM PROGRAM FOR THE PHILCO-2000

H. Bohl, Jr.
A. P. Hemphill

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ABSTRACT

The program which this document describes was written for the Philco-2000 computer to provide a nuclear design computing tool equivalent to the IBM-704 computer program MUFT-4, and to provide a set of routines for a future spatial multigroup program, P_3MG-1. In addition to the features of its 704 predecessor, MUFT-5 provides a more complete isotopic edit, an optional blackness coefficient edit, and the use of a complete P_1-library, which is described in the appendices of this report. The resultant program is found to be easier to use because of the simplicity of running several problems, more valuable because of the many additional results which are edited, and more economical because of the changes made in programming.

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MUFT-5
A FAST NEUTRON SPECTRUM PROGRAM FOR THE PHILCO-2000

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PART ONE

DESCRIPTION OF PROBLEM SOLVED

A. INTRODUCTION

This program solves the P_1 or B_1 multigroup equation for the first two Legendre coefficients of the directional neutron flux (these components being referred to as flux and current) and the isotropic and anisotropic components of the slowing down densities due to a cosine-shaped neutron source (Ref. 1). Hydrogen may be treated exactly or in a Selengut-Goertzel approximation (Ref. 2). For energy degradation by heavy elements, both age and Grueling-Goertzel approximations are available (Ref. 3). The program also takes into account slowing down of neutrons by inelastic scattering and removal of neutrons resulting from capture and fission resonances (Ref. 2). Only the non-thermal neutron energy range is considered.

Few-group data is edited by the program for three few-group schemes. The program will print for all schemes few-group diffusion constants; absorption removal, nu-fission and fission macroscopic cross sections; source, flux, and current integrals; flux-weighted absorption, nu-fission and fission cross section integrals; and non-absorption probabilities and group ages. In addition, an age-to-thermal quantity is printed for each scheme. Optional editing includes the flux, current and net slowing down density spectra; few-group smooth absorption, resonance absorption nu-fission, and fission macroscopic cross sections and flux-weighted integrals

for every isotope in a case; and few-group blackness diffusion constants and absorption cross sections for an absorbing plate assumed adjacent to a region which has the flux spectrum of the MUFT-5 problem.

Input to the program consists of data specified on cards and data in a multigroup library on a tape created by MILC-1 or MILC-2. The following data is supplied on cards.

1) The dimensions of the problem, the few-group cutpoints, the approximation, and the edit; and in the case of a blackness edit, the half thickness of the absorbing plate, the mesh size in the plate, and the degree of approximation to be used in the blackness edit. This data is for all the cases in the job (as defined by BKS (Ref. 4)).
2) A list of isotope code numbers to be referred to in the job including the blackness edit. This information is used to create from the library tape a special library for the job.
3) Buckling for one case.
4) Isotope number densities for one case.
5) Isotope resonance self-shielding factors for one case.
6) Isotope number densities for the blackness edit for one case.

For each set of cards for one case an entire MUFT-5 problem will be run including all edits specified. All of the necessary data cards must be specified for the first case of a job. For subsequent cases only those cards which are needed to indicate the changes from the previous case are required.

B. BASIC MULTIGROUP EQUATIONS

The following set of equations are to be solved for $\bar{F}_0^m$ and $\bar{F}_1^m$, which are the average values of the fast neutron flux and current for the lethargy multigroup m,

and for q_i^m and p_i^m, which are the isotropic and anisotropic neutron slowing down densities at the low energy end of lethargy multigroup m computed for isotope i. The "bar" above a parameter indicates that this is an average quantity for the multigroup.

$$(\bar{\Sigma}_a^s + \bar{\Sigma}_{in})^m \Gamma_0^m + \epsilon_1 B \Gamma_0^m = \bar{\chi}^m \Delta^m - \sum_i q_i^m + (\rho_a)^m (\sum_i q_i^{m-1}) + \bar{\omega}^m \Delta^m \qquad (B.1)^*$$

$$3(\bar{\Sigma}_{tr})^m \Gamma_1^m = B\Gamma_0^m - 3\delta (\sum_i p_i^m - \sum_i p_i^{m-1}) \qquad (B.2)$$

$$(\lambda_0)_i^m (q_i^m - q_i^{m-1}) = - \bar{q}_i^m \Delta^m + (\bar{\xi}_0)_i^m \Gamma_0^m \qquad (B.3)$$

$$\delta(\lambda_1)_i^m (p_i^m - p_i^{m-1}) = - \bar{p}_i^m \Delta^m + (\bar{\xi}_1)_i^m \Gamma_1^m \qquad (B.4)$$

Here

$$(\bar{\Sigma}_a^s)^m = \sum_i N_i (\bar{\sigma}_f^s)_i^m + \sum_i N_i (\bar{\sigma}_c^s)_i^m \qquad (B.5)$$

$$(\bar{\Sigma}_{in})^m = \sum_i N_i (\bar{\sigma}_{in})_i^m \qquad (B.6)$$

$$(\bar{\Sigma}_{tr})^m = \bar{\gamma}^m \left[(\bar{\Sigma}_{s0})^m + (\bar{\Sigma}_a^s)^m + (\bar{\Sigma}_{in})^m \right] - (\bar{\Sigma}_{sl})^m \qquad (B.7)$$

$(\bar{\sigma}_{s0})_1^m$, $(\bar{\sigma}_c^s)_1^m$, $(\bar{\sigma}_f^s)_1^m$, $(\bar{\sigma}_{in})_1^m$, $(\bar{\sigma}_{sl})_i^m$, $\bar{\gamma}_i^m$, $(\nu_0)_i^m$, $(\lambda_0)_i^m$, $(\xi_1)_i^m$, and $(\lambda_1)_1^m$

are defined in Appendix B.

N_i are the atom number densities for the isotopes i in the composition as specified for each case. (See Card Series 200000, Part Two.)

$\bar{\chi}_m$ is the average source for group m. It is also found on the library file tape. (See Appendix B.) The source spectrum file number is called for by the requestor. (See Card Series 000002, Part Two.)

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* Since $\bar{F}_0^m$ and $\bar{F}_1^m$ are multiplied by Δ^m in many of the equations in this report, their products Γ_0^m and Γ_1^m, respectively, will be used.

$(\rho_a)^m$ is the absorption resonance escape probability for the multigroup m. The quantity is computed from the following set of equations.

$$(\rho_a)^m = \prod_i (\rho_a)_i^m \tag{B.8}$$

$$(\rho_a)_i^m = e^{-\sum_k (RI_a)_i^{m,k}} \tag{B.9}$$

$$(RI_a)_i^{m,k} = \frac{\frac{\pi}{2}(m_a)_i^{m,k}(L)_i^{m,k}}{\bar{\xi}^m \sqrt{\bar{A}_i^{m-1}\left[\bar{A}_i^{m-1} + (r_a)_i^{m,k}\right]}} \tag{B.10}$$

$$\bar{A}_i^{m-1} = \frac{\bar{Y}^{m-1}}{N_i} \tag{B.11}$$

$$\bar{Y}^{m-1} = (\bar{\Sigma}_{s0})^{m-1} + \frac{\epsilon B^2}{3(\bar{\Sigma}_{tr})^{m-1}} \tag{B.12}$$

$$\bar{\xi}^m = \frac{\sum_i N_i(\bar{\xi}_0)_i^m}{(\bar{\Sigma}_{s0})^m} \tag{B.13}$$

$$(\bar{\Sigma}_{s0})^m = \sum_i (\bar{\Sigma}_{s0})_i^m \tag{B.14}$$

where the summation in Eqs. (B.13) and (B.14) include only the isotopes specified as moderators. (See Card Series 200000, Part Two.)

$(r_a)_i^{m,k}$ and $(m_a)_i^{m,k}$ are resonance parameters found on the library file tape. (See Appendix B.) There are a pair of these parameters for each resonance, k, of multigroup, m, of isotope, i.

$L_i^{m,k}$ is the resonance self-shielding factor (L-factor) (Ref. 2) for resonance, k, of multigroup, m, of isotope, i. (See Card Series 300000, Part Two.) The L-factors are specified for the isotopes of the compositions which have resonance data in the library.

B^2 is the value of buckling specified by the requestor. (See Card Series 100000, Part Two.)

ϵ is a special parameter which when multiplied times B^2 will make $\epsilon B^2 = |B^2|$.

B in Eq. (B.2) is $\sqrt{|B^2|}$.

$\bar{\omega}$ is computed from the following.

$$\bar{\omega}^m = \sum_{r<m} \left[\sum_i N_i \left(a_i^{r,m}\right) \frac{(\Gamma_0)^r}{\Delta^m} \right] \tag{B.15a}$$

or $$\bar{\omega}^m = \sum_{r<m} \left[\sum_i A_i^{r,m} \frac{(\Gamma_0)^r}{\Delta^m} \right], \tag{B.15b}$$

where $\bar{\omega}^1 = 0$.

$a^{r,m}$ is defined by Eq. (1) of Appendix B.

Δ^m is the width of lethargy multigroup m. (See Appendix B.)

δ in Eq. (B.4) is a control parameter which is specified by the requestor when he checks the Selengut-Goertzel or non-Selengut-Goertzel approximation. $\delta = 0$ in the former case and = 1 in the latter case. (See Card Series 000001, Part Two.)

$\bar{\gamma}^m$ in Eq. (B.7) is set equal to 1 in all multigroups if a P_1 approximation is specified. (See Card Series 000001, Part Two.) If a B_1 approximation (Ref. 1) is requested, $\bar{\gamma}^m$ is specified in multigroup m in the following manner.

For $$\bar{C}^m = \frac{B}{\bar{\Sigma}^m} > 0.5, \quad \left[\text{here } \bar{\Sigma}^m = (\bar{\Sigma}_{s0})^m + (\bar{\Sigma}_{in})^m + (\bar{\Sigma}_a^s)^m \right] \tag{B.16}$$

$$\bar{\gamma}^m = \frac{(\bar{C}^m)^2 \tan^{-1}(\bar{C}^m)}{3\left[C^m - \tan^{-1}(\bar{C}^m)\right]} \tag{B.17}$$

For $\bar{c}^m \leq 0.5$,

$$\bar{\gamma}^m = 1 + \frac{4}{15}(\bar{c}^m)^2 - \frac{12}{175}(\bar{c}^m)^4 + \frac{92}{2625}(\bar{c}^m)^6 - \frac{7516}{336875}(\bar{c}^m)^8 \qquad (B.18)$$

$$+ \frac{347476}{21896875}(\bar{c}^m)^{10} - \frac{83263636}{6897515625}(\bar{c}^m)^{12} + \frac{48141692}{5011015625}(\bar{c}^m)^{14}$$

$$- \frac{3763564978156}{476522530859375}(\bar{c}^m)^{16} + \frac{428018269172764}{643305416660156 25}(\bar{c}^m)^{18}$$

C. SOLUTION OF EQUATIONS

Let $\bar{q}_i^m$ and $\bar{p}_i^m$ of Eqs. (B.3) and (B.4), respectively, be defined as

$$\bar{q}_i^m = \frac{1}{2}(q_i^m + q_i^{m-1}) \qquad (C.1)$$

and

$$p_i^m = \frac{1}{2}(p_i^m + p_i^{m-1}) \quad . \qquad (C.2)$$

Substitution of Eq. (C.1) into Eq. (B.3) results in

$$(\lambda_0)_i^m (q_i^m - q_i^{m-1}) = -\frac{\Delta^m}{2}(q_i^m + q_i^{m-1}) + (\bar{\xi}_0)_i^m \Gamma_0^m \qquad (C.3a)$$

$$q_i^m = \frac{\left[(\lambda_0)_i^m - \frac{\Delta^m}{2}\right] q_i^{m-1} + (\bar{\xi}_0)_i^m \Gamma_0^m}{(\lambda_0)_i^m + \frac{\Delta^m}{2}} \qquad (C.3b)$$

or

$$q_i^m = \left[1 - (\bar{K}_0)_i^m \Delta^m\right] q_i^{m-1} + (\bar{\Xi}_0)_i^m \Gamma_0^m \qquad (C.3c)$$

where

$$(\bar{K}_0)_i^m = \frac{1}{(\lambda_0)^m + \frac{\Delta^m}{2}} \qquad (C.4a)$$

and $$(\bar{\Xi}_0)_i^m = N_i(\bar{\xi}_0)_i^m(\bar{K}_0)_i^m \tag{C.4b}$$

Similarly, a substitution of Eq. (C.2) into Eq. (B.4) results in

$$p_i^m = 1 - (\bar{K}_1)_i^m \Delta^m \quad p_i^{m-1} + (\bar{\Xi}_1)_i^m \Gamma_i^m \tag{C.5}$$

where $$(\bar{K}_1)_i^m = \frac{1}{(\lambda_1)_i^m + \frac{\Delta^m}{2}} \tag{C.6a}$$

and $$(\bar{\Xi}_1)_i^m = N_i(\bar{\xi}_1)_i^m(\bar{K}_1)_i^m \tag{C.6b}$$

Replacing q_i^m of Eq. (B.1) by its equivalent in Eq. (C.3) results in

$$(\bar{\Sigma}_a^s + \bar{\Sigma}_{in})^m \Gamma_0^m + B\Gamma_1^m = \bar{\chi}^m \Delta^m - \sum_i \left[1 - (\bar{K}_0)_i^m \Delta^m \right] q^{m-1} \tag{C.7a}$$

$$- \sum_i (\bar{\Xi}_0)_i^m \Gamma_0^m + (\rho_a)^m \left(\sum_i q^{m-1} \right) + \bar{\omega}^m \Delta^m$$

$$\left[(\bar{\Sigma}_a^s)^m + (\bar{\Sigma}_{in})^m + \sum_i (\bar{\Xi}_0)_i^m \right] \Gamma_0^m + \Gamma_1^m = (\bar{\chi}^m + \bar{\omega}^m)^m \tag{C.7b}$$

$$+ \sum_i \left[(\rho_a)^m + (\bar{K}_0)_i^m \, {}^m - 1 \right] q_i^{m-1}$$

or $$\bar{\alpha}^m \bar{F}_0^m + \epsilon B \bar{F}_1^m = \bar{s}^m \tag{C.7c}$$

where $$\bar{\alpha}^m = (\bar{\Sigma}_a^s)^m + (\bar{\Sigma}_{in})^m + \sum_i (\bar{\Xi}_0)_i^m \tag{C.8}$$

and $$\bar{s}^m = \bar{\chi}^m + \bar{\omega}^m + \sum_i \left[(\bar{K}_0)_i^m - \frac{(K_a)^m}{\Delta^m} \right] q_i^{m-1} \qquad (C.9)$$

Here $$(K_a)^m = 1 - (\rho_a)^m \qquad (C.10)$$

Similarly, replacing p_i^m of Eq. (B.2) by its equivalent in Eq. (C.5) results in

$$3(\bar{\Sigma}_{tr})^m \Gamma_1^m = B\Gamma_0^m - 3\delta \sum_i \left\{ (\bar{\Xi}_1)_i^m \Gamma_1^m - (\bar{K}_1)_i^m p_i^{m-1} \Delta^m \right\} \qquad (C.11a)$$

$$- B\Gamma_0^m + 3\left[(\bar{\Sigma}_{tr})^m + \delta \sum_i (\bar{\Xi}_1)_i^m \right] \Gamma_1^m = 3\delta \sum_i (\bar{K}_1)_i^m p_i^{m-1} \Delta^m \qquad (C.11b)$$

or $$- B\bar{F}_0^m + \bar{\beta}^m F_1 = \bar{t}^m \qquad (C.11c)$$

where $$\bar{\beta}^m = 3 \left\{ (\bar{\Sigma}_{tr})^m + \delta \sum_i (\bar{\Xi}_1)_i^m \right\} \qquad (C.12)$$

and $$\bar{t}^m = 3\delta \sum_i (\bar{K}_1)_i^m p_i^{m-1} \qquad (C.13)$$

Equations (C.7c) and (C.11c) form a pair of linear simultaneous equations which can be solved in each multigroup for the unknowns $\bar{F}_0^m$ and $\bar{F}_1^m$ so that

$$\bar{F}_0^m = \frac{\bar{\beta}^m \bar{s}^m - \epsilon B \bar{t}^m}{W^m} \qquad (C.14)$$

and $$\bar{F}_1^m = \frac{B\bar{s}^m + \bar{\alpha}^m \bar{t}^m}{W^m} \qquad (C.15)$$

where $$W^m = \bar{\alpha}^m \bar{\beta}^m + \epsilon B^2 \qquad (C.16)$$

Knowing $\bar{F}_0^m$ and $\bar{F}_1^m$, the values of q_i^m and p_i^m can be obtained from Eqs. (C.3b) and (C.5), respectively, with initial conditions that

$$q_i^0 = 0 \tag{C.17}$$

and

$$p_i^0 = 0 \ .$$

D. FEW-GROUP EDIT

Define

$$a^{v,u} = \sum_{m^{v-1,u} < m \le m^{v,u}} \left\{ (\nu\bar{\Sigma}_f^s)^m \Gamma_0^m + \sum_i \left[(\bar{\nu}_i^m (K_f)_i^m \right] q^{m-1} \right\} \tag{D.1}$$

where $(K_f)_i^m = (1 - \rho_f)_i^m$ (D.2)

$$(\rho_f)_i^m = e^{-(r_{fa})_i^m (RI_a)_i^m} \tag{D.3}$$

Here, v is the few-group within the few-group scheme u; and $m^{v,u}$ is the last multigroup included in few-group v. $m^{0,u} = 0$ and $m^{u,u} = M$. The other values of $m^{v,u}$ are those multigroup numbers which are specified as breakpoints. (See Card Series 000001, Part Two.) u may be 1, 2, or 3; v is correspondingly then 1, 1 and 2, or 1 and 2 and 3. r_{fa} are fission-to-absorption ratios in the library. (See Appendix B.)

Also $$b^{v,u} = \sum_{m^{v-1,u} < m \le m^{v,u}} \left[(\bar{\Sigma}_f^s)^m \Gamma_0^m + (K_f)^m q^{m-1} \right] \tag{D.4}$$

where $(K_f)^m = \left[1 - \prod_i (\rho_f)_i^m \right]$. (D.5)

In addition, the following few-group quantities are computed:

$$\Gamma_0^{v,u} = \sum_{m^{v-1,u} < m \leq m^{v,u}} \Gamma_0^m \tag{D.6}$$

$$\Gamma_1^{v,u} = \sum_{m^{v-1,u} < m \leq m^{v,u}} \Gamma_1^m \tag{D.7}$$

$$\Xi^{v,u} = \sum_{m^{v-1,u} < m \leq m^{v,u}} \left[(\bar{\Sigma}_a^s)^m \Gamma_0^m + (K_a)^m q^{m-1} \right] \tag{D.8}$$

where $(K_a)^m = 1 - \prod_i (\rho_a)_i^m$ (D.9)

$$\chi^{v,u} = \sum_{m^{v-1,u} < m \leq m^{v,u}} \bar{\chi}^m \Delta^m \tag{D.10}$$

$$D^{v,u} = \frac{\Gamma_1^{v,u}}{B \Gamma_0^{v,u}} \tag{D.11}$$

where $D \equiv 0$ for $B = 0$

$$(\Sigma_a)^{v,u} = \frac{\Xi^{v,u}}{\Gamma_0^{v,u}} \tag{D.12}$$

$$(\nu\Sigma_f)^{v,u} = \frac{a^{v,u}}{\Gamma_0^{v,u}} \tag{D.13}$$

$$(\Sigma_f)^{v,u} = \frac{b^{v,u}}{\Gamma_0^{v,u}} \tag{D.14}$$

$$\Sigma_r^{1,1} = \frac{q^m}{\Gamma_0^{1,1}} \tag{D.15}$$

$$(\Sigma_r)^{1,2} = \frac{q^{m^{1,2}}}{\Gamma_0^{1,2}} \tag{D.16a}$$

$$(\Sigma_r)^{2,2} = \frac{q^m}{\Gamma_0^{2,2}} \tag{D.16b}$$

$$\Sigma_r^{1,3} = \frac{q^{m^{1,3}} + \sum_{m=m^{2,3}+1}^{m=m^{2,3}} \left\{ \sum_{r=1}^{r=m^{2,3} \text{ or } r<m} \left[\sum_i A_i^{r,m} (\Gamma_0)^r \right] \right\}}{\Gamma_0^{1,3}} \tag{D.17a}$$

$$\Sigma_r^{2,3} = \frac{q^{m^{2,3}}}{\Gamma_0^{2,3}} \tag{D.17b}$$

$$\Sigma_r^{3,3} = \frac{q^m}{\Gamma_0^{3,3}} \tag{D.17c}$$

$$p^{v,u} = \frac{(\Sigma_r)^{v,u}}{(\Sigma_a + \Sigma_r)^{v,u}} \tag{D.18}$$

$$T^{v,u} = \frac{D^{v,u}}{(\Sigma_a + \Sigma_r)^{v,u}} \tag{D.19}$$

and $$\tau^u = \sum_{v=1}^{u} \chi^{v,u} \left[\sum_{\ell=v}^{u} T^{\ell,u} \right] \tag{D.20}$$

E. ISOTOPIC EDIT

If Edit No. 3 is desired (See Card Series 000001, Part Two.), for all the isotopes in a composition the following few-group results are computed.

$$a_i^m = (\bar{\nu}\Sigma_f)_i^m \Gamma_0^m + \bar{\nu}_i^m (K_f)_i^m q^{m-1} \tag{E.1}$$

$$b_i^m = (\Sigma_f)_i^m \Gamma_0^m + (K_f)_i^m q^{m-1} \tag{E.2}$$

$$(\Xi^s)_i^m = (\bar{\Sigma}_a^s)^m \Gamma_0^m \tag{E.3}$$

$$(\Xi^r)_i^m = (K_a)_i^m q^{m-1} \tag{E.4}$$

$$(\nu\Sigma_f)_i^{v,u} = \frac{m^{v-1,u} \sum_{<m\leq m^{v,u}} (a_i^m)}{\Gamma_0^{v,u}} \tag{E.5a}$$

$$(\nu\sigma_f)_i^{v,u} = \frac{(\nu\Sigma_f)_i^{v,u}}{N_i} \tag{E.5b}$$

$$(\Sigma_f)_i^{v,u} = \frac{m^{v-1,u} \sum_{<m\leq m^{v,u}} (b_i^m)}{\Gamma_0^{v,u}} \tag{E.6a}$$

$$(\sigma_f)_i^{v,u} = \frac{(\Sigma_f)_i^{v,u}}{N_i} \tag{E.6b}$$

$$(\Sigma_a^s)_i^{v,u} = \frac{m^{v-1,u} \sum_{<m\leq m^{v,u}} (\Xi^s)_i^m}{\Gamma_0^{v,u}} \tag{E.7a}$$

$$(\sigma_a^s)_i^{v,u} = \frac{(\Sigma_a^s)_i^{v,u}}{N_i} \tag{E.7b}$$

$$(\Sigma_a^r)_i^{v,u} = \frac{m^{v-1,u} \sum_{\leq m \leq m^{v,u}} (\Xi^r)_i^m}{\Gamma_0^{v,u}} \qquad \text{(E.8a)}$$

$$(\sigma_a^r)_i^{v,u} = \frac{(\Sigma_a^r)_i^{v,u}}{N_i} \qquad \text{(E.8b)}$$

F. BLACKNESS COEFFICIENT EDIT (Ref. 7)

For a specially designated set of isotopes i_b (See Card Series 400001, Part Two.) the following are computed:

$$x^m = 2t \sum_{i_b} N_{i_b} (\bar{\sigma}_c^s + \bar{\sigma}_f^s)_{i_b}^m \qquad \text{(F.1)}$$

Here t is the half-thickness of the absorbing region. (See Card Series 000001, Part Two.)

Depending on the value of x^m, a pair of parameters Z^m and H^m are computed. For $x^m \leq 0.1$

$$Z^m = \frac{1 - 2(E_3)^m}{2 + 6(E_4)^m} \qquad \text{(F.2)}$$

and

$$H^m = \frac{1 + 2(E_3)^m}{2 - 6(E_4)^m} \qquad \text{(F.3)}$$

where

$$(E_3)^m = \frac{1}{2} - x^m + \frac{(x^m)^2}{2} \left[0.922784 - \ln x^m \right] + \frac{(x^m)^3}{3!1} \qquad \text{(F.4)}$$

$$- \frac{(x^m)^4}{4!2} + \frac{(x^m)^5}{5!3} - \frac{(x^m)^6}{6!4}$$

$$(E_4)^m = \frac{1}{3}\left[e^{-x^m} - x^m(E_3)^m\right] \tag{F.5}$$

For $0.1 \leq x^m \leq 1.0$

$$Z^m = \sum_{\ell=1}^{5} (c_1)_\ell (x^m)^\ell \tag{F.6}$$

and

$$\frac{1}{H^m} = \sum_{\ell=1}^{5} (c_2)_\ell (x^m)^\ell \tag{F.7}$$

For $1.0 \quad x \quad 5.0$

$$Z^m = \sum_{\ell=1}^{5} (c_2)_\ell (x_m)^\ell \tag{F.8}$$

and

$$\frac{1}{H^m} = \sum_{\ell=1}^{5} (c_4)_\ell (x^m)^\ell \tag{F.9}$$

The coefficients are listed in the following table.*

ℓ	c_1	c_2	c_3	c_4
1	0.48185978	1.5015455	0.44841752	1.6908063
2	-0.3702874	-0.04509368	-0.16643722	-0.54298383
3	0.48761401	-0.44060378	0.03089722	0.070222762
4	-0.45287395	0.25982516	-0.0027506313	-0.0010181291
5	0.16390206	-0.058972772	0.000087612	-0.00032670417

* The coefficients in this table were computed by Norman R. Candelore of Bettis and transmitted by private communication.

For $x^m \geq 5.0$

$$Z^m = H^m \equiv 0.5 \tag{F.10}$$

Knowing the multigroup values of Z^m and H^m, the following few-group quantities are to be computed.

$$Z^{v,u} = \frac{\sum_{m^{v-1,u} < m \leq m^{v,u}} \left[\frac{Z^m \Gamma_0^m}{1 + \delta_b \sqrt{3} Z^m} \right]}{\sum_{m^{v-1,u} < m \leq m^{v,u}} \left[\frac{\Gamma_0^m}{1 + \delta_b \sqrt{3} Z^m} \right]} \tag{F.11}$$

and

$$H^{v,u} = \frac{\sum_{m^{v-1,u} < m \leq m^{v,u}} \frac{H^m \Gamma_0^m}{1 + \delta_b \sqrt{3} H^m}}{\sum_{m^{v-1,u} < m \leq m^{v,u}} \frac{\Gamma_0^m}{1 + \delta_b \sqrt{3} H^m}} \tag{F.12}$$

where δ_b is an input parameter. (See Card Series 000001, Part Two.)

In addition, fictitious diffusion coefficients and absorption cross sections are to be computed in the following manner.

$$D^{v,u} = \frac{(\Theta_1)^{v,u} \, h \tanh(2tk^{v,u})}{\sinh(hk^{v,u})} \tag{F.13}$$

where $$k^{v,u} = \frac{1}{2t} \cosh^{-1} \frac{(\Theta_1)^{v,u}}{(\Theta_2)^{v,u}} \tag{F.14}$$

and $$(\Theta_1)^{v,k} = \frac{H^{v,k} + Z^{v,k}}{2} \tag{F.15}$$

$$(\Theta_2)^{v,k} = \frac{H^{v,k} - Z^{v,k}}{2}$$

The parameter h is an input quantity which is the mesh size in the absorbing region. (See Card Series 000001, Part Two.)

$$(\Sigma_a)^{v,u} = \frac{2D^{v,u}}{h^2} \left[\cosh(hk^{v,u}) - 1 \right] \qquad \text{(F.16)}$$

If $H^{v,u} >> Z^{v,u}$, i.e., $H^{v,u} > 100$,

$$D^{v,u} = 2t(\Theta_2)^{v,u} \qquad \text{(F.17)}$$

and $$(\Sigma_a)^{v,u} = \frac{Z^{v,u}}{t} \qquad \text{(F.18)}$$

If $H^{v,u} = Z^{v,u}$,

$$D^{v,u} = 0 \qquad \text{(F.19)}$$

and $$(\Sigma_a)^{v,u} = \frac{2Z^{v,u}}{h} \qquad \text{(F.20)}$$

PART TWO

PREPARATION OF INPUT

A. INTRODUCTION

A job, as described by BKS (Ref. 4), as run by MUFT-5 can result in the processing of one or more cases each of which is a complete MUFT-5 problem. Regardless of the number of cases in a job there must always be present, in a deck of cards of the first job, the following cards:

1) Accounting card.
2) BKS job control card.
3) Binary program cards (optional).
4) Filetape cards.
5) Data cards.

This deck constitutes part of the input of a MUFT-5 job. The rest of the input for a job is supplied via a file tape which contains a library of data representing the nuclear properties of isotopes which may be used in the job. (See Appendix B.)

B. THE ACCOUNTING CARD

The description of this card is found in the memorandum on the BKS Sequencing System (Ref. 4).

C. CONTROL CARD

Column 9 If the binary program cards for MUFT-5 follow this card, a "C" should be punched. If the MUFT-5 program is to be taken from the BKS System program library, a "T" is punched.

Columns 11-15 "MUFT5" is punched.

Columns 17-32 "23xxxxxxxxxxΔΔΔΔ". Here, x can be blank (Δ) or 4 or 5. x = 4 in the column of the card which corresponds to the number of the library being used (0 through 9; see Section F) indicates that this tape is a "library" tape as defined by BKS and the identification of this tape is found on this control card after the data-select character-code. x = 5 in a column indicates that that tape is a "file" tape as defined by BKS and the identification of it is found on a filetape card (See Section E). The remaining x-columns for which there are no library or file tapes are blank, i.e., Δ. Library tapes and filetapes must be output file tapes of either MILC1 or MILC2 (See Appendices B and C, respectively.).

Columns 33-80 Information punched into these columns will vary with the computing installation, that is, the data-select-character code for printing and the library tape identifications.

This control card is not present for subsequent MUFT-5 jobs.

D. BINARY PROGRAM CARDS

This is a deck of cards which the author assumes accompanied the distribution of this memorandum. This deck is included in the job only if there is a "C" punched in column 9 of the control card (see previous section). This deck is omitted if a "T" is punched in column 9 of the control card and is omitted from all the jobs after the first job of a set of consecutive MUFT-5 jobs on a BKS input tape.

E. FILETAPE CARDS

Filetape cards will vary with computer installation since they contain the identification of the filetapes which may be specified on the control card (see section C). If there are no filetapes specified on the control card, there are

to be no cards specified here. If there are filetapes specified on the control card, the description and ordering of the filetape cards which are required for each job are fully outlined in the BKS memorandum (Ref. 4).

F. DATA CARDS

There is a suggested MUFT-5 Input Form (See Appendix A) which should be filled out with the required parameters for each case in order to facilitate punching. This section will be a description of the quantities entered on this input form. Except for the title card, the only characters which should be entered into the spaces on the form should be +, -, 0, 1, 2, 3, 4, 5, 6, 7, 8, or 9. The quantities "half thickness", "mesh size", "δ_b", "Buckling", "N" and "L" are specified in floating point form such that a number which is written in scientific format as

$$\pm 0.ff\cdots f \times 10^{\pm e}$$

is entered on the form in excess-zero floating point format as

$$\pm ff\cdots f \pm e$$

The space for the sign of the fraction has been omitted in all places except for the buckling. The remaining parameters are fixed point quantities and are assumed positive with the exception of the isotope code numbers, i. (See Appendix F.)

The case number, ccc, which is part of the series number of card series 100000 through 400000 must be the same within a case but may be any three digit number -- e.g., this might be the composition number of a spatial nuclear design computer program. This case number will appear nowhere on the output pages, therefore the author suggests that it be included as part of the title card information.

Title Card All of the alphabetic and numeric information which is punched into this card will be printed at the top of every page of output for the case described on that form and all subsequent cases of that job until another of these cards is encountered by the program at the beginning of a case, at which time the new title card information will replace the old title card information. The author recommends specifying a unique title card for each case and using the first eight columns after the asterisk for a problem number, although the disregard of either of these recommendations will not cause a discontinue of the job.

Dimension Card 000001 This card will be referred to as a dimension card. This card is specified only for the first case of a job. All of the parameters of this card will be the same for every case of the job.

1) Total Number of Multigroups (M), fixed point quantity; this must be the same as the total number of multigroups in the MILC-1 library (See Appendix B.).
2) Multigroup Breakpoints for Few-Group Editing ($m^{1,3}$ and $m^{2,3}$), fixed point quantities; $1 < m^{1,3} < m^{2,3} < M \equiv m^{3,3}$; $m^{1,3} < U$ (See Appendix B.).
3) Edit Number Check the edit desired (See Part Four.).
4) Use Library No. Fixed point integer 0, 1, 2, ···, or 9. Corresponding to this number, a librarytape or filetape must be properly requested on the control card (See Section C.) and, if necessary, filetape card (See Section E.).
5) Approximations One of each of the pairs of approximations must be checked indicating that the corresponding number is to be punched in the card. (See Part One, Section B.).
6) Blackness Coefficient Edit All three quantities are floating point numbers: half thickness of plate (t), mesh size in plate (h), and δ_b. (See Part One, Section F.)

Library Card 000002 This card will be referred to as the library withdrawal card. The isotopes identified by their isotope code numbers, i, and the source spectrum identified by its spectrum number, s, must have information corresponding to these numbers on the tape called for by the Library No. of the dimension card and the BKS control card and filetape cards. The fixed point isotope code numbers must be entered in ascending order. The program will construct in core storage a custom made library for the job from the data read off the library tape. All of the information for the isotopes requested by this card will be read off the tape and included in the job library.

At this point it would be well to state a program restriction which must be met in order to insure that a job may be correctly processed.

There is a large section of core storage, 21,000 words, which is set aside for use by each case and by the job library, $(CS)_c$ and $(CS)_\ell$, respectively. The amount of storage occupied by these two sets of data must meet the following restriction.

$$(CS)_\ell + (CS)_c \leq 21000$$

The amount of storage occupied by the library $(CS)_\ell$ is dependent upon the following parameters.

1) M, the total number of multigroups.
2) L, the first multigroup with resonance data.
3) U, the last multigroup with inelastic scattering matrix data.
4) I_ℓ, the total number of isotopes in the job library.
5) $I_{\ell A}$, the total number of isotopes in the job library with absorption resonance data.
6) $I_{\ell F}$, the total number of isotopes in the job library with fission-to-absorption ratios.

7) I_U, the total number of isotopes in the job library with inelastic scattering matrix data. The amount of storage for the job library can be computed from

$$(CS)_{\ell} = (10M + 3)I_{\ell} + \left[24(M - L + 1) + 1\right] I_{\ell A} + \left[8(M - L + i) + 1\right] I_{\ell F}$$

$$+ \left[\frac{U(U - 1)}{2} + 1\right] I_U + M + 8$$

The amount of core storage occupied by the case $(CS)_c$ is dependent upon some of the above parameters and I_c, the total number of isotopes in each case, and can be computed from

$$(CS)_c = \left[10M - 3(L - 1)\right] I_c + 12M - 5L + \frac{U(U - 1)}{2} + 6$$

For example, in the multigroup library which is in general use at BAPL, M = 54, L = 26, and U = 25; the above equations would simplify to

$$(CS)_{\ell} = 543I_{\ell} + 697I_{\ell A} + 233I_{\ell F} + 301I_U + 62$$

and $$(CS)_c = 465I_c + 824$$

A typical job might have these values for the job library dimensions: $I_{\ell} = 10$, $I_{\ell A} = 7$, $I_{\ell F} = 2$; $I_U = 6$. Then, $(CS)_{\ell} = 12643$; and a case run in this job using all of the job-library isotopes would result in $(CS)_c = 5474$. The total storage is well within the limit of 21,000 words. (Note: All numbers in the above discussion are decimal.)

The remainder of the data entered on the input form may vary between cases. Each case after the first will be considered to have the same input as specified

for the previous case modified by the input specified for the current case. Only those changes from the previous case need be specified, with the exception that L-factors of an isotope for groups L through M must always be specified when changing any L-factors for that isotope. All of the case numbers, ccc, contained within a series number must be identical for a given case. Each case is followed by a blank card. The program interprets the input for the first case of a job as modifications of a fictitious previous case which had as its input:

1) The information on the dimension and library withdrawal cards which are supplied for the first case,
2) $B^2 = 0$,
3) $N_i = 0$, for all i in the job library, in both the MUFT-5 medium and the absorbing plate which is associated with the blackness edit,
4) $L_i^{m,k} = 1$, for all eight resonances of every multigroup within the resonance multigroup range for each isotope that has resonance data in the job library.

1ccOl Buckling (B^2). A signed floating point number within the ranges: $-10^{50} < B^2 < -10^{-50}$; $B^2 = 0$; $10^{-50} < B^2 < 10^{50}$.

2cccOs Isotope code numbers, i, and number densities, N_i, which are to be changed from the previous case. The entries must be made in ascending order according to code numbers. $N_i = 0$ eliminates isotope i from the case. $N_i \neq 0$ includes or modifies the isotope in the case. In every case at least one moderating isotope must be included in the list of isotopes. Moderators are indicated by making the sign of the isotope code number negative. The program has no other means of determining which isotopes are moderators in the computation of resonance escape probabilities (See Eqs. B.13 and B.14.). The number density of a moderator should not be zero. The first five isotope entries are made on card 2cccOl, the next five

on card 2cccO2, and the last five on card 2cccO3. There can be no more than three 2cccOs cards. Specify only as many as needed and use only as many spaces on each card as needed, leaving blank the unused spaces.

3cccmm Resonance Self Shielding Factors (See Part One, Section B.). These factors can be specified only for those isotopes which have absorption resonance data in the job library. The lethargy range under consideration as far as resonance data is concerned lies within and including the multigroups L and M. (See Appendix B.) Every multigroup within this range is assumed to have eight resonance peaks for each isotope. Different L-factors can be specified for each resonance peak of an isotope or one L-factor can be specified for all the resonance peaks of an isotope. In the first method the values of mm in the card series number start at L and run through M for an isotope i with the L-factors for all eight resonance peaks being entered in floating point format. In the second method only one card is specified for the isotope i with only one L-factor and the value of mm = OO; the rest of the spaces are blank. If the isotope is a moderator, just the code number i, not -i, is entered in the space for the isotope code number. The factors must be specified in order according to i. Due to space limitations more than one form may be needed; indicate on the additional forms that they are a continuation of that set of data from the previous form. Enter the Blackness Coefficient Edit input on the last form of a case.

4cccOl Blackness Coefficient Edit. Entries on this card describe the composition of the absorbing plate and must follow, in general, the same ordering rules as the 2cccOs series. If the isotope i_b is a moderator in the MUFT-5 medium, its code number must be positive. All isotopes must have data in the job library. Entries here in no way alter the entries of card series 2cccOs.

PART THREE

OPERATING INSTRUCTIONS

A. INTRODUCTION

Since MUFT-5 was programmed such that it would be run under supervisory control of the BKS system, all operating instructions concerned with arrangement of input decks and computer operations will not be discussed in this memorandum, because they are thoroughly outlined in Reference 4.

B. PUNCHING THE INPUT DECK

Punching of the BKS cards mentioned in Part Two, Section A, is described in Reference 4.

The data cards are punched from the input form and must be retained in the order in which they are punched. A blank card follows the last card of each case. The MUFT-5 control cards -- dimension card and library withdrawal card -- are punched in normal reading order. Each series number indicates the start of a card. Only the spaces which have been filled in should be punched. Entire rows which are blank are ignored. The description of the format of the data cards, the constitution of the various fields of a data card, and the procedure for punching the cards is outlined in detail in Appendix F.

PART FOUR

DESCRIPTION OF OUTPUT

A. INTRODUCTION

The only form of output available at the time of the writing of this memorandum is the printed page. After the basic MUFT-5 problem has been solved (See Part One, Sections B and C.), the input for that case is edited. The list of isotopes which have nonzero number densities are assumed to have been specified as input for that case. For the isotopes in this sublist the L-factors of those isotopes which have absorption resonance data in the job library are printed.

The program then proceeds to obtain the few-group results specified in Section D of Part One based on the multigroup breakpoints specified in the input. The few-group quantities are computed for three schemes.

Scheme 1 One few-group, which includes all of the multigroups from multigroup 1 through multigroup M.

Scheme 2 Two few-groups, which include in the first few-group the multigroups from multigroup 1 through the multigroup indicated by breakpoint 2 and in the second few-group the multigroups not included in the first few-group.

Scheme 3 Three few-groups, which include in the first few-group the multi-groups from multigroup 1 through the multigroup indicated by breakpoint 1, in the second few-group the multigroup next after breakpoint 1 through the multigroup indicated by breakpoint 2, and the third few group which is the same as the second few-group of scheme 2.

After this computation is completed, all of the few-group results are edited for printing off-line.

At this point if the edit specified for the job is Edit No. 1 (See Card Series 000001, Section F, Part Two.), the editing for the MUFT-5 portion of the program

is completed and the program will move on to determine if the blackness coefficient edit is requested for this job. If Edit No. 1 is not specified, the program will process, for printing, the multigroup values of the flux, current, and net slowing down densities. At this point if the edit specified for the job is Edit No. 2, the editing for the MUFT-5 portion of the program is complete and the program will move on to determine if the blackness coefficient edit is requested for this job. If Edit No. 2 has not been specified, the program will compute and process for printing isotope dependent few-group and multigroup quantities for every isotope which is listed at the beginning of the edit as input, for all three few-group schemes. After Edit No. 3 has been completed, the program will determine if the blackness coefficient edit is requested.

If Edit No. 4 is requested, the same information which is normally edited when Edit No. 3 is requested will be edited except that all of the multigroup results normally edited by Edits No. 2 and 3 will be omitted.

If the blackness coefficient edit is requested, the input for the blackness coefficient edit is processed for printing off-line at which time the program will scan another set of number densities for all the isotopes in the job library to determine which isotopes make up the absorbing plate. The computation outline in Section F of Part 1 is performed. The resultant multigroup spectra and few-group quantities, for all three few-group schemes, are processed for off-line printing.

The program proceeds to the next case, if there is one.

The following sections will list the titles which appear on the output pages for each of the edits. After each title will be a reference to the definition or equation in this report which describes the quantities printed under that title on the output pages.

B. EDIT NO. 1

"DIFFUSION CONSTANT" , Eq. (D.11)

"MACROSCOPIC CROSS SECTIONS"

"ABSORPTION" , Eq. (D.12)

"REMOVAL" , Eq. (D.15) through (D.17c)

"NU-FISSION" , Eq. (D.14)

"SPECTRUM INTEGRALS"

"SOURCE" , Eq. (D.10)

"FLUX" , Eq. (D.6)

"CURRENT" , Eq. (D.7)

"FLUX-WEIGHTED CROSS SECTION INTEGRALS"

"ABSORPTION" , Eq. (D.8)

"NU-FISSION" , Eq. (D.1)

"FISSION" , Eq. (D.4)

"NON-ABSORPTION PROBABILITY" , Eq. (D.18)

"GROUP AGE" , Eq. (D.19)

"AGE-TO-THERMAL" , Eq. (D.20)

C. EDIT NO. 2

"MULTIGROUP SPECTRA"

"FLUX" , Eq. (C.14)

"CURRENT" , Eq. (C.15)

"NET SLOWING DOWN DENSITIES"

"ISOTROPIC" , Sum over all the isotopes, i, of the quantity defined by Eq. (C.3c).

"ANISOTROPIC" , Sum over all the isotopes, i, of the quantity defined by Eq. (C.5).

D. EDIT NO. 3

"MULTIGROUP SPECTRA"

"SMOOTH ABSORPTION" , Eq. (E.3)

"RESONANCE ABSORPTION" , Eq. (E.4)

"NU-FISSION" , Eq. (E.1)

"FISSION" , Eq. (E.2)

"SLOWING DOWN DENSITIES"

"ISOTROPIC" , Eq. (C.3c)

"ANISOTROPIC" , Eq. (C.5)

"SPECTRUM INTEGRALS"

"SMOOTH ABSORPTION" , Numerator in Eq. (E.7a)

"RESONANCE ABSORPTION" , Numerator in Eq. (E.8a)

"NU-FISSION" , Numerator in Eq. (E.5a)

"FISSION" , Numerator in Eq. (E.6a)

"MACROSCOPIC CROSS SECTIONS"

"SMOOTH ABSORPTION" , Eq. (E.7a)

"RESONANCE ABSORPTION" , Eq. (E.8a)

"NU-FISSION" , Eq. (E.5a)

"FISSION" , Eq. (E.6a)

"MICROSCOPIC CROSS SECTIONS"

"SMOOTH ABSORPTION" , Eq. (E.7b)

"RESONANCE ABSORPTION" , Eq. (E.8b)

"NU-FISSION" , Eq. (E.5b)

"FISSION" , Eq. (E.6b)

E. BLACKNESS COEFFICIENT EDIT

"FICTITIOUS"

"DIFFUSION CONSTANT" , Eq. (F.13), Eq. (F.17), or Eq. (F.19)

"ABSORPTION CROSS SECTION" , Eq. (F.16), Eq. (F.18), or Eq. (F.20)

"AVERAGE BLACKNESS COEFFICIENT"

"ZETA" , Eq. (F.11)

"ETA" , Eq. (F.12)

"FLUX-WEIGHTED BLACKNESS COEFFICIENT INTEGRALS"

"ZETA"

"NUMERATOR" , Numerator in Eq. (F.11)

"DEONOMINATOR" , Denominator in Eq. (F.11)

"ETA"

"NUMERATOR" , Numerator in Eq. (F.12)

"DENOMINATOR" , Denominator in Eq. (F.12)

"MULTIGROUP RESULTS"

"OPTICAL THICKNESS" , Eq. (F.1)

"BLACKNESS COEFFICIENT"

"ZETA" , Eq. (F.2), Eq. (F.6), Eq. (F.8), or Eq. (F.10)

"ETA" , Eq. (F.3), Eq. (F.7), Eq. (F.9), or Eq. (F.10)

F. INPUT FORM EDIT

At the end of every job there will appear input forms which have been partially filled in with data from selected cases of the job. The input forms are exactly those "MACROSCOPIC DATA FORM" input sheets which are part of the specification of a WANDA, PDQ, CANDLE, TURBO, etc. problem. (Ref. 6) The edit will have filled-in

the series number and the few-group D, Σ_a, Σ_R, and $\nu\Sigma_f$ from the cases which did not have zero for a case number (See Part Two, Section F.). The sequence number entered in the form will be the same as the case number. The subseries number entered in the form will be the few-group number. The cases will appear in the order in which they were processed. The columns headed "KAPPA FISSION" and "COMP." will be blank. A row will be skipped for the insertion of thermal constants. Three forms will be edited, one form for each scheme. As many forms as necessary will be printed for each scheme. As many as 122 cases can be treated in this edit.

If all the case numbers are zero in a job, this edit is skipped.

APPENDIX A

MUFT-5 SAMPLE PROBLEM

The sample problem in this appendix is designed to display the types of input which can be specified and the format of the output. The problem does not represent any part of a reactor or experiment either in existence or proposed.

The 54-group library which was used to run the problem is exactly the library described in the Bettis Laboratory Report, WAPD-TM-224, "54-Group Library for P-1 Programs" by A. F. Henry, April 1960.

The one-page printout which follows the input form is an IBM-407 listing of the cards which should be punched from the information supplied on the input form. The first card of the deck is the BKS accounting card (See Section B, Part Two.).

DATE

MUFT - 5

Requestor _____
K.P. _____ V. _____

Title Card

*1,2,0,0,3,C,0,6, SAMPLE PROBLEM FOR WAPD-TM-218

Case No. — Remarks

(Specify 000001 and 000002 for first case only ; omit both for subsequent cases.)

Dimension Card

0,0,0,0,0,1 — Total No. of Multigroups 54 — Multigroup Breakpoints for Few-group Editing 10 25 — Edit No. (CHECK ONE) 1. ___ 2. ___ 3. ✓ 4. ___

Library 1

Approximations (Check one of each pair)

P_1 1. ✓ — Not Selengut-Goertzel 1. ✓

B 2. ___ — Selengut-Goertzel 2. ___

Blackness Coefficient Edit

Half Thickness ± 1 ; +1

Mesh Size ± 5 ; +0

δ_b 1 ; +1

Library Card (List i for isotopes to be used in any of the cases, in ascending order of i)

0,0,0,0,0,2 | 0,0,1 | 0,0,6 | 0,0,7 | 1,0,2 | 1,1,8 | 1,2,0 | 1,2,9

Source Spectrum No. Used for every case. 1

1,0,2,2,0,1 (Case No.)

Buckling (B^2) = +1 ; ±3

i = Isotope Code Numbers N = Number Density (Enter in ascending order of i)

Case	± i	N	±	± i	N	±	± i	N	±	± i	N	±	± i	N	±
2,0,2,2,0,1	-,0,0,1	6,6,8,	±1	+,0,0,6	2,3,4,5,6,	-2	+,0,0,7	7,8,9,0,1,	-2	+,1,0,2	3,3,4,	-1	+,1,1,8	1,1,1,1,1,	-3
2,0,2,2,0,2	+,1,2,0	2,2,2,2,2,	-4												
2,0,3															

Resonance Self Shielding Factors If m, the group no. = 0, first L same for all resonances of i; enter in ascending order of i.

Case	m	i	L ±	L ±	L ±	L ±	L ±	L ±	L ±	L ±
3,0,2,2,0,0		1,1,8	9,6,7,6,+0							
3										
3										
3										
3										
3										
3										
3										
3										
3										
3										
3										
3										
3										
3										

Blackness Coefficient Edit (Enter in ascending order of i)

Case	± i	N	±	± i	N	±	± i	N	±	± i	N	±	± i	N	±
4,0,2,2,0,1	+,1,2,9	3,3,2,1,0,	-2												

```
12003006$ MUFT5 BOHLH
        *12003006, SAMPLE PROBLEM FOR WAPD-TM-218
        000001,54,10,25,3,1,1,1,1+1,5+0,1+1
        000002,001,006,007,102,118,120,129,1
        102201,+1-3
        202201,-001,668-1,+006,23456-2,+007,78901-2,+102,334-1,+118,11111-3
        202202,+120,22222-4
        302200,118,9676+0
        402201,+129,33210-2
```

54 MULTIGROUPS WITH FEW-GROUP BREAKPOINTS AT 10 AND 25

EDIT NUMBER 3 LIBRARY NUMBER 1

F1, NON-SG APPROXIMATION

SOURCE SPECTRUM NUMBER 1

BUCKLING = 10000000-03

ISOTOPE	NUMBER DENSITY
-1	468000-01
6	234560-02
7	789010-02
102	334000-01
118	111110-03
120	222220-04

RESONANCE SELF SHIELDING FACTORS

ISOTOPE NO. 118

L = 9676+C0 FOR ALL RESONANCES

ISOTOPE NO. 120

L = 1000+C1 FOR ALL RESONANCES

FEW GROUP RESULTS

FEW GROUP	SCHEME	DIFFUSION CONSTANT	MACROSCOPIC CROSS SECTIONS ABSORPTION	REMOVAL	NU-FISSION	FISSION
1 OF	3	175812+01	151871-02	118049+00	374941-03	134873-03
2 OF	3	888483+00	251402-03	149905+00	451794-03	182215-03
3 OF	3	460067+00	770451-02	148380+00	687831-02	279834-02
1 OF	2	131291+01	869906-03	787446-01	414286-03	159110-03
2 OF	2	460067+00	770451-02	148380+00	687831-02	279834-02
1 OF	1	103185+01	312226-02	488991-01	254452-02	102887-02

FEW GROUP	SCHEME	SPECTRUM INTEGRALS SOURCE	FLUX	CURRENT
1 OF	3	751650+00	627399+01	110305+00
2 OF	3	248175+00	658133+01	584740-01
3 OF	3	000000+00	631890+01	290712-01
1 OF	2	999825+00	128553+02	168779+00
2 OF	2	000000+00	631890+01	290712-01
1 OF	1	999825+00	191742+02	197850+00

		FLUX-WEIGHTED CROSS SECTION INTEGRALS ABSORPTION	NU-FISSION	FISSION
1 OF	3	952837-02	235238-02	846195-03
2 OF	3	165456-02	297341-02	119922-02
3 OF	3	486841-01	434634-01	176824-01
1 OF	2	111829-01	539579-02	204541-02
2 OF	2	486841-01	434634-01	176824-01
1 OF	1	998670-01	487892-01	197278-01

FEW GROUP	SCHEME	NON-ABSORPTION PROBABILITY	GROUP AGE
1 OF	3	987298+00	147039+02
2 OF	3	998326+00	591704+01
3 OF	3	950639+00	294754+01
1 OF	2	988792+00	169158+02
2 OF	2	950639+00	294754+01
1 OF	1	939981+00	198352+02

SCHEME	AGE-TO-THERMAL
3	199153+02
2	198598+02
1	198317+02

MULTIGROUP SPECTRA

MULTIGROUP	FLUX	CURRENT	NET SLOWING DOWN DENSITIES ISOTROPIC	ANISOTROPIC
1	241640•00	753563•02	423864•02	724161•04
2	683980•00	188890•01	180805•01	273127•03
3	141829•01	347277•01	503088•01	689095•03
4	212954•01	443061•01	109550•00	123269•02
5	302547•01	552294•01	195898•00	196445•02
6	430746•01	836341•01	297349•00	333181•02
7	319584•01	584491•01	408934•00	388663•02
8	390493•01	569374•01	515496•00	452280•02
9	317352•01	440075•01	612176•00	469127•02
10	301531•01	355020•01	695635•00	468909•02
11	340983•01	405198•01	765456•00	513035•02
12	225044•01	287498•01	821733•00	506011•02
13	180483•01	168918•01	865398•00	449553•02
14	266462•01	236489•01	899345•00	471107•02
15	152388•01	169815•01	928152•00	454082•02
16	175604•01	161379•01	943622•00	451094•02
17	132282•01	127276•01	957103•00	432803•02
18	134392•01	114228•01	966685•00	419822•02
19	111178•01	944870•02	973413•00	400193•02
20	106604•01	821985•02	978064•00	381322•02
21	960140•00	706025•02	983264•00	349115•02
22	838861•00	552584•02	985606•00	313051•02
23	764006•00	423972•02	986585•00	272745•02
24	739382•00	389675•02	986775•00	249304•02
25	728172•00	385107•02	986576•00	238089•02
26	719068•00	347482•02	986232•00	221045•02
27	731523•00	352250•02	985816•00	215417•02
28	707365•00	345196•02	985328•00	211675•02
29	713650•00	339506•02	984709•00	208924•02
30	701425•00	330916•02	983919•00	204821•02
31	711078•00	327958•02	982869•00	201975•02
32	700351•00	322470•02	981447•00	198859•02
33	711268•00	322675•02	980699•00	198078•02
34	696977•00	318683•02	979796•00	196777•02
35	706987•00	319744•02	978949•00	196091•02
36	697378•00	316804•02	977881•00	195056•02
37	703219•00	317099•02	976819•00	194405•02
38	695396•00	314069•02	975127•00	193377•02
39	694068•00	314780•02	972389•00	192810•02
40	692270•00	313527•02	970669•00	192141•02
41	690433•00	312573•02	967522•00	191548•02
42	689719•00	311715•02	966172•00	190983•02
43	688625•00	310953•02	963416•00	190437•02
44	688861•00	308755•02	960006•00	189441•02
45	682952•00	308350•02	957259•00	189018•02
46	681468•00	307395•02	955135•00	188408•02
47	683092•00	307540•02	953926•00	188019•02
48	679800•00	306203•02	951889•00	187406•02
49	681079•00	305825•02	950725•00	187045•02
50	678141•00	304001•02	949238•00	186582•02
51	673701•00	301178•02	947811•00	185949•02
52	664963•00	297653•02	944509•00	185075•02
53	658050•00	292217•02	940977•00	183616•02
54	644082•00	283197•02	937608•00	182005•02

ISOTOPE NO. =1 MULTIGROUP SPECTRA

MULTIGROUP	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1	711438-07		0+00000+00	000000+00
2	828221-06		0+00000+00	000000+00
3	536238-06		0+00000+00	000000+00
4	912553-06		0+00000+00	000000+00
5	144877-05		0+00000+00	000000+00
6	234992-05		0+00000+00	000000+00
7	199232-05		0+00000+00	000000+00
8	275548-05		0+00000+00	000000+00
9	254018-05		0+00000+00	000000+00
10	273532-05		0+00000+00	000000+00
11	350491-05		0+00000+00	000000+00
12	262099-05		0+00000+00	000000+00
13	238201-05		0+00000+00	000000+00
14	398535-05		0+00000+00	000000+00
15	259305-05		0+00000+00	000000+00
16	339168-05		0+00000+00	000000+00
17	287846-05		0+00000+00	000000+00
18	331266-05		0+00000+00	000000+00
19	310622-05		0+00000+00	000000+00
20	337541-05		0+00000+00	000000+00
21	729242-05		0+00000+00	000000+00
22	817845-05		0+00000+00	000000+00
23	956408-05		0+00000+00	000000+00
24	118859-04		0+00000+00	000000+00
25	150303-04		0+00000+00	000000+00
26	190646-04	0+00000+00	0+00000+00	000000+00
27	249215-04	0+00000+00	0+00000+00	000000+00
28	309501-04	0+00000+00	0+00000+00	000000+00
29	400681-04	0+00000+00	0+00000+00	000000+00
30	505099-04	0+00000+00	0+00000+00	000000+00
31	657875-04	0+00000+00	0+00000+00	000000+00
32	831809-04	0+00000+00	0+00000+00	000000+00
33	512543-04	0+00000+00	0+00000+00	000000+00
34	569056-04	0+00000+00	0+00000+00	000000+00
35	654090-04	0+00000+00	0+00000+00	000000+00
36	731149-04	0+00000+00	0+00000+00	000000+00
37	835451-04	0+00000+00	0+00000+00	000000+00
38	936133-04	0+00000+00	0+00000+00	000000+00
39	106008-03	0+00000+00	0+00000+00	000000+00
40	119655-03	0+00000+00	0+00000+00	000000+00
41	135250-03	0+00000+00	0+00000+00	000000+00
42	153078-03	0+00000+00	0+00000+00	000000+00
43	173191-03	0+00000+00	0+00000+00	000000+00
44	193979-03	0+00000+00	0+00000+00	000000+00
45	220578-03	0+00000+00	0+00000+00	000000+00
46	249237-03	0+00000+00	0+00000+00	000000+00
47	283625-03	0+00000+00	0+00000+00	000000+00
48	319464-03	0+00000+00	0+00000+00	000000+00
49	362604-03	0+00000+00	0+00000+00	000000+00
50	409170-03	0+00000+00	0+00000+00	000000+00
51	468066-03	0+00000+00	0+00000+00	000000+00
52	537972-03	0+00000+00	0+00000+00	000000+00
53	701302-03	0+00000+00	0+00000+00	000000+00
54	764477-03	0+00000+00	0+00000+00	000000+00

ISOTOPE NO. =1

MULTIGROUP	SLOWING DOWN DENSITIES ISOTROPIC	ANISOTROPIC
1	38766A+02	724161+04
2	156782+01	273127+03
3	446695+01	689095+03
4	926715+01	123269+02
5	169311+00	196445+02
6	293779+00	333181+02
7	367614+00	388663+02
8	481414+00	452280+02
9	556746+00	469127+02
10	631538+00	468599+02
11	747571+00	513035+02
12	773532+00	506011+02
13	776451+00	440553+02
14	895623+00	471107+02
15	883786+00	454082+02
16	930472+00	451094+02
17	928174+00	432803+02
18	952333+00	419822+02
19	951127+00	400193+02
20	960520+00	381322+02
21	970757+00	349115+02
22	969102+00	313051+02
23	969332+00	272745+02
24	974255+00	240394+02
25	973688+00	238089+02
26	969444+00	221045+02
27	975524+00	215417+02
28	969946+00	211675+02
29	972876+00	208924+02
30	967938+00	204821+02
31	970263+00	201975+02
32	965782+00	198859+02
33	967610+00	198078+02
34	964684+00	196777+02
35	965454+00	196091+02
36	963128+00	195056+02
37	963097+00	194405+02
38	960692+00	193377+02
39	958691+00	192810+02
40	956314+00	192181+02
41	953906+00	191568+02
42	951816+00	190983+02
43	949858+00	190437+02
44	945972+00	189641+02
45	943586+00	189018+02
46	941187+00	188408+02
47	940181+00	188019+02
48	938122+00	187496+02
49	936910+00	187065+02
50	935577+00	186562+02
51	934167+00	185949+02
52	931192+00	185075+02
53	927651+00	183616+02
54	924822+00	182005+02

ISOTOPE NO. =1 SPECTRUM INTEGRALS

FEW GROUP	SCHEME	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1 OF 3		156128-04	000000+00	000000+00	000000+00
2 OF 3		830919-04	000000+00	000000+00	000000+00
3 OF 3		590588-02	000000+00	000000+00	000000+00
1 OF 2		987047-04	000000+00	000000+00	000000+00
2 OF 2		590588-02	000000+00	000000+00	000000+00
1 OF 1		800459-02	000000+00	000000+00	000000+00

ISOTOPE NO. =1 MACROSCOPIC CROSS SECTIONS

FEW GROUP	SCHEME	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1 OF 3		248849-05	000000+00	000000+00	000000+00
2 OF 3		126254-04	000000+00	000000+00	000000+00
3 OF 3		934637-03	000000+00	000000+00	000000+00
1 OF 2		767812-05	000000+00	000000+00	000000+00
2 OF 2		934637-03	000000+00	000000+00	000000+00
1 OF 1		313159-03	000000+00	000000+00	000000+00

ISOTOPE NO. =1 MICROSCOPIC CROSS SECTIONS

FEW GROUP	SCHEME	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1 OF 3		372528-04	000000+00	000000+00	000000+00
2 OF 3		189003-03	000000+00	000000+00	000000+00
3 OF 3		139916-01	000000+00	000000+00	000000+00
1 OF 2		114942-03	000000+00	000000+00	000000+00
2 OF 2		139916-01	000000+00	000000+00	000000+00
1 OF 1		468801-02	000000+00	000000+00	000000+00

ISOTOPE NO. 6 MULTIGROUP SPECTRA

MULTIGROUP	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1	113398-04		0n0000+P0	000000+00
2	160434-04		0n0000+P0	000000+00
3	124753-04		0n0000+P0	000000+00
4	000000+00		0n0000+P0	000000+00
5	000000+00		0n0000+P0	000000+00
6	000000+00		0n0000+P0	000000+00
7	000000+00		0n0000+P0	000000+00
8	000000+00		0n0000+P0	000000+00
9	000000+00		0n0000+P0	000000+00
10	000000+00		0n0000+P0	000000+00
11	000000+00		0n0000+P0	000000+00
12	000000+00		0n0000+P0	000000+00
13	000000+00		0n0000+P0	000000+00
14	000000+00		0n0000+P0	000000+00
15	000000+00		0n0000+P0	000000+00
16	000000+00		0n0000+P0	000000+00
17	000000+00		0n0000+P0	000000+00
18	000000+00		0n0000+P0	000000+00
19	000000+00		0n0000+P0	000000+00
20	000000+00		0n0000+P0	000000+00
21	000000+00		0n0000+P0	000000+00
22	000000+00		0n0000+P0	000000+00
23	000000+00		0n0000+P0	000000+00
24	000000+00		0n0000+P0	000000+00
25	000000+00		0n0000+P0	000000+00
26	843323-05	000000+00	0n0000+P0	000000+00
27	857930-05	000000+00	0n0000+P0	000000+00
28	829598-05	000000+00	0n0000+P0	000000+00
29	836968-05	000000+00	0n0000+P0	000000+00
30	164526-04	000000+00	0n0000+P0	000000+00
31	166791-04	000000+00	0n0000+P0	000000+00
32	246411-04	000000+00	0n0000+P0	000000+00
33	125126-04	000000+00	0n0000+P0	000000+00
34	163483-04	000000+00	0n0000+P0	000000+00
35	165831-04	000000+00	0n0000+P0	000000+00
36	204471-04	000000+00	0n0000+P0	000000+00
37	247421-04	000000+00	0n0000+P0	000000+00
38	244668-04	000000+00	0n0000+P0	000000+00
39	285249-04	000000+00	0n0000+P0	000000+00
40	324758-04	000000+00	0n0000+P0	000000+00
41	364383-04	000000+00	0n0000+P0	000000+00
42	404451-04	000000+00	0n0000+P0	000000+00
43	484572-04	000000+00	0n0000+P0	000000+00
44	519034-04	000000+00	0n0000+P0	000000+00
45	600725-04	000000+00	0n0000+P0	000000+00
46	679043-04	000000+00	0n0000+P0	000000+00
47	762077-04	000000+00	0n0000+P0	000000+00
48	876996-04	000000+00	0n0000+P0	000000+00
49	998462-04	000000+00	0n0000+P0	000000+00
50	111345-03	000000+00	0n0000+P0	000000+00
51	128340-03	000000+00	0n0000+P0	000000+00
52	142083-03	000000+00	0n0000+P0	000000+00
53	194484-03	000000+00	0n0000+P0	000000+00
54	209137-03	000000+00	0n0000+P0	000000+00

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ISOTOPE NO. 6

MULTIGROUP	SLOWING DOWN DENSITIES ISOTROPIC	ANISOTROPIC
1	940872.05	000000.00
2	305394.04	000000.00
3	108086.03	000000.00
4	194514.03	000000.00
5	304044.03	000000.00
6	558132.03	000000.00
7	181920.03	000000.00
8	898597.03	000000.00
9	-139306.04	000000.00
10	851920.03	000000.00
11	621490.03	000000.00
12	175847.03	000000.00
13	886398.03	000000.00
14	397830.03	000000.00
15	226190.03	000000.00
16	839573.03	000000.00
17	-111656.03	000000.00
18	777423.03	000000.00
19	-233385.05	000000.00
20	660814.03	000000.00
21	-176983.04	000000.00
22	697633.03	000000.00
23	-302270.03	000000.00
24	953671.03	000000.00
25	-191220.04	000000.00
26	775279.03	000000.00
27	484703.04	000000.00
28	882803.03	000000.00
29	216270.03	000000.00
30	980133.03	000000.00
31	315162.03	000000.00
32	100120.02	000000.00
33	341555.03	000000.00
34	974222.03	000000.00
35	360452.03	000000.00
36	956081.03	000000.00
37	371479.03	000000.00
38	941312.03	000000.00
39	370666.03	000000.00
40	936224.03	000000.00
41	367198.03	000000.00
42	934876.03	000000.00
43	365133.03	000000.00
44	920219.03	000000.00
45	369080.03	000000.00
46	916851.03	000000.00
47	374412.03	000000.00
48	897879.03	000000.00
49	376806.03	000000.00
50	892181.03	000000.00
51	368497.03	000000.00
52	875830.03	000000.00
53	344664.03	000000.00
54	839258.03	000000.00

ISOTOPE NO. 6 SPECTRUM INTEGRALS

FEW GROUP	SCHEME	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1	OF 3	398545+04	000000+00	000000+00	000000+00
2	OF 3	000000+00	000000+00	000000+00	000000+00
3	OF 3	162192+02	000000+00	000000+00	000000+00
1	OF 2	398545+04	000000+00	000000+00	000000+00
2	OF 2	162192+02	000000+00	000000+00	000000+00
1	OF 1	166177+02	000000+00	000000+00	000000+00

ISOTOPE NO. 6 MACROSCOPIC CROSS SECTIONS

FEW GROUP	SCHEME	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1	OF 3	635233+05	000000+00	000000+00	000000+00
2	OF 3	000000+00	000000+00	000000+00	000000+00
3	OF 3	256677+03	000000+00	000000+00	000000+00
1	OF 2	310023+05	000000+00	000000+00	000000+00
2	OF 2	256677+03	000000+00	000000+00	000000+00
1	OF 1	866669+04	000000+00	000000+00	000000+00

ISOTOPE NO. 6 MICROSCOPIC CROSS SECTIONS

FEW GROUP	SCHEME	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1	OF 3	278919+02	000000+00	000000+00	000000+00
2	OF 3	000000+00	000000+00	000000+00	000000+00
3	OF 3	109429+00	000000+00	000000+00	000000+00
1	OF 2	132172+02	000000+00	000000+00	000000+00
2	OF 2	109429+00	000000+00	000000+00	000000+00
1	OF 1	369487+01	000000+00	000000+00	000000+00

ISOTOPE NO. 7 MULTIGROUP SPECTRA

MULTIGROUP	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1	000000+00		0+00000+00	000000+00
2	000000+00		0+00000+00	000000+00
3	000000+00		0+00000+00	000000+00
4	000000+00		0+00000+00	000000+00
5	000000+00		0+00000+00	000000+00
6	000000+00		0+00000+00	000000+00
7	000000+00		0+00000+00	000000+00
8	000000+00		0+00000+00	000000+00
9	000000+00		0+00000+00	000000+00
10	000000+00		0+00000+00	000000+00
11	000000+00		0+00000+00	000000+00
12	000000+00		0+00000+00	000000+00
13	000000+00		0+00000+00	000000+00
14	000000+00		0+00000+00	000000+00
15	000000+00		0+00000+00	000000+00
16	000000+00		0+00000+00	000000+00
17	000000+00		0+00000+00	000000+00
18	000000+00		0+00000+00	000000+00
19	000000+00		0+00000+00	000000+00
20	000000+00		0+00000+00	000000+00
21	000000+00		0+00000+00	000000+00
22	000000+00		0+00000+00	000000+00
23	000000+00		0+00000+00	000000+00
24	000000+00		0+00000+00	000000+00
25	000000+00		0+00000+00	000000+00
26	540493-04	000000+00	0+00000+00	000000+00
27	549763-04	000000+00	0+00000+00	000000+00
28	931608-04	000000+00	0+00000+00	000000+00
29	536330-04	000000+00	0+00000+00	000000+00
30	102401-03	000000+00	0+00000+00	000000+00
31	106952-03	000000+00	0+00000+00	000000+00
32	157973-03	000000+00	0+00000+00	000000+00
33	801671-04	000000+00	0+00000+00	000000+00
34	104746-03	000000+00	0+00000+00	000000+00
35	106251-03	000000+00	0+00000+00	000000+00
36	131012-03	000000+00	0+00000+00	000000+00
37	158534-03	000000+00	0+00000+00	000000+00
38	156770-03	000000+00	0+00000+00	000000+00
39	182774-03	000000+00	0+00000+00	000000+00
40	208078-03	000000+00	0+00000+00	000000+00
41	233470-03	000000+00	0+00000+00	000000+00
42	259146-03	000000+00	0+00000+00	000000+00
43	310473-03	000000+00	0+00000+00	000000+00
44	332557-03	000000+00	0+00000+00	000000+00
45	384891-03	000000+00	0+00000+00	000000+00
46	436078-03	000000+00	0+00000+00	000000+00
47	488272-03	000000+00	0+00000+00	000000+00
48	561913-03	000000+00	0+00000+00	000000+00
49	639735-03	000000+00	0+00000+00	000000+00
50	713409-03	000000+00	0+00000+00	000000+00
51	822298-03	000000+00	0+00000+00	000000+00
52	910352-03	000000+00	0+00000+00	000000+00
53	124010-02	000000+00	0+00000+00	000000+00
54	133998-02	000000+00	0+00000+00	000000+00

ISOTOPE NO. 7

MULTIGROUP	SLOWING DOWN DENSITIES ISOTROPIC	ANISOTROPIC
1	347757.04	000000.00
2	979392.04	000000.00
3	309146.03	000000.00
4	558787.03	000000.00
5	959589.03	000000.00
6	188277.02	000000.00
7	813261.03	000000.00
8	304487.02	000000.00
9	756010.03	000000.00
10	308992.02	000000.00
11	220773.02	000000.00
12	141204.02	000000.00
13	202100.02	000000.00
14	387165.02	000000.00
15	-156372.03	000000.00
16	499991.02	000000.00
17	-992460.03	000000.00
18	586676.02	000000.00
19	-122774.02	000000.00
20	618913.02	000000.00
21	-539247.03	000000.00
22	839234.02	000000.00
23	427750.02	000000.00
24	491973.02	000000.00
25	906433.03	000000.00
26	974140.02	000000.00
27	-231369.02	000000.00
28	790682.02	000000.00
29	-230218.02	000000.00
30	829153.02	000000.00
31	-191544.02	000000.00
32	826308.02	000000.00
33	-177845.02	000000.00
34	816304.02	000000.00
35	-158675.02	000000.00
36	810517.02	000000.00
37	-164009.02	000000.00
38	803325.02	000000.00
39	-165118.02	000000.00
40	803842.02	000000.00
41	-167510.02	000000.00
42	806167.02	000000.00
43	-169925.02	000000.00
44	798306.02	000000.00
45	-165743.02	000000.00
46	795267.02	000000.00
47	-166349.02	000000.00
48	791144.02	000000.00
49	-163604.02	000000.00
50	789988.02	000000.00
51	-166844.02	000000.00
52	782074.02	000000.00
53	-176594.02	000000.00
54	773898.02	000000.00

ISOTOPE NO. 7 SPECTRUM INTEGRALS

FEW GROUP	SCHEME	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1 OF	3	000000+00	000000+00	000000+00	000000+00
2 OF	3	000000+00	000000+00	000000+00	000000+00
3 OF	3	103919-01	000000+00	000000+00	000000+00
1 OF	2	000000+00	000000+00	000000+00	000000+00
2 OF	2	103919-01	000000+00	000000+00	000000+00
1 OF	1	103919-01	000000+00	000000+00	000000+00

ISOTOPE NO. 7 MACROSCOPIC CROSS SECTIONS

FEW GROUP	SCHEME	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1 OF	3	000000+00	000000+00	000000+00	000000+00
2 OF	3	000000+00	000000+00	000000+00	000000+00
3 OF	3	164458-02	000000+00	000000+00	000000+00
1 OF	2	000000+00	000000+00	000000+00	000000+00
2 OF	2	164458-02	000000+00	000000+00	000000+00
1 OF	1	541974-03	000000+00	000000+00	000000+00

ISOTOPE NO. 7 MICROSCOPIC CROSS SECTIONS

FEW GROUP	SCHEME	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1 OF	3	000000+00	000000+00	000000+00	000000+00
2 OF	3	000000+00	000000+00	000000+00	000000+00
3 OF	3	208436+00	000000+00	000000+00	000000+00
1 OF	2	000000+00	000000+00	000000+00	000000+00
2 OF	2	208436+00	000000+00	000000+00	000000+00
1 OF	1	686904-01	000000+00	000000+00	000000+00

ISOTOPE NO. 102 MULTIGROUP SPECTRA

MULTIGROUP	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1	405308-03		0.00000+00	0.00000+00
2	171337-02		0.00000+00	0.00000+00
3	355281-02		0.00000+00	0.00000+00
4	266724-02		0.00000+00	0.00000+00
5	0.00000+00		0.00000+00	0.00000+00
6	0.00000+00		0.00000+00	0.00000+00
7	0.00000+00		0.00000+00	0.00000+00
8	0.00000+00		0.00000+00	0.00000+00
9	0.00000+00		0.00000+00	0.00000+00
10	0.00000+00		0.00000+00	0.00000+00
11	0.00000+00		0.00000+00	0.00000+00
12	0.00000+00		0.00000+00	0.00000+00
13	0.00000+00		0.00000+00	0.00000+00
14	0.00000+00		0.00000+00	0.00000+00
15	0.00000+00		0.00000+00	0.00000+00
16	0.00000+00		0.00000+00	0.00000+00
17	0.00000+00		0.00000+00	0.00000+00
18	0.00000+00		0.00000+00	0.00000+00
19	0.00000+00		0.00000+00	0.00000+00
20	0.00000+00		0.00000+00	0.00000+00
21	0.00000+00		0.00000+00	0.00000+00
22	0.00000+00		0.00000+00	0.00000+00
23	0.00000+00		0.00000+00	0.00000+00
24	0.00000+00		0.00000+00	0.00000+00
25	0.00000+00		0.00000+00	0.00000+00
26	0.00000+00	0.00000+00	0.00000+00	0.00000+00
27	0.00000+00	0.00000+00	0.00000+00	0.00000+00
28	0.00000+00	0.00000+00	0.00000+00	0.00000+00
29	0.00000+00	0.00000+00	0.00000+00	0.00000+00
30	0.00000+00	0.00000+00	0.00000+00	0.00000+00
31	0.00000+00	0.00000+00	0.00000+00	0.00000+00
32	0.00000+00	0.00000+00	0.00000+00	0.00000+00
33	0.00000+00	0.00000+00	0.00000+00	0.00000+00
34	0.00000+00	0.00000+00	0.00000+00	0.00000+00
35	0.00000+00	0.00000+00	0.00000+00	0.00000+00
36	0.00000+00	0.00000+00	0.00000+00	0.00000+00
37	0.00000+00	0.00000+00	0.00000+00	0.00000+00
38	0.00000+00	0.00000+00	0.00000+00	0.00000+00
39	0.00000+00	0.00000+00	0.00000+00	0.00000+00
40	0.00000+00	0.00000+00	0.00000+00	0.00000+00
41	0.00000+00	0.00000+00	0.00000+00	0.00000+00
42	0.00000+00	0.00000+00	0.00000+00	0.00000+00
43	0.00000+00	0.00000+00	0.00000+00	0.00000+00
44	0.00000+00	0.00000+00	0.00000+00	0.00000+00
45	0.00000+00	0.00000+00	0.00000+00	0.00000+00
46	0.00000+00	0.00000+00	0.00000+00	0.00000+00
47	0.00000+00	0.00000+00	0.00000+00	0.00000+00
48	0.00000+00	0.00000+00	0.00000+00	0.00000+00
49	0.00000+00	0.00000+00	0.00000+00	0.00000+00
50	0.00000+00	0.00000+00	0.00000+00	0.00000+00
51	0.00000+00	0.00000+00	0.00000+00	0.00000+00
52	0.00000+00	0.00000+00	0.00000+00	0.00000+00
53	0.00000+00	0.00000+00	0.00000+00	0.00000+00
54	0.00000+00	0.00000+00	0.00000+00	0.00000+00

ISOTOPE NO. 102

MULTIGROUP	SLOWING DOWN DENSITIES ISOTROPIC	ANISOTROPIC
1	516529•03	000000•00
2	227055•02	000000•00
3	521404•02	000000•00
4	161239•01	000000•00
5	253068•01	000000•00
6	130895•02	000000•00
7	403201•01	000000•00
8	301093•01	000000•00
9	546872•01	000000•00
10	601239•01	000000•00
11	150425•01	000000•00
12	465925•01	000000•00
13	860261•01	000000•00
14	-587667•03	000000•00
15	413037•01	000000•00
16	706264•02	000000•00
17	300303•01	000000•00
18	765479•02	000000•00
19	235374•01	000000•00
20	106440•01	000000•00
21	130868•01	000000•00
22	736633•02	000000•00
23	133031•01	000000•00
24	670014•02	000000•00
25	120270•01	000000•00
26	622584•02	000000•00
27	125875•01	000000•00
28	654961•02	000000•00
29	139493•01	000000•00
30	666704•02	000000•00
31	142330•01	000000•00
32	635173•02	000000•00
33	145539•01	000000•00
34	593170•02	000000•00
35	148481•01	000000•00
36	564926•02	000000•00
37	150197•01	000000•00
38	541932•02	000000•00
39	150071•01	000000•00
40	534010•02	000000•00
41	149531•01	000000•00
42	531912•02	000000•00
43	149209•01	000000•00
44	509092•02	000000•00
45	149824•01	000000•00
46	503848•02	000000•00
47	150654•01	000000•00
48	491526•02	000000•00
49	151030•01	000000•00
50	482890•02	000000•00
51	149725•01	000000•00
52	457208•02	000000•00
53	147893•01	000000•00
54	416154•02	000000•00

ISOTOPE NO. 102 SPECTRUM INTEGRALS

FEW GROUP	SCHEME	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1	OF 3	853873-02	000000+00	0n0000+00	000000+00
2	OF 3	000000+00	000000+00	0n0000+00	000000+00
3	OF 3	000000+00	000000+00	0n0000+00	000000+00
1	OF 2	853873-02	000000+00	0n0000+00	000000+00
2	OF 2	000000+00	000000+00	0n0000+00	000000+00
1	OF 1	853873-02	000000+00	0n0000+00	000000+00

ISOTOPE NO. 102 MACROSCOPIC CROSS SECTIONS

FEW GROUP	SCHEME	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1	OF 3	134097-02	000000+00	0n0000+00	000000+00
2	OF 3	000000+00	000000+00	0n0000+00	000000+00
3	OF 3	000000+00	000000+00	0n0000+00	000000+00
1	OF 2	664218-03	000000+00	0n0000+00	000000+00
2	OF 2	000000+00	000000+00	0n0000+00	000000+00
1	OF 1	445323-03	000000+00	0n0000+00	000000+00

ISOTOPE NO. 102 MICROSCOPIC CROSS SECTIONS

FEW GROUP	SCHEME	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1	OF 3	407477-01	000000+00	0n0000+00	000000+00
2	OF 3	000000+00	000000+00	0n0000+00	000000+00
3	OF 3	000000+00	000000+00	0n0000+00	000000+00
1	OF 2	198868-01	000000+00	0n0000+00	000000+00
2	OF 2	000000+00	000000+00	0n0000+00	000000+00
1	OF 1	133330-01	000000+00	0n0000+00	000000+00

ISOTOPE NO. 118 MULTIGROUP SPECTRA

MULTIGROUP	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1	133055-04		468313-04	131088-04
2	289835-04		935656-04	281189-04
3	458485-04		137152-03	437695-04
4	710247-04		199250-03	667840-04
5	101675-03		270144-03	942087-04
6	148151-03		375864-03	135329-03
7	114987-03		273520-03	101023-03
8	135825-03		320787-03	121052-03
9	110437-03		253533-03	972321-04
10	102620-03		229911-03	892859-04
11	113953-03		249932-03	980317-04
12	774893-04		166787-03	659497-04
13	646221-04		136531-03	543949-04
14	100211-03		208375-03	834166-04
15	607809-04		124689-03	500798-04
16	754778-04		152836-03	619655-04
17	606615-04		121276-03	489805-04
18	662893-04		130961-03	530097-04
19	590443-04		115424-03	467870-04
20	612906-04		118493-03	480896-04
21	124204-03		240012-03	975066-04
22	131770-03		245745-03	999167-04
23	144973-03		265883-03	108148-03
24	177286-03		319960-03	130171-03
25	211855-03		376361-03	153117-03
26	238928-03	000000+00	418592-03	170298-03
27	296629-03	000000+00	513847-03	209051-03
28	377061-03	000000+00	647468-03	263412-03
29	473779-03	000000+00	807583-03	328553-03
30	571656-03	000000+00	968362-03	393963-03
31	820379-03	000000+00	138213-02	562299-03
32	105950-02	000000+00	177643-02	722716-03
33	579616-03	000000+00	969518-03	394434-03
34	581041-03	000000+00	970930-03	395008-03
35	631215-03	000000+00	105192-02	427959-03
36	685593-03	000000+00	114695-02	464178-03
37	785156-03	000000+00	130477-02	530827-03
38	140978-02	000000+00	234141-02	952567-03
39	000000+00	179293-02	302537-02	123083-02
40	000000+00	135101-02	243709-02	991493-03
41	000000+00	190610-02	313413-02	127507-02
42	000000+00	889118-03	156356-02	636111-03
43	000000+00	221637-02	176153-02	716653-03
44	000000+00	282171-02	430067-02	174966-02
45	000000+00	335362-03	338592-03	137751-03
46	000000+00	135503-02	187994-02	764824-03
47	000000+00	350548-03	118866-03	483588-04
48	000000+00	106370-02	172477-02	701696-03
49	000000+00	506256-04	802830-04	326619-04
50	000000+00	244383-03	167652-03	682065-04
51	000000+00	000000+00	000000+00	000000+00
52	000000+00	174104-02	322540-02	131221-02
53	137788-02	000000+00	295792-02	120339-02
54	104467-02	000000+00	245370-02	998249-03

ISOTOPE NO. 118

MULTIGROUP	SLOWING DOWN DENSITIES ISOTROPIC	ANISOTROPIC
1	118306.05	000000.00
2	312704.05	000000.00
3	773663.05	000000.00
4	100216.04	000000.00
5	154929.04	000000.00
6	192076.04	000000.00
7	647746.05	000000.00
8	267115.04	000000.00
9	238651.05	000000.00
10	283901.04	000000.00
11	110453.04	000000.00
12	185477.04	000000.00
13	831832.05	000000.00
14	355190.04	000000.00
15	-858017.05	000000.00
16	419325.04	000000.00
17	-154032.04	000000.00
18	436135.04	000000.00
19	-192618.04	000000.00
20	437591.04	000000.00
21	-204642.04	000000.00
22	417114.04	000000.00
23	-224247.04	000000.00
24	403570.04	000000.00
25	-234118.04	000000.00
26	396370.04	000000.00
27	-239381.04	000000.00
28	376173.04	000000.00
29	-246440.04	000000.00
30	366021.04	000000.00
31	-255679.04	000000.00
32	362705.04	000000.00
33	-256359.04	000000.00
34	359253.04	000000.00
35	-256014.04	000000.00
36	356535.04	000000.00
37	-255836.04	000000.00
38	355087.04	000000.00
39	-256225.04	000000.00
40	354376.04	000000.00
41	-257006.04	000000.00
42	353624.04	000000.00
43	-257613.04	000000.00
44	352155.04	000000.00
45	-257837.04	000000.00
46	351331.04	000000.00
47	-258096.04	000000.00
48	349798.04	000000.00
49	-258566.04	000000.00
50	349405.04	000000.00
51	-259796.04	000000.00
52	348243.04	000000.00
53	-256991.04	000000.00
54	350558.04	000000.00

ISOTOPE NO. 118 SPECTRUM INTEGRALS

FEW GROUP	SCHEME	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1 OF	3	869857-03	000000+00	220056-02	789907-03
2 OF	3	153192-02	000000+00	297326-02	119916-02
3 OF	3	109337-01	161179-01	434634-01	176824-01
1 OF	2	240177-02	000000+00	517382-02	198907-02
2 OF	2	109337-01	161179-01	434634-01	176824-01
1 OF	1	133355-01	161179-01	486372-01	196715-01

ISOTOPE NO. 118 MACROSCOPIC CROSS SECTIONS

FEW GROUP	SCHEME	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1 OF	3	138645-03	000000+00	350743-03	125902-03
2 OF	3	232767-03	000000+00	451773-03	182206-03
3 OF	3	173031-02	255075-02	687831-02	279834-02
1 OF	2	186831-03	000000 00	402465-03	154727-03
2 OF	2	173031-02	255075-02	687831-02	279834-02
1 OF	1	695489-03	840604-03	253659-02	102593-02

ISOTOPE NO. 118 MICROSCOPIC CROSS SECTIONS

FEW GROUP	SCHEME	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1 OF	3	124782+01	000000+00	315672+01	113313+01
2 OF	3	209492+01	000000+00	406599+01	163987+01
3 OF	3	155730+02	229570+02	619054+02	251853+02
1 OF	2	168150+01	000000+00	362222+01	139256+01
2 OF	2	155730+02	229570+02	619054+02	251853+02
1 OF	1	625946+01	756551+01	228296+02	923330+01

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ISOTOPE NO. 120 MULTIGROUP SPECTRA

MULTIGROUP	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1	140048-05		477545-P5	139613-05
2	321097-05		101150-P4	319187-05
3	478230-05		140268-P4	472364-05
4	685089-05		188829-P4	670797-05
5	992847-05		259569-P4	962257-05
6	146069-04		362769-P4	139393-04
7	101725-04		237125-P4	937438-05
8	775447-05		151857-P4	613936-05
9	301129-05		243243-P5	100141-05
10	258611-05		457519-P6	190633-06
11	277908-05		122980-P6	512417-07
12	164568-05		189035-P7	787645-08
13	124331-05		000000+P0	000000+00
14	189482-05		000000+P0	000000+00
15	124872-05		000000+P0	000000+00
16	174940-05		000000+P0	000000+00
17	154327-05		000000+P0	000000+00
18	179934-05		000000+P0	000000+00
19	164766-05		000000+P0	000000+00
20	177967-05		000000+P0	000000+00
21	373384-05		000000+P0	000000+00
22	393329-05		000000+P0	000000+00
23	429962-05		000000+P0	000000+00
24	481415-05		000000+P0	000000+00
25	542078-05		000000+P0	000000+00
26	671124-05	000000+00	000000+P0	000000+00
27	991610-05	000000+00	000000+P0	000000+00
28	447994-05	000000+00	000000+P0	000000+00
29	121843-04	136798-04	000000+P0	000000+00
30	630108-05	233806-04	000000+P0	000000+00
31	182508-06	256159-04	000000+P0	000000+00
32	231113-06	861212-04	000000+P0	000000+00
33	140672-06	899075-05	000000+P0	000000+00
34	156431-06	136817-03	000000+P0	000000+00
35	170887-06	196829-04	000000+P0	000000+00
36	200688-06	148795-03	000000+P0	000000+00
37	229325-06	000000+00	000000+P0	000000+00
38	256908-06	000000+00	000000+P0	000000+00
39	291110-06	620969-03	000000+P0	000000+00
40	328440-06	000000+00	000000+P0	000000+00
41	371296-06	828910-03	000000+P0	000000+00
42	420341-06	000000+00	000000+P0	000000+00
43	475146-06	000000+00	000000+P0	000000+00
44	532201-06	872352-03	000000+P0	000000+00
45	604406-06	174690-02	000000+P0	000000+00
46	681161-06	000000+00	000000+P0	000000+00
47	774043-06	000000+00	000000+P0	000000+00
48	874289-06	000000+00	000000+P0	000000+00
49	995122-06	000000+00	000000+P0	000000+00
50	112306-05	000000+00	000000+P0	000000+00
51	128428-05	000000+00	000000+P0	000000+00
52	139301-05	000000+00	000000+P0	000000+00
53	192675-05	000000+00	000000+P0	000000+00
54	209982-05	000000+00	000000+P0	000000+00

ISOTOPE NO. 120

MULTIGROUP	SLOWING DOWN DENSITIES ISOTROPIC	ANISOTROPIC
1	613329.07	000000.00
2	134922.06	000000.00
3	354793.06	000000.00
4	579071.06	000000.00
5	107887.05	000000.00
6	167022.05	000000.00
7	534182.06	000000.00
8	273378.05	000000.00
9	899510.06	000000.00
10	339961.05	000000.00
11	221973.05	000000.00
12	208706.05	000000.00
13	186747.05	000000.00
14	476796.05	000000.00
15	-460510.06	000000.00
16	599646.05	000000.00
17	-145948.05	000000.00
18	640984.05	000000.00
19	-208036.05	000000.00
20	644917.05	000000.00
21	-228391.05	000000.00
22	610535.05	000000.00
23	-251626.05	000000.00
24	607511.05	000000.00
25	-276439.05	000000.00
26	596661.05	000000.00
27	-286759.05	000000.00
28	556812.05	000000.00
29	-340182.05	000000.00
30	536766.05	000000.00
31	-318926.05	000000.00
32	530212.05	000000.00
33	-320279.05	000000.00
34	523392.05	000000.00
35	-319593.05	000000.00
36	518018.05	000000.00
37	-319244.05	000000.00
38	515158.05	000000.00
39	-315844.05	000000.00
40	520169.05	000000.00
41	-310586.05	000000.00
42	526359.05	000000.00
43	-304012.05	000000.00
44	528936.05	000000.00
45	-300650.05	000000.00
46	528975.05	000000.00
47	-299703.05	000000.00
48	527570.05	000000.00
49	-299275.05	000000.00
50	526585.05	000000.00
51	-300763.05	000000.00
52	523656.05	000000.00
53	-303080.05	000000.00
54	518974.05	000000.00

ISOTOPE NO. 120 SPECTRUM INTEGRALS

FEW GROUP	SCHEME	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1 OF	3	643073-04	000000+00	151822-P3	562872-04
2 OF	3	395496-04	000000+00	141883-P6	591181-07
3 OF	3	553446-04	366074-02	000000+P0	000000+00
1 OF	2	103857-03	000000+00	151964-P3	563464-04
2 OF	2	553446-04	366074-02	000000+P0	000000+00
1 OF	1	159202-03	366074-02	151964-P3	563464-04

ISOTOPE NO. 120 MACROSCOPIC CROSS SECTIONS

FEW GROUP	SCHEME	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1 OF	3	102498-04	000000+00	241987-P4	897192-05
2 OF	3	600937-05	000000+00	215585-P7	898270-08
3 OF	3	875858-05	579331-03	000000+P0	000000+00
1 OF	2	807891-05	000000+00	118211-P4	438312-05
2 OF	2	875858-05	579331-03	000000+P0	000000+00
1 OF	1	830289-05	190920-03	792544-P5	293869-05

ISOTOPE NO. 120 MICROSCOPIC CROSS SECTIONS

FEW GROUP	SCHEME	SMOOTH ABSORPTION	RESONANCE ABSORPTION	NU-FISSION	FISSION
1 OF	3	461247+00	000000+00	108895+P1	403722+00
2 OF	3	270424+00	000000+00	970142-P3	404226-03
3 OF	3	394140+00	260702+02	000000+P0	000000+00
1 OF	2	363554+00	000000+00	531955+P0	197242+00
2 OF	2	394140+00	260702+02	000000+P0	000000+00
1 OF	1	373634+00	859147+01	356648+P0	132241+00

BLACKNESS COEFFICIENT EDIT

DIMENSIONS OF ABSORBING REGION
HALF THICKNESS = 100000+01 CM. MESH SIZE = 500000+00 CM.

SURFACE-SUPPRESSED SPECTRUM APPROXIMATION

ISOTOPE	NUMBER DENSITY
129	332100-02

FEW GROUP RESULTS

FEW GROUP	SCHEME	FICTITIOUS DIFFUSION CONSTANT	FICTITIOUS ABSORPTION CROSS SECTION	AVERAGE BLACKNESS COEFFICIENT ZETA	AVERAGE BLACKNESS COEFFICIENT ETA
1 OF	3	476322+03	696629-03	696629-03	476323+03
2 OF	3	480744+02	666953-02	666926-02	480769-02
3 OF	3	129855+01	206615+00	196992+00	137552+01
1 OF	2	860339+02	373901-02	373908-02	860353+02
2 OF	2	129855+01	206615+00	196992+00	137552+01
1 OF	1	506760+01	560071-01	558146-01	508860+01

FLUX-WEIGHTED BLACKNESS COEFFICIENT INTEGRALS

FEW GROUP	SCHEME	ZETA NUMERATOR	ZETA DENOMINATOR	ETA NUMERATOR	ETA DENOMINATOR
1 OF	3	436538-02	626643+01	361791+01	759549-02
2 OF	3	433913-01	650617+01	375468+01	780967-01
3 OF	3	928105+00	471138+01	256966+01	186813+01
1 OF	2	477567-01	127726+02	737255+01	856921-01
2 OF	2	928105+00	471138+01	256966+01	186813+01
1 OF	1	975862+00	174840+02	994221+01	195382+01

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MULTIGROUP RESULTS

MULTIGROUP	OPTICAL THICKNESS	BLACKNESS COEFFICIENT ZETA	ETA
1	836892=03	417305-03	796599+03
2	111586=02	555989-03	597449+03
3	114907=02	572487-03	580182+03
4	647595=03	323088-03	102945+04
5	850176=03	423914-03	784152+03
6	131512=02	654936-03	506927+03
7	223835=02	111224-02	297839+03
8	178006=02	885461-03	374521+03
9	127526=02	635154-03	522769+03
10	158080=02	786723-03	421730+03
11	242433=02	120414-02	274992+03
12	352026=02	174436-02	189382+03
13	415125=02	205439-02	160597+03
14	516748=02	255226-02	129015+03
15	614385=02	302902-02	108513+03
16	737262=02	362493-02	904289+02
17	916596=02	449561-02	727380+02
18	114574=01	559922-02	581924+02
19	135829=01	661691-02	490883+02
20	150419=01	759765-02	426283+02
21	193282=01	934166-02	345011+02
22	245422=01	117845-01	271752+02
23	300325=01	143290-01	222112+02
24	375432=01	177481-01	177727+02
25	481837=01	225656-01	138545+02
26	618935=01	286325-01	107936+02
27	795180=01	362648-01	841075+01
28	102154+00	458321-01	655840+01
29	131007+00	577410-01	512762+01
30	168109+00	725173-01	401195+01
31	216031+00	908225-01	314098+01
32	277370+00	113160+00	246881+01
33	332565+00	132358+00	207854+01
34	377133+00	147304+00	184829+01
35	427526+00	163442+00	164713+01
36	494374+00	181380+00	147191+01
37	548476+00	200961+00	131905+01
38	621485+00	221186+00	118550+01
39	704384+00	243043+00	106947+01
40	797837+00	265866+00	969242+00
41	903976+00	289727+00	882659+00
42	102453+01	315010+00	808827+00
43	116016+01	339464+00	747446+00
44	131425+01	364129+00	694752+00
45	148861+01	387754+00	650206+00
46	168222+01	409580+00	613695+00
47	190313+01	429455+00	583526+00
48	216270+01	447833+00	558773+00
49	245747+01	462912+00	540042+00
50	278492+01	474533+00	526792+00
51	307126+01	481565+00	519310+00
52	337798+01	489534+00	511105+00
53	419389+01	494439+00	505431+00
54	475288+01	497661+00	500519+00

MACROSCOPIC DATA FORM PROBLEM ..... PAGE .... OF ....

	DIFFUSION	ABSORPTION	REMOVAL	NU-FISSION	KAPPA-FISSION	COMP.
021022	175812+01	151871-02	118049+00	374941+03		
022022	888483+00	251402-03	149905+00	451794+03		
023022	460067+00	770451-02	148380+00	887831+02		
024022						

MACROSCOPIC DATA FORM PROBLEM ..... PAGE .... OF ....

	DIFFUSION	ABSORPTION	REMOVAL	NU-FISSION	KAPPA-FISSION	COMP.
021022	131291*01	869906-03	767446-01	414286-03		
022022	460067*00	770451-02	148380*00	687831*02		
023022						

MACROSCOPIC DATA FORM PROBLEM ..... PAGE .... OF ....

	DIFFUSION	ABSORPTION	REMOVAL	NU-FISSION	KAPPA-FISSION	COMP.
021022	103185-01	312226-02	488991-01	254452-02		
022022						

APPENDIX B

MILC-1 - A P_1-MULTIGROUP ISOTOPE LIBRARY WRITING PROGRAM FOR THE PHILCO-2000

PART 1

DESCRIPTION OF PROBLEM

The programs MUFT-5 and P_3MG-1* will require a library of multigroup parameters, these being the same as the P1MG-2 parameters. A library tape must be available to run all MUFT-5 and P_3MG-1 problems. The creation of this multigroup isotope library is performed by this program using data specified on sets of cards. The data in general will consist of:

1) A table of contents that indicates the dimensions of the library, lists of isotopes for each of the types of nuclear phenomena treated in the MUFT-5 and P_3MG-1 programs, and a list of source spectra numbers for the library;
2) The lethargy increments for the multigroup structure of the library;
3) The microscopic quantities which must be present for all the isotopes contained in the library, i.e., cross sections of the nuclear reactions (symmetric scattering, smooth capture, smooth fission, and inelastic scattering), the number of neutrons produced by fissioning, the average cosine of the scattering angle, and four coefficients which describe isotropic and anisotropic slowing down;
4) The parameters which describe absorption resonances for certain isotopes;
5) The fission-to-absorption ratios which describe fission resonances for certain isotopes;

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* A proposed Philco-2000 program to be equivalent to P1MG-2 (Ref. 5).

6) The inelastic scattering matrix for certain isotopes; and

7) The source distribution spectra.

Isotopes will be identified in the library by a three-digit code number without any program restriction concerning which isotope is which code number, e.g., hydrogen is not assumed to be code number 001.

The program will produce one library tape per job (as defined by BKS, see Ref. 4) where each subset of data in the seven sets of information described above is considered a case within the job.

PART 2

PREPARATION OF INPUT

A. INTRODUCTION

A job, as run by MILC-1, will always result in the processing of many "cases", the sum total of which is considered a complete MILC-1 problem. Regardless of the number of cases in the job, the following cards must always be present:

1) Accounting card
2) BKS control card
3) Binary program cards (optional)
4) Data cards

There is no other input for a MILC-1 run.

B. THE ACCOUNTING CARD

The description of this card is found in Reference 4.

C. BKS CONTROL CARD

Column 9 - If the binary program cards for MILC-1 follow the card, a "C" should be punched. If the MILC-1 program is to be taken from the BKS System program library, a "T" is punched.

Columns 11-15 - "MILC1" is punched.

Columns 17-19 - "236" is punched.

All other columns are blank.

D. BINARY PROGRAM CARDS

This is the deck of cards which the author assumes accompanied the distribution of this memorandum. This deck is included in the job only if there is a

"C" punched in column 9 of the BKS control card (See previous section.). This deck is omitted if a "T" is punched in column 9 of the BKS control card.

E. DATA CARDS

There are suggested MILC Input Forms (See Appendix E.) which should be filled out with the required parameters for each case in order to facilitate punching. This section will be a description of the quantities entered on these input forms. Except for the remarks card, the only characters which should be entered into the spaces on the form should be +, -, 0, 1, 2, 3, 4, 5, 6, 7, 8, or 9. The only floating point quantities (See Part Two, Section F.) which should be entered into the spaces are those to be entered in the columns headed by "f" (for fraction) and "e" (for exponent). The rest of the fields are either card series numbers or fixed point integers. The fraction part of the floating point field must be no more than five columns wide; the exponent, only one column. All of the series numbers on Form 1 are entered and should not be changed. All of the series numbers on Form 2 must be specified. Although the specification of a comments card is optional, the author recommends that one be specified in order to aid in finding errors which may occur in input decks.

Input Form 1 - Table of Contents

100001 - This dimension card contains the sizes of all the lists which are specified on the rest of the form. Also, from these parameters the quantity of information in each of the cases is checked.

Multigroups, total number of multigroups, $M \leq 80$.

Total No. of Isotopes, I_L, $0 < I_L \leq 341$.

Total No. of Absorption Resonance Isotopes, $I_{LA} \leq 341$.

Total No. of Fission Resonance Isotopes, $I_{FA} \leq 314$.

Total No. of Scattering Matrix Isotopes, $I_{LU} \leq 341$.

Total No. of Source Spectra, S; $0 < S < 100$.

Last Matrix Multigroup, U; $1 < U < 30$.

The following restrictions must be adhered to:

$$(M - L + 1) \leq 50$$

$$I_L + I_{LA} + I_{LF} + I_{LU} + S \leq 1000$$

The rest of the form consists of lists of the isotope code numbers in ascending order in each category. The list on card series 100003 must be a sublist of the list on card series 100002. The list on card series 100005 must be a sublist of the list on card series 100002. The list on card series 100004 must be a sublist of the list on card series 100003. The signs of all the numbers are positive for this program. The source spectrum numbers must be in ascending, consecutive order. Use all the spaces in one row (card) before going to the next row. Use only as many spaces and rows as necessary. All unused spaces must remain blank. Empty lists are blank. Lists 100002 and 100006 must never be empty. If more rows are needed than available for a list, use a second form, ignoring the rest of the first form for that list and the beginning of the second and successive forms for that list.

The cards punched from Form 1 constitute the first "case" of the MILC-1 job.

Input Form 2 - Library Data

Every card which is input to MILC-1 must have as its first field a series number -- a six digit number. The first digit of this number indicates the file of the library into which the data punched into the rest of the card is to be placed. The file numbers and the data which the files contain are:

File	Data
1	Table of contents
2	Lethargy increments
3	Microscopic cross sections
4	Absorption resonance parameters
5	Fission-to-absorption ratios
6	Inelastic scattering matrices
7	Source spectra

This file number must be entered into the form as the first digit of every row.

The digits 2, 3, and 4 of the series number must be the isotope number for files 3, 4, 5, and 6 and the spectrum number for file 7.

The digits 5 and 6 of the series number must be the group number into which all the information in that row is to be placed for files 3, 4, 5, and the probability matrix of 6. For files 2, 7, and the inelastic scattering cross sections of file 6 the digits must be the group number which corresponds to the first entry of the row.

The second field of every row in files 2 through 7 must be a card sequence number, indicated by a c on the form. This number will be used to distinguish between cards which have the same series number.

The remaining fields of each row must contain floating point format data (See Part Two, Section F.) as required for that particular file. Only as many fields as required must be used. All unused fields and rows are left blank. Use as many forms as necessary for each case, starting each new case on a new form.

File 2 - Lethargy Increments

Only one "case" for this file may be present in a job. The increments of lethargy, Δ^m, for which all the data in the library has been compiled, are entered eight-to-a-row for $m = 1, 2, \cdots, M$. The card sequence number is zero.

File 3 - Microscopic Cross Sections

For every entry in the list of card series 100002 there must be a corresponding case of data for file 3.

The data in this file is not exclusively cross section data but includes slowing down parameters and fission-product parameters. Two rows on the input form are used for each multigroup. The card sequence numbers are 1 and 2. The five floating point fields of the first row of multigroup m for isotope i must contain, in the following order:

$(\bar{\sigma}_{s0})_i^m$, symmetric scattering cross section

$(\bar{\sigma}_c^s)_i^m$, smooth capture cross section

$(\bar{\sigma}_{in})_i^m$, inelastic scattering cross section

$(\bar{\sigma}_f^s)_i^m$, smooth fission cross section

$(\bar{\sigma}_{sl})_i^m$, anisotropic scattering cross section

The "bar" indicates that the parameter is an average value for the energy range of the multigroup.

The five fields of the second card must contain, in the following order:

$\bar{\nu}_i^m$, number of neutrons per fission

$(\lambda_0)_i^m$, isotropic Grueling-Goertzel parameter

$(\bar{\xi}_0)_i^m$, isotropic slowing down power

$(\lambda_1)_i^m$, anisotropic Grueling-Goertzel parameter

$(\bar{\xi}_1)_i^m$, anisotropic slowing down power

The data must be specified for the multigroups 1 through M.

File 4 - Absorption Resonance Parameters (See page 73 of Reference 2.)

For every entry in the list of card series 100003 there must be a corresponding case of data for file 4. Two rows of the input form are used for each multigroup. Both rows must have all eight floating point fields specified. The card sequence numbers are 1 and 2. The floating point fields of the first row of multigroup m for isotope i contain the values of $(r_a)_i^{m,k}$ for the resonances k = 1, 2, ···, 8. The resonances within a multigroup are numbered starting at the high energy end of the group. The second row contains the corresponding values of $(m_a)_i^{m,k}$.

The data must be specified for the multigroups L through M.

File 5 - Fission-to-Absorption Ratios

For every entry in the list of card series 100004 there must be a corresponding case of data for file 5. One card for each multigroup is specified; the card sequence number is zero. Every row must have eight floating point fields specified. These fields are the values of $(r_{fa})_i^{m,k}$ for the resonances, k = 1, 2, ···, 8, in multigroup m of isotope i. The resonances for a multigroup are numbered the same as described under File 4, above.

The data must be specified for the multigroups L through M.

File 6 - Inelastic Scattering Matrices

For every entry in the list of card series 100005 there must be a corresponding case of data for file 6. The data in each case is made up of two parts: the inelastic scattering cross sections and the probability matrix.

The inelastic scattering cross sections, $(\bar{\sigma}_{in})_i^m$, are the same as specified in file 3 and must be specified here. The card sequence number is zero. Cross sections for eight multigroups are specified for each row, using as many rows as necessary and as many spaces in the last row as necessary.

The data must be specified for the multigroup 1 through M.

Only the lower triangular part of the scattering probability matrix is specified, i.e., the matrix accounts for only the scattering which occurs out of a group. Therefore, the elements of the matrix are $p_i^{r,m}$, where the scattering due to isotope i is out of multigroup r and into multigroup m. For each row of the matrix (each multigroup m) there must be m - 1 elements specified. Eight elements are specified in a row of the input form using as many rows as necessary. The card sequence numbers within a multigroup are 1, 2, 3, ···. The unused fields of the last row of the form used for each multigroup are left blank.

The data must be specified for the multigroups 2 through U.

The inelastic scattering cross section cards and the scattering probability matrix cards are one case. The program performs the computation

$$a_i^{r,m} = (\bar{\sigma}_{in})_i^m \; p_i^{r,m} \qquad (1)$$

and enters the quantities $a_i^{r,m}$ into the library.

File 7 - Source Spectra

For every entry in the list of card series 100006 there must be a corresponding case of data for file 7. The values of the source spectrum, $\bar{\chi}^m$, are specified in

the same way as the lethargy increments of file 2. The isotope number, i, in the card series number must be the spectrum number s. The card sequence number is zero.

F. ARRANGEMENT OF CASES FOR A JOB

A set of cards in any file for an isotope is one case of the MILC-1 job. Each source spectra is a case of the job. The cases are grouped together by files and are in order according to the lists in the table of contents which is the first case. There are therefore $I_L + I_{LA} + I_{LF} + I_{LU} + S + 2$ cases in a job.

PART 3

OPERATING INSTRUCTIONS

(See Part Three.)

PART 4

DESCRIPTION OF OUTPUT

The only output from MILC-1 is a file tape which will have the accounting card information as its BKS label. This tape can be used as an input librarytape or a filetape in a MUFT-5 job. (See Part Two, Sections C and E.)

APPENDIX C

MILC-2 - A PROGRAM FOR THE PHILCO-2000 TO MODIFY A TAPE WRITTEN BY MILC-1

PART 1

DESCRIPTION OF PROBLEM

During the period of time while using the programs MUFT-5 and P3MG-1 there will be changes required in the MILC library. MILC-2 will take care of making the following changes in a MILC library:

1) Add any set of data to any file with the appropriate modification of the table of contents.
2) Replace any set of data on any file with another set of data.
3) Delete any set of data from any file with the appropriate modification of the table of contents.

Additions, replacements, and deletions may be performed in one job. Each of the additions and replacements must have the correct deck of cards, exactly the same format as the MILC-1 cards, as a case within the job. The changes which modify the table of contents are restricted such that the resultant library is an acceptable MILC library, i.e., it could have been written originally with MILC-1.

The original library tape will also be the final library tape, thus there will only be one file tape associated with any job.

PART 2

PREPARATION OF INPUT

A. INTRODUCTION

The arrangement of a job is the same as described in Part 2, Appendix B, with the exception that a file tape card must precede the data cards. The description of the accounting card, BKS control card, and binary deck is similar to that found in Part 2, Appendix B.

B. DATA CARDS

The MILC Input Form 1 and Input Forms 2 (See Appendix E.) are to be used. (See Part 2, Appendix B.) A comment card is recommended as the first card of each case in a MILC-2 job. The deck of cards punched from Input Form 1 is considered as the first case.

Input Form 1 - Table of Contents

The notation used here is explained in Appendix B. The description of the information which is entered on card 100001 is found in Part 2,E, Appendix B. The rest of the form consists of the lists of the isotope code numbers, in ascending order in each category, of the data which is to be added, replaced, or deleted by this MILC-2 job. The sign of the entry will indicate whether the information is to be added (+), replaced (+), or deleted (-).

Input Form 2 - Library Data

For the entries in the lists on Form 1 which have positive signs, there should be Forms 2 filled in according to the description in Part 2, Appendix B. The data sets must be in the order in which they are found on Form 1.

Nothing is required for a deletion.

PART 3

OPERATING INSTRUCTIONS

(See Part Three.)

NOTE: The input filetape must be write-enabled.

PART 4

DESCRIPTION OF OUTPUT

The only output from MILC-2 is the same filetape as was necessary as input.

APPENDIX D

MILC-3 - A PROGRAM FOR THE PHILCO-2000 TO EDIT A TAPE WRITTEN BY MILC-1 OR MODIFIED BY MILC-2

PART 1

DESCRIPTION OF PROBLEM

A. INTRODUCTION

Any library tape, written by MILC-1 or modified by MILC-2 to run MUFT-5 problems, may be edited by MILC-3.

The library tape to be edited will consist of the following:[1]

1) A table of contents that indicates the dimensions of the library, lists of isotopes for each type of nuclear phenomena to be treated and a list of source spectra numbers for the library.
2) The lethargy increments for the multigroup structure of the library.
3) The microscopic cross sections and parameters which must be present for all isotopes in the library.
4) The absorption resonance parameters for certain isotopes.
5) The fission-to-absorption parameters for certain isotopes.
6) The inelastic scattering matrix for certain isotopes.
7) The source distribution spectra.

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[1] See Appendix B, Part 2, Section E, for further description of these parameters.

PART 2

PREPARATION OF INPUT

The user may request an edit of any combination of the isotopes and source spectra that exist on the library tape. The table of contents[2] and the lethargy increments will always be edited regardless of the information requested by the user in an edit.

In order to run a MILC-3 edit, the following cards must always be present:

1) Accounting Card
2) BKS Control Card
3) Binary Program Cards (optional)
4) Filetape Card
5) Data Cards

Accounting Card

The description of this card is found in the BKS System Report - Reference 4.

BKS Control Card

This control card specifies the tape assignments for the input, output, and library tapes. It is card 0001 which has been included in the MILC-3 binary program deck that accompanies this report.

Binary Program Cards

The binary program cards must be included in the input deck unless the MILC-3 program has been placed on a system program library tape. If the program has been placed on a system tape, the binary cards are omitted and column 9 of the BKS control card should be changed from a C-punch to a T-punch.

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[2] Appendix B, Part 2, Input Form 1.

File Tape Card

Preceding the title card in the data cards (See Section F.) there must be one filetape card which specifies the library tape to be edited. The filetape card must be punched as follows:

Columns 9-19	"FILETAPE 13,"
Columns 20-34	Library tape identification. Further description of the filetape card is in Reference 4.

Data Cards

The MILC Input Form 1 (See Appendix A.) should be used to specify the necessary information for a MILC-3 edit. All numbers on this input form must be fixed point quantities.

1. Title Card

Column 9	"*" which indicates this is a title card.
Columns 10-80	Any information desired by the user. This information is printed at the top of each page of output.

2. Card 100001 - Dimension Card

This card specifies the number of multigroups, the number of isotopes to be edited under each section, the first resonance multigroup, and the last matrix multigroup.

a. Total Number of Multigroups (M)

This number must be the same as the total number of multigroups on the library tape.

b. Total Number of Isotopes (I_L)

"I_L" specifies the total number of isotopes for which the microscopic cross sections and parameters are to be edited. $I_L \leqq$ the total number of isotopes on the library tape. If $I_L = 0$ the microscopic cross section and parameter edit is omitted.

c. Total Number of Absorption Resonance Isotopes (I_{LA})

"I_{LA}" specifies the number of absorption resonance isotopes to be edited where $I_{LA} \leqq$ the total number of absorption resonance isotopes on the library tape. If $I_{LA} = 0$ the absorption resonance edit is omitted.

d. Total Number of Fission-to-Absorption Isotopes (I_{FA})

"I_{FA}" specifies the total number of fission-to-absorption isotopes to be edited where $I_{FA} \leqq$ the total number of fission-to-absorption isotopes on the library tape. If $I_{FA} = 0$ the fission-to-absorption edit is omitted.

e. Total Number of Inelastic Scattering Matrix Isotopes (I_{LU})

"I_{LU}" specifies the total number of inelastic scattering matrix isotopes to be edited where $I_{LU} \leqq$ the total number of inelastic scattering matrix isotopes on the library tape. If $I_{LU} = 0$, the inelastic scattering matrix edit is omitted.

f. Total Number of Source Spectra (S)

"S" specifies the total number of source spectra to be edited where S = the total number of source spectra on the library tape. If S = 0, the source spectra edit is omitted.

g. First Resonance Multigroup (L)

"L" must be equal to the first resonance multigroup on the library tape.

h. Last Matrix Multigroup (U)

"U" must be equal to the last matrix multigroup on the library tape.

If I_L, I_{LA}, I_{FA}, I_{LU}, and S all equal zero on the dimension card, MILC-3 will edit the table of contents of the library tapes, the lethargy increments, and the isotopes that exist on the tape under each type of nuclear phenomena. In this case, the remainder of the data cards are omitted.

3. Card Series 100002

A list of all isotopes, in ascending order, for which the microscopic cross sections and parameters are to be edited. The total number of isotopes specified in this series must correspond to I_L on the dimension card. If $I_L = 0$ on the dimension card, this series is omitted from the data cards.

4. Card Series 100003

A list of all isotopes, in ascending order, for which the absorption resonance parameters are to be edited. The total number of isotopes in this series must correspond to I_{LA} on the dimension card. If $I_{LA} = 0$ on the dimension card, this series is omitted from the data cards.

5. Card Series 100004

A list of all isotopes, in ascending order, for which the fission-to-absorption parameters are to be edited. The total number of isotopes in this series must correspond to I_{FA} on the dimension card. If $I_{FA} = 0$ on the dimension card, this series is omitted from the data cards.

6. Card Series 100005

A list of all isotopes, in ascending order, for which the inelastic scattering matrix parameters are to be edited. The total number of isotopes in

this series must correspond to I_{LU} on the dimension card. If I_{LU} = 0 on the dimension card, this series is omitted from the data cards.

7. Card Series 100006

A list of all source spectra, in ascending order, to be edited. The total number of source spectra in this series must correspond to "S" on the dimension card. If S = 0 on the dimension card, this series is omitted from the data cards.

One blank card must follow the last data card. There is only one case in a MILC-3 job, i.e., in the BKS sense.

PART 3

OUTPUT

The first page of output contains the values of M, I_L, I_{LA}, I_{FA}, I_{LU}, L, and U as they exist on the library tape. Following these numbers are the lethargy increments for each multigroup and a list of all isotopes and source spectra requested in the edit. (See Appendix E. Sample MILC-3 problem.)

The edits appear for all isotopes that have been requested, in the following order:

1) Microscopic Cross Sections and Parameters
2) Resonance Absorption Parameters
3) Fission-to-Absorption Ratios
4) Inelastic Scattering Matrix Parameters
5) Source Spectra

The titles for each section of output and the parameters under each section follow in the order in which they are edited. After each title is a reference to

the equation(s) in the MUFT-5 report which describes the parameters listed in the output.

MICROSCOPIC CROSS SECTIONS AND PARAMETERS FOR ISOTOPE XXX

"SYMMETRIC SCATTERING" $(\bar{\sigma}_{s0})_i^m$	Eq. B.7; B.14
"SMOOTH CAPTURE" $(\bar{\sigma}_c{}^s)_i^m$	Eq. B.5; F.1
"INELASTIC SCATTERING" $(\bar{\sigma}_{in})_i^m$	Eq. B.6 and Eq. 1, App. B
"SMOOTH FISSION" $(\bar{\sigma}_f{}^s)_i^m$	Eq. B.5; F.1
"ANISOTROPIC SCATTERING" $(\bar{\sigma}_{si})_i^m$	Eq. B.7
"NEUTRONS PER FISSION" $\bar{\nu}_i{}^m$	Eq. D.1, E.1
"ISOTROPIC GRUELING-GOERTZEL" $(\lambda_0)_i^m$	Eq. B.3
"ISOTROPIC SLOWING DOWN POWER" $(\bar{\xi}_0)_i^m$	Eq. B.3; B.13
"ANISOTROPIC GRUELING-GOERTZEL" $(\lambda_1)_i^m$	Eq. B.4
"ANISOTROPIC SLOWING DOWN POWER" $(\bar{\xi}_1)_i^m$	Eq. B.4

ABSORPTION RESONANCE PARAMETERS FOR ISOTOPE XXX

R - $(r_a)_i^{m,k}$ where $k = 1, 2, \cdots, 8$	Eq. B.10
M - $(m_a)_i^{m,k}$ where $k = 1, 2, \cdots, 8$	Eq. B.10

FISSION-TO-ABSORPTION RATIOS FOR ISOTOPE XXX

$(r_{fa})_i^{m,k}$ where $k = 1, 2, \cdots, 8$	Eq. D.3

INELASTIC SCATTERING MATRIX FOR ISOTOPE XXX

$a_i^{r,m}$	Eq. B.15a; D.17a

SOURCE SPECTRUM XX

$(\bar{\chi}^m)$	Eq. B.1; D.10

PART 4

ERRORS

If MILC-3 detects input errors or tape errors, appropriate error comments are printed off-line and the problem is rejected.

APPENDIX E

MILC-1, MILC-2, AND MILC-3 SAMPLE PROBLEMS

Each of the sample problems in this appendix is designed to display the types of input which can be specified and the format of the output. The spectrum data in the MILC-2 sample problem is purely fictitious and should not resemble any actual source spectrum; in fact, the spectrum is not properly normalized.

The MILC-1 sample problem contains only the table of contents specifications. This table of contents is exactly that one which was specified for the MILC-1 problems which created the library described in the Bettis Laboratory Report, WAPD-TM-224, "54-Group Library for P-1 Programs", by A. F. Henry, April 1960. The MILC sample problem is the entire input specification for the problem which would edit the library described in WAPD-TM-224. The input forms for the data which created the cards for the remainder of the MILC-1 input deck have been omitted from this report. The source spectrum which is specified as part of the MILC-2 sample problem input will give an indication of how the Input Form 2 is filled in. There is no off-line information edited for either MILC-1 or MILC-2 if the job runs successfully; therefore, no printouts are included for these problems in this appendix.

The one-page printout which follows each input form is an IBM-407 listing of the cards which should be punched from the information supplied on the input form. The first card of the deck is the BKS accounting card (See Section B in Part 2 of Appendices B, C, and D.).

DATE

REQUESTOR BOHLH

K.P. _____ V. _____

MILC INPUT FORM I
TABLE OF CONTENTS

12003007, MILC1 SAMPLE PROBLEM FOR WAPD-TM-218

9 ◄ REMARKS ► 80

DIMENSION CARD

100001 Multigroups 54 ; Total No. Of Isotopes 28 ; Total No. Of Absorption Resonance Isotopes 15 ;
Total No. Of Fission Resonance Isotopes 3 ; Total No. Of Scattering Matrix Isotopes 23 ;
Total No. Of Source Spectra 2 ; First Resonance Multigroup 26 ; Last Matrix Multigroup 25

ALL ISOTOPES IN ASCENDING ORDER

± i	± i	± i	± i	± i	± i	± i	± i	± i	± i	± i	± i	± i
100002	1	2	3	6	7	8	9	11	14	18	20	21
100002	22	23	29	40	48	54	94	95	96	97	102	103
100002	104	118	120	129								
100002												
100002												

ALL ABSORPTION RESONANCE ISOTOPES IN ASCENDING ORDER

100003	8	9	14	20	21	22	23	54	94	95	96	97
100003	103	118	120									
100003												

ALL FISSION RESONANCE ISOTOPES IN ASCENDING ORDER

100004	21	23	118									

ALL SCATTERING MATRIX ISOTOPES N ASCENDING ORDER

100005	6	7	8	9	11	14	20	21	22	23	40	48
100005	54	94	95	96	97	102	103	104	118	120		
100005												

ALL SOURCE SPECTRA IN CONSECUTIVE ORDER

s s	s s	s s	s s	s s	s s	s s	s s	s s	s s
100006	1	2							

```
12003007$ MILC1 BOHLH
        * 12003007, MILC1 SAMPLE PROBLEM FOR WAPD-TM-218
        100001,54,28,15,3,22,2,26,25
        100002,1,2,3,6,7,8,9,11,14,18,20,21
        100002,22,23,29,40,48,54,94,95,96,97,102,103
        100002,104,118,120,129
        100003,8,9,14,20,21,22,23,54,94,95,96,97
        100003,103,118,120
        100004,21,23,118
        100005,6,7,8,9,11,14,20,21,22,23,40,48
        100005,54,94,95,96,97,102,103,104,118,120
        100006,1,2
```

DATE _____

REQUESTOR BOHLH

K.P. _____ V. _____

MILC INPUT FORM I
TABLE OF CONTENTS

12003008. MILC2 SAMPLE PROBLEM FOR WAPD-TM-218

9 ← REMARKS → 80

DIMENSION CARD

100001	Multigroups 54 ; Total No. Of Isotopes 1 ; Total No. Of Absorption Resonance Isotopes 0 ; Total No. Of Fission Resonance Isotopes 3 ; Total No. Of Scattering Matrix Isotopes 1 ; Total No. Of Source Spectra 2 ; First Resonance Multigroup 26 ; Last Matrix Multigroup 25

ALL ISOTOPES IN ASCENDING ORDER

± i	± i	± i	± i	± i	± i	± i	± i	± i	± i	± i	± i	± i	± i
100002	- 40												
100002													
100002													
100002													
100002													

ALL ABSORPTION RESONANCE ISOTOPES IN ASCENDING ORDER

100003												
100003												
100003												

ALL FISSION RESONANCE ISOTOPES IN ASCENDING ORDER

100004	- 21	- 23	- 118									

ALL SCATTERING MATRIX ISOTOPES IN ASCENDING ORDER

100005	- 40											
100005												
100005												

ALL SOURCE SPECTRA IN CONSECUTIVE ORDER

S S	S S	S S	S S	S S	S S	S S	S S	S S	S S	S S	S S	S S	S S	S S	S S	S S	S S	S S	S S	S S	S S	S S	S S
100006	-2	+6																					

DATE

MILC INPUT FORM 2
LIBRARY DATA

REQUESTOR BOHLH
K.P. _____ V. _____

12003008, MILC2 SAMPLE PROBLEM SPECTRUM 6

*1 9 ← REMARKS → 80

F i m c	f	± e	f	± e	f	± e	f	± e	f	± e	f	± e	f	± e	f	± e
7 0 0 6 01 0	0	+0	0	+0	1	+0	2	+0	1234	+0	2345	+0	3456	+0	4567	+0
7 0 0 6 09 0	23312	+0	33122	+0	11222	+0	92242	-1	63211	-1	22211	-1	0	+0	0	+0
7 0 0 6 17 0	0	+0	0	+0	0	+0	0	+0	0	+0	0	+0	0	+0	0	+0
7 0 0 6 25 0	0	+0	0	+0	0	+0	0	+0	0	+0	0	+0	0	+0	0	+0
7 0 0 6 33 0	0	+0	0	+0	0	+0	0	+0	0	+0	0	+0	0	+0	0	+0
7 0 0 6 41 0	0	+0	0	+0	0	+0	0	+0	0	+0	0	+0	0	+0	0	+0
7 0 0 6 49 0	0	+0	0	+0	0	+0	0	+0	0	+0	0	+0				

9 16 18 26 34 42 50 58 66 74 80

```
12003008$ MILC2 BOHLH
        * 12003008, MILC2 SAMPLE PROBLEM FOR WAPD-TM-218
        100001,54,1,0,3,1,2,26,25
        100002,-40
        100004,-21,-23,-118
        100005,-40
        100006,-2,+6
        -
        * 12003008, MILC2 SAMPLE PROBLEM SPECTRUM 6
        700601,0,0+0,0+0,1+0,2+0,1234+0,2345+0,3456+0,4567+0
        700609,0,23312+0,33122+0,11222+0,92242-1,63211-1,22211-1,0+0,0+0
        700617,0,0+0,0+0,0+0,0+0,0+0,0+0,0+0,0+0
        700625,0,0+0,0+0,0+0,0+0,0+0,0+0,0+0,0+0
        700633,0,0+0,0+0,0+0,0+0,0+0,0+0,0+0,0+0
        700641,0,0+0,0+0,0+0,0+0,0+0,0+0,0+0,0+0
        700649,0,0+0,0+0,0+0,0+0,0+0,0+0
        -
```

DATE

REQUESTOR HEMPH

K. P. _____ V. _____

MILC INPUT FORM I
TABLE OF CONTENTS

12003009, MILC3 SAMPLE PROBLEM FOR WAPD-TM-218

9 ◄ REMARKS ► 80

DIMENSION CARD

100001 Multigroups 54 ; Total No. Of Isotopes 28 ; Total No. Of Absorption Resonance Isotopes 15 ;
Total No. Of Fission Resonance Isotopes 3 ; Total No. Of Scattering Matrix Isotopes 22 ;
Total No. Of Source Spectra 2 ; First Resonance Multigroup 26 ; Last Matrix Multigroup 25

ALL ISOTOPES IN ASCENDING ORDER

	± i	± i	± i	± i	± i	± i	± i	± i	± i	± i	± i	± i	± i
100002	1	2	3	6	7	8	9	11	14	18	20	21	
100002	22	23	29	40	48	54	94	95	96	97	102	103	
100002	104	118	120	129									
100002													
100002													

ALL ABSORPTION RESONANCE ISOTOPES IN ASCENDING ORDER

100003	8	9	14	20	21	22	23	54	94	95	96	97
100003	103	118	120									
100003												

ALL FISSION RESONANCE ISOTOPES IN ASCENDING ORDER

100004	21	23	118									

ALL SCATTERING MATRIX ISOTOPES IN ASCENDING ORDER

100005	6	7	8	9	11	14	20	21	22	23	40	48
100005	54	94	95	96	97	102	103	104	118	120		
100005												

ALL SOURCE SPECTRA IN CONSECUTIVE ORDER

	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
100006	1	2																						

```
120030093 MILC3 HEMPH
        * 12003009, MILC3 SAMPLE PROBLEM FOR WAPD-TM-218
        100001,54,28,15,3,22,2,26,25
        100002,1,2,3,6,7,8,9,11,14,18,20,21
        100002,22,23,29,40,48,54,94,95,96,97,102,103
        100002,104,118,120,129
        100003,8,9,14,20,21,22,23,54,94,95,96,97
        100003,103,118,120
        100004,21,23,118
        100005,6,7,8,9,11,14,20,21,22,23,40,48
        100005,54,94,95,96,97,102,103,104,118,120
        100006,1,2
```

APPENDIX F

WB-INP1

A. K. Rigler

Function: This subroutine converts six bit binary coded decimal data to binary fixed or floating representation required by the Philco-2000. This binary coded decimal information is prepared from cards by the Bettis-Knolls Sequencing System (BKS) and is stored on magnetic tape. Each data card contains an identification number in addition to data. The converted data are stored in a list beginning at location L. A table beginning at location T is also formed, one word per card, in which the card number and other descriptive information appears. These are described in detail below. A blank card is used to terminate the input.

Parameters: A JMPL INPUT enters this routine. The A and Q registers must contain command constants of the following form:

(A) = P/T,T15; P/L,T39
and (Q) = P/iT,T15; P/oT,T39; N/ds,T47.

The symbol T represents the first location to be used for storing the card information table, L the first location for the converted data list, iT and oT specify locations from which the physical input and output tape numbers may be obtained, and ds is the data select number to be used if off-line printing is required.

Results: The construction of the table and list is terminated when a blank card, columns 9-80, is detected. Control is returned to α+1H with the following command constants in the A and Q registers:

(A) = P/T+n_c,T15; P/L+n_n,T39
and (Q) = N/δ,T ; N/γ,T39.

The parameters T and L are the same as required on entry with n_c being the number of cards read and n_n being the number of numbers converted. The value δ equals zero except when γ, the case number, is the last case. The last case is indicated by $\delta = 1$.

Accuracy: Fixed point numbers are integers and are converted exactly. The error in the fractional part of a floating binary number may be 2^{-35}. The number ranges are $-2^{39} \leq N \leq 2^{39}-1$ for fixed point and $-2^{2047} < N < 2^{2047}$ for floating point.

Extent: 440 words and 30 pool constants.

Error Stops: None.

Description: I. Cards will be punched in the following format:

A. Comment Cards -- These are identified by an asterisk in column 9. The first comment card is retained in the BKS System as a page title for all output. All subsequent comment cards are processed for off-line printing as they are encountered. If no comment card is present, the page title for the previous case is used.

B. Data Cards -- All cards which do not have an asterisk in column 9 are assumed to be data cards.

1. Card columns 1-8 are ignored.

2. Beginning in column 9 is a decimal card number of no more than 6 digits and separated from subsequent data by a comma.

3. The remainder of the card contains numbers of the forms below, separated by commas.

a.	(±)xx...x	a fixed point binary integer anchored at 39.
b.	(±)xx...x.x...x	a floating point binary number.
c.	(±)xx...x.x...x±yyy	a floating point binary number. If the decimal point is absent, xx...x is assumed to be a fraction. ±yyy is the power of 10.

The sign (±) implies the plus sign is optional and may be omitted. Blank columns may precede or follow the significant digits. Blank columns between significant digits cause a format error. The last number on the card need not be followed by a comma.

II. The card description words stored in the table beginning at T have the following form:

Bits	Information
0-23	Card number in 4 bit binary coded decimal.
24	Zero.
25-39	Address of the first data number on the card.
40-46	The number of data numbers on the card.
47	0 if the card format is correct; 1 if the card contains a range or format error.

The location immediately following the last entry in this table contains the sentinel 48/1T47.

Example:

Cols. 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 ...

Cards

1	0	1	0	1	0	,	1	,	0	,	1	+	1	,	Δ	Δ	...
Δ	Δ	2	0	Δ	,	1	,	2	Δ	,	Δ	3	Δ	,	4	Δ	...
Δ	Δ	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	...

	loc	word
Table T	40000	0401 0020 2400 0004
	40001	0000 0040 2400 1010
	40002	7777 7777 7777 7777
List L	50000	2000 0000 0000 0001
	50001	2000 0000 0000 0001
	50002	0000 0000 0000 0400
	50003	0000 0000 0000 1000
	50004	0000 0000 0000 1400
	50005	0000 0000 0000 2000

at entry (A) = 2000 0000 2400 0000
(Q) = does not affect table and list

at exit (A) = 2000 1000 2400 3000
(Q) = not affected by table and list

Restriction: This subroutine in its present form may be used only with the BKS System.

ACKNOWLEDGMENTS

The authors would like to thank Dr. Ely M. Gelbard of Bettis for his advice and assistance in producing this program and Mr. Victor C. Coca of Bettis for his help in transcribing the Bettis 54-group library from IBM-704 card form to Philco-2000 card form.

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