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SLOP-1--A THERMAL MULTIGROUP PROGRAM FOR THE IBM-704

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**BETTIS ATOMIC POWER LABORATORY
PITTSBURGH, PENNSYLVANIA**

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A THERMAL MULTIGROUP PROGRAM FOR THE IBM-704

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ABSTRACT

SLOP-1 is a thermal multigroup program, written for the IBM-704. It has been used extensively to test the utility of various H_2O scattering kernels, and to assess the accuracy of other computing methods.

PART ONE: PHYSICAL CONTENT AND METHOD OF SOLUTION

I. INTRODUCTION

This report has been written in two parts, which cover much the same material from different points of view. Part One describes the problem solved by SLOP-1, the physical approximations in the program and library, the method of solution, suggested modes of operation, and edits. No attempt is made, in this first part, to list all equations, all combinations of input options and all possible operating procedures. It is intended that Part One be adequate as an overall description of the program and a rough guide to problem requestors.

A detailed presentation of the content of SLOP-1 will be found in Part Two. Part Two includes the derivation of all basic equations and complete input and running instructions. The method of solution, outlined in Part One, is described more fully in Part Two.

II. GENERAL DESCRIPTION OF PROGRAM

SLOP-1 is a one-dimensional thermal multigroup program for the IBM-704. It is designed to compute the thermal flux level and energy spectrum, as a function of position in a heterogeneous array of diffusing media. The several different versions of SLOP-1 which are now in operation may be separated into two distinct classes. Of most general interest are the SLOP-1 programs which

compute the thermal flux due to a slowing-down source. In addition, however, modified SLOP-1 program tapes may be used to study pulsed neutron problems. Only the treatment of inhomogeneous problems (with specified slowing-down sources) will be elaborated in this report.

Various approximations to the transport equation are available in SLOP-1; the flexibility of the program and the degree of precision incorporated in it are functions of geometry. Again, for the sake of clarity, it seems desirable to confine discussion to the version of SLOP-1 which has been most extensively tested and used. This particular form of the program contains

- (a) a P_1 and double- P_1 treatment of slab problems and
- (b) a P_1 approximation for cylinders and spheres.

The major limitations of SLOP-1 are listed below:

- (a) isotropic slowing-down into the thermal group,
- (b) regionwise constant slowing-down,
- (c) no transverse buckling, and
- (d) only one moderating material in any problem.

A single set of transfer matrices is contained in every SLOP-1 library. These matrices are multiplied by the region dependent number density of the moderator (which is always denoted as "hydrogen"). Thus the moderating material may vary in density from one region to another, but the form of moderation must be the same in all regions. It follows, for example, that all regions must be at the same temperature.

Restrictions on numbers of points, regions and isotopes will be found in Part Two.

III. HEAVY ELEMENT TREATMENT

As indicated in section II, the moderating material in SLOP-1 is always taken to be hydrogen. In fact, the program was intended, primarily, for analysis of thermal neutron phenomena in water. For this reason, heavy element moderation was not considered important and was treated very crudely. Of course, it is not necessary that the moderating material should actually be hydrogen. With transfer matrices properly chosen, the program could be used to treat any mixture of which one moderating component is much lighter than all others. At present, however, all SLOP-1 libraries contain transfer matrices for hydrogen (bound or free), and only hydrogen moderation will be considered here.

The SLOP-1 treatment of heavy elements is the same in all geometries but, for simplicity, it will be described in the notation of slab geometry. In slab geometry, the transport equation takes the form:

$$\begin{aligned} \mu \frac{\partial}{\partial x} F(x, E, \mu) + \Sigma_T F(x, E, \mu) &= \frac{1}{2} S(x, E) \\ + \sum_{\ell} \frac{2\ell+1}{2} P_{\ell}(\mu) \int_0^{\infty} K_{\ell}(E' \rightarrow E) F_{\ell}(x, E') dE' & \quad (1.1) \end{aligned}$$

Here E is the neutron energy: the equation has already been averaged over the velocity distribution of scattering nucleons. Assume that, for the heavy elements, $K_{\ell}(E' \rightarrow E) \approx 0$ unless $E' = E$. Then

$$\int_0^{\infty} K_{Oh}(E' \rightarrow E) F_0(x, E') dE' \approx \Sigma_{sh} F_0(x, E)$$

$$\int_0^{\infty} K_{1h}(E' \rightarrow E) F_1(x, E') dE' \approx \bar{\mu}_h \Sigma_{sh} F_1(x, E) \quad (1.2)$$

The approximations implied by Eq. (1.2) above are made in all versions of SLOP-1. Further, the higher moments of the heavy element scattering kernels are set equal to zero:

$$\int_0^{\infty} K_{\ell h}(E' \rightarrow E) F_{\ell}(x, E') dE' \approx 0 \text{ for } \ell > 1. \quad (1.3)$$

It will be seen from Eq. (1.1) that the source is assumed to be isotropic. Assumptions relating to properties of the other physical parameters in Eq. (1.1) will be specified in the following sections.

IV. P₁ APPROXIMATION

In slab geometry with the indicated approximations for heavy elements, Eq. (1.1) leads directly to the P₁ equations

$$\frac{\partial F_1(x, E)}{\partial x} + \left[\Sigma_{ah} + \Sigma_{aH} + \Sigma_{SH} \right] F_0(x, E) = S(x, E)$$

$$+ N_H \int_0^{\infty} k_0(E' \rightarrow E) F_0(x, E') dE' \quad , \quad (1.4)$$

$$\frac{1}{3} \frac{\partial F_0(x, E)}{\partial x} + \left[\Sigma_{ah} + \Sigma_{aH} + \Sigma_{Sh}(1 - \bar{\mu}_h) + \Sigma_{SH} \right] F_1(x, E)$$

$$= N_H \int_0^{\infty} k_1(E' \rightarrow E) F_1(x, E') dE' \quad , \quad (1.5)$$

where:

- (a) F_0 and F_1 are the flux and current, respectively;
- (b) Σ_{ah} is the net absorption cross section of heavy elements;
- (c) Σ_{aH} is the absorption cross section of hydrogen;
- (d) Σ_{SH} is the scattering cross section of hydrogen;
- (e) S is an isotropic source distribution;
- (f) N_H is the number density of hydrogen;
- (g) k_0 and k_1 are the P_0 and P_1 components, respectively, of the hydrogen differential scattering cross section; and
- (h) $\bar{\mu}_h$ is the cosine of the scattering angle, averaged over all collisions with heavy elements.

Before proceeding, it is convenient to truncate the range of integration in the energy transfer integrals at some energy E^0 . To compensate, in part, for this truncation, isotropic slowing down into the range 0 to E^0 may be included in the source $S(x, E)$. Since no anisotropic sources are permitted in SLOP-1, anisotropic slowing down into the range 0 to E^0 must be ignored. On all presently available library tapes, it is assumed that there is no source into the thermal energy range aside from slowing down.

Upon introduction of any desired numerical integration scheme, Eq. (1.4) and (1.5) now take the form:

$$\frac{\partial F_1^m(x)}{\partial x} + \left[\Sigma_{ah}^m + \Sigma_{aH}^m + \Sigma_{SH}^m - N_H a_{H0}^{mm} \right] F_0^m(x) = S^m(x) + N_H \sum_{r \neq m} a_0^{m,r} F_0^r(x), \quad (1.6)$$

$$\frac{1}{3} \frac{\partial F_0^m(x)}{\partial x} + \left[\Sigma_{ah}^m + \Sigma_{SH}^m (1 - \bar{\mu}_h^m) + \Sigma_{SH}^m + \Sigma_{aH}^m - N_H a_{H1}^{mm} \right] F_1^m(x) = N_H \sum_{r \neq m} a_1^{m,r} F_1^r(x). \quad (1.7)$$

The proper interpretation of the quantities F_1^m and F_0^m depends on the nature of the numerical integration scheme. For example, these quantities could represent group average fluxes and currents. However, the formulation of the SLOP-1 edit routines requires, instead, that they be values of the flux and current at energy mesh points, and that all cross sections, Σ^m , be evaluated at these same mesh points.

Generalizing Eq. (1.6) and (1.7) to other one-dimensional geometries, one may write

$$\left[\frac{\partial}{\partial \rho} + \frac{G}{\rho} \right] F_1^m(\rho) + \alpha^m F_0^m(\rho) = s^m, \quad (1.8)$$

$$\frac{\partial}{\partial \rho} F_0^m(\rho) + \beta^m F_1^m(\rho) = t^m \quad \text{in the notation of} \quad (1.9)$$

the PLMG report (Ref. 1).

V. DOUBLE- P_1 APPROXIMATION

The SLOP-1 double- P_1 equations can be derived from Eqs. (22) through (25) of the SIMPL report (Ref. 2), modified to include anisotropic sources. One finds that

$$\frac{\partial F_1^m}{\partial x} + \Sigma_0^m F_0^m = S^m + S_{OH}^m \quad (1.10)$$

$$\frac{1}{3} \frac{\partial F_0^m}{\partial x} + \frac{2}{3} \frac{\partial f_2^m}{\partial x} + \Sigma_1^m F_1^m = S_{1H}^m \quad (1.11)$$

$$\frac{2}{5} \frac{\partial F_1^m}{\partial x} + \frac{8}{15} \frac{\partial f_3^m}{\partial x} + \Sigma_2^m f_2^m = S_{2H}^m, \text{ and} \quad (1.12)$$

$$\frac{1}{3} \frac{\partial f_2^m}{\partial x} + \Sigma_3^m f_3^m = \frac{7}{8} S_{3H}^m, \quad (1.13)$$

where

$$\Sigma_0^m \equiv \Sigma_{ah}^m + \Sigma_{aH}^m + \Sigma_{SH}^m, \quad (1.14)$$

$$\Sigma_T^m \equiv \Sigma_0^m + \Sigma_{Sh}^m, \quad (1.15)$$

$$\Sigma_1^m \equiv \Sigma_T^m - \bar{\mu}_h^m \Sigma_{Sh}^m, \quad (1.16)$$

$$\Sigma_2^m \equiv \frac{16}{15} \Sigma_T^m, \quad (1.17)$$

$$\Sigma_3^m \equiv 2 \Sigma_T^m, \text{ and} \quad (1.18)$$

$$\begin{aligned} S_{\ell H}^m &\equiv N_H \sum_r a_{\ell}^{m,r} F_{\ell}^r \text{ for } \ell = 0,1 \\ &\equiv N_H \sum_r a_{\ell}^{m,r} f_{\ell}^r \text{ for } \ell = 2,3. \end{aligned} \quad (1.19)$$

Following the substitutions

$$\varphi_0^m \equiv F_0^m + 2 f_2^m,$$

$$\varphi_2^m \equiv F_2^m, \quad (1.20)$$

Equations (1.10) through (1.13) become

$$\frac{\partial F_1^m}{\partial x} + \Sigma_0^m \varphi_0^m = 2 \Sigma_0^m \varphi_2^m + S^m + S_{OH}^m \quad (1.21)$$

$$\frac{\partial \varphi_0^m}{\partial x} + 3 \Sigma_1^m F_1^m = 3 S_{1H}^m \quad (1.22)$$

$$\frac{\partial f_3^m}{\partial x} + \left(\frac{7}{2} \Sigma_T^m - \frac{3}{2} \Sigma_{UH}^m \right) \varphi_2^m = \frac{3}{4} \Sigma_U^m \varphi_U^m - \frac{3}{4} S^m - \frac{3}{4} S_{OH}^m + \frac{15}{8} S_{2H}^m \quad (1.23)$$

$$\frac{\partial \varphi_2^m}{\partial x} + 6 \Sigma_T^m f_3^m = \frac{21}{8} S_{3H}^m \quad (1.24)$$

To facilitate the iterative solution of Eq. (1.21) through (1.24), diagonal terms in S_{KH}^m will be transferred to the right hand side wherever possible. Thus

$$\frac{\partial F_1^m}{\partial x} + (\Sigma_0^m - N_H a_{00}^{mm}) \varphi_0^m = 2(\Sigma_0^m - N_H a_{00}^{mm}) \varphi_2^m + S^m + S_{OH}^m \quad (1.25)$$

$$\frac{\partial \varphi_0^m}{\partial x} + 3(\Sigma_1^m - N_H a_{11}^{m,m}) F_1^m = 3 S_{1H}^m \quad (1.26)$$

$$\begin{aligned} \frac{\partial f_3^m}{\partial x} + \left(\frac{7}{2} \Sigma_0^m + 2 \Sigma_{Sh}^m - \frac{15}{8} N_H a_{22}^{m,m} - \frac{3}{2} N_H a_{00}^{m,m} \right) \varphi_2^m \\ = \frac{3}{4} (\Sigma_0^m - N_H a_{00}^{m,m}) \varphi_0^m - \frac{3}{4} S^m + \frac{15}{8} S_{2H}^m - \frac{3}{4} S_{OH}^m \end{aligned} \quad (1.27)$$

$$\frac{\partial \phi_2^m}{\partial x} + (6 \Sigma_0^m + 6 \Sigma_{Sh}^m - \frac{21}{8} N_H a_3^{m,m}) F_3^m = \frac{21}{8} S_{3H}^m, \quad (1.28)$$

where

$$\begin{aligned} S_{\ell H}^m &= N_H \sum_{r \neq m} a_{\ell}^{m,r} F_{\ell}^r, \quad \ell = 0, 1 \\ &= N_H \sum_{r \neq m} a_{\ell}^{m,r} f_{\ell}^r, \quad \ell = 2, 3. \end{aligned} \quad (1.29)$$

Again, it is convenient to introduce the notation of PLMG (Ref. 1):

$$\frac{\partial F_1^m}{\partial x} + \alpha_0^m \phi_0^m = s_0^m \quad (1.30)$$

$$\frac{\partial \phi_0^m}{\partial x} + \beta_0^m F_1^m = t_0^m \quad (1.31)$$

$$\frac{\partial f_2^m}{\partial x} + \alpha_2^m \phi_2^m = s_2^m \quad (1.32)$$

$$\frac{\partial \phi_2^m}{\partial x} + \beta_2^m f_3^m = t_2^m. \quad (1.33)$$

In order to simplify programming, Eqs. (1.30) through (1.33) will be written in a form more similar to that of the P_1 approximation,

$$\left(\frac{\partial}{\partial \rho} + \frac{G}{\rho} \right) F_1^m + \alpha_0^m \phi_0^m = s_0^m \quad (1.34)$$

$$\frac{\partial \phi_0^m}{\partial \rho} + \beta_0^m F_1^m = t_0^m \quad (1.35)$$

$$\left(\frac{\partial}{\partial \rho} + \frac{G}{\rho} \right) f_3^m + \alpha_2^m \phi_2^m = s_2^m \quad (1.36)$$

$$\frac{\partial \phi_2^m}{\partial \rho} + \beta_2^m f_3^m = t_2^m \quad (1.37)$$

These are the basic SLOP-1 equations. Of course, when $G = 0$ Eqs. (1.34) through (1.37) are identical with the four equations which precede them. It is not clear, at this time, whether the use of other G values is meaningful. This question is now being examined.

VI. LIBRARY

Several SLOP-1 libraries may be stored on each program tape, along with the routines for solving multigroup equations. Most of the physical content is injected into the computations through the choice of library constants. The library contains heavy element cross sections, hydrogen cross sections and hydrogen transfer matrices. Two types of data are supplied separately when the tape is constructed. Heavy element cross sections and hydrogen absorption cross sections are punched onto cards manually. Hydrogen scattering data are computed by an auxiliary program [e.g., the ECESS program (Ref. 3)] which writes an output tape in a prescribed format. These data are then transferred automatically to the SLOP-1 program tape.

One class of program tapes has been released for general use. The distributed tapes contain 36-group libraries for moderator temperatures of 21 and 273 degrees centigrade. Since the differential scattering cross section of the

water molecule is not known at this time, many as yet unevaluated assumptions find their way into a SLOP-1 library, and these should be clearly stated.

Most Bettis tapes, as well as those released externally, incorporate the "Radkowsky" treatment of scattering by protons bound in water. The resulting transfer matrices cannot be described simply without reference to the ECESS program. ECESS was developed at Bettis by W. W. Clendenin and programmed by G. R. Culpepper for the IBM-704. It computes P_0 through P_3 transfer matrices for a free particle of any mass at any temperature, by the procedure outlined below.

Consider the integral

$$S_{\ell}^m = N_H \int_0^{E^0} k_{\ell}(E' \rightarrow E) F_{\ell}(E', \rho) dE' \quad (1.38)$$

Introduce, in the interval from 0 to E^0 , M energy mesh points E^m , $1 \leq m \leq M$. Assume that the integrand in Eq. (1.38) is linear in each subinterval and that $F_{\ell}(E, \rho)$ behaves like $1/E$ in the first subinterval $E^0 < E < E^1$. These assumptions lead to the approximation

$$S_{\ell}^m = N_H \int_0^{E^0} k_{\ell}(E' \rightarrow E^m) F_{\ell}(E', \rho) dE' \approx N_H \sum_{r=1}^M a_{\ell}^{m,r} F_{\ell}^r(\rho) \quad (1.39)$$

and define the transfer matrix $a_{\ell}^{m,r}$.

On the Bettis production tapes, $E^1 = .648$ ev, $E^0 = .64801$ ev. Having chosen E^0 close to E^1 , it can be shown that there will be an accurate balance between neutron loss and production rates, provided that both are computed by trapezoidal integration. When a SLOP-1 problem has converged satisfactorily,

loss and production rates should agree to within about three parts in 10,000.

Neutron balance may usually be checked with the aid of information provided by the edits.

In constructing the "Radkowsky" kernel, the P_0 matrix and the hydrogen scattering cross section are taken directly from ECESS output for a free proton. The P_1 matrix is assumed to be diagonal, with diagonal elements chosen so that Σ_{tr}^m is the same as the SOFOCATE Σ_{tr}^m (Ref. 4) at all energies E^m . Heavy element cross sections are also taken directly from SOFOCATE. P_2 and P_3 matrices are set equal to zero.

In addition to the transfer matrices, ECESS computes a slowing down spectrum resulting from collisions between neutrons (with $E > E_0$) and free particles in thermal motion. This spectrum function, $X(E)$, is independent of the epithermal flux distribution if the scatterer has mass one. It is then an error function, normalized to one at $E = \infty$. For other masses, the computation of $X(E)$ is based on the assumption that the epithermal flux has a $1/E$ spectrum. Present SLOP-1 library tapes use the mass one $X(E)$, and the source function is written in the form

$$S(\rho, E) = S(\rho) X(E) \quad , \quad (1.40)$$

$$X(E) = \operatorname{erf} \left(\sqrt{\frac{E}{kT}} \right) \quad .$$

The total production rate is then

$$\int S(\rho) dV_p \int_0^{E_0} X(E) dE \approx E_0 \left(1 - \frac{kT}{2E_0} \right) \int S(\rho) dV_p \quad ,$$

where dV_p is a geometry dependent volume element.

Several other hydrogen kernels are being used experimentally at Bettis. It must be understood that the program itself is in no way tied to any kernel and that the kernel may be modified at will.

VII. METHOD OF SOLUTION

Difference equations are derived from Eq. (1.34) through (1.37) by essentially the same method as is used in PLMG. Equations (1.34) and (1.36) are multiplied by ρ^G and integrated from the midpoint of one mesh interval to the midpoint of the next. Equations (1.35) and (1.37) are written, in central difference form, at interval midpoints. Finally F_1^m and f_3^m are eliminated, leaving two coupled second order difference equations in ϕ_0^m and ϕ_2^m . These equations, which will be further discussed in Part Two, are simply difference approximations to the differential equations:

$$-\nabla \cdot D_0^m \nabla \phi_0^m + \alpha_0^m \phi_0^m = s_0^m - \left[\frac{\partial}{\partial \rho} + \frac{G}{\rho} \right] D_0^m t_0^m, \quad (1.41)$$

$$-\nabla \cdot D_2^m \nabla \phi_2^m + \alpha_2^m \phi_2^m = s_2^m - \left[\frac{\partial}{\partial \rho} + \frac{G}{\rho} \right] D_2^m t_2^m. \quad (1.42)$$

Here

$$D_0^m = 1/\beta_0^m, \quad D_2^m = 1/\beta_2^m. \quad (1.43)$$

Note that if the ϕ_2^m are set equal to zero and Eq. (1.42) are deleted, the P_1 equations result. This is the basis of the P_1 , or "Gear One", mode of operation.

In all, three different modes of operation ("Gears") are available in SLOP-1. These gears are controlled through input specifications; they may be used in many different ways. If only a P_1 solution is desired, the computation is terminated after convergence in Gear One. If a double- P_1 solution is felt to be necessary, computation may be started in Gears One, Two or Three, but should be terminated only after convergence in Gear Three. It is probably most efficient to start a double- P_1 calculation in Gear One, converging coarsely in that gear, more finely in Gear Two, and attaining the most stringent convergence criterion in Gear Three. In describing the operation of the three gears, it will be assumed that this recommendation is being followed.

A. Gear One

In Gear One, Eq. (1.8) and (1.9) which couple all fluxes and currents, are solved iteratively. Starting values of $F_0^m(\rho)$ and $F_1^m(\rho)$ may be taken directly from the output tape of another SLOP-1 problem. Otherwise $F_1^m(\rho)$ is set equal to zero, while $F_0^m(\rho)$ is constructed from input flux and spectrum guesses. If starting values are not taken from tape, the problem requestor must supply guessed values of the thermal flux $\left[\text{i.e. } \int_0^{E^1} F_0(\rho, E) dE \right]$ at all mesh points, and normalized spectrum functions in all regions. The zeroth iterate of $F_0^m(\rho)$ is then the product of the pointwise flux and regionwise spectrum guesses. It has proven most convenient to use the Maxwellian spectrum guess stored in the program tape, and a flux guess which comes from a one-group WANDA (Ref. 5) problem. Flux guess cards in the required form are punched after termination of a one-group WANDA calculation, at the option of the problem requestor. If

a WANDA flux guess is to be used in a SLOP-1 problem, then the WANDA and SLOP-1 sources should be equivalent. In a one group WANDA problem, the source represents an integral over the thermal range:

$$S(x)_W = \int_0^{E^0} S(E,x) dE . \quad \text{In SLOP-1,}$$

$$S(E,x) = S(x)_{\text{SLOP-1}} \cdot \chi(E) .$$

Corresponding WANDA and SLOP-1 sources must, then, be normalized according to the following prescription:

$$\begin{aligned} S(x)_W &= S(x)_{\text{SLOP-1}} \cdot \int_0^{E^0} \chi(E) dE \\ &\approx E_0 \left(1 - \frac{kT}{2E_0} \right) S(x)_{\text{SLOP-1}} . \end{aligned} \quad (1.44)$$

Having determined starting values for $F_0^m(\rho)$ and $F_1^m(\rho)$, and having assumed that $\phi_2^m = 0$, it is possible to construct the functions s_0^1 and t_0^1 of Eqs. (1.34) and (1.35). The equations for F_0^1 and F_1^1 are then solved directly (i.e., non-iteratively) as in PLMG-2, yielding first iterates, $F_0^{1(1)}$ and $F_1^{1(1)}$, of the flux and current. In subsequent calculations at energies $E^2, E^3, \dots, E^m$, most recently computed fluxes are used in downscattering integrals, and guesses are used in upscattering integrals.

After a complete sweep of the energy mesh the absorption rate $I^{(1)}(\rho_n) \equiv I_n^{(1)}$ is computed at all spatial mesh points, from the definition

$$I_n^{(1)} \equiv \int_0^{E^1} \Sigma_a(E) F_{On}^{(1)}(E) dE. \quad \text{Similarly} \quad (1.45)$$

$$I_n^{(0)} \equiv \int_0^{E^1} \Sigma_a(E) F_{On}^{(0)}(E) dE. \quad \text{The absorption} \quad (1.46)$$

are then used to form $g_n^{(1)}$, where

$$g_n^{(1)} = I_n^{(1)} / I_n^{(0)}. \quad \text{If} \quad (1.47)$$

$$\left| 1 - \epsilon_1 \right| \leq g_n^{(1)} \leq \left| 1 + \epsilon_1 \right| \quad \text{for all } n, \quad (1.48)$$

computation in Gear One terminates. Otherwise the energy mesh is swept again and again until

$$\left| 1 - \epsilon_1 \right| \leq g_n^{(t)} \leq \left| 1 + \epsilon_1 \right|, \quad \text{where} \quad (1.49)$$

$$g_n^{(t)} \equiv I_n^{(t)} / I_n^{(t-1)} \quad (1.50)$$

The convergence parameter, ϵ_1 , is specified by the problem requestor. After Eq. (1.45) is satisfied, the computation either terminates, or switches into Gear Two.

Extrapolation is used as in PLMG-2, being delayed, as in PLMG-2, until the formation of source terms for the third iteration.

B. Gear Two

The use of Gear Two is appropriate after the scattering source has partially converged, so that a rough computation of transport corrections is possible but an accurate computation is not.

On entering Gear Two, guessed values of F_0^m and F_1^m are taken from the last Gear One results. Guesses for f_2^m and f_3^m are not available, and are set to zero. SLOP-1 then solves Eqs. (1.41) and (1.42) for $m = 1$, re-solves Eq. (1.41), constructs all flux moments and proceeds to energy E^2 . The same iterative process is repeated at all energies. All computed moments are stored, and convergence is tested as in Gear One. Here, however, the convergence parameter ϵ_2 is used in place of ϵ_1 . If convergence is not satisfactory, the sweep of the energy mesh (or "outer cycle") is repeated until the convergence criterion is met. As in Gear One, latest information is used throughout the Gear Two iterative process. Successive iterates are extrapolated as in Gear One. All moments are extrapolated after completion of an outer cycle.

C. Gear Three

Converged flux moments from Gear Two are used as guesses in Gear Three. For $m = 1$ Eqs. (1.41) and (1.42) are solved by a second, "inner" iterative process. This process is continued until the scalar flux, F_0^1 , meets the same convergence criterion as in FLIP (Ref. 6). The convergence parameter for the inner cycle is entered on the SLOP-1 input form as " δ ". In the same manner, the double- P_1 equations are solved successively for all m values. Convergence of the outer

cycle is tested as in Gears One and Two, using the convergence parameters ϵ_3 . It has been the general practice at Bettis to set $\delta = \epsilon_3$.

Gear Three is a device intended to insure the accuracy of the final solution. If convergence parameters have been properly chosen, only two or three outer cycles should be necessary in Gear Three, and only one or two inner cycles should suffice to solve each pair of double- P_1 equations.

VIII. BOUNDARY CONDITIONS

A. P_1 Approximation

If only a P_1 approximation is requested, boundary conditions are applied exactly as in PLMG. At each boundary, $F_1^m = C_0^m F_0^m$. Left and right hand values of C_0^m are required for all m . If the boundary conditions are energy independent at either boundary then, at that boundary, only one C_0 need be entered. Boundary conditions are imposed, numerically, as in PLMG.

B. Double- P_1 Approximation

Double- P_1 boundary conditions are sufficiently general so as to permit the use of blackness theory. At a left hand boundary, it is postulated that

$$\psi_0^m = c_{00}^m \chi_0^m + c_{01}^m \chi_1^m, \quad (1.49)$$

$$\psi_1^m = c_{10}^m \chi_0^m + c_{11}^m \chi_1^m. \quad (1.50)$$

Here the ψ 's and χ 's are right and left half-range moments, respectively. At a cell boundary,

$$c_{00}^m = 1, c_{01}^m = 0, c_{10}^m = 0, c_{11}^m = -1. \quad (1.51)$$

If the entering flux vanishes,

$$c_{00}^m = c_{01}^m = c_{10}^m = c_{11}^m = 0. \quad (1.52)$$

If the flux is antisymmetric about $X = 0$, then

$$c_{00}^m = -1, c_{01}^m = 0, c_{10}^m = 0, c_{11}^m = 1. \quad (1.53)$$

Other C values may be used to represent a grey foil at the left hand boundary of a cell.

Before they can be incorporated in SLOP-1, Eqs. (1.49) and (1.50) must be transformed into relations between φ_0^m and φ_2^m . This is done through the substitutions

$$F_0^m = \psi_0^m + \chi_0^m = \varphi_0^m - 2\varphi_2^m, \quad (1.54)$$

$$F_2^m = \frac{3}{4}(\psi_1^m - \chi_1^m) = \varphi_2^m \quad (1.55)$$

$$F_1^m = -D_0^m \frac{\partial \varphi_0^m}{\partial x}, \quad \text{and} \quad (1.56)$$

$$f_3^m \equiv -D_2^m \frac{\partial \phi_2^m}{\partial x}, \text{ which lead to the equations (1.57)}$$

$$-D_0^{m,m'} = (C_{L,R})_{1,0}^m \phi_0^m + (C_{L,R})_{1,2}^m \phi_2^m, \text{ and (1.58)}$$

$$-D_2^{m,m'} = (C_{L,R})_{3,0}^m \phi_0^m + (C_{L,R})_{3,2}^m \phi_2^m. \quad (1.59)$$

Definitions of the coefficients $C_{L,R}$ will be found in Part Two. Equations (1.58) and (1.59) are differenced precisely as in FLIP.

In treating right hand boundary conditions, it is not necessary to modify the preceding derivation. One need only determine the input C's and the $(C_{L,R})$'s as for a left hand boundary, and then reverse the signs of the $(C_{L,R})$'s.

In summary, $C_{00}^m, C_{01}^m, C_{10}^m$ and C_{11}^m are required as input, for all m. If boundary conditions are energy independent at either boundary then, at that boundary, only one set of four C values need be entered. The C values for a right hand boundary are determined as if it were a left hand boundary. Thus the conditions (1.51), (1.52) and (1.53) may be used at either boundary.

IX. EDITS

A detailed description of SLOP-1 edits will be found in Part Two. This section contains only a summary of classes of information edited. All the indicated integrals are evaluated by the trapezoidal rule.

A. One-Group Edits

1. Flux Components

The net thermal flux may be computed and printed at every spatial mesh point. The thermal group is cut off at energy E^1 , so that

$$F_{On} \equiv \int_0^1 F_{On}(E) dE . \quad (1.60)$$

In addition, the second moment, f_{2n} , is also printed out, where

$$f_{2n} \equiv \int_0^1 f_{2n}(E) dE .$$

2. Cross Sections

Various cross section averages are computed at all mesh points, from the definition

$$\Sigma_n = \int_0^1 \Sigma_n(E) F_{On}(E) dE / F_{On} . \quad (1.61)$$

Macroscopic cross sections are edited for each element present at a given mesh point, and the sum over all elements is printed out in addition.

Unlike other Σ 's, the total cross section is averaged over $F_2(E)$:

$$\Sigma_{Tn} = \int_0^1 \left[\Sigma_{ah}(E) + \Sigma_{aH}(E) + \Sigma_{Sh}(E) + \Sigma_{SH}(E) \right] f_{2n}(E) dE / f_{2n} . \quad (1.62)$$

This quantity is useful in one-group P_3 and double- P_1 calculations.

3. Diffusion Parameters

Two spatially dependent parameters are calculated at the midpoints of all mesh intervals:

$$D_{0(n+1/2)} = - h_n \int_0^{E^1} F_{1(n+1/2)}(E) dE / [\Phi_{0(n+1)} - \Phi_{0n}] , \text{ and } (1.63)$$

$$D_{2(n+1/2)} = - h_n \int_0^{E^1} f_{3(n+1/2)}(E) dE / [\Phi_{2(n+1)} - \Phi_{2n}] . (1.64)$$

Here

$$\Phi_n = \int_0^{E^1} \varphi_n(E) dE , \text{ the } \varphi_n(E) \text{'s being } (1.65)$$

defined by Eqs. (1.54) and (1.55). With the aid of the edited D 's and flux components, one may compute the odd moments of the total thermal flux,

$$F_{1(n+1/2)} = - h_n D_{0(n+1/2)} [\Phi_{0(n+1)} - \Phi_{0n}] \text{ and } (1.66)$$

$$f_{3(n+1/2)} = - h_n D_{2(n+1/2)} [\Phi_{2(n+1)} - \Phi_{2n}] ; \text{ the } (1.67)$$

current is edited explicitly, but f_3 is not.

A Maxwell average diffusion constant appears to have some value in one-group thermal calculations. Unlike D_0 and D_2 above, this Maxwellian diffusion coefficient is computed at mesh points, from the definition

$$D_{Mn} \equiv \int_0^{E^1} \left[\frac{1}{3\Sigma_{tr}(E)} \right] \varphi_M(E) dE / \int_0^{E^1} \varphi_M(E) dE . (1.68)$$

A very simply expression is used for the calculation of Σ_{tr} in Eq. (1.67), namely:

$$\Sigma_{tr}(E^m) \equiv \left[\Sigma_{SH}^m - N_H \alpha_1^{mm} + \Sigma_{Sh}^m (1 - \mu_h^m) + \Sigma_{aH}^m + \Sigma_{ah}^m \right] . (1.69)$$

It should be noted that this definition is useful only if the a_1 matrix is diagonal, i.e., only for Selengut-Goertzel scattering kernels.

B. Few-Group Edits^{*}

These edits are designed to supply all parameters needed for few-group P_1 , P_3 or double- P_1 thermal neutron calculations. When few-group edits are desired, the problem requestor must specify values of m for those energies, E^m , which have been selected as cut-points separating groups. Let the upper and lower energy cut-points of group K be designated $E^{u(K)}$ and $E^{l(K)}$. Then, for example,

$$F_{On}^{(K)} \equiv \int_{E^{l(K)}}^{E^{u(K)}} F_{On}(E) dE \quad (1.70)$$

for all the groups comprising the thermal energy range. In a similar manner, the other integrals in section A may be evaluated over subintervals to provide few-group parameters in place of one-group parameters.

This subdivision of the range of integration does not, in itself, yield all the necessary few-group parameters. Few-group calculations require transfer matrices which have no one-group analogues. It will be seen that the effect of P_1 and P_3 energy transfer are automatically incorporated into D_0 and D_2 , as in MUFT (Ref. 7). Isotropic and P_2 transfer matrices, on the other hand, must be inserted explicitly into the few-group thermal codes used at Bettis. For work with the Radkowsky kernel, it is sufficient to compute and edit a few-group P_0 transfer matrix, defined through the relation:

^{*}Few-group edits have been formulated in collaboration with M. Goldsmith.

$$a_{On}^{KL} \equiv \frac{\int_{E_L(K)}^{E_U(K)} dE \int_{E_L(L)}^{E_U(L)} k_O(E' \rightarrow E) F_{On}(E') dE'}{\int_{E_L(L)}^{E_U(L)} F_{On}(E) dE} \quad (1.71)$$

The integral in Eq. (1.71) is evaluated by the trapezoidal rule and it is assumed, further, that the integration in Eq. (1.39) is also trapezoidal. It is then possible to derive a simple relation between few-group and multigroup transfer matrices.

One other essential piece of information appears in the few-group edit, and not in the one-group edit, namely the source spectrum:

$$\chi^{(K)} \equiv \int_{E_L(K)}^{E_U(K)} \chi(E) dE$$

C. Multigroup Edits

At the requestor's option, SLOP-1 prints F_{On}^m , f_{2n}^m , $F_{1(n+1/2)}^m$ and $F_{3(n+1/2)}^m$ for all n and selection m values. The simplest multigroup edit prints F_0 only. More detailed edits print: F_0 and F_1 ; F_0 , F_1 and f_1 ; F_0 , F_1 , f_2 and f_3 .

PART TWO: DESCRIPTION OF THE COMPUTER PROGRAM

Part Two will be primarily concerned with the description of the procedures involved in running a SLOP-1 problem on the IBM-704. For the benefit of the users who may have some desire to delve into the instruction-by-instruction programming it may be useful to have a list of the actual equations and formulas which are incorporated in this program. Therefore, the first section of Part Two will cover these equations. Section II will describe the manner in which recommended input forms for SLOP-1 should be filled out in order to insure that the problem be correctly specified. Section III is for the personnel who will be punching the input cards and arranging the data deck. Section IV is intended to be the console operator's manual for running the problems. Finally, Section V will aid the problem requestor in interpreting the results and edits which are produced by the program.

I. EQUATIONS OF THE PROGRAM

Part Two, Section VII, contains an outline of the method of solution of the system of equations, Eqs. (1.34) through (1.37). If the method of solution of PLMG-2 Eqs. (1.24) and (1.34) (Ref. 1) is applied to the pair of Eqs. (1.34) and (1.35) of Part One of this report, a three-point equation in the variable $(F_0)^m$ will be obtained for each multigroup m at every mesh point n such that

$$\begin{aligned}
& - \frac{1}{(\beta_1)_{n+}^m} \frac{(\rho_{n+1/2})^G}{h_{n+}} \left[(F_0)_{n+1} - (F_0)_n \right]^m - \frac{1}{(\beta_1)_{n-}^m} \frac{(\rho_{n-1/2})^G}{h_{n-}} \left[(F_0)_n - (F_0)_{n-1} \right]^m \\
& + \frac{1}{2} (\rho_n)^G \left[(\alpha_1)_{n+}^m h_{n+} + (\alpha_1)_{n-}^m h_{n-} \right] (F_0)_n^m = \frac{1}{2} (\rho_n)^G \left[(s_1)_{n+}^m h_{n+} + (s_1)_{n-}^m h_{n-} \right] \\
& - \left[(\rho_{n+1/2})^G \left(\frac{t_{n+1/2}}{(\beta_1)_{n+}} \right)^m - (\rho_{n-1/2})^G \left(\frac{t_{n-1/2}}{(\beta_1)_{n-}} \right)^m \right], \quad (2.1)
\end{aligned}$$

where the "+" and "-" in the subscripts indicate "to the right" and "to the left", respectively.

Here

$$(\alpha_1)_{n+}^m = \left[(\Sigma_T)_{n+}^m - (N_H)_{n+} (a_0)^{m,m} \right] \quad (2.2)$$

$$(\beta_1)_{n+}^m = 3 \left[(\Sigma_T)_{n+}^m - (N_H)_{n+} (a_1)^{m,m} + (1 - \bar{\mu})_{n+}^m (\Sigma_{S_h})_{n+}^m \right] \quad (2.3)$$

$$(s_1)_{n+}^m = 2(\alpha_1)_{n+}^m (F_2)_n^m + (N_H)_{n+} \sum_{r \neq m} (a_0)^{r,m} (F_0)_n^r + I^m(z) S_{n+} \quad (2.4)$$

and

$$(t_1)_{n+1/2}^m = 3(N_H)_{n+} \sum_{r \neq m} (a_1)^{r,m} (F_1)_{n+1/2}^r \quad (2.5)$$

where the parameters have the same meanings as in Part One.

An equation in $(f_2)^m$ similar to Eq. (2.1) can be obtained for the pair of equations, Eqs. (1.36) and (1.37), in terms of $(\alpha_2)^m$, $(\beta_2)^m$, $(s_2)^m$ and $(t_2)^m$ where these four quantities are computed from the equations

$$(\alpha_2)_{n+}^m = \frac{1}{2} \left[(\Sigma_T)_{n+}^m + (\Sigma_{S_h})_{n+}^m \right] - \frac{3}{2} (N_H)_{n+} (a_0)^{m,m} - \frac{15}{8} (N_H)_{n+} (a_2)^{m,m} \quad (2.6)$$

$$(\beta_2)_{n+}^m = 6 \left[(\Sigma_T)_{n+}^m + (\Sigma_{S_h})_{n+}^m \right] - \frac{21}{8} (N_H)_{n+} (a_3)^{m,m} \quad (2.7)$$

$$\begin{aligned} (s_2)_{n+}^m = \frac{15}{8} (N_H)_{n+}^m \sum_{r \neq m} \left[(a_2)^{r,m} (F_2)_n^r - \frac{2}{5} (a_0)^{r,m} (F_0)_n^r \right] \\ + \frac{3}{4} (\alpha_1)_{n+}^m (\varphi_2)_n^m - \frac{3}{4} I^m(z) s_{n+} \end{aligned} \quad (2.8)$$

and

$$(t_2)_{n+}^m = \frac{21}{8} (N_H) \sum_{r \neq m} (a_3)^{r,m} (f_3)^r \quad (2.9)$$

The boundary conditions imposed in the program for the left end (L) and the right end (R) are

$$(F_1)^m = (C_{L,R})_{1,0}^m \varphi_0^m + (C_{L,R})_{1,2}^m \varphi_2^m \quad (2.10a)$$

and

$$(f_3)^m = (C_{L,R})_{3,0}^m \varphi_N^m + (C_{L,R})_{3,2}^m \varphi_2^m \quad (2.10b)$$

The program uses a scheme for computing $(\varphi_0)_n^m$ and $(\varphi_2)_n^m$ which is the same as that used in PLMG-2. Using the PLMG-2 notation the boundary condition parameters in the recursion formulas at point zero are

P₁

$$(a_1)_1^m = \frac{(\alpha_1)_{0+}^m (\beta_1)_{0+}^m h_+^2}{2(1+G)} + 1 - (C_L)_{1,0}^m (\beta_1)_{0+}^m h_+ \quad (2.11a)$$

$$(b_1)_0^m = \frac{(\beta_1)_{0+}^m (\beta_1)_{0+}^m h_+^2}{2(1+G)} + (C_L)_{1,2}^m (\varphi_2)_0^m (\beta_1)_{0+}^m h_+ - h_+ t_{1/2}^m \quad (2.11b)$$

and DP₁

$$(a_2)_1^m = \frac{(\alpha_2)_{0+}^m (\beta_2)_{0+}^m h_+^2}{2} + 1 - (C_L)_{3,2}^m (\beta_2)_{0+}^m h_+ \quad (2.12a)$$

$$(b_2)_0^m = \frac{(\beta_2)_{0+}^m (\beta_2)_{0+}^m h_+^2}{2} + (C_L)_{3,0}^m (\varphi_2)_0^m (\beta_2)_{0+}^m h_+ - h_+ (t_2)_{1/2}^m \quad (2.12b)$$

At the right boundary

$$(\varphi_0)_N^m = \frac{\left(\frac{\rho_N - \frac{h_-}{2}}{\rho_N} \right)^G \left[h_- (t_1)_{N-1/2}^m + \frac{(b_1)_{N-1}^m}{(a_1)_N^m} \right] + \frac{(\beta_1)_{N-}^m (\beta_1)_{N-}^m h_-^2}{2} - (\beta_1)_{N-}^m (C_R)_{1,2}^m (\varphi_2)_{N-}^m h_-}{(C_R)_{1,0}^m (\beta_1)_{N-}^m h_- + \frac{(\alpha_1)_{N-}^m (\beta_1)_{N-}^m h_-^2}{2} + \left[1 - \frac{1}{(a_1)_N^m} \right] \left(\frac{\rho_N - \frac{h_-}{2}}{\rho_N} \right)^G} \quad (2.13)$$

(2.13)
and DP₁

$$(\varphi_2)_N^m = \frac{h_- (t_2)_{N-1/2}^m + \frac{(b_2)_{N-1}^m}{(a_2)_N^m} + \frac{(\beta_2)_{N-1}^m (\beta_2)_{N-1}^m h_-^2}{2} - (\beta_2)_{N-}^m (C_R)_{3,0}^m h_- (\varphi_0)_N^m}{(C_R)_{3,2}^m (\beta_2)_{N-}^m h_- + \frac{(\alpha_2)_{N-}^m (\beta_2)_{N-}^m h_-^2}{2} - \frac{1}{(a_2)_N^m} + 1} \quad (2.14)$$

The quantities $(c_{L,R})_{1,0}, (c_{L,R})_{1,2}$, etc., are not input to the program in the DPl problems; instead, quantities $c_{0,0}, c_{0,1}, c_{1,0}$ and $c_{1,1}$ are input. These latter four numbers are the coefficients of FLIP-type DPl boundary conditions (Ref. 6)

$$(\psi_0)^m = (c_{0,0})^m (\chi_0)^m + (c_{0,1})^m (\chi_1)^m \quad (2.15a)$$

$$(\psi_1)^m = (c_{1,0})^m (\chi_0)^m + (c_{1,1})^m (\chi_1)^m \quad (2.15b)$$

The DPl boundary conditions required by the program are computed for the left boundary as

$$(c_L)_{1,0} = \frac{1}{2} \left[U(c_{0,0} + c_{1,0} - 1) + W(c_{0,1} + c_{1,1} + 1) \right] \quad (2.16a)$$

$$(c_L)_{1,2} = \frac{1}{2} \left[(V - 2U)(c_{0,0} + c_{1,0} - 1) + (X - 2W)(c_{0,1} + c_{1,1} + 1) \right] \quad (2.16b)$$

$$(c_L)_{3,0} = \frac{1}{8} \left[U(1 - c_{0,0} + 3c_{1,0}) + W(3 - c_{0,1} + 3c_{1,1}) \right] \quad (2.16c)$$

$$(c_L)_{3,2} = \frac{1}{8} \left[(V - 2U)(1 - c_{0,0} + 3c_{1,0}) + (X - 2W)(3 - c_{0,1} + 3c_{1,1}) \right] \quad (2.16d)$$

where

$$U = \frac{(c_{1,1} - 1)}{\Delta} \quad (2.17a)$$

$$V = \frac{-c_{0,1}}{\frac{3}{4}\Delta} \quad (2.17b)$$

$$W = \frac{-C_{1,0}}{\Delta} \quad (2.17c)$$

$$X = \frac{(C_{0,0} + 1)}{\frac{3}{4} \Delta} \quad (2.17d)$$

and

$$\Delta = (C_{0,0} + 1)(C_{1,1} - 1) - C_{1,0}C_{0,1} \quad (2.17e)$$

At the right boundary Eqs. (2.16) and (2.17) are used with the sign of the resultant coefficients being reversed after computing them.

The system of simultaneous equations of Eq. (2.1) with its boundary conditions is solved by the same method as used in PLMG-2.

II. PREPARATION OF INPUT FORMS

A. Format of Numbers

In the description of each of the input quantities, the portion of the input form (see Appendix A) has been duplicated immediately preceding the paragraph describing its function. The piece of data will be designated as either fixed or floating point using the abbreviations fx and fl, respectively. A fixed point number is an integer. A floating point number is a fraction part with an exponent part preceding the fraction. The fraction is that number obtained by writing the input number as a fraction f ,

$$1 < f \leq \frac{1}{10}$$

times the appropriate power of ten. Then the number

$$ff \dots f \times 10^P$$

becomes

$$EEff \dots f$$

where $EE \equiv 50 + P$. This notation is commonly called the excess-fifty (x's - 50) floating point form.

Wherever a quantity which is entered on the form in floating point is to be designated as being zero, three zeros (000) must be entered and not 500 or any other zero fraction with a nonzero exponent.

Significant figures in the fraction part of all of the floating point numbers have been marked-off and should not be exceeded in order to insure that all the data will fit on its punchcard. No floating point number can have a fraction part of more than eight (8) significant figures.

The Comments Card may contain any remarks for the operator or for additional problem description using any of the following 48 characters:

A through Z	26
0 through 9	10
(/ , * - + = S .)	10
- (hyphen)	1
(blank)	1

Cards Type 2 through 6 must contain only +, -, and the ten decimal symbols; and, therefore, these are the only twelve characters which can be entered on the input forms for those cards.

Cards Type 7 and 8 are punched in binary form, so that the integers entered on the form are not those which would be found punched in those cards.

B. Input Form I

Comments Card

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Positions 1 through 56 may contain any characters [see (I,A)] .

Positions 65 through 72 must contain an eight digit integer.

Card Type 1 Dimensions and Controls

Total number of : Groups $\underline{\hspace{2cm}}$ Points $\underline{\hspace{2cm}}$ Regions $\underline{\hspace{2cm}}$
(M $\leq$ 50) (N $\leq$ 250) (J $\leq$ 25)

1. Groups (M; fx). Total number of multigroups for which the spatial flux is to be computed. This number must be the same as the number of groups on the LP tape to be used in running the problem (see Appendix B).
 $0 < M \leq 50$.
2. Points (N; fx). Total number of spatial points not counting the origin, which is point zero. $2 < N \leq 250$, for P-1; $2 < N \leq 150$, for DP1. (These values are for 32K core storage.)
3. Regions (J; fx). Total number of regions in the problem from point zero which is the origin to point N which is the rightmost point considered. Input Form II defines a region and therefore in proceeding from the origin, each time that the information on Form II must be changed, a new region must be defined by a new Form II. $0 < J \leq 25$.

Geometry 0, Slab _____ Edit No. _____ Temperature _____ °C
 1, Cylinder (P) (E) (T > 0, Integer)
 2, Sphere

4. Geometry (P; fx). Parameter which designates the type of coordinate system -- 0 for rectangular, 1 for cylindrical, 2 for spherical.
5. Edit No. (E; fx). Parameter which designates the type of Final Edit desired. These edits are described in detail in Section D, Part Two.
6. Temperature ($0 < T < 32,767$; fx). The temperature in degrees centigrade which is assumed in every region.

7. Gear Control. Since the program was originally designed for experimentation with thermal multigroup double-Pl approximations, it was not known exactly what would be the best manner in which to run problems. One scheme, or several schemes, might be the best, or equally as good, in arriving at a solution. It was also desirable to be able to skip certain phases, or gears, in the iteration scheme or include only certain gears. Briefly, the gears accomplish the following.

Gear 1 will solve for F_0 and F_1 in each of the multigroups at all points until the criteria that

$$\left| 1 - \bar{g}^{(t)} \right| < \epsilon_1$$

and

$$\left| 1 - \bar{g}^{(T)} \right| < \epsilon_1$$

are satisfied on iteration t . Here $\bar{g}^{(t)}$ is the maximum over all points n of the ratios

$$\frac{\int \Sigma_a(F_0)_n^{(t)} \Delta E}{\int \Sigma_a(F_0)_n^{(t-1)} \Delta E}$$

and $\bar{g}^{(t)}$ is the minimum of these ratios.

Gear 2 will solve for F_0 , F_1 , F_2 , and F_3 in each multigroup at all points, iterating within a group only once before leaving that group.

The criteria for convergence in Gear 2 are that

$$|1 - \bar{g}^{(t)}| < \epsilon_2$$

and

$$|1 - g^{(t)}| < \epsilon_2$$

Gear 3 will solve for F_0 , F_1 , F_2 , and F_3 in each multigroup at all points, iterating within each group until the criteria

$$|1 - \bar{g}^{(l)}| < \delta$$

and

$$|1 - g^{(l)}| < \delta$$

are satisfied. Here, on inner iteration l ,

$$g_n^{(l)} = \frac{(F_0)_n^{(l)}}{(F_0)_n^{(l-1)}}$$

Gear 3 is converged whenever

$$|1 - \bar{g}^{(t)}| < \epsilon_3$$

and

$$|1 - g^{(t)}| < \epsilon_3$$

are satisfied.

The Final Edit will always be processed after Gear 3 is converged.

One outer iteration in any of these gears may also be requested.

By proper specification of γ_k and ϵ_k for the problem, the desired functioning of Gear k can be accomplished. The control center of the iteration routine will first interpret γ_k and then ϵ_k . If γ_k is zero and ϵ_k is nonzero, then Gear k will be run normally to convergence. If γ_k is zero and ϵ_k is also zero, then Gear k will be skipped. If γ_k is one, only one outer iteration ($t = 1$) will be performed in Gear k. In the case of $\gamma_3 = 1$, δ must not be zero. Any of the 27 possible combinations of γ and ϵ is permissible. See also Part Two, Section C.

- a. γ_1 (fx). Controls Gear 1; 0 to converge or skip, 1 for one iteration.
- b. γ_2 (fx). Controls Gear 2; 0 to converge or skip, 1 for one iteration.
- c. γ_3 (fx). Controls Gear 3; 0 to converge or skip, 1 for one iteration.
- d. θ (fl). Extrapolation factor similar to that used in PLMG-2 (Ref. 1). $0 \leq \theta < 1$.
- e. γ_4 (fl). 000.
- f. γ_5 (fx). 000.
- g. ϵ_1 (fl). Convergence criterion for Gear 1. $\epsilon_1 = 000$ when $\gamma_1 = 0$ will cause skipping of Gear 1.
- h. ϵ_2 (fl). Convergence criterion for Gear 2. $\epsilon_2 = 000$ when $\gamma_2 = 0$ will cause skipping of Gear 2.
- i. ϵ_3 (fl). Convergence criterion for Gear 3. $\epsilon_3 = 000$ when $\gamma_3 = 0$ will cause skipping of Gear 3.

Library No. _____

8. Library No. (fx). Since there may be more than one library of data with the same number of multigroups, it is desirable to check the library to insure that the one which has been requested is being used. The number entered here must correspond to the number assigned to the library at the time when the LP tape was written. (See Appendix B.)

Card Type 2 Boundary Conditions

At Left

m	$C_{0,0}^m$	$C_{0,1}^m$	$C_{1,0}^m$	$C_{1,1}^m$

At Right

$C_{0,0}^m$	$C_{0,1}^m$	$C_{1,0}^m$	$C_{1,1}^m$

1. m (fx). Group number of the data on that line. If $m = 0$ on the first line, then the boundary conditions on that card will be imposed upon F_0 , F_1 , F_2 , and F_3 in every multigroup. If $m \neq 0$ in the first line, then the boundary conditions for all groups ($m = 1, 2, \dots, M$) must be specified.

Regardless of the values of γ_k and ϵ_k on Card Type 1, all of the eight boundary condition coefficients must be specified. When specifying the value zero, use 000; when specifying the value infinity, use 704.

2. $(C_{0,0}^m)_{\text{left}}$ (fl). Left boundary condition coefficient of X_0^m in group m.
3. $(C_{0,1}^m)_{\text{left}}$ (fl). Left boundary condition coefficient of X_1^m in group m.
etc.

C. Input Form II

Card Type 3 Region Dimensions

Mesh point number at right end of region $\underline{\hspace{1cm}}$ Total number of isotopes in reg. $\underline{\hspace{1cm}}$
 (n_j) $(I_j \leq 15)$

1. Mesh point number at right end of region $(n_j; fx)$. Mesh point at which two regions meet (or the end of the last region).

$$1 \leq n_1; n_J \equiv N_0$$

2. Total number of isotopes in region $(I_j; fx)$. The number of isotopes specified on Cards Type 4 for region j . $0 < I_j \leq 15$.

Spectrum $\underline{\hspace{1cm}}$
 (X_j)

Mesh Size

h_j

Source

S_j

3. Spectrum $(x_j; fx)$. If there is no flux guess available from a previous problem, $(F_0)^m, (0)$ for each point n in region j will be $X_j^m \phi_n$, where ϕ_n is supplied via Cards Type 6 or CHOMP cards (Ref. 5) and X_j^m will be taken from the LP tape library (Maxwellian distribution for temperature T) or may be supplied on Cards Type 5.
 $X_j = 0$ will take the X off of tape for region j ; $X = 1$ will take X from cards for region j .
4. Mesh size $(h_j > 0; fl)$. Distance between mesh points in this region.
5. Source $(S_j; fl)$. Neutrons from higher energies.

Card Type 4 Composition

j	$\pm i$	N_i	$\pm i$	N_i	$\pm i$	N_i	$\pm i$	N_i	$\pm i$	N_i

1. j (fx). Number of the region for which this data is to be used.
2. i (fx). Code number of isotope as it is listed on the LP tape. The Bettis Standard code numbers are listed in Ref. 8 and the appendices of Ref. 7 and Ref. 1. The isotopes must be entered across the row in ascending order according to their code numbers. If hydrogen is not present in a region, the isotope code number (01) and a number density of zero must be specified. Provisions have been made in the program to permit nonhydrogenous moderators for which there are corresponding matrices in the library. Hydrogen must not be in the mixture, in this case, and a nonhydrogenous moderator must be specified. The nonhydrogenous moderator is specified by making negative the isotope code number for the moderator.
3. N_i (fl). Number density for the isotope whose code number immediately precedes it in the row.

Card Type 5 Flux Guess Spectrum

If on Card Type 3 for this region the spectrum is indicated $\left[X_j = 0, \right.$ see (3) under Card Type 3 $\left. \right]$ to be taken from the LP tape (a Maxwellian distribution), then no Type 5 cards are specified for this region. If $X_j = 1$, these cards must be included. In either case if the flux guess is specified on cards -- either CHOMP cards from a one-group WANDA (Ref. 5) or Type 6 cards -- the initial guess for F_0 at each point n in this region for group m will be computed from the equation

$$(F_0)_n^m = X_{j\phi_n}^m .$$

Whenever a guess for F_0 is to be taken from a tape which is a result of a previous problem or run, Sense Switch 5 down (see Part Two, Section IV), X is not used and the cards are not specified.

If no groups are specified for Card Types 7 or 8 and the flux guess is from CHOMP cards or from tape, Form III is omitted.

Card Type 6

C	Not Used	ϕ	ϕ	ϕ	ϕ	ϕ
0	0					

1. c (fx). Row (card) number. If $c = 0$ in the first row, then the initial guess for ϕ at every point n will be the first value of ϕ specified in that row. This one value will then constitute a complete specification of ϕ . If $c = 1$ in the first row, then the initial guess for ϕ_n must be specified for each point starting with the origin (point 0) through the outer boundary (point N), five (5) points to a row. Values of c must be zero or start at one and be consecutive.

2. Not used (fx). Not used.

3. ϕ (f1). Value of the initial flux guess at a particular point in the reactor. From this ϕ and the previously specified spectrum (see Card Type 3, and Card Type 5) the initial guess for F_0 in each group at each point will be computed.

Card Type 7

Breakpoints : Row 9 _____ Row 8 _____ Row 7 _____
 Row 6 _____ Row 5 _____ Row 4 _____

Breakpoints. The energy points which determine the sets of multigroups over which the few group quantities are to be averaged. As many as 6 few groups may be specified. The averaging will be done over all M groups and as many as 6 of these structures. The breakpoints are the multigroup numbers which correspond to these energy points. The last entry must be M in all structures. The few group edit stops after encountering the first blank row of this card. If only the averages over all M groups is desired to be edited, this card is a blank. If Edit No. 1 is specified, this card is omitted.

Card Type 8

Groups to be edited _____

If a Final Edit (see Part Two, Section V) is selected such that the multigroup results are desired (Edit 3, 4, 5 or 6), certain of these groups may be selected for editing. The group numbers of those groups desired should be entered here. If the results of all the multigroups is desired, then nothing is specified and this card is a blank. If Edit No. 1 or No. 2 is requested, this card is omitted.

III. PUNCHING OF INPUT DECK

A. General Description of the Format

The punching of cards and arrangement of the input deck is very similar to the PLMG-2 program (Ref. 1). The data for any one problem is entered on three different types of input forms. SLOP-1 Input Form I and SLOP-1 Input Form II

must always be included in the complete problem; however, SLOP-1 Input Form III may be absent under certain circumstances and in its stead must be supplied a set of binary CHOMP cards from a WANDA problem or a tape reel number or problem number of a previously run SLOP-1 problem.

The Comments Card is the only input card which may have nonnumeric information or blanks in columns 1-72. Card Types 7 and 8 are punched with binary information and will therefore have blank columns. The rest of the cards must have one and only one punch in each column (1-72) and must contain the eight-position problem number in columns 2-9 preceded by a sign in column 1. The sign for each piece of data (field) is punched in the column preceding the high order position of a fixed point number and preceding the two-position exponent of a floating point number. In punching, the sign for all data should be assumed to be positive. There are only certain numbers which could conceivably be negative and a position has been indicated on the form where the sign is to be inserted. If this position is left vacant on the input form, a plus sign is assumed. All floating point numbers are identifiable on the form since they are found in a box of which the first two positions (the exponent) have been marked off from the rest of the number. For example,

Mesh Size	h _j						
	5	1	3	1	4	1	5 9 2 7

On any card of Types 1 through 6 which does not have enough fields, or positions within fields, to entirely fill out the 72 columns of the card, +000...00 should be punched at the end of the right most field clear out to column 72. Column 72 cannot have a sign punched in it.

B. Comments Card

Punch in the columns as indicated.

C. Card Type 1

Punch in normal reading order. The last field on the card should contain the Library No. whose units position is column 72, for the convenience of the operator.

D. Card Type 2

Each row becomes one card. The signs for the C-fields are supplied.

There must be as many Forms II as there are Total Regions specified on Form I. The Forms II should first be arranged in ascending order according to "Mesh point number at right end of region" and then punched.

E. Card Type 3

Punch in normal reading order.

F. Card Type 4

Each row becomes one card.

G. Card Type 5 (If "Spectrum" on Card Type 3 of this Form II is zero, then these cards are not specified.)

Each row becomes one card.

H. Card Type 6 (If CHOMP cards are supplied or if the flux guess is indicated to be taken from a previous problem, then these cards are not specified.)

Each row becomes one card.

Note: There must be five fields beyond the "Not used" field even if there is only one ϕ -entry. Make the other four fields +000.

I. Card Type 7

If there are no entries, the card is a blank or omitted depending upon the desired edit. A 9, 8, 7, 6, 5, or 4 is punched into the columns corresponding to the entries made.

J. Card Type 8

If there are no entries, the card is a blank. A 9 is punched into the columns corresponding to the entries made.

K. The arrangement of the input deck is identical to that of PLMG-2 with the following additions:

1. A Comments Card is the top card of the deck.
2. A set of flux cards may not be present at all in the deck. This is true in the case when the reel number, or problem number of a tape 3 which is to be used as the initial flux guess is supplied on the tally card -- of course, this tape 3 will have been saved from a previous SLOP-1 case.
3. Again a blank card, as in PLMG-2, should precede a set of GHOMP binary cards. Also two blank cards should be placed after the Type 8 card. If either Edit No. 1 or Edit No. 2 is requested, the Type 8 card is not needed and the two blanks should follow the Type 7 card. If Edit No. 1 is requested, the Type 7 card is also not needed.

IV. COMPUTER OPERATING INSTRUCTIONS AND NOTES

A. Machine Configuration

1. 16K or 32K words of magnetic core storage.
2. Nine tape units.
3. No magnetic drums
4. On-line card reader.
5. On-line printer.
6. On-line punch.
7. Off-line printer.
8. Additional instructions
 - a. STZ,
 - b. CAD,
 - c. Floating point hardware.

B. Necessary Input for One Case

1. Data Deck

There will be a comments card on top of this deck which may contain some information relevant to the operation of the problem. There may also be an additional card or note for this problem may contain a problem number associated with a tape 3 which was saved from a previous SLOP-1 problem or it may contain the reel number of a tape 3 which came from a previous SLOP-1 problem. This tape 3 is the tape which contains the latest flux values during the running of a problem.

The first card after the comments card will contain the library number of the LP tape in the last field.

2. SLOP-1 LP Tape

The proper Library-Program tape to be used can be determined from the library number.

3. Flux Guess Tape

See (1) above.

C. Running Instructions

1. Mount SLOP-1 LP Tape as logical 1.
2. Mount blank tapes as logicals 2-8. Logical 5 should be a full tape reel.
3. Mount flux tape, if necessary, as logical 9; also set sense switch 5 down if such a tape is mounted.
4. Place problem input deck in card reader.
5. Insert GELAC printer board.
6. Push CLEAR.
7. Push LOAD TAPE.

D. Progress of Program

1. Coefficient tape preparation routine

a. The comments card is read and printed on-line and off-line.*

*All information which is printed on-line is also placed on a BCD tape for off-line printing. The on-line printing is for the benefit of the operator. Error indications are printed on-line only.

- b. Card Type 1 is read and the general statement of the problem is printed on-line. The LP tape is checked to determine if the proper library is available on that tape and also to determine if the requested temperature is in the library.
- c. Card Type 2 is read and the boundary conditions are printed.
- d. Card Type 3 for the first region is read and printed.
- e. Card Type 4 for the first region is read and printed. The library is searched for the information for each isotope in the region.
- f. One record for each point in the first region is written on each of the logical tapes 6, 7, and 8.
- g. If Cards Type 5 are included for the first region, then they are read and printed. If they are not included, a record is read from the library in their stead.
- h. Once, and only once, at this time a record is read from file 5 of the library.
- i. The LP tape is rewound and file 1 is skipped.
- j. One record is written on each of the logical tapes 2, 3, and 4.
- k. Steps d, e, f, g, i, and j are repeated for the rest of the regions in the case.
- l. The LP tape is searched for the end of file 5.

- m. Tapes 2, 3, 4, 6, 7, and 8 are rewound.
- n. Tape 6 is read into core and rewound; the information is sorted (from one record for each point containing one word for each group into one record for each group containing one word for each point, except in the DPl mode when there will be two words for each group in the record for each point before sorting and two sets of one word for each point in the record for each group); the tape is rewritten and rewound.
- o. Tape 7 is processed in a manner similar to Tape 6 (however, there is one less point-record, except in the case of DPl when there are two less words per group-record).
- p. Tape 8 is processed exactly the same as Tape 7.
- q. Tape 3 is read into core and rewound; the information is sorted (from one record for each point containing one set for each group consisting of one word for each isotope in the region into one record for each group containing one set for each region consisting of one word for each isotope); the tape is rewritten and rewound.
- r. Tape 4 is processed exactly the same as Tape 3.
- s. Tape 2 is processed similar to Tape 3; however, the information is not rewritten onto tape but is retained in core.
- t. Tapes 3, 4, 6, 7, and 8 are read one record at a time and merged with one "record" of the information from Tape 2 in core and the new record is written onto Tape 2.
- u. Tapes 2, 3, 4, 6, 7, and 8 are rewound.

This is the first plateau. Up to this point a restart, except from the very beginning, is impossible. Beyond this point a restart is possible, requiring only the coefficient tape (logical 2), whatever flux guess is available, the Type 7 and 8 cards followed by two blanks (i.e., the last four cards of the input deck^{*}), and in some restarting cases, the comments card. Beyond this point tapes 4, 6, 7, and 8 are not used again.

v. The iteration routine is read in from the LP tape.

2. The iteration routine

- a. The flux guess is read in either from cards (decimal or binary) or from tape 9. If the flux guess is from cards, the flux guess is printed on-line. If the flux guess is from tape 9, the flux guess is edited off-line only.
- b. The initial flux is written onto tape 3.
- c. The iteration process will proceed as follows.

(1) In Gear One

- (a) The flux in each group is solved for by reading the coefficients for that group from Tape 2.
- (b) After the last group flux is computed, Tape 3 is read and rewound and the convergence test is made. Tape 2 is rewound.
- (c) If the convergence test is met or if "GAMMA 1" is 1, control is transferred to Gear Two.

^{*}Three cards, if Edit No. 2 is requested; two cards, if Edit No. 1 is requested.

(d) Regardless of the results of (c) the new flux is written on Tape 3 and the tape is rewound.

(e) If the convergence test is not met another iteration is performed.

(f) After each iteration, ratios and NTC's^{*} are printed. The ratios are used to compute the NTC's which are printed. The NTC's are printed so that the operator is informed as to how close the iteration process is to satisfying the criterion, EPSILON. Both the "MAXIMUM" and "MINIMUM" NTC's must satisfy the criterion.

(g) "Gear one is converged" will be printed and the paper restored.

(h) If GAMMA 1 is 1, only one iteration is performed in this gear.

(2) In Gear Two

(a) Approximately the same apparent process is being performed as in Gear One; however, each iteration will take about twice as long as those in Gear One.

(b) The NTC's must satisfy EPSILON 2.

(c) If GAMMA 2 is 1, only one iteration is performed in this gear.

(3) In Gear Three

^{*}Nearness to convergence.

- (a) A variable number of inner iterations will be made within each group until a certain criterion (DELTA) is met for the group. After convergence within a group the total number of inner iterations taken to converge is printed in a typewriter-like fashion on-line.
- (b) Outer iterations are performed as in the other two gears and the number of these iterations is determined by the NTC's and EPSILON 3.
- (c) If GAMMA 3 is 1, only one outer iteration is performed in this gear.
- (4) If both GAMMA and EPSILON are zero for any gear, that gear will be skipped.
- (5) After all of the gears have been performed, or skipped as the case may be, the edit routine is read in from the LP Tape.

3. The edit routine

- a. All information needed for the various edits is gleaned off of Tape 2. Tape 2 is rewound.
- b. Tape 3 is read and rewound.
- c. Final Edits 1 or 2 are performed.
Card Type 7 is read before Edit 2.
- d. Final Edit 3, 4, 5, or 6 is performed (if requested).
 - (1) The Card Type 8 is read before any of these edits are performed.

(2) These edits amount to printing, off-line, the one, two, three or four components of the flux for each group as specified by the Card Type 8 -- a blank card means all groups will be edited. As a consequence, these four edits may require a considerable amount of time.

(3) Tape 3 is read one record at a time during these edits.

3. At the end of the edit routine an appropriate comment is printed on-line and the paper is restored. All the tapes are rewound except for Tape 5, so that another case can be processed.

E. End of Problem

1. Remove Tape 5 for off-line printer.
2. Remove LP tape.
3. If there is an indication by the problem requestor to save tapes, save Tape 2 and Tape 3 or only those which are indicated.

F. Print Tape 5 "PROGRAMMED" on the off-line Printer.

G. Error Procedures

1. During the coefficient tape preparation routine
 - a. There is only one unidentified error stop which may occur and that is within the output routine (GROUT2), and if it does occur it only means that the machine has made an error and the case must be started over.

- b. All other errors are identified by printing the address of the location in core storage of the instruction which detected the error. Following this will be a brief description of the error along with a prescription indicating "what to do till the doctor comes," "how to repair the damage," "where to look for the monkey wrench," "the advisability of restarting," "how to restart," "whom to charge the waste time to," "what tapes to save," etc.
 - c. Error cards from RWT5 will be punched due to some errors in reading or writing tapes and should be handled in the customary manner.
- 2. During the iteration routine -- similar to the coefficient tape preparation routine.
 - 3. During the edit routine -- similar to the iteration routine.

H. Restarting

- 1. During the coefficient tape preparation routine -- impossible.
- 2. During the iteration routine
 - a. Follow directions in Error Notes which are printed on-line.
 - b. In most cases all that is required is to throw a certain sense switch -- usually 6 -- and then press START.
 - c. If an error has occurred such that there is no on-line printout, the following steps can be taken to restart.

- (1) Rewind Tapes 1, 2, and 3. If a Tape 9 is used as the initial flux guess, rewind Tape 9 also. Run out the card reader.
- (2) Check the on-line printout to see if the flux tape has been written and if a restart from tape is possible (this should be printed following the last page of the last region).
- (3) If a restart from tape is not possible and a Tape 9 was not specified as part of the input, take off from the bottom of the input deck the flux cards and whatever cards follow them.
- (4) If a Tape 9 has been specified, select the last three (3)^{*} cards from the bottom of the input deck.
- (5) If the printout indicates a restart from tape is possible, depress sense switch 5. Also select the last three (3)^{*} cards from the bottom of the input deck. Rewind tape 3 and change the logic to 9 and ready a blank tape 3.
- (6) Place the comments card from the input deck on top of the flux cards and the last three^{*} cards of the input deck (or on top of just the last three^{*} cards, as the case may be) and ready these in the card reader.
- (7) Depress sense switch 6.
- (8) Push CLEAR.
- (9) Push LOAD TAPE.

^{*}If edit 3, 4, 5, or 6 is requested, select the last four cards.

- (10) If the iteration routine has proceeded beyond the first outer iteration, then sense switch 5 should always be depressed during a restart of this kind and the latest flux on tape 3 should be used as a flux guess via tape 9.
- (11) If the iteration routine has completed the processing of one gear and is working on another, then sense switch 2 or 3 should be depressed before step (9) if the routine is to start in either Gear Two or Gear Three, respectively.

3. During the edit routine

- a. Follow the on-line Error Notes.
- b. If an unexplained error occurs, proceed as follows.
 - (1) Rewind tapes 1, 2, and 3.
 - (2) Runout card reader.
 - (3) Select the comments card and the last three (3)^{*} cards from the input deck, and ready them in that order in the card reader.
 - (4) Depress sense switches 4 and 6.
 - (5) Push CLEAR.
 - (6) Push LOAD TAPE.

I. Forced Edit

1. For problems which are to be run only a certain length of time and then edited, depress sense switch 1 at the desired time. The

^{*}See footnote on preceding page.

iteration routine will complete the outer iteration on which it is working and then proceed into the edit routine as if the entire iteration portion had converged in all gears.

2. If a case is "spinning its wheels" on one group in Gear Three, depression of sense switch 1 will have no effect. To force an edit under these circumstances:

- a. Push CLEAR.

- b. Perform a restart as described in the edit routine.

3. If it appears that a problem is going nowhere fast or at worst standing still or the problem is to be temporarily removed from the machine, then

- a. Push CLEAR.

- b. Save all tapes necessary for restarting.

4. Step (3) is a good procedure to follow in most questionable cases since nothing will be lost and a considerable amount of machine time may be saved if a lengthy edit need not be performed.

J. Sense Switch Settings

1. Down to force an edit. Effective only at the end of an outer iteration.
2. Down to restart in Gear Two.
3. Down to restart in Gear Three.
4. Down to restart in edit routine.

5. Down to indicate that the latest flux guess is to be taken from Tape 9 at any time in running the problem from the beginning or from a restart.

6. Down for all restarts.

K. Printing of Tape 5

1. Contains one file for each case.
2. Program control.
3. End of printout indication.
 - a. Restore
 - b. Title and page number atop of next sheet.

V. OUTPUT

A. All information which is printed on-line -- with the exception of the Error Notes directed to the operator -- is also edited on Tape 5 for printing off-line. This consists of:

1. The entire printout of the input read from cards and the possible flux guess from tape.
2. The possible printout of flux distributions which were edited at the beginning of every restart which may have occurred during the running of the case.
3. Supervisory results which are printed after each iteration.

$$\text{RATIO} \equiv g^t = \frac{\int (\Sigma_a F_o)^t dE}{\int (\Sigma_a F_o)^{t-1} dE} \quad \text{on outer iteration } t.$$

$$\text{MAXIMUM RATIO} \equiv \max_{\text{all pts.}} \left[g^t \right] \equiv \bar{g}^t$$

$$\text{MINIMUM RATIO} \equiv g^t$$

$$\text{NTC (Nearness to Convergence)} \equiv |1 - g^t|$$

B. Final Edits

1. Final Edit No. 1

TOTAL FLUX

$$\Phi_n = \sum_m \frac{(F_o)_n^m + (F_o)_n^{m+1}}{2} \Delta E,$$

for all points n

REGIONWISE VOLUME INTEGRAL OF TOTAL FLUX

$$\Phi_j = \int_{V_j} \Phi_n dV_j,$$

for all regions j

2. Final Edit No. 2

Final Edit No. 1.

ELEMENTWISE ABSORPTION

$$(\Sigma_a)_{n,i} = \frac{\frac{1}{2} \sum_m (\Sigma_{a,i} F_o)_n^m + (\Sigma_{a,i} F_o)_n^{m+1}}{\Phi_n} \Delta E^m,$$

for all isotopes at the points in the regions in which they are found.

TOTAL ABSORPTION

$$(\Sigma_a)_n = \sum_i (\Sigma_a)_{n,i} ,$$

at all points for all isotopes at the point.

FLUX-WEIGHTED REGIONWISE VOLUME INTEGRAL OF TOTAL ABSORPTION

$$\int_{V_j} (\Sigma_a F_o)_n dV_j ,$$

for each region.

Same as [1], [2], and [3] for NU-FISSION.

Same as [b] and [c] for SCATTERING -- includes heavy isotopes only.

DIFFUSION

$$D_{n+1/2} = - \frac{\frac{1}{2} \sum_m \left[(F_1)^m + (F_1)^{m+1} \right]_{n+1/2} \Delta E^m}{\frac{1}{h} \left[\Phi_{n+1} - \Phi_m \right]}$$

FLUX-WEIGHTED REGIONWISE VOLUME INTEGRAL OF DIFFUSION

for slabs

$$\frac{h_j}{2} \sum_{n_j} D_{n+1/2} (\Phi_{n+1} + \Phi_n)$$

for cylinders

$$\pi h_j \sum_{n_j} (rD)_{n+1/2} (\Phi_{n+1} + \Phi_n)$$

for spheres

$$2 \pi h_j \sum_{n_j} (r^2 D)_{n+1/2} (\Phi_{n+1} + \Phi_n)$$

Few Group Edit. [see (8), below].

3. Final Edit No. 3

a. Final Edit No. 2.

b. For the groups as specified by "Groups to be edited" on Form III, $(F_o)_n$ at all points will be printed.

4. Final Edit No. 4

a. Final Edit No. 3.

b. $(F_1)_n$ will be printed in addition to $(F_o)_n$.

5. Final Edit No. 5

a. Final Edit No. 4.

b. $(F_2)_n$ will be printed in addition to $(F_o)_n$ and $(F_1)_n$.

6. Final Edit No. 6

a. Final Edit No. 5.

b. $(F_3)_n$ will be printed in addition to $(F_o)_n$, $(F_1)_n$ and $(F_2)_n$.

7. Few Group Edit (optional in Final Edit No. 2)

- a. If Card Type 7 is blank, Final Edit No. 2 is processed as above.
- b. If Card Type 7 is not blank, the following few group quantities are computed using the multigroup numbers which were specified on Form III as the breakpoints, which indicate the subsets of multigroups over which the averaging is to be done.

8. The following quantities are edited for both a few group edit and an edit over all the groups except where noted. The capital lettered phases indicate the name for the quantity as it appears on the printed output.

FLUX

$$(F_o)_n^k = \sum_{m=u_k}^{v_k-1} (\bar{F}_o)_n^m \Delta E^m$$

TOTAL CURRENT

$$(\Phi_1)_{n+1/2}^k = \sum_{m=u_k}^{v_k-1} (\bar{\Phi}_1)_{n+1/2}^m \Delta E^m$$

REGIONWISE VOLUME INTEGRAL OF TOTAL FLUX (not edited for few groups)

$$\Phi_j = \int_{V_P} (F_o)_n dV_P, dV_P = \begin{cases} 1 & , P = 0 \\ 2\pi r & , P = 1 \\ 4\pi r^2 & , P = 2 \end{cases}$$

ELEMENTWISE ABSORPTION

$$(\Sigma_a)_{n,i}^k = \sum_{m=u_k}^{v_k-1} \left[\frac{(\Sigma_a)_{j,i}^m (F_o)_n^m}{(F_o)_n^k} \right] \Delta E^m$$

ABSORPTION

$$(\Sigma_a)_n^k = \sum_i (\Sigma_a)_{n,i}^k$$

FLUX-WEIGHTED REGIONWISE VOLUME INTEGRAL OF THE TOTAL ABSORPTION

(not edited for few groups)

$$(\Sigma_a)_j = \int_{V_P} \left[(\Sigma_a)_n (F_o)_n \right] dV_P$$

ISOTOPIC ACTIVATION

$$A_{n,i}^k = \sum_{m=u_k}^{v_k-1} \left[\frac{(\Sigma_a)_{j,i}^m (F_o)_n^m}{(F_o)_n^k} \right] \Delta E^m$$

TOTAL ACTIVATION

$$A_n^k = \sum_i A_{n,i}^k$$

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

$$\int_{V_P} A_{n,i}^k dV_P$$

CAPTURE FRACTION

$$\frac{\int_{V_P} A_{n,i}^k dV_P}{\int_{V_P} A_n^k dV_P}$$

ELEMENTWISE NU-FISSION

$$(v\Sigma_f)_{n,i}^k = \sum_{m=u_k}^{v_k-1} \left[\overline{(v\Sigma_f)_{j,i}^m (F_o)_n^m} \right] \Delta E^m / (F_o)_n^k$$

NU-FISSION

$$(v\Sigma_f)_n^k = \sum_i (v\Sigma_f)_{n,i}^k$$

FLUX-WEIGHTED REGIONWISE VOLUME INTEGRAL OF TOTAL NU-FISSION

(not edited for few groups)

$$(v\Sigma_f)_j = \int_{V_P} \left[(v\Sigma_f)_n (F_o)_n \right] dV_P$$

MAXWELLIAN DIFFUSION COEFFICIENT

$$\frac{\sum_{m=u_k}^{v_k-1} \frac{\overline{\chi_j^m}}{\beta_{1,j}^m} \Delta E^m}{\sum_{m=u_k}^{v_k-1} (\overline{\chi_j^m}) \Delta E^m}$$

TOTAL SCATTERING (not edited for few groups)

$$(\Sigma_{ST})_n = \sum_m \left[\overline{(\Sigma_{ST})_j^m (F_o)_n^m} \right] \Delta E^m / (F_o)_n$$

FLUX-WEIGHTED REGIONWISE VOLUME INTEGRAL OF THE TOTAL SCATTERING

(not edited for few groups)

$$(\Sigma_{ST})_j = \int_{V_P} \left[(\Sigma_{ST})_n (F_o)_n \right] dV_P$$

DIFFUSION

$$D_{n+1/2}^k = h_j \sum_{m=u_k}^{v_k-1} (\overline{F_1})_{n+1/2}^m \Delta E^m / \left[(F_o)_n^k - (F_o)_{n+1}^k \right]$$

FLUX-WEIGHTED REGIONWISE VOLUME INTEGRAL OF DIFFUSION (not edited for few groups)

Slab

$$h_j \sum_{n_j} D_{n+1/2} \left[\frac{(F_o)_{n+1} + (F_o)_n}{2} \right]$$

Cylinder

$$2\pi h_j \sum_{n_j} r_{n+1/2} D_{n+1/2} \left[\frac{(F_o)_{n+1} + (F_o)_n}{2} \right]$$

Sphere

$$4\pi h_j \sum_{n_j} (r_{n+1/2})^2 D_{n+1/2} \left[\frac{(F_o)_{n+1} + (F_o)_n}{2} \right]$$

BOUNDARY CHECK (not edited for few groups)

$$\int (F_1)_o^m dE = \sum_m \left[\overline{(C_L)_{1,o}^m (\psi_o)_o^m + (C_L)_{1,2}^m (\psi_2)_o^m} \right] \Delta E^m$$

Same thing at point N.

SCATTERING CROSS SECTION OF HYDROGEN (edited only for few groups)

$$(\Sigma_s)_n^k = \sum_{m=u_k}^{v_k-1} \left[\overline{(\Sigma_{SH})_j^m (F_o)_n^m} \right] \Delta E^m / (F_o)_n^k \quad \text{where}$$

$$(\Sigma_{SH})_j^m = (\alpha_1)_j^m + (N_H)_j a_o^{m,m} - (\Sigma_a)_j^m$$

SPECTRUM (edited only for few groups)

$$\int I(z) = \sum_{m=u_k}^{v_k-1} \overline{S I(z)^m} \Delta E^m$$

TRANSFER COEFFICIENT (edited only for few groups)

$$(a_o)_n^{\ell,k} = \sum_{m=u_k}^{v_k-1} \Delta E^m \left\{ \sum_{r=u_\ell}^{v_\ell} \overline{(a_o^m)^r} (F_o)^r - \left[\frac{(\Delta E)^{u_\ell-1}}{(\Delta E)^{u_\ell-1} + (\Delta E)^{u_\ell}} \right] \overline{(a_o^m)^{u_\ell}} (F_o)^{u_\ell} \right. \\ \left. - \left[\frac{(\Delta E)^{v_\ell}}{(\Delta E)^{v_\ell} + (\Delta E)^{v_\ell+1}} \right] \overline{(a_o^m)^{v_\ell}} (F_o)^{v_\ell} \right\} / (F_o)_n^{\ell}$$

DOUBLE-P₁ F₂ (edited only for gears 2, 3)

$$(F_2)_n^k = \sum_{m=u_k}^{v_k-1} \overline{(F_2)_n^m} \Delta E^m$$

DOUBLE-P₁ D₂ (edited only for gears 2, 3)

$$(D_2)_{n+1/2}^k = h_j \sum_{m=u_k}^{v_k-1} \overline{(F_3)_{n+1/2}^m} \Delta E^m / \left[(\psi_2)_n^k - (\psi_2)_{n+1}^k \right]$$

DOUBLE-P₁ SIGMA_T

$$\sum_{m=u_k}^{v_k-1} \left[\overline{(\Sigma)_j^m (F_2)_n^m} \right] \Delta E^m / (F_2)_n^k$$

where

$$(\Sigma)_j^m = (\Sigma_a)_j^m + (\Sigma_{ST})_j^m$$

When editing after gears 2 and 3, ψ_o replaces F_o in calculating the diffusion and the flux-weighted regionwise volume integral of diffusion.

APPENDIX A

Sample Problem

The sample problem in this appendix does not represent any existing or proposed reactor or part thereof but has been designed only for the purpose of displaying the final results which a user of the SLOP-1 program would obtain by correctly following the procedures outlined in the report.

Problem No.

Mesh point number at right end of region $\frac{10}{(n_j)}$ Total number of isotopes in reg. $\frac{6}{(I_j \leq 15)}$

S									
5	1	1							

$\left\{ \begin{array}{l} +i, \text{ normal isotope} \\ -i, \text{ designates nonhydrogenous moderator} \\ \quad \text{if } i = 0 \text{ is not in region.} \end{array} \right.$

Card Type 4

[illegible] χ , value of source distribution spectrum

Cards Type 5

(not needed if $X_j = 0$ on Card Type 3)

[illegible]

Problem No.

Spectrum $\frac{0}{(X_j)}$

512

$\left\{ \begin{array}{l} +i, \text{ normal isotope} \\ -i, \text{ designates nonhydrogenous moderator} \\ \quad \text{if } i = 0 \text{ is not in region.} \end{array} \right\}$

j	$\pm i$	N _i	$\pm i$	N _i	$\pm i$	N _i	$\pm i$	N _i	$\pm i$	N _i
2	-0.1	49,66,92,	+0.2	49,33,46,						

[illegible]

Card Type 3

Card Type 4:

Cards Type 5:

(not needed if $X_j = 0$ on Card Type 3)

APPENDIX A, SAMPLE PROBLEM, WAPD-TM-188

SLO P1 12003096SLO12096

+12003096+36+14+2+0+6+21+0+0+0+506+000+0+485+481+475+475+00000000000036SLO12096

+12003096+00+511+000+000-511+511+000+000-511+00000000000000000000000000SLO12096

+12003096+10+6+0+511+511+00SLO12096

+12003096+1-01+492804+02+491402+03+492267+09+482944+18+473972+0000000000SLO12096

+12003096+1+20+46244+000SLO12096

+12003096+14+2+0+505+512+00SLO12096

+12003096+2-01+496692+02+493346+00SLO12096

+12003096+001+000+5318+5318+5318+5318+5318+0000000000000000000000000000SLO12096

+12003096+002+000+5318+5318+5318+5318+5318+0000000000000000000000000000SLO12096

+12003096+003-000+53215+5325+5325+5325+5325+0000000000000000000000000000SLO12096

9 9 9

9 9 9 9 9 9

36 GROUPS 14 POINTS 2 REGIONS

SLAB GEOMETRY EDIT NO. 6

TEMPERATURE 21 DEGREES CENTIGRADE

GAMMA

EPSILON

1 0 1 -2 50000

2 0 2 -2 10000

3 0 3 -3 50000

DELTA -3 50000

THETA 6000 INITIAL FLUX GUESS COMES FROM CARDS

LIBRARY NUMBER 19

BOUNDARY CONDITIONS

AT LEFT BOUNDARY

AT RIGHT BOUNDARY

GROUP	C	C	C	C	C	C	C	C
	0.0	0.1	1.0	1.1	0.0	0.1	1.0	1.1
ALL	1 1000	0000	0000	1-1000	1 1000	0000	0000	1-1000

REGION 1

SLO P1 12003096

ENDS AT MESH POINT 10 MESH SIZE 1 10000000

6 ISOTOPES SPECTRUM FROM TAPE SOURCE GUESS 1 10000000

ISOTOPE	NUMBER DENSITY
---------	----------------

1	-1 28040000
2	-1 14020000
3	-1 22670000
9	-2 29440000
18	-3 39720000
20	-4 24400000

REGION 2

SLO P1 12003096

ENDS AT MESH POINT 14 MESH SIZE 50000000

2 ISOTOPES SPECTRUM FROM TAPE SOURCE GUESS 1 20000000

ISOTOPE	NUMBER DENSITY
---------	----------------

1	~1 66919999
2	~1 33460000

INITIAL FLUX

POINT

0	3 18000000	3 18000000	3 18000000	3 18000000
4	3 18000000	3 18000000	3 18000000	3 18000000
8	3 18000000	3 18000000	3 21500000	3 18000000
12	3 25000000	3 25000000	3 25000000	3 25000000

P1 APPROXIMATION

GEAR ONE

OUTER ITERATION

		MAXIMUM	AT POINT	MINIMUM	AT POINT
1	RATIO	1.26946084	15	.87505943	1
	NTC	.26946084		.12494057	
2	RATIO	1.15426052	15	.85361800	
	NTC	.15426052		.14638200	
3	RATIO	1.18726228	15	.82583330	
	NTC	.18726228		.17416670	
4	RATIO	1.13171224	15	.92929082	
	NTC	.13171224		.07070918	
5	RATIO	1.09820227	15	.97882310	
	NTC	.09820227		.02117690	
6	RATIO	1.07572021	15	.99260488	
	NTC	.07572021		.00739512	
7	RATIO	1.06034124	15	.99801937	
	NTC	.06034124		.00198063	
8	RATIO	1.04901677	15	.99935648	
	NTC	.04901677		.00064352	
9	RATIO	1.04039465	15	.99985605	
	NTC	.04039465		.00014395	
10	RATIO	1.03361219	15	.99998228	
	NTC	.03361219		.00001772	
11	RATIO	1.02817756	15	1.00002034	
	NTC	.02817756		.00002034	
12	RATIO	1.02375464	15	1.00002891	
	NTC	.02375464		.00002891	
13	RATIO	1.02011679	15	1.00002830	
	NTC	.02011679		.00002830	
14	RATIO	1.01709814	15	1.00002553	
	NTC	.01709814		.00002553	
15	RATIO	1.01457629	15	1.00002263	
	NTC	.01457629		.00002263	
16	RATIO	1.01245755	15	1.00001960	
	NTC	.01245755		.00001960	
17	RATIO	1.01066913	15	1.00001711	
	NTC	.01066913		.00001711	
18	RATIO	1.00915369	15	1.00001481	

SLO P1

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	NTC	.00915369		.00001481
19	RATIO	1.00786532	15	1.00001287
	NTC	.00786532		.00001287
20	RATIO	1.00676693	15	1.00001113
	NTC	.00676693		.00001113
21	RATIO	1.00582826	15	1.00000966
	NTC	.00582826		.00000966
22	RATIO	1.00502449	15	1.00000839
	NTC	.00502449		.00000839
23	RATIO	1.00433506	15	1.00000726
	NTC	.00433506		.00000726

GEAR 1 HAS CONVERGED

DOUBLE P1 APPROXIMATION

GEAR TWO

OUTER ITERATION

		MAXIMUM	AT POINT	MINIMUM	AT POINT
1	RATIO NTC	1.01055849 .01055849	12	.98905335 .01094665	9
2	RATIO NTC	1.00641058 .00641058	12	.99245690 .00754310	9
3	RATIO NTC	1.00720361 .00720361	12	.99462155 .00537845	9
4	RATIO NTC	1.00512856 .00512856	13	.99975254 .00024746	8
5	RATIO NTC	1.00430080 .00430080	15	1.00005317 .00005317	
6	RATIO NTC	1.00377439 .00377439	15	1.00002064 .00002064	
7	RATIO NTC	1.00328624 .00328624	15	1.00000995 .00000995	
8	RATIO NTC	1.00285509 .00285509	15	1.00000705 .00000705	
9	RATIO NTC	1.00247978 .00247978	15	1.00000602 .00000602	
10	RATIO NTC	1.00215402 .00215402	15	1.00000528 .00000528	
11	RATIO NTC	1.00187157 .00187157	15	1.00000468 .00000468	
12	RATIO NTC	1.00162651 .00162651	15	1.00000407 .00000407	
13	RATIO NTC	1.00141391 .00141391	15	1.00000355 .00000355	
14	RATIO NTC	1.00122929 .00122929	15	1.00000308 .00000308	
15	RATIO NTC	1.00106902 .00106902	15	1.00000273 .00000273	
16	RATIO NTC	1.00092977 .00092977	15	1.00000235 .00000235	

GEAR 2 HAS CONVERGED

SLO P1
GEAR THREE

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INNER ITERATION
GROUP

1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1

OUTER ITERATION

		MAXIMUM	AT POINT	MINIMUM	AT POINT
1	RATIO	1.00080878	15	1.00000203	
	NTC	.00080878		.00000203	

INNER ITERATION
GROUP

1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1

OUTER ITERATION

		MAXIMUM	AT POINT	MINIMUM	AT POINT
2	RATIO	1.00043975	15	1.00000112	
	NTC	.00043975		.00000112	

GEAR 3 HAS CONVERGED

FINAL EDIT NO. 6

DOUBLE P1

9 ROW FEW GROUP SCHEME

FEW GROUP 1 MG 1 THRU 22

FLUX

REGION 1

POINT

0

1 20558926

1 20561671

1 20571541

1 20594387

4

1 20643607

1 20747663

1 20965667

1 21418752

8

1 22352982

1 24283996

1 28645810

REGION 2

POINT

10

1 28645810

1 34004918

1 37516343

1 39593235

14

1 40282561

TOTAL CURRENT

POINT

0.5

-3-13632076

-3-49011288

-2-11333788

-2-24364127

4.5

-2-51295705

-1-10673370

-1-21942065

-1-44404359

8.5

-1-87880317

-16837453

-22360852

-16645919

12.5

-10122697

-1-33860305

9 ROW FEW GROUP SCHEME

FEW GROUP 1 MG 1 THRU 22

AVERAGE MACROSCOPIC CROSS SECTIONS

TOTAL ACTIVATION

REGION 1

POINT

0

16971033

16974088

16985063

17010435

4

17065034

17180369

17421904

17923919

8

18959630

21104080

25976011

REGION 2

POINT

10

-1 23511411

-1 28943169

-1 32497715

-1 34598710

14

-1 35295841

ISOTOPIC ACTIVATION

ISOTOPE 1

REGION 1

POINT

0

-2 64196660

-2 64208341

-2 64250308

-2 64347313

4

-2 64556035

-2 64996866

-2 65919880

-2 67837798

8

-2 71793194

-2 79975165

-2 98484974

REGION 2

POINT

10

-1 23504331

-1 28934454

-1 32487929

-1 34588300

14

-1 35285212

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

-1 68922570

-1 62702726

CAPTURE FRACTION

REGION

1

-1 37849156

99969887

9 ROW FEW GROUP SCHEME

FEW GROUP 1 MG 1 THRU 22

ISOTOPIC ACTIVATION

ISOTOPE 2

REGION 1

POINT

0

-5 19336783

-5 19340301

-5 19352942

-5 19382161

4

-5 19445030

-5 19577814

-5 19855836

-5 20433536

8

-5 21624947

-5 24089453

-5 29664823

REGION 2

POINT

10

-5 70797787

-5 87153950

-5 97857432

-4 10418399

14

-4 10628318

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

-4 20760282

-4 18886792

CAPTURE FRACTION

REGION

1

-4 11400607

-3 30112096

9 ROW FEW GROUP SCHEME

FEW GROUP 1 MG 1 THRU 22

ISOTOPIC ACTIVATION

ISOTOPE 3

REGION 1
POINT

0	-2	28142363	-2	28147484	-2	28165881	-2	28208406
4	-2	28299904	-2	28493156	-2	28697783	-2	29738555
8	-2	31472512	-2	35059303	-2	43173584		

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1	-1	30214095	00000000
---	----	----------	----------

CAPTURE FRACTION

REGION

1	-1	16592214	00000000
---	----	----------	----------

9 ROW FEW GROUP SCHEME

FEW GROUP 1 MG 1 THRU 22

ISOTOPIC ACTIVATION

ISOTOPE 9

REGION 1

POINT

0	-3 46691329	-3 46699826	-3 46730348	-3 46800902
4	-3 46952709	-3 47273334	-3 47944657	-3 49339591
8	-3 52216418	-3 58167307	-3 71629807	

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

-2 50128564	00000000
-------------	----------

CAPTURE FRACTION

REGION

1

-2 27528339	00000000
-------------	----------

9 ROW FEW GROUP SCHEME

FEW GROUP 1 MG 1 THRU 22

ISOTOPIC ACTIVATION

ISOTOPE 18

REGION 1

POINT

0

15996165

15999043

16009381

16033279

4

16084709

16193349

16420868

16893754

8

17869404

19889605

24480453

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

1 17163170

00000000

CAPTURE FRACTION

REGION

1

94252359

00000000

9 ROW FEW GROUP SCHEME

FEW GROUP 1 MG 1 THRU 22

ISOTOPIC ACTIVATION

ISOTOPE 20

REGION 1

POINT

0	-4 45932034	-4 45940393	-4 45970420	-4 46039825
4	-4 46189163	-4 46504574	-4 47164980	-4 48537231
8	-4 51367276	-4 57221390	-4 70464964	

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

-3 49313374	00000000
-------------	----------

CAPTURE FRACTION

REGION

1

-3 27080673	00000000
-------------	----------

9 ROW FEW GROUP SCHEME

FEW GROUP 1 MG 1 THRU 22

ELEMENTWISE ABSORPTION

ISOTOPE 1

REGION 1

POINT

0	-2 31225688	-2 31227200	-2 31232617	-2 31245073
4	-2 31271683	-2 31327319	-2 31441823	-2 31672151
8	-2 32117950	-2 32933281	-2 34380238	

REGION 2

POINT

10	-2 82051551	-2 85089026	-2 86596738	-2 87359116
14	-2 87594262			

ISOTOPE 2

REGION 1

POINT

0	-6 94055414	-6 94059967	-6 94076284	-6 94113802
4	-6 94193957	-6 94361540	-6 94706437	-6 95400214
8	-6 96743011	-6 99198885	-5 10355729	

REGION 2

POINT

10	-5 24714884	-5 25629807	-5 26083948	-5 26313585
14	-5 26384413			

ISOTOPE 3

REGION 1

POINT

0	-2 13688635	-2 13689298	-2 13691672	-2 13697133
4	-2 13708798	-2 13733188	-2 13783383	-2 13884354
8	-2 14079782	-2 14437205	-2 15071518	

ISOTOPE 9

REGION 1

POINT

0	-3 22710977	-3 22712077	-3 22716017	-3 22725076
4	-3 22744430	-3 22784895	-3 22860176	-3 23035698
8	-3 23359934	-3 23952939	-3 25005335	

ISOTOPE 18

REGION 1

POINT

0	-1 77806426	-1 77810030	-1 77822951	-1 77852664
4	-1 77916172	-1 78049027	-1 78322659	-1 78873659
8	-1 79941925	-1 81904168	-1 85459106	

ISOTOPE 20

REGION 1

SLO P1

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POINT

0	-4 22341651	-4 22342733	-4 22346609	-4 22355521
4	-4 22374560	-4 22414367	-4 22496293	-4 22661091
8	-4 22980055	-4 23563416	-4 24598698	

ABSORPTION

REGION 1

POINT

0	-1 82548249	-1 82552084	-1 82565826	-1 82597431
4	-1 82664981	-1 82806284	-1 83097304	-1 83683281
8	-1 84819243	-1 86905801	-1 90679968	

REGION 2

POINT

10	-2 82076265	-2 85114655	-2 86622821	-2 87385429
14	-2 87620646			

9 ROW FEW GROUP SCHEME

FEW GROUP 1 MG 1 THRU 22

ELEMENTWISE NU-FISSION

ISOTOPE 1

REGION 1

POINT

0

00000000

00000000

00000000

00000000

4

00000000

00000000

00000000

00000000

8

00000000

00000000

00000000

REGION 2

POINT

10

00000000

00000000

00000000

00000000

14

00000000

ISOTOPE 2

REGION 1

POINT

0

00000000

00000000

00000000

00000000

4

00000000

00000000

00000000

00000000

8

00000000

00000000

00000000

REGION 2

POINT

10

00000000

00000000

00000000

00000000

14

00000000

ISOTOPE 3

REGION 1

POINT

0

00000000

00000000

00000000

00000000

4

00000000

00000000

00000000

00000000

8

00000000

00000000

00000000

ISOTOPE 9

REGION 1

POINT

0

00000000

00000000

00000000

00000000

4

00000000

00000000

00000000

00000000

8

00000000

00000000

00000000

ISOTOPE 10

REGION 1

POINT

0

16100476

16101254

16104042

16110454

4

16124165

16152853

16211962

16331024

8

16561912

16985889

17750973

ISOTOPE 20

REGION 1

SLO P1

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POINT

0
4
800000000
00000000
0000000000000000
00000000
0000000000000000
00000000
0000000000000000
00000000
00000000

NU-FISSION

REGION 1

POINT

0
4
816100476
16124165
1656191216101254
16152853
1698588916104042
16211962
1775097316110454
16331024

REGION 2

POINT

10
1400000000
00000000

00000000

00000000

00000000

MAXWELLIAN

DIFFUSION

COEFFICIENT

REGION

1

41027145

24997166

9 ROW FEW GROUP SCHEME

FEW GROUP 1 MG 1 THRU 22

DOUBLE P1 F
2

REGION 1

POINT

0	-3 11147966	-3 14467377	-3 26300622	-3 53240474
4	-2 10989821	-2 22574182	-2 45728388	-2 90582552
8	-1 17238163	-1 29310774	-1 19410802	

REGION 2

POINT

10	-1 19410802	-1-21392584	-1-28312592	-1-29770069
14	-1-30016055			

DOUBLE P1 D
2

POINT

0.5	17253834	19721717	19725193	19728092
4.5	19729546	19729279	19727401	19724750
8.5	19725741	19683837	-1 98635824	-1 99015465
12.5	-1 99906044	10115259		

DOUBLE P1 SIGMA
T

REGION 1

POINT

0	96787138	96727404	96629318	96556312
4	96509594	96483254	96474443	96481999
8	96503502	96521592	96228769	

REGION 2

POINT

10	1 16884329	1 16911857	1 16894812	1 16885444
14	1 16882349			

9 ROW FEW GROUP SCHEME

FEW GROUP 1 MG 1 THRU 22

DIFFUSION

POINT

05
405
805
120539990957
40318818
40451857
2471671940051287
40381657
40437571
2473696440142162
40424304
2461000840237453
40447503
24675066

SCATTERING CROSS SECTION OF HYDROGEN

REGION 1

POINT

0
4
861870062
61880740
6207806561870411
61893676
6226861761871669
61920332
6260679461874560
61974018

REGION 2

POINT

10
141 14941678
1 15072017

1 15013003

1 15048512

1 15066476

SPECTRUM

REGION

1

54986963

1 10997393

9 ROW FEW GROUP SCHEME

FEW GROUP 2 MG 23 THRU 29

FLUX

REGION 1

POINT

0	1 15684921	1 15694145	1 15727617	1 15806489
4	1 15981081	1 16364379	1 17209333	1 19088680
8	1 23328333	1 33196521	1 59482880	

REGION 2

POINT

10	1 59482880	1 97360850	2 12099229	2 13462386
14	2 13909905			

TOTAL CURRENT

POINT

0.5	-3-30891833	-2-11213100	-2-26432883	-2-58531957
4.5	-1-12849164	-1-28295085	-1-62727975	-14023475
8.5	-31631735	-71971417	1-10731428	-75304300
12.5	-44307039	-14607603		

9 ROW FEW GROUP SCHEME

FEW GROUP 2 MG 23 THRU 29

AVERAGE MACROSCOPIC CROSS SECTIONS

TOTAL ACTIVATION

REGION 1

POINT

0	30072075	30089779	30154047	30305606
4	30641555	31380686	33015557	36671020
8	44984721	64577539	1 11787631	

REGION 2

POINT

10	-1 95897410	15886837	19787484	22031823
14	22767926			

ISOTOPIC ACTIVATION

ISOTOPE 1

REGION 1

POINT

0	-1 10312503	-1 10318572	-1 10340606	-1 10392557
4	-1 10507682	-1 10760866	-1 11320518	-1 12570604
8	-1 15409318	-1 22083679	-1 40169660	

REGION 2

POINT

10	-1 95868533	15882053	19781525	22025169
14	22761070			

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

13894548	36931364
----------	----------

CAPTURE FRACTION

REGION

1

-1 34240339	99969888
-------------	----------

9 ROW FEW GROUP SCHEME

FEW GROUP 2 MG 23 THRU 29

ISOTOPIC ACTIVATION

ISOTOPE 2

REGION 1

POINT

0

-5 31062461

-5 31080744

-5 31147110

-5 31303592

4

-5 31650362

-5 32412984

-5 34098722

-5 37864127

8

-5 46414662

-5 66518618

-4 12099570

REGION 2

POINT

10

-4 28876720

-4 47838597

-4 59584262

-4 66342438

14

-4 68538997

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

-4 41851999

-3 11124158

CAPTURE FRACTION

REGION

1

-4 10313590

-3 30112096

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9 ROW FEW GROUP SCHEME

FEW GROUP 2 MG 23 THRU 29

ISOTOPIC ACTIVATION

ISOTOPE 3

REGION 1

POINT

0	-2 45207679	-2 45234287	-2 45330875	-2 45558616
4	-2 46063298	-2 47173203	-2 49626591	-2 55106686
8	-2 67550963	-2 96809852	-1 17609470	

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

-1 60910554 00000000

CAPTURE FRACTION

REGION

1

-1 15010190 00000000

9 ROW FEW GROUP SCHEME

FEW GROUP 2 MG 23 THRU 29

ISOTOPIC ACTIVATION

ISOTOPE 9

REGION 1

POINT

0

-3 75004597

-3 75048745

-3 75208994

-3 75588042

4

-3 76424166

-3 78265622

-3 82336068

-3 91428158

8

-2 11207461

-2 16061838

-2 29216082

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

-1 10105743

00000000

CAPTURE FRACTION

REGION

1

-2 24903585

00000000

9 ROW FEW GROUP SCHEME

FEW GROUP 2 MG 23 THRU 29

ISOTOPIC ACTIVATION

ISOTOPE 18

REGION 1
POINT0
4
828506055
29045396
4264471628522836
29746579
6122398928583759
31296463
1 1117762928727429
34762093

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

1 38469492

00000000

CAPTURE FRACTION

REGION

1

94800383

00000000

9 ROW FEW GROUP SCHEME

FEW GROUP 2 MG 23 THRU 29

ISOTOPIC ACTIVATION

ISOTOPE 20

REGION 1

POINT

0

4

8

-4 73734873

-4 75181356

-3 11025205

-4 73828301

-4 76992865

-3 15800640

-4 73905945

-4 80997119

-3 28740970

-4 74937648

-4 89941352

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

-3 99414030

00000000

CAPTURE FRACTION

REGION

1

-3 24498603

00000000

9 ROW FEW GROUP SCHEME

FEW GROUP 2 MG 23 THRU 29

ELEMENTWISE ABSORPTION

ISOTOPE 1

REGION 1

POINT

0	-2 65747880	-2 65747911	-2 65748076	-2 65748671
4	-2 65750757	-2 65757867	-2 65781272	-2 65853712
8	-2 66054089	-2 66524078	-2 67531665	

REGION 2

POINT

10	-1 16116996	-1 16312566	-1 16349409	-1 16360538
14	-1 16363210			

ISOTOPE 2

REGION 1

POINT

0	-5 19804028	-5 19804038	-5 19804087	-5 19804266
4	-5 19804895	-5 19807036	-5 19814086	-5 19835906
8	-5 19896262	-5 20037828	-5 20341265	

REGION 2

POINT

10	-5 48546271	-5 49135352	-5 49246328	-5 49279849
14	-5 49237898			

ISOTOPE 3

REGION 1

POINT

0	-2 28822382	-2 28822397	-2 28822469	-2 28822730
4	-2 28823644	-2 28826760	-2 28837022	-2 28868778
8	-2 28956618	-2 29162650	-2 29604266	

ISOTOPE 9

REGION 1

POINT

0	-3 47819557	-3 47819582	-3 47819700	-3 47820134
4	-3 47821650	-3 47826821	-3 47843845	-3 47896532
8	-3 48042269	-3 48384100	-3 49116790	

ISOTOPE 18

REGION 1

POINT

0	18174178	18174189	18174246	18174453
4	18175176	18177640	18185750	18210842
8	18280224	18442893	18791338	

ISOTOPE 20

REGION 1

POINT

0	-4 47041916	-4 47041939	-4 47042056	-4 47042482
4	-4 47043974	-4 47049061	-4 47069809	-4 47117628
8	-4 47261005	-4 47597277	-4 48318053	

ABSORPTION

REGION 1

POINT

0	19172602	19172614	19172673	19172889
4	19173644	19176216	19184681	19210873
8	19283298	19453104	19816847	

REGION 2

POINT

10	-1 16121850	-1 16317480	-1 16354334	-1 16365466
14	-1 16368139			

9 ROW FEW GROUP SCHEME

FEW GROUP 2 MG 23 THRU 29

ELEMENTWISE NU-FISSION

ISOTOPE 1

REGION 1

POINT

0

00000000

00000000

00000000

00000000

4

00000000

00000000

00000000

00000000

8

00000000

00000000

00000000

REGION 2

POINT

10

00000000

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14

00000000

ISOTOPE 2

REGION 1

POINT

0

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4

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8

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00000000

00000000

REGION 2

POINT

10

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14

00000000

ISOTOPE 3

REGION 1

POINT

0

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4

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00000000

ISOTOPE 9

REGION 1

POINT

0

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4

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ISOTOPE 18

REGION 1

POINT

0

38028659

38028683

38028802

38029230

4

38030720

38035732

38052405

38103756

8

38245578

38577767

39288710

ISOTOPE 20

REGION 1

POINT

0
4
8

00000000
00000000
00000000

SLO P1

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00000000

NU-FISSION

REGION 1

POINT

0
4
8

38028659
38030720
38245578

38028683
38035782
38577767

38028802
38052405
39288710

38029230
38102753

REGION 2

POINT

10
14

00000000
00000000

00000000

00000000

00000000

MAXWELLIAN

DIFFUSION

COEFFICIENT

REGION

1

27807380

16232382

9 ROW FEW GROUP SCHEME

FEW GROUP 2 MG 23 THRU 29

DOUBLE P1 F
2REGION 1
POINT

0	-3 21959022	-3 28873794	-3 54088707	-2 11403962
4	-2 24836539	-2 54754090	-1 12171189	-1 27232560
8	-1 60805945	12752135	10923731	

REGION 2
POINT

10	10923731	-10662803	-12030778	-11725418
14	-11561625			

DOUBLE P1 D
2

POINT

0.5	15200156	17930966	17917093	17894326
4.5	17859109	17805623	17725178	17604939
8.5	17420395	18240421	-1 87149145	-1 93141871
12.5	-1 77667925	-1 82225293		

DOUBLE P1 SIGMA
TREGION 1
POINT

0	1 11024288	1 11027239	1 11034155	1 11044305
4	1 11059408	1 11082353	1 11117342	1 11170457
8	1 11250171	1 11366031	1 11464693	

REGION 2
POINT

10	1 19224483	1 19223294	1 19067819	1 19007998
14	1 18992494			

9 ROW FEW GROUP SCHEME

FEW GROUP 2 MG 23 THRU 29

DIFFUSION

POINT

0.5	29123748	29113457	29091172	29054383
4.5	28996162	28905868	28766723	28554527
8.5	28296329	27766024	15988104	16119699
12.5	16179144	16202069		

SCATTERING CROSS SECTION OF HYDROGEN

REGION 1

POINT

0	73170704	73170710	73170751	73170932
4	73171652	73174296	73183426	73212643
8	73295506	73499928	73927914	

REGION 2

POINT

10	1 17643567	1 17728565	1 17744362	1 17749084
14	1 17750211			

SPECTRUM

REGION

1

-1 70581392

14116278

9 ROW FEW GROUP SCHEME

FEW GROUP 3 MG 30 THRU 36

FLUX

REGION 1

POINT

0

36326988

38347894

38423797

38602877

4

39000408

39878323

41837455

46307059

8

56939232

84600746

1 18112991

REGION 2

POINT

10

1 18112991

1 34703810

1 43830337

1 48930631

14

1 50588763

TOTAL CURRENT

POINT

0.5

-4-34393837

-3-12493360

-3-29507782

-3-65627967

4.5

-2-14541007

-2-32638749

-2-75249038

-1-18223039

8.5

-1-48245750

-14962953

-26433031

-15914791

12.5

-1-88869879

-1-28819918

9 NOW FEW GROUP SCHEME

FEW GROUP 3 NG 30 THRU 33

AVERAGE MACROSCOPIC CROSS SECTIONS

TOTAL ACTIVATION

REGION 1

POINT

0

16569860

16578823

16618861

16600115

4

16858438

17234363

18072440

19981497

8

24514830

36326805

78768133

REGION 2

POINT

10

-1 58226745

11306766

14276894

15934052

14

16473849

ISOTOPIC ACTIVATION

ISOTOPE 1

REGION 1

POINT

0

-2 51327294

-2 51355073

-2 51455919

-2 51693804

4

-2 52221703

-2 53386887

-2 55984686

-2 61902779

8

-2 75957524

-1 11257363

-1 24390112

REGION 2

POINT

10

-1 58209212

11303361

14272595

15930052

14

16468888

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

-1 71414619

26325457

CAPTURE FRACTION

REGION

1

-1 30977688

99969888

9 ROW FEW GROUP SCHEME

FEW GROUP 3 MG 30 THRU 36

ISOTOPIC ACTIVATION

ISOTOPE 2

REGION 1

POINT

0	-5 15460379	-5 15468747	-5 15499123	-5 15570777
4	-5 15729786	-5 16080753	-5 16863240	-5 18645839
8	-5 22879292	-5 33908490	-5 73465863	

REGION 2

POINT

10	-4 17533293	-4 34047041	-4 42990722	-4 47983178
14	-4 49606212			

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

-4 21510916	-4 79295345
-------------	-------------

CAPTURE FRACTION

REGION

1

-5 93308409	-3 30112096
-------------	-------------

9 ROW FEW GROUP SCHEME

FEW GROUP 3 MG 30 THRU 36

ISOTOPIC ACTIVATION

ISOTOPE 3

REGION 1

POINT

0	-2 22500724	-2 22512902	-2 22557111	-2 22661394
4	-2 22892813	-2 23403603	-2 24542419	-2 27136777
8	-2 33298060	-2 49349731	-1 10692073	

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

-1 31306553

00000000

CAPTURE FRACTION

REGION

1

-1 13579917

00000000

9 ROW FEW GROUP SCHEME

FEW GROUP 3 MG 30 THRU 36

ISOTOPIIC ACTIVATION

ISOTOPE 9

REGION 1

POINT

0	-3 37331219	-3 37351423	-3 37424770	-3 37597788
4	-3 37981738	-3 38829197	-3 40718619	-3 45022950
8	-3 55245207	-3 81876726	-2 17739346	

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

-2 51941075	00000000
-------------	----------

CAPTURE FRACTION

REGION

1

-2 22530603	00000000
-------------	----------

9 ROW FEW GROUP SCHEME

FEW GROUP 3 MG 30 THRU 36

ISOTOPIC ACTIVATION

ISOTOPE 18

REGION 1

POINT

0

15790422

15793963

15829970

15903111

4

16065418

16423648

17222276

19041463

8

23361365

34617302

75064337

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

1 21969089

00000000

CAPTURE FRACTION

REGION

1

95295835

00000000

9 ROW FEW GROUP SCHEME

FEW GROUP 3 MG 30 THRU 36

ISOTOPIC ACTIVATION

ISOTOPE 20

REGION 1

POINT

0	-4 36724139	-4 36744015	-4 36816169	-4 36986373
4	-4 37364080	-4 38197756	-4 40056454	-4 44290787
8	-4 54346809	-4 80545246	-3 17450869	

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

-3 51096407 00000000

CAPTURE FRACTION

REGION

1

-3 22164210 00000000

9 ROW FEW GROUP SCHEME

FEW GROUP 3 MG 30 THRU 36

ELEMENTWISE ABSORPTION

ISOTOPE 1

REGION 1

POINT

0	-1 13391946	-1 13391889	-1 13391680	-1 13391179
4	-1 13390040	-1 13387445	-1 13381475	-1 13367393
8	-1 13340103	-1 13306458	-1 13465536	

REGION 2

POINT

10	-1 32136721	-1 32570951	-1 32563280	-1 32556402
14	-1 32554440			

ISOTOPE 2

REGION 1

POINT

0	-5 40338102	-5 40337931	-5 40337301	-5 40335793
4	-5 40332363	-5 40324547	-5 40306563	-5 40265651
8	-5 40181948	-5 40080604	-5 40559764	

REGION 2

POINT

10	-5 96799550	-5 98107503	-5 98084397	-5 98063681
14	-5 98057768			

ISOTOPE 3

REGION 1

POINT

0	-2 58707259	-2 58707010	-2 58706094	-2 58703098
4	-2 58698907	-2 58687531	-2 58661358	-2 58601615
8	-2 58479995	-2 58332501	-2 59029262	

ISOTOPE 9

REGION 1

POINT

0	-3 97401913	-3 97401498	-3 97399978	-3 97395336
4	-3 97388053	-3 97369182	-3 97325757	-3 97226970
8	-3 97024854	-3 96780147	-3 97937145	

ISOTOPE 18

REGION 1

POINT

0	41199224	41199037	41198348	41196699
4	41192947	41184400	41164732	41120001
8	41028593	40918435	41442265	

ISOTOPE 20

REGION 1

POINT

0
4
8-4 95017962
-4 95804328
-4 95447037

SLO P1

-4 95817557
-4 95785764
-4 95206307-4 95816060
-4 95742047
-4 96344492

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-4 95812478
-4 95645863

ABSORPTION

REGION 1

POINT

0
4
843232878
43226312
4305437443232682
43217371
4293910743231962
43196796
4348709443230237
43150002

REGION 2

POINT

10
14-1 32146400
-1 32564245

-1 32580762

-1 32573088

-1 32566209

9 ROW FEW GROUP SCHEME

FEW GROUP 3 MG 30 THRU 36

ELEMENTWISE NU-FISSION

ISOTOPE 1

REGION 1

POINT

0

00000000

00000000

00000000

00000000

4

00000000

00000000

00000000

00000000

8

00000000

00000000

00000000

REGION 2

POINT

10

00000000

00000000

00000000

00000000

14

00000000

ISOTOPE 2

REGION 1

POINT

0

00000000

00000000

00000000

00000000

4

00000000

00000000

00000000

00000000

8

00000000

00000000

00000000

REGION 2

POINT

10

00000000

00000000

00000000

00000000

14

00000000

ISOTOPE 3

REGION 1

POINT

0

00000000

00000000

00000000

00000000

4

00000000

00000000

00000000

00000000

8

00000000

00000000

00000000

ISOTOPE 9

REGION 1

POINT

0

00000000

00000000

00000000

00000000

4

00000000

00000000

00000000

00000000

8

00000000

00000000

00000000

ISOTOPE 18

REGION 1

POINT

0

85375693

85375305

85373878

85370460

4

85362688

85344975

85304222

85211539

8

85022139

84793894

85879283

ISOTOPE 20

REGION 1

POINT

SLO P1

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0	00000000	00000000	00000000	00000000
4	00000000	00000000	00000000	00000000
8	00000000	00000000	00000000	00000000

NU-FISSION

REGION 1

POINT

0	85375693	85375305	85373878	85370460
4	85362688	85344975	85304222	85211539
8	85022139	84793894	85879283	

REGION 2

POINT

10	00000000	00000000	00000000	00000000
14	00000000			

MAXWELLIAN DIFFUSION COEFFICIENT

REGION

1	15384271	-1.86039753
---	----------	-------------

9 ROW FEW GROUP SCHEME

FEW GROUP 3 MG 30 THRU 36

DOUBLE P1 F

2

REGION 1

POINT

0

-4 16522299

-4 21755462

-4 40921757

-4 88992887

4

-3 19257912

-3 43849589

-2 10388710

-2 26309365

8

-2 73970411

-1 22901033

-1 26235733

REGION 2

POINT

10

-1 26235733

-1-26974630

-1-20254467

-1-17346574

14

-1-16623656

DOUBLE P1 D

2

POINT

0.5

10698113

13247357

13252136

13260145

4.5

13271605

13282402

13272830

13186412

8.5

12909573

11459522

-1 64038901

-1 60253637

12.5

-1 64001555

-1 64992375

DOUBLE P1 SIGMA

T

REGION 1

POINT

0

1 15942269

1 15940779

1 15936821

1 15930538

4

1 15920597

1 15905528

1 15887200

1 15883613

8

1 15964161

1 16312135

1 16668335

REGION 2

POINT

10

1 26837839

1 26849269

1 26208411

1 26114589

14

1 26108302

9 ROW FEW GROUP SCHEME

FEW GROUP 3 MG 30 THRU 36

DIFFUSION

POINT				
0.5	15667202	15668163	15671179	15676136
4.5	15684438	15697687	15716117	15729322
8.5	15683395	15394603	-1 85077857	-1 85998654
12.5	-1 86139874	-1 86153575		

SCATTERING CROSS SECTION OF HYDROGEN

REGION 1				
POINT				
0	1 11020038	1 11020003	1 11019871	1 11019557
4	1 11018342	1 11017214	1 11013468	1 11004936
8	1 10987393	1 10965721	1 11065688	
REGION 2				
POINT				
10	1 26409265	1 26683691	1 26678472	1 26674068
14	1 26672821			

SPECTRUM

REGION		
1	-1 14710879	-1 29421757

9 ROW FEW GROUP SCHEME

TRANSFER COEFFICIENT

FEW GROUP

MG

1	1 THRU 22
2	23 THRU 29
3	30 THRU 36

L= 1		K= 1						
POINT								
0	2	13613647	2	13612956	2	13610482	2	13604788
4	2	13592609	2	13567115	2	13514575	2	13408723
8	2	13203537	2	12827792	2	12162553	2	11572791
12	2	11277992	2	11128744	2	11082698		
L= 2		K= 1						
POINT								
0	1	21681779	1	21681603	1	21680913	1	21679045
4	1	21674111	1	21660886	1	21625366	1	21533140
8	1	21314963	1	20873151	1	20065584	1	19456497
12	1	19328185	1	19286185	1	19275627		
L= 3		K= 1						
POINT								
0	1	10611172	1	10611156	1	10611096	1	10610953
4	1	10610629	1	10609893	1	10608199	1	10604290
8	1	10595866	1	10583384	1	10629691	1	10685236
12	1	10683550	1	10682554	1	10682263		
L= 1		K= 2						
POINT								
0	1	69937740	1	69944488	1	69968671	1	70024322
4	1	70143343	1	70392482	1	70905913	1	71940224
8	1	73945249	1	77616869	1	84119714	1	89881949
12	1	92760514	1	94217671	1	94667225		
L= 2		K= 2						
POINT								
0	2	17680855	2	17680873	2	17680943	2	17631125
4	2	17681581	2	17682733	2	17685628	2	17692602
8	2	17707731	2	17735270	2	17778262	2	17807683
12	2	17814807	2	17817332	2	17817994		
L= 3		K= 2						
POINT								
0	2	18276364	2	18276335	2	18276233	2	18275986
4	2	18275428	2	18274160	2	18271242	2	18264510
8	2	18250800	2	18229019	2	18308260	2	18403929
12	2	18401025	2	18399310	2	18398851		
L= 1		K= 3						
POINT								
0	1	14576726	1	14578132	1	14583172	1	14594772
4	1	14619579	1	14671505	1	14778517	1	14994092
8	1	15411938	1	16177243	1	17532594	1	18733584
12	1	19333547	1	19637254	1	19730953		

L= 2 K= 3
POINT

0	1 62460829	1 62460845	1 62460982	1 62461681
4	1 62464623	1 62475755	1 62514888	1 62641564
8	1 63003973	1 63878033	1 65803421	1 67388452
12	1 67681581	1 67768892	1 67789682	

L= 3 K= 3
POINT

0	2 19963657	2 19963559	2 19963200	2 19962339
4	2 19960381	2 19955916	2 19945643	2 19922338
8	2 19875124	2 19820035	2 20092709	2 20401566
12	2 20396840	2 20392073	2 20390694	

EDIT OVER ALL GROUPS

TOTAL FLUX

REGION 1
POINT

0	1 40076545	1 40090605	1 40141538	1 40261164
4	1 40524728	1 41099874	1 42358745	1 45138133
8	1 51375237	1 65940590	2 10624168	

REGION 2
POINT

10	2 10624168	2 16606958	2 20233897	2 22314773
14	2 22997037			

REGIONWISE VOLUME INTEGRAL OF TOTAL FLUX

REGION
1

2 48008973	2 37983114
------------	------------

TOTAL CURRENT

POINT

0.5	-3-47963292	-2-17363565	-2-40717449	-2-89458880
4.5	-1-19432835	-1-42232330	-1-92194943	-20286215
8.5	-45244341	1-10377182	1-15610816	1-10786501
12.5	-63316704	-20875625		

AVERAGE MACROSCOPIC CROSS SECTIONS

TOTAL ACTIVATION

REGION 1

POINT

0	63612968	63642689	63750472	64004156
4	64565027	65795417	68509901	74576432
8	88459180	1 12200842	1 22262045	

REGION 2

POINT

10	17763557	30087920	37314149	41426546
14	42771358			

ISOTOPIC ACTIVATION

ISOTOPE 1

REGION 1

POINT

0	-1 21864898	-1 21874914	-1 21911228	-1 21996666
4	-1 22185455	-1 22599241	-1 23510975	-1 25544662
8	-1 30184390	-1 41338559	-1 74408269	

REGION 2

POINT

10	17758208	30078860	37302913	41414072
14	42758479			

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

27928267	69527093
----------	----------

CAPTURE FRACTION

REGION

1

-1 34124264	99969889
-------------	----------

SLO PI
ISOTOPIC ACTIVATION

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ISOTOPE 2

REGION 1
POINT

0	-5 65859623	-5 65889792	-5 65999174	-5 66256530
4	-5 66825179	-5 68071551	-5 70817798	-5 76943502
8	-5 90918902	-4 12451656	-4 22412639	

REGION 2
POINT

10	-4 53489792	-4 90601033	-3 11236073	-3 12474401
14	-3 12879353			

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION
1

-4 84123197	-3 20942371
-------------	-------------

CAPTURE FRACTION

REGION
1

-4 10278626	-3 30112096
-------------	-------------

ISOTOPIC ACTIVATION

ISOTOPE 3

REGION 1

POINT

0	-2 95850766	-2 95894673	-2 96053866	-2 96428415
4	-2 97256015	-2 99069961	-1 10306679	-1 11198202
8	-1 13232153	-1 18121889	-1 32618902	

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

12243120

00000000

CAPTURE FRACTION

REGION

1

-1 14959305

00000000

ISOTOPIC ACTIVATION

ISOTOPE 9

33
75REGION 1
POINT

0	-2 15902714	-2 15909999	-2 15936411	-2 15998553
4	-2 16135861	-2 16436815	-2 17099934	-2 18579070
8	-2 21953623	-2 30066241	-2 54118408	

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION
1

-1 20312706	00000000
-------------	----------

CAPTURE FRACTION

REGION
1

-2 24819162	00000000
-------------	----------

ISOTOPIC ACTIVATION

ISOTOPE 18

REGION 1

POINT

0

60292641

60320842

60423110

60663819

4

61196022

62363575

64939607

70697309

8

83875485

1 11573090

1 21132108

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

1 77601751

00000000

CAPTURE FRACTION

REGION

1

94818010

00000000

ISOTOPIC ACTIVATION

ISOTOPE 20

REGION 1

POINT

0	-3 15644104	-3 15651271	-3 15677253	-3 15738384
4	-3 15873460	-3 16169519	-3 16821855	-3 18276937
8	-3 21596613	-3 29577304	-3 53238335	

REGIONWISE VOLUME INTEGRAL OF ACTIVATION

REGION

1

-2 19982381	00000000
-------------	----------

CAPTURE FRACTION

REGION

1

-3 24415552	00000000
-------------	----------

ELEMENTWISE ABSORPTION

ISOTOPE 1

REGION 1

POINT

0	-2 54557842	-2 54563690	-2 54584924	-2 54634953
4	-2 54745475	-2 54986157	-2 55504417	-2 56592192
8	-2 58752799	-2 62690610	-2 70036797	

REGION 2

POINT

10	-1 16714916	-1 18112203	-1 18435852	-1 18559038
14	-1 18593038			

ISOTOPE 2

REGION 1

POINT

0	-5 16433458	-5 16435220	-5 16441616	-5 16456685
4	-5 16489976	-5 16562472	-5 16718578	-5 17046229
8	-5 17697028	-5 18883143	-5 21095900	

REGION 2

POINT

10	-5 50347277	-5 54556069	-5 55530936	-5 55901987
14	-5 56004400			

ISOTOPE 3

REGION 1

POINT

0	-2 23916923	-2 23919487	-2 23928795	-2 23950727
4	-2 23999177	-2 24104687	-2 24331880	-2 24808737
8	-2 25755897	-2 27482145	-2 30702547	

ISOTOPE 9

REGION 1

POINT

0	-3 39680852	-3 39685106	-3 39700549	-3 39736936
4	-3 39817321	-3 39992373	-3 40369312	-3 41160470
8	-3 42731915	-3 45595954	-3 50938962	

ISOTOPE 18

REGION 1

POINT

0	15044371	15046129	15052515	15067577
4	15100908	15173666	15330862	15662434
8	16326053	17550782	19890600	

ISOTOPE 20

REGION 1

POINT

0	-4 39035562	-4 39039747	-4 39054939	-4 39090734
4	-4 39169811	-4 39342017	-4 39712826	-4 40491118
8	-4 42037009	-4 44854471	-4 50110592	

TOTAL ABSORPTION

REGION 1

POINT

0	15072867	15874714	15881422	15897244
4	15932254	16008666	16173732	16521823
8	17218252	18502780	20954155	

REGION 2

POINT

10	-1 16719951	-1 18117659	-1 18441405	-1 18564628
14	-1 18593639			

FLUX-WEIGHTED REGIONWISE VOLUME INTEGRAL OF TOTAL ABSORPTION

REGION

1	1 81842837	69548034
---	------------	----------

ELEMENTWISE NU-FISSION

ISOTOPE 1

REGION 1

POINT

0	00000000	00000000	00000000	00000000
4	00000000	00000000	00000000	00000000
8	00000000	00000000	00000000	

REGION 2

POINT

10	00000000	00000000	00000000	00000000
14	00000000			

ISOTOPE 2

REGION 1

POINT

0	00000000	00000000	00000000	00000000
4	00000000	00000000	00000000	00000000
8	00000000	00000000	00000000	

REGION 2

POINT

10	00000000	00000000	00000000	00000000
14	00000000			

ISOTOPE 3

REGION 1

POINT

0	00000000	00000000	00000000	00000000
4	00000000	00000000	00000000	00000000
8	00000000	00000000	00000000	

ISOTOPE 9

REGION 1

POINT

0	00000000	00000000	00000000	00000000
4	00000000	00000000	00000000	00000000
8	00000000	00000000	00000000	

ISOTOPE 18

REGION 1

POINT

0	31307697	31311392	31324814	31356472
4	31426512	31579351	31909402	32605025
8	33995429	36555565	41424677	

ISOTOPE 20

REGION 1

POINT

0	00000000	00000000	00000000	00000000
4	00000000	00000000	00000000	00000000
8	00000000	00000000	00000000	

TOTAL NU-FISSION

REGION 1

POINT

0

31307697

31311392

31324814

31356472

4

31426512

31579351

31909402

32605025

8

33995429

36555565

41424677

REGION 2

POINT

10

00000000

00000000

00000000

00000000

14

00000000

FLUX-WEIGHTED REGIONWISE VOLUME INTEGRAL OF TOTAL NU-FISSION

REGION

1

2 16154881

00000000

MAXWELLIAN

DIFFUSION

COEFFICIENT

REGION

1

26165567

15291394

SLO P1
DOUBLE P1 F

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2

REGION 1

POINT

0	-3 34759218	-3 45516717	-3 84481504	-2 17597938
4	-2 37752151	-2 81713230	-1 17782899	-1 38921751
8	-1 85441148	17973315	15488385	

REGION 2

POINT

10	15488385	-15459524	-16887484	-16437082
14	-16225596			

DOUBLE P1 D

2

POINT

0.5	15614844	18244419	18214564	18167055
4.5	18095372	17986493	17814699	17524988
8.5	16973865	19725455	-1 84720015	11054461
12.5	-1 61648485	-1 74907545		

DOUBLE P1 SIGMA

T

REGION 1

POINT

0	1 10826505	1 10831566	1 10844748	1 10865722
4	1 10897378	1 10945012	1 11018014	1 11134770
8	1 11335512	1 11716751	1 12115311	

REGION 2

POINT

10	1 20220827	1 20214332	1 19559931	1 19373552
14	1 19331172			

TOTAL SCATTERING

REGION 1

POINT

0	91692442	91694535	91702154	91720135
4	91759972	91847093	92035910	92436361
8	93246427	94777221	97914840	

REGION 2

POINT

10	1 19814831	1 20449204	1 20585127	1 20635449
14	1 20649198			

FLUX-WEIGHTED REGIONWISE VOLUME INTEGRAL OF TOTAL SCATTERING

REGION

1	2 44693196	2 77964249
---	------------	------------

DIFFUSION

POINT

0.5	29586386	29567046	29521283	29439637
4.5	29307441	29103604	28791399	28303103
8.5	27502163	26070635	14551926	14987993
12.5	15148382	15204523		

FLUX-WEIGHTED REGIONWISE VOLUME INTEGRAL OF DIFFUSION

REGION

1	2 13867396	1 56305178
---	------------	------------

BOUNDARY CHECK

POINT

0

00000000

POINT

14

00000000

GROUP 1

F
0

POINT

0	1 17486202	1 17485819	1 17484484	1 17481565
4	1 17475669	1 17463988	1 17440950	1 17395467
8	1 17304284	1 17101419	1 16370488	1 15766257
12	1 15613133	1 15550127	1 15531829	

F
1

POINT

0.5	-4 46069555	-3 16015797	-3 35056052	-3 70795977
4.5	-2 14025277	-2 27653045	-2 54459881	-1 10728550
8.5	-1 21227838	-1 43336322	-1 44798278	-1 22983309
12.5	-1 11101276	-2 33049145		

F
2

POINT

0	-4-45592286	-4-56448955	-4-94189764	-3-17680270
4	-3-34364232	-3-67414546	-2-13254116	-2-26024659
8	-2-50391325	-2-87379446	-3-44990252	-2 90471625
12	-2 60760375	-2 40931867	-2 34799209	

F
3

POINT

0.5	-5 22416639	-5 83715250	-4 18324893	-4 37007741
4.5	-4 73310968	-3 14446143	-3 28327139	-3 54049226
8.5	-3 82045667	-2-18384225	-2-21066034	-3 65904381
12.5	-3 43982854	-3 13603234		

GROUP 7

F
0

POINT

0	1 23466454	1 23465992	1 23464404	1 23460998
4	1 23454292	1 23441384	1 23416707	1 23369601
8	1 23278946	1 23092256	1 22542613	1 22084550
12	1 21939342	1 21875055	1 21856014	

F
1

POINT

0.5	-4 44078683	-3 15141501	-3 32431375	-3 63728887
4.5	-2 12241198	-2 23343676	-2 44372542	-2 84174357
8.5	-1 15969901	-1 30720287	-1 31965724	-1 17270240
12.5	-2 85713202	-2 25874702		

F
2

POINT

0	-4-40694555	-4-49506140	-4-79741635	-3-14427490
4	-3-27046578	-3-51148963	-3-96796701	-2-18258200
8	-2-33882529	-2-56178984	-3-38095868	-2 59104043
12	-2 41958737	-2 29559360	-2 25633273	

F
3

POINT

0.5	-5 17174983	-5 63837025	-4 13625084	-4 26643027
4.5	-4 50888022	-4 96377317	-3 18112085	-3 32988073
8.5	-3 47075115	-2-11056894	-2-13283127	-3 36199354
12.5	-3 26179143	-4 82892566		

GROUP 14

F
0

POINT

0	1 36941346	1 36941670	1 36942922	1 36946139
4	1 36953836	1 36971729	1 37012547	1 37104404
8	1 37310414	1 37797475	1 39451473	1 41027380
12	1 41619396	1 41919879	1 42014899	

F
1

POINT

0.5	-4-26771137	-3-10162793	-3-25504690	-3-59786167
4.5	-2-13667858	-2-30772635	-2-68490751	-1-15113340
8.5	-1-33232420	-1-74729840	-1-85684122	-1-47753238
12.5	-1-24994373	-2-78223117		

F
2

POINT

0	-4 23664016	-4 32982042	-4 67372113	-3 15006305
4	-3 33598649	-3 74621433	-2 16431972	-2 35891532
8	-2 77173979	-1 15091395	-2 37362985	-1-14786648
12	-1-10796638	-2-82391033	-2-74876685	

F
3

POINT

0.5	-5-16907728	-5-71275493	-4-17138194	-4-38533752
4.5	-4-85022188	-3-18590510	-3-40331108	-3-85560358
8.5	-2-15283053	-2 23534121	-2 38389921	-3-82695361
12.5	-3-53006442	-3-15573936		

GROUP 22

F
0

POINT

0	2 11511665	2 11516970	2 11536045	2 11580207
4	2 11675473	2 11877407	2 12302144	2 13189449
8	2 15030151	2 18857232	2 27477289	2 38272990
12	2 45424791	2 49657730	2 51062344	

F
1

POINT

0.5	-2-25756825	-2-92488800	-1-21359231	-1-45905899
4.5	-1-96793186	-20205924	-41739157	-84969818
8.5	1-16920978	1-32550893	1-43689300	1-32643263
12.5	1-19842093	-66326493		

F
2

POINT

0	-2 20935044	-2 27109038	-2 49157228	-2 99526829
4	-1 20601629	-1 42523400	-1 86689424	17295800
8	33138480	56613375	38877043	-41078874
12	-55099164	-57908481	-58330619	

F
3

POINT

0.5	-3-10577950	-3-43175350	-3-98635087	-2-20853048
4.5	-2-42927794	-2-86487080	-1-16893341	-1-31023557
8.5	-1-45969160	-1 34731753	15657180	-1 27454904
12.5	-2 55012797	-3 82664149		

GROUP 29

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F
0

POINT

0	2 26227566	2 26242825	2 26298279	2 26429372
4	2 26721259	2 27368444	2 28818713	2 32131045
8	2 39918767	2 59200778	3 11582844	3 20279858
12	3 25506158	3 28479087	3 29449879	

F
1

POINT

0.5	-2-37812738	-1-13754896	-1-32583287	-1-72790339
4.5	-16220727	-35616137	-84468548	1-20078176
8.5	1-49534711	2-12751820	2-20246012	2-13502870
12.5	1-77567391	1-25334277		

F
2

POINT

0	-2 23143997	-2 30538352	-2 57714636	-1 12344063
4	-1 27512126	-1 62944341	14826008	36169403
8	91187214	1 22347214	1 21453621	1-20983477
12	1-20582216	1-18885498	1-18321538	

F
3

POINT

0.5	-4-97285716	-3-43483649	-2-10516545	-2-24269791
4.5	-2-56693624	-1-13651020	-1-34150686	-1-88031727
8.5	-21166364	-1 14298019	67901845	-2-64204072
12.5	-1-27148482	-2-90236936		

GROUP 36

F
0

POINT

0	1 10527958	1 10533327	1 10552806	1 10598702
4	1 10700352	1 10923943	1 11419318	1 12534247
8	1 15120165	1 21624914	1 51090956	2 11054123
12	2 13868855	2 15446679	2 15961090	

F
1

POINT

0.5	-4-29240761	-3-10609802	-3-24999445	-3-55372173
4.5	-2-12181098	-2-26992770	-2-60774307	-1-14113091
8.5	-1-35890122	-16087727	-42804671	-20593643
12.5	-11488539	-1-37437322		

F
2

POINT

0	-5 30574925	-5 40287289	-5 75577268	-4 15958349
4	-4 34924732	-4 77886540	-3 17768166	-3 42290077
8	-2 11516490	-2 65717192	-1 15440044	-1-14340898
12	-2-59362093	-2-50348842	-2-48664425	

F
3

POINT

0.5	-7-22683241	-6-10196703	-6-24272796	-6-54801554
4.5	-5-12413405	-5-28834848	-5-70853724	-4-21056484
8.5	-3-15660776	-3-25624178	-3 86049193	-3-24284547
12.5	-4-26042930	-5-48669646		

SLO P1 EDIT IS COMPLETED

APPENDIX B

SLOP-1 Library Routines

G. Culpepper

LTP7

LTP7 is the library-program tape writing routine for SLOP-1 and is similar to LTP1 and LTP4 for MUFT-4 and PLMG, respectively. The LTP7 program deck contains the SLOP-1 coefficient, iteration and edit routines. In addition, library information on cards must be inserted into the deck and a previously prepared tape containing the elastic scattering transfer coefficients and other relevant quantities must be available.

I. Description of library-program tape

File 1

Record 1. Loader

Record 2. Coefficient Routine

File 2

Record 1. Table of contents for library

M = Number of groups

I = Number of isotopes in the library ($I \leq 99$)

T = Number of temperatures in the library ($T \leq 32767$)

L = Library number ($0 < L \leq 9999$)

i = Isotope numbers (on tape) in ascending order

t = Temperatures in degrees centigrade (on tape) in ascending order

Record 2. Energy increments

$$\Delta F^0, \Delta E^1, \dots, \Delta E^m$$

$$\text{where } E^0 > E^1 > \dots > E^m > 0$$

File 3

Record i.

$$(\sigma_s)_i^1, (\sigma_a)_i^1, (v\sigma_f)_i^1, (1-\bar{\mu})_i^1,$$

$$(\sigma_s)_i^2, (\sigma_a)_i^2, (v\sigma_f)_i^2, (1-\bar{\mu})_i^2,$$

$$\vdots \quad \vdots \quad \vdots \quad \vdots$$

$$(\sigma_s)_i^M, (\sigma_a)_i^M, (v\sigma_f)_i^M, (1-\bar{\mu})_i^M.$$

File 4 - Maxwellian flux distribution spectrum for temperature t.

Record t.

$$X_t^1, X_t^2, \dots, X_t^M$$

$$\text{Here (Ref. 3) } X_t^m = \left(Z^2 e^{-Z^2} \right)_t^m$$

File 5 - Source distribution spectrum $\left[I(Z)_t^m \right]$ and scattering cross section

$$\left[(p_o)_t^m \right] \text{ and the transfer coefficients } \left[(a_{\ell})_t^{r,m} \right] \text{ of the moderator}$$

for temperature t.

Record t.

$$I(Z)_t^1, I(Z)_t^2, \dots, I(Z)_t^M,$$

$$(p_o)_t^1, (p_o)_t^2, \dots, (p_o)_t^M,$$

$$\begin{aligned}
& (a_o)_t^{1,1}, (a_o)_t^{2,1}, \dots, (a_o)_t^{M,1}, \\
& (a_o)_t^{1,2}, (a_o)_t^{2,2}, \dots, (a_o)_t^{M,2}, \\
& \vdots \quad \quad \quad \vdots \quad \quad \quad \vdots \\
& (a_o)_t^{1,M}, (a_o)_t^{2,M}, \dots, (a_o)_t^{M,M}, \\
& (a_1)_t^{1,1}, (a_1)_t^{2,1}, \dots, (a_1)_t^{M,1}, \\
& \vdots \quad \quad \quad \vdots \quad \quad \quad \vdots \\
& (a_1)_t^{1,M}, (a_1)_t^{2,M}, \dots, (a_1)_t^{M,M}, \\
& (a_2)_t^{1,1}, (a_2)_t^{2,1}, \dots, (a_2)_t^{M,1}, \\
& \vdots \quad \quad \quad \vdots \quad \quad \quad \vdots \\
& (a_2)_t^{1,M}, (a_2)_t^{2,M}, \dots, (a_2)_t^{M,M}, \\
& (a_3)_t^{1,1}, (a_3)_t^{2,1}, \dots, (a_3)_t^{M,1}, \\
& \vdots \quad \quad \quad \vdots \quad \quad \quad \vdots \\
& (a_3)_t^{1,M}, (a_3)_t^{2,M}, \dots, (a_3)_t^{M,M},
\end{aligned}$$

Here (see Ref. 3)

$$I(Z)_t^m = f(Z_n) \quad (\text{ECESS, Eqs. 24, 25})$$

$$(p_o)_t^m = p_{\ell}, \text{ where } \ell = 0 \quad (\text{ECESS, Eq. 22})$$

$$(a_{\ell})_t^{r,M} = A_{\ell}^{j \rightarrow n} \quad (\text{ECESS, Eq. 21})$$

File 6

Record 1. Loader

Record 2. Iteration Routine, Section 1

Record 3. Iteration Routine, Section 2

File 7

Record 1. Loader

Record 2. Edit Routine

II. Input to LTP7^{*}

The first field on every card must contain the file number associated with the data on the card.

File 2

Record 1.

First card: Control card

<u>Field</u>	<u>Information</u>
2	M (fixed pt. integer)
3	I (fixed pt. integer)
4	T (fixed pt. integer)
5	L (fixed pt. integer)

Fill in rest of card with zeros.

Second card(s): Isotope numbers.

<u>Field</u>	<u>Information</u>
2	$\pm i_1$
3	$\pm i_2$
$\vdots$	$\vdots$ (all fixed pt. integers)
17	$\pm i_{16}$

If the sign is positive, then only one card is supplied for that isotope in File 3. The $(\sigma_s)_i^m$ and $(1-\bar{\mu})_i^m$ will be considered to be constant over all the groups and the $(\sigma_a)_i^m$ and $(\nu\sigma_f)_i^m$ will be considered to be 1/v-type

^{*}The field format of these cards is the same as for the input cards to SLOP-1.

cross sections over all the groups. If the sign is negative, then the data for that isotope in File 3 must be specified for every group.

Fill in rest of card with zeros. Use as many cards as necessary.

Third card(s): Temperature numbers.

<u>Field</u>	<u>Information</u>
2	t_1
3	t_2
:	(all fixed pt. integers)
:	:
17	t_{16}

Fill in rest of card with zeros. Use as many cards as necessary.

Record 2:

Cards with energy levels.

<u>Field</u>	<u>Information</u>
2	0
3	0
4	E^m
5	E^m
:	(all floating pt.)
:	:
11	E^m

Start with highest energy level, E^0 , and specify levels in descending magnitude, ending with E^M . Fill in rest of card with zeros. Use as many cards as necessary.

File 3

Record i.

Cards with microscopic cross sections

<u>Field</u>	<u>Information</u>
2	i (fixed pt. integer)
3	m (fixed pt. integer)
4	$(\sigma_s)_i^m$
5	$\sqrt{E} (\sigma_a)_i^m$ (all floating pt.)
6	$\sqrt{E} (v\sigma_f)_i^m$
7	$(1-\bar{\mu})_i^m$

Fill in rest of card with zeros. The two cross sections, $\sqrt{E} (\sigma_a)_i^m$ and $\sqrt{E} (v\sigma_f)_i^m$ are divided by $\sqrt{E^m}$ before being placed onto the tape. If the same values of the four quantities are to be used in each group (designated by a positive isotope number on the second card for File 2, Record 1), only one card for that isotope is required ($m = 1$). If different values are to be used (a negative isotope number on the second card), there must be one card for each group with all four floating point quantities.

A blank card should be placed after every deck (or group of cards) that will be used to write one complete record.

Files 4 and 5

Information for Files 4 and 5 is taken from a tape which has previously been written by ECESS, FEFS, or FEFS2, hereafter called the ECESS tape.

III. Operating Instructions

Place a blank on logical tape 1. Place the ECESS tape on logical tape 3.

Place LTP7 and assembled decks in hopper.

CLEAR, LOAD CARDS.

End-of-run programmed stop: 00351.

Error stops.

02227	WH001 blank card return. Input error.
02230	WH001 count end-of-file return. Machine error.
02301	RWT end-of-file return. Writing tape 1. Machine error.
02302	RWT error return. Writing tape 1. Machine error.
02322	Same as 02227.
02323	Same as 02230.
02333	Input error. Energy levels not specified in proper order. (E_M is not greater than E_{M+1} .)
02342	SQRT error return due to negative energy.
02355	Same as 02301.
02356	Same as 02302.
02412	Same as 02227.
02413	Same as 02230.
02454	Same as 02301.
02455	Same as 02302.
02471	RWT end-of-file return. Machine error. Reading tape 3.
02472	RWT error return. Reading tape 3. Bad tape 3.
02477	Same as 02301.
02500	Same as 02302.

02535	Same as 02474.
02536	RWT error return. Machine error. Reading tape 3.
02547	Same as 02301.
02550	Same as 02302
02565	File number wrong on one of first few cards.
02566	File number wrong on one of energy cards.
02567	File number wrong on one of cross section cards.
02570	Element number wrong on one of cross section cards.
02571	Group number wrong on one of cross section cards.
02572	Block size wrong on ECESS tape. Probably wrong tape.

LTP9

This routine edits onto tape for off-line printing a complete listing of the SLOP-1 library-program tape. It is similar to LTP3 and LTP6 for MUFT-4 and PLMG except for the use of sense switches. Unlike LTP3 and LTP6, sense switches must be used in order to have the matrices in each record of File 5 printed out. To print $(a_0)^{r,m}$, $(a_1)^{r,m}$, $(a_2)^{r,m}$, and/or $(a_3)^{r,m}$ the sense switches 1, 2, 3, and/or 4, respectively, should be down. If a sense switch is up, the printing of the corresponding matrix is skipped for each temperature.

Operating Instructions

Put the SLOP-1 library-program tape on logical tape 1 and a blank on logical tape 2.

Place LTP9 in hopper.

CLEAR, LOAD CARDS.

End-of-run programmed stop is 02204.

Error stops

01651	Impossible end-of-file return. Reading tape 1.
01652	Bad tape 1. Reading File 2, Record 2.
01710	End-of-file return. Reading tape 1. Bad tape.
01711	RWT error return. Reading tape 1. Bad tape.
02013	Same as 1710.
02014	Same as 1711.
02057	Same as 1710.
02060	Same as 1711.
02473	Wrong record length in File 4.
02474	Record misplaced in File 3.
02475	Wrong record length in File 3.
02476	Record misplaced in File 4.
02477	Record misplaced in File 5.
02500	Wrong record length in File 5.
00603	GLOUT error stop.
00662	GLOUT error stop.

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