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DRACO — A THREE-DIMENSIONAL FEW-GROUP DEPLETION CODE FOR THE IBM-704

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D. S. McCarty • C. M. King • J. T. Mandel • H. P. Henderson

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DRACO is a three-dimensional few-group depletion code programmed for the IBM-704. It is used in studying the neutron flux, the power level, and the related buildup and depletion of materials at different stages in the lifetime of a reactor. The three sections of the code are described, and the background documents are referenced.

DRACO—A THREE-DIMENSIONAL FEW-GROUP DEPLETION CODE FOR THE IBM-704

D. S. McCarty, C. M. King,
J. T. Mandel, and H. P. Henderson

I. INTRODUCTION

DRACO is essentially a three-dimensional version of TURBO (Ref 1) with various modifications and several additional features.

It provides a means for studying the neutron flux, the power level, and the related buildup and depletion of materials at different stages in the lifetime of a reactor. Group constants are calculated and used in solving the neutron diffusion equations. The resulting fluxes are normalized to a specified output power. With the assumption that these fluxes are constant for a specified period of time (referred to as a "time-step"), new isotopic densities are calculated for new isotopic densities are calculated for the time-dependent elements (U-235, U-236, U-238, Pu-239, Pu-240, Pu-241, Pm-149, I-135, Sm-149, Xe-135, lumped fission products, B-10, and one unnamed poison).

The code requires the following quantities as input for each time-step: information describing the geometry of the problem; option control information; the length of the time-step; net power per time-step; initial eigenvalue guess; convergence criterion; percentage of homogeneous poison per group; integral of the fission spectrum for thermal groups; the iodine yield for U-235, U-238, Pu-239, and Pu-241; thermal cross sections; flux guess; material buckling for two-group problems; resonance escape probability of U-238; homogeneous poison; isotopic densities; thermal self-shielding (optional); and logarithmic derivatives (optional). The geometry, the number of lethargy groups, the mesh spacing, and the time-dependent isotopic densities may not be changed between time-steps. All other data may be adjusted as desired by the problem originator.

During a time-step calculation the most important information printed on-line pertains to the progress of the iteration. A binary output tape is generated from which various quantities may be edited for off-line printing. Information vital to the running of succeeding time-steps and the maximum-xenon case is accumulated on a history tape for each problem.

DRACO-1 requires 16,384 or 32,768 words of core storage, at least one drum unit, and nine tape units. DRACO-2, the maximum-xenon calculation, requires ten tape units. DRACO-3, the off-line edit routine, requires a maximum of nine tapes.

II. NOTATION

For convenience, the notation used throughout this report is defined herein.

B^2 = material buckling equivalent to the B^2 which is input to the MUFT code

c = composition

D = diffusion coefficient

g = thermal self-shielding

i = group number

K = thermal group

M = element number, 1-30 (See Appendix I.)

N = isotopic density

p_r = resonance escape probability of U-238

P = net power per time-step

(rp) = mesh rectangular parallelepiped

t^i = fraction of homogeneous poison per group

(x, y, z) = interior point

Δt = length of time-step

ϵ = convergence criterion

κ = energy produced per fission

λ = eigenvalue

ν = number of neutrons produced per fission for a certain element

σ_a = microscopic absorption cross section

σ_f = microscopic fission cross section

σ_r = microscopic removal cross section

σ_{tr} = microscopic transport cross section

Σ_a = macroscopic absorption cross section

$\nu\Sigma_f$ = macroscopic fission cross section

Σ_p = homogeneous poison

Σ_r = macroscopic removal cross section

φ = pointwise, source-normalized flux

$\overline{\varphi}$ = average flux for mesh rectangular parallelepiped

Φ = power-normalized flux for mesh rectangular parallelepiped

χ = integral of the fission spectrum

III. REGION OF SOLUTION

A mesh is imposed on the region under consideration by defining a set of X, Y, and Z coordinate axes and by spacing horizontal and vertical planes along these axes. With ss, tt, and uu

referring to the number of the last plane in the X, Y, and Z coordinate directions, respectively, and with numbering of planes beginning at zero, the following conditions must be met:

1) ss = tt;

2) $3 \leq ss \leq 28$, $3 \leq uu \leq 28$;

3) $1/2\ ss(ss-1)\ (uu-1) \leq 2685$ or 4750 for machines of 16,384 or 32,768 words of core storage, respectively; and

4) the plane x = y is always a plane of symmetry.

Interior points are defined as those points where planes parallel to the XY, XZ, and YZ planes intersect on and within the plane limits of x = 1, y = ss, x = y, z = 1, and z = uu-1.

A mesh rectangular parallelepiped is defined by its eight vertices—(x,y,z), (x+1,y,z), (x,y+1,z), (x+1,y+1,z), (x,y,z+1), (x+1,y,z+1), (x,y+1,z+1), and (x+1,y+1,z+1)—where values of z range from zero to uu-1 and values of x and y fall on and within the limits of x = 0, y = ss-1, and x = y.

A composition, made up of one or more mesh rectangular parallelepipeds, is identified by the material which is initially contained in that region and by the parameters which apply to that region. A maximum of fifty compositions is handled by the code; any of thirty elements (see Appendix I) which are described by their isotopic densities and thermal self-shielding may be included in a composition. At the beginning of each time-step, a composition number is assigned to each rectangular parallelepiped of the mesh. This number indicates which parameters and which time-independent isotopic densities apply to the rectangular parallelepiped for that time-step. At the beginning of life, the number also identifies the initial isotopic densities of the time-dependent elements which are to be associated with the mesh rectangular parallelepiped.

Zero flux or zero current may be imposed at any of the outer boundaries. If zero current is imposed at some boundary, the first plane interior to that boundary is a plane of symmetry.

The code will handle only two- or four-lethargy groups.

IV. GROUP CONSTANTS

For use in the solution of the neutron diffusion equations, D, Σ_r, Σ_a, and $\nu\Sigma_f$ are evaluated for every rectangular parallelepiped of the mesh.

In a four-group scheme these quantities are calculated (Ref 2) as follows:

1) Diffusion coefficient

$$D^i(rp) = \left[3 \sum_{M=1}^{30} N^M(rp)\, \sigma_{tr}^{M,i}\right]^{-1} \quad \text{for } i = 1, 2, 3$$

and

$$D^4(rp) = \left[3 \sum_{M=1}^{30} N^M(rp)\, (\sigma_{tr})_c^{M,4}\right]^{-1};$$

2) Removal cross section

$$\Sigma_r^i(rp) = \sum_{M=1}^{30} N^M(rp)\, \sigma_r^{M,i} \quad \text{for } i = 1, 2,$$

$$\Sigma_r^3(rp) = p_r \frac{(a+1)}{(a+p_r)} \sum_{M=1}^{30} N^M(rp)\, \sigma_r^3 -$$

$$\frac{a}{a+p_r}\left[N^{20}(rp)\,\sigma_a^{20,3}+p_r\sum_{M\neq 20}N^{M}(rp)\,\sigma_a^{M,3}\right];$$

and

$$\Sigma_r^4(rp)=0\ ;$$

3) Absorption cross section

$$\Sigma_a^i(rp)=\sum_{M=1}^{30}N^M(rp)\,\sigma_a^{M,i}+t^i(\Sigma_p)_c\quad\text{for } i=1,\ 2\ ,$$

$$\Sigma_a^3(rp)=\sum_{M=1}^{30}N^M(rp)\,\sigma_a^{M,3}+\frac{(1-p_r)}{p_r}\left[\Sigma_r^3(rp)+N^{20}(rp)\,\sigma_a^{20,3}\right]\ ,$$

and

$$\Sigma_a^4(rp)=\sum_{M=1}^{30}N^M(rp)\,g_c^M\,(\nu_a)_c^{M,4}+t^i(\Sigma_p)_c\ ;$$

4) Fission cross section:

$$\nu\Sigma_f^i(rp)=\sum_{\substack{M=18,20\\21,23}}N^M(rp)\,(\nu\sigma_f)^{M,i}\quad\text{for } i=1,\ 2,\ 3$$

and

$$\nu\Sigma_f^4(rp)=\sum_{\substack{M=18,20\\21,23}}N^M(rp)\,g_c^M\,(\nu\sigma_f)_c^{M,4}\ .$$

In a two-group scheme the preceding equations for the thermal constants are valid. Quantities for three, fast neutron energy groups are calculated as above with the exception that the $t^i(\Sigma_p)_c$ term is omitted in the absorption cross section. These values are applied in the following editing procedure to obtain constants for the epithermal group of this scheme.

For i = 1, 2, 3, a group flux is defined as

$$\Gamma^i(rp)=\frac{\Gamma_{(rp)}^{i-1}\,\Sigma_r^{i-1}(rp)+\chi^i}{D^i(rp)\,B_c^2+\Sigma_r^i(rp)+\Sigma_a^i(rp)}\ ,$$

where the χ's are program constants.

The group constants then become

$$D^i(rp)=\frac{\sum_{i=1}^{3}D^i(rp)\,\Gamma^i(rp)}{\sum_{i=1}^{3}\Gamma^i(rp)}\ ;$$

$$\Sigma_r^1(rp)=\frac{\Sigma_r^3(rp)\,\Gamma^3(rp)}{\sum_{i=1}^{3}\Gamma^i(rp)}\ ,$$

$$\Sigma_a^1(rp) = \frac{\sum_{i=1}^{3} \Sigma_a^i(rp)\ \Gamma^i(rp)}{\sum_{i=1}^{3} \Gamma^i(rp)} + t^1(\Sigma_p)_c \ ,$$

and

$$\nu\Sigma_f^1(rp) = \frac{\sum_{i=1}^{3} (\nu\Sigma_f)^i(rp)\ \Gamma^i(rp)}{\sum_{i=1}^{3} \Gamma^i(rp)} \ .$$

The isotopic densities for elements 1-17 are input for each time-step and are assumed to be constant within a composition. At time-step zero this is also true of the densities for elements 18-30. Thereafter, the time-dependent isotopic densities resulting from the previous flux calculations are available on the history tape. These densities are assumed to be constant within a mesh rectangular parallelepiped.

Microscopic cross sections for the three, fast neutron energy groups are maintained in a library record on the program tape (see Appendix II). For each time-step, a maximum of four sets of thermal cross sections may be specified to be used in designated compositions.

The resonance escape probability of U-238 is input for each composition. The thermal self-shielding for an element is constant within a composition and, unless otherwise specified, is assumed to equal unity.

V. NEUTRON-DIFFUSION EQUATIONS

A modified version of TKO-1 provides the solution to the neutron-diffusion equations (Ref 3)

$$\left\{ - \nabla \cdot D^i \nabla \varphi^i + \Sigma_T^i \varphi^i = \frac{\chi^i \sum_{i=1}^{K} \nu\Sigma_f^i \varphi^i}{\lambda} + \Sigma_r^{i-1} \phi^j \right\}_{i=1}^{K} \ ,$$

where K = 2 or 4 and $\Sigma_T^i = \Sigma_r^i + \Sigma_a^i$. With the assumption that φ and $D\frac{\partial\varphi}{\partial n}$ (where $\frac{\partial\varphi}{\partial n}$ is normal to an interface) are continuous within a rectangular parallelepiped and across region interfaces, a seven-point approximation method is used in an iterative procedure to obtain a flux value at each interior point of the mesh.

The following equation may be applied at the boundaries of a region or regions in which the flux is not defined.

$$\frac{D^i}{\varphi^i} \frac{\partial\varphi^i}{\partial n} = - c \ ,$$

where c is a positive constant and $\frac{\partial\phi^j}{\partial n}$ is taken perpendicular to the interface in the direction of the parallelepiped in which the group flux is not defined.

The initial flux guess required in the solution of the above equations may be supplied in any of three ways. At time-step zero, a flux guess may be specified for each composition, or a tape containing flux values from some problem with identical geometry may be used. For succeeding time-steps these options, as well as the option to use the fluxes from the previous time-step calculation, are available. Under the first flux option, if the logarithmic derivative condition is to be applied at the boundary of a composition, the flux guess supplied for that composition must be zero. For the other two options, fluxes interior to such regions are automatically set to zero by the code.

VI. DEPLETION EQUATIONS

An average flux,

$$\bar{\varphi}^i(rp) = \frac{\sum_{v=1}^{8} \varphi^i(v)}{8} ,$$

is calculated for each rectangular parallelepiped of the mesh where $\varphi^i(v)$ refers to the point flux at the vertex v of the parallelepiped.

The total power contribution of each parallelepiped is then evaluated by

$$p(rp) = \sum_{i=1}^{K} \sum_{\substack{M=18,20\\21,23}} \kappa^{Mi} \left[\nu\Sigma_f(rp)\right]^{Mi} \bar{\varphi}^i(rp) .$$

From the relation

$$P = \beta \int_{\Pi} p(rp)\, dv^* ,$$

β is determined and used to obtain the power-normalized fluxes,

$$\Phi^i(rp) = \beta\, \bar{\varphi}^i(rp) .$$

With these fluxes, the various parameters, and the isotopic densities used in calculating the group constants for a time-step, new isotopic densities are evaluated for the time-dependent elements. The following coupled first-order differential equations are solved with a trapezoidal rule scheme applied in approximating the difference equations for the U-235 and U-238 chains and with a semi-analytic method employed in solving the equations for the fission product chains (Ref 4).

Uranium-235 (18)**

$$\frac{dN^{18}(rp)}{dt} = - N^{18}_{(rp)}(t) \left[\sum_{i=1}^{K-1} \sigma_a^{18,i}\, \Phi^i(rp) + (\sigma_a)_c^{18,K}\, g_c^{18} \Phi^K(rp) \right]$$

Uranium-236 (19)

$$\frac{dN^{19}(rp)}{dt} = - N^{19}_{(rp)}(t) \left[\sum_{i=1}^{K-1} \sigma_a^{19,i}\, \Phi^i(rp) + (\sigma_a)_c^{19,K}\, g_c^{19} \Phi^K(rp) \right]$$

$$+ N^{18}_{(rp)}(t) \left[\sum_{i=1}^{K-1} (\sigma_a - \sigma_f)^{18,i}\, \Phi^i(rp) + (\sigma_a - \sigma_f)_c^{18,K}\, g_c^{18} \Phi^K(rp) \right]$$

Uranium-238 (20)

$$\frac{dN^{20}(rp)}{dt} = - N^{20}_{(rp)}(t) \left[\sum_{i=1}^{K-1} \sigma_a^{20,i}\, \Phi^i(rp) + (\sigma_a)_c^{20,K}\, g_c^{20} \Phi^K(rp) \right]$$

$$- \left[\frac{1-p_r}{p_r}\right] \left[\Sigma_r^{K-1}(rp) + \Sigma_{a,s}^{20,K-1}(rp) \right] \Phi^{K-1}(rp)$$

*The integration is performed over the region bounded by the planes x = 0, x = ss, y = 0, y = ss, z = 0, and z = uu.

**Number in parentheses indicates element number (see Appendix I).

Plutonium-239 (21)

$$\frac{dN^{21}(rp)}{dt} = - N^{21}_{(rp)}(t)\left[\sum_{i=1}^{K-1} \sigma_a^{21,i}\Phi^i(rp) + (\sigma_a)^{21,K} g_c^{21}\Phi^K(rp)\right]$$

$$+ N^{20}_{(rp)}(t)\left[\sum_{i=1}^{K-1} (\sigma_a - \sigma_f)^{20,i}\Phi^i(rp) + (\sigma_a - \sigma_f)^{20,K} g_c^{20}\Phi^K(rp)\right]$$

$$+ \left[\frac{1-p_r}{p_r}\right]\left[\Sigma_r^{K-1}(rp) + \Sigma_{a,s}^{20,K-1}(rp)\right]\Phi^{K-1}(rp)$$

Plutonium-240 (22)

$$\frac{dN^{22}(rp)}{dt} = - N^{22}_{(rp)}(t)\left[\sum_{i=1}^{K-1} \sigma_a^{22,i}\Phi^i(rp) + (\sigma_a)_c^{22,K} g_c^{22}\Phi^K(rp)\right]$$

$$+ N^{21}_{(rp)}(t)\left[\sum_{i=1}^{K-1} (\sigma_a - \sigma_f)^{21,i}\Phi^i(rp) + (\sigma_a - \sigma_f)_c^{21,K} g_c^{21}\Phi^K(rp)\right]$$

Plutonium-241 (23)

$$\frac{dN^{23}(rp)}{dt} = - \lambda^{23} N^{23}_{(rp)}(t) - N^{23}_{(rp)}(t)\left[\sum_{i=1}^{K-1} \sigma_a^{23,i}\Phi^i(rp) + (\sigma_a)_c^{23,K} g_c^{23}\Phi^K(rp)\right]$$

$$+ N^{22}_{(rp)}(t)\left[\sum_{i=1}^{K-1} (\sigma_a - \sigma_f)^{22,i}\Phi^i(rp) + (\sigma_a - \sigma_f)_c^{22,K} g_c^{22}\Phi^K(rp)\right]$$

Promethium-149 (24)

$$\frac{dN^{24}(rp)}{dt} = - \lambda^{24} N^{24}_{(rp)}(t) + \sum_A N^A_{(rp)}(t)\left[\sum_{i=1}^{K-1} \gamma_{24}^{A,i}\sigma_f^{A,i}\Phi^i(rp) + \gamma_{24}^{A,K}(\sigma_f)_c^{A,K} g_c^A \Phi^K(rp)\right],$$

where A refers to elements 18, 20, 21, 23; λ^{24} is the decay constant of Pm-149; and γ_{24}^A, a program constant is the Pm-149 yield for elements A.

Samarium-149 (26)

$$\frac{dN^{26}(rp)}{dt} = - N^2_{(rp)}(t)\left[\sum_{i=1}^{K-1} \sigma_a^{26,i}\Phi^1(rp) + (\sigma_a)_c^{26,K} g_c^{26}\Phi^K(rp) + \lambda^{24} N^{24}_{(rp)}(t)\right]$$

Iodine-135 (25)

$$\frac{dN^{25}(rp)}{dt} = - \lambda^{25} N^{25}_{(rp)}(t) + \sum_A N^A_{(rp)}(t)\left[\sum_{i=1}^{K-1} \gamma_{25}^{A,i}\sigma_f^{A,i}\Phi^i(rp) + \gamma_{25}^{A,K}(\sigma_f)_c^{A,K} g_c^A \Phi^K(rp)\right],$$

where γ_{24}^{A}, an input quantity, is the I-135 yield for elements A and γ^{25} is the decay constant of I-135.

Xenon-135 (27)

$$\frac{dN^{27}(rp)}{dt} = -\lambda^{27} N^{27}_{(rp)}(t) - N^{27}_{(rp)}(t)\left[\sum_{i=1}^{K-1} (\sigma_a)^{27,i}\,\Phi^{i}(rp) + (\sigma_a)^{27,K}_{c}\, g_c^{27}\,\Phi^{K}(rp)\right]$$

$$+\lambda^{25} N^{25}_{(rp)}(t) + \sum_{A} N^{A}_{(rp)}(t)\left[\sum_{i=1}^{K-1} \gamma_{27}^{A,i}\,\sigma_f^{A,i}\,\Phi^{i}(rp) + \gamma_{27}^{A,K}\,\sigma_{f,c}^{A,K}\, g_c^{A}\,\Phi^{K}(rp)\right]$$

where γ_{27}^{A}, a program constant, is the Xe-135 yield for elements A and λ^{27} is the decay constant of Xe-135.

Lumped Fission Products (28)

$$\frac{dN^{28}(rp)}{dt} = \sum_{A} N^{A}_{(rp)}(t)\left[\sum_{i=1}^{K-1} \gamma_{28}^{A,i}\,\sigma_f^{A,i}\,\Phi^{i}(rp) + \gamma_{28}^{A,K}\,(\sigma_f)^{A,K}_{c}\, g_c^{A}\,\Phi^{K}(rp)\right],$$

where γ_{28}^{A}, a program constant, is the fission product yield for elements A.

Burnable Poisons

Boron-10 (29)

Unnamed poison (30)

$$\frac{dN^{M}(rp)}{dt} = -N^{M}_{(rp)}(t)\left[\sum_{i=1}^{K-1} \sigma_a^{M,i}\,\Phi^{i}(rp) + (\sigma_a)^{M,K}_{c}\, g_c^{M}\,\Phi^{K}(rp)\right]$$

VII. MAXIMUM-XENON CALCULATION (DRACO-2)

A maximum-xenon calculation may be done at any time-step except zero. The power-normalized fluxes of the requested time-step are reduced by a specified percent and are used to calculate new isotopic densities for a specified interval of time. With the group constants corresponding to these new densities, the neutron-diffusion equations are solved at each interior point. The resulting source-normalized fluxes are averaged for each mesh rectangular parallelepiped and are normalized by

$$\beta = \frac{1}{\int p(rp)\, dv}.$$

The calculation ends here, and selective editing may be done from the binary output tape.

Non-zero power may not be specified unless the requested time-step has been completed on DRACO-1 since the source-normalized fluxes corresponding to this time-step are read from the history tape and are used to obtain the power-normalized fluxes required in the depletion. When zero power is specified, the requested time-step need not be completed as the fluxes used in the depletion are set to zero, and the necessary isotopic densities are already available on the history tape.

The initial flux guess for the DRACO-2 iteration may be supplied by expanding a flat flux guess, by using a flux tape from a problem with the same number of points and groups, or by requesting that fluxes be copied from the DRACO-1 history tape (for zero power the fluxes of the previous time-step are used, and for percent power the fluxes of the specified time-step are used).

In submitting a DRACO-2 problem the requestor must specify to which history tape generated by DRACO-1 the problem refers. This tape must be identified by the DRACO-1 problem number and the number of the time-step which must be complete for a problem of zero or non-zero power.

VIII. OUTPUT

During a time-step calculation the following information is edited on-line:

1) At time-step zero only, the composition values of D, Σ_a, $\nu\Sigma_f$, and Σ_r.

2) The omegas, the eigenvalues, and other information pertaining to the progress of the iteration.

3) The composition integrated volume and the composition integrated and averaged fluxes for each group.

4) The percentage of power for each fissionable element in each composition, and the percentage of power contributed by each composition.

5) The normalization factor used to obtain the power normalized fluxes.

Under option, a picture of the composition arrangement may be obtained for off-line printing. If desired at all, this may be requested immediately after the input has been processed, in which case the program stops and tapes are saved for a restart, or at the end of a time-step calculation.

The binary output tape generated during a time-step calculation contains the restart record and the composition description; the initial isotopic densities of elements 18-30, the group constants, and values of $(\kappa\nu\Sigma_f)^{M,i}$ for each mesh rectangular parallelepiped; the power normalized fluxes and the source terms for each interior point; the element power, the total power, and the group power for each mesh rectangular parallelepiped; the power normalized fluxes; and the final isotopic densities of elements 18-30 (DRACO-1 only) for each rectangular parallelepiped. From this tape, certain data can be processed upon request for off-line editing. The editing procedure and the information available are described in Section XI.

IX. CODE ROUTINES—DRACO-1 AND DRACO-2

A. Input Routine

Decimal data is read by means of the subroutine WH001, and information is checked against input restrictions wherever possible. The sequence of cards is always checked. In the event of any error, the nature of the error is printed on-line and the program stops. A restart at such a point is impossible; the data deck must be re-read.

At time-step zero, the image of the title card, the dimensions of the problem, the number of groups, the boundary conditions, and the mesh spacing are recorded at the beginning of the history tape. At future time-steps, corresponding information is checked against this identification to insure that the proper history tape is used and that the requestor has not made any prohibited changes.

For each time-step the composition description is expanded so that a composition number is assigned to each rectangular parallelepiped of the mesh. The library of the fast cross sections is merged with the thermal cross sections. The routine always processes cards containing the flat flux guess, the MUFT buckling (for two-group problems only), the resonance escape probability of U-238, and the homogeneous poison. The flat flux guess, however, is ignored if the requestor does not ask for the expansion of a flat flux guess. Isotopic densities which are not specified are automatically set to zero, and after time-step zero, any cards containing densities for elements 18-30 are processed, but the information is ignored. Unless otherwise specified, thermal self-shielding is always set equal to one.

B. Restart and Positioner

Normally this routine searches through the history tape (tape 7 for DRACO-1 and tape 10 for DRACO-2) and positions it correctly for the specified time-step calculation. If requested, the flux values of the previous time-step are transferred to another tape to supply the initial flux guess for the iteration. In DRACO-2, if a non-zero power level is indicated, the fluxes for the requested time-step are copied for use in the percentage flux routine and the depletion calculation.

When a restart is initiated, "DRACO RESTART OF," the problem identification and the time-step number are printed on-line. The history tape and the binary output tape are positioned correctly, and the calculation is continued at the best restart point which may occur at the beginning of any routine (except the input routine) and, in the iteration, at the beginning of a group calculation or the source calculation.

C. Partial Sums

In preparation for the computation of the group parameters, the following quantities are calculated.

$$1)\quad (\Sigma_r)_c^i = \sum_{m=1}^{17} N_c^{m} \sigma_r^{m,i} \qquad \text{for } i = 1, 2, 3 ,$$

$$2)\quad (\Sigma_{tr})_c^i = \sum_{m=1}^{17} N_c^{m} \sigma_{tr}^{m,i} \qquad \text{for } i = 1, 2, 3$$

and

$$(\Sigma_{tr})_c^4 = \sum_{m=1}^{17} N_c^{m} (\sigma_{tr})_c^{m,4} ,$$

$$3)\quad (\Sigma_a)_c^i = \sum_{m=1}^{17} N_c^{m} \sigma_a^{m,i} \qquad \text{for } i = 1, 2, 3$$

and

$$(\Sigma_a)_c^4 = \sum_{m=1}^{17} N_c^{m} g_c^{m} (\sigma_a)_c^{m,4} .$$

The isotopic densities, the cross sections, and the thermal self-shielding factors which pertain to the time-independent elements are discarded.

At time-step zero, isotopic densities for elements 18-30 are assigned to each mesh rectangular parallelepiped according to the composition number of the rectangular parallelepiped. These values are recorded on the history tape as the initial isotopic densities for time-step zero.

D. Flux Expansion

When the option to expand a flat flux guess is used, this routine calculates a flux value for each interior point for each lethargy group by averaging the composition flux values of the eight rectangular parallelepipeds surrounding the point.

If a flux tape is used, the tape is copied and the program stops so that the original tape may be saved; instructions to the machine operator are printed on-line.

When either a flux tape or the fluxes of the previous time-step are used, the appropriate group fluxes are set to zero for points interior to a boundary at which a logarithmic derivative condition is to be applied.

E. Percentage Flux Routine (DRACO-2 only)

In a maximum-xenon calculation for a given time-step, this routine reduces the flux level (or power level) by the specified fraction. If a zero power level is requested, all fluxes to be used in the depletion equations are set equal to zero. Otherwise, the averaged, power-normalized fluxes are multiplied by the specified percentage for use in the depletion equations.

F. Macroscopic Data Calculation

The group constants are calculated as indicated in Section IV.

In preparation for the power calculation. the following quantities are evaluated:

$$(\kappa^M \, \nu\Sigma_f(rp)^M)^i = (\kappa^M \, \nu \, \sigma_f^M \, N^M(rp))^i$$

for i = 1, 2, 3 and M = 18, 20, 21, 23;

and

$$(\kappa^M \, \nu\Sigma_f^M(rp))^K = (\kappa^M \, \nu \, (\sigma_f)_c^M \, g_c^M \, N^M(rp))^K \quad .$$

For a two-group scheme, these quantities are edited using the same procedure applied to the group constants.

The isotopic densities, read for this calculation from the history tape, the macroscopic data, and $(\kappa^M \, \nu\Sigma_f(rp)^M)^i$ are recorded on the binary output tape.

At time-step zero, the composition values of D, Σ_a, $\nu\Sigma_f$, and Σ_r are edited on-line.

G. Coefficient Routine (Ref 3)

The group constants are combined according to the difference equations used in solving the neutron-diffusion equations.

H. Omega Routine (Ref 3)

This routine estimates the optimum overrelaxation factors, ω^i, to be used in the group iterations. Under option, this routine may be skipped, and the omegas of the previous time-step used.

I. Iteration Routine (Ref 3)

A group source is calculated to start the inner iterations which result in group fluxes. These fluxes are used to evaluate a new source approximation from which a new eigenvalue approximation is determined. Under certain conditions the source is extrapolated and renormalized before repeating the above series of source, flux, and eigenvalue calculations referred to as an outer iteration. If $\bar{\sigma}$ (the approximation to the homogeneous spectral norm of the outer iteration matrix) is non-zero, the source extrapolations are begun at the end of the second outer iteration. If $\bar{\sigma}$ is zero, a value of $\bar{\sigma}$ is calculated at the end of the fourth iteration, and depending on its value the extrapolation may or may not be performed. Under option, $\bar{\sigma}$ from the previous time-step may be used initially instead of a zero value.

A problem is considered converged when

$$\frac{\lambda \max - \lambda \min}{2\lambda} \leq \epsilon^2 \quad .$$

For each iteration, the number of inner iterations, the initial and final residues, and the eigenvalue are printed on-line.

J. Average Routine

This routine calculates and prints on-line the composition integrated volumes and the composition integrated and averaged fluxes for each group.

K. Flux Normalization

As described in Section VI, an average flux is calculated for each mesh rectangular parallelepiped for each lethargy group.

The following power quantities are calculated and recorded on the binary output tape. (All integration is performed over the region bounded by the planes x = 0, x = ss, y = 0, y = ss, z = 0, and z = uu.)

1) For each mesh rectangular parallelepiped

a) the power contribution of each fissionable element (M = 18, 20, 21, 23)

$$p(rp)^M = \sum_{i=1}^{K} \left[\kappa_\nu \Sigma_f(rp)\right]^{M,i} \bar{\varphi}^i(rp) \ ;$$

b) the power for each lethargy group

$$p(rp)^i = \sum_{M} \left[\kappa_\nu \Sigma_f(rp)\right]^{M,i} \bar{\varphi}^i(rp) \ ;$$

c) the total power

$$p(rp) = \sum_{M} \sum_{i=1}^{K} \left[\kappa_\nu \Sigma_f(rp)\right]^{M,i} \bar{\varphi}^i(rp) \ .$$

2) For each composition

a) the integrated power for each fissionable isotope

$$P_c^M = \int_c p(rp)^M \, dv \ ;$$

b) the total power

$$P_c = \int_c p(rp) \, dv \ .$$

3) For the entire region under consideration

a) the integrated power for each fissionable isotope

$$P^M = \int_R p(rp)^M \, dv \ ;$$

b) the total integrated power

$$P_R = \int_R p(rp) \, dv \ .$$

The average fluxes are normalized and recorded on the binary output tape.

In DRACO-1 the normalization factor is given by

$$\beta = \frac{P}{\int_R p(rp) \, dv} \ ,$$

where P is the net power per time-step.

In DRACO-2 this factor is given by

$$\beta = \frac{1}{\int_R p(rp) \, dv} \ .$$

Information printed on-line includes:

1) percentage of power for each fissionable element per composition (P_c^M/P_c),

2) the percentage of power per composition with respect to the total power (P_c/P_R),

3) the normalization factor, β.

L. Depletion

The depletion equations listed in Section VI are solved for each rectangular parallelepiped of the mesh and are recorded on the binary output tape and the history tape.

In DRACO-2 this routine follows the Percentage Flux Routine. The initial isotopic densities used in the depletion equations are the densities recorded on the history tape for the requested time-step. The new isotopic densities are recorded on the binary output tape as the initial isotopic densities for the xenon calculation. There are no final isotopic densities recorded for a maximum-xenon calculation.

M. Picture Edit

When requested, this routine prepares a BCD output tape containing a picture representation of the composition numbering for the region under consideration. This picture, if desired at all, may be obtained immediately after the input has been processed or at the end of a time-step calculation. If the edit is performed, the number of the tape (4 or 9) containing the BCD picture is printed on-line. When the edit follows the input, the program stops, and tapes are saved for a restart.

At the end of a time-step calculation, the number of the flux tape (5 or 6) is indicated so that it can be saved if requested.

N. Continuation of History Tape (DRACO-0)

When the end of tape 7 is sensed during the running of a DRACO-1 problem, a six-word record of zeros and/or three end-of-files are written on 7 as end-of-tape identification. Tapes 1, 7, and 9 are rewound, and the following statement is printed on-line.

"End of tape 7 has been reached. Load routine to write new tape 7."

DRACO-0, the routine which continues the history tape, copies onto tape 4 the problem identification record and all information available for the time-step during which the end-of-tape was sensed. The time-step identification on tape 7 is rewritten with an impossible time-step number so that no future reference may be made to this tape for the incomplete time-step. Operating instructions and information pertinent to labeling the history tapes are printed on-line as follows:

"Remove tape 7 and save... where T equals number of time-step being run, this tape includes time-step T-1. Turn tape indicator to * blank *.

Continuation of history tape is on logical 4. Set tape indicator to 7. This tape begins with time-step T.

Mount blank tape and set to logical 4.

Restart problem."

X. INPUT—DRACO-1 AND DRACO-2

For convenience, the input data is divided into the following card number series.

1000 general information

2000 mesh spacing in the X coordinate direction

3000 mesh spacing in the Z coordinate direction

4000 composition description

5000 thermal microscopic cross sections

6000 composition flux guess

7000 MUFT buckling, included only for two-group problems

8000 resonance escape probability of U-238

9000 homogeneous poison

10000 isotopic densities

11000 thermal self-shielding

12000 logarithmic derivatives

There are eight input forms which apply to a DRACO problem. At least one of each of these forms is necessary to specify a problem. These forms must be completed as described below.

Card numbers are always in fixed decimal form. In general, all control information is in fixed decimal form while values for specific quantities are indicated in floating decimal form. If $N = \pm 0.xxxx \cdot 10^{\pm y}$, the floating decimal equivalent is ±ccxxxx where cc = 50 ± y. A floating point zero is indicated as all zeros.

Form 1

Identification Card

This card must remain the same for all time-steps of one problem. Columns 1-49 are available to the requestor for identification. Column 72 must contain a 1 or a 2, where

1 = normal time-step

2 = maximum-xenon calculation

Card 01001

This card must contain the following information; unless otherwise indicated, numbers are of fixed decimal form.

Number of groups = 2 or 4

Number of compositions ≤ 50

ss number of last plane in the x coordinate direction where numbering of planes begins at zero. ss must be ≤ 28.

uu number of last plane in the z coordinate direction where numbering of planes begins at zero. uu must be ≤ 28 and $1/2(ss-1)(ss)(uu-1) \leq 2685$ or ≤ 4750 for machines with 16,384 and 32,768 words of core storage, respectively.

a = 0 zero flux at x = 0, y = 0

a = 1 plane of symmetry at x = 1, y = 1

b = 0 zero flux at x = ss, y = ss

b = 1 plane of symmetry at x = ss-1, y = ss-1

c = 0 zero flux at z = 0

c = 1 plane of symmetry at z = 1

d = 0 zero flux at z = uu

d = 1 plane of symmetry at z = uu-1

Flux option

DRACO-I

+1 expand flat flux guess

+2 use fluxes of previous time-step

+3 use flux tape

DRACO-2

+1 expand flat flux guess

+2 for zero power use fluxes of previous time-step; for percent power use fluxes of specified time-step

+3 use flux tape

Picture option

+1 no picture desired

+2 obtain picture at end of time-step

+3 obtain picture after input; save tapes for restart of problem.

Sigma option

+1 initial $\overline{\sigma}$ equals zero

+2 use $\overline{\sigma}$ of previous time-step as initial $\overline{\sigma}$

Omega option

+1 calculate omegas

+2 skip omega routine and use omegas of previous time-step

Number of sets of thermal cross sections being used in time-step is ≤ 4.

Time-step number

Δt the size of the time-step in seconds (floating point).

P the total power in watts for the region considered (floating point). In DRACO-2 this becomes the fraction of power to be used in calculating maximum xenon.

Card 1002 (floating point)

λ_0 initial eigenvalue guess

ϵ_0 convergence criterion

t_1, t_2, t_3, t_4 for four-group problems and t_1, t_2 (t_3 and t_4 equal zero) for two-group problems

Card 1003 (floating point)

χ_1, χ_2, χ_3 for four-group or χ_1 (χ_2, χ_3 = 0) for two-group problems

$$\sum_{i}^{K-1} \chi_i \text{ must be } \geq 0.95 \text{ and } < 1.05$$

Card 1004 (floating point)

γ_i, iodine yield for elements 18, 20, 21, 23

Form 2

Mesh Description

Because of the symmetry imposed at x = y, the mesh in the X coordinate direction equals that in the Y direction, and only the mesh in one direction must be described. As many pairs as necessary of the following values should be used to specify the mesh: Δ, a floating point value of the mesh width which applies at each mesh interval between the previous plane N (initially assumed to be zero) and some other plane N in the X direction. Values of N are in fixed decimal form and must be in ascending order with the last N equal to ss. Cards in this series are numbered beginning at 02001.

Similarly, the mesh in the Z direction is described with N referring to the number of the plane in the Z direction to which the preceding Δ applies. Here, the last N must equal uu. Cards in this series are numbered beginning at 03001.

Since symmetry may occur at any first interior plane, the following restrictions apply. If on card 01001, a = 1, the mesh cannot change at x = 1 (y = 1). If b = 1, it cannot change at x = ss-1 (y = ss-1). If c = 1, it cannot change at z = 1, and if d = 1, it cannot change at z = uu-1.

All cards must be filled except the last card of a series which should be filled with zeros if incomplete.

Form 3

Composition Description

A composition number is assigned to each mesh rectangular parallelepiped of the region under consideration. Between planes z = 0 and z = 1, it is necessary to give every mesh rectangular parallelepiped a number. Thereafter in going from XY plane to XY plane it is only necessary to indicate changes which occur within the limits of x = 0, x = y, and y = ss, although the whole plane may be described. Composition numbering is reflected to complete the description of the space between any two XY planes.

In describing the material composition it is necessary to specify the numbers of the planes in the Z direction between which a certain description applies. These plane limits are indicated by P_1 and P_2, where

1) initially P_1 must equal zero
2) any succeeding P_1 must equal the previous P_2
3) the values of P_2 must be in ascending order, and
4) the last P_2 must equal uu.

The space between the first two XY planes within any P_1 and P_2 should be adequately described (that is, if between planes z = 0 and z = 1 assign a number to each mesh rectangular parallelepiped, and thereafter indicate changes which occur from the previous plane within x = 0, x = y, y = ss). This description will be repeated as requested, $P_2 - P_1$ times.

If more than one card is required to describe the composition between P_1 and P_2, P_1 and P_2 are indicated only on the first card. These values must be zero on the remainder of the cards used for that particular interval.

The limits in the X and Y directions within which a certain composition number V applies are indicated by

X_1 = left boundary,

X_2 = right boundary, $X_1 < X_2$,

Y_1 = upper boundary, and

Y_2 = lower boundary, $Y_1 < Y_2$.

All cards, except the last one, for any limits $P_1 - P_2$ must be filled. Incomplete cards should be filled with zeros.

The following restrictions are set by the position of planes of symmetry.

If, on card 01001, a = 1, the composition numbering may not change at the first interior plane in the X or Y coordinate direction x = 1, y = 1. If b = 1, it cannot change at x = ss-1, y = ss-1. If c = 1, it cannot change at z = 1, and if d = 1, it cannot change at z = uu-1.

Form 4

Thermal Cross Sections

A maximum of four sets of thermal cross sections may be input at each time-step. Each set requires a control card or cards indicating in what compositions the set is to be used. On the first of such control cards, the total number of compositions in which the set applies must be specified. This number is followed by the numbers of the compositions in which the set is to be used. If there is only one set, the "total number" on the first control card should be zero, indicating that the set should be used in all compositions. Allowing for a maximum of 50 compositions, three control cards may be needed. Fill incomplete cards with zeros. Control numbers are of fixed decimal form.

Following the essential control card or cards for each set, specify (in barns) σ_{tr}, σ_a, σ_f, and $\nu\sigma_f$ as indicated on the input form. These are all floating point values.

This series of cards must be preceded by a control card numbered 05000; remaining cards are numbered beginning at 05001.

Form 5

A flux guess must be supplied for each composition for each lethargy group. When a logarithmic derivative boundary condition is being applied in a composition, the flux value for that composition must be zero. The flat flux guess will be used at any time-step if requested on card 01001 under the flux option.

This series is preceded by a control card numbered 06000. Cards for group one are numbered beginning at 06011, for group two beginning at 06021, for group three beginning at 06031, and for group four (see form 6) beginning at 06041.

Form 6

This form contains the flux guess for group four. Cards are numbered beginning at 06041 as indicated.

For two-group problems a value for the MUFT buckling must be supplied for every composition. Cards are numbered beginning at 07001.

Form 7

Values (in floating point form) for the resonance escape probability of U-238 and for the homogeneous poison must be supplied for each composition.

p_r^{28} cards are numbered beginning at 08001.

Σ_p cards begin at 09001.

Form 8

This form is used to specify isotopic densities, thermal self-shielding factors, and logarithmic derivatives.

Isotopic Densities

Each element requires a control card followed by cards containing isotopic densities. On the control card the element number (1-30) must be indicated. This number is followed by the number(s) of the composition(s) in which that element appears (that is, compositions in which elements 1-17 are non-zero for the particular time-step and, at the beginning of life, in which elements 18-30 are non-zero). If an element is present in all compositions it is only necessary to set the first composition number on the control card to zero.

A control card is followed by cards containing floating point values of the isotopic densities of an element for each composition in which it appears. If an element appears in more than 21 or less than 50 compositions, another control card may be used for that element followed by the necessary cards containing isotopic densities.

Elements need not be specified in order.

Cards are numbered beginning at 10001. This series must be followed by a control card numbered 11000.

Thermal Self-Shielding

Thermal self-shielding factors which are not equal to one must be specified just as the isotopic densities are. Each element requires a control card containing the element number (1-30) and the numbers of the compositions in which the self-shielding is not one. A control card is followed by cards containing appropriate self-shielding values.

Cards are numbered beginning at 11001. The series is followed by a control card numbered 12000. This card must always be present whether or not self-shielding values have been specified.

Logarithmic Derivatives

Logarithmic derivatives are specified in the same manner as are the isotopic densities. Here group number replaces element number.

Cards are numbered beginning at 12001. The series must be followed by a control card numbered 13000. This card must be present whether or not logarithmic derivatives have been specified.

XI. OUTPUT ROUTINES (DRACO-3)

The output routine sorts from the binary output tape (9) the information needed for the edits requested and writes this information on tapes 2, 3, 4, 5, and 8 The selected edit routines process this information and prepare a BCD tape (10) to be printed on the off-line printer. Since DRACO-3 is independent of the main calculation, it can be used whenever the binary output tape of a DRACO-1 or DRACO-2 problem is available. Editing options may be added if they use only the information available as set forth in Section VIII.

A. Edit Control Deck

Selection of data for editing is accomplished by means of an edit control deck which contains the following:

1) The title card used as problem identification in the DRACO-1 or DRACO-2 data deck.

2) A master control card specifying which edits are to be done. Columns 1-7 and 11 of this card are blank. Columns 8-10 contain DEC. The numbers of the edits desired are indicated in columns 12-72. These numbers must be specified in ascending order and separated by commas. The number of the last edit requested is always preceded by a minus sign.

3) Control cards are required by each edit requested. Columns 1-7 and 11 are blank; columns 8-10 contain DEC. All cards of this type must have a card number beginning in column 12 and of the form x000+n where x is the edit number and n, referring to the sequencing of the cards for the particular edit, begins at one. On the last card for each edit, this number is negative. In general, the remainder of the information in columns 12-72 indicates what data is to be processed and under what options. Most cards require a description of the limits of the rectangular parallelepiped for which data is to be processed.

B. Selection of Rectangular Parallelepiped

Because of the large volume of data available, it is possible to specify any rectangular parallelepiped for which editing is desired. Values for interior points and for mesh rectangular

parallelepipeds are printed accordingly in picture format for each XY plane or for the space between XY planes.

The boundaries describing such a rectangular parallelepiped are given by

X_1 and X_2, the numbers of the limiting planes in the X coordinate direction;

Y_1 and Y_2, the numbers of the limiting planes in the Y direction; and

Z_1 and Z_2, the numbers of the limiting planes in the Z direction.

In pointwise edits, data for points included on the plane limits are processed. The following restrictions apply:

$X_1 > 0,\ X_2 < ss,\ X_1 \leq X_2$;

$Y_1 > 0,\ Y_2 < ss,\ Y_1 \leq Y_2$;

and

$Z_1 > 0,\ Z_2 < uu,\ Z_1 \leq Z_2$.

For edits of data pertaining to mesh rectangular parallelepipeds, the following restrictions apply:

$X_1 \geq 0,\ X_2 \leq ss,\ X_1 < X_2$;

$Y_1 \geq 0,\ Y_2 \leq ss,\ Y_1 < Y_2$;

and

$Z_1 \geq 0,\ Z_2 \leq uu,\ Z_1 < Z_2$.

C. Options

The edits available are described below. All control cards are of the format described in Section XI-A-3.

1) Point Flux

This option prints the values of the flux in a specified group at each point of a specified rectangular parallelepiped.

Control Card format (columns 12-72)

$\pm(1000+n)$, G, X_1, X_2, Y_1, Y_2, Z_1, Z_2,
where G refers to group number, and X_1, X_2, Y_1, Y_2, Z_1, Z_2 are as described in Section XI-B.

For minimum running time, groups should be requested in ascending order, and all control cards pertaining to one group should be together.

2) Point Power

This option prints the value of the power at each point of a specified rectangular parallelepiped. This power is given by

$$p(x,y,z) = \frac{\sum_{i=1}^{K} \varphi^i(x,y,z) \left(\frac{\sum_{\ell=1}^{8} K\, \Sigma_f^{i,\ell}(rp)}{\sum_{R=1}^{8} n^{\ell}} \right)}{\frac{\int_{\Omega} P dv}{\int_{R} dv}} ,$$

where ℓ refers to the octants about the point (x, y, z), and n = 1 if the octant ℓ is a fuel region ($\kappa\nu\Sigma_f^i(rp)_\ell \neq 0$ for some i) or n = 0 if the octant is a non-fuel region. The integrals are taken over all fuel regions of the mesh.

Control Card format (columns 12-72)

±(2000+n), X_1, X_2, Y_1, Y_2, Z_1, Z_2,

where X_1, X_2, Y_1, Y_2, Z_1, Z_2 are as described in Section XI-B.

3) Rectangle Power

For each mesh block of a specified rectangular parallelepiped, this option prints the power produced by a specified fissionable element as

$$p(rp)^M = \sum_{i=1}^{K} \kappa\nu\Sigma_f(rp)^{i,M}\bar{\varphi}(rp)^i$$

or the total power as

$$p(rp) = \sum_{\substack{M=18,20\\21,23}} p(rp)^M .$$

Under option, the values may be normalized by

$$\frac{\int P dv}{\int dv},$$

where the integrals may be taken over all fuel regions of the mesh or over the fuel regions of the plane interval containing each mesh block.

Control Card format (columns 12-72)

±(3000+n), E, φ, X_1, X_2, Y_1, Y_2, Z_1, Z_2,

where E signifies element number, 18, 20, 21, 23 or 0 for total power; φ, indicating option,

= 0 for unnormalized power,

= 1 for normalization by the total average power of the region under consideration,

= 2 for normalization by the average power per plane; and X_1, X_2, Y_1, Y_2, Z_1, Z_2 are as described in Section XI-B.

For minimum running time, all control cards pertaining to one element should be together.

4) Initial Isotopic Densities

This option prints the initial isotopic densities of any selected time-dependent element for each mesh block of a specified rectangular parallelepiped.

Control Card format (columns 12-72)

±(4000+n), E, X_1, X_2, Y_1, Y_2, Z_1, Z_2

where E denotes element number 18-30, and X_1, X_2, Y_1, Y_2, Z_1, Z_2 are as described in Section XI-B.

5) Final Isotopic Densities

This option requires control cards as specified for edit 4. Card numbers begin at 5001. This edit is not available for DRACO-2 problems. The densities resulting from the depletion are recorded on the binary output tape as initial densities and must be obtained by means of edit 4.

6) Macroscopic Data

This option prints the values of $D(rp)^i$, $\Sigma_{tr}(rp)^i$, $\Sigma_a(rp)^i$, or $\nu\Sigma_f(rp)^i$ for any group, or $\Sigma_r(rp)$ for any of the fast groups over any selected portion of the mesh.

Control Card format (columns 12-72)

$\pm(6000+n)$, A, G, X_1, X_2, Y_1, Y_2, Z_1, Z_2

where A = 1 for diffusion coefficient

= 2 for absorption cross section

= 3 for fission cross section

= 4 for removal cross section

= 5 for transport cross section,

G indicates group number, and X_1, X_2, Y_1, Y_2, Z_1, Z_2 are as described in Section XI-B.

7) Initial Integrated Isotopic Densities

This option prints the averaged isotopic densities of elements 18-30 for each composition and the entire region. The composition averaged isotopic densities are defined as

$$\bar{N}_c^M = \int_c N(rp)^M \, dv \Big/ \int_c dv \ .$$

No control cards are necessary.

8) Final Integrated Isotopic Densities

This option corresponds to edit 7. Edit 8 is not available for DRACO-2 problems.

9) Power Integrals

This option prints the integrated power for each fissionable element for each composition, the total integrated power for each composition, the integrated power for each fissionable element over the entire mesh, the composition volumes, and the total volume. No control cards are necessary.

10) Average Block Stick Power

Prints in picture format the values of the average stick power normalized by the average power of the entire mesh. This stick power is given by

$$p_z^M = \frac{\dfrac{\int_z p(rp)^M \, dv}{\int_z dv}}{\dfrac{\int_R P \, dv}{\int_R dv}} \ ,$$

where M refers to element number 18, 20, 21, 23, or 0 (indicating total power), and the integration is performed along each stick in the Z direction.

Control Card format (columns 12-72)

$\pm(10000+n)$, M

11) Point Stick Power

This option prints for the specified stick or sticks the point power (as defined for edit 2) for every point of the stick in the Z direction and the average point stick power which is defined as

$$\frac{\sum_{z=0}^{uu-1} \frac{p(x,y,z) + p(x,y,z+1)}{2} dz}{DZ},$$

where dz is the distance between the points (x, y, z) and (x, y, z+1) and is considered equal to zero if the points are not included in the same fuel region; and DZ is the total length of the fuel region or regions of the stick.

Control Card format (columns 12-72)

±(11000+n), X, Y,

where X and Y indicate the numbers of the interior planes which intersect to form the stick in the Z direction. X and Y must refer to interior planes and, therefore, may not equal 0 or ss.

If all of the sticks are desired, only one control card is necessary and should be of the following form

-11001, 0, 0 .

XII. OPERATING INSTRUCTIONS (DRACO-0, 1, and 2)

A. Tape Configuration

DRACO-1		DRACO-2	
1	Program	1	Program
2-5	Blanks	2-5	Blanks
6	Blank or flux tape (remove file-protect ring). If column 27 of card 1001 contains a 3, a flux tape is to be used. This tape must always be mounted as logical 6.	6	Blank or flux tape (remove file-protect ring). If column 27 of card 1001 contains a 3, a flux tape is to be used. This tape must always be mounted as logical 6.
7	History tape—at time-step 0, this is a blank.	7-9	Blanks
8-9	Blanks		
10	Not needed	10	Specified history tape generated by DRACO-1.

B. Sense Switches

1 Up-normal
Down-stops iteration at best point

2 Up-normal
Down-restart

3 UP

4 Up-normal
Down-programmers use only

5 Up

6 Up-normal
Down-brings in octal dump (NYDS1) for restart failures (this requires control cards or blank card in card hopper).

C. Starting Procedure

1) Mount tapes as indicated.

2) Set proper sense switches.

3) GLOUT printer panel in printer; 72-72 panel in card reader and card punch.

4) Ready card reader with data deck in hopper except in the case of a restart.

5) Clear, load tape.

6) At program stop $(00007)_8$ manually enter the code number 0, 1, or 2 into the address portion of the MQ. Start. (0 indicates the routine which continues the history tape after an end of tape has been sensed in DRACO-1).

D. Program Stops

1) Normal stops:

$(1623)_8$ - occurs when the requestor has used a specified flux tape. SEE ON-LINE INSTRUCTIONS.

$(25252)_8$ - occurs when the requestor has asked for a BCD picture edit immediately after the input routine. SEE ON-LINE INSTRUCTIONS. Label and save all tapes except 9, which contains the BCD edit. The problem will be continued at some later time by means of a restart.

$(10000)_8$ - end of time-step calculation

a) SEE ON-LINE INSTRUCTIONS.

b) Edit binary output tape (9) if requested. SAVE TAPE 9.

c) SAVE HISTORY TAPE—TAPE 7 FOR DRACO-1, TAPE 10 FOR DRACO-2. Upon request, save flux tape. This may be tape 5 or 6 and will be indicated on-line.

d) Clear the card punch. In the event of tape errors which do not result in a program stop, cards indicating the nature of the difficulty are punched according to the format specified by the tape routine WB-RWT5. The address of the 9L word indicates the octal address of the tape in error. Note the number of the tape reel and identify the tape unit.

e) If there has been a BCD picture edit (indicated on-line) print tape (4 or 9) off-line. Return on-line and off-line edits to requestor.

2) At all other stops consult the list of possible Program Stops of DRACO-1 and DRACO-2 (Section XII-F).

E. Restart

1) Rewind tape 1.

2) Set sense switch as indicated (2 down - all others up).

3) All tapes must have been saved for a restart except in the case where the requestor obtained a BCD picture edit immediately after the input. All tapes but 9 must have been saved for this restart; 9 will be a blank.

4) Proceed as for starting a problem except that there is no data deck in the card hopper.

5) At program stop $(1012)_8$ hit start (DRACO-1).
At program stop $(1026)_8$ hit start (DRACO-2).

6) If the restart fails, dump core; backspace one record in each tape and dump.

F. Program Stops

6	Tape loader	Load tape to try again
160	Sigma	Machine error - restart
245	Iteration	Machine error - restart
251	Average	Machine error - start to proceed
251	Picture	Machine error - start to proceed
267	Sigma	Over or underflow - restart
330	Average	Machine error - restart
330	Picture	Machine error - restart
441	Rest	Tape 1 error - restart
442	Rest	Tape 2 error - restart
443	Rest	Tape 5 error - restart
444	Rest	Tape 7 error - restart
445	Rest	Tape 9 error - restart
446	Rest	Record numbering error on tape 1 - restart
446	Rest (2)	Tape 10 error - restart
447	Rest (2)	Record numbering error on tape 1 - restart
452	Rest	Restart is impossible - quit
454	Rest (2)	Restart is impossible - quit
565	Depletion	MQ overflow light on - restart
645	Depletion	Error checking calc - start to try again
674	Coef	Machine error - restart
745	Depletion	Negative isotopic density - restart
771	Depletion	Error checking calc - restart
776	Depletion	MQ overflow light on - restart
1012	Rest	Stop in all restarts, may fudge values - hit start
1014	Part. Sums	Tape 2 error - restart
1015	Part. Sums	Tape 3 error - restart
1016	Part. Sums	Tape 4 error - restart
1017	Part. Sums	Tape 7 error - restart
1020	Part. Sums	Tape 8 error - restart
1021	Part. Sums	Machine error - restart
1022	Rest (2)	Stop for entering rout. no. - load MQ, hit start
1022	Part. Sums	Over or underflow - restart
1026	Rest (2)	Stop in all restarts, may fudge values - hit start
1027	Rest	Stop for entering rout. no. - load MQ, hit start
1050	Depletion	Error checking calc - restart
1055	Rest	Restart impossible in input routine - start to rewind all tapes. Reload data deck, try again.
1057	Rest (2)	Restart impossible in input routine - start to rewind all tapes. Reload data deck, try again.
1063	Rest	Routine number incorrect - restart
1067	Depletion	Error checking calc - restart
1073	Depletion	Over or underflow - restart

1133	Rest	Error in restart record - restart
1135	Depletion	Error - ln return - restart
1143	Depletion	Error checking calc - restart
1147	Rest (2)	Problem may be complete - hit start to rewind
1152	Depletion	Machine error - restart
1170	Depletion	Negative isotopic density - restart
1174	Depleteion	Over or underflow - restart
1177	Rest (2)	EOF missing on tape 9 - restart
1205	Depletion	Error - ln return - restart
1207	Sigma	Over or underflow - restart
1213	Depletion	Error - checking calc - restart
1224	Rest	Problem may be complete - hit start to rewind
1226	Depletion	Probably machine error - restart
1244	Rest (2)	Error in restart record - restart
1254	Rest	EOF missing on tape 9 - restart
1254	Depletion	Error - checking calc - restart
1262	Rest (2)	Bad record on tape 9 - start to try 3 more times
1272	Rest	Bad record on tape 9 - start to try 3 more times
1274	DRACO-0	Tape 7 positioned incorrectly - start over
1275	DRACO-0	Error - tape 2 - start over
1276	DRACO-0	Error - tape 4 - start over
1277	DRACO-0	Error - tape 7 - start over
1302	Expan	Error copying 6 to 5 - hit start to try again
1311	Depletion	Error - checking calc - restart
1315	Depletion	Over or underflow - restart
1324	Depletion	Probably machine error - restart
1325	Picture	Tape 2 error - restart
1344	Depletion	Error - ln return - restart
1351	Picture	Error in requesting picture restart
1352	Depletion	Error checking calc - restart
1357	Depletion	Probably machine error - restart
1363	Depletion	Over or underflow - restart
1372	Depletion	Machine error - restart
1377	Depletion	Machine error - restart
1413	Picture	Error in requesting picture - restart
1431	Percnt	AC overflow - restart
1434	Percnt	MQ overflow - restart
1443	Depletion	Tape 2 error - restart
1444	Depletion	Tape 3 error - restart
1445	Depletion	Tape 7 error - restart
1450	Depletion	Machine error - restart
1456	Sigma	Tape error - 2, 4 or 5 - read - restart
1471	Sigma	Machine error - restart
1513	Percnt	Drum error - restart
1541	Depletion	Machine error - restart
1566	Flux	Drum error - restart
1574	Rest (2)	Error in time-step no. on restart rec. - restart
1576	Rest	Error in time-step no. on rest. rec. - restart
1602	Flux	Incorrect no. of flux tape records - restart

1602	Expan	Calculation does not check - restart
1604	Expan	Impossible end of tape - restart
1605	Rest (2)	Machine error - restart
1605	Expan	Tape 2 error - restart
1606	Expan	Tape 3 error - restart
1607	Expan	Tape 5 error - restart
1610	Expan	Tape 6 error - restart
1611	Expan	Tape 8 error - restart
1611	Iteration	Machine error - sq rt - restart
1612	Expan	Tape 9 error - restart
1614	Iteration	Machine error - ln return - restart
1615	Omega	Impossible end of tape - restart
1625	Expan	Flux tape stop - see on-line instructions
1626	Omega	Tape 4 error - restart
1631	Sigma	Machine error - restart
1635	Omega	Drum error - restart
1637	Rest	Too many records in a file of tape 7 - restart
1642	Rest (2)	Too many records in a file of tape 10 - restart
1645	Iteration	Machine error - hyp cos - restart
1653	Iteration	Machine error - hyp cos - restart
1656	Sigma	Tape error - 2, 3, 4, or 5 - write - restart
1657	Sigma	Tape error - 2, 3, 4, or 5 - write - restart
1660	Iteration	Machine error - hyp cos - restart
1700	Rest	Error in no. of files on tape 7 - restart
1703	Rest (2)	Error in no. of files on tape 10 - restart
1707	Omega	Tape EOF error - restart
1710	Omega	Tape 2 error - restart
1733	Depletion	Machine error - restart
1735	Rest	Double end of file missing on tape 7 - restart
1737	Rest	Machine error - restart
1745	Rest (2)	Double EOF missing on tape 10 - restart
1747	Rest (2)	Machine error - restart
1751	Rest	Machine error - restart
1762	Rest (2)	Machine error - restart
2001	Percnt	AC overflow - restart
2004	Percnt	MQ overflow - restart
2026	Rest	End of tape 7 - see on-line instructions
2037	Rest	EOF in wrong plane on tape 7 - restart
2041	Rest	Incorrect tape 7 is mounted - mount 7, restart
2042	Flux	Drum error - restart
2046	Rest (2)	Machine error - restart
2051	Power	Length of KSIG records incorrect - restart
2053	Rest (2)	Machine error - restart
2073	Rest (2)	End of tape 10 - see on-line instructions
2104	Rest (2)	EOF in wrong place on tape 10 - restart
2105	Rest (2)	Incorrect tape mounted on 10 - mount and restart
2201	Coef	Impossible end of tape - restart
2207	Power	Divide error - restart
2211	Iteration	Stop at best point in iteration - save tapes for restart

2223	Average	Tape 2 error - restart
2224	Average	Tape 3 error - restart
2225	Average	Tape 5 error - restart
2226	Average	Tape 6 error - restart
2255	Average	Impossible end of tape - restart
2270	Power	AC overflow - restart
2274	Power	MQ overflow - restart
2353	Coef	Over or underflow - restart
2354	Coef	CKSUM of 1st pass does not check with 2nd pass
2355	Coef	Machine error - restart
2356	Coef	Tape 1 error - restart
2357	Coef	Tape 2 error - restart
2360	Coef	Tape 3 error - restart
2361	Coef	Tape 4 error - restart
2440	Coef	Machine error - restart
2500	Picture	Tape 2 error - restart
2574	Omega	Machine error - restart
2576	Omega	Machine error - restart
2663	Picture	Impossible end of tape - restart
2664	Picture	Tape 3 error - restart
2720	Depletion	Tape 3 error - extra record - restart
2734	Power	Impossible end of tape - restart
2734	Norm	Impossible end of tape - restart
2735	Norm	Tape 3 error - restart
2736	Norm	Tape 2 error - restart
2737	Depletion	Tape 8 error - restart
2757	Depletion	Error - positioning tape 8 - restart
2760	Power	Machine error - restart
2761	Power	Tape 3 error - restart
2762	Power	Tape 8 error - restart
2763	Power	Tape 9 error - restart
3010	Flux	Flux tape (5 or 6) error - restart
3011	Flux	Tape 2 error - restart
3012	Flux	Tape 7 error - restart
3013	Flux	Tape 9 error - restart
3022	Flux	AC overflow - restart
3026	Flux	MQ overflow - restart
3064	Depletion	Machine error - checking count in index 1 - restart
3066	Norm	Drum error - hit start to try 3 more times
3102	Norm	Drum error - hit start to try 3 more times
3103	Percnt	Drum error - hit start to try again
3113	Power	Drum error - hit start to try 3 more times
3127	Power	Drum error - hit start to try 3 more times
3251	Percnt	Drum error - hit start to try 3 more times
3264	Percnt	Drum error - hit start to try 3 more times
3272	Sigma	Tape 2 error - restart
3273	Sigma	Tape 3 error - restart
3276	Sigma	Tape 7 error - restart
3277	Sigma	Tape 8 error - restart

3300	Sigma	Tape 9 error - restart
3300	Norm	AC overflow - restart
3301	Sigma	Diffusion not acceptable - restart (or WSTRE)
3302	Sigma	Total not acceptable - restart (or WSTRE)
3303	Sigma	Removal not acceptable - restart (or WSTRE)
3304	Sigma	Absorption not acceptable - restart (or WSTRE)
3304	Norm	MQ overflow - restart
3305	Sigma	Fission not acceptable - restart (or WSTRE)
3306	Sigma	Sum weight factors zero for 2 grp - restart
3307	Sigma	Machine error - restart
3310	Sigma	Machine error - restart
3406	Percnt	Tape 3 error - restart
3407	Percnt	Tape 2 error - restart
3410	Percnt	Impossible end of tape - restart
3727	Iteration	Tape 2 error - restart
3730	Iteration	Tape 4 error - restart
3731	Iteration	Tape 5 error - restart
3732	Iteration	Tape 6 error - restart
3733	Iteration	Impossible end of tape - restart
3734	Iteration	Drum error - restart
3735	Iteration	AC or MQ overflow - restart
3736	Iteration	AC or MQ overflow - restart
3737	Iteration	AC or MQ overflow - restart
3740	Iteration	AC or MQ overflow - restart
3741	Iteration	AC or MQ overflow - restart
7465	Percnt	Machine error - restart
10000	Picture	End of time-step calc - see on-line instructions
25252	Picture	Picture after input - see on-line instructions
77777	Pwr of Depl	End of tape 7. Load DRACO-0 to continue history tape.

XIII. OPERATING INSTRUCTIONS—DRACO-3 (EDITS)

A. Tape Configuration

1 All DRACO program tape

9 Binary output tape from specified DRACO-1 or DRACO-2 problem

10 Blank

2-8 Blanks when needed. The tapes required vary with the edits requested and may be determined by comparing the edit numbers on the master control card with the following table.

TABLE I

TAPES NEEDED FOR EACH EDIT

EDIT NO. 27	TAPE NO. 29
1	5
2	3, 5, 6, 8
3	8
4	2
5	2
6	4
7	2
8	2
9	8
10	8
11	8

B. Sense Switches

1 Up-normal
Down-restart

2-5 Up

6 Up-normal
Down-brings in octal dump (NYDS1) which requires control cards or blank card in card hopper.

C. Starting Procedure

1) Mount tapes as indicated.

2) Set proper sense switches.

3) GLOUT-2 printer panel in printer.

4) 72-72 panels in card reader and card punch.

5) Ready card reader with control deck in hopper.

6) Clear, load tape.

7) At program stop $(0007)_8$, manually enter the code number, in this case 3, into the address portion of the MQ. Start.

8) Always check information printed on-line to determine the progress of the sort and edits.

D. Program Stops

1) Normal stop:

$(4731)_8$ Program has been successfully completed. Save tapes 9 and 10. Print 10, the BCD output tape, off-line.

2) For all other program stops, consult the list of DRACO-3 Program Stops (Section XIII-F).

E. Restart Procedure

1) In general, a restart cannot be initiated unless EDIT SORT HAS BEEN COMPLETED has been printed on-line, and at least one card has been punched.

2) Rewind all tapes except 10.

3) Remove the control deck from the card reader and the restart card or cards from the card punch. A restart card is recognized by the 12L word which contains punches in columns 1 through 36. The 9L word will have one or more bits punched.

4) Depending on the type of error necessitating the restart, proceed with (a) or (b) as directed by the comments listed with the program stop.

a) NORMAL RESTART: Insert the last restart card into the control deck in place of the master control card which follows the title card.

b) BYPASS EDIT: Obtain the most recent restart card from the card punch. If there is only one bit punched in the 9L word of this card, remove the edit from the machine. Otherwise, omitting the leftmost bit, punch the 9L word on a blank card. Insert this card into the control deck in place of the master control card (second card of control deck). When all edits have been completed, save tapes pertaining to edits which have been skipped.

5) The leftmost punch in the 9L word of the inserted restart card indicates at which edit the restart will begin. Remove all control cards pertaining to edits preceding this one. An

edit control card is identified by its card number which begins in column 12 and is of the form (x000+n) where x indicates the edit number and n refers to sequencing within the set of cards for the edit. The number of the last card for an edit is negative.

6) Depress sense switch 1.

7) Ready the card reader with the corrected control deck in the hopper.

8) Clear, load tape. At program stop $(0007)_8$ enter 3 into the address of the MQ. Start.

9) When a restart fails, save all tapes.

F. Program Stops

0351	Cont, Edit 1-6	GLOUT2 - machine error - normal restart
0356	Sort	GLOUT2 - machine error - if sort has been completed - normal restart; otherwise reload deck, start over
0430	Cont, Edit 1-6	GLOUT2 - machine error - normal restart
0435	Sort	GLOUT2 - machine error - if sort has been completed - normal restart; otherwise reload deck, start over
1276	Cont, Edit 1-6	Boundary error - restart - bypass edit
1340	Sort	DBC - machine error - reload deck, start over
1362	Cont, Edit 1-6	Machine error - normal restart
1407	Sort	DBC - loading or requestor error - reload deck, start over
1411	Cont, Edit 1-6	Machine error - normal restart
1725	Sort	DBC - loading or requestor error - reload deck, start over
2005	Sort	DBC - machine error - normal restart
2206	Sort	CSH - machine error or illegal punch - reload deck, start over
2472	Sort	Tape 9 error - if sort has been completed - normal restart, otherwise reload deck, start over
2473	Sort	Tape 9 error - if sort has been completed - normal restart, otherwise reload deck, start over
2520	Sort	Title card wrong - remove problem - save all tapes if this is a restart
3617	Cont, Edit 1-6	DBC - machine error - normal restart
3666	Cont, Edit 1-6	DBC - loading or requestor error - normal restart
3701	Sort	Tape 2 error - reload deck, start over
3713	Sort	Tape 3 error - reload deck, start over
3725	Sort	Tape 4 error - reload deck, start over
3737	Sort	Tape 5 error - reload deck, start over
3753	Sort	Tape 8 error - reload deck, start over
4204	Cont, Edit 1-6	DBC - loading or requestor error - reload deck, start over
4256	Sort	End of tape - remove problem - save all tapes
4264	Cont, Edit 1-6	DBC - machine error - normal restart
4321	Sort	Tape 9 positioned wrong - reload deck, start over
4337	Sort	Tape 9 positioned wrong - reload deck, start over
4465	Control	CSH - machine error or illegal punch - normal restart
4710	Control	Tape 1 error - rewind tape 1 - normal restart
4731	Control	Normal end of program - get off the machine
4746	Control	End of tape - remove problem - save all tapes
5050	Edit 1-6	Boundary error - restart - bypass edit
5051	Edit 1-6	Card number error - restart - bypass edit
5052	Edit 1	Machine error - normal restart
	Edit 3, 4, 5	Element number error - restart - bypass edit

	Edit 6	Error selecting output - restart - bypass edit
5053	Edit 1,6	Group number error - restart - bypass edit
	Edit 2	Machine error - normal restart
5054	Edit 3	Option number error - restart - bypass edit
	Edit 6	Sigma R requested for last group - restart - bypass edit
5055	Edit 11	Tape 3 error - normal restart
5056	Edit 11	Tape 5 error - normal restart
5057	Edit 2	Tape 9 error - normal restart
	Edit 11	Tape 6 error - normal restart
5060	Edit 11	Tape 8 error - normal restart
5061	Edit 1	Tape 9 error - normal restart
	Edit 11	Tape 9 error - normal restart
5062	Edit 4,5	Tape 9 error - normal restart
5064	Edit 6	Tape 9 error - normal restart
5076	Edit 6	Tape 4 error - normal restart
5107	Edit 3	Tape 9 error - normal restart
5174	Edit 3	Tape 8 error - normal restart
5211	Edit 7,8,9	GLOUT2 - machine error - normal restart
5222	Edit 3	Erroneous division - normal restart
5226	Edit 4,5	Tape 2 error - normal restart
5265	Edit 1	Tape 5 error - normal restart
5270	Edit 7,8,9	GLOUT2 - machine error - normal restart
5315	Edit 2	Tape 5 error - normal restart
5356	Edit 2	Tape 6 error - normal restart
5371	Edit 3	Tape 8 error - normal restart
5414	Edit 3	Tape 8 error - normal restart
5417	Edit 2	Erroneous division - normal restart
5432	Edit 2	Tape 6 error - normal restart
5457	Edit 2	Tape 3 error - normal restart
5562	Edit 10	Over or underflow - normal restart
5563	Edit 10	Machine error - normal restart
5564	Edit 10	Machine error - normal restart
5565	Edit 10	Tape 8 error - normal restart
5566	Edit 10	Tape 9 error - normal restart
5636	Edit 2	Erroneous division - normal restart
5720	Edit 7,8	Tape 9 error - normal restart
5723	Edit 9	Tape 9 error - normal restart
5756	Edit 9	Tape 8 error - normal restart
6025	Edit 7,8	Tape 2 error - normal restart
6031	Edit 7,8	Machine error - normal restart
6173	Sort	Machine error - false EOF - reload deck - start over
6174	Sort	Machine error - false EOF - reload deck - start over
6264	Sort	Tape errors (DRACO-1) and/or requestor error (DRACO-2). May restart as indicated on-line to get available information.
6266	Sort	Tape errors (DRACO-1) and/or requestor error (DRACO-2). Requested edits cannot be done. Tape 9 probably bad.

APPENDIX I

NUMBERING OF ELEMENTS

Element Number	Element	Element	Element Number
1	H	Al	9
2	O	B-10	29
3	Zr	C	4
4	C	Cd	13
5	Mo	Co	12
6	Fe	Cr	11
7	Ni	Fe	6
8	Nb	Lumped Fission Products	28
9	Al	H	1
10	Sn	Hf	14
11	Cr	I	25
12	Co	In	17
13	Cd	Li	16
14	Hf	Mn	15
15	Mn	Mo	5
16	Li	Nb	8
17	In	Ni	7
18	U-235	O	2
19	U-236	Pm-149	24
20	U-238	Pu-239	21
21	Pu-239	Pu-240	22
22	Pu-240	Pu-241	23
23	Pu-241	Sm	26
24	Pm-149	Sn	10
25	I-135	U-235	18
26	Sm-149	U-236	19
27	Xe-135	U-238	20
28	Lumped Fission Products	unnamed burnable poison	30
29	B-10	Xe	27
30	unnamed burnable poison	Zr	3

APPENDIX II

PROGRAM CONSTANTS

Microscopic Cross Sections

Element No.	Element	Group	σ_{tr}	σ_r	σ_a^s	σ_f	$\nu\sigma_f$	ν
1	Hydrogen	1	1.5659	1.4505	0.0000	0.0000	0.0000	0.00
		2	2.5837	2.2128	0.0002	0.0000	0.0000	0.00
		3	6.3389	2.2543	0.0142	0.0000	0.0000	0.00
2	Oxygen	1	1.2777	0.2371	0.0425	0.0000	0.0000	0.00
		2	3.9450	0.0889	0.0000	0.0000	0.0000	0.00
		3	4.2553	0.0450	0.0000	0.0000	0.0000	0.00
3	Zirconium	1	1.8906	0.0823	0.0000	0.0000	0.0000	0.00
		2	7.4082	0.0318	0.0000	0.0000	0.0000	0.00
		3	10.0029	0.0183	0.0077	0.0000	0.0000	0.00
4	Carbon	1	0.9797	0.2248	0.0000	0.0000	0.0000	0.00
		2	3.6306	0.1141	0.0000	0.0000	0.0000	0.00
		3	4.8184	0.0809	0.0000	0.0000	0.0000	0.00
6	Iron	1	2.4500	0.2310	0.0000	0.0000	0.0000	0.00
		2	3.8200	0.0548	0.0000	0.0000	0.0000	0.00
		3	9.9800	0.0000	0.1084	0.0000	0.0000	0.00
7	Nickel	1	2.7000	0.2460	0.0000	0.0000	0.0000	0.00
		2	6.1600	0.0942	0.0000	0.0000	0.0000	0.00
		3	17.4000	0.0000	0.2020	0.0000	0.0000	0.00
8	Niobium	1	1.8906	0.0823	0.0000	0.0000	0.0000	0.00
		2	7.4082	0.0318	0.0000	0.0000	0.0000	0.00
		3	10.0029	0.0183	0.0077	0.0000	0.0000	0.00
11	Chromium	1	2.9200	0.2540	0.0000	0.0000	0.0000	0.00
		2	5.6600	0.0834	0.0000	0.0000	0.0000	0.00
		3	5.5400	0.0000	0.0984	0.0000	0.0000	0.00
18	Uranium-235	1	4.9349	0.1472	1.8186	1.3159	3.6451	2.77
		2	7.9808	0.0000	2.6953	1.9120	4.7414	2.48
		3	22.6183	0.0000	34.1205	25.3917	62.4637	2.46
20	Uranium-238	1	5.8050	2.3055	0.1684	0.4156	1.1220	2.70
		2	8.9462	0.0400	0.3186	0.0000	0.0000	0.00
		3	8.9904	--	0.3248	0.0000	0.0000	0.00
29	Boron-10	1	0.4492	0.0000	0.4492	0.0000	0.0000	0.00
		2	2.2919	0.0000	2.2919	0.0000	0.0000	0.00
		3	172.0860	0.0000	172.0860	0.0000	0.0000	0.00

Note that all cross sections are in barns (1×10^{-24} cm^2).

Calculation of Group Constants

a = 0.67

κ Energy produced per fission neutron (watts/fission neutron second)

Group	Element (18) U-235	(20) U-238	(21) Pu-239	(23) Pu-241
1	0.114352×10^{-10}	0.117317×10^{-10}	0	0
2	0.127724×10^{-10}	0	0	0
3	0.128762×10^{-10}	0	0	0
4	$0.12904891 \times 10^{-10}$	$0.12800819 \times 10^{-10}$	$0.10946907 \times 10^{-10}$	$0.10582010 \times 10^{-10}$

χ^i (for 2 group edit of constants)

i	χ
1	0.75165
2	0.248175
3	0

Calculation of Isotopic Densities

Yields

Element	γ^{24} Pm-149	γ^{27} Xe-135	γ^{28} Lumped Fission Products
(18) U-235	0.14×10^{-3}	0.3×10^{-2}	1.0
(20) U-238	0.14×10^{-3}	0.3×10^{-2}	1.0
(21) Pu-239	0.14×10^{-3}	0.3×10^{-2}	1.0
(23) Pu-241	0.14×10^{-3}	0.3×10^{-2}	1.0

Decay Constants

Element	λ^M/sec
(23) Pu-241)	0.17×10^{-8}
(24) Pm-149	0.385×10^{-5}
(25) I-135	0.288×10^{-4}
(27) Xe-135	0.211×10^{-4}

APPENDIX III

SAMPLE PROBLEM

DRACO - FORM I

TITLE CARD

DRACO TEST PROBLEM	50 – 67	68 – 71
DRACO TEST PROBLEM	(shaded)	DRAC1

	GRPS	CMPS	SS	UU	A	E	C	D	FLX	PIC	SIG	Ω	XSEC	T.S.	Δt	P	
+01001	+2	+02	+09	+04	+0	+0	+1	+1	+1	+2	+1	+1	+2	+00	+5718	+5564953 3	+00000000000

	λ_0	ϵ_0	t_1	t_2	t_3	t_4
+01002	+4978471	+495	+	+	+	+

	χ_1	χ_2	χ_3	
+01003	+511	+	+	+0000000000000000000000000000000000000

	γ_i				
+01004	+496	+496	+496	+496	+0000000000000000000000000

DRACO - FORM 2
MESH DESCRIPTION

FOR χ MESH (EQUAL TO γ MESH), START NUMBERING CARDS AT 02001

FOR Z MESH, START NUMBERING AT 03001

	CD #	7	Δ	18	N	21	Δ	32	N	35	Δ	46	N	49	Δ	60	N	63	72
+	2001	+	5113	+	06	+	5115	+	09	+		+		+		+		+	000000000
+		+		+		+		+		+		+		+		+		+	000000000
+		+		+		+		+		+		+		+		+		+	000000000
+	3001	+	505	+	04	+		+		+		+		+		+		+	000000000
+		+		+		+		+		+		+		+		+		+	000000000
+		+		+		+		+		+		+		+		+		+	000000000
+		+		+		+		+		+		+		+		+		+	000000000
+		+		+		+		+		+		+		+		+		+	000000000
+		+		+		+		+		+		+		+		+		+	000000000
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+		+		+		+		+		+		+		+		+		+	000000000
+		+		+		+		+		+		+		+		+		+	000000000

DRACO-FORM 3
COMPOSITION DESCRIPTION
BEGIN NUMBERING CARDS AT 04001

+ 04000 + ←—— ALL ZEROS ——→

CD #	P1	P2	V	X1	X2	Y1	Y2	V	X1	X2	Y1	Y2	V	X1	X2	Y	Y2	V	X1	X2	Y1	Y2
04001	00	04	02	00	09	00	09	01	00	06	00	06										

(Card column markers: 7 before P1, 13 before V, 28 before the second V, 43 before the third V, 58 before the fourth V.)

DRACO - FORM 4
THERMAL CROSS SECTIONS

05000 CONTROL CARD NEEDED ONLY BEFORE FIRST SET OF CROSS SECTIONS
FOR FOLLOWING CARDS BEGIN NUMBERING AT 05001

05000	ALL ZEROS

CD #	CMPS	COMPOSITIONS IN WHICH "SET" IS TO BE USED
05001	01	02
	00	
	00	

	CD #	7	13	29	40	51	62	72
σ_{tR}	05002	5222398	514025	518046	0	0	0	
	05003	0	0	0	0	0	0	
	05004	0	0	0	0	0	534282	
	05005	52119	521006	53997	53383	54109	0	
	05006	0	555	5727	5265	0	0	
σ_a	05007	502151	0	501416	0	0	0	
	05008	0	0	0	0	0	0	
	05009	0	0	0	0	0	534182	
	05010	5139	51179	53987	53373	54108	0	
	05011	0	555	5727	5265	0	0	
σ_f	05012	533546	0	53651	53805	0000000000000000000000		
$\nu\sigma_f$	05013	53872316	0	54187488	542415	0000000000000000000000		

DRACO - FORM 4
THERMAL CROSS SECTIONS

05000 CONTROL CARD NEEDED ONLY BEFORE FIRST SET OF CROSS SECTIONS
FOR FOLLOWING CARDS BEGIN NUMBERING AT 05001

	ALL ZEROS

CD #	CMPS	COMPOSITIONS IN WHICH "SET" IS TO BE USED
05014	01	01
	00	
	00	

	CD #	7	18	29	40	51	62	72
	05015	5222398	514025	518046	0	0	0	
	05016	0	0	0	0	0	0	
σ_{tR}	05017	0	0	0	0	0	534282	
	05018	52119	521006	53997	53383	54109	0	
	05019	0	555	5727	5265	0	0	
	05020	502151	0	501416	0	0	0	
	05021	0	0	0	0	0	0	
σ_a	05022	0	0	0	0	0	53372198	
	05023	5139	5117005	53987	53373	54108	0	
	05024	0	555	5727	5265	0	0	
σ_f	05025	53315594	0	53651	53805	0		
$\nu\sigma_f$	05026	5377636124	0	54187488	542415	0		

DRACO - FORM 5
FLUX GUESS FOR EACH COMPOSITION

06011 BEGINS GROUP 1
06021 BEGINS GROUP 2, etc.

+	06000	+	← ALL ZEROS →																				
			7	ϕ			18	ϕ			29	ϕ			40	ϕ			51	ϕ			62	ϕ	72
+	06011	+	513				+	512			+				+				+				+		
+		+					+				+				+				+				+		
+		+					+				+				+				+				+		
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+		+					+				+				+				+				+		
+		+					+				+				+				+				+		
+	06021	+	513				+	512			+				+				+				+		
+		+					+				+				+				+				+		
+		+					+				+				+				+				+		
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+	06031	+					+				+				+				+				+		
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+		+					+				+				+				+				+		

DRACO - FORM 6

FLUX (Continued)

1	7	18	29	40	51	62	72
06041							

MUFT BUCKLING
FOR 2 GROUP PROBLEM ONLY

1	7	18	29	40	51	62	72
07001	485	485					

DRACO - FORM 7

P_r^{28}

ONE VA_UE FOR EACH COMPOSITION

1	7	18	25	40	51	62	72
08001	511	511					

Σ_p

ONE VALUE FOR EACH COMPOSITION

1	7	18	29	40	51	62	72
09001	0	0					

DRACO - FORM 8

FOR ISOTOPIC DENSITIES BEGIN NUMBERING AT 10001 (CONTROL CARD = 11000)
FOR SELF SHIELDING BEGIN NUMBERING AT 11001 (CONTROL CARD = 12000)
FOR LOGARITHMIC DERIVATIVES BEGIN AT 12001 (CONTROL CARD = 13000)

CD #	ELEM OR GRP	← COMPOSITION NUMBERS →
10001	01	0

CD # (7 … 72)

CD #							
10002	49273804	4923643					

CD #		
10003	02	0

CD # (7 … 72)

CD #							
10004	49136902	4925464					

CONTROL CARD IF NEEDED

CD #	← ALL ZEROS →

DRACO - FORM 8

FOR ISOTOPIC DENSITIES BEGIN NUMBERING AT 10001 (CONTROL CARD = 11000)
FOR SELF SHIELDING BEGIN NUMBERING AT 11001 (CONTROL CARD = 12000)
FOR LOGARITHMIC DERIVATIVES BEGIN AT 12001 (CONTROL CARD = 13000)

CD #	ELEM OR GRP	COMPOSITION NUMBERS
10005	03	0

CD #	7			72
10006	492021	4910345		

CD #	
10007	18 0

CD #	7			72
10003	47141848	464915		

CONTROL CARD IF NEEDED

CD #	ALL ZEROS

DRACO - FORM 8

FOR ISOTOPIC DENSITIES BEGIN NUMBERING AT 10001 (CONTROL CARD = 11000)
FOR SELF SHIELDING BEGIN NUMBERING AT 11001 (CONTROL CARD = 12000)
FOR LOGARITHMIC DERIVATIVES BEGIN AT 12001 (CONTROL CARD = 13000)

CD #	ELEM OR CRP	COMPOSITION NUMBERS
10009	20	01

CD # (7 ... 72)

CD #	
10010	485071

CD #

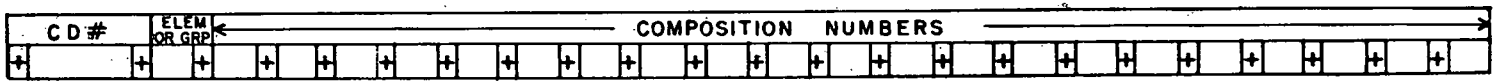
CD # (7 ... 72)

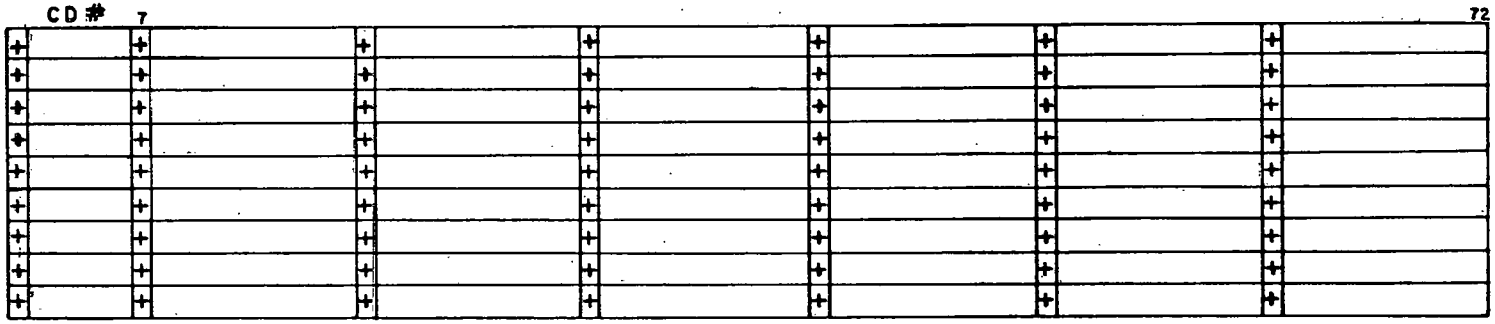
CONTROL CARD IF NEEDED

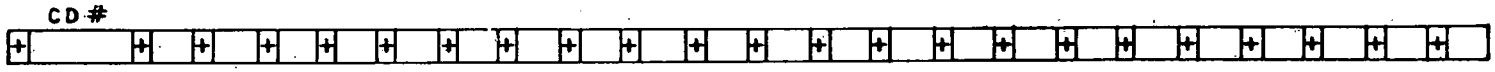
CD #	
11000	ALL ZEROS

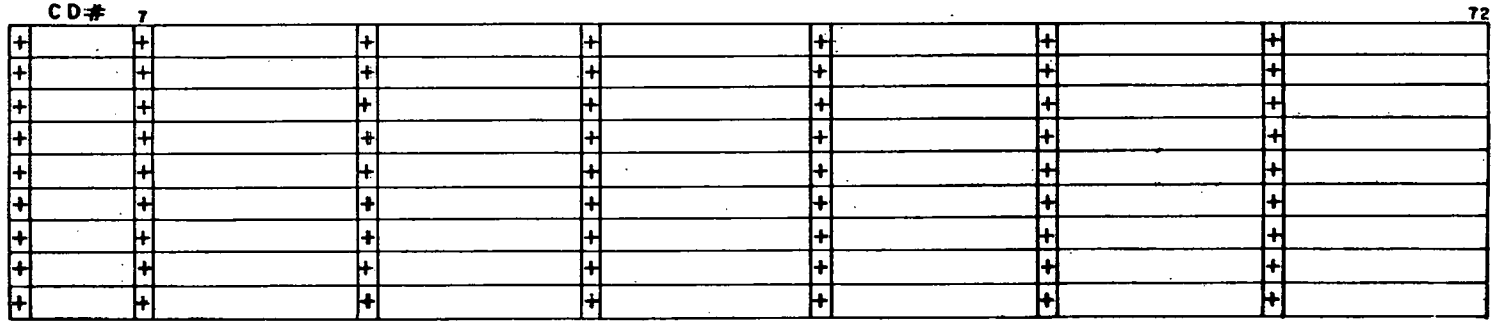
DRACO - FORM 8

FOR ISOTOPIC DENSITIES BEGIN NUMBERING AT 10001 (CONTROL CARD = 11000)
FOR SELF SHIELDING BEGIN NUMBERING AT 11001 (CONTROL CARD = 12000)
FOR LOGARITHMIC DERIVATIVES BEGIN AT 12001 (CONTROL CARD = 13000)

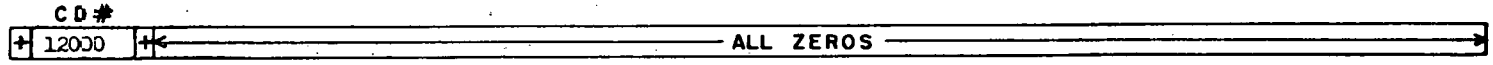






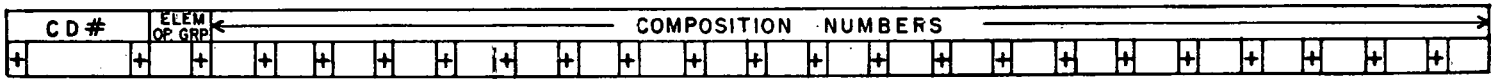


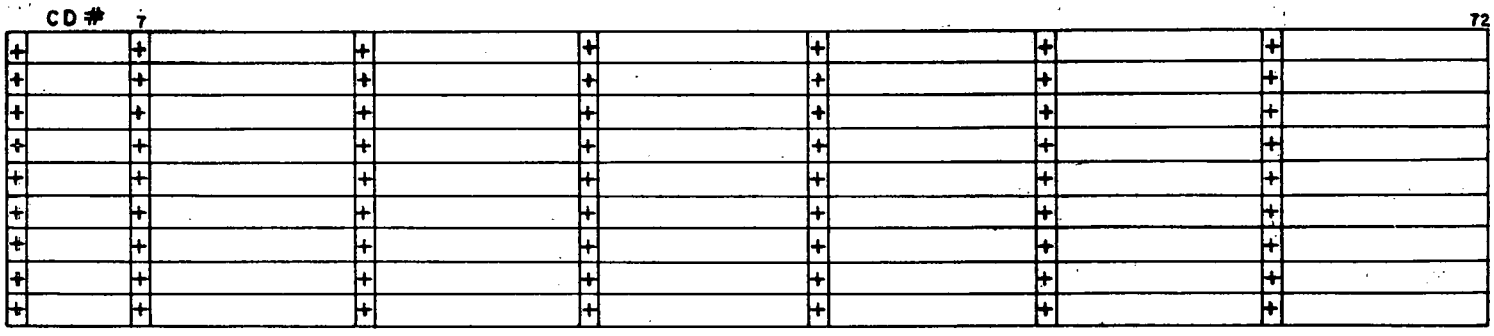
CONTROL CARD IF NEEDED

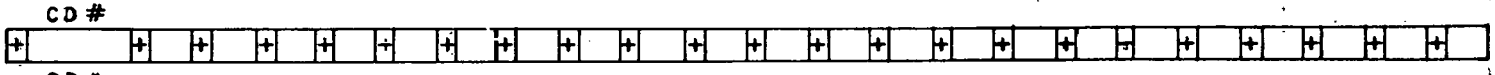


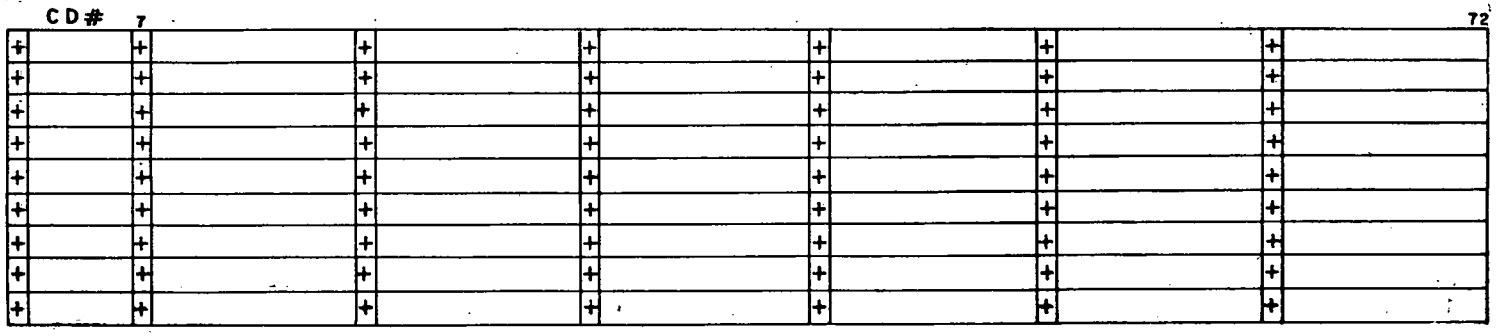
DRACO - FORM 8

FOR ISOTOPIC DENSITIES BEGIN NUMBERING AT 10001 (CONTROL CARD = 11000)
FOR SELF SHIELDING BEGIN NUMBERING AT 11001 (CONTROL CARD = 12000)
FOR LOGARITHMIC DERIVATIVES BEGIN AT 12001 (CONTROL CARD = 13000)

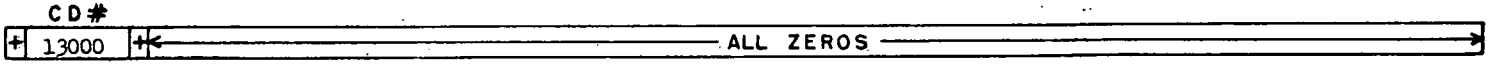








CONTROL CARD IF NEEDED



```
DRACO TEST PROBLEM                                                    DRAC1
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+01002+4978471000+4950003000+0000000000+0000000000+0000000000+0000000000
+01003+5110000000+0000003000+0000000000+0000000000+0000000000+0000000000
+01004+4960000000+4960003000+4960000000+4960000000+0000000000000000000
+02001+5113000000+06+5115000000+09+0000000000+00+0000000000+00+000000000
+03001+5050000000+04+0003000000+00+0000000000+00+0000000000+00+000000000
+04000+000000000000000003000000000000000000000000000000000000000000000000
+04001+00+04+02+00+09+00+09+01+00+06+00+06+000000000000000000000000000000
+05000+000000000000000000000000000000000000000000000000000000000000000000
+05001+1+2+000000000000000000000000000000000000000000000000000000000000000
+05002+5222398000+5140250000+5180460000+0000000000+0000000000+0000000000
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+05026+5377636124+0000000000+5418748800+5424150000+0000000000000000000000
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+10C10+486771000C+00C0000000+0000000000+0000000000+0000000000+0000000000+0000000000
+11C00+000C00000C0C0C0000000000000000000000000000000000000000000000000000000000
+12C00+000C00000C0C0C0000000000000000000000000000000000000000000000000000000000
+13C00+000C00000C0C0C0000000000000000000000000000000000000000000000000000000000

DRACO TEST PROBLEM                                                    DRAC1
       DEC 1,8,-10
       DEC 1001,1,1,8,1,8,1,3
       DEC -1002,2,1,8,1,8,1,3
       DEC -10001,0
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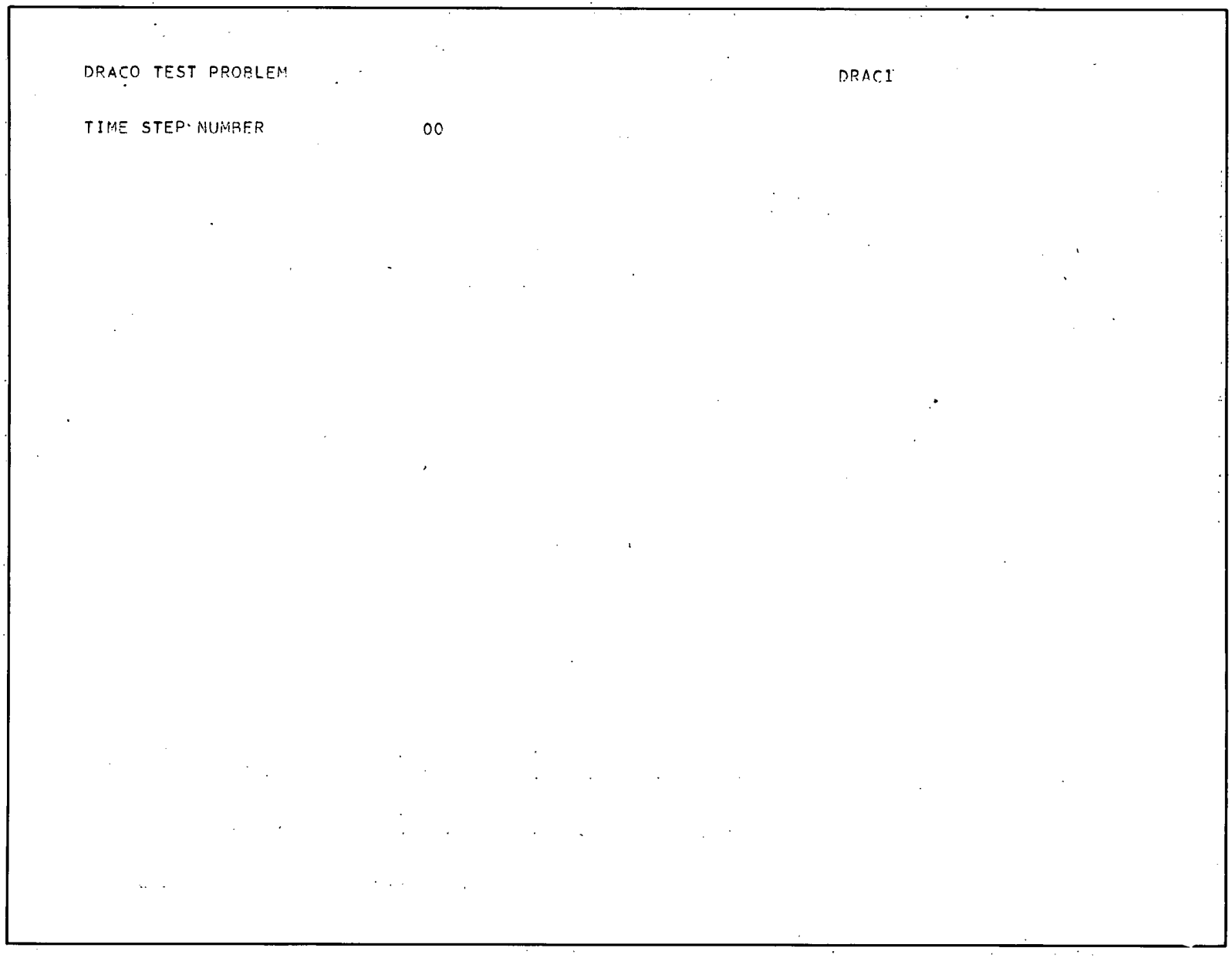

DRACO TEST PROBLEM
DRAC1
TIME STEP NUMBER
00

COMP	GROUP	DIFFUSION	ABSORPTION	NU. FISSION	REMOVAL
1	1	1.3145989	.00464127	.00561297	.01955861
1	2	.3472821	.07306089	.11012529	...
2	1	2.0566880	.00110364	.00109670	.01673006
2	2	.4526953	.02710499	.04287433	...

GROUP	IT. NO.	PI	SHK1	SHK2	SHK3	SHK4	WMIN	OMEGA	WMAX	NMIN	NMAX
1	10	0.97079266	0.97221736	0.97222104	0.97221206	0.97225981	1.54462998	1.71445149	1.83453305	9	19
2	10	0.94900888	0.95099417	0.95120477	0.95121406	0.95035646	1.52232711	1.63557936	1.70015906	7	14

GROUP	INITIAL RES.	NO. INNER IT.	FINAL RES.
1	69.4077	18	2.8404
2	29.8516	10	1.1896

OUTER IT.	MAX. LAMBDA	LAMBDA	MIN. LAMBDA	EPSILON SQ.	ALPHA	BETA	RENORM.
1	.107545	.080963	.015512	.568369	.000000	.000000	1.180668

GROUP	INITIAL RES.	NO. INNER IT.	FINAL RES.
1	28.9715	15	1.2470
2	2.5386	15	.1082

OUTER IT.	MAX. LAMBDA	LAMBDA	MIN. LAMBDA	EPSILON SQ.	ALPHA	BETA	RENORM.
2	.081705	.078433	.060579	.132760	.000000	.000000	1.016839

GROUP	INITIAL RES.	NO. INNER IT.	FINAL RES.
1	3.8991	16	.1537
2	.4879	15	.0183

OUTER IT.	MAX. LAMBD	LAMBDA	MIN. LAMBDA	EPSILON SQ.	ALPHA	BETA	RENORM.
3	.079125	.078430	.075294	.024426	.000000	.000000	1.001585

GROUP	INITIAL RES.	NO. INNER IT.	FINAL RES.
1	.7228	17	.0286
2	.0900	15	.0038

OUTER IT.	MAX. LAMBDA	LAMBDA	MIN. LAMBDA	EPSILON SQ.	ALPHA	BETA	RENORM.	SIGMA
4	.078690	.078458	.077829	.005482	1.101892	.000000	1.000077	.184940

GROUP	INITIAL RES.	NO. INNER IT.	FINAL RES.
1	.1980	17	.0090
2	.0246	15	.0011

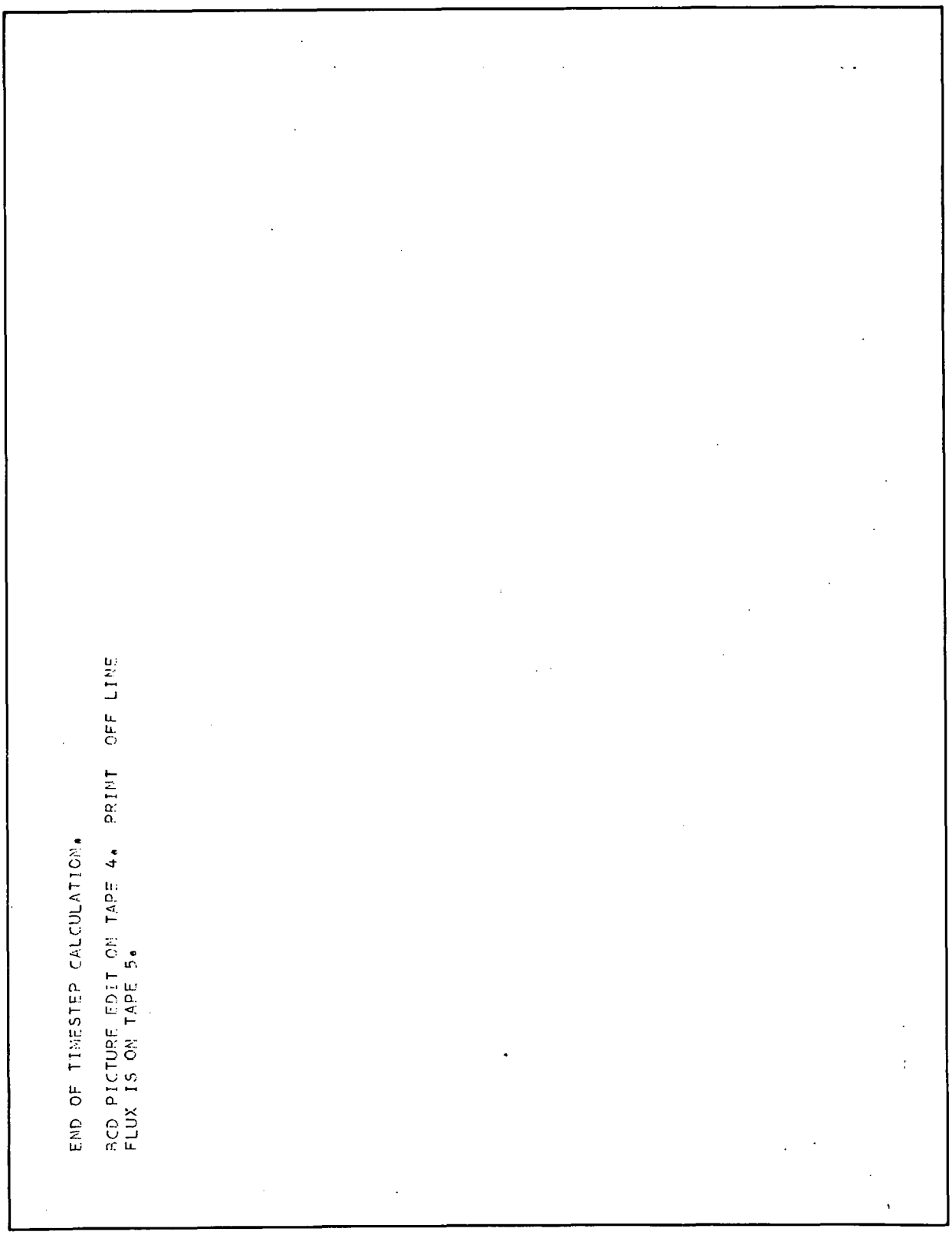
OUTER IT.	MAX. LAMBDA	LAMBDA	MIN. LAMBDA	EPSILON SQ.	ALPHA	BETA	RENORM.
5	.078547	.078472	.078370	.001128	.000000	.000000	1.000000

			COMPOSITION-INTEGRATED VOLUME
1	2 608400	2 904499	
			COMPOSITION-INTEGRATED FLUX - GROUP 1
1	3 797521	3 472508	
			COMPOSITION-AVERAGED FLUX - GROUP 1
1	2 131085	1 522397	
			COMPOSITION-INTEGRATED FLUX - GROUP 2
1	3 124229	2 986504	
			COMPOSITION-AVERAGED FLUX - GROUP 2
1	1 204190	1 109066	

POWER

COMPOSITION PERCENTAGES	18	20	21	23	COMPOSITION TOTAL/REACTOR TOTAL
1	90705	-1 92949	00000	00000	79116
2	1 10000	00000	00000	02000	20884

NORMALIZATION FACTOR 15 22161255


END OF TIMESTEP CALCULATION.
BCD PICTURE EDIT ON TAPE 4. PRINT OFF LINE
FLUX IS ON TAPE 5.

```
DRACO TEST PROBLEM                    OOT.S.      DRAC1                    PAGE  1
                              2 GROUPS     2 COMPS    SS= 9    UU= 4    B.C.=0.0.1.1

  MESH    XX    MESH    XX
 1.3000    6   1.5000    9

  MESH    ZZ
 .5000     4
```

DRACC TEST PROBLEM T.S.00 DRAC1 PAGE 1

EDIT 10 -AVG. (BLK) STICK POWER-TOTAL

	1	2	3	4	5	6	7	8	9
1	1402	3986	5949	6990	6970	5965	1561	-1 9767	-1 3312
2	3986	1 1134	1 1693	1 1990	1 1986	1 1702	4462	2795	-1 9485
3	5949	1 1693	1 2529	1 2978	1 2978	1 2560	6739	4232	1438
4	6990	1 1990	1 2978	1 3514	1 3528	1 3051	8095	5108	1740
5	6970	1 1986	1 2978	1 3528	1 3567	1 3121	8407	5345	1827
6	5965	1 1702	1 2560	1 3051	1 3121	1 2797	7753	4978	1709
7	1561	4462	6739	8095	8407	7753	6247	4030	1387
8	-1 9767	2795	4232	5108	5345	4978	4030	2599	-1 8957
9	-1 3312	-1 9485	1438	1740	1827	1709	1387	-1 8957	-1 3089

EDIT 10 COMPLETED

```
DRACO TEST PROBLEM                                    7.5.00      DRAC1     FINAL AVERAGE ISOTOPIC DENSITIES PAGE   1

            COMPOSITION  1                 COMPOSITION VOLUME=   2 60839990
-4 9947  -5 7250  -2 6769  -4 1186  -5 1675  -5 2177  -7 8803  -7 5048  -7 1534  -8 1243  -4 4362     0000     0000

            COMPOSITION  2                 COMPOSITION VOLUME=   2 90449994
-4 4032  -5 1457     0000     0000     0000     0000  -7 1488  -8 8534  -8 4981  -9 3872  -5 7373     0000     0000

            REACTOR TOTALS                        TOTAL VOLUME=   3 15128998

 35 5147  34 3040  37 2179  34 3828  33 5411  32 7030  32 3556  32 2039  31 7295  30 5870  35 1762     0000     0000

                                                                                                  EDIT 8  COMPLETED
```

DRACO TEST PROBLEM T.S.00 DRAC1 PLANE 1 PAGE 1

EDIT 1 POINTWISE FLUX - GROUP 1

	1	2	3	4	5	6	7	8
1	1 3984	1 7331	1 9499	2 1011	1 9003	1 6223	1 3917	1 1900
2	1 7331	2 1350	2 1750	2 1865	2 1663	2 1152	1 7268	1 3531
3	1 9499	2 1750	2 2272	2 2426	2 2171	2 1512	1 9582	1 4671
4	2 1011	2 1865	2 2426	2 2601	2 2343	2 1651	2 1056	1 5182
5	1 9003	2 1663	2 2171	2 2343	2 2140	2 1554	2 1015	1 5042
6	1 6223	2 1152	2 1512	2 1651	2 1554	2 1251	1 8593	1 4352
7	1 3917	1 7268	1 9582	2 1056	2 1015	1 8593	1 6057	1 3113
8	1 1900	1 3531	1 4671	1 5182	1 5042	1 4352	1 3113	1 1613

```
DRACO TEST PROBLEM                                  CDT.S.      DRAC1          PLANE  0.          PAGE  2

COLUMN
   0   1   2   3   4   5   6   7   8   9
ROW
 0 ..........................................
   .001 001 001 001 001 001.002 002 002.
 1 .                         .             .
   .001 001 001 001 001 001.002 002 002.
 2 .                         .             .
   .001 001 001 001 001 001.002 002 002.
 3 .                         .             .
   .001 001 001 001 001 001.002 002 002.
 4 .                         .             .
   .001 001 001 001 001 001.002 002 002.
 5 .                         .             .
   .001 001 001 001 001 001.002 002 002.
 6 . . . . . . . . . . . . .             .
   .002 002 002 002 002 002 002 002 002.
 7 .                                       .
   .002 002 002 002 002 002 002 002 002.
 8 .                                       .
   .002 002 002 002 002 002 002 002 002.
 9 ..........................................
```

DRACO TEST PROBLEM T.S.00 DRAC1 PLANE 2 PAGE 2

EDIT 1 POINTWISE FLUX - GROUP 1

	1	2	3	4	5	6	7	8
1	1 3984	1 7331	1 9499	2 1011	1 9003	1 6223	1 3917	1 1900
2	1 7331	2 1350	2 1750	2 1865	2 1663	2 1152	1 7268	1 3531
3	1 9499	2 1750	2 2272	2 2426	2 2171	2 1512	1 9582	1 4671
4	2 1011	2 1865	2 2425	2 2601	2 2343	2 1651	2 1056	1 5182
5	1 9003	2 1663	2 2171	2 2343	2 2140	2 1554	2 1015	1 5042
6	1 6223	2 1152	2 1512	2 1651	2 1554	2 1251	1 8593	1 4352
7	1 3917	1 7268	1 9582	2 1056	2 1015	1 8593	1 6057	1 3113
8	1 1900	1 3531	1 4671	1 5182	1 5042	1 4352	1 3113	1 1613

DRACO TEST PROBLEM T.S.00 DRAC1 PLANE 3 PAGE 3

EDIT 1 POINTWISE FLUX - GROUP 1

	1	2	3	4	5	6	7	8
1	1 3984	1 7331	1 9499	2 1011	1 9003	1 6223	1 3917	1 1900
2	1 7331	2 1350	2 1750	2 1865	2 1663	2 1152	1 7268	1 3531
3	1 9499	2 1750	2 2272	2 2426	2 2171	2 1512	1 9582	1 4671
4	2 1011	2 1865	2 2426	2 2601	2 2343	2 1651	2 1056	1 5182
5	1 9003	2 1663	2 2171	2 2343	2 2140	2 1554	2 1015	1 5042
6	1 6223	2 1152	2 1512	2 1651	2 1554	2 1251	1 8593	1 4352
7	1 3917	1 7268	1 9582	2 1056	2 1015	1 8593	1 6057	1 3113
8	1 1900	1 3531	1 4671	1 5182	1 5042	1 4352	1 3113	1 1613

DRACO TEST PROBLEM T.S.00 DRAC1 PLANE 1 PAGE 4

EDIT 1 POINTWISE FLUX - GROUP 2

	1	2	3	4	5	6	7	8
1	5698	1 1051	1 1371	1 1483	1 1384	1 1125	8047	4157
2	1 1051	1 1940	1 2532	1 2743	1 2565	1 2089	1 1498	7750
3	1 1371	1 2532	1 3309	1 3593	1 3371	1 2760	1 1988	1 1031
4	1 1483	1 2743	1 3593	1 3916	1 3698	1 3058	1 2219	1 1156
5	1 1384	1 2565	1 3371	1 3698	1 3532	1 2976	1 2183	1 1144
6	1 1125	1 2089	1 2760	1 3058	1 2976	1 2594	1 1920	1 1011
7	8047	1 1498	1 1988	1 2219	1 2183	1 1920	1 1410	7429
8	4157	7750	1 1031	1 1156	1 1144	1 1011	7429	3918

DRACC TEST PROBLEM — *S.00 DRAC1 — PLANE 2 PAGE 5

EDIT 1 POINTWISE FLUX - GROUP 2

	1	2	3	4	5	6	7	8
1	5698	1 1051	1 1371	1 1483	1 1384	1 1125	8047	4157
2	1 1051	1 1940	1 2532	1 2743	1 2565	1 2089	1 1498	7750
3	1 1371	1 2532	1 3309	1 3593	1 3371	1 2760	1 1988	1 1031
4	1 1483	1 2743	1 3593	1 3916	1 3698	1 3058	1 2219	1 1156
5	1 1384	1 2565	1 3371	1 3698	1 3532	1 2976	1 2183	1 1144
6	1 1125	1 2089	1 2760	1 3058	1 2976	1 2594	1 1920	1 1011
7	8047	1 1498	1 1988	1 2219	1 2183	1 1920	1 1410	7429
8	4157	7750	1 1031	1 1156	1 1144	1 1011	7429	3918

DRACO TEST PROBLEM T.S.00 DRAC1 PLANE 3 PAGE 6

EDIT 1 POINTWISE FLUX - GROUP 2

	1	2	3	4	5	6	7	8
1	5698	1 1051	1 1371	1 1483	1 1384	1 1125	8047	4157
2	1 1051	1 1940	1 2532	1 2743	1 2565	1 2089	1 1498	7750
3	1 1371	1 2532	1 3309	1 3593	1 3371	1 2760	1 1988	1 1031
4	1 1483	1 2743	1 3593	1 3916	1 3698	1 3058	1 2219	1 1156
5	1 1384	1 2565	1 3371	1 3698	1 3532	1 2976	1 2183	1 1144
6	1 1125	1 2089	1 2760	1 3058	1 2976	1 2594	1 1920	1 1011
7	8047	1 1498	1 1988	1 2219	1 2183	1 1920	1 1410	7429
8	4157	7750	1 1031	1 1156	1 1144	1 1011	7429	3918

EDIT 1 COMPLETED

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