1968

ZAP - a computer program to predict fission product concentrations as a function of neutron flux, irradiation and cooling times

Bruce Earl Koopmann

ZAP - A COMPUTER PROGRAM TO PREDICT FISSION PRODUCT CONCENTRATIONS AS A FUNCTION OF NEUTRON FLUX, IRRADIATION AND COOLING TIMES

BY

BRUCE EARL KOOPMANN, [illegible]

A

THESIS

submitted to the faculty of

THE UNIVERSITY OF MISSOURI - ROLLA

in partial fulfillment of the requirements for the

Degree of

MASTER OF SCIENCE IN NUCLEAR ENGINEERING

Rolla, Missouri

1968

Approved by

D. Kay Edwards (advisor) [signature]

Herbert R. Alcorn

ABSTRACT

The development of a computer code was undertaken to calculate the fission product nuclide concentration for spent fuel discharged from a nuclear reactor, as a function of irradiation time, cooling time, neutron flux, and element cross section. The necessary input data was prepared from the basic nuclear data for fission of uranium-235 and plutonium-239. Calculations are also made for total or selective element beta heating and total gamma flux according to user selected input groups. These calculations would be useful in fuel element shielding, cooling, shipping and processing studies.

Acknowledgement

The author wishes to express his sincere appreciation to Dr. Doyle R. Edwards and Herbert R. Alcorn for their guidance and assistance in the preparation of this thesis.

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

FIGURES

TABLES

I. INTRODUCTION

Knowledge of the fission product spectrum, with respect to both atomic numbers and mass numbers, is often necessary in the reprocessing of nuclear fuel and the waste disposal industry. From this information, activity levels for shielding requirements and heat generation rates for cooling requirements may be calculated. These will depend upon irradiation time, cooling time, half-lives, cross sections, neutron energy, and decay energies as major factors.

At the present time, although calculation methods and equations are well known, the data required is far from complete. The data that is known, if compared from different reliable sources, may still vary. Although the nuclear decay equations and their solutions are relatively standard, the length and complexity of these equations lend themselves well to human error. The input data and number of equations to be solved represent a momentous task and the solution of such equations might very well prove economically unfeasible.

The technique described herein is incorporated in a computer program that solves such equations as mentioned above in a relatively short period of time with a minimum chance of human error.

II. PRELIMINARY RESEARCH

The importance of fission product concentration is ever present in almost all phases of the reactor industry. Glasstone and Sesonke (Ref. 1), Lamarsh (Ref. 2), Meghreblian and Holmes (Ref. 3) and others indicate this fact in their treatment of the different facets of the nuclear industry. Known fission product concentrations are necessary for deducing effects of reactor mishaps and fallout from nuclear weaponry. Reactor control is dependent on fission product buildup as is heat generation in spent fuel. Handling of spent and partially spent fuel, fuel reprocessing and waste disposal require knowledge of the activity of the subject material so that human dosage and processing techniques may be determined. Knowledge of fission product concentrations and fission product activity can not only help the nuclear industry be more efficient, but help save lives as well.

When reactors were in their infancy, fission product calculations were a long and tedious process requiring many man hours of computations involving the buildup and decay equations. These equations were generalized and put in symmetric form by Bateman (Ref. 4). These formulae were developed some time before the beginning of the nuclear age, and, although exact by theory, still required many hours of calculation and were subject to human error.

As early as 1950, graphical representations were given for general and specific irradiation and cooling times (Ref. 5). Graphical methods are still employed today, but are generally used for rough calculations rather than accurate answers. Later editions of these graphs also give average and total beta energy of fission products in addition to fission product concentrations (Ref. 6). As nuclear knowledge increased and digital computers came into being, hours of calculations were condensed to seconds with a minimum of human error. The more exact methods of calculating fission product concentrations became economically available to the user due to the great speed and relative availability of large computers. Some of the earlier programs written calculate only the fission product spectra. One, which might be called the predecessor of the program presented in this paper, was written by W.D. Owengs of Martin Company (Ref. 7), and calculates only the total fission product activity. Another program along this line is Delayne's method for specific calculations on individual isotopes (Ref. 8).

Later programs, such as FIP, written by G. Casadei (Ref. 9), numerically solve the differential equations governing the buildup and decay of fission products as a function of irradiation and decay times only. Another program along this line, by N. Harris of Atomics International (Ref. 10) obviously written for nuclear fallout

or reactor mishaps, calculates fission product buildup and decay and then calculates dose rates to various organs of the body due to inhalation of airborne contaminations.

Perhaps the best of the more recent programs in this area is a computer code developed by Oak Ridge Laboratory (Ref. 11) called PHOEBE. This code calculates fission product buildup and decay as a function of neutron flux, irradiation and cooling times. Functions are also developed for beta and gamma release rates. The derivation, usage, and modification for other purposes of these functions are explained in this report.

By no means are the references noted a complete list of available material. Literally hundreds of articles exist on different methods of calculating fission product buildup and decay, and beta and gamma release rates. Also, many computer programs exist using many of these methods and other shortened versions.

The Bateman equations are the basis of all decay and production of radioisotopes in decay chains. These equations, though simply solved, are tedious. They begin with the basic differential equation for decay to a daughter and proceed through a chain. Evans (Ref. 4) states that the solution of an accumulation of products is:

$$N = A_o(h_a e^{-\lambda_a t} + h_b e^{-\lambda_b t} + \cdots + h_m e^{-\lambda_m t} + h_n e^{-\lambda_n t}) \qquad (1)$$

where:

N = number of atoms in decay daughter N after time t

$$h_a = \frac{\lambda_a}{\lambda_n - \lambda_a} \frac{\lambda_b}{\lambda_b - \lambda_a} \frac{\lambda_c}{\lambda_c - \lambda_a} \cdots \frac{\lambda_m}{\lambda_m - \lambda_a}$$

$$h_b = \frac{\lambda_a}{\lambda_a - \lambda_b} \frac{\lambda_b}{\lambda_n - \lambda_b} \frac{\lambda_c}{\lambda_c - \lambda_b} \cdots \frac{\lambda_m}{\lambda_m - \lambda_b}$$

$$h_m = \frac{\lambda_a}{\lambda_a - \lambda_m} \frac{\lambda_b}{\lambda_b - \lambda_m} \frac{\lambda_c}{\lambda_c - \lambda_m} \cdots \frac{\lambda_m}{\lambda_n - \lambda_m}$$

$$h_n = \frac{\lambda_a}{\lambda_a - \lambda_n} \frac{\lambda_b}{\lambda_b - \lambda_n} \frac{\lambda_c}{\lambda_c - \lambda_n} \cdots \frac{\lambda_m}{\lambda_m - \lambda_n}$$

Equation (1) can be stated in a more general sense as follows: The number of atoms present of a given nuclide (N) after any time (t) is equal to the number of atoms present at the beginning of the chain (A_o) times a sum of probabilities of decay. The probabilities of decay is the probability that the atom will decay ($e^{-\lambda_j t}$) times the probability that an atom belongs to this decay daughter (h), i.e., the fraction of A_o decaying by this mode. This could be made more general by letting, "probability that

something will happen to the atom", replace, "probability that the atom will decay".

A_o need not be the number of atoms beginning the chain, but may be broken down into the number of atoms present at each step of the chain (Y).

If we now follow closely the general solution of the original decay equation letting each element be removed (μ) instead of just decaying (λ) but considering the parent only, decays to the daughter, then $e^{-\lambda_j t}$ becomes $e^{-\lambda_j t}$ and h_j remains with μ's replacing λ's in denominator.

The Bateman solutions may then be written as follows

$$N = Y_a h_a P_a + Y_b h_b P_b + \cdots Y_m h_m P_m + Y_n h_n P_n \qquad (2)$$

where: Y_j = yield of a node in a decay chain and is a function of all Y's and h's whose subscript is less than j.

h_j = has the same form except lambda in the denominator becomes mu's with same subscripts and since Y_j is a function of $h_{x>j}$, h_j only contains parameters from j to n.

P_j = probability of some type of change (i.e., $e^{-\mu_j t}$ for decay, $1-e^{-\mu_j t}$ for no decay).

Remembering that the rate of production for an element is Y_i/μ_i from the previous element, using the step ahead technique we may generalize the Bateman equations as is

done in the next section.

The complex interrelationships between nucleons when they form medium and heavy nuclei will probably continue to defy precise analysis for a long time to come. In the absence of exact theory, a number of nuclear models have been developed, each utilizing a different set of simplifying assumptions. Each model is capable of explaining a portion of experimental knowledge about nuclei. The two models considered were the Nuclear Shell Model and the Liquid Drop Model.

The Nuclear Shell Model, in contrast with the situation with atoms, assumes the nucleus contains no massive central body which can act as a force center. It also assumes that each nuclon experiences a central attractive force due to the other nucleons present. This allows one to think of each nucleon as moving independently in a cloud with little interaction of other nucleons. From this model (as described in Ref. 4) we obtain the theoretical calculations of the most stable atomic number for a specified mass number.

The Liquid Drop Model, originated in Bohr's concept of the compound nucleus in nuclear reactions, gives semiemperical forms predicting decay energies, binding energies, and energetics of fission. This model assumes that interactions between nucleons is strong. Levels of energy

are quantized states of the system rather than states of individual particles. Energies of captured particles appear to be shared by target and captured particles almost instantaneously and these particles have a small mean free path. From this model (as described in Ref. 4) we obtain the semi-emperical formulae for beta decay.

It is interesting to note that Geilikman (Ref. 12) states that the Liquid Drop Model and Nuclear Shell Model are not incompatible for fission analysis and gives cases in point.

For the so called "removal" constant, μ, substituted in the Bateman equations we have $\mu=\lambda+\phi\sigma$. Cross sections (σ) depend not only on the element considered, but also on neutron properties. Westcott effective cross sections (Ref. 13) were chosen to be included in this paper due to their simplicity and good accuracy. Westcott defined his cross section in terms of neutron spectrum. If this spectrum is present, the effective cross section at a desired temperature is simply a multiple of the 2200 meter cross sections. Another method considered was the statistical method for fission products by the GUNYA programs as outlined in Ref. 14. This method is reasonably accurate, according to the author, but since it entails programming and programs in itself, it was not chosen. Other available methods were considered but for ease of calculation

both by the author and user, Westcott effective cross sections were thought most appropriate.

To perform the necessary calculations, it is necessary to know the instantaneous fission yield spectrum as a function of mass number (A) and atomic number (Z); that is, the instantaneous partial fission yield Y(Z,A) is desired. This three dimensional surface is sketched in Figure 1, and experimental values may be taken directly from Ref. 15, or calculated as follows.

For a given mass number, the distribution of fission products with respect to atomic number is approximately a Gaussian distribution centered about the most probable atomic number, $Z_p(A)$. These curves are shown as slices parallel to the Y,Z plane in Figure 1. A typical instantaneous fission yield curve, or spectrum, as a function of mass number (A) is shown in Figure 2 and tabulated in Tables I through IV taken from Ref. 15 for the four different types of fissions considered in this paper. Figure 2 corresponds to a view of Figure 1 parallel to the Z axis. From the total mass yield curve Y(A) and these Gaussian distributions, the instantaneous partial fission yield surface Y(Z,A) may be constructed. This surface will give the probability of producing a nuclide ($_ZX^A$) from a fission.

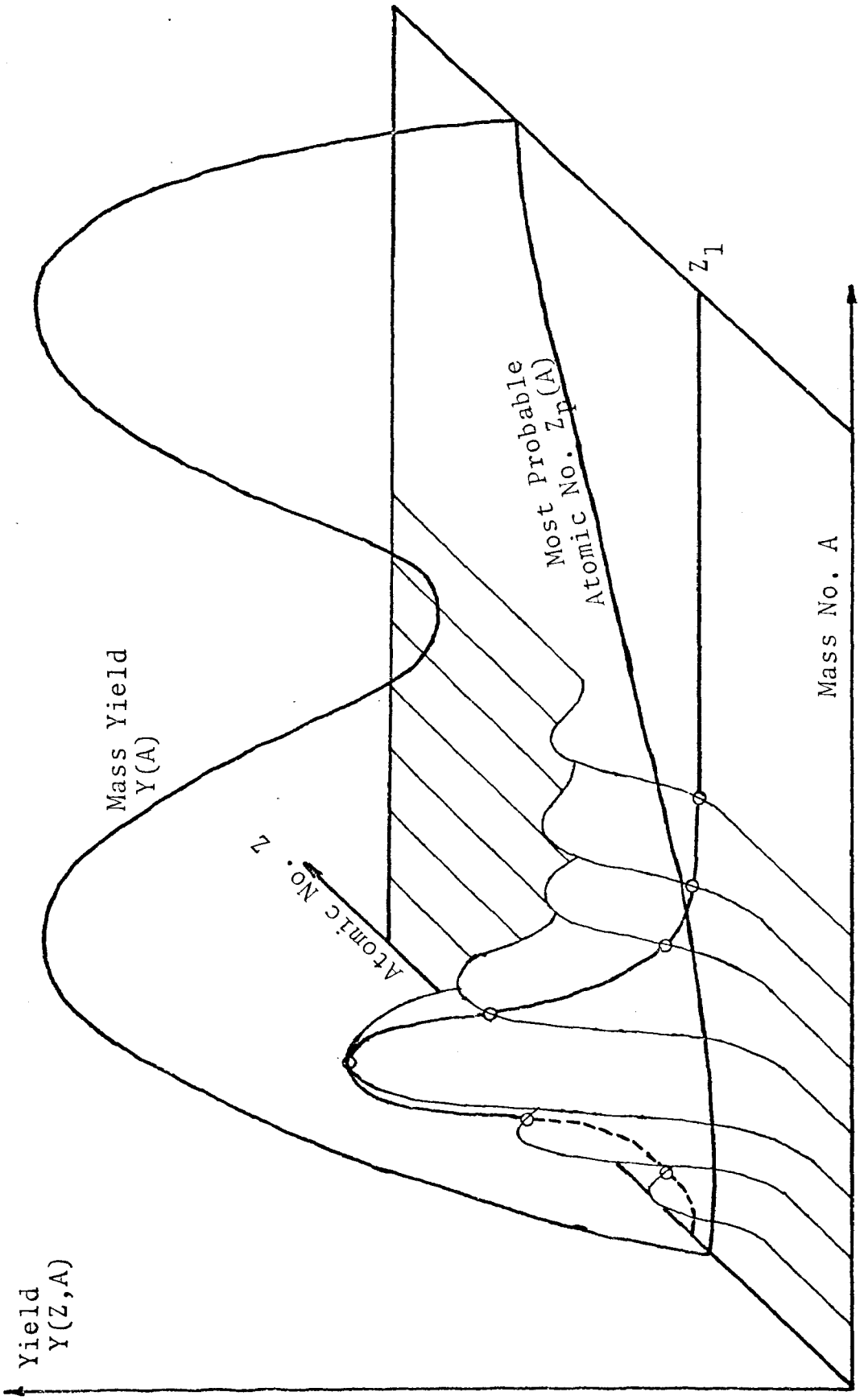


Fig. 1. Instantaneous Partial Fission Yield.

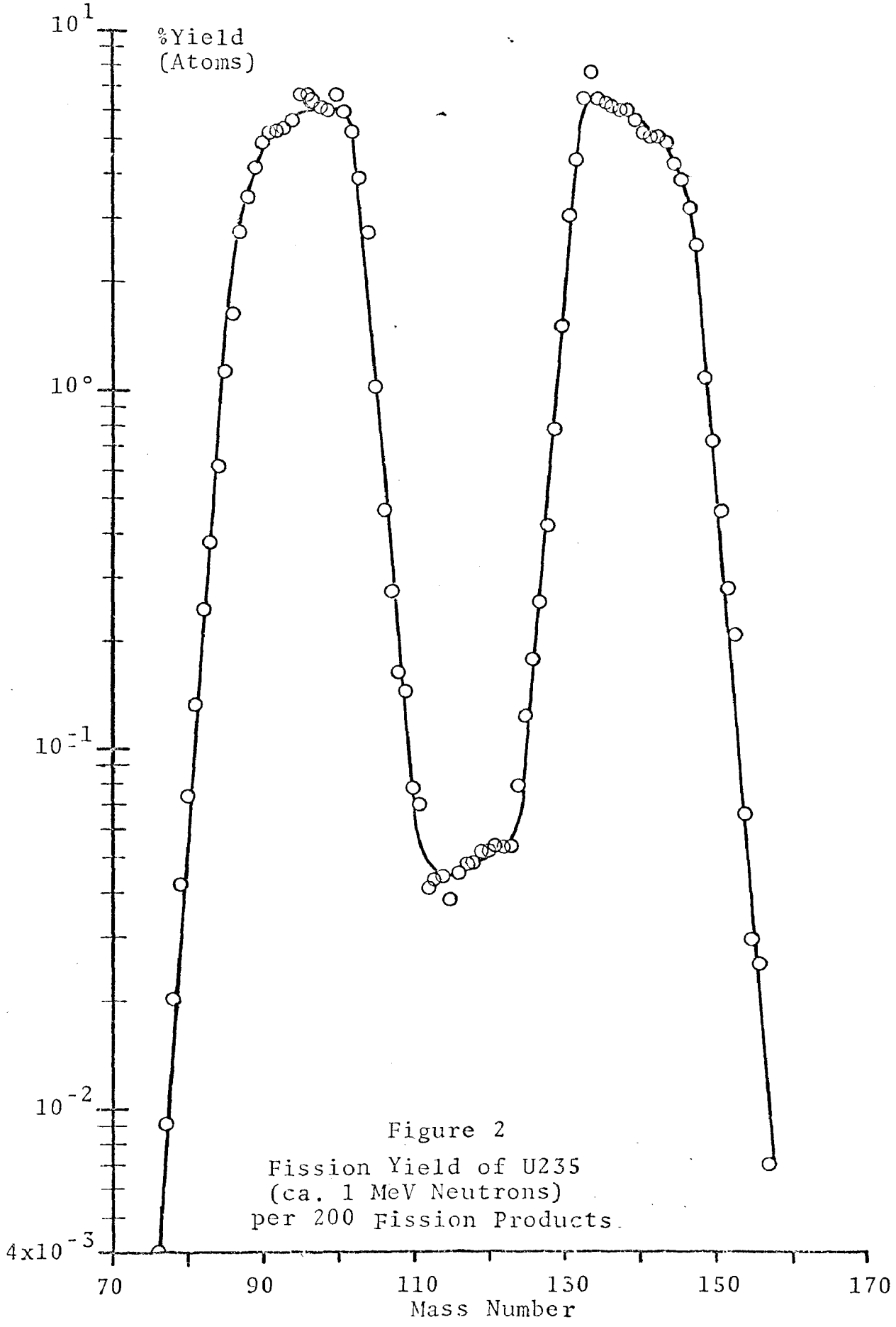


Figure 2
Fission Yield of U235
(ca. 1 MeV Neutrons)
per 200 Fission Products

Table I

Fission Yield of U235

(ca. 1 MeV Neutrons)/200 Atoms Fissioned

Mass	Yield	Mass	Yield	Mass	Yield
70	.000E 00	100	.668E 01	130	.151E 00
71	.000E 00	101	.599E 01	131	.308E 01
72	.000E 00	102	.525E 01	132	.440E 01
73	.000E 00	103	.396E 01	133	.655E 01
74	.990E-03	104	.274E 01	134	.773E 01
75	.198E-02	105	.101E 01	135	.649E 01
76	.396E-02	106	.465E 00	136	.636E 01
77	.891E-02	107	.277E 00	137	.624E 01
78	.198E-01	108	.161E 00	138	.606E 01
79	.416E-01	109	.144E 00	139	.619E 01
80	.743E-01	110	.782E-01	140	.574E 01
81	.131E 00	111	.703E-01	141	.525E 01
82	.247E 00	112	.406E-01	142	.514E 01
83	.378E 00	113	.425E-01	143	.514E 01
84	.619E 00	114	.435E-01	144	.495E 01
85	.113E 01	115	.376E-01	145	.427E 01
86	.162E 01	116	.445E-01	146	.383E 01
87	.286E 01	117	.475E-01	147	.320E 01
88	.346E 01	118	.475E-01	148	.225E 01
89	.414E 01	119	.515E-01	149	.108E 01
90	.495E 01	120	.515E-01	150	.728E 00
91	.526E 01	121	.544E-01	151	.460E 00
92	.525E 01	122	.525E-01	152	.279E 00
93	.537E 01	123	.525E-01	153	.208E 00
94	.564E 01	124	.792E-01	154	.663E-01
95	.670E 01	125	.121E 00	155	.287E-01
96	.668E 01	126	.178E 00	156	.247E-01
97	.649E 01	127	.257E 00	157	.693E-02
98	.618E 01	128	.425E 00	158	.000E 00
99	.604E 01	129	.782E 00	159	.000E 00
				160	.000E 00

Yield Sum = 199.9999

Table II

Fission Yield of PU239
(ca. 2 MeV Neutrons)/200 Atoms Fissioned

Mass	Yield	Mass	Yield	Mass	Yield
70	.000E 00	100	.585E 01	130	.292E 01
71	.000E 00	101	.604E 01	131	.477E 01
72	.000E 00	102	.619E 01	132	.622E 01
73	.000E 00	103	.627E 01	133	.609E 01
74	.000E 00	104	.643E 01	134	.614E 01
75	.000E 00	105	.470E 01	135	.606E 01
76	.000E 00	106	.619E 01	136	.585E 01
77	.000E 00	107	.468E 01	137	.663E 01
78	.000E 00	108	.321E 01	138	.546E 01
79	.000E 00	109	.165E 01	139	.516E 01
80	.000E 00	110	.819E 00	140	.487E 01
81	.000E 00	111	.477E 00	141	.458E 01
82	.780E-02	112	.180E 00	142	.429E 01
83	.955E-01	113	.165E 00	143	.477E 01
84	.195E 00	114	.123E 00	144	.360E 01
85	.321E 00	115	.916E-01	145	.316E 01
86	.516E 00	116	.780E-01	146	.282E 01
87	.789E 00	117	.682E-01	147	.248E 01
88	.123E 01	118	.682E-01	148	.214E 01
89	.179E 01	119	.682E-01	149	.185E 01
90	.224E 01	120	.682E-01	150	.154E 01
91	.270E 01	121	.877E-01	151	.126E 01
92	.321E 01	122	.107E 00	152	.877E 00
93	.365E 01	123	.124E 00	153	.468E 00
94	.409E 01	124	.175E 00	154	.292E 00
95	.513E 01	125	.253E 00	155	.175E 00
96	.497E 01	126	.390E 00	156	.780E-01
97	.507E 01	127	.604E 00	157	.195E-01
98	.546E 01	128	.107E 01	158	.000E 00
99	.575E 01	129	.175E 01	159	.000E 00
				160	.000E 00

Yield Sum = 199.9999

Table III

Fission Yield of U235

(Thermal Fissions)

Mass	Yield	Mass	Yield	Mass	Yield
70	.000E 00	100	.632E 01	130	.200E 00
71	.000E 00	101	.501E 01	131	.288E 01
72	.160E-04	102	.411E 01	132	.432E 01
73	.110E-03	103	.300E 01	133	.651E 01
74	.351E-03	104	.180E 01	134	.792E 01
75	.381E-03	105	.902E 00	135	.633E 01
76	.100E-02	106	.381E 00	136	.638E 01
77	.802E-02	107	.190E 00	137	.606E 01
78	.210E-01	108	.822E-01	138	.575E 01
79	.561E-01	109	.300E-01	139	.657E 01
80	.802E-01	110	.220E-01	140	.646E 01
81	.140E 00	111	.190E-01	141	.601E 01
82	.290E 00	112	.100E-01	142	.596E 01
83	.545E 00	113	.100E-01	143	.599E 01
84	.100E 01	114	.110E-01	144	.568E 01
85	.130E 01	115	.110E-01	145	.396E 01
86	.202E 01	116	.110E-01	146	.308E 01
87	.249E 01	117	.110E-01	147	.238E 01
88	.358E 01	118	.120E-01	148	.170E 01
89	.480E 01	119	.130E-01	149	.113E 01
90	.578E 01	120	.140E-01	150	.672E 00
91	.585E 01	121	.150E-01	151	.451E 00
92	.604E 01	122	.160E-01	152	.285E 00
93	.647E 01	123	.170E-01	153	.150E 00
94	.642E 01	124	.190E-01	154	.772E-01
95	.629E 01	125	.210E-01	155	.331E-01
96	.635E 01	126	.501E-01	156	.140E-01
97	.611E 01	127	.130E 00	157	.802E-02
98	.579E 01	128	.371E 00	158	.200E-02
99	.607E 01	129	.902E 00	159	.100E-02
				160	.461E-03

Yield Sum = 200.0000

Table IV

Fission Yield of PU239

(Thermal Fissions)

Mass	Yield	Mass	Yield	Mass	Yield
70	.000E 00	100	.708E 01	130	.249E 01
71	.000E 00	101	.589E 01	131	.376E 01
72	.129E-03	102	.597E 01	132	.508E 01
73	.249E-03	103	.565E 01	133	.678E 01
74	.349E-03	104	.591E 01	134	.738E 01
75	.149E-02	105	.549E 01	135	.698E 01
76	.199E-02	106	.455E 01	136	.668E 01
77	.378E-02	107	.339E 01	137	.661E 01
78	.159E-01	108	.197E 01	138	.629E 01
79	.219E-01	109	.139E 01	139	.585E 01
80	.688E-01	110	.599E 00	140	.548E 01
81	.124E 00	111	.229E 01	141	.528E 01
82	.196E 00	112	.119E 00	142	.449E 01
83	.373E 00	113	.598E 01	143	.468E 01
84	.468E 00	114	.508E 01	144	.388E 01
85	.664E 00	115	.408E-01	145	.312E 01
86	.757E 00	116	.378E-01	146	.259E 01
87	.917E 00	117	.369E-01	147	.194E 01
88	.141E 01	118	.359E-01	148	.172E 01
89	.170E 01	119	.359E-01	149	.137E 01
90	.224E 01	120	.359E-01	150	.100E 01
91	.260E 01	121	.428E-01	151	.797E 01
92	.313E 01	122	.458E-01	152	.618E 01
93	.395E 01	123	.498E-01	153	.369E 01
94	.446E 01	124	.797E-01	154	.289E 00
95	.501E 01	125	.119E 00	155	.194E 00
96	.515E 01	126	.194E 00	156	.109E 00
97	.563E 01	127	.388E 00	157	.807E-01
98	.587E 01	128	.997E 00	158	.418E-01
99	.608E 01	129	.197E 01	159	.209E-01
				160	.897E-01

Yield Sum = 200.0000

III. THEORY

The buildup and decay of a radioactive nuclide (i.e. burnup time) is governed by the first order differential equation:

$$\frac{dC_i}{dt} = \lambda_{i-1} C_{i-1} + R_i - \mu_i C_i \qquad (3)$$

where:

C_i = concentration of the i'th nuclide in a straight line decay chain

λ_i = decay constant

R_i = production rate

$i-1$ = parent of i'th nuclide

$\mu_i = \lambda_i + \phi\sigma_i$ = removal rate constant

where:

ϕ = neutron flux

σ_i = microscopic cross section for neutron absorption

Obviously for the period of time after reactor shutdown (i.e. cooling time), $R_i=0$ and $\mu_i=\lambda_i$. Equation (3) reduces to

$$\frac{dC_i}{dt} = \lambda_{i-1} C_{i-1} - \lambda_i C_i \qquad (4)$$

Equations (3) and (4) may be solved by conventional techniques with a step ahead technique from the first nuclide in a straight line decay chain giving a condensed form of the familiar Bateman equations. Using the initial

condition of zero concentration, the concentration of the i'th nuclide (N_i) in the decay chain after burnup time (T) from equation (3) is:

$$N_i(T) = \sum_{m=1}^{i} Y_m \left\{ \frac{Q}{T} r_m \left[\prod_{\ell=m}^{i-1} \lambda_\ell \right] \left[\sum_{j=m}^{i} \frac{1-e^{-\mu_j t}}{\mu_j \prod_{\substack{K=m \\ K\neq j}}^{i} (\mu_K - \mu_j)} \right] \right\} \tag{5}$$

where:

Y_m = yield fraction of m'th nuclide

Q = basis of calculation, number of nuclei fissioned

r_m = equivalent straight line decay branching fraction

For the last nuclide in the decay chain $\lambda_{max}=0$ and application of L'Hospitals rule yields the following for the terms in braces in equation (5).

$$\left\{ \frac{Q}{T} r_m \left[\prod_{K=m}^{i-1} \lambda_K \right] \left[\sum_{j=m}^{i=1} \frac{1-e^{-\mu_j T}}{\mu_j \prod_{\substack{K=m \\ K\neq j}}^{i} (\mu_K - \mu_j)} \right] + r_m Q \right\}$$

when: i = IMAX $i \neq m$

or $\{r_m Q\}$

when i=m=IMAX

where IMAX denotes last member of a chain.

Using equation (5) for initial conditions, equation (4) may be solved in similar manner to obtain the concentration of the i'th nuclide (n_i) in the decay chain after cooling time (t):

$$n_i(t) = \sum_{m=1}^{i} N_m(T) \left[\prod_{\ell=m}^{i-1} \lambda_\ell \right] \left[\sum_{j=m}^{i} \frac{e^{-\lambda_j t}}{\prod_{\substack{K=m \\ K \neq j}}^{i} (\lambda_K - \lambda_j)} \right] \quad (6)$$

The instantaneous fission yield percentages (Y_m) used were taken from Refs. 15, 16 and 17, and tabulated in Tables I through IV. Yields are given by mass number (A) only and form the familiar "M" shaped curve of fission products shown in Figure 2. No information is given here with respect to atomic number (Z).

The most stable atomic number for a specified mass number is taken from Ref. 18 and is a result of theoretical calculations based upon the Nuclear Shell Model. Use is then made of the fact that the deviation of the most probable atomic number from the most stable atomic number is the same for both the light and heavy fission fragments to calculate the most probable atomic number for both the heavy and light fission fragments. The terms heavy and light fission fragments are arbitrary; they refer to the upper and lower halves respectively of the fission product yield curve for mass numbers. Calculations were

performed using the relation:

$$Z_{p\ell} = \tfrac{1}{2}\,[Z_f-(Z_{sh}-Z_{s\ell})]\ ,\quad Z_{ph} = Z_f-Z_{p\ell} \tag{7}$$

where:

Z_f = atomic no. of fissile material

Z_{sh} = most stable atomic number for high mass number (A)

$Z_{s\ell}$ = most stable atomic number for low mass number (A)

Z_{ph} = most probable atomic number for high mass number (A)

$Z_{p\ell}$ = most probable atomic number for low mass number (A)

The atomic number has been found (Ref. 18 and 19) from experimental data to have an empirical Gaussian distribution about the most probable atomic number, for a specified mass number, of the form:

$$P(Z) = \frac{1}{\sqrt{\pi}}\ e^{-(Z-Z_p)^2} \tag{8}$$

From the relations (7) and (8), and yield data, the instantaneous partial fission product yields may be calculated by:

$$Y(Z,A) = Y(A)P(Z) = Y(A)\ \frac{1}{\sqrt{\pi}}\ e^{-[Z-Z_p(A)]^2} \tag{9}$$

where:

$Y(A)$ = absolute yield per mass number

$Y(Z,A)$ = absolute yield per mass number and atomic number

$P(Z)$ = probability of distribution about Z_p

Z = atomic number in question for specified mass number

Z_p = most probable atomic number for specified mass number

Since the partial yields for a given mass number (A) must sum to the total yield, any partial yield is not accounted for, and is assigned to the progenitor of that mass number. Thus:

$$Y_{prog}(A) = Y(A) - \sum_i Y(Z_i,A) \qquad (10)$$

The progenitor corresponds to all nuclides that are so unstable they decay almost instantaneously by β^- emission to the first member of the decay chain with a measurable half life. They are therefore added to the first member of their respective decay chains.

For nuclides with two different isomeric states, metastable and normal, or three different isomeric states, A, B, and metastable, the partial yield is divided equally between the states.

Evans (Ref. 4) states that semi-emperical equations

exist which predict the average beta energy released in radioactive decay based on the liquid drop model. These are:

$$Q_\beta = 2\gamma \left[\pm(Z_o - Z) - \tfrac{1}{2}\right] \quad \text{for odd A} \tag{11}$$

$$Q_\beta = 2\gamma \left[\pm(Z_o - Z) - \tfrac{1}{2}\right] \begin{Bmatrix} + 2\delta \text{ for odd Z} \\ - 2\delta \text{ for even Z} \end{Bmatrix} \text{for even A} \tag{12}$$

where:

$\pm$ = chosen according $Z \rightarrow (Z \pm 1)$

Q_β = energy of released electron (MeV)

Z = atomic number in question

Z_o = most stable isobar for specified mass number

δ = pairing energy (MeV)

$$\gamma = \frac{4a_a}{A}\left(1. + \frac{A^{2/3}}{4a_{a/a_c}}\right)$$

$$a_c = (.595 \pm .02) \text{ MeV}$$

$$\frac{a_a}{a_c} = \tfrac{1}{2}\left\{\frac{Z_o A^{2/3}}{A - 2Z_o}\right\} - \left\{\frac{A}{A - 2Z_o}\right\} \frac{(M_n - M_H)}{4a_c} \simeq 32 \pm 1 \text{ (average)}$$

It will be noted that pairing energy is not included in the liquid drop model development. As is suggested by Evans, a smooth function of δ was chosen, i.e. $\delta \simeq \frac{C}{A^x}$.

For the author's development, average values were chosen for the entire spectrum. They are:

$$\gamma_{av} = \frac{76}{A}\left(1 + \frac{A^{2/3}}{128}\right) \text{ MeV}$$

$$Z_o = \frac{77}{2\gamma_{av}}$$

$$\delta_{av} = \frac{33.5}{A^{3/4}} \text{ MeV}$$

Semi-emperical or emperical equations are available to predict average gamma release from radioactive decay. The author feels that due to the very complex nature of these equations, exact determinations of gamma decay energies would be best left to a separate project. For the purposes of data for this paper, gamma decay energies were used as follows:

Given Q_β as determined by equation (11) or (12)

If $|Z-Z_o| \leq 1$: then $Q_\gamma = .15Q_\beta$ (MeV) (13)

If $1 \leq |Z-Z_o| \leq 2$: then $Q_\gamma = .55Q_\beta$ (MeV) (14)

otherwise $Q_\gamma = .5$ (MeV) (15)

IV. APPLICATION

The actual intended purpose of this work was to develope a "single package type" computer program whereby a minimum of input would be required by a user and a maximum number of options may be chosen. The author believes this has been accomplished with a type of program control that is, whenever possible, completely alphabetic.

The program, described in Appendix 1 and listed in Appendix 2, once generated, requires a minimum of program control input, as described in Appendix 3.

Available mass yield data is as varied as there are types of operating reactors. Among other variables, type of fuel and energy of neutrons causing fission determine fission product spectra. Four curves were chosen as standards, they are: fissioning of the U-235 by thermal and 1 MeV neutrons, and Pu-239 by thermal and 2 MeV neutrons. However, any of these curves may be altered or deleted and others inserted in their place.

Neutron cross sections are only somewhat varied, but are not complete for all isotopes. The cross sections used by this paper were taken from BNL-325 (Ref. 20) whenever possible and from Chart of the Nuclides (Ref. 21) otherwise.

As stated above, the most stable atomic number for a

specified mass number was calculated by semi-emperical formulas taken from Refs. 18 and 19.

Nuclear decay chains are many and varied. The fission product decay chains have been summarized for uranium and plutonium in Ref. 22 and have been used in preparing this paper. A sample problem explaining breakdown of complex chains to simple straight line decay chains and ensuing calculations is included in Appendix 4.

A breakdown of the files used is included in Appendix 5. Input and output of a sample run are included in Appendix 3.

V. PROGRAM SUMMARY

The entire assembled program is named ZAP and is divided into 4 major steps. ZAP will, beginning with basic data, supply and make resident all work files, read and interpret input data, do calculations and output specified options, and rewrite all data sets to tape, or holding area, and free resident work files. More specifically:

1. Step 1 - STARTZAP

   This step reads files prepared by the author (or subsequent files after alteration by user) and creates working files on units specified by the user. Caution must be taken as two data sets are direct access or update type of files, consequently, at least these two data sets must reside on direct access volumes.

2. Step 2 - ZAP

   This step reads and interprets program input data and passes this data on to step 3. It also checks positioning of characters, notes errors detected, informs user of the number and location of errors, and suggests to the user whether or not to proceed.

3. Step 3 - SUPERZAP

   This step does the actual input, calculations, and output according to information from step 2.

This step is broken into ten major sections, and a detailed description of each section may be found in Appendix 1.

4. Step 4 - ENDZAP

   This step rewrites work files to tape or other device specified by the user and deletes work files.

Between any of these steps, permanent files may be altered, deleted, or completely rewritten using the support utilities described in Appendix 1 and listed in Appendix 2; or by the user writing his own routines following the file construction format listed in Appendix 5.

VI. CONCLUSIONS

The intention of this paper was to create and make usable a computer program that would incorporate as much useful output as possible concerning fission product build-up and decay with a minimum of input and man hours of work; this, the author believes, has been accomplished.

A number of program options have been included covering type of input and type of output desired. The user may specify cooling and burnup times (except infinite) as desired. He may choose yields specified completely by the program, input his own mass yield curve and use the program specified distribution, or input his own yields per mass number and atomic number. He may choose to: negate neutron burnup of fission products by using $\mu=\lambda$ instead of $\mu=\phi\sigma+\lambda$ in equation (5), leave mu unchanged, let $\mu=\lambda+\phi\sigma$ and choosing between Westcott effective cross sections or input his own cross-sections. Many more options are available and are listed and explained in Appendix 3.

It is possible to minimize input to 9 cards or make the input as extensive as necessary to cover a particular problem. It is entirely possible that a nuclear power company or similar facility, after alteration of some permanent files, may calculate how much of any isotope is present in their reactor after any time specified. The program

will also predict individual and total beta energy, and photon energies by group up to 80 groups.

All this information can be obtained, if chosen, by semi-emperical means rather than individual equations and human mechanics. The savings in time, human effort, and cost will be noteworthy.

VII. RECOMMENDATIONS

Although a number of options have been included in this initial coding, others may be introduced. Some suggestions are:

1. As the code now stands isotope concentrations are calculated on the basis that the reactor is being started for the first time, i.e. the concentration of fission products at program run time is zero. An option may be included to input concentrations, or take them from the output of the last run, and include them in the present run to predict concentrations for any number of burnup and cooling times for the same reactor.
2. An option may be included for multiple outputs such that more than one copy may be obtained at once. At the present time, only one copy of output is attainable when the program is run. To obtain multiple copies, subroutines OUTPUT, SPCASE HEAT, and/or SHIELD have to be run independently.
3. More options, for prediction of partial yields from other sources than listed in Appendix 3.
4. Different methods of calculating effective cross sections.
5. Different methods of calculating and/or inputting average beta and gamma decay energies.

6. A general update program may be written to update any or all permanent or work files.

The author feels that a better method for predicting average beta and gamma decay energies could be devised and would recommend that this area be investigated first.

REFERENCES

1. Glasstone, S., and A. Sesonske (1963) Nuclear Reactor Engineering, D. Van Nostrand Co, Inc, New York, 830 p.

2. Lamarsh, J.R. (1966) Nuclear Reactor Theory, Addison-Wesley, Massachusetts, 585 p.

3. Meghreblian, R.V., and D.K. Holmes (1960) Reactor Analysis, McGraw-Hill, New York, 808 p.

4. Evans, R.D. (1955) The Atomic Nucleus, McGraw-Hill, New York, 972 p.

5. Cook, G.B., and F. Morgan (1950), The Growth, Decay and Beta Absorption Characteristics of the Long-Lived Fission Products, (Atomic Energy Research Establishment, Harwell, England), AERE-C/M-58, 10 p.

6. MacBean, I.J. (1960) Uranium-235 Fission Product Decay Energies, (Atomic Energy Research Establishment, Winfrith, England), as quoted in Nuclear Power 5, No. 49, p. 115-117.

7. Owings, W.D. (1959) A Program for the Computation of Fission Product Activity, MND-1721, 45 p.

8. Delaney, J.A. (1959) Digital Analysis of Fission Product Buildups and Decay, DC59-11-85, 61 p.

9. Casadei, G., G. Cenacchi, A. DeMatteis, and B. Faleschine (1964) FIP- An IBM-7094 Program for Calculation of Concentrations of Fission Products, RT/FIMA(64)-3, Rome, Italy, 26 p.

10. Harris, A., P. Kenfield, W. Laks, and W. Sayer (196?), An Improved Method of Dose Calculation from Airborne Fission Products, CONF-642-8, 28 p.

11. Arnold, E.D. (1966) PHOEBE: A Code for Calculating Beta and Gamma Activity and Spectra for Uranium-235 Fission Products, ORNL-3931, 64 p.

12. Geilikman, B.T. (1964) Shell Effects in Nuclear Fission As translated by Elmar K. Wilip (Argonne National Laboratory) from IAE-818, ANL-Trans-243, 4 p.

13. Westcott, C.H. (1958) Effective Cross Section Values for Well Moderated Thermal Reactor Spectra, AECL-670, 27 p.

14. Cook, J.L (1966) Statistical Calculations of Fission Product Cross-Sections as quoted in Nuclear Data for Reactors - Volume One, IAEA, Vienna 1967, 9 p.

15. Koopman, B.E., and T.R. Hill (1967) Extension of a Computer Program for Fission Product Spectra in Fuel Irradiated with One and Two MeV Neutrons (II), AMU-ANL Report, Argonne National Laboratory, 34 p.

16. Koopman, B.E., G.D. Atkinson, and T.R. Hill (1967) Extension of a Computer Program for Fission Product Spectra in Fuel Irradiated with One and Two MeV Neutrons (I), AMU-ANL Report, Argonne National Laboratory, 105 p.

17. Burris, L., and I. Dillon (July 1957) Estimation of Fission Product Spectra in Discharged Fuel from Fast Reactors, ANL 5732 (Revised 1963 by ANL-LB-SL-2410).

18. Hyde, E.K. (Jan 1960) A Review of Nuclear Fission - Part One, UCRL-9030.

19. Steinberg, E.P., and L.E. Glendenin (1955) Proceedings of the International Conference on the Peaceful Uses of Atomic Energy - Volume 7, United Nations, Geneva, p. 614.

20. Hughes, D.J. and R.B. Swartz (1958) Neutron Cross Sections, 2nd Edition, Brookhaven National Laboratory (BNL-325), New York. As ammended by BNL-325 Suppliments (1966), Brookhaven National Laboratory.

21. Goldman, D.T. and J.R. Rosser (1960) Chart of the Nuclides, General Electric Co., New York.

22. Crocker, G.R. (1967) Fission Product Decay Chains: Schematics with Branching Fractions, Half-Lives, and Literature References, AD-659-980, 30 p.

APPENDIX 1
Program Description (ZAP)

STARTZAP

This routine reads such files from magnetic tape or other storage unit as is specified (See Appendix 3 for input format), and makes them resident on work files. The routine is extremely simple consisting of essentially all reads and writes and is very easy to follow (See Appendix 2 for listing).

ZAP

This routine essentially reads, interprets, and writes input to SUPERZAP. The entire text of any one card is not checked. Consequently, misspelled words will not necessarily cause errors. In general, column one is checked to determine the validity of the card. If confusion could result from two adjacent cards having the same character in column one, other characters are checked to determine correctness.

Once a valid card is determined, equal signs or commas are checked to ensure that numerical data is in proper columns. Each time a new card is read, column one is checked for a dollar sign denoting a comment.

Finally, data is tabulated and written to disk to later be picked up by SUPERZAP from files 9 and 11. Cards read are printed under column headings to help facilitate

error analysis. If cards are properly written, notation is printed specifying options chosen.

This routine calls ERR and REREAD as listed in this appendix under utilities.

SUPERZAP

This routine does the actual calculations and final output, and is broken into ten major subroutines. They are, with their purposes:

MAIN. This section reads data written by ZAP, places proper variables in common storage, and serves to call other subprograms as many times as there are burnup times.

TIME. This subroutine converts input cooling and burnup times to seconds for use in the other subprograms.

DTAPRP. This subroutine prepares work file 4 from files 14 through 18 or inputs files (See Appendix 5 for file construction) with yield data or input data as specified by ZAP. This routine prints the progenitor and oblong tables as specified. (See Theory, equations (7), (8), (9), and (10)).

CROSS. This subroutine calculates mu as specified by ZAP. This subprogram also prints mu, lambda, and/or cross sections with neutron flux as specified by ZAP. This information is written to file 4 completing its construction (See Theory, equation (3)).

ZEROF5. This subprogram sets previous cooling time answers to zero throughout file 5, (See recommendations for suggested changes).

CALC. This subprogram reads file 4, does the actual calculation concerning final concentrations and updates file 5 with lambda and final concentrations. (See Theory, equations (3), (4), and (5)).

OUTPUT. This subprogram ouputs the contents of file 5 when concentrations of all isotopes are desired. Options for printing individual concentrations, concentrations by mass number, or concentrations by atomic number are selected here.

SPCASE. This program outputs concentration of selected isotopes. With proper option selection, this routine will output as many isotopes as desired by the user.

HEAT. This subprogram calculates and outputs the individual and total average beta energy given off in one second by the fission products predicted. Energy of beta decay per isotope is input with subprogram DCYPRP (See Theory, equations (11), and (12)).

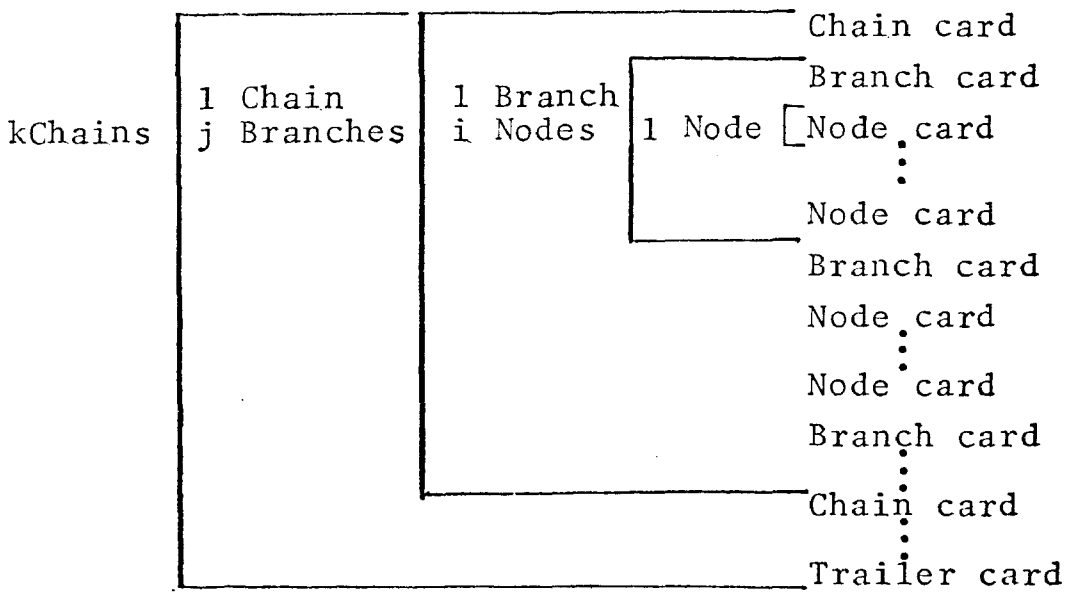
SHIELD. This subprogram inputs gamma groups by energy, scans file 5 and outputs the number of atoms decayed in one second per energy group. Energy of decay is determined and filed by subprogram DCYPRP. (See Theory, equation (13)).

ENDZAP. This routine writes all work files as they stand to tape or other specified device and frees the space of work files to the computer.

Support Utilities

DATA1. This routine reads the straight line decay chains and their associated data and records this data in more compact form on file 4. From this information, it also sets the format of file 5 with names, atomic numbers, and mass numbers. From other input data, it also writes file 18 with highest, lowest, and most stable atomic numbers per chain for all chains. This routine completes files 4 and 18.

The input to DATA1 consists of chain, branch, and node cards in a particular sequence. The branching fraction (r_m) indicated on node cards must be calculated as shown in Appendix 4. The chain number is the mass number of the first element in the decay chain.



Data Cards

Information	Columns	Format
Chain card		
Chain number	1-3	I3
Number of branches in chains	10-11	I2
Branch card		
Chain number	1-3	I3
Branch number	10-11	I2
Number of nodes in branch	21-22	I2
Node Card		
Chain number	1-3	I3
Branch number	10-11	I2
Node number	21-22	I2
Decay constant	48-61	E14.8
Branching fraction (r_m)	62-69	F8.6
Element symbol	71-72	A2
Element mass number	74-76	I3
Element state	77	A1
Atomic number	78-80	I3
Trailer card		
999	1-3	I3

DCYPRP. This routine calculates average beta and gamma decay per isotope (See Theory, equations (11), (12), (13), (14), (15)) and records this information on file 5 completing file 5 input.

DATA1X. This routine reads yields per mass number from cards and records the information completing files 14 through 17.

CRSPRP. This routine reads microscopic thermal cross sections from cards and records this information on file 12.

This completes file input to entire program. Options available in ZAP are explained in Appendix 3. The rest of the subprograms listed print files so that they may be checked for accuracy.

PYLD. This routine prints the contents of files 14, through 17, as prepared by DATA1X.

PXSEC. This routine prints the contents of file 12 as prepared by CRSPRP.

PRT4. This routine prints the contents of file 4 as prepared by DATA1 and DCYPRP.

F4BUG. This routine places a number as the first position of a specified record in file 4 thereby shortening the input for tests runs or checking validity of routines.

CHKZAP. This routine prints the contents of files 9 and 11 as prepared by ZAP.

Each of the above routines may have to be modified (i.e., limits of DO loops) to obtain desired results. See Appendix 5 for file formats.

APPENDIX 2

Program Listing

```
  SUBROUTINES AND PPOGRAMS MAY BE DELIMITED BY A /*
  IF THIS PROGRAM IS TO BE COPIED FROM THE LISTING, CARE
  MUST BE TAKEN IN THE TRANSLATION.  ONLY 60 CHARACTERS
  ARE PERMITTED ON A LINE IN THIS THESIS.  THEREFORE,
  WHEN AN 'X' APPEARS IN COLUMN 6, IT IS THE
  CONTINUATION OF THE PREVIOUS CARD BEGINNING IN COLUMN 61
     ***THIS SECTION IS NOT A PART OF ZAP***
/*
C     THIS IS PROGRAM STARTZAP
      DIMENSION CH(80),NNN(15),III(3),BG(4),N5(5),X(45),XS(4
     X2,109,2),
     1YLC(180)
      DEFINE FILE 4(2400,17,U,I4)
      DEFINE FILE 5(1500,45,U,I5)
      READ(1,101) IBGN,IEND
    1 READ(8,100,END=10) CH
      WRITE(3,102) CH
      GO TO 1
   10 CONTINUE
      WRITE(3,150)
   11 READ(8,100,END=21) CH
      IF(2.LT.IBGN.OR.2.GT.IEND)  GO TO 20
      WRITE(3,102) CH
   20 CONTINUE
      GO TO 11
   21 WRITE(3,151)
   22 READ(8,100,END=28) CH
      IF(3.LT.IBGN.OR.3.GT.IEND)  GO TO 25
      WRITE(3,102) CH
   25 CONTINUE
      GO TO 22
   28 WRITE(3,152)
      I4=1
      WRITE(3,175)
   26 READ(8     ,END=36) MSS,MAXB,NNN
      IF(4.LT.IBGN.OR.4.GT.IEND)  GO TO 35
      WRITE(4'I4) MSS,MAXB,NNN
      WRITE(3,105) MSS,MAXB,NNN
      IF(MSS.EQ.999)GO TO 35
      M=0
      DO 27 I=1,MAXB
   27 M=M+NNN(I)
      DO 29 I=1,M
      READ(8     ) III,BG,N1,N2,N3,N4,N5
      WRITE(4'I4) III,BG,N1,N2,N3,N4,N5
      WRITE(3,106) III,BG,N1,N2,N3,N4
   29 CONTINUE
   35 CONTINUE
      GO TO 26
   36 WRITE(3,153)
      I5=1
      WRITE(3,176)
```

```
      DO 37 I=1,1051
      READ(8,END=41) Q
      IF(5.LT.IBGN.OR.5.GT.IEND)  GO TO 40
      WRITE(5'I5) Q
      WRITE(3,108) Q
   40 CONTINUE
   37 CONTINUE
   41 WRITE(3,154)
      WRITE(3,177)
      DO 44 L=1,2
      DO 44 I=1,42
      READ(8     ) (XS(I,J,L),J=1,109)
      IF(6.LT.IBGN.OR.6.GT.IEND)  GO TO 45
      WRITE(12)    (XS(I,J,L),J=1,109)
      WRITE(3,110)(XS(I,J,L),J=1,109)
   45 CONTINUE
   44 CONTINUE
  406 READ(8     ,END=407) CHAR
      GO TO 406
  407 CONTINUE
      WRITE(3,155)
      DO 51 KK=7,10
      KKK=KK+7
      WRITE(3,178) KKK
      READ(8     ) YLD
      IF(KK.LT.IBGN.OR.KK.GT.IEND)  GO TO 50
      WRITE(3,110) YLD
      WRITE(KKK) YLD
   50 CONTINUE
  408 READ(8     ,END=409)  CHAR
      GO TO 408
  409 CONTINUE
      WRITE(3,156)  KKK
   51 CONTINUE
      IF(11.LT.IBGN.OR.11.GT.IEND)  GO TO 60
      WRITE(3,179)
      WRITE(3,111)
      DO 53 I=1,2
      READ(8     ) YLD
      WRITE(3,113) I
      WRITE(3,114) YLD
   53 WRITE(18) YLD
      I=3
      READ(8     ) YLD
      WRITE(3,113) I
      WRITE(3,115) YLD
      WRITE(18) YLD
      WRITE(3,157)
   60 WRITE(3,158)
      CALL EXIT
  101 FORMAT(T15,I2,T30,I2)
  102 FORMAT(T2,80A1)
```

```
  100 FORMAT(80A1)
  103 FORMAT(17I4)
  104 FORMAT(3I4,4E10.4,2A4,2I4,6I2)
  105 FORMAT(1X,17(I4,3X))
  106 FORMAT(1X,3I4,4E10.4,2A4,2I4)
  107 FORMAT(I4,A4,I4,A4,12E10.4,2I4,A4,12E10.4,2I4,12E10.4)
  108 FORMAT(1X,I4,A4,I4,A4/12E12.4/2I4,A4/12E12.4/2I4/12E12
     X.4)
  109 FORMAT(40(5E12.4))
  110 FORMAT(10E12.4)
  111 FORMAT('1PART 1 CONTAINS ZLOW-180 EACH**PART 2 CONTAIN
     XS ZHI-180 EA
     1CH**PART 3 CONTAINS ZSTABLE-180 EACH')
  112 FORMAT(60(30I4))
  113 FORMAT('1THIS IS PART',I2//)
  114 FORMAT(30I4)
  115 FORMAT(10F12.4)
  150 FORMAT(//T10,'END FILE FT08F001'/'1')
  151 FORMAT(//T10,'END FILE FT08F002'/'1')
  152 FORMAT(//T10,'END FILE FT08F003'/'1')
  153 FORMAT(//T10,'END FILE FT08F004')
  154 FORMAT(//T10,'END FILE FT08F005')
  155 FORMAT(//T10,'END FILE FT08F006')
  156 FORMAT(//T10,'END FILE FT08F00',T24,I3)
  157 FORMAT(//T10,'END FILE FT08F011')
  158 FORMAT('1',T10,'END OF STARTZAP')
  175 FORMAT('1',T5,'THIS IS PROGRAM FILE 4'//)
  176 FORMAT('1',T5,'THIS IS PROGRAM FILE 5'//)
  177 FORMAT('1',T5,'THIS IS PROGRAM FILE 12'//)
  179 FORMAT('1',T5,'THIS IS PROGRAM FILE 18'//)
  178 FORMAT('1',T5,'THIS IS PROGRAM FILE',I3,//)
      END
/*
```

```
C   THIS IS PROGRAM ZAP
      DIMENSION IHLDC(11),PGTITL(8),CLTM(22),COOLTM(11),BURN
     XTM(11),
     1BTM(22),IC(11),IS(11)
      INTEGER L/'L'/,BLK/' '/,DOL/'$'/,Y/'Y'/,I/'I'/,P/'P'/,
     XN/'N'/,
     2O/'0'/,DEC/'.'/,W/'W'/,F/'F'/,LP/'('/,EQ/'='/,A/'A'/,C
     XOM/','/,
     3E/'E'/,CC/'C'/,B/'B'/,M/'M'/,COL/':'/,T/'T'/,S/'S'/,G/
     X'G'/,C(80)
      DATA IER,IYLD,IPROG,IOBL,IMU/5*0/,CLTM/22*' '/,COOLTM/
     X11*0./,
     1LCMAX,LBMAX,IPOUT,ICASE,ICASEN,IHEAT,ICOOLM,NBODS/8*0/
     X,IS/11*0/,
     2ISHLD,ISMAX,IGPMAX/3*0/,BURNTM/11*0./,BTM/22*' '/,IC/1
     X1*0/
      WRITE(3,120)
      WRITE(3,121)
      WRITE(3,122)
      CALL REREAD
      READ(1,100) C
      WRITE(3,101) C
      IF(C(1).NE.DOL) CALL ERR(1,C,&990,IER)
      IF(C(2).NE.DOL) CALL ERR(2,C,&990,IER)
      WRITE(3,103)
   10 READ(1,100) C
      WRITE(3,101) C
C     CHECK  FOR COMMENT CARDS
C
      IF(C(1).EQ.DOL) GO TO 10
C
C     FIND PROPER IYLD
      IF(C(1).NE.Y) CALL ERR(1,C,&500,IER)
      IF(C(12).EQ.I) GO TO 501
      IF(C(12).NE.P) CALL ERR(12,C,&502,IER)
      IF(C(33).EQ.I) GO TO 503
      IF(C(33).NE.P) CALL ERR(33,C,&504,IER)
      READ(99,150) IYLD
      WRITE(3,107) IYLD
   15 READ(1,100) C
      WRITE(3,101) C
      IF(C(1).EQ.DOL) GO TO 15
C
C     CHECK AND SET IPROG AND IOBL
      IF(C(1).NE.Y) CALL ERR(1,C,&505,IER)
      IF(C(15).NE.N) GO TO 16
      IPROG=0
      IOBL=0
      GO TO 25
   16 IF(C(15).NE.P)  CALL ERR(15,C,&506,IER)
      IF(C(21).EQ.0) GO TO 507
      IF(C(21).NE.P)  CALL ERR(21,C,&508,IER)
```

```
      IPROG=1
      IF(C(39).EQ.BLK) GO TO 509
      IF(C(39).EQ.0   ) GO TO 510
      WRITE(3,104) (C(II),II=35,42)
   25 WRITE(3,113) (C(KK),KK=1,70)
      IPL=IYLD+2
C     DECIDE WHERE ACCORDIND TO IYLD
C
      GO TO(27,27,36,36,36,36),IPL
   27 CONTINUE
   28 READ(1,100) C
      WRITE(3,101) C
      IF(C(1).EQ.DOL) GO TO 28
      WRITE(9,100) C
      IF(IPL.EQ.1) GO TO 32
  208 READ(1,100) C
      WRITE(3,101) C
      IF(C(1).EQ.DOL) GO TO 208
C
C     CHECK  COL 5 FOR FOR L
      IF(C(5).NE.L) GO TO 29
      IF(C(41).NE.DEC) CALL ERR(41,C,&511,IER)
      IF(C(44).EQ.BLK) CALL ERR(44,C,&511,IER)
      WRITE(9,100) C
      GO TO 31
   29 IF(C(5).NE.F)  CALL ERR(5,0,&512,IER)
      WRITE(9,100) C
  209 READ(1,100) C
      WRITE(3,101) C
      IF(C(1).EQ.DOL) GO TO 209
      IF(C(14).NE.LP) CALL ERR(14,C,&513,IER)
      IF(C(16).NE.EQ) CALL ERR(16,C,&514,IER)
      IF(C(22).NE.EQ) CALL ERR(22,C,&515,IER)
      IF(C(49).NE.EQ) CALL  ERR(49,C,&516,IER)
      WRITE(9,100) C
   31 WRITE(3,113) (C(KK),KK=1,80)
      WRITE(3,108)
      DO 33 II=1,18
  303 READ(1,100) C
      WRITE(3,101) C
      IF(C(1).EQ.DOL) GO TO 303
      WRITE(9,100) C
      IF(C(78).EQ.E) GO TO 306
   33 CONTINUE
      GO TO 36
  306 IF(II.EQ.18) GO TO 36
      WRITE(3,109)
      IER=IER+1
      GO TO 36
   32 DO 34 II=1,10000
      READ(1,100) C
      WRITE(3,101) C
```

```
      IF(C(1).EQ.DOL) GO TO 34
      IF(C(1).NE.A) CALL ERR(1,C,&517,IER)
      IF(C(8).NE.EQ) CALL ERR(8,0,&518,IER)
      IF(C(20).NE.EQ)  CALL ERR(20,0,&519,IER)
      IF(C(30).NE.EQ)  CALL ERR(30,0,&520,IER)
      WRITE(9,100) C
      IF(C(45).EQ.COM) GO TO 36
   34 CONTINUE
C
C     END DTPAR INPUT -  BEGIN CROSS INPUT
C
   36 READ(1,100) C
      WRITE(3,101) C
      IF(C(1).EQ.DOL) GO TO 36
      IF(C(3).NE.EQ)  CALL ERR(3,C,&521,IER)
      IF(C(4).EQ.D) GO TO 522
      IF(C(4).EQ.L) GO TO 523
      IF(C(4).NE.P) CALL ERR(4,C,&524,IER)
      IMU=3
      WRITE(3,112)
   37 READ(1,100) C
      WRITE(3,101) C
      IF(C(1).EQ.DOL) GO TO 37
      IF(C(1).NE.W.AND.C(1).NE.I)  CALL ERR(1,0,&525,IER)
      WRITE(9,100) C
      WRITE(3,114) (C(KK),KK=1,25)
C     CHECK PHI CARD
   38 READ(1,100) C
      WRITE(3,101) C
      IF(C(1).EQ.DOL) GO TO 38
      IF(C(1).NE.P) CALL ERR(1,C,&526,IER)
      IF(C(4).NE.EQ) CALL ERR(4,C,&526,IER)
      IF(C(63).NE.LP.AND.C(63).NE.BLK) CALL ERR(63,C,&527,IE
     XR)
      WRITE(9,100) C
      WRITE(3,113) (C(KK),KK=1,18),(C(KK),KK=31,38),(C(KK),K
     XK=62,69)
C     WRITE  CROSS SECTIONS TO DISK
  401 WRITE(3,127)
      DO 40  II=1,10000
   39 READ(1,100) C
      WRITE(3,101) C
      IF(C(1).EQ.DOL) GO TO 39
      IF(C(2).NE.EQ)  CALL ERR(2,C,&40,IER)
      IF(C(8).NE.EQ)  CALL ERR(8,0,&40,IER)
      IF(C(15).NE.EQ)  CALL ERR(15,0,&40,IER)
      IF(C(35).NE.EQ.AND.C(35).NE.BLK)  CALL ERR(35,0,&40,IE
     XR)
      IF(C(55).NE.EQ.AND.C(55).NE.BLK)  CALL ERR(55,0,&40,IE
     XR)
      WRITE(9,100) C
      IF(C(72).EQ.E) GO TO 41
```

```
   40 CONTINUE
C
C     END CROSS INPUT - BEGIN OUTPUT INPUT
C
   41 READ(1,100) C
      WRITE(3,101) C
      IF(C(1).EQ.DOL) GO TO 41
      READ(99,151) PGTITL
      WRITE(3,123)  PGTITL
C     READ CLTM,COOLMX,LCMAX
      DO 45 II=1,11
   42 READ(1,100) C
      WRITE(3,101) C
      IF(C(1).EQ.DOL) GO TO 42
      IF(C(10).NE.CC) CALL ERR(10,0,&528,IER)
      READ(99,152)  CLTM(2*II-1),CLTM(2*II),IHLDC(II)
      READ(99,153)  COOLTM(II)
      WRITE(3,124)  C(23),C(24),C(9),(C(KK),KK=1,8)
      LCMAX=II
      IF(C(25).EQ.COM)  GO TO 47
   45 CONTINUE
      IER=IER+1
      WRITE(3,115)
   47 DO 50 II=1,11
   48 READ(1,100) C
      WRITE(3,101) C
      IF(C(1).EQ.DOL) GO TO 48
      IF(C(10).NE.I)  CALL ERR(10,0,&529,IER)
      READ(99,152) BTM(2*II-1),BTM(2*II)
      READ(99,153) BURNTM(II)
      WRITE(3,125) C(27),C(28),C(9),(C(KK),KK=1,8)
      LBMAX=II
      IF(C(29).EQ.COM) GO TO 52
   50 CONTINUE
      IER=IER+1
      WRITE(3,116)
C     END READ BURNTM,BTM,LBMAX
C     READ OUTPUT FORMAT
   52 READ(1,100) C
      WRITE(3,101) C
      IF(C(1).EQ.DOL) GO TO 52
      IF(C(1).NE.O)  GO TO 60
      IF(C(16).NE.T)  GO TO 53
      IPOUT=3
   51 WRITE(3,113)(C(KK),KK=1,40)
      GO TO 55
   53 IF(C(15).NE.M) GO TO 54
      IPOUT=2
      GO TO 51
   54 IF(C(16).NE.L) CALL ERR(14,16,&530,IER)
      IPOUT=1
      GO TO 51
```

```
C       READ OPTION
   55 READ(1,100) C
      WRITE(3,101) C
      IF(C(1).EQ.DOL) GO TO 55
      ICASE=0
      IF(C(7).NE.COL) GO TO 65
      ICASE=1
      WRITE(3,113) (C(KK),KK=1,60)
      GO TO 602
   60 IF(C(1).NE.N) CALL ERR(1,0,&531,IER)
      WRITE(3,113)(C(KK),KK=1,78)
      IF(C(11).NE.BLK) GO TO 62
      ICASE=0
      IPOUT=0
      GO TO 64
   62 IF(C(11).NE.L) CALL ERR(11,0,&532,IER)
      ICASE=1
      IPOUT=0
  602 DO 63 II=1,10000
  603 READ(1,100) C
      WRITE(3,101) C
      IF(C(1).EQ.DOL) GO TO 603
      WRITE(9,100) C
      ICASEN=II
      IF(C(27).EQ.COM) GO TO 64
   63 CONTINUE
   64 READ(1,100) C
      WRITE(3,101) C
      IF(C(1).EQ.DOL) GO TO 64
C     END  OUTPUT INPUT - BEGIN HEAT INPUT
   65 CONTINUE
   66 IF(C(1).NE.N) GO TO 68
      IHEAT=0
      GO TO 545
   68 IF(C(1).NE.CC) GO TO 74
      IHEAT=1
      GO TO 546
  609 IF(C(38).NE.EQ) CALL ERR(38,0,&533,IER)
      IKP=0
      IF(C(39).EQ.A) GO TO 534
      DO 70  II=1,11
      IF(C(38+3*II).NE.COM) GO TO 71
      IKP=IKP+1
   70 CONTINUE
   71 ICOOLM=IKP+1
      READ(99,154) (IC(II),II=1,ICOOLM)
      DO 72 III=1,ICOOLM
      DO 72 II=1,LCMAX
      IF(IC(III).EQ.IHLDC(II))  IC(III)=II
   72 CONTINUE
      GO TO 80
   74 IF(C(1).NE.S) CALL ERR(1,0,&535,IER)
```

```
      GO TO 547
  740 IF(C(38).NE.EQ)  CALL ERR(38,C,&533,IER)
      IKP=0
      IF(C(39).EQ.A) GO TO 536
      DO 75  II=1,11
      IF(C(38+3*II).NE.COM) GO TO 76
      IKP=IKP+1
   75 CONTINUE
   76 ICOOLM=IKP+1
      READ(99,154) (IC(II),II=1,ICOOLM)
      DO 79 III=1,ICOOLM
      DO 79 II=1,LCMAX
      IF(IC(III).EQ.IHLDC(II))  IC(III)=II
   79 CONTINUE
      NBCDS=0
   77 READ(1,100) C
      WRITE(3,101) C
      IF(C(1).EQ.DOL) GO TO 77
      IF(C(1).NE.A)  CALL ERR(1,C,&535,IER)
      IF(C(11).NE.EQ)  CALL ERR(11,C,&561,IER)
      IF(C(19).NE.EQ)  CALL ERR(19,C,&562,IER)
      WRITE(9,100) C
      NBCDS=NBCDS+1
  880 IF(C(23).EQ.COM) GO TO 80
      GO TO 77
C
C     END HEAT INPUT - BEGIN SHIELD INPUT
C
   80 READ(1,100) C
      WRITE(3,101) C
      IF(C(1).EQ.DOL) GO TO 80
      IF(C(1).NE.N) GO TO 81
      ISHLD=0
      WRITE(3,113) (C(KK),KK=1,60)
      GO TO 89
   81 IF(C(1).NE.G)  CALL ERR(1,C,&538,IER)
      ISHLD=1
      GO TO 544
   82 IF(C(35).NE.EQ) CALL ERR(35,C,&538,IER)
      IF(C(36).EQ.A) GO TO 539
      ISMAX=0
      DO 84 II=1,11
      IF(C(35+3*II).NE.COM)  GO TO 85
      ISMAX=ISMAX+1
   84 CONTINUE
   85 ISMAX=ISMAX+1
      READ(99,156) (IS(II),II=1,ISMAX)
      DO 860 III=1,ISMAX
      DO 860 II=1,LCMAX
      IF(IS(III).EQ.IHLDC(II))  IS(III)=II
  860 CONTINUE
   86 IGPMAX=0
```

```
 87 READ(1,100) C
    WRITE(3,101) C
    IF(C(1).EQ.DOL) GO TO 87
    IF(C(1).NE.G)  CALL ERR(1,0,&540,IER)
    IF(C(10).NE.EQ) CALL ERR(10,C,&541,IER)
    IF(C(25).NE.EQ) CALL ERR(25,C,&542,IER)
    IF(C(47).NE.EQ) CALL ERR(47,C,&543,IER)
    WRITE(9,100) C
    IGPMAX=IGPMAX+1
 88 IF(C(57).EQ.COM) GO TO 89
    GO TO 87
 89 READ(1,100,END=94) C
    WRITE(3,101) C
    IF(C(1).NE.DOL) CALL ERR(1,C,&548,IER)
    IF(C(2).NE.DOL) GO TO 89
    WRITE(3,126)
 94 ENDFILE 9
    WRITE(11) IER,IYLD,IPROG,IOBL,IMU,PGTITL,CLTM,CPCLTM,L
   XCMAX,
   ABURNTM,BTM,LBMAX,IPOUT,ICASE,ICASEN,IHEAT,ICPOLT,IC,NB
   XCDS,ISHLD,
   BIS,ISMAX,IGPMAX
    ENDFILE 11
    IF(IER.EQ.0) GO TO 98
    WRITE(3,118) IER
    CALL EXIT
 98 WRITE(3,119)
    CALL EXIT
990 WRITE(3,102)
    CALL EXIT
500 WRITE(3,104) (C(II),II=1,5)
    GO TO 15
501 IYLD=-1
    WRITE(3,105)
    GO TO 15
502 WRITE(3,104) (C(II),II=9,15)
    GO TO 15
503 WRITE(3,106)
    IYLD=0
    GO TO 15
504 WRITE(3,104) (C(II),II=30,35)
    GO TO 15
505 WRITE(3,104) (C(II),II=1,5)
    GO TO 25
506 WRITE(3,104) (C(II),II=11,18)
    GO TO 25
507 IPROG=0
    IOBL=1
    GO TO 25
508 WRITE(3,104) (C(II),II=17,24)
    GO TO 25
509 IOBL=0
```

```
      GO TO 25
  510 IOBL=1
      GO TO 25
  511 WRITE(3,104) (C(II),II=39,48)
      GO TO 209
  512 WRITE(3,104) (C(II),II=2,8)
      GO TO 209
  513 WRITE(3,104) (C(II),II=11,17)
      GO TO 31
  514 WRITE(3,104) (C(II),II=14,20)
      GO TO 31
  515 WRITE(3,104) (C(II),II=19,25)
      GO TO 31
  516 WRITE(3,104) (C(II),II=46,54)
      GO TO 31
  517 WRITE(3,104) (C(KK),KK=1,5)
      GO TO 34
  518 WRITE(3,104) (C(KK),KK=5,13)
      GO TO 34
  519 WRITE(3,104) (C(KK),KK=17,24)
      GO TO 34
  520 WRITE(3,104) (C(KK),KK=27,34)
      GO TO 34
  521 WRITE(3,104) (C(KK),KK=1,6)
      GO TO 37
  522 IMU=2
      WRITE(3,111)
      GO TO 41
  523 IMU=1
      WRITE(3,110)
      GO TO 41
  524 WRITE(3,104) (C(KK),KK=1,7)
      GO TO 37
  525 WRITE(3,104) (C(KK),KK=1,6)
      GO TO 38
  526 WRITE(3,104) (C(KK),KK=1,9)
      GO TO 401
  527 WRITE(3,104) (C(KK),KK=60,66)
      GO TO 401
  528 WRITE(3,104) (C(KK),KK=7,14)
      GO TO 45
  529 WRITE(3,104) (C(KK),KK=7,14)
      GO TO 50
  530 WRITE(3,104) (C(KK),KK=13,18)
      GO TO 55
  531 WRITE(3,104) (C(KK),KK=1,7)
      GO TO 55
  532 WRITE(3,104) (C(KK),KK=7,14)
      GO TO 64
  533 WRITE(3,104) (C(KK),KK=35,42)
      GO TO 80
  534 DO 604 III=1,LCMAX
```

```
  604 IC(III)=II
      ICOCLM=LCMAX
      GO TO 80
  535 WRITE(3,104) (C(KK),KK=1,7)
      GO TO 880
  536 ICOCLM=LCMAX
      DO 605 II=1,LCMAX
  605 IC(II)=II
      GO TO 77
  537 WRITE(3,113) (C(KK),KK=1,35)
      GO TO 66
  538 WRITE(3,104)  (C(KK),KK=1,7)
      GO TO 86
  539 ISMAX=LCMAX
      DO 801 II=1,LCMAX
  801 IS(II)=II
      GO TO 86
  540 WRITE(3,104) (C(KK),KK=1,7)
      GO TO 88
  541 WRITE(3,104) (C(KK),KK=7,15)
      GO TO 88
  542 WRITE(3,104) (C(KK),KK=22,29)
      GO TO 88
  543 WRITE(3,104) (C(KK),KK=44,51)
      GO TO 88
  544 WRITE(3,113) (C(KK),KK=1,80)
      GO TO 82
  545 WRITE(3,113) (C(KK),KK=1,80)
      GO TO 80
  546 WRITE(3,113) (C(KK),KK=1,80)
      GO TO 609
  547 WRITE(3,113) (C(KK),KK=1,80)
      IHEAT=2
      GO TO 740
  548 WRITE(3,117)
      GO TO 89
  561 WRITE(3,104) (C(KK),KK=8,15)
      GO TO 880
  562 WRITE(3,104) (C(KK),KK=16,22)
      GO TO 880
C
C     FORMAT STMTS
C
  100 FORMAT(80A1)
  101 FORMAT(T41,80A1)
  102 FORMAT(//T40,'SUPERZAP ENTRY CARD MISPLACED-JOB TERMIN
     XATED')
  103 FORMAT(T2, '*** BEGIN SUPERZAP INPUT ***')
  104 FORMAT(T2,'**MISPLACED CHARACTER IN..',10A1,'CARD SKIP
     XPED**')
  105 FORMAT(T2,'# PARTIAL YIELD INPUT CHOSEN')
  106 FORMAT(T2,'# USER YIELD CURVE CHOSEN-PROGRAM DISTRIBUT
     XION CHOSEN')
```

```
107 FORMAT(T2,'# YIELD DATA TAKEN FROM PROGRAM CURVE',I2)
108 FORMAT(T2,'*** WILL NOT CHECK POSITIONS OF YIELD CHARA
   XCTERS***')
109 FORMAT(T2,'**IMPROPER NO. OF INPUT YIELD DATA CARDS**'
   X)
110 FORMAT(T2,'# SET MU=LAMBDA')
111 FORMAT(T2,'# LEAVE MU UNCHANGED')
112 FORMAT(T2,'# SET MU=PHI*SIGMA+LAMBDA')
113 FORMAT(T2,'# ',80A1)
114 FORMAT(T2,'# ',25A1)
115 FORMAT(T2,'**TOO MANY COOLING TIMES OR '',END'' MISSIN
   XG**')
116 FORMAT(T2,'**TOO MANY BURNUP TIMES OR '',END'' MISSING
   X**')
117 FORMAT(T2,'**TOO MANY CARDS IN DECK**')
118 FORMAT(//T22,'***THIS DATA CHECK HAS ',I4,' TERMINAL E
   XRRORS-DATA M
   CAY OR MAY NOT BE ON FILE IN PROPER ORDER***'/T45,'****
   X**SUGGEST NO
   DGO STATUS TO SUPERZAP******')
119 FORMAT(//T40,'***NO ERRORS DETECTED-SUGGEST GO STATUS
   XTO SUPERZAP*
   J**')
120 FORMAT('1',T51,'PROGRAM=ZAP   INPUT DATA CHECK MADE'/T
   X51,'LEGEND:'
   E/T51,'*** DENOTES INFORMATION'/T51,'**  DENOTES ERROR
   XCONDITION MA
   RKED BY ''$'''/T51,'#   DENOTES PROGRAM SETTINGS')
121 FORMAT(/T33,'***FIRST ERROR DETECTED IS CERTAIN-OTHER
   XERRORS MAY R
   ESULT FROM THIS***')
122 FORMAT(//T75,'CARD COLUMNS'/T41,'000000000111111111122
   X222222223333
   G333333444444444555555555566666666677777777773'/T41,'
   X123456789012
   H345678901234567890123456789012345678901234567890123456
   X789012345678
   I90'/)
123 FORMAT(T2,'# PAGE TITLE IS '',8A4,'''')
124 FORMAT(T2,'# COOLING TIME NO. ',14A1)
125 FORMAT(T2,'# IRRIDIATION TIME NO. ',14A1)
126 FORMAT(T2,'*** END SUPERZAP INPUT ***')
127 FORMAT(T2,'***CROSS SECTION DATA-ERRORS MARKED WITH $
   XONLY***')
150 FORMAT(T52,I2)
151 FORMAT(8A4)
152 FORMAT(2A4,T23,I2)
153 FORMAT(F4.1)
154 FORMAT(T39,11(I2,1X))
155 FORMAT(T38,11(I2,1X))
156 FORMAT(T36,11(I2,1X))
    END
```

```
/*
      SUBROUTINE  ERR(I,J,*,IER)
      INTEGER C(80),DOL,BLK
      DATA C/80*' '/,DOL/'$'/,BLK/' '/
      DO 30 K=I,J
   30 C(K)=DOL
      WRITE(3,100) C
      DO 35 K=I,J
   35 C(K)=BLK
      IER=IER+1
      RETURN 1
  100 FORMAT(T41,80A1)
      END
/*
REREAD$  CSECT
REREAD   ENTER
         L      1,=A(ZZZ)
         L      15,=V(IHCFCOMH)
         MVI    74(15),X'50'
         EX     0,74(15)
         MVI    74(15),X'58'
         RETRN
         SPACE  3
         USING  *,1
ZZZ      STM    4,15,SAVE
         DROP   1
         USING  ZZZ,11
         LR     11,1
         LR     4,0                GET ADDR. OF TYPE OF CALL IND
         CLC    0(2,4),INIT         IS THIS A READ INITIALIZATION
     X?
         BE     CHK99               B IF YES
         L      1,=V(IHCFIOSH)
         LR     0,4
         LM     4,15,SAVE
         BR     1
CHK99    CLC    0(4,14),=F'99' (NO EOF, NO ERR, UNIT= CONSTAN
     XT "99")
         BE     ITIS99             B IF DSRN = 99
         LR     2,14               PUT DSRN OR A(DSRN) INTO 2
         L      1,=V(IHCFIOSH)
         BALR   0,1               * SIMULATE THE CALL FROM IBCOM
INIT     DC     X'00F0'           *  TO FIOCS= FOR INIT.
         STM    2,3,SV1            STORE BUFFER ADDRESS & BUFFER
     XLENGTH
         B      LEAVE
         SPACE  3
ITIS99   LM     2,3,SV1            RESTORE 2 & 3 AS THEY WERE AFT
     XER
         SPACE  1
LEAVE    LA     1,2(4)             GET RETURN ADDR.
         LM     4,15,SAVE
```

```
          BR    1
          EJECT
SAVE     DC    18F'0'
SV1       DS    F
SV2       DS    F
          LTORG
          END
/*
MEMBER NAME  ENTER
          MACRO
&NAME     ENTER &BASE=12
          LCLC  &C1
&C1       SETC  'SVR&SYSNDX'
          AIF   ('&BASE' GT '2' AND '&BASE' LT '13').BASECK
          MNOTE 13,'REGISTER &BASE MAY NOT BE USED FOR A BASE
     X REG.'
          MEXIT
.BASECK   ANOP
  MNOTE *,' &BASE IS THE BASE REGISTER FOR THIS ROUTINE'
  MNOTE *,' &C1 IS THE 18 WORD SAVE AREA FOR THIS ROUTINE'
  MNOTE *,' &NAME IS THE LOGICAL ENTRY POINT FOR THIS ROUTIN
     XE'
          ENTRY &NAME           DEFINE ENTRY POINT
          USING *,&BASE         SET UP BASE REGISTERING
&NAME     SAVE  (14,12),,*      SAVE REGISTERS 14,15,0,1,...,1
     X2
          LR    &BASE,15        PROVIDE ADDRESSABILITY
          LA    2,&C1           PICK UP ADDR OF THIS SAVE AREA
          ST    2,8(0,13)       STORE A(SAVE) IN CALLER'S SAVE
     X AREA.
          ST    13,4(0,2)       STORE CALLER'S SAVE AREA ADDR
     XIN SAVE
          LR    13,2            SET UP SAVE AREA POINTER REG.
          B     BYP&SYSNDX      BOUNCE AROUND SAVE AREA
          DS    0D
&C1       DS    18F             18 WORD SAVE AREA
BYP&SYSNDX EQU *
          MEND
/*
MEMBER NAME  RETRN
          MACRO
&NAME     RETRN &RC=
&NAME     L     13,4(0,13)      PICK UP THE OLD SAVE AREA ADDR
     X.
          LM    14,15,12(13)    RESTORE THE REGS. 14,15
          LM    2,12,28(13)     RESTORE THE REGS. 2,3,...,12
          MVI   12(13),X'FF'    SET RETURN INDICATION
          AIF   (T'&RC EQ '0').NORC
          AIF   ('&RC' LT '4096').RCOK
          MNOTE 1,'RETURN CODE RC=&RC IS > 4095, RC IGNORED'
          AGO   .NORC
.RCOK     LA    15,&RC.(0,0)    LOAD RETURN CODE
```

```
.NORC    BR      14              RETURN
         MEND
/*
```

```
      DATA SEC,MIN,HR,DAY,YR/' SEC',' MIN',' HRS','DAYS',' Y
     XRS'/
C     BTM=ALPHA BURNUP TIMES
C     CLTM= ALPHA COOLING TIMES
C     LBMAX=MAX BURNUP TIMES
C     LCMAX= MAX COOLING TIMES
C    BURNTM=RETURNED BURNUP TIMES IN SEC/INITIAL AS READ
C    COOLTM=RETURNED COOLING TIMES IN SEC/INITIAL AS READ
      TDAY=3600.*24.
      TYR=TDAY*365.25
      DO 10 I=1,LCMAX
      A=CLTM(2*I)
      IF(A.EQ.YR) COOLTM(I)=COOLTM(I)*TYR
      IF(A.EQ.DAY)  COOLTM(I)=COOLTM(I)*TDAY
      IF(A.EQ.HR) COOLTM(I)=COOLTM(I)*3600.
      IF(A.EQ.MIN) COOLTM(I)=COOLTM(I)*60.
   10 CONTINUE
      DO 20 I=1,LBMAX
      A=BTM(2*I)
      IF(A.EQ.YR) BURNTM(I)=BURNTM(I)*TYR
      IF(A.EQ.DAY)  BURNTM(I)=BURNTM(I)*TDAY
      IF(A.EQ.HR) BURNTM(I)=BURNTM(I)*3600.
      IF(A.EQ.MIN) BURNTM(I)=BURNTM(I)*60.
   20 CONTINUE
      RETURN
      END
/*
      SUBROUTINE  DTAPRP
C
C    THIS ROUTINE PREPARES RECORD TYPE B WITH MU AND YIELDS
C
      COMMON PTR4,X9(49),IYLD,IOBL,X8(33),IPROG
      DIMENSION Q(17),ZS(180),Y(68,180),MXN(15),YTOT(180),TI
     XTLE(20)
      INTEGER  ALOW,AHI,ZLOW(180),ZHI(180),PTR4
      REAL LAMBDA
      REAL LIBR
      EQUIVALENCE (Q(1),MASS),(Q(7),YLD),(Q(10),NATOM),(Q(11
     X),NSTATE),
     1(Q(4),LAMBDA)
      DATA YTOT/180*0./,ITITLE/0/,END/'END '/,LIBR/'LIBR'/
      DATA ALOW,AHI/72,161/
      DO 10 I=1,68
      DO 10 J=1,180
   10 Y(I,J)=0.
      AHI=161
      ALOW=72
C    DATA DEFINITIONS
C       Q()     ELEMENTS OF  RECORD A  EQUIVALENCED
C       ZS()    MOST STABLE ATOMIC NO PER MASS NO.
C       ZHI()   HIGHES MASS NO PER CHAIN
C       ZLOW()  LOWEST MASS NO PER CHAIN
```

```
C      YTOT()    TOTAL YIELD OF FISSION(ABSOULTE) PER MASS NO.
C      Y(,)      PARTIAL YIELD OF FISSION PER AT. NO. PER MASS
     X NO.
C      ALOW      LOWEST  MASS NO. CONSIDERED
C      AHI       HIGHEST MASS NO. CONSIDERED
C      AF        COMPOUND FISSION NUCLEI MASS
C      ZF        COMPOUND FISSION NUCLEI AT. NO.
C      ALH       AF MINUS FISSION NEUTRONS PRODUCED
C      IPROG     SWITCH   1-PRINT PROGENITORS   0- NO PRINT
C      IYLD  SWITCH >0 - USE LIBRARY, =0 - USE PROGRAMMERS TO
     XTAL YIELDS
C                          .0 - USE PROGRAMMERS PARTIAL YIELDS
C      ITITLE  SWITCH =0 - PRINT PROGENITOR HEADING, ¬=0 - SK
     XIP HEADING
C   CHECK TO SEE IF READ YIELDS FROM TAPE OR CARDS
      IF(IYLD)500,550,14
   14 IYLD=IYLD+13
      READ(IYLD) AF,ZF,ALH,(YTOT(I),I=4,180)
   15 READ(18) ZLOW
      READ(18) ZHI
      READ(18) ZS
C
C   BEGIN  PARTIAL YIELD CALCULATIONS
      DO 200 IAL=ALOW,AHI
      AL=IAL
      AH=ALH-AL
C
C   INTERPOLATE TO FIND ZHI STABLE - FIND ZLOW STABLE
      IAH=AH
      FIAH=IAH
      ZLS=ZS(IAL)
      ZHS=ZS(IAH)+(ZS(IAH+1)-ZS(IAH))*(AH-FIAH)
C   FIND  ZLOW AND ZHI PROBABLE AND FINAL YIELD
      ZLP=(ZLS-ZHS+ZF)/2.
      ZHP=ZF-ZLP
      YIELD=YTOT(IAL)
      J=ZLOW(IAL)
      K=ZHI(IAL)
      SUM=0.
      DO 98 IANO=J,K
      A=IANO
      YHOLD=YIELD*EXP(-(A-ZLP)**2)/1.772454
      IF(YHOLD.LT.0.) YHOLD=0.
      Y(IANO,IAL)=YHOLD
   98 SUM=SUM+YHOLD
      YPROG=YIELD-SUM
      IF(YPROG.LT.0.) YPROG=0.
      Y(J,IAL)=Y(J,IAL)+YPROG
C
C   OPTION -  PRINT  PROGENETORS
      IF(IPROG.EQ.0) GO TO 200
      IF(ITITLE.GT.0) GO TO 99
```

```
      WRITE(3,600)
      ITITLE=1
   99 WRITE(  3 ,601)IAL,YPROG
  200 CONTINUE
  201 PTR4=1
C
C  READ FILE 4 AND UPDATE RECORD A
  210 READ(4'PTR4) MASSN,MXB,MXN
      IF(MASSN.EQ.999) GO TO 400
      K=0
      DO 215 J=1,MXB
  215 K=K+MXN(J)
      DO 300 I=1,K
      READ(4'PTR4) Q
      PTR4=PTR4-1
      YLD=Y(NATOM,MASS)
      IF(IYLD.LT.0) GO TO 300
      G=NSTATE
      IF(NSTATE.GT.1) YLD=YLD/G
  300 WRITE(4'PTR4) Q
      GO TO 210
  400 PTR4=1
      IF(IOBL.NE.1) GO TO 450
      WRITE(3,609)
      DO 410 I=ALOW,AHI
      JK=ZLOW(I)
      JL=ZHI(I)
      DO 409 J=JK,JL
      WRITE(3,610) I,J,Y(J,I)
  409 CONTINUE
  410 CONTINUE
  450 CONTINUE
      WRITE(  3 ,602)
      REWIND 14
      REWIND 18
      RETURN
  500 READ(1,605) TITLE
      WRITE(3,606) TITLE
  501 READ(1,603) NATOM,MASS,Y(NATOM,MASS),ENDCK
      WRITE(3,603) NATOM,MASS,Y(NATOM,MASS)
      IF(ENDCK.EQ.END)  GO TO 201
      GO TO 501
  550 READ(1,605) TITLE
      WRITE(3,606) TITLE
      READ(1,608) (TITLE(KK),KK=1,4),IDTA
      IF(TITLE(2).EQ.LIBR)  GO TO 552
      READ(1,607)IAF,IZ,AA
      AF=IAF
      ZF=IZF
      ALH=AF-AA
      GO TO 551
  552 IDTA=IDTA+13
```

```
      READ(IDTA) AF,ZF,ALH
  551 READ(1,604) (YTOT(I),I=ALOW,AHI)
      GO TO 15
  600 FORMAT('1',T55,'PROGENITOR OPTION EFFECTED'//)
  601 FORMAT(T45,'PROGENITOR TO CHAIN ',I3,' IS ',E14.8,' AT
     XOMS')
  602 FORMAT('1  END SUBROUTINE - DATA PREP')
  603 FORMAT(T9,I2,T21,I3,T31,E14.8,T46,A4)
  604 FORMAT(5(E14.8,2X))
  605 FORMAT(20A4)
  606 FORMAT(' ',20A4)
  607 FORMAT(T17,I3,T23,I2,T50,F3.1)
  608 FORMAT(4A4,T43,I2)
  609 FORMAT('1',T54,'ORLONG TABLE OPTION EFFECTED'//)
  610 FORMAT(T35,'PARTIAL YIELD TO MASS NO.',I4,',ATOMIC NO.
     X',I3,
     1' IS ',E14.8,' ATOMS')
      END
/*
      SUBROUTINE CROSS
      COMMON PTR4,PTR5,X9(50),IMU
      DIMENSION Q(17),TITLE(20),MAXN(15)
      REAL MU(42,109,2),MUL,LMDA,MS
      INTEGER  PTR4,E,Z
      EQUIVALENCE  (Q(1),MASS),(Q(4),LMDA),(Q(5),MUL),(Q(10)
     X,NATOM),
     1(Q(8),NAME),(Q(9),STATE)
      DATA  MU/9156*0./ ,END/'END '/,ENDCK/' '/,LINE/1/,IPRI
     XNT/0/
      DATA TITLE/'CONV','ERT ','- LA','MBDA','=MU ',15*' '/
      DATA INDE/'INDE'/,PHI/0./,B/'B'/,MS/'M'/,Z/' '/,E/'0'/
C       DATA DEFINITIONS
C       LINE     0-PRINT HEADING,  ¬=0 - SKIP HEADING
C      PHI       FLUX
C      IPRINT    1-PRINT MU,LAMBDA,AND/OR X-SECTIONS,   ¬=0  S
     XKIP PRINT
C      X(,)      X-SECTION HOLD AREA
C      MUL       FINAL MU
C      IMU  =2-USE OLD MU    =1-MU=LAMBDA   NOT1 OR 2-FIND NEW
     X MU
C      JXSEC    =1-PRINT X-SECTIONS,  =0 SKIP
C      JMU  =1-PRINT MU'S      ,      =0-SKIP
C      JLMDA    =1-PRINT LAMBDA,  =0 SKIP
C
      IF(IMU.EQ.2) GO TO 1000
      IF(IMU.EQ.1) GO TO 198
      READ(1,100) TITLE
      WRITE(3,103) TITLE
      READ(1,102) PHI,JMU,JXSEC,JLMDA
      IF(JMU.NE.E.AND.JMU.NE.Z)  IPRINT=1
      IF(JXSEC.NE.E.AND.JXSEC.NE.Z)   IPRINT=1
      IF(JLMDA.NE.E.AND.JLMDA.NE.Z) IPRINT=1
```

```
C
C   USE INDEPENDENT CROSS SECTIONS OR WESTCOTT APPROXIMATIONS
      IF(TITLE(1).EQ.INDE)  GO TO 60
C
C   READ  2200 METER CROSS SECTIONS FROM LIBRARY
      DO 2 L=1,2
      DO 2 I=1,42
    2 READ(12) (MU(I,J,L),J=1,109)
C
C   READ INPUT DATA  IF S=0, R CONTAINS  RS - IF R&S=0, T CON
     XTAINS G+RS
C   IF MASS=0 USE SAM G+RS FOR ALL MASS NO.'S  THIS AT. NO.
    4 IF(ENDCK.EQ.END)  GO TO 200
      READ(1,101) NATOM,MASS,STATE,T,R,S,ENDCK
      IF(S.EQ.0.) S=1.
      A=T+R*S
      IF(MASS.EQ.0) GO TO 49
      IF(NATOM.NE.51)  GO TO 20
      IF(MASS.NE.124)  GO TO 20
      IF(STATE.NE.MS) GO TO 20
      L=1
      NATOM=68
      MASS=180
      GO TO 21
   20 L=1
      IF((STATE.EQ.B).OR.(STATE.EQ.MS)) L=2
   21 MU(NATOM-26,MASS-71,L)=MU(NATOM-26,MASS-71,L)*A
      GO TO 4
   49 DO 50 K=1,109
      DO 50 L=1,2
   50 MU(NATOM-26,K,L)=MU(NATOM-26,K,L)*A
      IF(NATOM.EQ.51)  MU(42,109,1)=MU(42,109,1)*A
      GO TO 4
C
C   INDEPENDENT CROSS SECTION READIN SAME FORMAT AS WESTCOTT
     X S&T DUMMY
   60 IF(ENDCK.EQ.END) GO TO 200
      READ(1,101) NATOM,MASS, STATE,R,S,T,ENDCK
      IF(MASS.EQ.0)  GO TO 65
      IF(NATOM.NE.51)  GO TO 62
      IF(MASS.NE.124)  GO TO 62
      IF(STATE.NE.MS) GO TO 62
      L=1
      NATOM=68
      MASS=180
      GO TO 63
   62 L=1
      IF((STATE.EQ.MS).OR.(STATE.EQ.B))  L=2
   63 MU(NATOM-26,MASS-71,L)=R
      GO TO 60
   65 DO 66 L=1,2
      DO 66 K=1,109
```

```
   66 MU(NATOM-26,K,L)=R
      IF(NATOM.EQ.51)  MU(42,109,1)=R
      GO TO 60
  200 WRITE(3,104) PHI,JMU,JXSEC,JLMDA
  198 PHI=PHI*1.E-24
      PTR4=1
  201 READ(4'PTR4) MASS,MAXB,MAXN
      IF(MASS.EQ.999) GO TO 999
      M=0
      DO 202 I=1,MAXB
  202 M=M+MAXN(I)
C   READ MASS & BRANCH CARDS
C   READ CHAIN NODE CARDS  REPLACE MU CHECK OPTIONS
      DO 250 I=1,M
      READ(4'PTR4) Q
      PTR4=PTR4-1
      FIND(4'PTR4)
      NN=NATOM
      MM=MASS
      IF(NN.NE.51)  GO TO 220
      IF(MM.NE.124)  GO TO 220
      IF(STATE.NE.MS) GO TO 220
      L=1
      NN=68
      MM=180
      GO TO 222
  220 L=1
      IF((STATE.EQ.MS).OR.(STATE.EQ.3))  L=2
  222 MUL=MU(NN-26,MM-71,L)*PHI+LMDA
      WRITE(4'PTR4) Q
      IF(IPRINT.EQ.0) GO TO 250
      IF(LINE.NE.0) GO TO 400
      LINE=1
      WRITE(3,105)
  400 WRITE(3,106) MASS,STATE,NATOM,NAME
      IF(JMU.EQ.E) GO TO 401
      WRITE(3,107) MUL
  401 IF(JXSEC.EQ.E) GO TO 402
      WRITE(3,108)  MU(NN-26,MM-71,L)
  402 IF(JLMDA.EQ.E) GO TO 250
      WRITE(3,109) LMDA
  250 CONTINUE
      GO TO 201
  999 WRITE(3,103) END,TITLE
      WRITE(3,110)
 1000 RETURN
  100 FORMAT(20A4)
  101 FORMAT(T3,I2,T9,I3,A1,T16,E14.8,T36,E14.8,T56,E14.8,T7
     X2,A4)
  102 FORMAT(4X,E14.8,T64,3(A1,1X))
  103 FORMAT(' ',21A4)
  104 FORMAT('1PHI=',E14.8,',OPTIONS-PRINT(MU,X-SECTIONS,LAM
     XBDA)=(',2(A1
```

```
     1,',',A1,')')
  105 FORMAT(' ',T42,'OPTION TO PRINT SOME OR ALL X-SECTION
     XDATA EFFECTE
     1D',/T3,'ALL ISOTOPES PRINTED - 0''S UNDER MASS DENOTE
     XSAME X-SECTI
     2ON USED FOR ALL MASSES THAT ELEMENT - BLANKS DENOTE OP
     XTION NOT EFF
     3ECTED'//)
  106 FORMAT(' MASS=',I4,A1,T11,'AT.NO.=',I3,T22,'NAME=',A2)
  107 FORMAT('+',T32,'MU(1/SEC)='E14.8)
  108 FORMAT('+',T58,'X-SECTION(BARNS)=',E14.8)
  109 FORMAT('+',T91,'LAMBDA(1/SEC)=',E14.8)
  110 FORMAT('1 END SUBROUTINE CROSS - CALCULATION OF MU')
      END
/*
      SUBROUTINE ZEROF5
      COMMON PTR4,PTR5
      DIMENSION A(11),B(11),Q(45)
      INTEGER PTR5
      EQUIVALENCE (A(1),Q(6)),(B(1),Q(21))
      DO 10 I=1,42
      DO 10 J=1,25
      PTR5=(I-1)*25+J
      READ(5'PTR5) Q
      PTR5=PTR5-1
      FIND (5'PTR5)
      DO 5 K=1,11
      A(K)=0.
      B(K)=0.
    5 CONTINUE
      WRITE(5'PTR5) Q
   10 CONTINUE
      RETURN
      END
/*
      SUBROUTINE CALC
      COMMON PTR4,PTR5,X9(11),COOLTM(11),X8(24),COOLMX,X7(42
     X),BURNTM
      INTEGER PTR4,PTR5,BRNCH,DCHK,ONE/1/,COOLMX
      REAL LMDA(15),LMDAFL(2),MU(15), MSTATE
      DIMENSION MNCHK(45),R(15),YLD(15),BFF(15),ANS(2,11),ST
     XATE(2)
      DIMENSION AFF(11),MAXN(15),Q(17)
      DATA  MSTATE,ASTATE,BSTATE/'M','A','B'/
      NATOML=26
      PTR4=1
      PTR5=1
C
C   ZERO OUT MNCHK FILE
      DO 20 I=1,45
   20 MNCHK(I)=0
C
```

```
C   READ AFILE  FOR CHAIN, MAX BRANCHES, NODES EACH BRANCH
    1 READ(4'PTR4) MASSC,MAXB,MAXN
      IF(MASSC.EQ.999) GO TO 1000
C
C   BEGIN BRANCH AND NODE DO LOOPS
      DO 902 KKK=1,MAXB
      KK=MAXN(KKK)
      DO 900 I=1,KK
C
C   READ NODE DATA
      READ(4'PTR4)MASS,BRNCH,NODE,LMDA(I),MU(I),R(I),YLD(I),
     XNAME,STATE1,
     1NATOM,(Q(J),J=1,7)
C
C   CHECK FOR 51 SB 124M
      IF(MASS.NE.124) GO TO 30
      IF(NATOM.NE.51) GO TO 30
      IF(STATE1.NE.MSTATE) GO TO 30
      PTR5=1050
      GO TO 35
C
C   CALCULATE RELATIVE RECORD NO.
   30 NBRR=NATOM-26
      IF(MNCHK(NBRR).EQ.0) MNCHK(NBRR)=MASS
      MASSR=MASS-MNCHK(NBRR)+1
      PTR5=25*(NBRR-1)+MASSR
   35 FIND(5'PTR5)
C
C   BEGIN ACTUAL BURNUP CALCULATIONS
  150 BAN=0.
C
C   SIGMA SUMMATION  M=1 TO I
      DO 475 M=1,I
      II=I
      SUM=0.
C
C   CHECK  KK AND/OR M =I    IF SO DIFFERENT EQUATIONS
      IF(I.NE.KK) GO TO 398
      II=II-1
      IF(I.NE.M) GO TO 398
      BAN=100.*R(M)*YLD(M)+BAN
      GO TO 475
C
C   SIGMA SUM  J=1 TO I OR I-1
  398 DO 450 J=M,II
      DPOD=1.
C
C   PI SUM UNDER SIGMA SUM ON J
      DO 401 K=M,I
      IF(K.EQ.J) GO TO 401
      HLDDD=MU(K)-MU(J)
      IF(HLDDD.EQ.0.)  HLDDD=6.3
```

```
      DPOD=DPOD*HLDDD
  401 CONTINUE
C
C   END   PI SUM
C   CHECK   SATURATION FACTORS TO ASSUMPTIONS
      EXPP=MU(J)*BURNTM
      IF(EXPP.LT.1.E-04) GO TO 405
      IF(EXPP.GT.10.) GO TO 404
      EXPP=1.-EXP(-EXPP)
      GO TO 405
  404 EXPP=1
  405 SUM=SUM+EXPP/(    MU(J)*DPOD)
  450 CONTINUE
C
C   END OF SIGMA SUM ON J
C   PI SUM OF LAMBDAS
      L=I-1
      PIAMD=1
      IF(M.GT.L) GO TO 471
      DO 470 LL=M,L
  470 PIAMD=PIAMD*LMDA(LL)
C
C   FINAL SUMS
  471 IF(I.EQ.KK) GO TO 474
      BAN=BAN+YLD(M)*R(M)*(PIAMD*SUM)*100./BURNTM
      GO TO 475
  474 BAN=BAN+YLD(M)*(((100./BURNTM)*R(M)*(PIAMD*SUM))+(100.
     X*R(M)))
  475 CONTINUE
C
C   END OF BURNUP TIME CALCULATIONS
C   CHECK AND TEMP STORE ANSWERS
      IF(BAN.LE.0.) GO TO 900
      BEF(I)=BAN
C
C   END   BURNUP   CSECT - BEGIN   COOL TIME CSECT
C
      DO 601   LC=1,COOLMX
      IF(COOLTM(LC).NE.0.) GO TO 502
      AEF(LC)=BAN
      GO TO 806
  502 SSUM=0.
C
C   SIGMA SUM   M=1 TO I
      DO 600 M=1,I
      ASUM=0.
C
C   SIGMA SUM   J=M TO I
      DO 550 J=M,I
C
C   PI SUM OVER K=1 TOI AND CHECK ATTENUATION FACTOR
      DPOD=1
```

```
      DO 525 K=M,I
      IF(K.EQ.J) GO TO 525
      HLDDD=LMDA(K)-LMDA(J)
      IF(HLDDD.EQ.0.) HLDDD=6.3
      DPOD=DPOD*HLDDD
  525 CONTINUE
      EXPP=EXP(-LMDA(J)*COOLTM(LC))
C
C  END PI SUM
  550 ASUM=ASUM+EXPP/DPOD
C  END SIGMA SUM OVER J
C  PI SUM OF LAMBDAS K=1 TO I-1 AND CHECK VALUE
      L=I-1
      PIAMD=1.
      IF(M.GT.L) GO TO 600
      DO 575 LL=M,L
  575 PIAMD=PIAMD*LMDA(LL)
C  END PI SUM
  600 SSUM=SSUM+BFF(M)*(ASUM*PIAMD)
      IF(SSUM.LT.0.) SSUM=0.
  601 AFF(LC)=SSUM
      DO 620 LC=1,COOLMX
      IF(AFF(LC).GT.0.) GO TO 621
  620 CONTINUE
      GO TO 900
  621 CONTINUE
C  END  COOLING TIME  CSECT
C
C  WRITE ANSWERS TO DISK
  806 READ(5'PTR5)NATOM,NAME,MASS,STATE(1),LMDAFL(1),(ANS(1,
     XL),L=1,11),
     1DCHK,NREC,STATE(2),LMDAFL(2),(ANS(2,L),L=1,11),(Q(J),J
     X=1,14)
      PTR5=PTR5-1
      FIND(5'PTR5)
C
C  CHECK STATE OF ELEMENT  K= POSITION IN RECORD  L=SUBRECOD
     XS WRITTEN
      K=1
      IF((STATE1.EQ.MSTATE).OR.(STATE1.EQ.BSTATE)) K=2
      DO 650 LC=1,COOLMX
  650 ANS(K,LC)=ANS(K,LC)+AFF(LC)
      STATE(K)=STATE1
      LMDAFL(K)=LMDA(I)
      WRITE(5'PTR5)NATOM,NAME,MASS,STATE(1),LMDAFL(1),(ANS(1
     X,L),L=1,11),
     1ONE,NREC,STATE(2),LMDAFL(2),(ANS(2,L),L=1,11),(Q(J),J=
     X1,14)
  900 CONTINUE
  902 CONTINUE
      GO TO 1
 1000 PTR5=1
```

```
      PTR4=1
      WRITE(3,800)
      RETURN
  800 FORMAT(//' NOTE:COMPLETION - CALC')
      END
/*
      SUBROUTINE OUTPUT
      COMMON PTR4,PTR5,X9(22),CLTM(22),BURNTM(2),LCMAX,X8(4)
     X,
     1PGTITL(8),IPOUT
      DIMENSION SUM(11),STATE(2) ,ANS(2,11),Q(14),LLL(2),HLD
     XMAS(161,11),
     1NMASS(161)
      REAL LMDA(2)
      INTEGER DCHK,PTR5
      DATA SEC,AMIN,HRS,DAYS,YRS,ALL/'S','M','H','D','Y','AL
     XL'/,
     AHLDMAS/1771*0./,NMASS/161*0/,IPLACE,IPAGE/5,1/,KPTR/0/
C      LCMAX = MAX COOLING TIMES
C      BURNTM= ALPHA BURN TIME CONSIDERED
C      PGTITL= ALPHA TYPE REACTION
C      CLTM= ALPHA ALL COOLING TIMES
C      IPOUT = TYPE OF OUPUT DESIRED
C         1-ALL ELEMENTS  2-BY MASS NO.  3-BY ATOMIC NO.
C      ICASE = SPECIAL OPTION   1-TAKEN   0-NOT TAKEN
C      ICASEN= NO. SPECIAL OPTION OUTPUT
      PTR5=1
      ADY=3600.*24.
      AYR=ADY*365.
  500 WRITE(3,200) IPAGE
      WRITE(3,201) PGTITL,BURNTM
      GO TO (501,502,503),IPOUT
  501 WRITE(3,202) ((CLTM(2*K-1),CLTM(2*K)),K=1,LCMAX)
      GO TO 504
  502 WRITE(3,210) ((CLTM(2*K-1),CLTM(2*K)),K=1,LCMAX)
      GO TO 504
  503 WRITE(3,211) ((CLTM(2*K-1),CLTM(2*K)),K=1,LCMAX)
  504 LINE=5
      IPAGE=IPAGE+1
      GO TO (48,49,90,404,5),IPLACE
    5 DO 400 KKK=27,66
      DO 10 I=1,11
   10 SUM(I)=0.
      KCHK=0
      NCHK=1
      DO 390 KK=1,25
   12 READ(5'PTR5) NATOM,NAME,MASS,STATE(1),LMDA(1),(ANS(1,J
     X),J=1,11),
     1DCHK,NREC,STATE(2),LMDA(2),(ANS(2,L),L=1,11),Q
      DO 90 I=1,2
      IF(DCHK.NE.1) GO TO 48
      LLL(I)=0
```

```
      DO 15 J=1,LCMAX
      IF(ANS(I,J).GT.0.) LLL(I)=1
   15 CONTINUE
      IF(LLL(I).EQ.0) GO TO 48
      DO 20 J=1,LCMAX
   20 SUM(J)=SUM(J)+ANS(I,J)
      GO TO (30,50,70),IPOUT
   30 IF(LMDA(I).EQ.0.) GO TO 45
   35 THALF=.693/LMDA(I)
      IF(THALF.GT.60.) GO TO 36
      TM=SEC
      GO TO 40
   36 IF(THALF.GT.3600.) GO TO 37
      TM=AMIN
      THALF=THALF/60.
      GO TO 40
   37 IF(THALF.GT.ADY) GO TO 38
      TM=HRS
      THALF=THALF/3600.
      GO TO 40
   38 IF(THALF.GT.AYR) GO TO 39
      TM=DAYS
      THALF=THALF/ADY
      GO TO 40
   39 THALF=THALF/AYR
      TM=YRS
   40 IF(LINE.EQ.5.OR.NCHK.EQ.1) GO TO 43
      WRITE(3,203) MASS,STATE(I),THALF,TM,(ANS(I,J),J=1,LCMA
     XX)
      GO TO 47
   43 WRITE(3,204) NATOM,NAME,MASS,STATE(I),THALF,TM,
     1(ANS(I,J),J=1,LCMAX)
      GO TO 47
   45 IF(LINE.EQ.5.OR.NCHK.EQ.1) GO TO 46
      WRITE(3,205) MASS,STATE(I),(ANS(I,J),J=1,LCMAX)
      GO TO 47
   46 WRITE(3,206) NATOM,NAME,MASS,STATE(I),(ANS(I,J),J=1,LC
     XMAX)
   47 NCHK=NCHK+1
      LINE=LINE+1
      IPLACE=1
      IF(LINE.GE.58) GO TO 500
   48 IF(KK.LT.25) GO TO 49
      KCHK=KCHK+1
      IF(KCHK.NE.2)  GO TO 49
      LINE=LINE+2
      WRITE(3,207) NATOM,NAME,(SUM(J),J=1,LCMAX)
      IPLACE=2
      WRITE(3,213)
      IF(LINE.GE.58) GO TO 500
   49 GO TO 90
   50 DO 53 J=1,LCMAX
```

```
 53 HLDMAS(MASS,J)=HLDMAS(MASS,J)+ANS(I,J)
    NMASS(MASS)=NMASS(MASS)+1
    GO TO 90
 70 NCHK=NCHK+1
    IF(KK.LT.25) GO TO 90
    WRITE(3,208) NATOM,NAME,ALL,NCHK,(SUM(J),J=1,LCMAX)
    IPLACE=3
    LINE=LINE+2
    IF(LINE.GE.58) GO TO 500
 90 CONTINUE
    IF(NATOM.NE.51) GO TO 390
    IF(MASS.NE.124)  GO TO 390
    IF(KPTR.EQ.1)  GO TO 360
    KPTR=1
    KHLD=PTR5
    PTR5=1050
    GO TO 12
360 PTR5=KHLD
    KPTR=0
390 CONTINUE
400 CONTINUE
    IF(IPOUT.NE.2) GO TO 450
    IPLACE=4
    DO 405 I=72,161
    WRITE(3,209) ALL,I,NMASS(I),(HLDMAS(I,J),J=1,LCMAX)
    LINE=LINE+2
    IF(LINE.GE.58) GO TO 500
404 CONTINUE
405 CONTINUE
450 WRITE(3,212)
    RETURN
200 FORMAT(T1,'1',T64,'TABLE',I3)
201 FORMAT(T24,'FISSION PRODUCT SPECTRA FOR CA. ',8A4,' ('
   X,A4,' ',
   1A4,' IRRIDIATION)'/T43,'ATOMS PER 200 ATOMS FISSIONED
   XAFTER COOLIN
   2G FOR'/)
202 FORMAT(T3,'ELE',T8,'MASS',T14,'HALF-LIFE',T24,11(' ',A
   X4,' ',A4))
203 FORMAT(T7,I4,A1,T13,E9.3,A1,T13,' ',T24,1P11E10.3)
204 FORMAT(T1,I3,T5,A2,T7,I4,A1,T13,E9.3,A1,T13,' ',T24,1P
   X11E10.3)
205 FORMAT(T7,I4,A1,T15,'STABLE',T24,1P11E10.3)
206 FORMAT(T1,I3,T5,A2,T7,I4,A1,T15,'STABLE',T24,1P11E10.3
   X)
207 FORMAT(T4,'TOTALS FOR',I3,1X,A2,' =',T24,1P11E10.3)
208 FORMAT(T1,I3,T5,A2,T8,A3,T16,I3,T24,1P11E10.3)
209 FORMAT(T3,A3,T8,I4,T16,I3,T24,1P11E10.3)
210 FORMAT(T3,'ELE',T8,'MASS',T14,'ISOTOPES',T24,11(' ',A4
   X,' ',A4))
211 FORMAT(T3,'ELE',T8,'MASS',T13,'AT. NO.''S',T24,11(' ',
   XA4,' ',A4))
```

```
  212 FORMAT('1',T14,'END SUBROUTINE OUTPUT')
  213 FORMAT(' ')
      END
/*
      SUBROUTINE SPCASE(ICASEN)
      COMMON PTR4,PTR5,X9(22),CLTM(22),BURNTM(2),LCMAX
      DATA BLK/' '/,S/'/S'/
      DIMENSION STATE(2),ANS(2,11),Q(14)
      INTEGER PTR5,DCHK
      REAL LMDA(2)
      DATA IPLACE,IPAGE/1,1/
C     VARIABLES AS IN CALC AND OUTPUT
C     VAR ARE BURNTM,LCMAX,CLTM, ALL OF FILE 5
   20 WRITE(3,100) IPAGE,BURNTM
      WRITE(3,101)  ((CLTM(2*K-1),CLTM(2*K)),K=1,LCMAX)
      LINE=5
      IPAGE=IPAGE+1
      GO TO (21,50),IPLACE
   21 IPLACE=2
      DO 99 I=1,ICASEN
      READ(1,107) NATOM,MASS
      PTR5=(NATOM-27)*25+1
      FIND (5'PTR5)
      LL=0
      IF(NATOM.NE.51) GO TO 25
      LL=LL+1
      IF(MASS.NE.124) GO TO 25
      LL=LL+1
   25 READ(5'PTR5) NATOM1,NAME,MASS1
      MASSR=MASS-MASS1
      IF(MASSR.GE.0) GO TO 27
      WRITE(3,105) NATOM,NAME,MASS
      GO TO 99
   27 PTR5=PTR5-1+MASSR
   30 READ(5'PTR5) NATOM,NAME,MASS,STATE(1),LMDA(1),(ANS(1,J
     X),J=1,11),
     ADCHK,NREC,STATE(2),LMDA(2),(ANS(2,K),K=1,11)
      DO 51 J=1,2
      IF(DCHK.NE.1) GO TO 62
      DO 35 K=1,LCMAX
      IF(ANS(J,K).NE.0.) GO TO 36
   35 CONTINUE
      GO TO 48
   36 WRITE(3,102) NATOM,NAME,MASS,STATE(J),LMDA(J),S,
     1(ANS(J,K),K=1,LCMAX)
      GO TO 49
   48 IF(LL.EQ.3) GO TO 51
      IF(STATE(J).EQ.BLK.AND.J.EQ.2)  GO TO 49
      WRITE(3,103) NATOM,NAME,MASS,STATE(J)
   49 LINE=LINE+1
      IF(LINE.GE.58) GO TO 20
   50 IF(LL.EQ.3) GO TO 51
```

```
      IF(LL.EQ.2) GO TO 60
   51 CONTINUE
   99 CONTINUE
      WRITE(3,104)
      RETURN
   60 PTR5=1050
      LL=3
      GO TO 30
   62 WRITE(3,106) NATOM,NAME,MASS
      GO TO 99
  100 FORMAT(T1,'1',T64,'TABLE',I3/T54,'ISOTOPES OF SPECIAL
     XINTEREST'/
     CT54,'(IRRIDIATION TIME=',A4,' ',A4,')'/)
  101 FORMAT(T3,'ELE',T8,'MASS',T14,'DCY CONST',T24,11(' ',A
     X4,' ',A4))
  102 FORMAT(T1,I3,T5,A2,T7,I4,A1,T13,1PE9.2,A2,T24,11E10.3)
  103 FORMAT(T1,I3,T5,A2,T7,I4,A1,T48,'THIS STATE HAS CONCEN
     XTRATIONS OF
     XZERO FOR ALL COOLING TIMES')
  104 FORMAT(T1,'1',T14,'END SUBROUTINE SPECIAL ISOTOPE OUTP
     XUT')
  105 FORMAT(T1,I3,T5,A2,T7,I4,T44,'THIS ELEMENT NOT FOUND I
     XN ANY DECAY
     YSCHEME - ELEMENT OUTPUT IGNORED')
  106 FORMAT(T1,I3,T5,A2,T7,I4,T44,'THIS ENTIRE ELEMENT HAS
     XCONCENTRATIO
     ZNS OF ZERO FOR ALL COOLING TIMES')
  107 FORMAT(T12,I2,T24,I3)
      END
/*
      SUBROUTINE  HEAT
      COMMON PTR4,PTR5,X9(22),CLTM(22),BURNTM(2),X8(14),IHEA
     XT,ICOOLM,
     1IC(11),NBCDS
      INTEGER  DCHK,PTR4,PTR5
      DIMENSION A(11),BANS(11)
      DATA  BANS/11*0./,WCONV/1./
      WRITE(3,101) BURNTM
      IF(IHEAT.EQ.1) GO TO 200
      IPLACE=1
      WRITE(3,102)
      WRITE(3,104)  ((CLTM(2*IC(K)-1),CLTM(2*IC(K))),K=1,ICO
     XOLM)
      DO 30  I=1,NBCDS
    5 READ(1,100) NATM,MAS
      PTR5=(NATM   -27)*25+1
      READ(5'PTR5) NATOM,NAME,MASS
      MASSR=MAS   -MASS
      IF(MASSR.GE.0) GO TO 8
      WRITE(3,107)  NATOM,NAME,MAS
      GO TO 30
    8 PTR5=PTR5-1+MASSR
```

```
      CALL        HEAT2(A,BANS,PTR5,IC,ICOOLM,NCONV,NATOM,MAS
     XS)
   20 WRITE(3,106)  NATOM,NAME,MASS,(A(K),K=1,ICOOLM)
   30 CONTINUE
      GO TO 500
  200 IPLACE=2
      WRITE(3,103)
      WRITE(3,104)    ((CLTM(2*IC(K)-1),CLTM(2*IC(K))),K=1,IC
     XOOLM)
      DO 205  I=1,1050
      PTR5=I
      CALL        HEAT2(A,BANS,PTR5,IC,ICOOLM,NCONV,NATOM,MAS
     XS)
  204 CONTINUE
  205 CONTINUE
  500 WRITE(3,105) (BANS(K),K=1,ICOOLM)
      PTR5=1
      PTR4=1
      WRITE(3,108)
      RETURN
  100 FORMAT(T12,I2,T20,I3)
  101 FORMAT('1',T41,'BETA HEATING OPTION EFFECTED (',A4,' '
     X,A4,
     1' IRRIDIATION)'/T51,'OUTPUT IS PER 200 ATOMS FISSIONED
     X')
  102 FORMAT(/T41,'SELECTED ELEMENTS LISTED FOR BETA DECAY I
     XN MEV      '
     1//T3,'ELE',T8,'MASS')
  103 FORMAT(/T47,'TOTAL HEATING FOR BETA DECAY IN MEV
     X'///)
  104 FORMAT('+',T13,'COOL TIMES=',T24,11(' ',A4,' ',A4))
  105 FORMAT(T4,'TOTAL BETA HEATING=',T24,1P11E10.3)
  106 FORMAT(T1,I3,T5,A2,T7,I4,T24,1P11E10.3)
  107 FORMAT(T1,I3,T5,A2,T7,I4,T27,'ELEMENT NOT FOUND IN ANY
     X DECAY SCHEM
     1E-ELEMENT DELETED')
  108 FORMAT('1')
      END
/*
      SUBROUTINE HEAT2(A,BANS,PTR5,IC,ICOOLM,NCONV,NATOM,MAS
     XS)
      DIMENSION A(11),BANS(11),IC(11)
      INTEGER PTR5,DCHK
      REAL LMDA(2)
      DIMENSION Q(14),CT(2,11),NDCY(2),RD(2),B1(2),B2(2)
      EQUIVALENCE  (Q(1),NDCY(1)),(Q(3),RD(1)),(Q(5),B1(1)),
     X(Q(9),B2(1))
  300 READ(5'PTR5) NATOM,NAME,MASS,ST,LMDA(1),(CT(1,L),L=1,1
     X1),DCHK,NRR,
     1S1,LMDA(2),(CT(2,L),L=1,11),Q
      DO 306  LC=1,ICOOLM
  306 A(LC)=0.
```

```
      IF(DCHK.NE.1) GO TO 334
      IF(NDCY(1).EQ.0) GO TO 321
      DO 320  LC=1,ICOOLM
      HLD=CT(1,IC(LC))-CT(1,IC(LC))*EXP(-LMDA(1))
      A(LC)=HLD*RD(1) *B1(1)*WCONV+A(LC)
      IF(NDCY(1).EQ.1)  GO TO 320
      A(LC)=A(LC)+HLD*(1.-RD(1))*B1(2)*WCONV
  320 CONTINUE
  321 IF(NDCY(2).EQ.0) GO TO 331
      DO 330 LC=1,ICOOLM
      HLD=CT(2,IC(LC))-CT(2,IC(LC))*EXP(-LMDA(2))
      A(LC)=A(LC)+HLD*RD(2)*B2(1)*WCONV
      IF(NDCY(2).EQ.1) GO TO 330
      A(LC)=A(LC)+HLD*(1.-RD(2))*B2(2)*WCONV
  330 CONTINUE
  331 DO 333  LC=1,ICOOLM
  333 BANS(LC)=BANS(LC)+A(LC)
  334 RETURN
      END
/*
      SUBROUTINE SHIELD
      COMMON PTR4,PTR5,X9(22),CLTM(22),BURNTM(2),X2(28),ISHL
     XD,
     1IS(11),ISMAX,IGPMAX
      INTEGER DCHK,PTR4,PTR5
      REAL  LMDA(2)
      DIMENSION NDCY(2),RD(2),G(2,2),CT(2,11),GPMAX(80),
     1GPMIN(80),IGP(80),ANS(80,11),ZRO(2),ZR(2)
      DATA ANS/880*0./
      DO 10 I=1,IGPMAX
   10 READ(1,100)  IGP(I),GPMAX(I),GPMIN(I)
      DO 200  I=1,1050
      PTR5=I
      READ(5'PTR5) NATOM,NAME,MASS,ST,LMDA(1),(CT(1,L),L=1,1
     X1),DCHK,NRR,
     ASI,LMDA(2),(CT(2,L),L=1,11),NDCY,RD,ZRO,(G(1,L),L=1,2)
     X,ZR,
     B(G(2,L),L=1,2),QQ,QQQ
      IF(DCHK.NE.1) GO TO 200
      DO 90  K=1,2
      IF(NDCY(K).EQ.0) GO TO 90
      DO 20 J=1,IGPMAX
      IF(G(K,1).GE.GPMIN(J).AND.G(K,1).LE.GPMAX(J)) GO TO 18
      GO TO 20
   18 DO 19 LC=1,ISMAX
   19 ANS(IGP(J),LC)=ANS(IGP(J),LC)+RD(K)*(CT(K,IS(LC))-CT(K
     X,IS(LC))*
     1EXP(-LMDA(K)))
      GO TO 21
   20 CONTINUE
   21 IF(NDCY(K).EQ.1) GO TO 90
      DO 40 J=1,IGPMAX
```

```
      IF(G(K,2).GE.GPMIN(J).AND.G(K,2).LE.GPMAX(J)) GO TO 38
      GO TO 40
   38 DO 39 LC=1,ISMAX
   39 ANS(IGP(J),LC)=ANS(IGP(J),LC)+(1.-RD(K))*(CT(K,IS(LC))
     X-
     1CT(K,IS(LC))*EXP(-LMDA(K)))
   40 CONTINUE
   90 CONTINUE
  200 CONTINUE
      WRITE(3,101) BURNTM
      WRITE(3,102) ((CLTM(2*IS(I)-1),CLTM(IS(I)*2)),I=1,ISMA
     XX)
      DO 220 J=1,IGPMAX
      DO 218 I=1,IGPMAX
      IF(J.NE.IGP(I)) GO TO 218
      WRITE(3,103) I, GPMIN(I), GPMAX(I),(ANS(I,IS(LC)),LC=1
     X,ISMAX)
      GO TO 220
  218 CONTINUE
  220 CONTINUE
      RETURN
  100 FORMAT(T11,I2,T26,F6.2,T48,F6.2)
  101 FORMAT('1',T40,'GAMMA ENERGY GROUP OPTION EFFECTED(',A
     X4,' ',A4,
     1' IRRIDIATION)'/T41,'OUTPUT IS ATOMS PER 200 ATOMS FIS
     XSIONED IN EN
     2ERGY GROUP')
  102 FORMAT(/T8,'LOWER',T17,'UPPER'/T8,'ENERGY',T17,'ENERGY
     X'/T2,'GP.',
     AT3,'BOUND',T17,'BOUND',T26,'COOLING TIMES  = '/T2,'NO.
     X',T8,'(MEV)'
     B,T17,'(MEV)',T24,11(' ',A4,' ',A4))
  103 FORMAT(T1,I3,T6,F7.3,T15,F7.3,T24,1P11E10.3)
  104 FORMAT('1',T12,'END SUBROUTINE SHIELD')
      END
/*
```

```
C   THIS IS PROGRAM ENDZAP
      DEFINE FILE 4(2400,17,U,I4)
      DEFINE FILE 5(1500,45,U,I5)
      DIMENSION NNN(15),III(3),BG(4),N5(6),Q(45),XS(42,109,2
     X),YLD(180)
      I4=1
   20 READ(4'I4) MSS,MAXB,NNN
      WRITE(8     ) MSS,MAXB,NNN
      IF(MSS.EQ.999)  GO TO 24
      M=0
      DO 21 I=1,MAXB
   21 M=M+NNN(I)
      DO 22 I=1,M
      READ(4'I4)     III,BG,N1,N2,N3,N4,N5
      WRITE(8     )  III,BG,N1,N2,N3,N4,N5
   22 CONTINUE
      GO TO 20
   24 END FILE 8
      I5=1
      DO 25 I=1,1050
      READ(5'I5) Q
      WRITE(8     ) Q
   25 CONTINUE
      END FILE 8
      DO 44 L=1,2
      DO 44 I=1,42
      READ(12)      (XS(I,J,L),J=1,109)
      WRITE(8     ) (XS(I,J,L),J=1,109)
   44 CONTINUE
      END FILE 8
      DO 51 KK=7,10
      KKK=KK+7
      READ(KKK) YLD
      WRITE(8     ) YLD
      END FILE 8
   51 CONTINUE
      DO 55 I=1,2
      READ(18) YLD
      WRITE(8     ) YLD
   55 CONTINUE
      READ(18) YLD
      WRITE(8)      YLD
      END FILE 8
      WRITE(3,150)
      CALL EXIT
  103 FORMAT(17I4)
  104 FORMAT(3I4,4E10.4,2A4,2I4,6I2)
  107 FORMAT(I4,A4,I4,A4,12E10.4,2I4,A4,12E10.4,2I4,12E10.4)
  109 FORMAT(40(5E12.4))
  112 FORMAT(60(30I4))
  150 FORMAT('1',T10,'END OF ENDZAP')
      END
/*
```

```
C    THIS IS CHKZAP

      DIMENSION PGTITL(8),CLTM(22),COOLTM(11),BURNTM(11),BTM
     X(22),IC(11),
     1IS(11)
      REAL C(80)
      WRITE(3,103)
   30 READ(9,100,END=99) C
      WRITE(3,101) C
      GO TO 30
   99 READ(11) IER,IYLD,IPROG,IOBL,IMU,PGTITL,CLTM,COOLTM,LC
     XMAX,BURNTM,
     2BTM,LBMAX,IPOUT,ICASE,ICASEN,IHEAT,ICOOLM,IC,NRCDS,ISH
     XLD,IS,
     3ISMAX,IGPMAX
      WRITE(3,104)
      WRITE(3,102) IER,IYLD,IPROG,IOBL,IMU,PGTITL,CLTM,COOLT
     XM,LCMAX,
     4BURNTM,BTM,LBMAX,IPOUT,ICASE,ICASEN,IHEAT,ICOOLM,IC,NR
     XCDS,ISHLD,
     5IS,ISMAX,IGPMAX
      CALL EXIT
  100 FORMAT(80A1)
  101 FORMAT(' ',80A1)
  102 FORMAT(5(2X,I4),8A4/2X,11(2A4,2X)/2X,11(F10.4,1X)/2X,I
     X4/11(F10.4,1
     6X)/2X,11(2A4,2X)/19(2X,I4)/13(2X,I4))
  103 FORMAT('1OUTPUT FROM 9 (80A1)')
  104 FORMAT('1OUTPUT FROM 11')
      END
/*
C    THIS IS F4BUG
      DIMENSION N(17)
      INTEGER PTR4
      DEFINE FILE 4(2400,17,U,PTR4)
      PTR4=15
C  FIRST WORD IN RECORD 15 SHOULD BE 77 - IS CHANGED HERE TO
     X 999
      READ(4'PTR4) N
      N(1)=77
      PTR4=15
      WRITE(4'PTR4) N
      CALL EXIT
      END
/*
C    THIS IS PFILE5
      DIMENSION Q(45)
      INTEGER PTR5
      DEFINE FILE 5(1500,45,U,PTR5)
      DO 50 I=5,8
      DO 10 J=1,5
      PTR5=(I-1)*25+J
```

```
      READ(5'PTR5) Q
      WRITE(3,101) (Q(L),L=1,31)
      WRITE(3,100) (Q(L),L=1,3),(Q(L),L=32,43)
   10 CONTINUE
   50 CONTINUE
      CALL EXIT
  100 FORMAT(I3,A2,I4,2I2,10F10.3)
  101 FORMAT(I3,A2,I4,A1,12E10.4/2I2,A1,12E10.4)
      END
/*
C    THIS IS DCYPRP
      DIMENSION Z(90),GAM(90),DEL(90),L(4),K(4),C(4),D(4)
      DIMENSION OUT(31)
      INTEGER PTR5
      DATA BLK/'    '/,L/122,128,146,152/,K/51,53,61,63/
      DEFINE FILE 5(1500,45,U,PTR5)
      DO 10 I=72,161
      B=I
      GAM(I-71)=(1.+B**(.6667)/128.)*76.*2./B
      Z(I-71)=77./GAM(I-71)
   10 DEL(I-71)=(33.5/(B**.75))*2.
      DO 5 I=1,4
      B=L(I)
      Q=GAM(L(I)-71)*(B-Z(L(I)-71)-.5)
      Q=ABS(Q+DEL(L(I)-71))
      B=Z(L(I)-71)
      IF(ABS(B-K(I)).LE.1) GO TO 2
      IF(ABS(B-K(I)).LE.2) GO TO 3
      C(I)=Q
      D(I)=0
      GO TO 5
    2 C(I)=.85*Q
      D(I)=.15*Q
      GO TO 5
    3 C(I)=.45*Q
      D(I)=.55*Q
    5 CONTINUE
      M=72
   12 READ(1,100,END=999) M1,TI,N,NR1,NR2,R1,R2
      IF(M1.NE.0) M=M1
      KKK=0
      IF(M.NE.99) GO TO 14
      M=51
      KKK=1
   14 B=M
      PTR5=(M-27)*25+1
      READ(5'PTR5) NATOM,NAME,MASS
      MASSR=N-MASS
      PTR5=PTR5-1+MASSR
      FIND (5'PTR5)
      Q=GAM(N-71)*(Z(N-71)-B-.5)
   15 IF(MOD(2,N).EQ.1) GO TO 20
```

```
      IF(MOD(2,M).EQ.1) Q=Q+2.*DEL(N-71)
      Q=Q-DEL(N-71)
   20 Q=ABS(Q)
      B=M
      IF(ABS(B-Z(N-71)).LE.1) GO TO 25
      IF(ABS(B-Z(N-71)).LE.2) GO TO 27
      R=0.5
      GO TO 30
   25 Q=.85*Q
      R=.15*Q
      GO TO 30
   27 Q=.45*Q
      R=.55*Q
   30 B11=0.
      READ(5'PTR5) OUT
      PTR5=PTR5-1
      FIND(5'PTR5)
      B12=0.
      B21=0.
      B22=0.
      G11=0.
      G12=0.
      G21=0.
      G22=0.
      IF(M.EQ.51.AND.N.EQ.122) GO TO 35
      IF(M.EQ.53.AND.N.EQ.128) GO TO 36
      IF(M.EQ.61.AND.N.EQ.146) GO TO 37
      IF(M.EQ.63.AND.N.EQ.152) GO TO 38
      GO TO 41
   35 B11=Q
      B12=C(1)
      G11=R
      G12=D(1)
      GO TO 66
   36 B11=Q
      B12=C(2)
      G11=R
      G12=D(2)
      GO TO 66
   37 B11=Q
      B12=C(3)
      G11=R
      G12=D(3)
      GO TO 66
   38 B11=Q
      B12=C(4)
      G11=R
      G12=D(4)
      B21=Q
      B22=C(4)
      G21=R
      G22=D(4)
```

```
      GO TO 66
   41 IF(NR1.EQ.0) GO TO 55
      B11=Q
      G11=R
      IF(NR1.EQ.1) GO TO 55
      B12=ABS(Q-.31)
      G12=R
   55 IF(NR2.EQ.0) GO TO 65
      IF(TI.EQ.BLK) GO TO 58
      B21=ABS(Q-.25)
      G21=R
   57 IF(NR2.EQ.1) GO TO 65
      B22=ABS(Q-.25)
      G22=R
      GO TO 65
   58 G21=.5*Q
      IF(Q.GE.1.) G21=1./Q
      GO TO 57
   65 IF(KKK.EQ.1) M=99
   66 WRITE(3,101) M,N,NR1,NR2,R1,R2,B11,B12,G11,G12,B21,B22
     X,G21,G22
      WRITE(5'PTR5)OUT,NR1,NR2,R1,R2,B11,B12,G11,G12,B21,B22
     X,G21,G22
      GO TO 12
  999 CALL EXIT
  100 FORMAT(I2,A1,I3,2I2,2F5.2)
  101 FORMAT(2X,I2,1X,I3,2I2,10E10.3)
      END
/*
C    THIS IS DATA1
C      THIS ROUTINE INITIALIZES AND READYS FILES 4 AND 5  + Z
     XHI,ZLOW,ZS
C
      DIMENSION NS(166,72),NODE(200),R(200),STATE(200),NATOM
     X(200),
     1NAME(72),MASLOW(72),ZERO(12),IZERO(2),ZS(180),MAXN(15)
     X,Q(16),
     2MNN(17),NAMEE(200),MASSA(200)
      REAL MU,LMDA(200)
      INTEGER BRNCH(200),ZHI(180),ZLOW(180),PTR4,PTR5
      DATA IZERO/2*0/,ZERO/12*0./,MASLOW/72*0/,BLK/' '/,NS/1
     X1952*1/
      DATA NS(75,32)   ,NS(77,32)   ,NS(77,34)   ,NS(78,32)
     X   ,
     ANS(79,34)   ,NS(83,34)   ,NS(83,36)   ,NS(84,35)   ,NS
     X(85,36)   ,
     BNS(83,37)   ,NS(91,39)   ,NS(93,41)   ,NS(95,41)   ,NS
     X(97,41)   ,
     CNS(99,43)   ,NS(100,41)   ,NS(102,43)   ,NS(103,45)
     X,
     DNS(104,45)  ,NS(105,45)   ,NS(106,45)   ,NS(109,45)
     X,
```

```
      ENS(109,46)   ,NS(109,47)   ,NS(110,47)   ,NS(111,47)
      X ,
      FNS(111,46)   ,NS(113,47)   ,NS(113,48)   ,NS(115,47)
      X ,
      GNS(115,48)   ,NS(115,49)   ,NS(117,48)   ,NS(117,49)
      X ,
      HNS(118,49)   ,NS(119,48)   ,NS(119,49)   ,NS(120,49)
      X ,
      INS(121,49)   ,NS(123,49)   ,NS(123,50)   ,NS(125,50)
      X ,
      JNS(125,52)   ,NS(126,51)   ,NS(127,50)   ,NS(127,52)
      X ,
      KNS(128,51)   ,NS(129,50)   ,NS(129,52)   ,NS(129,54)
      X ,
      LNS(130,51)   ,NS(131,52)   ,NS(131,54)   ,NS(133,52)
      X ,
      MNS(133,54)   ,NS(134,55)   ,NS(135,54)   ,NS(137,56)
      X ,
      NNS(148,62)   ,NS(151,63)/60*2/    ,NS(152,63)/3/
       DATA YLD,MU/2*0./,MEND,IS,MS/999,51,124/,MCHK/72/
       DATA Q/16*0./
C  DATA FOR NSTATE RECORD B NO.2
C
       DATA  NS(78,33),NS(107,47)/2*2/,PTR4,PTR5/2*1/
       DATA NAME/72*' '/
C DATA  FOR ZHI,ZLOW,ZSTABLE  RECORD  TYPE  C
       DATA  ZS/69*0.,31.2,31.584,31.968,32.352,32.736,33.120
      X,33.504,
      A33.888,34.272,34.656,35.040,35.424,35.808,36.192,36.57
      X6,36.960,
      B37.344,38.164,38.555,38.945,39.336,40.188,40.585,40.98
      X2,41.379,
      C41.776,42.173,42.570,42.967,43.364,43.761,44.158,44.55
      X5,44.952,
      D45.349,45.746,46.143,46.540,46.937,47.334,47.731,48.12
      X8,48.525,
      E48.922,49.319,49.716,49.557,49.930,50.304,50.677,51.05
      X1,50.750,
      F51.100,51.450,51.800,52.150,52.500,52.850,53.200,53.55
      X0,53.900,
      G54.250,54.600,54.950,55.300,55.650,56.000,57.075,57.42
      X9,57.782,
      H58.136,59.228,59.585,55.942,60.299,60.656,61.013,61.37
      X0,61.727,
      I62.081,62.441,62.798,63.155,63.512,63.869,63.913,64.27
      X7,64.640,
      J65.001,65.080,65.450,65.820,66.820,66.560,66.930,67.30
      X0,15*0./
       DATA ZHI/71*0,3*32,33,3*34,35,34,35,3*36,37,3*38,39,3*
      X40,41,5*42,
      A4*44,45,3*46,47,46,47,46,2*48,49,48,50,48,4*50,51,52,5
      X1,3*52,53,
```

```
     B5*54,55,4*56,58,57,58,59,58,3*60,5*62,63,64,63,2*64,65
     X,2*66,19*0/
      DATA ZLOW/71*0,4*27,3*28,3*29,2*30,2*31,3*32,2*33,3*34
     X,3*35,2*36,
     C37,3*38,4*39,3*40,2*41,3*42,3*43,2*44,2*45,2*46,3*47,5
     X*48,2*49,
     D50,3*51,2*52,3*53,3*54,2*55,2*56,3*57,2*58,3*59,3*60,1
     X9*0/
C
C   WRITE   ZHI, ZLOW ,& ZSTABLE  MASTER FILE
      WRITE(18) ZLOW
      WRITE(18) ZHI
      WRITE(18) ZS
      DEFINE FILE 4(2400,17,U,PTR4)
      DEFINE FILE 5(1500,45,U,PTR5)
      PTR5=1
      PTR4=1
    1 READ(1,600)MASSC,MAXB
      IF(MASSC.EQ.MEND) GO TO 80
      IF(MASSC.NE.MCHK) GO TO 400
      DO 5 I=1,15
    5 MAXN(I)=0
      M=0
C     READ  CHAIN CARDS     M GIVES  TOTAL NODES THIS CHAIN
C
C     READ  BRANCH CARDS
      DO 50  I=1,MAXB
      READ(1,601)MASSB,MAXBC,MAXN(I)
      IF((MAXBC.NE.I).OR.(MASSB.NE.MASSC)) GO TO 401
      K=MAXN(I)
C
C     READ NODE CARDS AND STORE DATA IN CORE
      DO   50  J=1,K
      M=M+1
      READ(1,602) MASSN,BRNCH(M),NODE(M),LMDA(M),R(M),
     1NAMEE(M),MASSA(M),STATE(M),NATOM(M)
      IF(( MASSN .NE.MASSB).OR.(BRNCH(M).NE.I).OR.(NODE(M).N
     XE.J))GO TO 2
      NNATOM=NATOM(M)
C
C   HOLD  DATA FOR  RECORD  TYPE  A
      NAME(NNATOM)=NAMEE(M)
      IF(MASLOW(NNATOM).EQ.0) MASLOW(NNATOM)=MASSN
   50 CONTINUE
C
C   WRITE OUT RECORDS IN USEABLE FORM TO MASTER UNIT
      WRITE(4'PTR4) MASSC,MAXB,MAXN
      WRITE(3,700) MASSC,MAXB,MAXN
      DO 60 I=1,M
      MA=MASSA(I)
      N=NATOM(I)
      WRITE(3,701) MASSA(I),BRNCH(I),NODE(I),LMDA(I),MU,R(I)
     X,YLD,
```

```
     1NAMEE(I),STATE(I),N,NS(MA       ,N),(Q(L),L=1,6)
      WRITE(4'PTR4) MASSA(I),BRNCH(I),NODE(I),LMDA(I),MU,R(I
     X),YLD,
     1NAMEE(I),STATE(I),N,NS(MA       ,N),(Q(L),L=1,6)
   60 CONTINUE
      MCHK=MCHK+1
      GO TO 1
   80 WRITE(4'PTR4) MEND,Q
C
C  WRITE OUT FORMAT FOR  A TYPE RECORDS
C
      DO 100 I=27,66
      M=MASLOW(I)-1
      WRITE(3,700) MASLOW(I)
      DO 100 J=1,25
      M=M+1
      WRITE(5'PTR5) I,NAME(I),M,BLK,ZERO,IZERO,BLK,ZERO,  IZ
     XERO,
     1(Q(L),L=1,12)
  100 CONTINUE
      DO 105 I=1,49
      WRITE(5'PTR5)IZERO(1),BLK,IZERO(1),BLK,ZERO,IZERO,BLK,
     XZERO,  IZERO
     1,(Q(L),L=1,12)
  105 CONTINUE
      WRITE(5'PTR5) IS,NAME(IS),MS,BLK,ZERO,IZERO,BLK,ZERO,
     X IZERO,
     1(Q(L),L=1,12)
  999 CALL EXIT
  400 WRITE(3,603)MCHK
      GO TO 999
  401 WRITE(3,604)MASSC,I
      GO TO 999
    2 WRITE(3,605)MASSC,I,J
      GO TO 999
  600 FORMAT(I3,T10,I2)
  601 FORMAT(I3,T10,I2,T21,I2)
  602 FORMAT(I3,T10,I2,T21,I2,T48,E12.6,T62,F8.6,T71,A2,1X,I
     X3,A1,I3)
  603 FORMAT(6X,'ERROR HALT - INPUT CHAIN',I4)
  604 FORMAT(6X,'ERROR HALT - INPUT CHAIN',I4,'BRNCH',I2)
  605 FORMAT(6X,'ERROR HALT-INPUT CHAIN',I4,'BRNCH',I2,'NODE
     X',I2)
  700 FORMAT(17(2X,I4))
  701 FORMAT(3(2X,I4),4(3X,E12.4),2(2X,A4),2(2X,I4),6F4.0)
      END
/*
C    THIS IS DATA1X
      DIMENSION YLD(180)
      DATA YLD/180*0./
      DO 60 K=14,17
      READ(1,99) (YLD(I),I=1,3)
```

```
      READ(1,100) (YLD(I),I=70,160)
      DO 15 I=70,160
   15 YLD(I)=YLD(I)*1.E-02
      WRITE(K)  YLD
   60 CONTINUE
      RETURN
  100 FORMAT(5E14.8)
   99 FORMAT(3F9.2)
      END
/*
C    THIS IS PXSEC
      DIMENSION X(42,109,2)
      DO 10 L=1,2
      DO 10 I=1,42
   10 READ(12) (X(I,J,L),J=1,109)
      DO 20 I=8,14
      DO 20 J=1,10
      JJ=J+71
      II=I+26
   20 WRITE(3,100) II,JJ,(X(I ,J ,L),L=1,2)
      CALL EXIT
  100 FORMAT(2(I4,2X),2(F16.4,3X))
      END
/*
C     THIS IS PRT4
      DIMENSION MAXN(15),Q(17)
      INTEGER PTR4
      DEFINE FILE 4(2400,17,U,PTR4)
      PTR4=1
      DO 50 I=1,89
      READ(4'PTR4) M,N,MAXN
      WRITE(3,700) M,N,MAXN
      MX=0
      DO 5 J=1,N
    5 MX=MX+MAXN(J)
      DO 20 J=1,MX
      READ(4'PTR4) Q
      WRITE(3,701) Q
   20 CONTINUE
   50 CONTINUE
      CALL EXIT
  700 FORMAT(17(2X,I4))
  701 FORMAT(3(2X,I4),4(3X,E12.4),2(2X,A4),2(2X,I4),6F4.0)
      END
/*
C    THIS IS PYLD
      DIMENSION Y(180)
      DO 60 KK=14,17
      READ(KK) Y
      WRITE(3,100) (Y(I),I=1,3),(Y(J),J=72,79)
   60 CONTINUE
      CALL EXIT
```

```
  100 FORMAT(11E11.4)
      END
/*
C    THIS IS CRSPRP
      DIMENSION X(42,109,2)
      INTEGER B
      DATA X/9156*0./,X(19,33,1)/40./,B/'B'/,M/'M'/
      DATA X(42,109,1)/15./
    1 READ(1,100,END=50) I,J,K,Y
      L=1
      IF((J.EQ.B).OR.(J.EQ.M)) L=2
      X(K-26,I-71,L)=Y
      GO TO 1
   50 DO 55 L=1,2
      DO 55 I=1,42
   55 WRITE(12) (X(I,J,L),J=1,109)
      CALL EXIT
  100 FORMAT(T4,I3,T7,A1,T11,I2,T17,F9.4)
      END
/*
```

KNOWN ERRORS IN PROGRAM

1. Change irridation to irradiation in subroutines OUTPUT, SPCASE, HEAT, SHIELD and ZAP.

APPENDIX 3
Description of Input

Input to ZAP is done on alphanumeric coded cards. At least one card must be chosen per group. Comments may be placed on any input card when it does not overlay an option field. The ",END" where specified may be extended into comments (i.e., Group 7 last card may be ...TIME 09,END COOLING TIMES). Comment cards may be placed anywhere in data deck. They are denoted by a dollar sign in column one and any legal character including blank other than a dollar sign in column two.

It will be noted that cards should be written exactly as shown because of spacing. ZAP checks key characters in input and not the entire card. Therefore misspelling will not necessarily cause errors. Key position will be explained below. CAUTION: begin all cards in column 1 as this position is always checked. "END" or ",END" must be properly placed to denote end of sections.

Lower case "b" denotes blank. Lower case "x" denotes data. "x" fields without decimal point are fixed point numbers and must be right justified. "x" fields with a decimal point are floating point fields and a decimal point may be anywhere within a field. "A" fields are alphanumeric character fields and letters must be right justified. "↓" denotes column 1; "]" denotes options; ")" denote necessary cards under an option (See INPUT CARDS).

1st card - has dollar signs in columns 1 and 2. User comments in columns 3-80.

Group 1 - Key checks are columns 12 and 33

If 1] is chosen the program calculates partial yields from the distribution shown in equation (9) of theory and chooses a mass yield curve as specified in column 53. Yield curves 1 and 3 denote fissioning of U-235 by 1 MeV and thermal neutrons respectively. Yield curves 2 and 4 denote fissioning of PU-239 by 2 MeV and thermal neutrons respectively.

If 2] is chosen, the program distribution is taken, but mass yields are read from cards. 2a) is a title card. It must be present and all 80 columns are a comment. 2b) denotes type of fission reaction constants used. If constants are desired from a yield library, (reference yields of preceeding paragraph) choose desired curve data and place number in column 44 of card 2b1). If all data is to be read, use cards under 2b2). Key checks in 2b1) and 2b2) are columns 5-8. Key checks in 2b3) are columns 14, 16, 22, and 49. 2c) are input

yields per mass number. Card format is 5(E14.8,2X). There must be exactly 18 cards with an "END" in columns 78-80 of the last card.

If 3] is chosen, the program expects partial yields (i.e., yields per mass number and atomic numbers) as input. Card 3a) is a title card and is identical to 2a). There may be as many 3b cards as necessary to complete input. The ",END" must be present to denote end of section. Key positions in card type 3b) are columns 8, 20 and 30.

Group 2 - Key checks are columns 14, 15, 21, and 39.

The cards themselves are self explanatory. Progenitor yields are the different between the sum of the calculated partial yields in a chain and the actual input yield. These progenitors correspond to elements which decay instantaneously to the first member of the input chain and are thus treated.

The so-called "oblong table" is a table of calculated partial yields.

Group 3 - Key check is column 4

If 1] is chosen, the program skips calculation of mu and leaves mu's unchanged.

If 2] is chosen, the program uses lambda for mu.

If 3] is chosen, the program calculates mu as shown from input information. Choose either Westcott averaged effective cross sections (card 3a1) or input cross sections (card 3a2). 3b gives neutron flux and options may be chosen. If any character other than a zero or blank is in columns 64, 66, or 68, the corresponding option of printing mu, cross sections, and/or lambdas is effected. The entire text beginning with ",OPTIONS" need not be present. 3c) is a double purpose card used with both 3a1 and 3a2. See listing under "input cards" for details.

Group 4 - No positions checked

This card is a user inserted page title heading. Only 32 columns are used however all columns may be filled.

Group 5 - Key column checked is 9

These cards (from 1 through 11) are the cooling times (i.e., time after reactor shutdown). Columns 1-4 contain the time. Columns 5-8 contain the units of time.

Units are to be chosen from "SEC", "MIN", "DAYS", or "YRS", (right justified). The cooling times must be sequentially numbered beginning with 01. These sequence numbers to be placed in appropraite columns. Again, ",END" denotes end of section.

Group 6 - Key columns checked are none
Identical to Group 5 except that these cards indicate irradation time (i.e., time for which reactor is at power)

Group 7 - Key columns checked are 7, 11, and 15
This group indicates type of output desired. If no output is desired, choose card d]. If only selected isotopes are desired, choose card c] with as many b2 cards as necessary to obtain desired output. Card a1 determines how output is collected. "ALL ELEMENTS" outputs each isotope with non zero concentration by atomic number and sums concentrations for that atomic number. "MASS NUMBER ONLY" outputs sums of all concentrations by mass numbers. "ATOMIC NUMBER ONLY" outputs sums of all concentrations by atomic numbers. If selected isotopes are also

desired, use card b1 with as many b2 cards as necessary in addition to card a1 to obtain desired output.

Group 8 - Key columns checked are 11, 19, 38, 39, 41 44, 47, 50, 53, 56, 59, 62, 68 and 71

If 1] is chosen, no beta heating is calculated.

If 2] is chosen, beta heating energy from all elements for indicated cooling times is calculated and printed out.

If 3] is chosen, beta heating energy from isotopes listed on cards 3b) and for cooling times indicated is calculated and printed out. There may be as many 3b) type cards as necessary to obtain desired output.

Group 9 - Key columns checked are 10, 25, 35, 36, 38, 41, 44, 47, 48, 50, 53, 56, 59, 62, 65, and 68.

If 1] is chosen, no gamma grouping is done.

If 2] is chosen, gamma grouping for all cooling times indicated is done. Card type 2b) gives group number, upper and lower energy limits in MeV. Group numbers must be sequential beginning with 01, but need not be listed in sequential order.

INPUT CARDS

Begin all cards in column 1. Numbers where decimal point is indicated are floating point numbers with decimal point moveable in field. Fixed point numbers must be right justified in their field.

1st Card $$ Comment (78 Columns)

Group 1

1] YIELDbDATA=PROGRAMbDISTRIBUTION,PROGRAMbYIELDbCURVEbx

2] YIELDbDATA=PROGRAMbDISTRIBUTION,INPUTbYIELDbCURVE

a) Title card (80 characters)

b) 1] USEbLIBRARYbREACTIONbDATAbYIELDbCURVEbNO.bbx

2] USEbFOLLOWINGbDATA

3] COMPOUNDbNUC=(A=xxx,Z=xx),AVE.bNEUTRONSbRELEASED=x.x,bMASSb YIELDSb72bTOb161bARE:

c) 18 cards of Format 5(E14.8,2X) - reads from mass numbers 72 to 161. Use full card. Last card must have "END" beginning in column 78.

3] YIELDbDATA=INPUTbPARTIALbYIELDS

a) Title card (80 characters)

↓ As many as needed

b) AT.NO=xx,MASSbNO=xxx,YIELD=x,xxxxxxxxE±xx,END

Note: ",END" denotes last card and must be present on last card indicating end of section

Group 2

↓

1] YIELDbOPTIONS=PRINTbPROGENITORS

↓

2] YIELDbOPTIONS=PRINTbOBLONGbTABLE

↓

3] YIELDbOPTIONS=PRINTbPROGENITORS,PRINTbOBLONGbTABLE

↓

4] YIELDbOPTIONS=NONE

Group 3

↓

1] MU=OLD MU

↓

2] MU=LAMBDA

↓

3] MU=PHI*SIGMA+LAMBDA,DATA FOLLOWS-USE

↓

a) 1] WESTCOTT X-SECTIONS

↓ or

2] INDEPENDENT X-SECTIONS

↓

b) PHI=x.xxxxxxxxE± xxN/SQ.CM/SEC,OPTIONS=PRINT(MU,X-SEC,LAMBDA)=

(x,x,x)

Note: ",OPTIONS=-----" is optional. If specified, place character other than a blank or zero in indicated position to get printout of mu, cross section and/or lambdas. Blank or zero denotes option not effected.

c) The card type depends on type of cross sections chosen

Westcott	Card Columns	Independent	Information
Z=xx	1-4	Z=xx	Atomic number
A=xxxA	7-12	A=xxxA	Mass number and state
G= x.xxxxxxxx E±xx	14-31	X=x.xxxxxxxx E±xx	G factor or cross section
R= x.xxxxxxxx E±xx	34-51	no meaning	R factor
S= x.xxxxxxxx E±xx	54-71	no meaning	S factor
END	72-74	END	Denotes last card

Note: If S is not specified, it is assumed 1. If R is not specified, G is assumed to contain final correction factor. If A=000, the same correction factor or cross section is used for all mass numbers for specified atomic number.

Group 4

Page title card (columns 1-32)

example - 1bMEVbNEUTRONbFISSIONbOFbPU-239

Group 5

x.xxAAAA=COOLINGbTIMEbxx,END

Note: One card for each cooling time up to eleven times. Times must be sequentially numbered in xx beginning with 01, ",END" must be on last cooling time card. "AAAA" denotes "MIN", "HRS", "DAYS", or "YRS".

Group 6

x.xxAAAA=IRRADIATIONbTIMEbxx,END

Note: Same format as Group 5

Group 7

a 1] OUTPUTbFORMAT=ALLbELEMENTS

2] OUTPUTbFORMAT=MASSbNUMBERbONLY

3] OUTPUTbFORMAT=ATOMICbNUMBERbONLY

b 1] OPTION:bELEMENTSbOFbSPECIALbINTEREST

2] ATOMICbNO.=xx,MASSbNO.=xxx,END

Note: There may be as many b2 cards as desired. The ",END" must be

on the last card of this series.

If output is desired for all elements, choose one card from a] depending on type of output desired. In addition, to output specific elements in a separate table, follow card a] with card b1 and as many b2 cards as required. If option is not desired, only an a] card should be input.

↓

c] NObOUTPUTbLIST-ELEMENTSbOFbSPECIALbINTERESTbONLY

If elements and isotopes are not desired and the user feels only certain isotopes are of interest, use card c] with as many b2 cards as is necessary to complete desired list.

↓

d] NObOUTPUT

If no output is desired, use card d]. It is then the users responsibility to obtain output from file 5.

Group 8

↓

1] NObBETAbHEATbGENERATION

↓

2] CALCULATEbBETAbHEATbFORbCOOLINGbTIMES= ALLbTIMES / xx,xx,xx,...

Note: If "ALL TIMES" is chosen, program will calculate beta heating for all cooling times as specified in group 6. If specific

cooling times only are desired, list the sequence numbers of the cooling times desired in "xx,xx,xx,..." for as many times as desired. Last cooling time sequence number is followed by any legal character except a comma. The sequence numbers need not be in order.

3]

a) ↓ SELECTIVEbBETAbHEATbFORbCOOLINGbTIMES= ALLbTIMES / xx,xx,xx,...

Note: Same format as for 2) note.

b) ↓ ATOMICbNO.=xx,MASS=xxx,END

Note: ",END" msut be on last card of 3b) input denoting end of deck. Use as many 3b cards as desired.

Group 9

1] ↓ NObGAMMAbGENERATION

2]

a) ↓ GAMMAbGENERATIONbFORbCOOLINGbTIMES= ALLbTIMES / xx,xx,xx,...

Note: Same format as in Group 8, 2) note.

b) ↓ GROUPbNO.=xx-UPPERbLIMIT=xxx.xxMEV,LOWERbLIMIT=xxx.xxMEV,END

Note: Group numbers must be from 1 to a maximum of 80 numbered

sequentially but not necessarily given in sequential order. ",END" must be on last group card denoting end of group input.

Last Card $$ Comments (78 columns)

ZAP SAMPLE INPUT

```
                                        PROGRAM=ZAP    INPUT DATA CHECK MADE
                                        LEGEND:
                                        ***  DENOTES INFORMATION
                                        **   DENOTES ERROR CONDITION MARKED BY '$'
                                        #    DENOTES PROGRAM SETTINGS

                                  ***FIRST ERROR DETECTED IS CERTAIN-OTHER ERRORS MAY RESULT FROM THIS***

                                                                                    CARD COLUMNS
                                  000000000111111111122222222233333333334444444445555555555666666666777777777
                                  123456789012345678901234567890123456789012345678901234567890123456789012345678
                                  $$    BEGIN ZAP INPUT      SAMPLE PROBLEM
*** BEGIN SUPERZAP INPUT ***
                                  YIELD DATA=PROGRAM DISTRIBUTION,PROGRAM YIELD CURVE 1
# YIELD DATA TAKEN FROM PROGRAM CURVE 1
                                  YIELD OPTIONS=PRINT PROGENITORS,PRINT OBLONG TABLE
# YIELD OPTIONS=PRINT PROGENITORS,PRINT OBLONG TABLE
                                  MU=LAMBDA
# SET MU=LAMBDA
                                  1 MEV NEUTRON FISSION OF U-235
# PAGE TITLE IS '1 MEV NEUTRON FISSION OF U-235  '
                                  $  COOLING AND IRRIDIATION TIMES FOLLOW INPUT PAGE HEADING
                                  5.00 SEC=COOLING TIME  1
# COOLING TIME NO.  1=5.00 SEC
                                  10.0 SEC=COOLING TIME  2
# COOLING TIME NO.  2=10.0 SEC
                                  30.0 SEC=COOLING TIME  3
# COOLING TIME NO.  3=30.0 SEC
                                  1.00 MIN=COOLING TIME  4
# COOLING TIME NO.  4=1.00 MIN
                                  15.0 MIN=COOLING TIME  5
# COOLING TIME NO.  5=15.0 MIN
                                  3.00 HRS=COOLING TIME  6
# COOLING TIME NO.  6=3.00 HRS
                                  1.00DAYS=COOLING TIME  7
# COOLING TIME NO.  7=1.00DAYS
                                  15.0DAYS=COOLING TIME  8
# COOLING TIME NO.  8=15.0DAYS
                                  120.0AYS=COOLING TIME  9
# COOLING TIME NO.  9=120.0AYS
                                  1.00 YRS=COOLING TIME 10
# COOLING TIME NO. 10=1.00 YRS
                                  10.0 YRS=COOLING TIME 11,END COOLING TIMES
# COOLING TIME NO. 11=10.0 YRS
                                  5.00 SEC=IRRIDIATION TIME  1,END IRRIDIATION TIMES
# IRRIDIATION TIME NO.  1=5.00 SEC
                                  OUTPUT FORMAT=ALL ELEMENTS
# OUTPUT FORMAT=ALL ELEMENTS
                                  SELECTIVE BETA HEAT FOR COOLING TIMES=ALL TIMES=SELECTIONS ARE:
# SELECTIVE BETA HEAT FOR COOLING TIMES=ALL TIMES=SELECTIONS ARE:
                                  $  ELEMENTS CHOSEN AT RANDOM
                                  ATOMIC NO.=31,MASS= 72
                                  ATOMIC NO.=34,MASS= 79
                                  ATOMIC NO.=34,MASS= 80
                                  ATOMIC NO.= 35,MASS= 81
                                  ATOMIC NO.= 35,MASS= 84
                                  ATOMIC NO.=38,MASS= 82
```

```
                                        ATOMIC NO.=40,MASS= 92
                                        ATOMIC NO.=40,MASS= 93
                                        ATOMIC NO.=40,MASS=100
                                        ATOMIC NO.=42,MASS= 95
                                        ATOMIC NO.=42,MASS=104
                                        ATOMIC NO.=46,MASS=106
                                        ATOMIC NO.=46,MASS=109
                                        ATOMIC NO.=48,MASS=118
                                        ATOMIC NO.=48,MASS=120,END SELECTIVE BETAS
                                        $  GAMMA GROUPS CHOSEN AT RANDOM
                                        $  COOLING TIMES CHOSEN AT RANDOM
                                        GAMMA GENERATION FOR COOLING TIMES=01,02,03,04,05,08,10,11
# GAMMA GENERATION FOR COOLING TIMES=01,02,03,04,05,08,10,11
                                        GROUP NO.=01-UPPER LIMIT=.5     MEV,LOWER LIMIT=0.     MEV
                                        GROUP NO.=02-UPPER LIMIT=1.     MEV,LOWER LIMIT=.501   MEV
                                        GROUP NO.=03-UPPER LIMIT=10.    MEV,LOWER LIMIT=1.01   MEV,END GAMMA DATA
                                        $  ALL CARDS FOLLOWING $$ CARD ARE IGNORED
                                        $$   END ZAP INPUT     SAMPLE PROBLEM
*** END SUPERZAP INPUT ***

                                       ***NO ERRORS DETECTED-SUGGEST GO STATUS TO SUPERZAP***
```

SUPERZAP SAMPLE OUTPUT

TABLE 1

FISSION PRODUCT SPECTRA FOR CA. 1 MEV NEUTRON FISSION OF U-235 (5.00 SEC IRRIDIATION)

ATOMS PER 200 ATOMS FISSIONED AFTER COOLING FOR

FLE	MASS	HALF-LIFE	5.00 SEC	10.0 SEC	30.0 SEC	1.00 MIN	15.0 MIN	3.00 HRS	1.00 DAYS	15.0 DAYS	120. DAYS	1.00 YRS	10.0 YRS
TOTALS FOR 27 CO =			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 NI	74	.150E 01S	1.009E-06	1.002E-07	9.726E-13	9.303E-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 28 NI =			1.009E-06	1.002E-07	9.726E-13	9.303E-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 CU	74	.400E 01S	9.017E-06	4.222E-05	1.325E-06	7.330E-09	4.595E-72	0.0	0.0	0.0	0.0	0.0	0.0
	75	.250E 01S	5.324E-05	1.331E-05	5.206E-08	1.273E-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	76	.200E 01S	7.631E-05	5.360E-06	5.242E-09	1.603E-13	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	77	.150E 01S	9.781E-06	9.700E-07	9.425E-11	9.015E-17	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 29 CU =			1.025E-04	6.187E-05	1.383E-06	7.343E-09	4.595E-72	0.0	0.0	0.0	0.0	0.0	0.0
30 ZN	74	.450E 01M	7.557E-04	8.225E-04	8.228E-04	7.445E-04	8.621E-05	7.945E-16	0.0	0.0	0.0	0.0	0.0
	75	.950E 01S	8.876E-04	6.484E-04	1.540E-04	1.737E-05	4.247E-32	0.0	0.0	0.0	0.0	0.0	0.0
	76	.800E 01S	1.247E-03	8.274E-04	1.476E-04	1.098E-05	2.748E-37	0.0	0.0	0.0	0.0	0.0	0.0
	77	.350E 01S	7.906E-04	2.947E-04	5.650E-06	1.487E-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	78	.250E 01S	4.625E-04	1.157E-04	4.523E-07	1.106E-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	79	.150E 01S	1.368E-04	1.358E-05	1.318E-09	1.261E-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	80	.150E 01S	9.377E-05	9.307E-06	9.035E-10	8.642E-16	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 30 ZN =			4.363E-03	2.713E-03	1.111E-03	7.720E-04	8.621E-05	7.945E-16	0.0	0.0	0.0	0.0	0.0
31 GA	74	.780E 01M	1.208E-04	1.330E-04	1.760E-04	2.266E-04	3.688E-04	2.462E-10	0.0	0.0	0.0	0.0	0.0
	75	.200E 01M	9.842E-04	1.231E-03	1.569E-03	1.442E-03	1.143E-05	1.691E-30	0.0	0.0	0.0	0.0	0.0
	76	.320E 02S	2.221E-03	2.412E-03	2.088E-03	1.178E-03	1.501E-11	0.0	0.0	0.0	0.0	0.0	0.0
	77	.150E 02S	5.266E-03	4.612E-03	1.977E-03	4.961E-04	6.942E-21	0.0	0.0	0.0	0.0	0.0	0.0
	78	.800E 01S	7.760E-03	5.300E-03	9.664E-04	7.192E-05	1.801E-36	0.0	0.0	0.0	0.0	0.0	0.0
	79	.450E 01S	9.044E-03	3.730E-03	1.755E-04	1.730E-06	1.142E-62	0.0	0.0	0.0	0.0	0.0	0.0
	80	.300E 01S	5.566E-03	1.734E-03	1.784E-05	1.747E-08	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	81	.200E 01S	2.107E-03	3.726E-04	3.644E-07	1.114E-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	82	.150E 01S	7.082E-04	7.029E-05	6.824E-09	6.527E-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 31 GA =			3.278E-02	1.973E-02	6.970E-03	3.417E-03	3.803E-04	2.462E-10	5.938E-59	0.0	0.0	0.0	0.0
32 GE	74	STABLE	4.081E-06	5.076E-06	1.064E-05	1.961E-05	5.356E-04	9.907E-04	9.907E-04	9.907E-04	9.907E-04	9.907E-04	9.907E-04
	75	.137E 01H	1.479E-05	1.868E-05	5.690E-05	1.753E-04	1.789E-03	4.485E-04	1.064E-08	0.0	0.0	0.0	0.0
	75M	.490E 00S	4.150E-05	4.980E-05	2.004E-04	3.460E-04	7.880E-06	1.167E-30	0.0	0.0	0.0	0.0	0.0
	76	STABLE	4.631E-04	7.157E-04	1.725E-03	2.771E-03	3.961E-03	3.961E-03	3.961E-03	3.961E-03	3.961E-03	3.961E-03	3.961E-03
	77	.113E 02H	1.256E-03	1.742E-03	3.075E-03	3.946E-03	4.891E-03	4.132E-03	1.140E-03	1.282E-12	0.0	0.0	0.0
	77M	.530E 02S	1.508E-03	2.092E-03	3.191E-03	3.966E-03	1.746E-07	5.505E-59	0.0	0.0	0.0	0.0	0.0
	78	.150E 01H	8.758E-03	1.156E-02	1.597E-02	1.680E-02	1.515E-02	4.252E-03	2.601E-07	9.974E-75	0.0	0.0	0.0
	79	.250E 02S	3.688E-02	2.745E-02	1.922E-02	8.024E-03	5.195E-13	0.0	0.0	0.0	0.0	0.0	0.0
	80	.250E 02S	5.082E-02	4.788E-02	2.866E-02	1.240E-02	9.638E-13	0.0	0.0	0.0	0.0	0.0	0.0
	81	.760E 01S	4.953E-02	3.147E-02	4.416E-03	2.266E-04	1.735E-40	0.0	0.0	0.0	0.0	0.0	0.0
	82	.500E 01S	5.119E-02	2.550E-02	1.401E-03	2.504E-05	6.860E-56	0.0	0.0	0.0	0.0	0.0	0.0
	83	.200E 01S	1.610E-02	1.786E-03	1.747E-06	5.343E-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	84	.150E 01S	3.515E-03	3.489E-04	3.387E-09	3.240E-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	85	.100E 01S	5.214E-04	1.631E-05	1.560E-11	1.459E-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 32 GE =			2.437E-01	1.536E-01	7.713E-02	4.779E-02	2.633E-02	1.378E-02	6.092E-03	4.951E-03	4.951E-03	4.951E-03	4.951E-03
33 AS	75	STABLE	2.815E-07	2.936E-07	3.012E-07	8.597E-07	1.735E-04	1.533E-03	1.982E-03	1.982E-03	1.982E-03	1.982E-03	1.982E-03
	76	.113E 01D	2.099E-06	2.099E-06	2.099E-06	2.099E-06	2.086E-06	1.941E-06	1.121E-06	1.712E-10	4.105E-39	0.0	0.0
	77	.141E 01D	8.713E-05	1.740E-04	5.684E-04	1.509E-03	4.009E-03	4.556E-03	5.526E-03	1.739E-05	4.391E-25	7.375E-71	0.0
	78	.152E 01H	1.924E-04	3.035E-04	2.423E-04	3.133E-04	2.019E-03	6.023E-03	3.072E-06	4.738E-72	0.0	0.0	0.0
	78M	.600E 01M	1.520E-04	1.514E-04	1.457E-04	1.375E-04	2.730E-05	1.444E-13	9.050E-77	0.0	0.0	0.0	0.0
	79	.600E 01M	6.484E-03	1.023E-02	2.266E-02	3.195E-02	1.374E-02	4.170E-08	3.055E-50	0.0	0.0	0.0	0.0

TABLE 2
FISSION PRODUCT SPECTRA FOR CA. 1 MEV NEUTRON FISSION OF U-235 (5.00 SEC IRRIDIATION)
ATOMS PER 200 ATOMS FISSIONED AFTER COOLING FOR

ELE	MASS	HALF-LIFE	5.00 SEC	10.0 SEC	30.0 SEC	1.00 MIN	15.0 MIN	3.00 HRS	1.00 DAYS	15.0 DAYS	120. DAYS	1.00 YRS	10.0 YRS
33 AS	80	.150E 02S	1.378E-02	1.708E-02	1.996E-02	1.296E-02	1.446E-12	0.0	0.0	0.0	0.0	0.0	0.0
	81	.330E 02S	6.997E-02	8.172E-02	7.466E-02	4.246E-02	9.332E-10	0.0	0.0	0.0	0.0	0.0	0.0
	82	.180E 02S	1.465E-01	1.437E-01	8.070E-02	2.609E-02	2.355E-16	0.0	0.0	0.0	0.0	0.0	0.0
	83	.700E 01S	1.655E-01	1.070E-01	1.512E-02	7.759E-04	5.941E-40	0.0	0.0	0.0	0.0	0.0	0.0
	84	.400E 01S	1.305E-01	5.670E-02	1.791E-03	9.903E-06	6.208E-69	0.0	0.0	0.0	0.0	0.0	0.0
	85	.430E 00S	4.102E-04	1.231E-05	1.177E-11	1.101E-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	86	.200E 01S	3.537E-02	6.255E-03	6.117E-06	1.871E-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	87	.150E 01S	6.640E-03	6.591E-04	6.398E-08	6.120E-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 33 AS =			5.757E-01	4.239E-01	2.160E-01	1.162E-01	1.997E-02	1.212E-02	7.511E-03	1.999E-03	1.982E-03	1.982E-03	1.982E-03
34 SE	76	STABLE	4.009E-09	4.085E-09	4.390E-09	4.847E-09	1.761E-08	1.623E-07	9.826E-07	2.103E-06	2.103E-06	2.103E-06	2.103E-06
	77	STABLE	4.581E-08	5.469E-08	7.639E-08	8.942E-08	3.313E-07	2.364E-05	8.783E-04	4.972E-03	4.984E-03	4.984E-03	4.984E-03
	77M	.175E 02S	4.332E-08	3.554E-08	1.613E-08	5.019E-09	5.033E-10	5.722E-10	6.941E-10	2.185E-12	5.517E-03	7.820E-78	0.0
	78	STABLE	1.362E-06	1.413E-06	1.626E-06	1.970E-06	1.863E-05	1.721E-04	2.339E-04	2.339E-04	2.339E-04	2.339E-04	2.339E-04
	79	.600E 05Y	1.318E-05	1.430E-05	3.132E-05	1.198E-04	1.986E-02	4.161E-02	4.161E-02	4.161E-02	4.161E-02	4.161E-02	4.160E-02
	79M	.389E 01M	5.060E-05	1.031E-04	5.204E-04	1.511E-03	8.008E-03	3.175E-08	2.326E-50	0.0	0.0	0.0	0.0
	80	STABLE	3.942E-03	7.530E-03	2.567E-02	4.885E-02	7.430E-02	7.430E-02	7.430E-02	7.430E-02	7.430E-02	7.430E-02	7.430E-02
	81	.180E 02M	9.627E-03	1.716E-02	4.915E-02	8.210E-02	7.316E-02	6.193E-04	1.108E-10	0.0	0.0	0.0	0.0
	81M	.570E 02M	2.247E-03	2.727E-03	4.781E-03	6.928E-03	8.025E-03	1.080E-03	2.400E-10	0.0	0.0	0.0	0.0
	82	STABLE	5.004E-02	7.824E-02	1.652E-01	2.214E-01	2.475E-01	2.475E-01	2.475E-01	2.475E-01	2.475E-01	2.475E-01	2.475E-01
	83	.250E 02M	1.093E-01	1.464E-01	1.972E-01	2.025E-01	1.376E-01	1.420E-03	9.632E-19	0.0	0.0	0.0	0.0
	83M	.115E 01M	8.707E-02	1.114E-01	1.274E-01	9.933E-02	2.162E-05	1.421E-48	0.0	0.0	0.0	0.0	0.0
	84	.300E 01M	6.915E-01	7.546E-01	7.508E-01	6.706E-01	2.642E-02	7.393E-19	0.0	0.0	0.0	0.0	0.0
	85	.390E 02S	8.754E-01	8.017E-01	5.620E-01	3.298E-01	1.086E-07	0.0	0.0	0.0	0.0	0.0	0.0
	86	.160E 02S	9.684E-01	8.053E-01	3.416E-01	9.317E-02	1.474E-17	0.0	0.0	0.0	0.0	0.0	0.0
	87	.160E 02S	1.037E 00	8.401E-01	3.536E-01	9.643E-02	1.526E-17	0.0	0.0	0.0	0.0	0.0	0.0
	88	.250E 01S	1.303E-01	3.259E-02	1.274E-04	3.117E-08	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	89	.200E 01S	4.228E-02	7.477E-03	7.312E-06	2.236E-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 34 SE =			4.007E 00	3.605E 00	2.578E 00	1.853E 00	5.949E-01	3.667E-01	3.645E-01	3.686E-01	3.686E-01	3.686E-01	3.686E-01
35 BR	79	STABLE	7.680E-08	7.680E-08	7.680E-08	7.680E-08	7.680E-08	7.680E-08	7.845E-08	1.022E-07	2.424E-07	5.591E-07	4.888E-06
	81	STABLE	3.870E-05	8.136E-05	5.111E-04	1.806E-03	5.233E-02	1.318E-01	1.335E-01	1.335E-01	1.335E-01	1.335E-01	1.335E-01
	82	.150E 01D	1.953E-04	1.970E-04	2.037E-04	2.133E-04	3.444E-04	3.599E-04	2.399E-04	3.658E-07	2.735E-28	1.236E-77	0.0
	82M	.620E 01M	1.900E-04	1.883E-04	1.814E-04	1.715E-04	3.587E-05	3.509E-13	2.405E-74	0.0	0.0	0.0	0.0
	83	.248E 01H	6.429E-03	1.177E-02	3.869E-02	7.569E-02	2.280E-01	1.808E-01	5.161E-04	8.643E-45	0.0	0.0	0.0
	84	.222E 02D	2.914E-02	4.316E-02	1.021E-01	1.842E-01	8.282E-01	8.515E-01	8.286E-01	5.355E-01	2.026E-02	9.664E-06	2.914E-50
	84M	.600E 01M	6.170E-03	6.110E-03	5.880E-03	5.550E-03	1.102E-03	5.827E-12	3.652E-75	0.0	0.0	0.0	0.0
	85	.300E 01M	1.910E-01	2.611E-01	4.720E-01	6.387E-01	4.175E-02	1.168E-18	0.0	0.0	0.0	0.0	0.0
	86	.540E 02S	5.711E-01	7.216E-01	9.652E-01	8.547E-01	2.054E-05	1.367E-60	0.0	0.0	0.0	0.0	0.0
	87	.550E 02S	1.512E 00	1.616E 00	1.679E 00	1.356E 00	3.777E-05	2.531E-59	0.0	0.0	0.0	0.0	0.0
	88	.163E 02S	2.078E 00	1.766E 00	7.710E-01	2.154E-01	6.657E-17	0.0	0.0	0.0	0.0	0.0	0.0
	89	.440E 01S	9.043E-01	4.330E-01	1.913E-02	1.698E-04	5.927E-62	0.0	0.0	0.0	0.0	0.0	0.0
	90	.160E 01S	4.721E-03	5.414E-04	9.363E-08	2.130E-13	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	91	.200E 01S	4.072E-03	7.200E-04	7.042E-07	2.154E-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	92	.150E 01S	8.810E-03	8.745E-04	8.489E-08	9.120E-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 35 BR =			5.216E 00	4.861E 00	4.054E 00	3.333E 00	1.152E 00	1.164E 00	9.629E-01	6.690E-01	1.538E-01	1.335E-01	1.335E-01
36 KR	82	STABLE	4.853E-07	5.328E-07	7.196E-07	9.897E-07	5.576E-06	2.596E-05	1.459E-04	3.855E-04	3.858E-04	3.858E-04	3.858E-04
	83	STABLE	4.383E-05	4.393E-05	4.408E-05	4.435E-05	5.341E-04	7.952E-02	3.765E-01	3.785E-01	3.785E-01	3.785E-01	3.785E-01
	84	STABLE	2.213E-04	2.806E-04	5.119E-04	8.433E-04	5.490E-03	9.637E-03	3.256E-02	3.257E-01	8.409E-01	8.612E-01	8.612E-01
	85	.108E 02Y	7.512E-04	7.514E-04	7.551E-04	7.724E-04	6.023E-03	7.571E-02	1.997E-01	2.039E-01	2.002E-01	1.917E-01	1.073E-01
	85M	.440E 01H	4.793E-03	9.156E-03	3.801E-02	1.034E-01	1.003E 00	6.775E-01	2.480E-02	2.580E-25	0.0	0.0	0.0
	86	STABLE	6.968E-02	1.144E-01	3.534E-01	7.297E-01	1.721E 00	1.721E 00	1.721E 00	1.721E 00	1.721E 00	1.721E 00	1.721E 00

TABLE 3
FISSION PRODUCT SPECTRA FOR CA. 1 MEV NEUTRON FISSION OF U-235 (5.00 SEC IRRIDIATION)
ATOMS PER 200 ATOMS FISSIONED AFTER COOLING FOR

ELE	MASS	HALF-LIFE	5.00 SEC	10.0 SEC	30.0 SEC	1.00 MIN	15.0 MIN	3.00 HRS	1.00 DAYS	15.0 DAYS	120. DAYS	1.00 YRS	10.0 YRS
36 KR	87	.127E 01H	5.204E-01	6.444E-01	1.125E 00	1.720E 00	2.784E 00	6.233E-01	6.779E-06	0.0	0.0	0.0	0.0
	88	.280E 01H	1.951E 00	2.391E 00	3.393E 00	3.904E 00	3.874E 00	1.962E 00	1.085E-02	8.307E-39	0.0	0.0	0.0
	89	.320E 01M	4.136E 00	4.504E 00	4.543E 00	4.092E 00	1.974E-01	5.980E-17	0.0	0.0	0.0	0.0	0.0
	90	.330E 02S	1.281E 00	1.156E 00	7.401E-01	4.048E-01	8.837E-09	0.0	0.0	0.0	0.0	0.0	0.0
	91	.100E 02S	6.450E-01	4.588E-01	1.150E-01	1.438E-02	7.525E-28	0.0	0.0	0.0	0.0	0.0	0.0
	92	.300E 01S	4.503E-01	1.457E-01	1.452E-03	1.421E-06	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	93	.200E 01S	6.169E-02	1.091E-02	1.067E-05	3.263E-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	94	.140E 01S	5.076E-03	4.272E-04	2.144E-08	7.618E-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR	36 KR =		9.125E 00	9.437E 00	1.033E 01	1.097E 01	9.592E 00	5.148E 00	2.366E 00	2.630E 00	3.141E 00	3.153E 00	3.069E 00
37 RB	85	STABLE	7.957E-07	7.957E-07	7.957E-07	7.937E-07	7.969E-07	1.667E-06	2.745E-05	5.315E-04	4.275E-03	1.275E-02	9.712E-02
	86	.186E 02D	7.327E-05	7.655E-05	8.841E-05	1.018E-04	1.357E-04	1.351E-04	1.308E-04	7.761E-05	1.552E-06	1.669E-10	1.076E-63
	86M	.104E 01M	6.244E-05	5.907E-05	4.730E-05	3.390E-05	3.011E-09	5.360E-57	0.0	0.0	0.0	0.0	0.0
	87	.522E 11Y	6.842E-03	7.280E-03	9.967E-03	1.648E-02	3.760E-01	2.537E 00	3.160E 00	3.160E 00	3.160E 00	3.160E 00	3.160E 00
	88	.180E 02M	4.393E-02	4.454E-02	4.803E-02	5.468E-02	2.093E-01	2.349E-01	1.302E-03	9.968E-40	0.0	0.0	0.0
	89	.149E 02M	3.146E-01	3.917E-01	7.158E-01	1.161E 00	3.072E 00	1.544E-03	5.469E-29	0.0	0.0	0.0	0.0
	90	.291E 01S	5.789E-01	2.500E-01	7.469E-02	3.915E-02	8.547E-10	0.0	0.0	0.0	0.0	0.0	0.0
	91	.120E 01M	2.964E 00	2.917E 00	2.560E 00	1.959E 00	6.063E-04	2.511E-45	0.0	0.0	0.0	0.0	0.0
	91M	.140E 02M	3.160E 00	3.241E 00	3.359E 00	3.326E 00	1.667E 00	4.729E-04	3.871E-31	0.0	0.0	0.0	0.0
	92	.530E 01S	1.985E 00	1.248E 00	1.127E-01	2.294E-03	4.580E-51	0.0	0.0	0.0	0.0	0.0	0.0
	93	.560E 01S	1.531E 00	8.591E-01	7.372E-02	1.800E-03	1.290E-48	0.0	0.0	0.0	0.0	0.0	0.0
	94	.290E 01S	3.773E-01	1.164E-01	9.847E-04	7.583E-07	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	95	.200E 01S	9.806E-02	1.734E-02	1.696E-05	5.187E-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	96	.100E 01S	3.788E-03	1.185E-04	1.133E-10	1.060E-19	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR	37 RB =		1.106E 01	9.093E 00	6.954E 00	6.561E 00	5.325E 00	2.774E 00	3.162E 00	3.161E 00	3.165E 00	3.173E 00	3.257E 00
38 SR	86	STABLE	5.244E-08	5.260E-08	5.332E-08	5.455E-08	1.024E-07	6.803E-07	5.013E-06	5.816E-05	1.342E-04	1.358E-04	1.358E-04
	87	STABLE	1.817E-05	1.817E-05	1.817E-05	1.817E-05	1.817E-05	1.817E-05	1.817E-05	1.817E-05	1.817E-05	1.817E-05	1.817E-05
	88	STABLE	5.860E-04	7.280E-04	1.319E-03	2.306E-03	7.769E-02	1.965E 00	4.149E 00	4.161E 00	4.161E 00	4.161E 00	4.161E 00
	89	.519E 02D	3.991E-03	5.359E-03	1.395E-02	3.589E-02	2.020E 00	5.281E 00	5.221E 00	4.331E 00	1.066E 00	4.032E-02	3.490E-21
	90	.28IE 02Y	3.050E 00	3.507E 00	4.079E 00	4.470E 00	4.914E 00	4.914E 00	4.913E 00	4.909E 00	4.874E 00	4.794E 00	3.839E 00
	91	.970E 01H	1.392E 00	1.547E 00	2.131E 00	2.863E 00	6.404E 00	6.665E 00	1.487E 00	5.586E-11	0.0	0.0	0.0
	92	.270E 01H	2.796E 00	3.844E 00	5.118E 00	5.219E 00	4.918E 00	2.428E 00	1.108E-02	3.898E-40	0.0	0.0	0.0
	93	.780E 01M	3.630E 00	4.322E 00	4.976E 00	4.830E 00	1.393E 00	5.988E-07	1.444E-55	0.0	0.0	0.0	0.0
	94	.130E 01M	4.355E 00	4.424E 00	3.805E 00	2.915E 00	1.673E-03	1.057E-41	0.0	0.0	0.0	0.0	0.0
	95	.480E 02S	4.351E 00	4.125E 00	3.104E 00	2.013E 00	1.089E-05	9.177E-68	0.0	0.0	0.0	0.0	0.0
	96	.250E 01S	4.975E-01	1.258E-01	4.928E-04	1.205E-07	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	97	.150E 01S	4.714E-02	4.680E-03	4.543E-07	4.345E-13	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	98	.100E 01S	2.489E-03	7.792E-05	7.444E-11	6.963E-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	99	.100E 01S	6.393E-04	1.999E-05	1.912E-11	1.789E-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR	38 SR =		2.013E 01	2.191E 01	2.323E 01	2.235E 01	1.973E 01	2.125E 01	1.578E 01	1.340E 01	1.010E 01	8.996E 00	8.001E 00
39 Y	89	STABLE	3.358E-06	3.015E-06	3.585E-06	3.981E-06	3.998E-05	2.095E-03	1.906E-02	2.651E-01	1.168E 00	1.451E 00	1.462E 00
	89M	.160E 02S	1.339E-06	1.078E-06	4.534E-07	1.237E-07	1.957E-23	0.0	0.0	0.0	0.0	0.0	0.0
	90	.269E 01D	2.473E-02	2.474E-02	2.477E-02	2.481E-02	2.600E-02	3.579E-02	3.926E-02	2.317E-03	1.277E-03	1.256E-03	1.006E-03
	90M	.310E 01H	2.471E-02	2.470E-02	2.467E-02	2.462E-02	2.337E-02	1.264E-02	1.156E-04	2.767E-37	0.0	0.0	0.0
	91	.588E 02D	3.032E-02	3.041E-02	3.084E-02	3.166E-02	7.834E-02	1.226E 00	6.607E 00	6.943E 00	2.014E 00	1.119E-01	1.672E-18
	91M	.500E 02M	3.073E-02	3.078E-02	3.107E-02	3.175E-02	7.630E-02	3.337E-01	8.384E-02	3.150E-12	0.0	0.0	0.0
	92	.360E 01H	9.654E-03	1.085E-02	1.756E-02	2.864E-02	3.241E-01	2.065E 00	1.624E-01	1.680E-29	0.0	0.0	0.0
	93	.100E 02H	1.518E-01	1.814E-01	3.235E-01	5.418E-01	3.939E 00	4.421E 00	1.032E 00	7.963E-11	0.0	0.0	0.0
	94	.200E 02M	8.898E-01	1.081E 00	1.800E 00	2.652E 00	3.550E 00	1.168E-02	1.278E-21	0.0	0.0	0.0	0.0
	95	.100E 02M	2.137E 00	2.431E 00	3.401E 00	4.356E 00	2.480E 00	2.683E-05	3.213E-43	0.0	0.0	0.0	0.0
	96	.230E 01M	5.629E 00	5.859E 00	5.415E 00	4.658E 00	6.858E-02	1.759E-23	0.0	0.0	0.0	0.0	0.0

TABLE 4
FISSION PRODUCT SPECTRA FOR CA. 1 MEV NEUTRON FISSION OF U-235 (5.00 SEC IRRIDIATION)
ATOMS PER 200 ATOMS FISSIONED AFTER COOLING FOR

ELE	MASS	HALF-LIFE	5.00 SEC	10.0 SEC	30.0 SEC	1.00 MIN	15.0 MIN	3.00 HRS	1.00 DAYS	15.0 DAYS	120. DAYS	1.00 YRS	10.0 YRS
39 Y	97	.500E 01S	1.877E 00	9.654E-01	6.079E-02	9.507E-04	2.605E-54	0.0	0.0	0.0	0.0	0.0	0.0
	98	.250E 01S	3.938E-01	9.930E-02	3.892E-04	9.519E-08	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	99	.150E 01S	5.888E-02	5.975E-03	5.858E-07	5.603E-13	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	100	.150E 01S	2.518E-02	2.500E-03	2.427E-07	2.321E-13	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	101	.100E 01S	1.614E-03	5.048E-05	4.829E-11	4.517E-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 39 Y =			1.128E 01	1.075E 01	1.113E 01	1.235E 01	1.057E 01	8.109E 00	7.944E 00	7.711E 00	3.183E 00	1.564E 00	1.463E 00
40 ZR	90	STABLE	1.216E-04	1.220E-04	1.236E-04	1.260E-04	1.947E-04	1.167E-03	1.052E-02	5.222E-02	8.796E-02	1.681E-01	1.123E 00
	91	STABLE	4.328E-04	4.337E-04	4.343E-04	4.339E-04	4.406E-04	1.263E-03	4.831E-02	1.283E 00	6.212E 00	8.114E 00	8.226E 00
	92	STABLE	6.811E-04	6.847E-04	7.034E-04	7.389E-04	8.781E-03	7.577E-01	5.077E 00	5.251E 00	5.251E 00	5.251E 00	5.251E 00
	93	.850E 06Y	9.787E-04	9.934E-04	1.091E-03	1.344E-03	4.326E-02	9.532E-01	4.343E 00	5.375E 00	5.375E 00	5.375E 00	5.375E 00
	94	STABLE	2.155E-02	2.439E-02	4.115E-02	8.008E-02	2.095E 00	5.635E 00	5.647E 00	5.647E 00	5.647E 00	5.647E 00	5.647E 00
	95	.653E 02D	1.201E-01	1.333E-01	2.013E-01	3.372E-01	4.226E 00	6.699E 00	6.637E 00	5.720E 00	1.877E 00	1.390E-01	9.823E-17
	96	STABLE	5.505E-01	6.957E-01	1.266E 00	2.023E 00	6.612E 00	6.681E 00	6.681E 00	6.681E 00	6.681E 00	6.681E 00	6.681E 00
	97	.170E 02H	4.487E 00	5.440E 00	6.348E 00	6.406E 00	6.346E 00	5.473E 00	2.410E 00	2.714E-06	6.605E-51	0.0	0.0
	98	.600E 02S	4.925E 00	4.935E 00	3.999E 00	2.828E 00	1.730E-04	3.790E-54	0.0	0.0	0.0	0.0	0.0
	99	.350E 02S	4.159E 00	3.817E 00	2.573E 00	1.421E 00	8.498E-08	0.0	0.0	0.0	0.0	0.0	0.0
	100	.350E 01S	1.020E 00	3.909E-01	7.534E-03	1.983E-05	1.163E-77	0.0	0.0	0.0	0.0	0.0	0.0
	101	.250E 01S	3.157E-01	7.954E-02	3.114E-04	7.616E-08	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	102	.200E 01S	8.040E-02	1.422E-02	1.391E-05	4.253E-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	103	.150E 01S	1.061E-02	1.053E-03	1.023E-07	9.782E-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 40 ZR =			1.569E 01	1.553E 01	1.444E 01	1.310E 01	1.933E 01	2.640E 01	3.085E 01	3.001E 01	3.113E 01	3.137E 01	3.230E 01
41 NB	93	STABLE	3.274E-06	3.274E-06	3.274E-06	3.274E-06	3.274E-06	3.274E-06	3.274E-06	3.276E-06	3.805E-06	6.757E-06	3.805E-05
	93M	.136E 02Y	8.408E-07	8.408E-07	8.408E-07	8.408E-07	8.408E-07	8.409E-07	8.422E-07	8.822E-07	1.182E-06	1.866E-06	9.091E-06
	94	.200E 05Y	7.219E-05	7.280E-05	7.519E-05	7.863E-05	1.277E-04	1.424E-04	1.424E-04	1.424E-04	1.424E-04	1.424E-04	1.423E-04
	94M	.660E 01M	7.033E-05	6.972E-05	6.732E-05	6.388E-05	1.469E-05	4.393E-13	1.533E-70	0.0	0.0	0.0	0.0
	95	.353E 02D	4.288E-04	4.282E-04	4.275E-04	4.305E-04	6.862E-04	8.417E-03	6.861E-02	8.466E-01	1.461E 00	1.577E-01	1.157E-16
	95M	.375E 01D	4.283E-04	4.283E-04	4.283E-04	4.283E-04	4.328E-04	5.798E-04	1.636E-03	6.485E-03	2.287E-03	1.694E-04	1.197E-19
	96	.230E 02H	6.528E-03	6.527E-03	6.526E-03	6.525E-03	6.479E-03	5.964E-03	3.168E-03	1.271E-07	1.345E-40	0.0	0.0
	97	.122E 01H	4.787E-02	5.015E-02	5.825E-02	6.780E-02	1.326E-01	3.631E-01	1.859E-01	2.094E-07	5.096E-52	0.0	0.0
	97M	.600E 02S	4.079E-02	3.975E-02	3.187E-02	2.419E-02	5.606E-03	5.010E-03	2.129E-03	2.397E-09	5.833E-54	0.0	0.0
	98	.200E 01M	8.226E-01	1.082E 00	1.939E 00	2.701E 00	6.501E-02	9.674E-27	0.0	0.0	0.0	0.0	0.0
	98M	.510E 02M	4.748E-01	4.743E-01	4.722E-01	4.690E-01	3.877E-01	4.119E-02	1.511E-09	0.0	0.0	0.0	0.0
	99	.230E 01M	1.417E 00	1.578E 00	2.019E 00	2.268E 00	4.741E-02	1.216E-23	0.0	0.0	0.0	0.0	0.0
	99M	.100E 02S	9.312E-01	8.252E-01	5.297E-01	2.860E-01	1.700E-08	0.0	0.0	0.0	0.0	0.0	0.0
	100	.300E 01M	4.103E 00	4.669E 00	4.687E 00	4.182E 00	1.648E-01	4.611E-18	0.0	0.0	0.0	0.0	0.0
	101	.600E 02S	4.656E 00	4.624E 00	3.736E 00	2.642E 00	1.616E-04	3.540E-54	0.0	0.0	0.0	0.0	0.0
	102	.700E 01S	1.946E 00	1.235E 00	1.742E-01	8.889E-03	6.807E-39	0.0	0.0	0.0	0.0	0.0	0.0
	103	.400E 01S	6.173E-01	2.650E-01	9.341E-03	4.613E-05	2.892E-69	0.0	0.0	0.0	0.0	0.0	0.0
	104	.300E 01S	1.560E-01	4.914E-02	4.841E-04	4.735E-07	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	105	.200E 01S	1.171E-02	2.071E-03	2.026E-06	6.196E-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	106	.150E 01S	8.421E-04	8.557E-05	8.307E-09	7.946E-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	107	.100E 01S	3.076E-05	9.621E-07	9.202E-13	8.608E-22	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 41 NB =			1.523E 01	1.490E 01	1.366E 01	1.266E 01	9.111E-01	4.245E-01	2.616E-01	8.532E-01	1.464E 00	1.580E-01	1.895E-04
42 MO	94	STABLE	3.955E-08	4.078E-08	4.557E-08	5.246E-08	1.509E-07	1.802E-07	1.802E-07	1.804E-07	1.818E-07	1.852E-07	2.296E-07
	95	STABLE	0.0	0.0	0.0	0.0	0.0	5.747E-05	5.677E-04	1.326E-01	3.302E 00	6.282E 00	6.573E 00
	96	STABLE	1.577E-05	1.604E-05	1.713E-05	1.877E-05	6.448E-05	5.797E-04	3.376E-03	6.543E-03	6.543E-03	6.543E-03	6.543E-03
	97	STABLE	6.510E-04	6.833E-04	7.619E-04	1.062E-03	1.545E-02	4.595E-01	3.901E 00	6.500E 00	6.500E 00	6.500E 00	6.500E 00
	98	STABLE	3.500E-03	4.712E-03	2.468E-01	4.507E-01	5.205E 00	6.616E 00	6.658E 00	6.658E 00	6.658E 00	6.658E 00	6.658E 00
	99	.277E 01D	6.371E-01	8.785E-01	2.592E 00	3.229E 00	7.141E 00	6.395E 00	5.612E 00	1.692E-01	6.659E-13	1.529E-39	0.0
	100	STABLE	3.232E-01	4.047E-01	7.767E-01	1.280E 00	5.306E 00	5.471E 00	5.471E 00	5.471E 00	5.471E 00	5.471E 00	5.471E 00

TABLE 5

FISSION PRODUCT SPECTRA FOR CA. 1 MEV NEUTRON FISSION OF U-235 (5.00 SEC IRRIDIATION)

ATOMS PER 200 ATOMS FISSIONED AFTER COOLING FOR

ELE	MASS	HALF-LIFE	5.00 SEC	10.0 SEC	30.0 SEC	1.00 MIN	15.0 MIN	3.00 HRS	1.00 DAYS	15.0 DAYS	120. DAYS	1.00 YRS	10.0 YRS
42 MO	101	.146E 02M	9.980E-01	1.253E 00	2.203E 00	3.231E 00	3.122E 00	1.239E-03	1.316E-29	0.0	0.0	0.0	0.0
	102	.115E 02M	3.132E 00	3.891E 00	4.876E 00	4.892E 00	2.108E 00	1.013E-04	1.072E-37	0.0	0.0	0.0	0.0
	103	.103E 01M	2.920E 00	3.111E 00	2.707E 00	1.942E 00	1.624E-04	1.423E-52	0.0	0.0	0.0	0.0	0.0
	104	.160E 01M	2.082E 00	2.113E 00	1.872E 00	1.508E 00	3.508E-03	3.220E-34	0.0	0.0	0.0	0.0	0.0
	105	.420E 00S	6.035E-01	5.648E-01	4.076E-01	2.485E-01	2.377E-07	1.898E-78	0.0	0.0	0.0	0.0	0.0
	106	.400E 01S	6.165E-02	2.637E-02	8.289E-04	4.584E-06	2.873E-69	0.0	0.0	0.0	0.0	0.0	0.0
	107	.250E 01S	9.330E-03	2.344E-03	9.175E-06	2.244E-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	108	.200E 01S	1.364E-03	2.411E-04	2.359E-07	7.213E-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	109	.150E 01S	1.797E-04	1.784E-05	1.732E-09	1.657E-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	110	.100E 01S	5.347E-06	1.672E-07	1.600E-13	1.496E-22	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 42 MO =			1.081E 01	1.243E 01	1.517E 01	1.700E 01	2.390E 01	1.953E 01	2.165E 01	1.894E 01	2.194E 01	2.492E 01	2.521E 01
43 TC	99	.214E 06Y	8.508E-05	8.571E-05	8.769E-05	1.287E-04	2.333E-03	5.792E-02	1.147E 00	7.021E 00	7.205E 00	7.205E 00	7.204E 00
	99M	.600E 01H	2.070E-04	2.171E-04	2.956E-04	4.987E-04	1.386E-02	1.613E-01	4.452E-01	1.460E-02	5.746E-14	1.320E-40	0.0
	100	.160E 02S	2.255E-03	1.816E-03	7.636E-04	2.082E-04	3.295E-20	0.0	0.0	0.0	0.0	0.0	0.0
	101	.140E 02M	2.375E-02	2.813E-02	5.515E-02	1.183E-01	2.000E 00	8.811E-03	2.907E-28	0.0	0.0	0.0	0.0
	102	.500E 01S	1.922E-02	1.611E-02	1.705E-02	1.779E-02	7.694E-03	3.698E-07	3.912E-40	0.0	0.0	0.0	0.0
	102M	.450E 01M	4.539E-02	5.365E-02	9.556E-02	1.598E-01	5.137E-01	3.256E-05	3.446E-38	0.0	0.0	0.0	0.0
	103	.500E 02S	3.816E-01	5.204E-01	9.709E-01	1.266E 00	6.168E-04	5.930E-52	0.0	0.0	0.0	0.0	0.0
	104	.180E 02M	4.948E-01	5.691E-01	8.493E-01	1.194E 00	1.658E 00	2.896E-03	2.479E-24	0.0	0.0	0.0	0.0
	105	.780E 01M	3.746E-01	4.199E-01	5.645E-01	6.953E-01	2.790E-01	1.192E-07	2.749E-56	0.0	0.0	0.0	0.0
	106	.370E 02S	3.270E-01	3.320E-01	2.477E-01	1.418E-01	2.084E-08	0.0	0.0	0.0	0.0	0.0	0.0
	107	.290E 02S	1.818E-01	1.678E-01	1.056E-01	5.158E-02	9.883E-11	0.0	0.0	0.0	0.0	0.0	0.0
	108	.6C0E 02S	8.924E-02	8.532E-02	6.792E-02	4.803E-02	2.937E-06	6.435E-56	0.0	0.0	0.0	0.0	0.0
	109	.250E 01S	7.914E-03	2.047E-03	8.175E-06	2.001E-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	110	.900E 01S	1.272E-03	2.264E-04	2.218E-07	6.783E-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	111	.155E 01S	1.951E-04	1.937E-05	1.890E-09	1.798E-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	112	.150E 01S	3.292E-05	3.268E-06	3.173E-10	3.035E-16	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 43 TC =			1.940E 00	2.197E 00	2.975E 00	3.694E 00	4.476E 00	2.310E-01	1.592E 00	7.035E 00	7.205E 00	7.205E 00	7.204E 00
44 RU	99	STABLE	2.970E-06	2.970E-06	2.970E-06	2.970E-06	2.970E-06	2.970E-06	2.970E-06	2.409E-06	6.219E-06	1.516E-05	1.343E-04
	100	STABLE	9.648E-04	1.304E-03	2.356E-03	2.912E-03	3.120E-03	3.120E-03	3.120E-03	3.120E-03	3.120E-03	3.120E-03	3.120E-03
	101	STABLE	2.832E-02	4.096E-02	8.952E-02	1.728E-01	2.622E 00	5.251E 00	5.251E 00	5.251E 00	5.251E 00	5.251E 00	5.251E 00
	103	.396E 02D	3.362E-02	6.487E-02	2.769E-01	7.549E-01	3.961E 00	3.954E 00	3.894E 00	3.048E 00	4.853E-01	6.638E-03	6.895E-28
	104	STABLE	1.607E-02	1.778E-02	2.692E-02	4.673E-02	1.087E 00	2.746E 00	2.749E 00	2.749E 00	2.749E 00	2.749E 00	2.749E 00
	105	.440E 01H	2.659E-02	2.953E-02	4.422E-02	7.245E-02	7.204E-01	6.535E-01	2.393E-02	2.489E-25	0.0	0.0	0.0
	106	.1C1E 01Y	7.538E-02	1.065E-01	2.163E-01	3.231E-01	4.648E-01	4.648E-01	4.640E-01	4.520E-01	3.710E-01	2.340E-01	4.860E-04
	107	.420E 01M	8.255E-02	1.022E-01	1.594E-01	1.984E-01	2.548E-02	3.824E-14	0.0	0.0	0.0	0.0	0.0
	108	.450E 01M	6.415E-02	6.835E-02	8.211E-02	9.512E-02	1.816E-02	1.674E-13	0.0	0.0	0.0	0.0	0.0
	109	.160E 02S	8.177E-02	7.819E-02	3.432E-02	9.362E-03	1.481E-18	0.0	0.0	0.0	0.0	0.0	0.0
	110	.100E 02S	3.566E-02	2.606E-02	6.588E-03	8.239E-04	4.312E-29	0.0	0.0	0.0	0.0	0.0	0.0
	111	.420E 01S	1.112E-02	4.778E-03	1.504E-04	8.317E-07	5.213E-70	0.0	0.0	0.0	0.0	0.0	0.0
	112	.300E 01S	2.447E-03	7.850E-04	7.799E-06	7.629E-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	113	.200E 01S	8.228E-04	1.455E-04	1.423E-07	4.352E-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	114	.150E 01S	2.076E-04	2.061E-05	2.001E-09	1.914E-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	115	.100E 01S	1.318E-05	4.121E-07	3.942E-13	3.688E-22	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 44 RU =			4.606E-01	5.425E-01	9.387E-01	1.677E 00	9.902E 00	1.307E 01	1.239E 01	1.150E 01	8.860E 00	8.244E 00	8.004E 00
45 RH	103	STABLE	1.815E-06	2.466E-06	1.684E-06	2.522E-06	4.864E-05	5.058E-03	6.475E-02	9.118E-01	3.477E 00	3.956E 00	3.963E 00
	103M	.570E 02M	4.030E-06	4.085E-06	4.715E-06	7.735E-06	5.529E-04	3.480E-03	3.877E-03	3.034E-03	4.831E-04	6.609E-06	5.864E-31
	104	.420E 02S	2.015E-05	2.817E-05	2.166E-05	1.503E-05	5.917E-07	3.061E-18	0.0	0.0	0.0	0.0	0.0
	104M	.440E 01M	2.277E-05	3.234E-05	3.060E-05	2.837E-05	3.127E-06	1.618E-17	0.0	0.0	0.0	0.0	0.0
	105	.142E 01D	2.638E-05	4.021E-05	3.469E-05	1.974E-04	1.666E-02	3.520E-01	7.911E-01	1.013E-03	3.911E-25	3.460E-75	0.0

TABLE 7

FISSION PRODUCT SPECTRA FOR CA. 1 MEV NEUTRON FISSION OF U-235 (5.00 SEC IRRIDIATION)

ATOMS PER 200 ATOMS FISSIONED AFTER COOLING FOR

ELE	MASS	HALF-LIFE	5.00 SEC	10.0 SEC	30.0 SEC	1.00 MIN	15.0 MIN	3.00 HRS	1.00 DAYS	15.0 DAYS	120. DAYS	1.00 YRS	10.0 YRS
47 AG	115	.210E 02M	3.492E-03	4.957E-03	1.067E-02	1.755E-02	2.047E-02	8.839E-05	7.735E-23	0.0	0.0	0.0	0.0
	115M	.200E 02S	2.589E-03	3.201E-03	4.325E-03	3.894E-03	1.299E-08	7.961E-75	0.0	0.0	0.0	0.0	0.0
	116	.250E 01M	1.849E-02	2.527E-02	3.595E-02	3.495E-02	7.338E-04	1.004E-23	0.0	0.0	0.0	0.0	0.0
	117	.422E 02S	3.152E-02	3.530E-02	2.977E-02	1.837E-02	1.876E-08	0.0	0.0	0.0	0.0	0.0	0.0
	118	.350E 01S	1.423E-02	7.227E-03	2.015E-04	5.701E-07	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	119	.170E 02S	3.315E-02	2.979E-02	1.395E-02	4.111E-03	5.529E-18	0.0	0.0	0.0	0.0	0.0	0.0
	120	.600E 01S	1.834E-02	1.095E-02	1.103E-03	3.449E-05	2.526E-47	0.0	0.0	0.0	0.0	0.0	0.0
	121	.400E 01S	1.293E-02	5.659E-03	1.791E-04	9.906E-07	6.209E-70	0.0	0.0	0.0	0.0	0.0	0.0
	122	.300E 01S	5.933E-03	1.939E-03	1.942E-05	1.900E-08	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	123	.250E 01S	2.352E-03	5.882E-04	2.300E-06	5.626E-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	124	.200E 01S	1.029E-03	1.820E-04	1.780E-07	5.445E-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	125	.200E 01S	5.717E-04	1.011E-04	9.887E-08	3.024E-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 47 AG =			1.478E-01	1.208E-01	1.074E-01	9.817E-02	8.360E-02	9.682E-02	6.925E-02	1.797E-02	1.401E-06	1.585E-07	4.244E-07
48 CD	111	STABLE	6.418E-08	6.434E-08	6.493E-08	6.583E-08	9.190E-08	1.785E-06	6.711E-05	8.417E-04	1.142E-03	1.142E-03	1.142E-03
	111M	.490E 02M	1.277E-07	1.275E-07	1.269E-07	1.260E-07	1.034E-07	1.002E-08	1.828E-16	0.0	0.0	0.0	0.0
	113	.150E 16Y	1.337E-05	2.295E-05	1.189E-04	3.965E-04	4.949E-03	1.627E-02	4.071E-02	4.239E-02	4.239E-02	4.239E-02	4.239E-02
	113M	.136E 02Y	3.535E-06	8.120E-06	5.490E-05	1.996E-04	2.102E-03	2.109E-03	2.109E-03	2.105E-03	2.074E-03	2.004E-03	1.267E-03
	114	STABLE	1.085E-03	1.861E-03	5.421E-03	1.053E-02	4.301E-02	4.359E-02	4.359E-02	4.359E-02	4.359E-02	4.359E-02	4.359E-02
	115	.221E 01D	1.242E-04	2.052E-04	6.642E-04	1.493E-03	1.339E-02	3.093E-02	2.356E-02	2.912E-04	1.426E-18	5.369E-52	0.0
	115M	.430E 02D	1.160E-04	1.876E-04	5.756E-04	1.211E-03	3.731E-03	5.555E-03	5.486E-03	4.378E-03	8.060E-04	1.548E-05	1.519E-28
	116	STABLE	8.725E-04	1.082E-03	4.058E-03	9.059E-03	4.385E-02	4.458E-02	4.458E-02	4.458E-02	4.458E-02	4.458E-02	4.458E-02
	117	.270E 01H	2.716E-03	4.937E-03	1.375E-02	2.305E-02	3.584E-02	1.913E-02	1.631E-04	3.620E-37	0.0	0.0	0.0
	117M	.310E 01H	9.692E-04	1.523E-03	3.727E-03	6.050E-03	9.243E-03	4.998E-03	4.571E-05	1.094E-37	0.0	0.0	0.0
	118	.490E 02M	2.868E-02	3.904E-02	4.704E-02	4.692E-02	3.849E-02	3.731E-03	6.804E-11	0.0	0.0	0.0	0.0
	119	.390E 01M	6.761E-03	9.867E-03	1.766E-02	2.083E-02	1.915E-03	3.540E-16	0.0	0.0	0.0	0.0	0.0
	119M	.270E 01M	6.718E-03	9.771E-03	1.721E-02	1.970E-02	6.050E-04	2.451E-22	0.0	0.0	0.0	0.0	0.0
	120	.132E 02M	3.154E-02	3.966E-02	4.969E-02	4.835E-02	2.156E-02	1.568E-06	3.925E-38	0.0	0.0	0.0	0.0
	121	.128E 02S	3.058E-02	2.992E-02	1.268E-02	2.549E-03	4.526E-23	0.0	0.0	0.0	0.0	0.0	0.0
	122	.400E 02S	3.968E-02	4.832E-02	2.999E-02	1.785E-02	8.536E-09	0.0	0.0	0.0	0.0	0.0	0.0
	123	.900E 01S	2.627E-02	1.928E-02	4.305E-03	4.276E-04	3.474E-32	0.0	0.0	0.0	0.0	0.0	0.0
	124	.100E 02S	3.397E-02	2.470E-02	6.234E-03	7.796E-04	4.081E-29	0.0	0.0	0.0	0.0	0.0	0.0
	125	.500E 01S	2.192E-02	1.127E-02	7.152E-04	1.119E-05	3.065E-56	0.0	0.0	0.0	0.0	0.0	0.0
	126	.300E 01S	8.864E-03	2.723E-03	3.751E-05	2.691E-08	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	127	.150E 01S	1.142E-03	1.133E-04	1.100E-08	1.052E-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	128	.100E 01S	1.452E-04	4.542E-06	4.344E-12	4.064E-21	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 48 CD =			2.419E-01	2.366E-01	2.129E-01	2.094E-01	2.187E-01	1.709E-01	1.603E-01	1.382E-01	1.346E-01	1.337E-01	1.330E-01
49 IN	113	STABLE	4.584E-08	4.584E-08	4.585E-08	4.586E-08	4.723E-08	8.264E-08	3.412E-07	4.458E-06	3.508E-05	1.049E-04	8.424E-04
	113M	.170E 01H	2.611E-09	2.639E-09	2.604E-09	2.595E-09	2.359E-09	7.690E-10	1.473E-13	4.822E-73	0.0	0.0	0.0
	115	.600E 15Y	1.196E-08	1.187E-08	1.275E-08	1.795E-08	5.053E-07	1.017E-05	8.807E-05	1.196E-03	4.768E-03	5.558E-03	5.574E-03
	115M	.451E 01H	2.546E-07	2.574E-07	2.971E-07	4.039E-07	2.528E-05	8.538E-04	2.111E-03	2.708E-05	1.326E-19	4.994E-53	0.0
	117	.380E 02M	3.601E-06	3.175E-06	4.106E-06	7.708E-06	8.545E-04	2.672E-03	1.495E-05	7.839E-39	0.0	0.0	0.0
	117M	.190E 01M	3.922E-06	5.309E-06	1.893E-05	5.652E-05	4.634E-04	2.495E-04	2.140E-06	4.786E-39	0.0	0.0	0.0
	118	.570E 01S	2.532E-05	4.456E-05	8.556E-05	9.096E-05	7.477E-05	7.249E-06	1.322E-13	0.0	0.0	0.0	0.0
	118M	.470E 01M	1.632E-05	1.025E-05	9.707E-06	9.017E-06	1.144E-06	3.110E-17	0.0	0.0	0.0	0.0	0.0
	119	.240E 01M	4.434E-05	4.349E-05	4.090E-05	3.942E-05	2.131E-04	1.729E-06	2.873E-23	0.0	0.0	0.0	0.0
	119M	.226E 02M	2.445E-04	5.930E-04	2.623E-03	6.741E-03	3.551E-02	2.445E-04	4.063E-21	0.0	0.0	0.0	0.0
	120	.477E 02S	3.780E-04	5.137E-04	1.159E-03	1.891E-03	1.531E-03	1.114E-07	2.788E-39	0.0	0.0	0.0	0.0
	120M	.320E 01S	5.186E-05	1.756E-05	2.310E-07	3.483E-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	121	.300E 02S	4.948E-03	8.249E-03	1.401E-02	1.049E-02	4.724E-11	0.0	0.0	0.0	0.0	0.0	0.0
	121M	.310E 01M	5.108E-03	8.276E-03	1.404E-02	2.222E-02	1.032E-03	9.971E-20	0.0	0.0	0.0	0.0	0.0
	122	.450E 02S	6.208E-04	9.116E-03	1.718E-02	2.037E-02	3.593E-07	2.674E-73	0.0	0.0	0.0	0.0	0.0

TABLE 8

FISSION PRODUCT SPECTRA FOR CA. 1 MEV NEUTRON FISSION OF U-235 (5.00 SEC IRRIDIATION)

ATOMS PER 200 ATOMS FISSIONED AFTER COOLING FOR

ELE	MASS	HALF-LIFE	5.00 SEC	10.0 SEC	30.0 SEC	1.00 MIN	15.0 MIN	3.00 HRS	1.00 DAYS	15.0 DAYS	120. DAYS	1.00 YRS	10.0 YRS
49 IN	122M	.750E 01S	1.180E-03	7.434E-04	1.171E-04	7.325E-06	1.434E-39	0.0	0.0	0.0	0.0	0.0	0.0
	123	.100E 02S	8.533E-03	5.702E-03	5.975E-03	1.303E-03	1.799E-28	0.0	0.0	0.0	0.0	0.0	0.0
	123M	.600E 01S	6.994E-03	7.203E-03	3.010E-03	3.870E-04	3.474E-32	0.0	0.0	0.0	0.0	0.0	0.0
	124	.200E 02S	3.511E-02	3.976E-02	3.182E-02	1.410E-02	3.583E-15	0.0	0.0	0.0	0.0	0.0	0.0
	125	.150E 02S	6.870E-02	6.441E-02	3.127E-02	8.072E-03	1.132E-19	0.0	0.0	0.0	0.0	0.0	0.0
	126	.700E 01S	7.230E-02	4.864E-02	7.342E-03	3.791E-04	2.903E-40	0.0	0.0	0.0	0.0	0.0	0.0
	127	.300E 01S	3.393E-02	1.118E-02	1.124E-04	1.099E-07	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	128	.200E 01S	1.614E-02	2.897E-03	2.843E-06	8.694E-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	129	.150E 01S	6.139E-03	6.094E-04	5.916E-08	5.659E-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	130	.150E 01S	4.830E-03	4.795E-04	4.655E-08	4.452E-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	131	.100E 01S	6.742E-04	2.108E-05	2.017E-11	1.887E-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 49 IN =			2.717E-01	2.125E-01	1.343E-01	8.608E-02	3.971E-02	4.039E-03	2.216E-03	1.228E-03	4.803E-03	5.663E-03	6.416E-03
50 SN	115	STABLE	8.389E-09	8.389E-09	8.389E-09	8.389E-09	8.389E-09	8.389E-09	8.389E-09	8.389E-09	8.389E-09	8.389E-09	8.389E-09
	117	STABLE	3.099E-06	3.122E-06	3.220E-06	3.612E-06	1.069E-04	2.099E-03	7.189E-03	7.294E-03	7.294E-03	7.294E-03	7.294E-03
	117M	.140E 02D	1.162E-06	1.164E-06	1.179E-06	1.199E-06	8.250E-06	6.001E-04	2.366E-03	1.203E-03	6.653E-06	3.554E-11	0.0
	118	STABLE	1.536E-05	3.673E-05	2.088E-04	5.368E-04	8.988E-03	4.381E-02	4.755E-02	4.755E-02	4.755E-02	4.755E-02	4.755E-02
	119	STABLE	7.612E-07	1.199E-06	8.162E-06	4.016E-05	6.046E-03	2.306E-02	2.324E-02	2.434E-02	3.132E-02	4.142E-02	5.152E-02
	119M	.245E 03D	2.156E-06	3.606E-06	1.481E-05	5.530E-05	7.222E-03	2.821E-02	2.828E-02	2.718E-02	2.019E-02	1.009E-02	9.243E-07
	120	STABLE	2.356E-04	3.023E-04	5.637E-04	1.240E-03	2.843E-02	5.152E-02	5.152E-02	5.152E-02	5.152E-02	5.152E-02	5.152E-02
	121	.112E 01D	4.993E-04	1.395E-03	8.146E-03	1.931E-02	5.318E-02	5.050E-02	2.937E-02	5.030E-06	2.848E-34	0.0	0.0
	121M	.763E 02Y	4.622E-06	4.622E-06	4.622E-06	4.622E-06	4.622E-06	4.622E-06	4.622E-06	4.620E-06	4.608E-06	4.580E-06	4.221E-06
	122	STABLE	1.679E-03	2.706E-03	7.542E-03	1.662E-02	5.485E-02	5.485E-02	5.485E-02	5.485E-02	5.485E-02	5.485E-02	5.485E-02
	123	.410E 02M	8.238E-03	1.560E-02	3.892E-02	4.971E-02	4.091E-02	2.516E-03	1.417E-12	0.0	0.0	0.0	0.0
	123M	.129E 03D	1.073E-04	1.073E-04	1.073E-04	1.073E-04	1.073E-04	1.072E-04	1.067E-04	9.896E-05	5.629E-05	1.508E-05	3.228E-13
	124	STABLE	9.144E-03	1.560E-02	4.119E-02	6.436E-02	7.924E-02	7.924E-02	7.924E-02	7.924E-02	7.924E-02	7.924E-02	7.924E-02
	125	.970E 01D	1.521E-02	2.296E-02	4.486E-02	5.681E-02	6.081E-02	6.031E-02	5.666E-02	2.084E-02	1.151E-05	2.828E-13	0.0
	125M	.970E 01M	1.512E-02	2.276E-02	4.383E-02	5.399E-02	2.138E-02	1.624E-07	1.306E-46	0.0	0.0	0.0	0.0
	126	.200E 06Y	9.593E-02	1.257E-01	1.697E-01	1.767E-01	1.771E-01	1.771E-01	1.771E-01	1.771E-01	1.771E-01	1.771E-01	1.771E-01
	127	.225E 01H	1.075E-01	1.193E-01	1.247E-01	1.244E-01	1.158E-01	4.964E-02	7.705E-05	8.761E-50	0.0	0.0	0.0
	127M	.410E 01M	1.059E-01	1.161E-01	1.151E-01	1.058E-01	9.926E-03	7.669E-15	0.0	0.0	0.0	0.0	0.0
	128	.570E 02M	3.761E-01	3.827E-01	3.840E-01	3.817E-01	3.219E-01	4.331E-02	9.630E-09	0.0	0.0	0.0	0.0
	129	.620E 01M	4.036E-01	4.027E-01	3.883E-01	3.672E-01	7.678E-02	7.511E-10	5.149E-71	0.0	0.0	0.0	0.0
	129M	.200E 01M	3.926E-01	3.844E-01	3.428E-01	2.883E-01	2.254E-03	3.337E-28	0.0	0.0	0.0	0.0	0.0
	130	.260E 01M	8.226E-01	8.038E-01	7.405E-01	6.481E-01	1.553E-02	1.234E-21	0.0	0.0	0.0	0.0	0.0
	131	.132E 01M	9.387E-01	8.998E-01	7.545E-01	5.803E-01	3.729E-04	8.930E-42	0.0	0.0	0.0	0.0	0.0
	131M	.160E 01H	1.001E 00	1.001E 00	9.983E-01	9.947E-01	8.991E-01	2.732E-01	3.064E-05	1.920E-68	0.0	0.0	0.0
	132	.600E 02S	6.430E-01	6.070E-01	4.818E-01	3.407E-01	2.084E-05	4.565E-55	0.0	0.0	0.0	0.0	0.0
	133	.550E 02S	3.457E-01	3.246E-01	2.523E-01	1.729E-01	4.377E-06	2.933E-60	0.0	0.0	0.0	0.0	0.0
	134	.200E 02S	9.601E-02	9.073E-02	4.037E-02	1.428E-02	3.266E-15	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 50 SN =			5.373E 00	5.333E 00	4.978E 00	4.458E 00	1.980E 00	9.401E-01	5.576E-01	4.912E-01	4.691E-01	4.691E-01	4.691E-01
51 SB	121	STABLE	2.254E-09	2.254E-09	2.254E-09	2.254E-09	2.255E-09	2.268E-09	2.369E-09	3.978E-09	1.603E-08	4.407E-08	4.038E-07
	122	.280E 01D	7.450E-08	7.558E-08	7.939E-08	8.474E-08	1.399E-07	1.418E-07	1.142E-07	3.571E-09	1.847E-20	8.038E-47	0.0
	122M	.415E 01M	7.157E-08	7.058E-08	6.676E-08	6.141E-08	5.929E-09	6.410E-21	0.0	0.0	0.0	0.0	0.0
	123	STABLE	8.184E-06	2.492E-05	5.736E-04	1.149E-02	4.988E-02	5.240E-02	5.241E-02	5.245E-02	5.249E-02	5.251E-02	
	124A	.590E 02D	1.360E-05	1.364E-05	1.379E-05	1.400E-05	1.884E-05	2.702E-05	2.678E-05	2.272E-05	6.618E-06	3.713E-07	6.325E-24
	124B	.160E 01M	1.283E-05	1.289E-05	1.071E-05	8.627E-06	2.034E-08	4.070E-10	4.034E-10	3.423E-10	9.971E-11	5.594E-12	9.530E-29
	124M	.210E 02M	1.349E-05	1.345E-05	1.331E-05	1.309E-05	8.246E-06	3.560E-08	3.115E-26	0.0	0.0	0.0	0.0
	125	.281E 01Y	2.372E-04	3.504E-04	1.176E-03	2.973E-03	3.966E-02	6.154E-02	6.516E-02	1.002E-01	1.129E-01	9.566E-02	1.038E-02
	126	.125E 02D	6.134E-04	6.137E-04	6.149E-04	6.164E-04	6.515E-04	7.001E-04	6.670E-04	3.070E-04	9.144E-07	4.550E-09	4.548E-09
	126M	.190E 02M	6.102E-04	6.084E-04	6.010E-04	5.902E-04	3.542E-04	8.621E-07	3.201E-11	3.201E-11	3.201E-11	3.201E-11	3.201E-11
	127	.380E 01D	9.263E-03	1.083E-02	1.764E-02	2.729E-02	1.316E-01	2.041E-01	2.181E-01	1.803E-02	1.367E-10	1.476E-29	0.0

TABLE 9

FISSION PRODUCT SPECTRA FOR CA. 1 MEV NEUTRON FISSION OF U-235 (5.00 SEC IRRADIATION)
ATOMS PER 200 ATOMS FISSIONED AFTER COOLING FOR

ELE	MASS	HALF-LIFE	5.0 SEC	10.0 SEC	30.0 SEC	1.00 MIN	15.0 MIN	3.00 HRS	1.00 DAYS	15.0 DAYS	120. DAYS	1.00 YRS	10.0 YRS
51 SB	128	.960E 01H	1.931E-02	1.932E-02	1.936E-02	1.942E-02	2.087E-02	2.446E-02	5.688E-03	1.664E-13	0.0	0.0	0.0
	128M	.700E 01M	1.952E-02	1.974E-02	2.059E-02	2.179E-02	3.621E-02	5.881E-03	1.308E-09	0.0	0.0	0.0	0.0
	129	.450E 01H	1.912E-01	2.061E-01	2.626E-01	3.379E-01	8.878E-01	6.342E-01	2.499E-02	8.426E-25	0.0	0.0	0.0
	130	.123E 02M	3.174E-01	3.322E-01	3.874E-01	4.586E-01	5.267E-01	4.996E-05	7.378E-36	0.0	0.0	0.0	0.0
	130M	.356E 02M	2.974E-01	2.987E-01	3.036E-01	3.099E-01	2.875E-01	1.165E-02	2.595E-13	0.0	0.0	0.0	0.0
	131	.255E 02M	1.706E 00	1.742E 00	1.873E 00	2.024E 00	1.881E 00	1.164E-01	1.108E-05	6.943E-69	0.0	0.0	0.0
	132	.313E 01M	2.429E 00	2.420E 00	2.368E 00	2.253E 00	1.241E-01	1.691E-17	0.0	0.0	0.0	0.0	0.0
	133	.267E 01M	2.781E 00	2.742E 00	2.584E 00	2.344E 00	6.887E-02	1.734E-20	0.0	0.0	0.0	0.0	0.0
	135	.190E 01S	5.699E-02	9.220E-03	6.248E-06	1.106E-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	136	.300E 01S	4.692E-02	1.478E-02	1.456E-04	1.424E-07	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 51 SB =			9.143E 00	8.759E 00	8.131E 00	7.856E 00	4.017E 00	1.109E 00	3.670E-01	1.709E-01	1.653E-01	1.482E-01	6.289E-02
52 TE	122	STABLE	2.033E-11	2.139E-11	2.568E-11	3.252E-11	3.179E-10	4.268E-09	3.105E-08	1.383E-07	1.418E-07	1.418E-07	1.418E-07
	124	STABLE	7.300E-07	1.135E-06	2.349E-06	4.935E-06	1.354E-05	1.360E-05	1.387E-05	1.794E-05	3.403E-05	4.028E-05	4.065E-05
	125	STABLE	9.193E-08	8.946E-08	9.263E-08	9.030E-08	2.151E-07	3.428E-06	2.972E-05	6.166E-04	7.499E-03	2.451E-02	1.113E-01
	125M	.580E 02D	1.973E-07	1.974E-07	1.974E-07	1.975E-07	2.451E-07	1.626E-06	1.279E-05	2.358E-04	1.455E-03	1.689E-03	1.866E-04
	126	STABLE	9.332E-06	1.091E-05	1.716E-05	2.641E-05	2.273E-04	5.321E-04	5.659E-04	9.260E-04	1.232E-03	1.234E-03	1.239E-03
	127	.930E 01H	4.762E-05	4.769E-05	4.813E-05	4.919E-05	1.782E-04	2.711E-03	1.454E-02	1.728E-03	9.706E-05	2.041E-05	1.711E-14
	127M	.109E 03D	4.279E-05	4.282E-05	4.294E-05	4.326E-05	8.014E-05	8.751E-04	8.671E-03	4.935E-02	2.742E-02	5.767E-03	4.835E-12
	128	STABLE	7.684E-04	9.323E-04	1.606E-03	2.666E-03	4.654E-02	3.519E-01	4.199E-01	4.256E-01	4.256E-01	4.256E-01	4.256E-01
	129	.115E 01H	9.366E-03	9.386E-03	9.507E-03	9.741E-03	2.476E-02	1.035E-01	5.620E-03	1.020E-04	1.050E-05	5.183E-08	6.272E-39
	129M	.320E 02D	4.417E-03	4.425E-03	4.473E-03	4.577E-03	1.369E-02	1.321E-01	3.439E-01	2.606E-01	2.682E-02	1.324E-04	1.602E-35
	130	STABLE	6.765E-02	6.966E-02	7.838E-02	9.331E-02	6.801E-01	1.498E 00	1.510E 00	1.510E 00	1.510E 00	1.510E 00	1.510E 00
	131	.250E 02M	1.926E-01	1.955E-01	2.076E-01	2.271E-01	7.277E-01	1.808E-01	1.234E-03	5.201E-07	2.722E-32	0.0	0.0
	131M	.125E 01D	[illegible]	1.914E-01	1.939E-01	1.978E-01	3.192E-01	6.422E-01	4.333E-01	1.845E-04	9.656E-30	0.0	0.0
	132	.326E 01D	1.288E 00	1.303E 00	1.479E 00	1.735E 00	4.198E 00	4.218E 00	3.502E 00	1.783E-01	3.568E-11	7.928E-34	0.0
	133	.125E 02M	1.478E 00	1.489E 00	1.526E 00	1.574E 00	1.168E 00	1.410E-02	3.643E-10	0.0	0.0	0.0	0.0
	133M	.500E 02M	1.525E 00	1.567E 00	1.725E 00	1.942E 00	3.126E 00	3.229E-01	8.408E-09	0.0	0.0	0.0	0.0
	134	.420E 02M	5.144E 00	5.379E 00	6.037E 00	6.249E 00	5.015E 00	3.296E-01	3.083E-10	0.0	0.0	0.0	0.0
	135	.112E 02S	2.476E 00	[illegible]	5.943E-01	9.131E-02	2.444E-24	0.0	0.0	0.0	0.0	0.0	0.0
	136	.300E 02S	2.232E 00	2.040E 00	1.351E 00	7.195E-01	1.571E-08	0.0	0.0	0.0	0.0	0.0	0.0
	137	.390E 01S	1.083E-01	3.412E-02	3.362E-04	3.288E-07	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	138	.200E 01S	1.373E-02	2.429E-03	2.375E-06	7.264E-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 52 TE =			1.480E 01	1.429E 01	1.320E 01	1.285E 01	1.532E 01	7.797E 00	6.239E 00	2.427E 00	2.000E 00	1.969E 00	2.048E 00
53 I	127	STABLE	2.652E-08	2.448E-08	3.222E-08	3.246E-08	1.942E-07	1.966E-06	1.878E-05	3.210E-03	2.918E-02	5.091E-02	5.670E-02
	128	.250E 02M	3.151E-06	3.144E-06	3.115E-06	3.072E-06	2.084E-06	2.150E-08	1.458E-23	0.0	0.0	0.0	0.0
	129	.160E 08Y	9.046E-05	9.729E-05	1.293E-04	1.777E-04	2.522E-03	1.380E-01	6.333E-01	7.471E-01	9.810E-01	1.008E 00	1.008E 00
	130	.123E 02H	9.676E-04	9.635E-04	9.602E-04	9.594E-04	9.472E-04	8.113E-04	2.485E-04	1.492E-12	3.255E-74	0.0	0.0
	131	.805E 01D	1.471E-02	1.517E-02	1.705E-02	2.009E-02	2.168E-01	2.313E 00	3.343E 00	1.156E 00	1.372E-04	9.291E-14	0.0
	132	.238E 01H	7.364E-02	7.363E-02	7.357E-02	7.850E-02	8.035E-02	1.075E-01	1.099E-01	5.597E-03	1.120E-12	2.489E-35	0.0
	133	.208E 02H	4.267E-01	4.291E-01	4.634E-01	5.174E-01	2.177E 00	5.741E 00	2.375E 00	3.104E-05	1.351E-42	0.0	0.0
	134	.520E 02M	1.277E 00	1.232E 00	1.308E 00	1.351E 00	2.305E 00	1.435E 00	1.589E-07	0.0	0.0	0.0	0.0
	135	.670E 01H	[illegible]	[illegible]	5.730E 00	6.217E 00	6.158E 00	4.634E 00	5.290E-01	4.260E-16	0.0	0.0	0.0
	136	.139E 01M	[illegible]	[illegible]	3.515E 00	3.287E 00	4.032E-03	5.275E-39	0.0	0.0	0.0	0.0	0.0
	137	.244E 02S	[illegible]	2.694E 00	1.548E 00	6.624E-01	2.876E-11	0.0	0.0	0.0	0.0	0.0	0.0
	138	.630E 01S	[illegible]	[illegible]	6.232E-02	2.209E-03	1.709E-43	0.0	0.0	0.0	0.0	0.0	0.0
	139	.2[illegible]E 01S	[illegible]	1.531E-02	1.428E-05	4.581E-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	140	.1[illegible]E 01S	1.255E-02	1.349E-03	1.310E-07	1.253E-13	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 53 I =			1.277E 01	1.277E 01	1.272E 01	1.214E 01	1.094E 01	1.487E 01	7.580E 00	1.912E 00	1.010E 00	1.059E 00	1.065E 00
54 XE	128	STABLE	[illegible]	[illegible]	4.637E-08	8.565E-08	1.0[illegible]E-06	2.338E-06	2.958E-06	2.958E-06	2.958E-06	2.958E-06	2.958E-06

TABLE 10
FISSION PRODUCT SPECTRA FOR CA. 1 MEV NEUTRON FISSION OF U-235 (5.00 SEC IRRIDIATION)
ATOMS PER 200 ATOMS FISSIONED AFTER COOLING FOR

ELE	MASS	HALF-LIFE	5.00 SEC	10.0 SEC	30.0 SEC	1.00 MIN	15.0 MIN	3.00 HRS	1.00 DAYS	15.0 DAYS	120. DAYS	1.00 YRS	10.0 YRS
54 XE	129	STABLE	6.267E-07	6.267E-07	6.267E-07	6.267E-07	6.267E-07	6.270E-07	6.292E-07	6.479E-07	6.558E-07	7.986E-07	1.041E-06
	129M	.800E 01D	2.940E-08	2.940E-08	2.940E-08	2.940E-08	2.938E-08	2.909E-08	2.696E-08	8.018E-09	8.993E-13	5.339E-22	0.0
	130	STABLE	2.164E-06	2.[illegible]E-06	2.380E-06	2.830E-06	1.537E-05	1.513E-04	7.141E-04	9.626E-04	9.626E-04	9.626E-04	9.626E-04
	131	STABLE	1.329E-05	1.328E-05	1.349E-05	1.383E-05	9.873E-05	1.822E-02	2.645E-01	2.874E 00	4.044E 00	4.044E 00	4.044E 00
	131M	.118E 02D	5.252E-05	5.250E-05	5.252E-05	5.252E-05	5.316E-05	1.984E-04	2.114E-03	1.396E-02	8.580E-05	4.955E-11	0.0
	132	STABLE	7.327E-04	7.644E-04	8.914E-04	1.082E-03	6.453E-03	8.325E-02	7.972E-01	4.225E 00	4.409E 00	4.409E 00	4.409E 00
	133	.527E 01D	6.018E-03	6.036E-03	6.119E-03	6.256E-03	1.690E-02	4.641E-01	3.269E 00	1.108E 00	1.122E-06	[illegible]	0.0
	133M	.230E 01D	3.948E-03	3.949E-03	3.950E-03	3.953E-03	4.103E-03	1.486E-02	7.591E-02	2.779E-03	5.063E-17	[illegible]	0.0
	134	STABLE	5.252E-02	5.434E-02	6.010E-02	6.896E-02	4.174E-01	5.973E 00	7.738E 00	7.738E 00	7.738E 00	7.738E 00	7.738E 00
	135	.914E 01H	9.482E-02	9.561E-02	9.898E-02	1.046E-01	2.597E-01	1.602E 00	1.899E 00	3.365E-11	0.0	0.0	0.0
	135M	.153E 02M	8.013E-02	8.334E-02	8.851E-02	8.907E-02	3.009E-02	5.500E-02	6.267E-03	5.057E-18	0.0	0.0	0.0
	136	STABLE	1.344E 00	1.430E 00	2.125E 00	3.017E 00	7.045E 00	7.049E 00	7.049E 00	7.049E 00	7.049E 00	7.049E 00	7.049E 00
	137	.420E 01M	5.265E 00	5.534E 00	6.410E 00	6.713E 00	7.368E-01	1.106E-12	0.0	0.0	0.0	0.0	0.0
	138	.141E 02M	7.540E 00	7.906E 00	8.247E 00	9.104E 00	4.072E 00	1.219E-03	1.504E-30	0.0	0.0	0.0	0.0
	139	.410E 02S	3.962E 00	3.614E 00	2.588E 00	1.559E 00	1.063E-06	0.0	0.0	0.0	0.0	0.0	0.0
	140	.160E 02S	2.098E 00	1.700E 00	7.155E-01	1.951E-01	3.087E-17	0.0	0.0	0.0	0.0	0.0	0.0
	141	.170E 01S	3.629E-02	4.727E-03	1.361E-06	6.647E-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	142	.150E 01S	8.297E-03	8.236E-04	7.995E-08	7.648E-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	143	.100E 01S	3.229E-02	1.010E-03	9.660E-10	9.036E-19	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 54 XE =			2.042E 01	2.056E 01	2.034E 01	1.987E 01	1.264E 01	1.526E 01	2.110E 01	2.301E 01	2.324E 01	2.324E 01	2.324E 01
55 CS	133	STABLE	2.200E-05	2.145E-05	2.205E-05	2.218E-05	3.519E-05	3.343E-03	2.410E-01	5.450E 00	6.561E 00	6.561E 00	6.561E 00
	134	.210E 01Y	1.364E-04	1.365E-04	1.366E-04	1.369E-04	1.443E-04	2.060E-04	2.720E-04	2.690E-04	2.447E-04	1.960E-04	1.004E-05
	134M	.291E 01H	1.363E-04	1.362E-04	1.360E-04	1.358E-04	1.284E-04	6.672E-05	4.491E-07	7.974E-42	0.0	0.0	0.0
	136	.130E 02D	1.340E-02	1.340E-02	1.340E-02	1.340E-02	1.339E-02	1.331E-02	1.270E-02	6.022E-03	2.233E-05	4.689E-11	0.0
	137	.300E 02Y	5.930E-01	6.677E-01	1.001E 00	1.548E 00	8.166E 00	8.902E 00	8.902E 00	8.894E 00	8.835E 00	8.699E 00	7.065E 00
	138	.322E 02M	1.463E 00	1.492E 00	1.615E 00	1.798E 00	4.754E 00	3.420E-01	5.752E-13	0.0	0.0	0.0	0.0
	139	.950E 01M	2.028E 00	2.388E 00	3.359E 00	4.247E 00	2.134E 00	1.265E-05	1.529E-45	0.0	0.0	0.0	0.0
	140	.110E 01M	3.067E 00	3.309E 00	3.558E 00	3.029E 00	4.855E-04	3.478E-49	0.0	0.0	0.0	0.0	0.0
	141	.250E 02S	2.802E 00	2.468E 00	1.420E 00	6.184E-01	4.773E-11	0.0	0.0	0.0	0.0	0.0	0.0
	142	.900E 01S	1.169E 00	7.630E-01	1.353E-01	1.006E-02	2.518E-34	0.0	0.0	0.0	0.0	0.0	0.0
	143	.200E 01S	6.703E-01	1.279E-01	1.271E-04	3.897E-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	144	.150E 01S	8.538E-03	8.475E-04	9.227E-08	7.869E-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	145	.100E 01S	4.344E-04	1.359E-05	1.299E-11	1.216E-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 55 CS =			1.187E 01	1.123E 01	1.110E 01	1.124E 01	1.507E 01	9.261E 00	9.156E 00	1.435E 01	1.540E 01	1.526E 01	1.353E 01
56 BA	134	STABLE	1.990E-07	1.990E-07	1.991E-07	1.991E-07	2.003E-07	2.188E-07	4.240E-07	3.851E-06	2.822E-05	7.688E-05	2.629E-04
	135	STABLE	2.158E-06	2.158E-06	2.158E-06	2.158E-06	2.158E-06	2.158E-06	2.158E-06	2.158E-06	2.556E-06	4.198E-06	2.431E-05
	136	STABLE	4.360E-05	4.364E-05	4.381E-05	4.405E-05	5.100E-05	1.325E-04	7.391E-04	7.419E-03	1.342E-02	1.344E-02	1.344E-02
	137	STABLE	3.585E-03	3.661E-03	3.949E-03	4.334E-03	6.922E-03	7.051E-03	7.544E-03	1.543E-02	7.433E-02	2.104E-01	1.344E 00
	137M	.255E 01M	2.461E-03	2.325E-03	3.037E-03	2.651E-03	6.015E-05	1.372E-06	1.371E-06	1.370E-06	1.361E-06	1.340E-06	1.089E-06
	138	STABLE	4.643E-02	4.928E-02	6.023E-02	7.859E-02	1.157E 00	9.539E 00	9.983E 00	9.983E 00	9.983E 00	9.983E 00	9.983E 00
	139	.138E 01H	1.194E-01	1.329E-01	2.030E-01	3.423E-01	3.740E 00	1.548E 00	4.125E-05	0.0	0.0	0.0	0.0
	140	.128E 02S	4.093E-01	4.505E-01	6.081E-01	6.277E-01	1.159E-04	8.369E-50	0.0	0.0	0.0	0.0	0.0
	141	.180E 02M	2.267E 00	2.625E 00	3.636E 00	4.360E 00	2.913E 00	5.975E-03	4.343E-24	0.0	0.0	0.0	0.0
	142	.110E 02M	2.400E 00	2.922E 00	4.433E 00	4.418E 00	1.833E 00	5.506E-05	1.881E-39	0.0	0.0	0.0	0.0
	143	.130E 02S	3.486E 00	3.156E 00	1.139E 00	2.302E-01	8.223E-21	0.0	0.0	0.0	0.0	0.0	0.0
	144	.350E 01S	5.267E-01	2.035E-01	3.207E-03	1.028E-05	6.030E-73	0.0	0.0	0.0	0.0	0.0	0.0
	145	.200E 01S	5.629E-02	1.539E-02	1.507E-05	4.610E-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	146	.150E 01S	1.402E-02	1.392E-03	1.351E-07	1.292E-13	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	147	.100E 01S	2.577E-02	2.530E-02	5.326E-03	7.911E-04	4.141E-29	0.0	0.0	0.0	0.0	0.0	0.0
	148	.100E 01S	5.540E-05	1.732E-06	1.657E-12	1.550E-21	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 56 BA =			1.051E 01	1.057E 01	1.010E 01	1.006E 01	9.649E 00	1.120E 01	9.991E 00	1.021E 01	1.007E 01	1.021E 01	1.184E 01

TABLE 11
FISSION PRODUCT SPECTRA FOR CA. 1 MEV NEUTRON FISSION OF U-235 (5.00 SEC IRRIDIATION)
ATOMS PER 200 ATOMS FISSIONED AFTER COOLING FOR

ELE	MASS	HALF-LIFE	5.00 SEC	10.0 SEC	30.0 SEC	1.00 MIN	15.0 MIN	3.00 HRS	1.00 DAYS	15.0 DAYS	120. DAYS	1.00 YRS	10.0 YRS
57 LA	138	.110E 11Y	8.683E-05	8.683E-05	8.683E-05	8.683E-05	8.683E-05	8.683E-05	8.683E-05	8.683E-05	8.683E-05	8.683E-05	8.683E-05
	139	STABLE	1.208E-03	1.274E-03	1.757E-03	2.884E-03	2.767E-01	4.602E 00	6.151E 00	6.151E 00	6.151E 00	6.151E 00	6.151E 00
	140	.167E 01D	1.593E-01	2.759E-01	9.640E-01	1.894E 00	5.724E 00	5.460E 00	3.801E 00	1.160E-02	1.577E-21	1.352E-65	0.0
	141	.390E 01H	1.442E-01	1.520E-01	1.926E-01	2.703E-01	2.279E 00	3.328E 00	7.987E-02	9.397E-28	0.0	0.0	0.0
	142	.154E 01H	4.545E-01	4.737E-01	5.617E-01	6.995E-01	3.074E 00	1.497E 00	1.190E-04	3.029E-70	0.0	0.0	0.0
	143	.180E 02M	9.516E-01	1.850E 00	3.957E 00	4.779E 00	2.924E 00	5.394E-03	4.360E-24	0.0	0.0	0.0	0.0
	144	.150E 02S	3.025E 00	2.684E 00	1.166E 00	2.929E-01	4.099E-18	0.0	0.0	0.0	0.0	0.0	0.0
	145	.900E 01S	1.973E 00	1.338E 00	3.040E-01	3.018E-02	2.452E-30	0.0	0.0	0.0	0.0	0.0	0.0
	146	.400E 01S	6.803E-01	2.933E-01	9.242E-03	5.111E-05	3.204E-58	0.0	0.0	0.0	0.0	0.0	0.0
	147	.200E 01S	8.169E-02	1.919E-02	1.594E-03	1.978E-04	1.035E-29	0.0	0.0	0.0	0.0	0.0	0.0
	148	.200E 01S	2.037E-02	3.619E-03	3.542E-06	1.083E-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	149	.150E 01S	1.456E-03	1.445E-04	1.403E-08	1.342E-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	150	.150E 01S	2.416E-04	2.398E-05	2.328E-09	2.227E-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	151	.100E 01S	6.947E-06	2.173E-07	2.078E-13	1.944E-22	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 57 LA =			7.472E 00	7.152E 00	7.058E 00	7.970E 00	1.428E 01	1.489E 01	1.003E 01	6.163E 00	6.151E 00	6.151E 00	6.151E 00
58 CE	138	STABLE	4.778E-08	4.778E-08	4.778E-08	4.778E-08	4.778E-08	4.778E-08	4.778E-08	4.778E-08	4.778E-08	4.778E-08	4.778E-08
	141	.330E 02D	1.558E-03	1.593E-03	1.762E-03	2.104E-03	5.882E-02	1.915E 00	5.089E 00	3.852E 00	4.247E-01	2.462E-03	2.576E-33
	142	STABLE	1.052E-02	1.081E-02	1.210E-02	1.447E-02	2.343E-01	3.644E 00	5.142E 00	5.142E 00	5.142E 00	5.142E 00	5.142E 00
	143	.137E 01D	1.869E-03	6.389E-03	4.599E-02	1.323E-01	2.212E 00	4.868E 00	3.135E 00	2.703E-03	2.812E-26	0.0	0.0
	144	.283E 03D	1.394E 00	2.056E 00	3.775E 00	4.652E 00	4.945E 00	4.943E 00	4.933E 00	4.766E 00	3.684E 00	2.019E 00	6.372E-04
	145	.300E 01M	2.136E 00	2.735E 00	3.590E 00	3.452E 00	1.373E-01	3.841E-18	0.0	0.0	0.0	0.0	0.0
	146	.139E 02M	2.983E 00	3.369E 00	3.595E 00	3.516E 00	1.749E 00	4.680E-04	2.446E-31	0.0	0.0	0.0	0.0
	147	.120E 01M	2.430E 00	2.386E 00	2.001E 00	1.505E 00	4.639E-04	1.921E-45	0.0	0.0	0.0	0.0	0.0
	148	.400E 02S	1.217E 00	1.132E 00	9.032E-01	4.776E-01	2.285E-07	0.0	0.0	0.0	0.0	0.0	0.0
	149	.350E 01S	1.048E-01	3.965E-02	7.607E-04	2.002E-06	1.070E-78	0.0	0.0	0.0	0.0	0.0	0.0
	150	.250E 01S	2.005E-02	5.126E-03	2.020E-05	4.941E-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	151	.200E 01S	3.042E-03	5.400E-04	5.285E-07	1.615E-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	152	.150E 01S	2.514E-04	2.495E-05	2.422E-09	2.317E-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	153	.150E 01S	4.313E-05	4.281E-06	4.156E-10	3.975E-16	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	154	.100E 01S	6.050E-07	1.892E-08	1.810E-14	1.693E-23	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 58 CE =			1.030E 01	1.174E 01	1.382E 01	1.375E 01	9.337E 00	1.537E 01	1.830E 01	1.376E 01	9.251E 00	7.163E 00	5.142E 00
59 PR	141	STABLE	3.587E-06	7.639E-07	6.380E-07	8.906E-07	6.224E-06	2.387E-03	8.214E-02	1.398E 00	4.826E 00	5.248E 00	5.251E 00
	144	.173E 02M	8.712E-03	9.683E-03	8.570E-03	8.404E-03	4.886E-03	2.165E-04	2.097E-04	2.026E-04	1.566E-04	8.584E-05	2.709E-08
	145	.598E 01H	8.391E-02	1.312E-01	3.854E-01	7.969E-01	4.055E 00	3.049E 00	2.675E-01	3.287E-18	0.0	0.0	0.0
	146	.244E 02M	1.546E-01	1.675E-01	2.247E-01	3.096E-01	1.632E 00	5.145E-02	1.509E-17	0.0	0.0	0.0	0.0
	147	.120E 02M	6.410E-01	7.530E-01	1.158E 00	1.620E 00	1.467E 00	1.067E-04	2.672E-36	0.0	0.0	0.0	0.0
	148	.195E 01M	9.101E-01	9.830E-01	1.136E 00	1.289E 00	1.392E-02	4.756E-28	0.0	0.0	0.0	0.0	0.0
	149	.200E 02S	7.539E-01	7.339E-01	4.893E-01	2.454E-01	9.191E-10	0.0	0.0	0.0	0.0	0.0	0.0
	150	.150E 02S	2.886E-01	3.216E-01	1.301E-01	3.254E-02	4.553E-19	0.0	0.0	0.0	0.0	0.0	0.0
	151	.700E 01S	1.247E-01	7.785E-02	1.085E-02	5.568E-04	4.263E-43	0.0	0.0	0.0	0.0	0.0	0.0
	152	.500E 01S	3.351E-02	1.620E-02	1.059E-03	1.657E-05	4.539E-56	0.0	0.0	0.0	0.0	0.0	0.0
	153	.300E 01S	6.651E-03	1.025E-03	1.905E-05	1.863E-08	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	154	.200E 01S	2.135E-04	5.562E-05	5.443E-08	1.665E-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	155	.220E 01S	6.587E-05	1.165E-06	1.139E-08	3.484E-13	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	156	.150E 01S	5.101E-06	6.056E-07	5.879E-11	5.623E-17	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 59 PR =			3.105E 00	3.127E 00	3.595E 00	4.303E 00	7.173E 00	3.103E 00	3.498E-01	1.399E 00	4.326E 00	5.249E 00	5.251E 00
60 ND	144	STABLE	7.306E-05	[illegible]	2.173E-04	3.896E-04	4.023E-03	1.009E-02	2.069E-02	1.872E-01	1.269E 00	2.934E 00	4.953E 00
	145	STABLE	[illegible]	[illegible]	[illegible]	1.215E-03	9.794E-02	1.231E 00	4.013E 00	4.280E 00	4.280E 00	4.280E 00	4.280E 00
	146	STABLE	[illegible]	[illegible]	[illegible]	[illegible]	4.527E-01	3.780E 00	3.834E 00	3.834E 00	3.834E 00	3.834E 00	3.834E 00
	147	.110E 02D	[illegible]	[illegible]	[illegible]	[illegible]	1.742E 00	3.197E 00	3.016E 00	1.249E 00	1.673E-03	3.261E-19	0.0

TABLE 12

FISSION PRODUCT SPECTRA FOR CA. 1 MEV NEUTRON FISSION OF U-235 (5.00 SEC IRRIDIATION)

ATOMS PER 200 ATOMS FISSIONED AFTER COOLING FOR

ELE	MASS	HALF-LIFE	5.00 SEC	10.0 SEC	30.0 SEC	1.00 MIN	15.0 MIN	3.00 HRS	1.00 DAYS	15.0 DAYS	120. DAYS	1.00 YRS	10.0 YRS
60 ND	149	STABLE	1.103E-01	1.333E-01	2.683E-01	4.910E-01	2.244E 00	2.258E 00	2.258E 00	2.258E 00	2.258E 00	2.258E 00	2.258E 00
	148	.172E 01H	2.066E-01	2.130E-01	5.950E-01	8.278E-01	9.871E-01	3.260E-01	6.896E-05	1.109E-63	0.0	0.0	0.0
	150	STABLE	2.102E-01	2.232E-01	5.990E-01	6.865E-01	7.191E-01	7.191E-01	7.191E-01	7.191E-01	7.191E-01	7.191E-01	7.191E-01
	151	.130E 02M	3.706E-01	3.575E-01	4.179E-01	4.170E-01	1.980E-01	2.997E-05	2.024E-34	0.0	0.0	0.0	0.0
	152	.300E 01M	2.628E-01	2.156E-01	2.147E-01	1.922E-01	7.573E-03	2.119E-19	0.0	0.0	0.0	0.0	0.0
	153	.180E 02S	1.772E-01	9.216E-02	4.372E-02	1.378E-02	1.242E-16	0.0	0.0	0.0	0.0	0.0	0.0
	154	.120E 03S	2.091E-02	1.588E-02	5.024E-03	9.884E-04	7.603E-25	0.0	0.0	0.0	0.0	0.0	0.0
	155	.500E 01S	3.725E-03	1.838E-03	1.199E-04	1.875E-06	5.138E-57	0.0	0.0	0.0	0.0	0.0	0.0
	156	.450E 01S	1.361E-03	6.334E-04	2.015E-05	2.872E-07	1.896E-63	0.0	0.0	0.0	0.0	0.0	0.0
	157	.300E 01S	9.272E-05	2.543E-05	2.506E-07	2.451E-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTALS FOR 60 ND =		1.218E 00	1.556E 00	2.183E 00	2.734E 00	6.442E 00	1.151E 01	1.386E 01	1.253E 01	1.236E 01	1.403E 01	1.604E 01
61 PM	146	.553E 01Y	3.447E-06	3.447E-06	3.447E-06	3.447E-06	3.447E-06	3.447E-06	3.446E-06	3.429E-06	3.309E-06	3.041E-06	9.836E-07
	147	.260E 01Y	8.640E-05	8.656E-05	8.602E-05	8.792E-05	6.823E-04	2.246E-02	1.935E-01	1.949E 00	2.974E 00	2.487E 00	2.255E-01
	148	.540E 01D	9.015E-04	9.015E-04	9.015E-04	9.015E-04	9.004E-04	8.873E-04	7.939E-04	1.373E-04	1.311E-06	2.517E-08	2.470E-31
	148M	.430E 02D	9.015E-04	9.015E-04	9.015E-04	9.015E-04	9.014E-04	8.997E-04	8.871E-04	7.079E-04	1.303E-04	2.503E-06	2.457E-29
	149	.221E 01D	2.808E-03	3.043E-03	4.087E-03	6.539E-03	1.025E-01	7.462E-01	8.234E-01	1.026E-02	5.346E-17	2.326E-50	0.0
	150	.270E 01H	8.081E-03	8.078E-03	8.065E-03	8.046E-03	8.520E-03	4.206E-03	1.919E-05	6.753E-43	0.0	0.0	0.0
	151	.116E 02D	2.300E-02	2.449E-02	3.156E-02	4.274E-02	2.614E-01	4.304E-01	2.550E-01	5.874E-05	3.070E-32	0.0	0.0
	152	.360E 01M	4.105E-02	4.465E-02	5.949E-02	7.898E-02	7.684E-02	4.866E-10	3.050E-73	0.0	0.0	0.0	0.0
	153	.550E 01M	9.957E-02	1.078E-01	1.525E-01	1.721E-01	3.198E-02	2.992E-11	0.0	0.0	0.0	0.0	0.0
	154	.250E 01M	3.954E-02	4.336E-02	5.032E-02	4.759E-02	1.002E-03	1.371E-23	0.0	0.0	0.0	0.0	0.0
	155	.600E 02S	1.992E-02	2.063E-02	1.790E-02	1.275E-02	7.796E-07	1.708E-56	0.0	0.0	0.0	0.0	0.0
	156	.250E 02S	1.367E-02	1.259E-02	7.636E-03	3.340E-03	2.578E-13	0.0	0.0	0.0	0.0	0.0	0.0
	157	.130E 02S	2.340E-03	1.840E-03	6.445E-04	1.303E-04	4.654E-24	0.0	0.0	0.0	0.0	0.0	0.0
	TOTALS FOR 61 PM =		2.438E-01	2.608E-01	3.351E-01	3.751E-01	4.847E-01	1.205E 00	1.274E 00	1.960E 00	2.974E 00	2.487E 00	2.255E-01
62 SM	146	STABLE	2.631E-10	2.631E-10	2.631E-10	2.633E-10	2.669E-10	3.089E-10	6.299E-10	5.752E-09	4.339E-08	1.262E-07	7.639E-07
	147	STABLE	2.845E-07	5.673E-07	6.555E-07	5.868E-07	9.214E-07	1.749E-06	7.138E-05	1.235E-02	2.348E-01	7.227E-01	2.984E 00
	148	STABLE	7.676E-07	7.751E-07	8.050E-07	9.482E-07	2.105E-06	1.680E-05	1.229E-04	9.586E-04	1.672E-03	1.801E-03	1.804E-03
	149	STABLE	9.449E-07	9.836E-07	1.213E-06	2.047E-06	1.685E-04	1.761E-02	2.663E-01	1.079E 00	1.090E 00	1.090E 00	1.090E 00
	150	STABLE	7.175E-05	7.439E-05	8.792E-05	1.073E-04	6.331E-04	4.947E-03	9.153E-03	9.153E-03	9.153E-03	9.153E-03	9.153E-03
	151	.640E 02Y	3.243E-04	3.251E-04	3.290E-04	3.367E-04	1.300E-03	3.028E-02	2.057E-01	4.605E-01	4.594E-01	4.569E-01	4.242E-01
	152	STABLE	1.744E-03	2.156E-03	4.164E-03	8.180E-03	1.950E-01	2.794E-01	2.794E-01	2.794E-01	2.794E-01	2.794E-01	2.794E-01
	153	.194E 01D	5.139E-03	6.178E-03	1.178E-02	2.219E-02	1.756E-01	1.993E-01	1.458E-01	9.748E-04	4.770E-20	3.320E-68	0.0
	154	STABLE	9.533E-03	1.430E-02	1.095E-02	1.781E-02	6.529E-02	6.529E-02	6.529E-02	6.529E-02	6.529E-02	6.529E-02	6.529E-02
	155	.240E 02M	4.002E-03	6.066E-03	1.051E-02	1.558E-02	1.928E-02	1.644E-04	2.602E-20	0.0	0.0	0.0	0.0
	156	.100E 02M	6.320E-03	1.114E-02	1.669E-02	2.100E-02	2.396E-02	1.980E-02	4.620E-03	3.566E-13	0.0	0.0	0.0
	157	.300E 02S	3.531E-03	3.250E-03	3.965E-03	8.209E-03	1.209E-12	0.0	0.0	0.0	0.0	0.0	0.0
	TOTALS FOR 62 SM =		3.057E-02	3.611E-02	5.776E-02	8.717E-02	4.812E-01	6.178E-01	9.774E-01	1.909E 00	2.141E 00	2.624E 00	4.855E 00
63 EU	151	STABLE	1.202E-07	1.202E-07	1.202E-07	1.192E-07	9.762E-08	1.223E-07	2.623E-06	1.387E-04	1.230E-03	3.770E-03	3.649E-02
	152	.130E 02Y	1.745E-06	1.745E-06	1.745E-06	1.745E-06	1.745E-06	1.745E-06	1.745E-06	1.741E-06	1.715E-06	1.655E-06	1.024E-06
	152M	.930E 01H	1.745E-06	1.744E-06	1.744E-06	1.743E-06	1.713E-06	1.395E-06	2.918E-07	3.904E-18	0.0	0.0	0.0
	153	STABLE	3.490E-05	3.533E-05	3.575E-05	3.785E-05	4.559E-04	8.732E-03	6.230E-02	2.071E-01	2.081E-01	2.081E-01	2.081E-01
	154	.160E 02Y	8.379E-05	8.379E-05	8.379E-05	8.379E-05	8.379E-05	8.378E-05	8.364E-05	8.261E-05	8.024E-05	5.432E-05	
	155	.176E 01Y	1.143E-04	1.275E-04	2.079E-04	3.984E-04	9.449E-03	2.856E-02	2.870E-02	2.825E-02	2.513E-02	1.911E-02	4.861E-04
	156	.151E 02D	4.242E-04	4.051E-04	4.106E-04	4.216E-04	8.095E-04	4.951E-03	1.956E-02	1.279E-02	1.037E-04	1.351E-09	4.509E-75
	157	.151E 02D	9.764E-04	1.304E-03	3.032E-03	4.833E-03	5.924E-03	6.888E-03	6.617E-03	3.482E-03	2.821E-05	3.676E-10	1.227E-75
	TOTALS FOR 63 EU =		1.617E-03	2.049E-03	3.774E-03	5.778E-03	1.773E-02	4.922E-02	1.173E-01	2.518E-01	2.346E-01	2.310E-01	2.451E-01
64 GD	152	STABLE	3.500E-09	3.726E-09	4.267E-09	5.079E-09	2.761E-08	2.656E-07	1.093E-06	1.313E-06	1.320E-06	1.337E-06	1.507E-06
	154	STABLE	2.204E-07	2.204E-07	2.204E-07	2.204E-07	2.205E-07	2.217E-07	2.304E-07	3.694E-07	1.405E-06	3.774E-06	2.969E-05

TABLE 13

FISSION PRODUCT SPECTRA FOR CA. 1 MEV NEUTRON FISSION OF U-235 (5.00 SEC IRRIDIATION)

ATOMS PER 20C ATOMS FISSIONED AFTER COOLING FOR

ELE	MASS	HALF-LIFE	5.00 SEC	10.0 SEC	30.0 SEC	1.00 MIN	15.0 MIN	3.00 HRS	1.00 DAYS	15.0 DAYS	120. DAYS	1.00 YRS	10.0 YRS
64 GD	155	STABLE	4.268E-07	4.280E-07	4.365E-07	4.094E-07	4.534E-07	3.625E-06	3.168E-05	4.769E-04	3.603E-03	9.624E-03	2.824E-02
	156	STABLE	3.447E-06	3.443E-06	3.447E-06	3.459E-06	3.726E-06	1.922E-05	5.844E-04	1.197E-02	2.466E-02	2.477E-02	2.477E-02
	157	STABLE	7.226E-06	7.229E-06	7.253E-06	7.317E-06	1.036E-05	4.665E-05	3.176E-04	3.453E-03	6.907E-03	6.935E-03	6.935E-03
TOTALS FOR 64 GD =			1.130E-05	1.130E-05	1.133E-05	1.141E-05	1.479E-05	6.998E-05	9.350E-04	1.591E-02	3.518E-02	4.133E-02	5.998E-02
TOTALS FOR 65 TB =			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS FOR 66 DY =			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

BETA HEATING OPTION EFFECTED (5.00 SEC IRRIDIATION)
OUTPUT IS PER 200 ATOMS FISSIONED

SELECTED ELEMENTS LISTED FOR BETA DECAY IN MEV

ELE	MASS	COOL TIMES=	5.00 SEC	10.0 SEC	30.0 SEC	1.00 MIN	15.0 MIN	3.00 HRS	1.00 DAYS	15.0 DAYS	120. DAYS	1.00 YRS	10.0 YRS
31 GA	72		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34 SE	79		1.484E-07	3.023E-07	1.526E-06	4.431E-06	2.348E-05	9.308E-11	6.819E-53	0.0	0.0	0.0	0.0
34 SE	83		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35 BR	81		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35 BR	84		9.047E-09	1.341E-08	4.292E-08	8.583E-08	2.146E-07	2.575E-07	2.146E-07	1.717E-07	5.364E-09	2.619E-12	9.176E-57
38 SR	99		2.190E-09	2.190E-09	2.190E-09	4.380E-09	5.607E-07	5.607E-07	5.607E-07	5.607E-07	5.607E-07	4.380E-09	1.900E-27
40 ZR	92		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40 ZR	93		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40 ZR	100		5.419E-01	2.077E-01	4.004E-03	1.054E-05	6.179E-78	0.0	0.0	0.0	0.0	0.0	0.0
42 MO	95		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42 MO	104		3.136E-02	3.182E-02	2.820E-02	2.272E-02	5.283E-05	4.850E-36	0.0	0.0	0.0	0.0	0.0
46 PD	106		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46 PD	109		3.330E-06	6.646E-06	2.664E-05	5.963E-05	2.580E-05	2.045E-06	7.226E-07	4.334E-14	2.896E-68	0.0	0.0
49 IN	118		9.088E-07	1.427E-06	2.734E-06	2.906E-06	2.389E-06	2.316E-07	4.223E-15	0.0	0.0	0.0	0.0
49 IN	120		2.903E-06	3.983E-06	8.897E-06	1.452E-05	1.176E-05	8.551E-10	2.141E-41	0.0	0.0	0.0	0.0
TOTAL BETA HEATING=			5.732E-01	2.395E-01	3.224E-02	2.281E-02	1.170E-04	3.095E-06	1.498E-06	7.324E-07	5.661E-07	4.383E-09	1.900E-27

GAMMA ENERGY GROUP OPTION EFFECTED(5.00 SEC IRRIDIATION)
OUTPUT IS ATOMS PER 200 ATOMS FISSIONED IN ENERGY GROUP

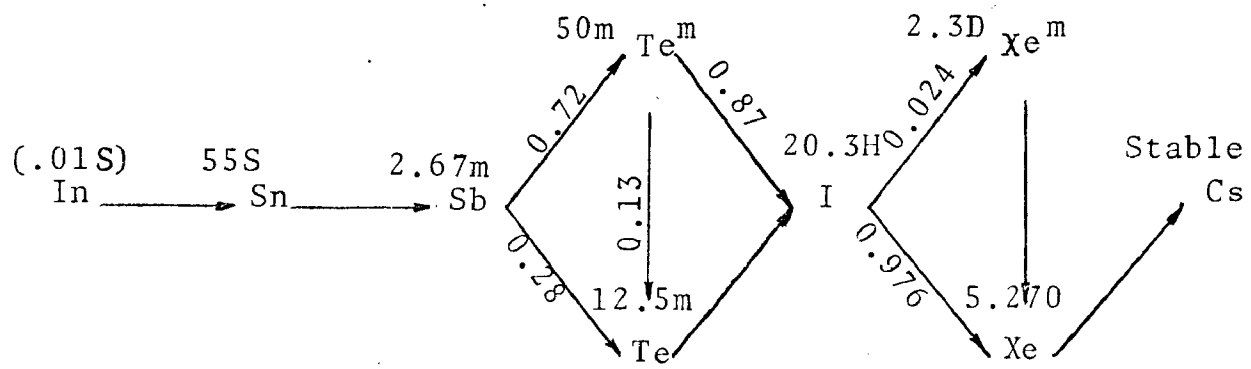
GP. NO.	LOWER ENERGY BOUND (MEV)	UPPER ENERGY BOUND (MEV)	COOLING TIMES = 5.00 SEC	10.0 SEC	30.0 SEC	1.00 MIN	15.0 MIN	15.0 DAYS	1.00 YRS	10.0 YRS
1	0.0	0.500	5.225E 00	3.225E 00	1.345E 00	7.948E-01	5.417E-02	8.004E-09	0.0	0.0
2	0.501	1.000	1.044E-03	1.273E-03	1.442E-03	1.176E-03	8.923E-05	-0.0	0.0	0.0
3	1.010	10.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX 4

Example of Program Procedure

The calculation of r_m and Y_m from basic nuclear data is demonstrated for the mass number 133 in a fission of U-235.

1. Reference 22 yields the decay chain;



2. The multibranch decay scheme may then be broken into the six equivalent straight line decay branches

1) $In \xrightarrow[r_1]{.015} Sn \xrightarrow[r_2]{.015} Sb \xrightarrow[r_3]{.015} Te^m \xrightarrow[r_4]{.020}$

$I \xrightarrow[r_5]{.015} Xe^m \xrightarrow[r_6]{.626} Xe \xrightarrow[r_7]{.611} Cs \xrightarrow{.015}_{r_8}$

2) $In \xrightarrow[r_1]{.611} Sn \xrightarrow[r_2]{.611} Sb \xrightarrow[r_3]{.611} Te^m \xrightarrow[r_4]{.849}$

$I \xrightarrow[r_5]{.611} Xe \xrightarrow[r_6]{.611} Cs \xrightarrow{.611}_{r_7}$

3) $In \xrightarrow[r_1]{.002} Sn \xrightarrow[r_2]{.002} Sb \xrightarrow[r_3]{.002} Te^m \xrightarrow[r_4]{.003} Te \xrightarrow[r_5]{.006}$

$I \xrightarrow[r_6]{.002} Xe^m \xrightarrow[r_7]{.094} Xe \xrightarrow[r_8]{.002} Cs \xrightarrow[r_9]{.002}$

4) $In \xrightarrow[r_1]{.091} Sn \xrightarrow[r_2]{.091} Sb \xrightarrow[r_3]{.091} Te^m \xrightarrow[r_4]{.126}$

$Te \xrightarrow[r_5]{.245} I \xrightarrow[r_6]{.091} Xe \xrightarrow[r_7]{.091} Cs \xrightarrow[r_8]{.091}$

5) $In \xrightarrow[r_1]{.006} Sn \xrightarrow[r_2]{.006} Sb \xrightarrow[r_3]{.006} Te \xrightarrow[r_4]{.017}$

$I \xrightarrow[r_5]{.006} Xe^m \xrightarrow[r_6]{.28} Xe \xrightarrow[r_7]{.006} Cs \xrightarrow[r_8]{.006}$

6) $In \xrightarrow[r_1]{.273} Sn \xrightarrow[r_2]{.273} Sb \xrightarrow[r_3]{.273} Tc \xrightarrow[r_4]{.731}$

$I \xrightarrow[r_5]{.273} Xe \xrightarrow[r_6]{.273} Cs \xrightarrow[r_7]{.273}$

Branching fractions, r_i, are then utilized in the nuclide concentrations for each decay branch. The terminating r_i of a branch is determined by the product of all branching fractions in that branch from the element of interest to the end of the branch. It is important to note that the r_i for a given nuclide must sum to unity when all the branches of the chain are considered. The equivalent branching fractions for the fourth branch of the chain are:

$r_1 = r_8 = (1)(1)(.72)(.13)(1)(.976)(1) = .0913536$

(Only 1st 3 digits noted on branches)

$r_1 = r_2 = r_3 = r_6 = r_7 = r_8$ since all atoms beginning this chain must pass through the nuclides represented by 1,2,3,6,7, and 8 of this branch.

$r_4 = {}^{r_3}/_{.72} = .126875$

$r_5 = {}^{r_3}/_{[(.72)(.13) + .28]} = .2445128$

for a check

$r_7 = r_6/[6024(1) + .976] = .0913536$

The equivalent branching fractions for branches 1 to 6, respectively, of the chain for I^{133} have the values: .0150336, .6113664, .0022464, .0913536, .00672, .27328, which sum to unity.

3. The total mass fission yield for A=133 from Table I is .06558.

4. To calculate the most probable atomic number for the heavy fission fragment, the nuclear reaction for the fission of U-235 by 1 MeV neutrons is used:

$$_{92}U^{235} + {}_{o}n^{1} = A_f = A_\ell + A_h + 2.6\ {}_{o}n^{1}$$

where: $A_f = 236$, $Z_f = 92$, $A_\ell + A_h = 236 - 2.6 = 233.4$

since $A_h = 133$, then $A_\ell = 100.4$

The most stable atomic number, for both heavy and light fission fragments is

$Z_{sh} = 54.950$ $(A_h = 133)$

$Z_{s\ell} = 43.916$ $(A_\ell = 100.4)$ by interpolation

The most probable atomic number for the heavy fission fragment is (from equation (7)).

$$Z_{ph} = 1/2[92 + (54.950 - 43.916)] = 51.515$$

5. The partial fission yields may then be calculated from each nuclide in the decay scheme from equation (9) in theory.

$$Y(Z,A) = Y(A)P(Z) = Y(A)\frac{1}{\sqrt{\pi}} e^{-[Z-Z_p(A)]^2}$$

Element	$Z-Z_p(A)$	$P(Z)$	$Y(Z,A)$
I_n	2.515	.0009	$.7319\times10^{-4}$
S_n	1.515	.0563	$.3726\times10^{-2}$
S_b	.515	.4327	$.2838\times10^{-1}$
T_e^m	.485	.4458/2	$.1462\times10^{-1}$
T_e	.485	.4458/2	$.1462\times10^{-1}$
I	1.485	.0622	$.4084\times10^{-2}$
X_e	2.485	.0011	$.3851\times10^{-4}$
C_s	3.485	.000015	$.1968\times10^{-6}$
			sum $\cong$ .06554

The element T_e has two states in this branch. Therefore the yield is divided equally between them.

APPENDIX 5

File Construction

File 4 Fortran FT04F001 dsname=BEKLIB.RECA11.PERM4

This file is constructed as a direct access file for update purposes. There are two separate types of records (a and b) which are borken into 17 words and written in binary .

Record type a) (1 per chain

Word No.	Information
1	Mass or chain number
2	Maximum member of straight line decays in this chain
3-17	Maximum number of nodes in branches 1-15 respectively

Record type b) (1 per each node of entire chain)

Word No.	Information
1	Mass or chain number
2	Branch number
3	Node number
4	Lambda
5	Mu
6	Branching fraction
7	Partial yield
8	Element symbol
9	Element state
10	Atomic number
11	Number of elemental states of this element

Word No.	Information
12-17	Blank

Trailer Card (1 each)

1	999

File 5 Fortran FT05F001 dsname=BEKLIB.RECB12.PERM5

There are 1050 of these records on a direct access file written in binary. There are 25 records allotted to each element with two states being contained in each 45 word record. Record 1050 is reserved for the element $_{51}Sb^{124m}$.

Word No.	Information
1	Atomic number
2	Element symbol
3	Mass number
4	State (1 of a possible 2)
5	Lambda (1 of a possible 2)
6-16	Final concentrations for cooling times 1-11 respectively (1 of a possible 2)
17	Check word - 0 if no data here, 1 if data is present
18	Check word - number of states in this record
19-31	Identical to words 4-16 for 2nd state if present
32	No. of possible decays (0,1,2) of 1st state

Word No.	Information
33	No. of possible decays (0,1,2) of 2nd state
34-35	Decay chain branching ratio to next element or elemental state (states 1 and 2 of this record respectively)
36-37	Beta decay energies to elements or element states from 1st state of this record
38-39	Gamma decay energy to elements or element states from 1st state of this record
40-43	Identical to words 36-39 for 2nd state of this record
44-45	Blank

File 9 Fortran FT09F001 dsname=BEKLIB.INSTREAM (in ZAP)

File 1 Fortran FT01F001 dsname=BEKLIB.INSTREAM (in-SUPERZAP)

This binary file contains 1 record of 112 words of constants and control parameters for the subprograms of SUPERZAP. They are:

Word No.	Information
1	Number of errors detected in ZAP
2	Code number specifying yield data to be used
3	Code number specifying progenitor option
4	Code number specifying oblong table option

Word No.	Information
5	Code number specifying how mu is to be calculated
6-13	Alphameric output page title given by user
14-35	Alphameric cooling times (2 words per time)
36-46	Numeric cooling times
47	Maximum number of cooling times ($\leq$ 11)
48-58	Numeric burnup times
59-80	Alphanumeric burnup times (2 words per time)
81	Maximum number of burnup times ($\leq$ 11)
82	Code number specifying output format
83	Code number specifying special output case
84	Maximum number of elements in special output case
85	Code number specifying type of beta heat calculations desired
86	Maximum number of cooling times to be calculated by beta heating
87-97	Cooling time code numbers to be used in beta heating calculations
98	Maximum number of beta heating cards read
99	Code specifying type of gamma calculations desired
100-110	Cooling time code numbers to be used by SHIELD

Word No.	Information
111	Maximum number of gamma energy groups

File 11 Fortran FT11F001 dsname=BEKLIB.ZAPDATA

This file contains all other data needed by SUPER ZAP that came from ZAP. It is written 80 character card images with number of records determined by options chosen.

File 12 Fortran FT12F001 dsname=BEKLIB.XSEC.PERM12

This machine language file contains the thermal cross sections for evaluating Westcott effective cross sections. This binary file contains 84 records of 109 words each. Cross sections are arranged as follows:

```
DO  X  STATE = 1,2
DO  X  NATOM = 27,66
DO  X  MASS = 72, 161
X        Cross section (NATOM, MASS, STATE)
```

File 14 Fortran FT14F001 dsname=BEKLIB.YLD1.PERM14

File 15 Fortran FT15F001 dsname=BEKLIB.YLD2.PERM15

File 16 Fortran FT16F001 dsname=BEKLIB.YLD3.PERM16

File 17 Fortran FT17F001 dsname=BEKLIB.YLD4.PERM17

These four files contain the information for each of the four resident mass yield curves. (See Appendix 5). They each contain one record of 180 words. They are:

Word	Information
1	Compound fission nucleus mass number

Word	Information
2	Compound fission nucleus atomic number
3	Work 1 minus average neutrons released per fission
4-180	Yield in atoms normalized 200 atoms per mass numbers 4-180 respectively

File 18 Fortran FT180F001 dsname=BEKLIB.RECC18.PERM18

This binary file contains 3 files of 180 words each corresponding to the lowest, the highest, and the most stable atomic numbers per mass number 1 through 180 respectively.

File 3 Fortran FT03F001 SYSOUT=A

This file points to the output device to be used.

VITA

Bruce Earl Koopmann was born on May 6, 1942, in St. Louis, Missouri. He received his primary and secondary education in Affton, Missouri. He received his college education from University of Missouri - Rolla, in Rolla, Missouri where he received his Bachelor of Science Degree in Applied Mathematics in January, 1965.

He has been enrolled in Graduate School of the University of Missouri - Rolla since January, 1967 and has held a research assistantship from the University of Missouri - Rolla through the Nuclear Engineering Department since January, 1967.