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**MAGIK—A Monte Carlo System for Computing
Induced Residual Activation Dose Rates**

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ABSTRACT

The photon dose rate from the induced activity produced by sustained bombardment of materials by neutrons and charged particles may present a significant radiation hazard. To minimize this hazard, the material configuration must be so designed that the photon dose rate decays to an acceptable level soon after the source beam is turned off. MAGIK calculates the time-independent photon dose rates that result from activities produced by nucleon-nucleus and meson-nucleus collisions over a wide range of energies. The system has been used both for high-energy accelerator studies and for fusion reactor studies. In the MAGIK system the lengthy photon transport calculations are carried out independent of time, and the time dependence is introduced in the final program, thereby permitting study of various operating scenarios with a minimum computing cost.

I. INTRODUCTION

The photon dose rate from the induced activity produced by the sustained bombardment of materials by high-energy (> 15 MeV) neutrons, protons and charged pions or by low-energy (< 15 MeV) neutrons may present a significant radiation hazard to personnel who work in the area soon after the source beam is turned off. To minimize this hazard, the material configuration (shields, beam stops, etc.) must be so designed that the photon dose rate decays to an acceptable level soon after the beam is turned off. MAGIK is a computer code system created to calculate the time-dependent photon dose rate from induced activity needed in designing appropriate material configurations.

Although the MAGIK system could have been designed as a single program, it is designed as several programs to give greater flexibility. One can start the sequence with output from at least three different transport codes, HETC¹, MORSE², or DOT³. All three programs have been used in conjunction with MAGIK to compute the time-dependent dose rate from induced activity.

Figure 1 pictorializes the sequence of programs. This operational sequence is best described by considering two different source beams. Assume for the first source a beam of low-energy (< 15 MeV) neutrons. These neutrons could be transported with either MORSE or DOT and the instantaneous (or prompt) dose equivalent rate would be computed. The omnidirectional neutron flux as a function of energy and position would be output for use by BOOKIE. Utilizing the neutron flux from the neutron transport, the isotopic composition of the material configuration, the reaction cross section data and the nuclear decay data, BOOKIE computes

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Fig. 1. Program Coupling for MAGIK.

the production of residual nuclei that are photon emitters. BOOKIE then outputs, for use by MORSE, the starting sites of the emitted photons. MORSE transports these photons with all boundary crossings transmitted to DERBI for introduction of time dependence. DERBI calculates the time-dependent photon dose rates at various surfaces in the material configuration.

For the second source assume a high energy (> 15 MeV) beam of neutrons or charged particles. Transport of this beam of nucleons or mesons would be carried out in HETC. One of the features of the code HETC is that it provides the type and spatial distribution of all residual nuclei produced by the nonelastic collisions of neutrons with energy > 15 MeV and all charged particles. Output from HETC includes neutrons with energy < 15 MeV and the type and spatial distribution of residual nuclei. At this point there are two operational paths to be taken. The first is to MORSE where the neutrons with energy < 15 MeV are transported just as if one had only a low-energy neutron source with the sequence of programs the same to DERBI. The second path from HETC has the residual nuclei processed in the program HANDY that prepares the residual data for use by BOOKIE. HANDY also calculates the prompt doses from the various nucleon-meson fluxes from HETC. Utilizing the residual production information from HANDY and the nuclear decay data, BOOKIE outputs the starting sites of the emitted photons. MORSE transports these photons with boundary crossings transmitted to DERBI. In DERBI, the time-dependent photon dose rates resulting from residuals produced by HETC and from residuals produced by neutrons with energy < 15 MeV are calculated at various surfaces.

Section II outlines the method of calculation. Sections III thru VI give a brief description of each program and the data required. Only

cylindrically symmetric geometries are presently allowed. Appendix A lists auxiliary tables describing group structure, decay data sets and reaction cross section data sets. The auxiliary tables are included to aid the user in data preparation.

The MAGIK system is available from the Radiation Shielding Information Center (RSIC) at the Oak Ridge National Laboratory. Only the modified subroutines for MORSE are included with MAGIK. All other programs mentioned in this document (MORSE, DOT and HEC) are also available from RSIC. Section VII outlines a sample problem that is included with MAGIK.

II. METHOD OF CALCULATION

To obtain the time dependence of the radioactive buildup and decay and the resulting time dependence of the photon dose rate it is necessary to specify in detail the time-dependence of the source beam. For energies > 15 MeV, the source beam may be neutrons, protons or charged pions, and for energies < 15 MeV the source beam consists of neutrons. Furthermore, the source beam is assumed to be uniform during a pulse.

With a specification of the incident current, $I(t)$, the photon dose rate as a function of irradiation time and time after the beam is turned off may be calculated. The production rate of nuclei of type k at a given position, $\vec{r}$, and time, t , by the nonelastic collisions of protons, neutrons and charged pions, may be written

$$P_k(\vec{r}, t) = \sum_{i=p,n,\pi^\pm} \sum_j \int_{E_{ijk}}^{E_{\max}} d\phi_i(\vec{r}, E, t) \sigma_{ijk}(E) n_j(\vec{r}) \quad (1)$$

where

$P_k(\vec{r}, t)$ = the number of nuclei of type k (defined by charge number Z and mass number A) per unit volume per unit time produced at $\vec{r}$ and t ,

$p, n, \pi^\pm$ = protons, neutrons, and positively and negatively charged pions, respectively,

E_{ijk} = the energy below which the production of nuclei of type k by the interaction of particles of type i with nuclei of type j becomes negligible,

$E_{\max}$ = the maximum energy of any particle being considered,

$\phi_i(\vec{r}, E, t)$ = the omnidirectional flux per unit energy for particles of type i with energy E at $\vec{r}$ and t ,

$\sigma_{ijk}(E)$ = the microscopic cross section for the production of a nucleus of type k by the interaction of a particle of type i at energy E with a nucleus of type j ,

$n_j(\vec{r})$ = the number of nuclei per unit volume of type j at $\vec{r}$.

If it is assumed that the nucleon-meson cascade takes place in times that are negligible compared to the times of interest then

$$\phi_i(\vec{r}, E, t) = \phi_i(\vec{r}, E) I(t), \quad (2)$$

where

$\phi_i(\vec{r}, E)$ = the steady-state omnidirectional flux per unit energy for particles of type i with energy E at $\vec{r}$ per unit incident current,

$I(t)$ = the incident current as a function of time, and

$P_k(\vec{r}, t)$ may be written in the form

$$P_k(\vec{r}, t) = P_k(\vec{r}) I(t), \quad (3)$$

where

$$P_k(\vec{r}) = \sum_{i=p,n,\dots} \sum_j \int_{E_{ijk}}^{\infty} \sigma_{ijk}(\vec{r}, E) n_j(\vec{r}) dE$$

Nuclei of type k may also be destroyed by interacting with neutrons. Here this destruction is neglected. Nuclei of type k may or may not be radioactive and produce photons. If a subscript ℓ is used to denote a particular type of produced nuclei that decays with decay constant λ_ℓ then the number, $Q_\ell(\vec{r}, t)$, of radioactive nuclei of type ℓ per unit volume at $\vec{r}$ and t , must satisfy the equation

$$\frac{d}{dt} Q_\ell(\vec{r}, t) = -\lambda_\ell Q_\ell(\vec{r}, t) + P_\ell(\vec{r}, t) \quad (5)$$

which may for convenience be written

$$Q_\ell(\vec{r}, t) = P_\ell(\vec{r}) R_\ell(t) \quad (6)$$

where

$$\frac{d}{dt} R_\ell(t) = -\lambda_\ell R_\ell(t) + I(t) \quad (7)$$

For the time-dependence of I specified previously, the solution of Eq. (7) may easily be obtained and is used here in the form

$$R_\ell[m t_d + (n_p - 1)t_0 + t_p + t_s] = R_\ell(t_d) \left[\frac{1 - e^{-\lambda_\ell t_d}}{1 - e^{-\lambda_\ell t_0}} \right] e^{-\lambda_\ell [(n_p - 1)t_0 + t_p + t_s]} \\ + e^{-\lambda_\ell t_s} \left[I_0 \left(\frac{1}{\lambda_\ell} \right) (e^{\lambda_\ell t_p} - 1) \right. \\ \left. + R_\ell[(n_p - 1)t_0] \right] \quad (8)$$

$$\begin{aligned}
 R_{\ell}(t_d) &= e^{-\lambda_{\ell}[t_d - (n_p - 1)t_0]} \\
 &\cdot \left(I_0 \left(\frac{1}{\lambda_{\ell}} \right) [e^{\lambda_{\ell} t_{p-1}}] \right. \\
 &\quad \left. + R_{\ell}[(n_p - 1)t_0] \right)
 \end{aligned}
 \tag{9}$$

$$\begin{aligned}
 R_{\ell}[(n_p - 1)t_0] &= I_0 \left(\frac{1}{\lambda_{\ell}} \right) \left[\frac{1 - e^{\lambda_{\ell}(n_p - 1)t_0}}{1 - e^{\lambda_{\ell} t_0}} \right] \\
 &\cdot e^{-\lambda_{\ell}(n_p - 1)t_0} (e^{\lambda_{\ell} t_{p-1}})
 \end{aligned}
 \tag{10}$$

$$t = m t_d + (n_p - 1)t_0 + t_p + t_s
 \tag{11}$$

where

$m + 1$ = the number of pulse periods,

t_d = time of pulse period,

n_p = the total number of incident pulses in a pulse period,

t_0 = the time between incident pulses,

t_s = time after the last pulse,

I_0 = the value of $I(t)$ during a pulse,

t_p = the pulse length

t = the total time that has elapsed since the beam was turned on.

If the ℓ th residual is a daughter of the p th residual, one has the

equations

$$\frac{d}{dt} R_p(t) = -\lambda_p R_p(t) + I(t) \quad (12)$$

and

$$\frac{d}{dt} R_\ell(t) = -\lambda_\ell R_\ell(t) + \lambda_p R_p(t) \quad (13)$$

the solution of which results in

$$R_\ell(t) = \frac{\lambda_p}{(\lambda_p - \lambda_\ell)} [R_\ell^*(t) - R_p^*(t)] \quad (14)$$

where $R_\ell^*(t)$ and $R_p^*(t)$ are obtained from Eq. (8) and in Eq. (6), $P_\ell(\vec{r})$ becomes $P_p(\vec{r})$. Also use $P_p(\vec{r})$ in Eq. (16) and (18). In a similar manner, if the ℓ th residual is also a granddaughter of the g th residual, the resulting equation is

$$R_\ell(t) = \frac{\lambda_p \lambda_g}{(\lambda_p - \lambda_\ell)(\lambda_g - \lambda_\ell)} R_\ell^*(t) + \frac{\lambda_g \lambda_p}{(\lambda_g - \lambda_p)} \left[\frac{R_g^*(t)}{(\lambda_g - \lambda_\ell)} - \frac{R_p^*(t)}{(\lambda_p - \lambda_\ell)} \right] \quad (15)$$

where $R_\ell^*(t)$, $R_p^*(t)$ and $R_g^*(t)$ are obtained from Eq. (8), and in Eq. (6). $P_\ell(\vec{r})$ becomes $P_g(\vec{r})$. Also use $P_g(\vec{r})$ in Eq. (16) and (18).

The production rate of photons may be written

$$S_Y(\vec{r}, E_Y, t) = \sum_{\ell} \lambda_\ell P_\ell(\vec{r}) R_\ell(t) \Gamma_\ell(E_Y) \quad (16)$$

where

$S_Y(\vec{r}, E_Y, t)$ = the number of photons produced per unit volume per unit energy per unit time at $\vec{r}$, E_Y , and t by the decay of all nuclei at $\vec{r}$ and t .

$\Gamma_\ell(E_Y)$ = the number of photons per unit energy per decay emitted at E_Y by nuclei of type ℓ ,

and the photon dose rate at $\vec{r}$ and t can, neglecting the time for the photon transport, be expressed as

$$D(\vec{r}, t) = \int dE_Y C(E_Y) \cdot \int d\vec{r}' dE_Y' S(\vec{r}', E_Y', t) \cdot V(\vec{r}, E_Y; \vec{r}', E_Y')$$
(17)

where

$D(\vec{r}, t)$ = the photon dose rate at $\vec{r}$ and t ,

$C(E_Y)$ = the photon flux-to-dose rate conversion factor,

$V(\vec{r}, E_Y; \vec{r}', E_Y')$ = the value function for the photon flux, i.e., the photon flux per unit energy range at $\vec{r}$ and E_Y due to one photon per unit time leaving $\vec{r}'$ with energy E_Y' .

Equation (17) may be written, using Eq. (16), as

$$D(\vec{r}, t) = \sum_{\ell} \lambda_{\ell} R_{\ell}(t) \left\{ \int dE_Y C(E_Y) \cdot \int d\vec{r}' dE_Y' P_{\ell}(\vec{r}') F_{\ell}(E_Y') \cdot V(\vec{r}, E_Y; \vec{r}', E_Y') \right\}$$
(18)

In Eq. (18) the bracket quantity is time-independent and contains all of the information that must be obtained by rather lengthy transport calculations. In the work reported here the bracket term was calculated for each ℓ value and then the time-dependence was introduced and the sum over ℓ carried out. The contribution by individual residuals to the total photon dose rate is therefore available at a given position $\vec{r}$.

The transport calculation for neutrons with energy > 15 MeV and all charged particles are carried out with the nucleon-meson transport code HETC¹. This code has been described in detail elsewhere⁴ and therefore will not be discussed here. A feature of the code is that it provides

the type and spatial distribution of all residual nuclei produced by the nonelastic collisions of neutrons with energy > 15 MeV and all charged particles (p, α) and of these residual nuclei it is the ones that are photon emitters - including the annihilation photons from positron emitters - that are of primary interest here.

The low-energy (< 15 MeV) neutrons that are produced by the high-energy nuclear reactions are transported with the Monte Carlo code MORSE². Source beams of low-energy neutrons can be transported with either the DOT³ or MORSE codes. The production of radioactive residual nuclei by neutrons with energy (< 15 MeV) is obtained by integrating over energy the product of the neutron flux per unit energy obtained from MORSE or DOT and the macroscopic residual nuclide production cross section. The macroscopic residual nucleus production cross sections were taken from the MONTAGE library of Muir⁵.

The MAGIK system has been used both for high-energy accelerator studies¹¹ and for fusion reactor studies¹². In the high-energy (> 15 MeV) transport calculations the most abundant isotope of each element has been used to represent the element. However, this approximation may not be adequate in all applications. For an element with a wide range of isotopes, HETC should be given data for the naturally occurring isotopic composition. In the low-energy (< 15 MeV) transport calculations the natural isotopic abundance of each element has been used.

The photon spectrum from the decay of each type of produced radioactive nucleus was obtained from the Evaluated Nuclear Structure Data Files of the Nuclear Data Project⁶. The photon flux-to-dose rate conversion factors used in the calculations were taken from the work of Claiborne and Trubey⁷.

III. HANDY - HETC ANALYSIS PROGRAM

A. Description

HANDY is an HETC analysis program that calculates the instantaneous dose equivalent rate during a pulse from charged particles and neutrons with energy > 15 MeV. HANDY also outputs residuals resulting from collisions of the cascade particles with the various nuclei in the material configuration.

One of the features of the code, HETC, is that it provides the type and spatial distribution of all residual nuclei produced by the nonelastic collisions of neutrons with energy > 15 MeV and all charged particles. It is part of these residual nuclei that are photon emitters - including the annihilation photons - from positron emitters that are of primary interest here.

Given a sufficiently large number of starting particles, HETC will determine which residuals are produced by nucleon-nucleus and meson-nucleus collisions within all geometric intervals. Because HETC is a Monte Carlo transport code, it is often necessary to use a device known as an "open window" to improve statistics in scoring residuals without resorting to an excessively large number of incident particles. This can be done since the spatial dependence of residual nuclei with similar A and Z's are basically similar except for the absolute normalization. The open window device permits one to prorate similar residuals. For any particular residual with a given (A,Z), three scores are to be kept. The first is considered a real score by summing the weights when HETC produced a residual with the given (A,Z), the second is a near-miss score by summing the weights whenever residuals with (A-1,Z) (A-1,Z+1) and (A,Z+1) were

produced and the final score is a sum of weights by geometric interval of all residuals, counted either as a real score or a near-miss score. The final number of residuals of a given (A,Z) produced in each geometric interval is the sum of weights in the geometric interval multiplied by the ratio of the real score to the sum of the real score plus the near-miss score.

The instantaneous dose equivalent rate as a function of position can be obtained from the flux per unit energy of the various types of particles and flux-to-dose rate conversion factors. The neutron flux-to-dose rate conversion factors were taken from the recommendations of the ICRP⁸. The proton, charged pion, and muon fluxes were converted to dose equivalent rate using the charged particle stopping powers in tissue⁹ and the dose equivalent as a function of linear energy transfer¹⁰.

B. Subroutines

A list of the subroutines and their purpose follows.

<u>SUBROUTINE</u>	<u>PURPOSE</u>
MAIN	<p>Calls appropriate subroutines for auxiliary processes.</p> <p>Calculates the instantaneous dose equivalent rates from boundary crossings of the nucleon mesons.</p> <p>Determines, with open-window scheme, the residuals produced by collisions in HETC.</p>
ALAG	Used in conjunction with SPACER for logarithmic interpolation.
BFIN	Used in conjunction with BUFNMT and REDNMT to obtain data from HETC history tape. For further detail see Ref. 1.

BFINMT See BFIN.
 FTOD Sets up flux-to-dose conversion factors.
 SORTAU Does binary sorting of several arrays according to
 the order of a particular array.
 SPACER See ALAG.
 REDNMT See BFIN.
 RITIT Used to minimize core storage requirements by writing
 values on disk to free certain large arrays.

C. IO Devices

<u>LOGICAL UNIT</u>	<u>PURPOSE</u>
5	Standard input
6	Standard output
11	Residual information for BOOKIE
14	Scratch device
16	Output of total dose equivalent rate by batches, summed from batch 1. Must be divided by number of incident particles
26	Scratch device
NHST	HETC history tape, if more than one tape, must also include NHST+1, NHST+2, etc.

D. Data

Card A Format (1615)

NHST = logical unit number of HETC history tape must be 58
 if it is a buffered tape (see Ref. 1)

IO = 6 , standard output unit

IN = 5 , standard input unit

Card B Format (1615)

NRBND = number of radii

NZBND = number of depths

NBCTOT = number of batches used in HETC

NCAZDK = 296 , number of decay data sets available

MAXZ = 60 , maximum Z in decay data

MAXA = 51 , maximum A in decay data

Card(s) C Format (8F10.2)

RBND(I) = NRBND values of radii

Card(s) D Format (8F10.2)

ZBND(I) = NZBND values of depths

The remaining data are more or less permanent depending on whether group structure, flux-to-dose conversion factors or entries in the decay data set are changed. On Cards A and B, only NHST, NRBND, NZBND and NBCTOT are subject to casual change. These permanent data will be included with the program HANDY.

IV. MORSE - MODIFICATIONS FOR MAGIK

A. Description

MORSE has been described in detail in Ref. 2. As modified here, MORSE is programmed for three modes of operation. The first mode is used to transport neutrons with energies < 15 MeV from the HETC code, the second mode is used for transporting the photons from induced activity with starting sites output by BOOKIE and the third mode has the neutron source left to the user's option with analysis carried out in BANKR, the same as in MODE 1.

Since MORSE can be rather lengthy in running time, some precautions were necessary to prevent having to restart from the beginning of a run should the job be stopped for any reason. When operating in MODE 1 or 3, boundary crossing information is output upon completion of every batch and the neutron flux from collisions is output upon completion of every fourth batch. BOOKIE is programmed so that one simply uses the last multiple of four batches as the quantity IMORSE (input on Card C of data for BOOKIE). When operating in MODE 2, information for DERBI is written out upon completion of every batch. Should the job be terminated before all batches for every residual have been completed, one saves the output noting the last batch in which a residual had all batches of photons transported. This number is used as the value of IFINI (MORSE data Card A1) for the next run. Then for all batches up to IFINI only one photon with a zero weight will be transported. After IFINI batches the proper input for the remaining residuals from BOOKIE will be used. A trivial program could then be written to combine the information from both runs.

Two subroutines have variables which may need dimension changes for certain cases. MAIN has an array NC, in common, with a large dimension that can be modified to suit a problem with a large number of cross sections to be stored. BANKR has one large array, COLIDS(NR,NZ+1,35), that can be reduced to (1,1,1) for operating MODE 2. Comments in BANKR will aid the user in making other dimension changes.

1. MODE 1

As modified here, MORSE is used to transport those neutrons with energies < 15 MeV from the HETC code along with the photons produced by

transporting these low-energy neutrons. From the boundary crossings of neutrons and gammas, the instantaneous dose equivalent rate as a function of position is computed using the neutron flux-to-dose rate conversion factors taken from the recommendations of the ICRP⁸ and the photon flux-to-dose rate conversion factors from Ref. 7. Neutron collisions are converted to volume-averaged omnidirectional neutron flux as a function of energy and position for use in the program BOOKIE. Subroutine SOURCE introduces a pseudo end of batch when more than 1500 source neutrons are encountered. All particles are transported and the ends of real batches are duly noted.

2. MODE 2

As modified here, MORSE is used to transport the photons from induced activity in the material configuration. Residual starting sites and gamma intensities by group are obtained from the BOOKIE program output. From the boundary crossings of these photons and the photon flux-to-dose rate conversion factors from Ref. 7, the bracketed quantity in Eq. (18) is computed for each residual for use in the time-dependent code DERBI. Subroutine SOURCE introduces a pseudo end of batch when more than 2500 source photons are encountered. All photons are transported and the ends of real batches are duly noted.

3. MODE 3

As programmed, this mode allows the user to specify a neutron source as an option in SOURCE. Analysis in BANKR will be carried out as if the program was operating with MODE = 1.

B. Subroutines Other Than Standard

A list of subroutines other than the standard follow along with the purpose of each.

<u>SUBROUTINE</u>	<u>PURPOSE</u>
MAIN	Always included to permit expansion of core storage.
ALAG	New, used in conjunction with spacer for interpolation.
BANKR	Modified to permit computation of dose equivalent rates and neutron flux as a function of energy and position if in MODE 1 or MODE 3, otherwise computes the bracketed quantity in Eq. (18) for MODE 2.
BFIN	New, used in conjunction with BUFNMT and REDNMT to pick up the neutrons produced in HETC with energy < 15 MeV.
BUFNMT	New, see BFIN.
DIREC	Modified to permit BANKR to handle analysis and other calculations.
GSTORE	Modified slightly due to SOURCE and BANKR changes.
GTMED	Necessary inclusion since geometry media and cross sections vary with problems.
MSOUR	Modified to obtain source neutrons from the HETC transport code or source photons from BOOKIE.
SCORIN	Modified as a dummy routine to permit BANKR analysis.

SOURCE	Modified to obtain source neutrons from the HETC transport code, source photons from BOOKIE, or left to user's option if MODE = 3 desired.
SPACER	New, used in conjunction with ALAG for interpolation.
REDNMT	New, see BFIN.

In addition to the above subroutines, all problems to date have been solved using the cylindrical geometry package rather than COMGEOM since BOOKIE is programmed to punch cards for the geometry input to the cylindrical geometry package.

C. IO Devices

<u>LOGICAL UNIT</u>	<u>PURPOSE</u>
5	Standard input
6	Standard output
IXTAPE	Cross-Section tape, if needed
JXTAPE	Processed cross-section tape, if needed
NHST	For MODE 1, logical unit for HETC history tape if more than 1 must include NHST+1, NHST+2, etc. For MODE 2, logical unit for BOOKIE histories. For MODE 3, left to user's option.
NOUT	Output tape to be used either by BOOKIE or DERBI

D. Data

All data required by the standard MORSE code up to and including cross section data. It should be noted that since pseudo end of batches are introduced when a large number of source particles are started NITS

should be a value 2 or 3 times greater than the actual number of batches. NUBCH and NBCTOT on card B1 below actually control the end of run. The following data cards follow all input to the standard MORSE.

CARD A1 Format (1615)

NHST = logical unit of history tape for MODE = 1, HETC histories for MODE = 2, BOOKIE histories. In addition, for a buffered HETC tape, NHST must be ≥ 58

MODE = 1 for HETC input, be careful of dimension of COLIDS in BANKR, must be (NRBND, NZBND+1, NGPQTN) where NGPQTN is number of neutron E groups

2 for BOOKIE input

3 for user's option, requires some programming in SOURCE

NANGL = number of isotropic angles used at each residual starting site for BOOKIE input

NOUI = logical unit for output tape

IFINI = number of batch completed previously (multiple of NUBCH), used as restart with MODE = 2, normally 0

Card B1 Format (1615)

NRBND = number of radii

NZBND = number of depths

NUBCH = number of batches used in HETC (can be less) or number of batches per residual in BOOKIE

NBCTOT = NUBCH if HETC input or total number of batches from BOOKIE (number of residuals times NUBCH)

NMAT = number of different nonvoid materials in geometry material configuration

Card(s) C1 Format (8F10.2)

RBND(I) IRBND values of radial boundaries

Card(s) D1 Format (8F10.2)

ZBND(I) = NZBND values of depth boundaries

Card E1 Format (16I5)

NECN1 = number of energies at which the neutron flux-to-dose
conversion factors are evaluated

NECG = number of energies at which the photon flux-to-dose
conversion factors are evaluated

Card(s) F1 Format (8F10.2)

ECN1(I) = NECN1 values of energies at which neutron flux-to-dose
factors are evaluated, in ascending order

Card(s) G1 Format (8F10.2)

CN1(I) = NECN1 values of neutron flux-to-dose factors at the
ECN1(I) energy points

Card(s) H1 Format (8F10.2)

ECG(I),CG(I) = NECG pairs of energy and photon flux-to-dose conversion
factors with energy in ascending order

Cards E1 through H1 are more or less permanent data.

If the user chooses MODE = 3 for his own source, any data required
by subroutine SCURCE are to be included here.

V. BOOKIE - RADIOACTIVE RESIDUAL PRODUCTION CODE

A. Description

BOOKIE is programmed to compute the spatial dependent production
of radioactive residual from collisions of high energy (> 15 MeV) neutrons,
protons and/or charged pions or from collisions of low energy (< 15 MeV)

neutrons with various target nuclei. The locations of these residual nuclei are transmitted to MUKSE for photon transport.

To permit transport of these photons independent of time, BOOKIE segregates the residuals so that time factors need not be considered until DERBI is run. The residual production rate is calculated along with a quantity called a pointer. The pointer permits sorting to be carried out as to how and where the residual was produced. All photons emitted by residuals with identical points are to be transported in the same batches. The equation for the pointer may be written

$$I = (K_2 + 10K_1 + 100J)N + M$$

where

I = the storage pointer,

K_1 = 1 or 2 for first or second entry in decay data set, i.e., if a residual has both a ground state and a metastable state appearing in the decay table with both half-lives within the time limits, they are each assumed to be produced with a 50% probability.

K_2 = the generation number

1 if no ancestor

2 if it is a daughter

3 if it is a granddaughter

(Note: three residuals with different time sequences can occur, from direct interaction and decay of parent and grand-parent)

J = index of unique residual from HANDY or reaction cross-section data sets (may be produced by different reactions, but only one considered unique for storage)

$N = 1$ if target material not considered

10 if target material is included

$M =$ material number, if considered

0 if material number not included

Basically, BOOKIE calculates the production of radioactive nuclei by geometric interval (Eq. (4)). Then utilizing the normalized weights by intervals, BOOKIE outputs by residuals and batches the random starting sites for photon transport needed by MORSE. Along with the starting sites, total weights per residual and half-lives (may be up to 3 for a granddaughter), a normalized gamma intensity array by group is written on tape for each residual for use by MORSE MODE 2.

B. Subroutines

A list of the subroutines along with the purpose of each follows.

<u>SUBROUTINE</u>	<u>PURPOSE</u>
MAIN	Reads in MODE to determine type of input and whether BOOKIE or BETTOR is to be called. Has a large array VARIB which can be modified to suit case.
BOOKIE	Used when MODE = 2 for neutron flux input. Solves Eq. (4) and sets up pointers, keeping track of everything from target nuclei through importance of each residual. Reads in reaction cross-section data and decay data. Determines storage order for residual data.
FIX	Utilizes information from BOOKIE to calculate residual production by geometric intervals.

BETTOR	Like BOOKIE but MODE = 1 for input from HANDY. Does not use reaction cross-sections and isotopic densities of target nuclei.
TIP	Utilizes information from BETTOR to calculate residuals produced by geometric interval.
PLACE	For each radioactive residual, this routine outputs in batch form the starting sites for the photon transport in MORSE - MODE 2. If ISITE = 1 (input data), will use only those sites from HANDY and if greater than 1, will output the site from HANDY and ISITE - 1 random starting sites in the same geometric interval. Used in conjunction with TIP for MODE = 1.
SLOTS	Binary sorting to get ascending order of fixed point variables changing a second array correspondingly.
ODDS	Binary sorting to get ascending order of floating point variables changing a second integer array correspondingly.
PARLAY	For each radioactive residual, generates random starting sites based on normalized weights by intervals utilizing binary searching. Output in form of batches for MORSE - MODE 2.
FLRAN	Generates random number from 0. to 1.0, function supplied is in assembly language.

C. IO Devices

<u>LOGICAL UNIT</u>	<u>PURPOSE</u>
5	Standard input
6	Standard output
7	Standard punch output
IFLUX	Neutron flux tape if MODE = 2 Output tape from HANDY if MODE = 1
INDKAY	Logical unit for decay data, if standard input, decay data cards must follow cards P
INMONT	Logical unit for reaction cross sections, if standard input, reaction data cards must follow cards M. Not required for MODE = 1.
26	SCRATCH unit for use by program for storing information from IFLUX
21	Output tape for MORSE - MODE 2

D. Data

Card A Format (1615)

MODE = 1 for input from HANDY
2 for neutron flux input

Card B Format (8F10.2)

TIMLO = lower time cutoff in minutes
TIMHI = upper time cutoff in years

If a residual other than a daughter or granddaughter has a half-life
out of this range it will not be considered.

Card C Format (1615)

NOR = number of radii in geometry

NOZ = number of depths in geometry
 NMAT = number of different materials (nonvoid)
 NEGRP = 35, number of energy groups for flux and reaction cross sections if MODE = 2
 MTNCLU = 0 do not include material number in pointer
 1 include material number in pointer
 caution, if 1 and NMAT > 9 code needs modification
 IMORSE = number of batches of boundary crossing on flux tape from MORSE - MODE 1
 NOHET = number of residuals produced by HANDY
 IFLUX = logical unit for neutron flux with MODE = 2 or logical unit for output from HANDY with MODE = 1, if negative will use $FLUX(IR,IZ) = 1.0/VOL(IR,IZ)$ for all groups (with MODE = 2, useful for a quick run to determine importance of residuals and therefore target nuclei)
 INDKEY = logical unit for decay data, if standard input, decay data cards must follow cards P
 INMONT = logical unit for reaction cross sections, if standard input and MODE = 2, reaction data cards must follow cards M
 Card(s) D Format (8F10.2)
 R(I) = NOR values of radii
 Card(s) E Format (8F10.2)
 Z(I) = NOZ values of depths
 Card(s) F Format (16I5)
 MAT(I,J) = material for NOR radial intervals for Z(J) repeats until all depths input (use 0 or 1000 for internal void)

Card(s) G Format (1615) Omit if MODE = 1

NTARG(I) = number of target nuclei in each material, NMAT values

Card(s) H Format (3F10.2) Omit if MODE = 1

DENMUL(I) = NMAT density multipliers used to vary density of materials when one is a multiple of the other. For instance, if Material 1 is 100% stainless steel and material 4 is 64% SS, the same DENSIT(I) values can be used for both with DENMUL(1) = 1.0 and DENMUL(4) = 0.64.

Card(s) I_k Format (8I10) Omit if MODE = 1

ID(I) = NTARG(k) values of identifiers of target nuclei
 $ID(I) = 1000 * Z(I) + A(I)$

Card(s) J_k Format (8F10.2) Omit if MODE = 1

DENSIT(I) = NTARG(k) values of isotopic densities for each target nuclei on card(s) I_k

Cards I_k and J_k repeat for next material with BOOKIE storing values appropriately.

Card K Format (1615)

NPAREN = number of daughter, parent, grandparent relationships described on card(s) L

Card(s) L Format (I1, I9, 2I10, 3I5, EF10.6) Omit if NPAREN = 0

IGEN(IP) = 2 for parent and daughter
 3 for grandparent, parent and daughter

IPAREN(IP) = ID of residual $1000 * Z(IP) + A(IP)$

IDAUGH(IP) = ID of daughter, $1000 * Z + A$

IKID(IP) = ID of granddaughter, $1000 * Z + A$

MOM(IP,1) = index in decay data that corresponds to ID of IPAREN(IP) with half-life desired

MOM(IP,2) = index in decay data that corresponds to ID of
 IDAUGH(IP) with half-life desired
 MOM(IP,3) = index in decay data that corresponds to ID of
 IKID(IP) with half-life desired
 WTDK(IP,1) = 1.0
 WTDK(IP,2) = fraction of residual decaying to daughter
 WTDK(IP,3) = fraction of daughter that decays to granddaughter

Card L repeats for NPAREN relationships. The appendix (and output from BOOKIE) lists the decay data by ID, half-life and index. Since the importance of daughters and granddaughters vary with problems it is left to the user's option as to what is to be included.

Card(s) M Format (7F10.2) Omit if MODE = 1

EGRP(I) = neutron energy group boundaries, high to low
 including thermal cutoff, NEGRP+1 values

Card N Format (1615) Omit if MODE = 1

NOMONT = number of reaction cross section sets available;
 for the collapsed MONTAGE 35 group set there are
 408 available sets

Card O Format (1615)

NGDCAY = number of residual decay data sets, 296 sets
 are available

NGAM = 21, number of gamma energy groups

Card(s) P Format (8F10.2)

EGAM(I) = gamma energy group boundaries, high to low,
 NGAM+1 values

Card Q Format (3Z4)

RANDS(I) = for I = 2,4 starting random number in hexadecimal,
must be odd, RANDS(1) is set to 16896

Card R Format (1615) Omit if MODE = 1

ICH00S = 100, chooses at least NSMALL starting sites
within each R,Z interval producing the residual
= NPART, chooses NPART starting sites over all
materials that produce the residual

NSMALL = -1, chooses at least NSMALL starting sites in
each material region that produces the residual
= smallest number of starting sites permitted in
either R,Z interval or material region

NPART = total weight of particles per batch (also smallest
number of starting sites per batch over whole
system

NBATCH = number of batches per residual, as programmed
DERBI requires no more than 10 but dimensions
of only two variables in DERBI need changing to
increase number of batches.

IFIRST = 1 is suggested but permits neglecting low-weighted
residuals with an index < IFIRST

Card S Format (1615) Omit if MODE = 2

MAXBCH = number of batches used in HETC

MAXCAS = number of incident particles per batch used
in HETC

IBATNU = number of batches per residual, see NBATCH
on card R

ICOMB = number of batches in HETC combined into each
new batch for MORSE

ISITE = number of starting sites for each residual site
from HANDY. If = 1, will only use those sites
from HANDY. If greater than 1, will use site
from HANDY and ISITE - 1 random sites in the
same geometric interval. Total weight of parti-
cles per batch will be MAXCAS*ICOMB*ISITE.

E. Neutron Flux Data

The omnidirectional neutron flux averaged over the given volumes
which is to be input to BOOKIE must be available as follows:

```
DO 10 IE = 1, NEGRP
  READ(IFLUX)((FLUX(IR,IZ),IR = 1,NOR),IZ = 1, NOZ)
10 CONTINUE
```

Where NEGRP, IFLUX, NOR AND NOZ are as defined under Section D of BOOKIE

F. Decay Data

The decay data must be available with IZEW(IDK) in ascending order
as follows:

```
DO 66 IDK = 1, NGDCAY
  READ(INDKAY, 61) IZEW(IDK), INDIL(IDK), INDIH(IDK), IHAFVEC(IDK), WTOTG(IDK), IV
61 FORMAT(3I5, 5X, 2E 15.6, 20X, I10)
  READ(INDKAY, 7) (WTGAM(IDK, IG), IG = 1, NGAM)
7 FORMAT (6E12.2)
```

66 CONTINUE

Where NGDCAY and NGAM are input on Card O and INDKAY is input on Card C.

The definition of the other variables follow.

IZEN(IDK)	=	residual ID, $1000 \cdot Z + A$
INDIL(IDK)	=	index of first nonzero WTGAM
INDIH(IDK)	=	index of last nonzero WTGAM
HAFVEC(IDK)	=	half-life in seconds
WTOTG(IDK)	=	total gamma intensity which is WTGAM summed
IV	=	index in decay data (should be same as IDK)
WTGAM(IDK,IG)	=	intensity by group

G. Reaction Cross-Section Data

These data are only needed for MODE = 2 when an omnidirectional volume averaged neutron flux is used to compute residual production.

BOOKIE does not retain any values except those which apply to the target materials input for a given run. Reaction cross-section data sets must be input, with IZAT(IMO) in ascending order as follows:

```

IM = 1
DO 45 IMO = 1, NOMONT
  READ(INMONT,3) IZAT(IM), IREAC, IZAR(IM), (ALP(I), I=1,14), ICE(IM), JJ
3  FORMAT(3I6,13A4,A2,2I4)
  NGROUP = ICE(IM)
  READ(INMONT,7) (XSECT(IM,IE) IE = 1, NGROUP)
7  FORMAT(6E12.2)
(BOOKIE increments IM if IZAT(IM) included in isotopic target nuclei)
45 CONTINUE

```

Where NOMONT is input on Card N and INMONT is input on Card C. The

definition of the other variables follow.

IZAT(IM) = target ID, $1000 \cdot Z + A$
 IREAC = reaction type, see Table III
 IZAR(IM) = residual ID, $1000 \cdot Z + A$
 ALP(I) = alphameric description of reaction
 ICE(IM) = number of energy group after which $XSECT = 0.0$
 JJ = index of reaction cross section
 XSECT(IM, IE) = ICE(IM) values of reaction cross sections

VI. DERBI - DOSE EMISSION RATE BY INDUCED ACTIVITY

A. Description

DERBI is the final program of the MAGIK system. It is here that the time-dependent photon dose rates are computed for individual activated residuals at selected surfaces and total induced residual activation dose rates are calculated at all surfaces. It should be noted that some residuals will seem to contribute more than once at given surfaces, but this is merely an illusion induced by the MAGIK system. Should a residual be produced by nucleon-meson collision and also by decay of a parent and even a grandparent, the photons emitted must retain their identity by some means in order that the correct half-lives are used in DERBI. Also, if a residual has two half-lives (within the cutoff times input to BOOKIE) given in the available decay data it assumed to be produced on a 50-50 basis.

Variation of input parameters allows the study of various operating scenarios. In addition, one has the option of combining radial or horizontal surfaces. Times after shutdown are input by the user and can vary greatly. There is some restriction in choice of FTO (time of pulse

in seconds) since it appears in an exponential and can cause overflow. Variation of FTO, ZT and NTZR can be used to prevent this since all other exponential arguments are negative in the program. DERBI is used to compute Eq. (8) and (18) described under METHOD OF CALCULATION. Dose rates are output as rem/h.

B. Subroutines

A list of the subroutines in DERBI follow along with the purpose of each.

<u>SUBROUTINE</u>	<u>PURPOSE</u>
MAIN	Reads in data from MORSE, calls various subroutines for auxiliary calculations and solves Eq. (18).
COMBIT	Used to combine dose emission rates over larger surfaces than those used in MORSE.
STATIC	Batch statistics routine.
FUNCT	This routine calculates Eq. (8) to provide time factors used in MAIN.
CONVER	Converts times after shutdown (input) to time in days for use in Eq. (8).

C. IO Devices

<u>LOGICAL UNIT</u>	<u>PURPOSE</u>
5	Standard input
6	Standard output
JINT(1)	Logical unit from MORSE containing photon data for photons from high energy produced residuals
JINT(2)	Same as JINT(1) except for photons from low energy produced residuals

D. Data

Card A Format (8F10.2)

DRPOLT = smallest residual weight to be considered
 suggested value 0.0, but can be any value to
 bypass low-weighted residuals from BOOKIE

FAKTOR = $(MAXCAS*ICOMB*ISITE)/NPART$ where the quantity
 in parenthesis is taken from the BOOKIE run with
 MODE = 1 and NPART from the run with MODE = 2.
 If less than or equ 1 to 0.0, DERBI assumes a
 value of 1.0.

Card B Format (1615)

NR = number of radial intervals (can be less than
 number used in MORSE)

NZ = number of depth intervals (can be less than
 number used in MORSE)

NIRIZ = number of surfaces for which dose is desired by
 residual, must be less than 81 and greater than
 0

NOVA(1) = number of residuals used to compute high E
 residual photon crossings

NOVA(2) = number of residuals used to compute low E
 residual photon crossings

MAXC = MAXCAS*ICOMB*ISITE from card S of BOOKIE run
 using MODE = 1

 = NPART from card R of BOOKIE run, if only MODE = 2
 residual used

MAXB = number of batches per residual
 NANGL = number of isotropic angles used in MORSE source
 at each starting site
 JINT(1) = logical number for data tape with high E
 residual photon crossings
 JINT(2) = logical number for data tape with low E residual
 photon crossings
 JRADZ1 = 1 for high E photon crossing included for doses
 by residual and surface
 = 2 for just low E photon crossings included for
 doses by residual and surface
 JRADZ2 = 1 for only high E photon crossings included for
 doses by residual and surface
 = 2 if low E residual photon crossings included
 for total doses by (R,Z) interval
 JRADZ3 = 1 for high E residual photon crossings included
 for total doses by (R,Z) interval
 JRADZ4 = 1 for only high E residual photon crossings
 included for total doses by (R,Z) interval
 = 2 for both or just low E residual photon crossings
 included for total doses by (R,Z) interval
 IHORIZ = 1 for doses from photon radial crossings
 = 2 for doses from photon horizontal crossings
 Card C Format (1615)
 NIRØLD = number of radii used in MORSE run
 NIZØLD = number of depths used in MORSE run

Note: These can be greater than NR,NZ.

Card(s) D Format (1615) - Not needed if NR*NZ = NIRØLD*NIZØLD

IROLD(j) = indices of MORSE radii which correspond to
radii of this run, NR values used to combine
MORSE data over larger surfaces

Card(s) E Format (1615) - Not needed if NR*NZ = NIRØLD*NIZØLD

IZØLD(j) = indices of MORSE depths which correspond to depths
of this run, NZ values used to combine MORSE data
over larger surfaces

Card(s) F Format (18A4)

TYTLES(I,J) = title cards for run with I = 1,18, j = 1,3
can use blank cards if necessary

Card(s) G Format (8F10.2)

R(I) = radii to be used in this run, NR values

Card(s) H Format (8F10.2)

Z(I) = depths to be used in this run, NZ values

Card(s) I Format (1615)

IRIZ(1) = 100*IR+IZ. Combined R and Z index for surface at
which dose by residual is computed. IR is the index
of R(IR) value and IZ the index of Z(IZ) to locate
surface interval. NIRIZ values where NIRIZ must be
less than 81 and greater than 0.

Card J Format (1615)

NTZR = number of pulses in a pulse period

NTPR = number of pulse periods

Card K Format (8F10.2)

FTØ = time of pulse in seconds

TP = time of pulse periods in days

RK = 1.0 constant
 QQ = pulse intensity
 ZT = time between starts of consecutive pulses in seconds

Card L Format (1615)

NOT = number of times on card(s) M
 NSEC = number of times on card(s) M in seconds
 NMIN = number of times on card(s) M in minutes
 NHR = number of times on card(s) M in hours
 NDAY = number of times on card(s) M in days
 NYR = number of times on card(s) M in years

Card(s) M Format (8F10.2)

TIN(I) = NOT values of time after shutdown, values expressed in seconds first, in minutes next, etc.

Card N Format (1615)

NUDA = number of times on card(s) 0 to be added to each of times on card(s) M
 NSEC = number of times on card(s) 0 in seconds
 NMIN = number of times on card(s) 0 in minutes
 NHR = number of times on card(s) 0 in hours
 NDAY = number of times on card(s) 0 in days
 NYR = number of times on card(s) 0 in years

Card O Format (8F10.2)

DAY(I) = NUDA values of time. Used for adding intervals of time to all values of TIN(J). Total number of times used in program will be $NUDA * NOT \leq 36$. $NUDA = 1$ and $DAY(I) = 0.0$ should be used if no additions required.

In subroutine MAIN there are two arrays which will probably need dimension changes according to data values of NR, NZ and MAXB. These arrays and their maximum dimensions are STATS (10, 13, 14, 5) with a maximum of STATS (MAXB, NR, NZ, 5) and BSUMRZ (10, 80, 36) with a maximum of BSUMRZ (MAXB, 80, 36). All other arrays should be adequately dimensioned for most problems.

VII. SAMPLE PROBLEM DESCRIPTION

The sample problem described here was chosen to introduce the user to the MAGIK system without requiring lengthy running times. The geometric configuration is 2 meters long with an outer radius of 1 meter, consisting of an aluminum cylinder with a radius of 15 cm surrounded by void and an iron pipe with thickness of 10 cm at the outer edge of the system. This material configuration was chosen for simplicity since Al has one naturally occurring isotope and Fe has only four naturally occurring isotopes. The user will need P_3 photon cross sections (or coupled neutron-gamma) for Al and Fe in the group structure shown in Table II. Al is considered the first material and Fe the second. The number density used for Fe was 8.411E-02 and for Al was 6.023E-02.

The operating scenario was taken to be a pulsating beam of neutrons of energy less than 15 MeV such that a neutron flux was obtained of 1.0/VOL(R,Z) in all groups and (R,Z) intervals during a pulse. Timing of the pulses, with an intensity of 1.0E+12 neutrons/sec, was 0.5 sec duration at intervals of 5 min. for 100 pulses in a day on 10 consecutive days. Results were obtained for 1, 2, 4, 8 and 16 hours after shutdown and for 1, 3 and 7 days after shutdown.

The sample problem starts in the program BOOKIE assuming a volume averaged omnidirectional neutron flux of $1.0/VOL(R,Z)$ for all groups (option in BOOKIE when IFLUX < 0 and MODE = 2). Input data (as well as core requirements and running time) for BOOKIE, MORSE - MODE 2 and DERBI are listed in Sections VII.1 through VII.3. Wherever possible, comments were included on the sample data cards to aid the user.

Most of the output from these programs is self-explanatory; however, some comments are included in Sections VII.4 through VII.6 for selected parts of the output. In addition to printed output, BOOKIE writes out information for MORSE - MODE 2 on logical 21 and punches cards (logical 7 used) for data input to the cylindrical geometry routines in MORSE - MODE 2. MORSE - MODE 2 passes information to DERBI on logical unit NOUT (data).

VII.1 DATA FOR MODE 1

WITH THE DATA LISTED BELOW, MODE 1 USED 500K CORE STORAGE ON THE IBM-360/91 WITH A RUNNING TIME OF 5.67 SECONDS. SECTION CONTROL SECTIONS AND DECAY DATA WERE INPUT TO MODE 1 FROM DISK.

```

***** DATA FOLLOWS *****
2
10.0 50.0
3 4 2 25 0 0 0 -24 4
15.0 50.0 100.0
50.0 100.0 150.0 200.0
1 1000 2
1 1000 2
1 1000 2
1 1000 2
1 1 4
1.0 1.0
1.007
6.023 -32
24054 24054 24054 24054
-0.855 -0.227710 -0.211642 -0.12777 -0.4
12
1 20041 21041 56 67 1.0 1.0 101
2 27041 28041 102 101 1.0 1.0 102
2 28041 29041 103 104 1.0 1.0 103
2 29041 30041 109 100 1.0 1.0 104
2 30041 31041 170 165 1.0 1.0 105
2 31041 32041 171 172 1.0 1.0 106
3 32041 33041 41045 173 180 1411.0 1.0 1.0 107
2 33041 34041 174 184 1.0 1.0 108
2 34041 35041 180 181 1.0 1.0 109
2 35041 36041 189 192 1.0 1.0 110
2 36041 37041 190 194 1.0 1.0 111
2 37041 38041 203 264 1.0 1.0 112
1.4918E-7 1.3400E-7 1.3214E-7 1.3030E-7 0.1473E6 5.7013E6 5.4481E6 CARD 001
4.4913E-7 3.8788E-7 3.8119E-7 2.4660E-7 2.3110E-7 1.6511E-7 1.4534E-7 CARD 002
1.1040E-7 9.0718E-8 7.6274E-8 4.9797E-8 3.3373E-8 2.2371E-8 1.4996E-8 CARD 003
6.6517E-8 3.1874E-8 1.4034E-8 7.1319E-9 3.3546E-9 1.5846E-9 4.5400E-9 CARD 004
1.0130E-8 2.7813E-9 1.0677E-9 5.0415E-10 2.3924E-10 1.1253E-10 4.1399E-11 CARD 005
1.0 1.0 CARD 006
404 MONTAGE DATA SETS ON LOG 1 -- UPDATED WITH AMPX AND CLOSE MONTAGE
254 21 DECAY DATA ON LOG 4 COMBINED FRANK, DUPLICATIONS, ETC.
14.0 12.0 10.0 8.0 7.5 7.0 6.5 6.0
5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0
1.5 1.0 0.40 0.20 0.10 0.010
512345678901 CARD 0 INITIAL RANDOM NUMBER
100 5 100 10 1 CARD 2
***** END OF DATA *****

```

VII.2 DATA FOR MODE-MODE 2

WITH THE DATA LISTED BELOW, MODE-MODE 2 USED 500K CORE STORAGE ON THE IBM 360/91 WITH A RUNNING TIME OF 3.88 MINUTES. DIMENSION OF 50 (144000) IN MAIN AND COLTOS (11,11) IN BANK0. FOR MODE 1 WANT COLTOS TO BE (XPRND,NZPRND,1,NZPRND). NOTE THAT WHAT FOR MODE 1 IS

THAT IS, BECAUSE SINCE ALTERNATING MATERIALS ARE DESIGNED IN ORDER
TO GET ALL BOUNDARY CROSSINGS USING CYLINDRICAL GEOMETRY ROUTINES.
DATA LISTED INCLUDES THAT FOR THE STANDARD WERSE SUBROUTINES.

***** DATA FOLLOWS *****
SAMPLE CASE---WSE ACTIVATED DESIGNS---PHOTON TRANSDUCER
3000 3000 3000 1 0 21 21 21 0 0 300 3 3
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
14.0 F0612.0 F0610.0 F0609.0 F067.5 F067.0 F066.5 F06
6.0 F065.5 F065.0 F064.5 F064.0 F063.5 F063.0 F06
2.5 F062.0 F061.5 F061.0 F060.40 F060.20 F060.10 F06
312578321431

1 1 1 0 0 1 21
1 1 21 1 1 1 1 1.0E-10 5.0E-09 0.
-1
0 0 0 0
2

1.5000E 01
9.0000E 01
1.0000E 02

5.0000E 01 1 5 3
1.0000E 02 2 1000 4
1.5000E 02 1 5 3
2.0000E 02 2 1000 4

CYL. CORR

PLAN

REMARK

FLUX, EFF. AND LOW DENSITY FF FOR ALTERNATE VOID

0 0 21 21 56 56 4 3 2 3 4 2 0
0 0 0 0 0 0 0 0 1 0 0 0
45 46 47 48 49 50 51 52

1 -1.100000E+1
2 -2.100000E+1
3 -2.100000E-10
14 2 5 18 0
1 4 10 70 4

CAPT A1

CAPT A1

15.0 90.0 100.0
50.0 100.0 150.0

PAGE
DEPTH

FLUX TO DOSE CONVERSION FACTORS HERE TO END OF DATA

1.0 F-91.0 F-92.5 F-81.0 F-71.0 F-61.0 F-51.0 F-41.0 F-3
1.0 F-21.0 F-15.0 F-11.0 2.5 5.0 7.0 10.0
14.0 20.0 40.0 60.0 100.0 200.0 300.0 400.0
600.0 1000.0 2000.0 3000.0 4000.0 6000.0 10000.0 20000.0
30000.0 100000.0 200000.0

1.05 F-91.05 F-91.05 F-91.15 F-91.25 F-91.20 F-91.10 F-91.02 F-9
9.00 F-105.71 F-91.52 F-83.22 F-84.03 F-84.16 F-84.16 F-84.16 F-8
4.25 F-84.26 F-84.44 F-84.15 F-85.00 F-85.55 F-86.20 F-86.40 F-8
9.35 F-81.20 F-71.80 F-72.0 F-72.70 F-72.50 F-73.20 F-74.20 F-7
5.0 F-70.0 F-71.15 F-6 F-6

0.05 1.574 -6.03 5.867 -7.05 2.921 -7.07 2.561 -7
0.10 2.765 -7.15 3.876 -7.20 5.135 -7.25 6.196 -7
0.20 7.565 -7.35 8.663 -7.40 9.769 -7.45 1.076 -6
0.50 1.172 -6.60 1.357 -6.75 1.581 -61.125 2.141 -7
1.575 2.727 -62.0 3.200 -62.4 3.570 -62.8 3.769 -6
3.25 6.765 -63.75 4.785 -64.25 5.190 -64.75 5.579 -6
5.75 5.561 -65.75 6.339 -66.25 6.710 -66.75 7.074 -6
7.5 7.725 -65.0 8.734 -611.7 1.721 -513.0 1.771 -6
15.0 1.726 -5

END OF DATA

VII.3 DATA FOR DEPR1

WITH THE DATA LISTED BELOW, DEPR1 USED 386K CORE STORAGE ON THE IBM 360/51 WITH A RUNNING TIME OF 1.15 SECONDS. THERE WAS NO METC FILE AND THEREFORE NO HIGH E PRODUCED RESIDUAL PHOTON CROSSINGS. NOTE THAT 4 DEPTHS WERE USED IN MORSE-WOLF 2 AND ONLY 2 DEPTHS USED IN DEPR1. FOR THE SAMPLE CASE, SURFACES BETWEEN JLD AND DEPTH 2 AND BETWEEN DEPTH 2 AND DEPTH 4 WERE COMBINED IN DEPR1.

```

***** DATA FOLLOWS *****
3.0 1 2 3 4 5 6 7 100 10 5 9 22 2 2 2 2 1
      : 4      NO. OF RADII AND DEPTHS USED IN MORSE NOTE WIZOLD GT NZ
      1 2 3      INDICES OF RADII USED IN MORSE THAT MATCH RADII BELOW
      2 4      INDICES OF DEPTHS USED IN MORSE THAT MATCH DEPTHS BELOW
      LOSS FROM METC RESIDUALS (HIGH ENERGY COLLISIONS)      CARD F1
      LOSS FROM MORSE RESIDUALS (LOW ENERGY COLLISIONS)      CARD F2
      LOSS COMBINED FROM HIGH AND LOW ENERGY COLLISIONS      CARD F3
15.0 50.0 100.0      RADII FOR USE IN DEPR1 NOT COMBINING
100.0 200.0      DEPTHS FOR USE IN DEPR1 SURFACES COMBINED
      101 102 201 202 301 302      (P.21) SURFACE INDICES WIZOLD VALUES
      100 10      NO. OF PULSES IN A PERIOD, NO. OF PULSE PERIODS
0.50 1.0 1.0 1.0 1.0 5+12300.0      CARD F
      F 0 0 5 0 0      CARD I
1.0 2.0 4.0 8.0 16.0 3.0 7.0      CARD M
      1 0 0 0 1 0
0.0      CARD O -- 0.0 TIME PERIOD ADDED TO TIMES ON CARD M
***** END OF DATA *****

```

VII.4 SELECTED OUTPUT FROM BOOKIE

THE FOLLOWING OUTPUT DESCRIBES REACTIONS OCCURRING IN BOTH ALUMINUM AND IRON. THE ID OF EITHER A TARGET OR A RESIDUAL NUCLEUS IS 10000Z + A. THE STORAGE POINTER DESCRIBED IN SECTION V IS LISTED HERE WITHOUT A MATERIAL NUMBER. THE TOTAL PHOTON INTENSITY OF THE DECAYING RESIDUAL AND ITS HALF-LIFE ARE SHOWN HERE. THE IMPORTANCE FUNCTION LISTED IS THE TOTAL NUMBER OF RESIDUALS PRODUCED BY A NEUTRON UNDERGOING THE REACTION SHOWN WITH THE TARGET NUCLEUS IN ALL INTERVALS CONTAINING THE GIVEN MATERIAL.

MATERIAL 1 HAS 1 NUCLEI IN 10 STORAGE POINTS 1 1 1

NUCLEI	DENSITY	RECT. REACT.	FRACTION RESID.	DECAY RESID.	DECAY WEIGHT	STORAGE POINTS	DECAY INDEX	TOTAL INTENSITY	HALFLIFE SECONDS	IMPORTANCE FACTOR
13027	6.62300E-02	4	11074	11074	1.00	1 1 1	23	1.99843E-02	5.40000E-04	2.14025E-01
MATERIAL	2 HAS	4 NUCLEI	14	10 STORAGE	5074	2 17	5			

NUCLEI	DENSITY	RECT. REACT.	FRACTION RESID.	DECAY RESID.	DECAY WEIGHT	STORAGE POINTS	DECAY INDEX	TOTAL INTENSITY	HALFLIFE SECONDS	IMPORTANCE FACTOR
26054	4.85500E-03	3	25054	25054	1.00	9 1 1	90	9.99760E-01	2.70000E-07	6.60728E-02
26054	4.85500E-03	4	24051	24051	1.00	5 1 1	92	9.82999E-02	2.33340E-04	6.66094E-04
26054	4.85500E-03	7	25052	25052	0.50	7 1 1	-80	3.58443E-07	4.83040E-05	6.38605E-04
				25052	0.50	2 2 1	89	2.93610E-03	1.26600E-03	5.23162E-04
26056	7.71000E-02	3	25056	25056	1.00	10 1 1	91	1.42511E-03	9.28260E-03	1.71801E-01
26056	7.71000E-02	7	25054	25054	1.00	9 1 1	90	9.99760E-01	2.70000E-07	6.60728E-02
26057	1.84200E-03	5	25056	25056	1.00	10 1 1	91	1.42511E-03	9.28260E-03	1.71801E-01
26058	2.77600E-04	2	26059	26059	1.00	15 1 1	95	1.03970E-00	3.84730E-04	7.08983E-03
26058	2.77600E-04	7	25056	25056	1.00	10 1 1	91	1.42511E-03	9.28260E-03	1.71801E-01

FROM THE ABOVE INFORMATION, BOOKIE DETERMINES STORAGE LOCATIONS BASED ON UNIQUE STORAGE POINTERS. BELOW IS A LISTING OF RESIDUALS SORTED ACCORDING TO ASCENDING POINTERS.

FOR 10 STORAGE POINTERS THERE WERE 7 UNIQUE POINTERS	WAT	POINTERS	ISTEP	ISTOP	TARGET	REACT.	RESID.	WEIGHT	WT-SUM
1	111	1	1	13027	4	11074	2.14025E-01	2.14025E-01	
2	511	3	2	26054	4	24051	6.66094E-04	6.66094E-04	
2	711	4	3	26054	7	25052	6.38605E-04	6.38605E-04	
2	721	5	4	26054	7	25052	5.23162E-04	5.23162E-04	
2	911	2	5	26054	3	25054	6.60728E-02	6.60728E-02	
2	911	7	5	26056	7	25054	3.63074E-06	3.63074E-06	
2	1011	6	6	26056	3	25056	1.71801E-01	1.71801E-01	
2	1011	8	6	26057	5	25056	4.98967E-04	1.72390E-01	
2	1011	10	6	26058	7	25056	9.07043E-04	1.72390E-01	
2	1511	9	7	26058	2	26059	7.08983E-03	7.08983E-03	

A LISTING OF RESIDUAL WEIGHTS (NUMBER PRODUCED) BY R,Z INTERVALS AND RESIDUALS FOLLOWS.

FOR RESIDUAL 11024 MAP OF WEIGHTS BY P,Z INTERVALS

IZ =	1	2	3	4
IP				
3	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0
1	5.3506E-02	5.3506E-02	5.3506E-02	5.3506E-02

TOTAL WEIGHT OVER ALL P,Z INTERVALS = 2.140244E-01

FOR RESIDUAL 24051 MAP OF WEIGHTS BY P,Z INTERVALS

IZ =	1	2	3	4
IP				
3	1.6652E-04	1.6652E-04	1.6652E-04	1.6652E-04
2	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0

TOTAL WEIGHT OVER ALL P,Z INTERVALS = 6.660924E-04

FOR RESIDUAL 25052 MAP OF WEIGHTS BY P,Z INTERVALS

IZ =	1	2	3	4
IP				
3	1.5567E-08	1.5567E-08	1.5567E-08	1.5567E-08
2	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0

TOTAL WEIGHT OVER ALL P,Z INTERVALS = 6.386654E-08

FOR RESIDUAL 25052 MAP OF WEIGHTS BY P,Z INTERVALS

IZ =	1	2	3	4
IP				
3	1.3079E-08	1.3079E-08	1.3079E-08	1.3079E-08
2	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0

TOTAL WEIGHT OVER ALL P,Z INTERVALS = 5.231621E-08

FOR RESIDUAL 25054 MAP OF WEIGHTS BY P,Z INTERVALS

IZ =	1	2	3	4
IP				
3	2.1519E-02	2.1519E-02	2.1519E-02	2.1519E-02
2	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0

TOTAL WEIGHT OVER ALL P,Z INTERVALS = 8.607543E-02

FOR RESIDUAL 25056 MAP OF WEIGHTS BY P,Z INTERVALS

IZ =	1	2	3	4
IP				
3	4.3095E-02	4.3095E-02	4.3095E-02	4.3095E-02
2	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0

TOTAL WEIGHT OVER ALL P,Z INTERVALS = 1.723797E-01

FOR RESIDUAL 26059 MAP OF WEIGHTS BY P,Z INTERVALS

IZ =	1	2	3	4
IP				
3	1.7725E-03	1.7725E-03	1.7725E-03	1.7725E-03
2	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0

TOTAL WEIGHT OVER ALL P,Z INTERVALS = 7.089827E-03

THE RESIDUALS PRODUCED, SORTED ACCORDING TO ASCENDING WEIGHTS, ARE SPECIFICALLY WEIGHTS USED IN MORSE - MODE 2 ARE NORMALIZED SO THAT PHOTONS ARE NOT KILLED TOO QUICKLY. THE TOTAL WEIGHT OF EACH RESIDUAL IS INCLUDED AS OUTPUT ON LOGICAL 21 FOR LATER USE IN DEPB1.

RESIDUALS SORTED ACCORDING TO ASCENDING WEIGHTS

I-NEW	I-OLD	PRINTED	RESID.	WEIGHT
1	4	721	25052	5.231621E-08
2	2	711	25052	6.386654E-09
3	2	511	24051	6.550924E-06
4	7	1511	26059	7.089827E-03
5	5	911	25056	8.607543E-02
6	6	1011	25056	1.723797E-01
7	1	111	11024	2.140244E-01

FIG. 5 SELECTED OUTPUT FROM MORSE - MODE 2

ONLY THE BRACKETED QUANTITY IN EQUATION (18) OF SECTION II IS SHOWN HERE AS A FUNCTION OF RADIAL AND DEPTH INTERVAL FOR EACH RESIDUAL. THE FIRST SECTION FOR EACH RESIDUAL HAS QUANTITIES COMPUTED FOR RADIAL CROSSINGS AND THE SECOND SECTION HAS QUANTITIES COMPUTED FOR HORIZONTAL CROSSINGS.

TABLE OF DMSFS PER UNIT AREA JAZ = 25052 WITH Z = 25 AND A = 57

BOUNDARY =	1.500000E 01	9.070000E 01	1.777000E 02
Z UPPER			
5.000000E 01	7.210444E-16	1.232814E-15	7.117931E-16
1.000000E 02	7.718789E-16	1.395363E-15	9.267944E-16
1.500000E 02	1.002046E-15	1.241263E-15	9.055864E-16
2.000000E 02	3.769281E-16	1.317372E-15	9.514459E-16
BOUNDARY =	1.500000E 01	9.070000E 01	1.077000E 02
Z UPPER			
0.0	6.360646E-16	1.077719E-15	7.271514E-16
5.000000E 01	9.785992E-16	1.162150E-15	7.023762E-16
1.000000E 02	7.148190E-16	7.300913E-15	1.673134E-15
1.500000E 02	2.126569E-16	1.153199E-15	7.747449E-15
2.000000E 02	0.0	7.114911E-16	8.694862E-16

TABLE OF DMSFS PER UNIT AREA JAZ = 25052 WITH Z = 25 AND A = 52

BOUNDARY =	1.500000E 01	9.070000E 01	1.077000E 02
Z UPPER			
5.000000E 01	1.062955E-15	1.219444E-15	9.681565E-16
1.000000E 02	1.067343E-15	1.251966E-15	8.539492E-16
1.500000E 02	1.772081E-15	1.199169E-15	7.442531E-16
2.000000E 02	5.922626E-16	1.091709E-15	8.114267E-16
BOUNDARY =	1.500000E 01	9.070000E 01	1.077000E 02
Z UPPER			
0.0	6.061599E-17	7.375466E-16	7.435296E-16
5.000000E 01	4.730241E-16	1.647499E-15	1.867097E-15
1.000000E 02	6.402678E-16	1.254715E-15	7.027583E-15
1.500000E 02	2.729780E-16	1.071815E-15	1.297404E-15
2.000000E 02	5.765429E-16	6.730194E-16	6.416403E-16

TABLE OF DOSES PER UNIT AREA JAZ = 26051 WITH Z = 26 AND A = 51

BOUNDARY =	1.500000E 01	9.000000E 01	1.000000E 02
Z UPPER			
5.000000E 01	1.677792E-16	3.357475E-16	2.357482E-16
1.000000E 02	2.602121E-16	3.451167E-16	1.557378E-16
1.500000E 02	3.379196E-16	4.795855E-16	1.441924E-16
2.000000E 02	1.708677E-16	3.278595E-16	2.227134E-16
BOUNDARY =	1.500000E 01	9.000000E 01	1.000000E 02
Z UPPER			
0.0	2.735007E-17	1.639561E-16	2.227121E-16
5.000000E 01	1.872927E-17	4.115279E-16	5.887773E-16
1.000000E 02	4.143287E-17	3.642178E-16	4.367842E-16
1.500000E 02	2.397811E-17	2.372048E-16	6.569706E-16
2.000000E 02	0.0	2.517166E-16	1.251329E-16

TABLE OF DOSES PER UNIT AREA JAZ = 26059 WITH Z = 26 AND A = 59

BOUNDARY =	1.500000E 01	9.000000E 01	1.000000E 02
Z UPPER			
5.000000E 01	1.567033E-15	2.259964E-15	1.152911E-15
1.000000E 02	7.387078E-16	2.272668E-15	1.103293E-15
1.500000E 02	1.213844E-15	2.067162E-15	1.057178E-15
2.000000E 02	7.920583E-16	2.177672E-15	7.611873E-16
BOUNDARY =	1.500000E 01	9.000000E 01	1.000000E 02
Z UPPER			
0.0	1.463439E-16	1.337772E-15	1.136223E-15
5.000000E 01	5.536095E-16	1.249242E-15	1.877364E-15
1.000000E 02	2.583446E-16	1.846057E-15	2.807714E-15
1.500000E 02	1.433111E-15	2.214194E-15	3.459104E-15
2.000000E 02	8.067225E-16	1.179194E-15	7.676672E-16

TABLE OF DOSES PER UNIT AREA JAZ = 25054 WITH Z = 25 AND A = 54

BOUNDARY =	1.500000E 01	9.000000E 01	1.000000E 02
Z UPPER			
5.000000E 01	3.978967E-16	8.872935E-16	6.754858E-16
1.000000E 02	7.049614E-16	1.032916E-15	6.657400E-16
1.500000E 02	4.628753E-16	1.616662E-15	4.981032E-16
2.000000E 02	4.554475E-16	1.201152E-15	6.140551E-16
BOUNDARY =	1.500000E 01	9.000000E 01	1.000000E 02
Z UPPER			
0.0	1.845003E-19	5.121773E-16	2.596495E-16
5.000000E 01	2.361761E-16	7.940908E-16	5.533713E-16
1.000000E 02	7.067374E-17	1.135617E-15	1.272516E-15
1.500000E 02	1.263039E-16	8.841104E-16	1.433048E-15
2.000000E 02	0.0	4.917657E-16	7.229123E-16

TABLE OF DOSES PER UNIT AREA JAZ = 25056 WITH Z = 25 AND A = 56

BOUNDARY =	1.500000E 01	9.000000E 01	1.000000E 02
Z UPPER			
5.000000E 01	1.065691E-15	1.431359E-15	1.022785E-15
1.000000E 02	2.487218E-15	1.804993E-15	1.041915E-15
1.500000E 02	8.267600E-16	1.755455E-15	1.061054E-15
2.000000E 02	1.697671E-15	1.692511E-15	2.612745E-16
BOUNDARY =	1.500000E 01	9.000000E 01	1.000000E 02
Z UPPER			
0.0	2.732291E-16	8.356190E-16	7.857350E-16
5.000000E 01	1.552238E-15	1.581514E-15	2.059517E-15
1.000000E 02	1.542773E-15	1.665098E-15	1.572910E-15
1.500000E 02	1.588332E-16	1.349051E-15	2.135701E-15
2.000000E 02	1.117836E-17	9.719517E-16	3.673607E-16

TABLE OF DOSES PER UNIT AREA JAZ = 11024 WITH Z = 11 AND A = 24

R BOUNDARY =	1.500000E 01	9.000000E 01	1.000000E 02
Z UPPER			
5.000000E 01	3.117467E-14	2.696590E-15	1.502571E-16
1.000000E 02	3.940104E-14	3.786312E-15	2.075713E-16
1.500000E 02	3.489229E-14	3.519713E-15	2.139752E-16
2.000000E 02	3.143302E-14	2.775820E-15	1.834533E-16
R BOUNDARY =	1.500000E 01	9.000000E 01	1.000000E 02
Z UPPER			
0.0	3.566150E-14	3.391148E-15	7.397664E-16
5.000000E 01	6.601983E-14	6.568422E-15	1.406930E-15
1.000000E 02	6.065092E-14	7.439650E-15	1.996755E-15
1.500000E 02	6.749983E-14	6.183056E-15	1.265741E-15
2.000000E 02	7.757184E-14	3.579128E-15	5.241215E-15

VII.6 SELECTED CLTPUT FROM DERBT

DOSES ARE OUTPUT IN REM/H FOR SIX SURFACES AS A FUNCTION OF TIME AFTER SHUTDOWN. DEPTH INTERVALS WERE SPACED 50 CM APART IN MORSE - MODE 2 WHICH WERE COMBINED TO GIVE INTERVALS OF 100 CM IN DERBT (SEE DATA FOR DERBT). THE DOSE RATES WERE OBTAINED FROM THE RADIAL CROSSINGS OF THE EMITTED PHOTONS. AS DOSES ARE COMPUTED FOR A SURFACE, THE CONTRIBUTION FROM EACH RESIDUAL IS AVAILABLE. BATCH STATISTICS ARE CALCULATED FOR THE TOTAL EMITTED DOSE RATE. THE HEADER INFORMATION IS SELF-EXPLANATORY. FOR EACH RESIDUAL TWO LINES OF PRINT ARE SHOWN. THE FIRST GIVES THE CONTRIBUTION TO THE TOTAL DOSE AND THE SECOND GIVES THE SUM OVER CONTRIBUTING RESIDUALS TO THAT POINT. THE RESIDUALS ARE LISTED AND USED IN ORDER OF ASCENDING HEIGHTS DETERMINED BY RUMBLE. BATCH STATISTICS ARE GIVEN FOR THE TOTAL DOSE RATES BY BATCHES AND THE AVERAGE OVER ALL BATCHES. SIGMA AND THE ERROR IN PERCENT FOR THESE QUANTITIES ARE INCLUDED HERE. TIME OF SHUTDOWN IS MEASURED TO THE END OF LAST PULSE AND NOT TO THE END OF THE LAST PULSE PERIOD.

DOSES AS FUNCTION OF TIME AND SURFACE WITH TO = 3.47220-03 DAYS

DOSES FROM MORSE RESIDUALS (LOW L. RGY COLLISIONS)

SURFACE RADIUS = 1.500000E 01 DEPTH INTERVAL 0.0

TO 1.000000E 02

THIS IS THE 1-TH SURFACE FOR RADIUS 1 AND DEPTH INTERVAL 1

SHUTDOWN AT 9.343760 CO DAYS

TIMES BELOW ARE TIMES AFTER SHUTDOWN

YEARS =	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DAYS =	0.0	0.0	0.0	0.0	0.0	1.00E 00	3.00E 00	7.00E 00
HOURS =	1.00E 00	2.00E 00	4.00E 00	8.00E 00	1.60E 01	0.0	0.0	0.0
Z--A								
25052 1	3.38E-11	4.71E-12	9.13E-14	3.44E-17	4.88E-24	6.93E-31	0.0	0.0
	3.38E-11	4.71E-12	9.13E-14	3.44E-17	4.88E-24	6.93E-31	0.0	0.0
25052 2	1.05E-10	1.05E-10	1.04E-10	1.02E-10	9.74E-11	9.35E-11	7.29E-11	4.44E-11
	1.35E-10	1.09E-10	1.04E-10	1.02E-10	9.74E-11	9.35E-11	7.29E-11	4.44E-11
24051 3	6.62E-08	6.61E-08	6.60E-08	6.57E-08	6.52E-08	6.46E-08	6.15E-08	5.56E-08
	6.63E-08	6.62E-08	6.61E-08	6.58E-08	6.53E-08	6.47E-08	6.16E-08	5.57E-08
26059 4	2.47E-06	2.45E-06	2.46E-06	2.45E-06	2.44E-06	2.43E-06	2.35E-06	2.21E-06
	2.53E-06	2.53E-06	2.53E-06	2.52E-06	2.51E-06	2.49E-06	2.42E-06	2.27E-06
25054 5	2.17E-06	2.17E-06	2.17E-06	2.17E-06	2.17E-06	2.17E-06	2.16E-06	2.14E-06
	4.70E-06	4.70E-06	4.70E-06	4.69E-06	4.67E-06	4.66E-06	4.57E-06	4.41E-06
25056 6	1.27E-03	9.71E-04	5.67E-04	1.94E-04	2.25E-05	2.62E-06	6.53E-12	4.05E-23
	1.28E-03	9.74E-04	5.72E-04	1.98E-04	2.72E-05	7.28E-06	4.57E-06	4.41E-06
11024 7	2.07E-02	1.97E-02	1.80E-02	1.50E-02	1.03E-02	7.14E-03	7.77E-04	9.20E-06
	2.20E-02	2.07E-02	1.86E-02	1.52E-02	1.04E-02	7.15E-03	7.82E-04	1.36E-05

BATCH								
1	2.36E-02	2.24E-02	2.03E-02	1.68E-02	1.16E-02	7.98E-03	8.71E-04	1.38E-05
2	2.39E-02	2.27E-02	2.05E-02	1.68E-02	1.15E-02	7.97E-03	8.71E-04	1.43E-05
3	1.57E-02	1.47E-02	1.31E-02	1.07E-02	7.28E-03	5.02E-03	5.51E-04	1.12E-05
4	2.10E-02	2.00E-02	1.81E-02	1.50E-02	1.04E-02	7.16E-03	7.82E-04	1.22E-05
5	2.40E-02	2.28E-02	2.05E-02	1.68E-02	1.15E-02	7.97E-03	8.73E-04	1.70E-05
6	2.23E-02	2.11E-02	1.89E-02	1.55E-02	1.06E-02	7.31E-03	8.01E-04	1.49E-05
7	2.25E-02	2.15E-02	1.95E-02	1.62E-02	1.12E-02	7.73E-03	8.44E-04	1.31E-05
8	1.93E-02	1.79E-02	1.57E-02	1.26E-02	8.47E-03	5.83E-03	6.39E-04	1.25E-05
9	1.99E-02	1.84E-02	1.69E-02	1.38E-02	9.46E-03	6.53E-03	7.14E-04	1.22E-05
10	2.74E-02	2.53E-02	2.20E-02	1.74E-02	1.16E-02	8.90E-03	8.74E-04	1.48E-05
AVERAGE	2.20E-02	2.07E-02	1.86E-02	1.52E-02	1.04E-02	7.15E-03	7.82E-04	1.36E-05
SIGMA	1.02E-03	9.49E-04	8.43E-04	6.91E-04	4.77E-04	3.30E-04	3.48E-05	5.36E-07
FRACR	4.64E 00	4.54E 00	4.54E 00	4.56E 00	4.60E 00	4.61E 00	4.58E 00	3.94E 00

DOSES AS FUNCTION OF TIME AND SURFACE WITH TO = 3.47220-03 DAYS

DOSES FROM MORSE RESIDUALS (LOW ENERGY COLLISIONS)

SURFACE RADIALS = 5.000000E 01 DEPTH INTERVAL 1.700000E 02 TO 2.300000E 02

THIS IS THE 4-TH SURFACE FOR RADII 2 AND DEPTH INTERVAL 2

SHUTDOWN AT 5.343760 00 DAYS TIMES BEFORE ARE TIMES AFTER SHUTDOWN

YEARS =	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DAYS =	0.0	0.0	0.0	0.0	0.0	0.0	1.70E 00	3.00E 00	7.00E 00
HOURS =	1.00E 00	2.00E 00	4.00E 00	5.00E 00	1.60E 01	0.0	0.0	0.0	0.0
7--A									
25052 1	6.07E-11	8.45E-12	1.64E-13	6.18E-17	8.76E-24	1.24E-30	0.0	0.0	0.0
	6.07E-11	8.45E-12	1.64E-13	6.18E-17	8.76E-24	1.24E-30	0.0	0.0	0.0
25052 2	1.12E-10	1.12E-10	1.10E-10	1.38E-10	1.04E-10	9.96E-11	7.77E-11	4.73E-11	4.73E-11
	1.73E-10	1.20E-10	1.11E-10	1.08E-10	1.04E-10	9.96E-11	7.77E-11	4.73E-11	4.73E-11
24051 3	1.25E-07	1.25E-07	1.25E-07	1.24E-07	1.23E-07	1.22E-07	1.16E-07	1.05E-07	1.05E-07
	1.25E-07	1.25E-07	1.25E-07	1.24E-07	1.23E-07	1.22E-07	1.16E-07	1.05E-07	1.05E-07
26059 4	4.56E-06	4.54E-06	4.53E-06	4.52E-06	4.50E-06	4.47E-06	4.33E-06	4.07E-06	4.07E-06
	4.66E-06	4.65E-06	4.65E-06	4.64E-06	4.62E-06	4.59E-06	4.45E-06	4.18E-06	4.18E-06
25054 5	5.55E-06	5.59E-06	5.58E-06	5.58E-06	5.58E-06	5.57E-06	5.55E-06	5.50E-06	5.50E-06
	1.02E-05	1.02E-05	1.02E-05	1.02E-05	1.02E-05	1.02E-05	1.00E-05	9.68E-06	9.68E-06
25056 6	1.24E-03	5.45E-04	5.52E-04	1.88E-04	2.19E-05	2.55E-06	6.15E-12	3.94E-23	3.94E-23
	1.25E-03	9.56E-04	5.62E-04	1.99E-04	3.21E-05	1.27E-05	1.30E-05	9.68E-06	9.68E-06
11024 7	1.85E-03	1.77E-03	1.61E-03	1.36E-03	9.25E-04	6.39E-04	6.76E-05	8.74E-07	8.74E-07
	3.10E-03	2.72E-03	2.17E-03	1.54E-03	9.57E-04	6.52E-04	7.96E-05	1.05E-05	1.05E-05

BATCH

1	2.48E-03	2.19E-03	1.76E-03	1.26E-03	7.93E-04	5.41E-04	6.85E-05	1.14E-05	1.14E-05
2	3.29E-03	2.90E-03	2.33E-03	1.66E-03	1.04E-03	7.05E-04	8.48E-05	9.91E-06	9.91E-06
3	2.57E-03	2.67E-03	2.20E-03	1.63E-03	1.05E-03	7.19E-04	8.57E-05	9.21E-06	9.21E-06
4	2.78E-03	2.45E-03	1.96E-03	1.39E-03	8.69E-04	5.92E-04	7.28E-05	9.97E-06	9.97E-06
5	2.90E-03	2.56E-03	2.05E-03	1.46E-03	9.15E-04	6.23E-04	7.44E-05	9.17E-06	9.17E-06
6	2.73E-03	2.46E-03	2.05E-03	1.54E-03	1.00E-03	6.89E-04	8.33E-05	1.02E-05	1.02E-05
7	3.83E-03	3.30E-03	2.55E-03	1.72E-03	1.03E-03	6.93E-04	8.19E-05	8.28E-05	8.28E-05
8	3.76E-03	3.27E-03	2.56E-03	1.76E-03	1.07E-03	7.23E-04	8.68E-05	1.01E-05	1.01E-05
9	2.82E-03	2.46E-03	1.94E-03	1.35E-03	8.29E-04	5.66E-04	7.74E-05	1.85E-05	1.85E-05
10	2.41E-03	2.97E-03	2.33E-03	1.91E-03	9.83E-04	6.67E-04	8.90E-05	7.29E-06	7.29E-06
AVERAGE	3.10E-03	2.72E-03	2.17E-03	1.54E-03	9.57E-04	6.52E-04	7.96E-05	1.05E-05	1.05E-05
STGMA	1.44E-04	1.18E-04	8.42E-05	5.25E-05	3.13E-05	2.10E-05	1.93E-06	9.40E-07	9.40E-07
ERROR	4.64E 00	4.34E 00	3.87E 00	3.42E 00	3.27E 00	3.22E 00	2.43E 00	9.35E 00	9.35E 00

DOSES AS FUNCTION OF TIME AND SURFACE WITH TO = 3.47220-03 DAYS

DOSES FROM MORSE RESIDUALS (LOW ENERGY COLLISIONS)

SURFACE RADIALS = 1.000000E 02 DEPTH INTERVAL 0.0 TO 1.000000E 02

THIS IS THE 5-TH SURFACE FOR RADII 3 AND DEPTH INTERVAL 1

SHUTDOWN AT 5.343760 00 DAYS TIMES BEFORE ARE TIMES AFTER SHUTDOWN

YEARS =	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DAYS =	0.0	0.0	0.0	0.0	0.0	0.0	1.00E 00	3.00E 00	7.00E 00
HOURS =	1.00E 00	2.00E 00	4.00E 00	5.00E 00	1.60E 01	0.0	0.0	0.0	0.0
7--A									
25052 1	3.64E-11	5.07E-12	9.85E-14	3.71E-17	5.26E-24	7.47E-31	0.0	0.0	0.0
	3.64E-11	5.07E-12	9.85E-14	3.71E-17	5.26E-24	7.47E-31	0.0	0.0	0.0
25052 2	8.43E-11	8.39E-11	8.30E-11	8.13E-11	7.80E-11	7.49E-11	5.84E-11	3.56E-11	3.56E-11
	1.21E-10	8.99E-11	8.31E-11	8.11E-11	7.90E-11	7.49E-11	5.84E-11	3.56E-11	3.56E-11
24051 3	6.04E-08	6.03E-08	6.02E-08	6.00E-08	5.95E-08	5.90E-08	5.81E-08	5.08E-08	5.08E-08
	6.05E-08	6.04E-08	6.03E-08	6.01E-08	5.96E-08	5.91E-08	5.82E-08	5.08E-08	5.08E-08
26059 4	2.41E-06	2.41E-06	2.41E-06	2.40E-06	2.39E-06	2.38E-06	2.30E-06	2.16E-06	2.16E-06
	2.47E-06	2.47E-06	2.47E-06	2.46E-06	2.45E-06	2.44E-06	2.36E-06	2.22E-06	2.22E-06
25054 5	2.64E-06	2.64E-06	2.64E-06	2.64E-06	2.64E-06	2.63E-06	2.62E-06	2.60E-06	2.60E-06
	5.11E-06	5.11E-06	5.11E-06	5.10E-06	5.09E-06	5.07E-06	4.98E-06	4.82E-06	4.82E-06
25056 6	7.38E-04	5.64E-04	3.30E-04	1.12E-04	1.31E-05	1.52E-06	3.80E-12	2.35E-23	2.35E-23
	7.43E-04	5.69E-04	3.35E-04	1.18E-04	1.82E-05	6.59E-06	4.98E-06	4.82E-06	4.82E-06
11024 7	1.05E-04	1.00E-04	9.13E-05	7.59E-05	5.24E-05	3.62E-05	3.94E-06	4.67E-08	4.67E-08
	8.48E-04	6.69E-04	4.26E-04	1.93E-04	7.06E-05	4.28E-05	8.92E-06	4.86E-06	4.86E-06

BATCH

1	4.72E-04	3.39E-04	2.75E-04	1.59E-04	8.29E-05	5.57E-05	1.08E-05	5.26E-06	5.26E-06
2	7.35E-04	5.81E-04	3.76E-04	1.76E-04	6.87E-05	4.26E-05	8.54E-06	4.43E-06	4.43E-06
3	9.74E-04	7.59E-04	4.68E-04	1.96E-04	5.72E-05	3.24E-05	8.88E-06	6.10E-06	6.10E-06
4	6.79E-04	5.30E-04	3.29E-04	1.38E-04	4.28E-05	2.49E-05	7.09E-06	4.94E-06	4.94E-06
5	1.38E-03	1.07E-03	6.61E-04	2.73E-04	7.86E-05	4.25E-05	7.45E-06	3.43E-06	3.43E-06
6	8.68E-04	6.89E-04	4.44E-04	2.08E-04	8.07E-05	4.98E-05	9.53E-06	4.69E-06	4.69E-06
7	6.42E-04	5.27E-04	3.43E-04	1.65E-04	6.74E-05	4.26E-05	9.21E-06	5.15E-06	5.15E-06
8	5.80E-04	7.64E-04	4.71E-04	1.95E-04	5.74E-05	3.20E-05	7.84E-06	4.97E-06	4.97E-06
9	7.23E-04	5.75E-04	3.73E-04	1.78E-04	7.14E-05	4.46E-05	8.93E-06	4.61E-06	4.61E-06
10	1.01E-03	8.05E-04	5.21E-04	2.44E-04	9.87E-05	6.11E-05	1.10E-05	5.04E-06	5.04E-06
AVERAGE	8.48E-04	6.69E-04	4.26E-04	1.93E-04	7.06E-05	4.28E-05	8.92E-06	4.86E-06	4.86E-06
STGMA	7.98E-05	6.08E-05	3.54E-05	1.29E-05	4.99E-06	3.00E-06	4.09E-07	2.15E-07	2.15E-07
ERROR	9.41E 00	9.08E 00	8.32E 00	6.69E 00	7.07E 00	8.17E 00	4.59E 00	4.43E 00	4.43E 00

DOSES AS A FUNCTION OF TIME AND SURFACE WITH TO = 3.47220-03 DAYS

DOSES FROM WORKS RESIDUALS (LOW ENERGY COLLISIONS)

SURFACE PATCHES = 1.00000E-02 DEPTH INTERVAL 1.00000E-02 TO 2.00000E-02

THIS IS THE ONLY SURFACE FOR PATCH 1 AND DEPTH INTERVAL 2

SHUTDOWN AT 0.343760 CO DAYS

TIMES BELOW ARE TIMES AFTER SHUTDOWN

YEARS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DAYS	0.0	0.0	0.0	0.0	0.0	1.00E-00	3.00E-00	7.00E-00
HOURS	1.00E-00	2.00E-00	4.00E-00	6.00E-00	8.00E-00	0.0	0.0	0.0
1--4								
25052	1	4.40E-11	6.13E-12	1.19E-13	4.49E-17	5.16E-24	9.03E-31	0.0
		4.40E-11	6.13E-12	1.19E-13	4.49E-17	6.36E-24	9.22E-31	0.0
25053	2	7.42E-11	7.54E-11	7.50E-11	7.35E-11	7.05E-11	6.76E-11	5.28E-11
		1.20E-10	9.19E-11	7.51E-11	7.35E-11	7.05E-11	6.75E-11	5.28E-11
24051	3	5.67E-08	5.64E-08	5.65E-08	5.63E-08	5.58E-08	5.53E-08	5.26E-08
		5.66E-08	5.67E-08	5.66E-08	5.63E-08	5.59E-08	5.54E-08	5.27E-08
26055	4	1.55E-06	1.55E-06	1.54E-06	1.56E-06	1.93E-06	1.92E-06	1.86E-06
		2.00E-06	2.00E-06	2.00E-06	1.99E-06	1.98E-06	1.97E-06	1.91E-06
25054	5	2.19E-06	2.19E-06	2.19E-06	2.19E-06	2.19E-06	2.18E-06	2.17E-06
		4.19E-06	4.19E-06	4.19E-06	4.19E-06	4.17E-06	4.16E-06	4.09E-06
25056	6	7.23E-04	5.53E-04	3.23E-04	1.13E-04	1.28E-05	1.49E-06	3.72E-12
		7.27E-04	5.57E-04	3.27E-04	1.14E-04	1.70E-05	5.65E-06	4.09E-06
11024	7	1.15E-04	1.10E-04	5.99E-05	3.31E-05	5.74E-05	3.97E-05	4.32E-06
		6.42E-04	6.64E-04	6.27E-04	1.97E-04	7.44E-05	6.53E-05	8.40E-06

PATCH								
1	6.88E-04	5.50E-04	3.51E-04	1.78E-04	7.48E-05	4.68E-05	7.34E-06	2.61E-06
2	6.88E-04	5.50E-04	3.51E-04	1.78E-04	9.72E-05	6.32E-05	1.05E-05	4.16E-06
3	1.04E-03	8.15E-04	5.15E-04	2.29E-04	7.85E-05	4.58E-05	7.31E-06	2.81E-06
4	1.00E-03	7.93E-04	4.84E-04	2.02E-04	6.08E-05	3.42E-05	7.98E-06	4.90E-06
5	1.08E-03	9.41E-04	5.10E-04	2.01E-04	5.00E-05	2.52E-05	5.55E-06	3.34E-06
6	7.31E-04	5.87E-04	3.89E-04	1.96E-04	8.59E-05	5.47E-05	9.72E-06	4.28E-06
7	6.46E-04	5.00E-04	3.16E-04	1.36E-04	4.46E-05	2.64E-05	7.19E-06	4.88E-06
8	1.06E-03	8.45E-04	5.47E-04	2.60E-04	1.02E-04	6.31E-05	1.07E-05	4.43E-06
9	5.58E-04	4.47E-04	2.95E-04	1.47E-04	6.36E-05	4.10E-05	8.81E-06	4.89E-06
10	5.21E-04	7.31E-04	4.71E-04	2.21E-04	8.58E-05	5.25E-05	8.91E-06	3.69E-06
AVERAGE	8.42E-04	6.66E-04	4.27E-04	1.77E-04	7.44E-05	4.53E-05	8.40E-06	4.00E-06
SIGMA	6.30E-05	4.80E-05	2.83E-05	1.10E-05	4.12E-06	4.33E-06	5.16E-07	2.70E-07
ERROR	7.48E-00	7.21E-00	6.62E-00	5.63E-00	3.23E-00	9.55E-00	6.15E-00	6.75E-00

TOTAL DOSE RATES BY R,Z INTERVAL ARE LISTED BELOW FOR EIGHT TIMES AFTER SHUTDOWN. TWO LINES OF PRINT ARE SHOWN FOR EACH INTERVAL. THE FIRST LINE GIVES THE TOTAL DOSE FROM EMITTED PHOTONS CROSSING THE APPROPRIATE RADII AND THE SECOND LINE GIVES THE STATISTICAL ERROR IN PERCENT.

DOSES AT 0.0 YEARS 0.0 DAYS 1.00000E-00 HOURS AFTER SHUTDOWN
DOSES FROM WORKS RESIDUALS (LOW ENERGY COLLISIONS)
SHUTDOWN AT 0.343760 CO DAYS TO = 3.47220-03 DAYS
Z INTERVAL 1 2
P INTERVAL

1	2.195E-02	2.034E-02
	4.640E-00	3.412E-00
2	3.066E-03	3.077E-03
	5.342E-00	4.642E-00
3	6.482E-04	3.420E-04
	5.405E-00	7.478E-00

DOSES AT 0.0 YEARS 0.0 DAYS 2.00000E-00 HOURS AFTER SHUTDOWN
DOSES FROM WORKS RESIDUALS (LOW ENERGY COLLISIONS)
SHUTDOWN AT 0.343760 CO DAYS TO = 3.47220-03 DAYS
Z INTERVAL 1 2
P INTERVAL

1	2.072E-02	1.925E-02
	4.581E-00	3.450E-00
2	2.707E-03	2.722E-03
	4.817E-00	4.362E-00
3	6.654E-04	6.664E-04
	5.083E-00	7.204E-00

DOSES AT 0.1 YEARS 0.1 DAYS 4.22222E 00 HOURS AFTER SHUTDOWN
 DOSES FROM MORSE RESIDUALS (LOW ENERGY COLLISIONS)
 SHUTDOWN AT 5.34376E 00 DAYS TO = 3.47222D-03 DAYS
 Z INTERVAL 1 2
 R INTERVAL

1	1.857E-02	1.732E-02
	4.535E 00	3.548E 00
2	2.174E-03	2.173E-03
	1.571E 00	1.872E 00
3	4.255E-04	4.264E-04
	8.372E 00	6.620E 00

DOSES AT 0.0 YEARS 0.0 DAYS 8.00000E 00 HOURS AFTER SHUTDOWN
 DOSES FROM MORSE RESIDUALS (LOW ENERGY COLLISIONS)
 SHUTDOWN AT 5.34376E 00 DAYS TO = 3.47222D-03 DAYS
 Z INTERVAL 1 2
 R INTERVAL

1	1.516E-02	1.420E-02
	4.558E 00	3.705E 00
2	1.559E-03	1.537E-03
	2.123E 00	1.415E 00
3	1.536E-04	1.974E-04
	6.654E 00	5.880E 00

DOSES AT 0.0 YEARS 0.0 DAYS 1.60000E 01 HOURS AFTER SHUTDOWN
 DOSES FROM MORSE RESIDUALS (LOW ENERGY COLLISIONS)
 SHUTDOWN AT 5.34376E 00 DAYS TO = 3.47222D-03 DAYS
 Z INTERVAL 1 2
 R INTERVAL

1	1.036E-02	9.735E-03
	4.600E 00	3.820E 00
2	5.789E-04	9.572E-04
	2.905E 00	1.265E 00
3	7.059E-05	7.439E-05
	7.075E 00	8.226E 00

DOSES AT 0.0 YEARS 0.0 DAYS 2.00000E 00 HOURS AFTER SHUTDOWN
 DOSES FROM MORSE RESIDUALS (LOW ENERGY COLLISIONS)
 SHUTDOWN AT 5.34376E 00 DAYS TO = 3.47222D-03 DAYS
 Z INTERVAL 1 2
 R INTERVAL

1	7.150E-03	6.719E-03
	4.608E 00	3.842E 00
2	6.673E-04	4.519E-04
	2.910E 00	3.224E 00
3	4.281E-05	4.531E-05
	8.167E 00	9.550E 00

DOSES AT 0.0 YEARS 3.00000E 00 DAYS 0.0 HOURS AFTER SHUTDOWN
 DOSES FROM MORSE RESIDUALS (LOW ENERGY COLLISIONS)
 SHUTDOWN AT 5.34376E 00 DAYS TO = 3.47222D-03 DAYS
 Z INTERVAL 1 2
 R INTERVAL

1	7.813E-04	7.344E-04
	4.583E 00	3.860E 00
2	7.997E-05	7.956E-05
	2.851E 00	2.430E 00
3	8.974E-06	8.402E-06
	4.588E 00	6.147E 00

DOSES AT 0.0 YEARS 7.00000E 00 DAYS 0.0 HOURS AFTER SHUTDOWN
 DOSES FROM MORSE RESIDUALS (LOW ENERGY COLLISIONS)
 SHUTDOWN AT 5.34376E 00 DAYS TO = 3.47222D-03 DAYS
 Z INTERVAL 1 2
 R INTERVAL

1	1.361E-05	1.246E-05
	3.938E 00	5.017E 00
2	4.042E-06	1.040E-05
	5.197E 00	8.954E 00
3	4.862E-06	4.001E-06
	4.427E 00	6.748E 00

Appendix A

Auxiliary Tables

(These tables are included to enable the user to prepare data. The user is not restricted to the group structures, reaction cross sections or decay data supplied, but some modification of the dimensions in various programs would need to be made for larger group structures. With knowledge of the group structure used in MAGIK it is a trivial matter to regroup neutron flux data to correspond to that given in Table I. The user must also supply a set of photon cross sections to MORSE - MODE 2 which should have the group structure shown in Table II. The user may also wish to add reaction cross sections for other target nuclei and decay data for other residuals. Tables III, IV and V, as well as Sections F and G of BOOKIE, describe the order and formats of these data.)

TABLE I
NEUTRON ENERGY GROUP STRUCTURE

Group	E-Upper (EV)	E-Lower (EV)	Group	E-Upper (EV)	E-Lower (EV)
1	1.4918E7	1.3499E7	19	3.3373E5	2.2371E5
2	1.3499E7	1.2214E7	20	2.3471E5	1.4996E5
3	1.2214E7	1.0 E7	21	1.4996E5	8.6517E4
4	1.0 E7	8.1873E6	22	8.6517E4	3.1828E4
5	8.1873E6	6.7032E6	23	3.1828E4	1.5034E4
6	6.7032E6	5.4881E6	24	1.5034E4	7.1018E3
7	5.4881E6	4.4933E6	25	7.1018E3	3.3546E3
8	4.4933E6	3.6788E6	26	3.3546E3	1.5846E3
9	3.6788E6	3.0119E6	27	1.5846E3	4.5400E2
10	3.0119E6	2.4660E6	28	4.5400E2	1.0130E2
11	2.4660E6	2.0190E6	29	1.0130E2	2.2603E1
12	2.0190E6	1.6530E6	30	2.2603E1	1.0677E1
13	1.6530E6	1.3534E6	31	1.0677E1	5.0435E0
14	1.3534E6	1.1080E6	32	5.0435E0	2.3824E0
15	1.1080E6	9.0718E5	33	2.3824E0	1.1253E0
16	9.0718E5	7.4274E5	34	1.1253E0	4.1399E-1
17	7.4274E5	4.9787E5	35	4.1399E-1	1.0 E-4
18	4.9787E5	3.3373E5			

TABLE II
GAMMA ENERGY GROUP STRUCTURE

Group	E-Upper (EV)	E-Lower (EV)	Group	E-Upper (EV)	E-Lower (EV)
1	14.0E6	12.0E6	12	4.0E6	3.5E6
2	12.0E6	10.0E6	13	3.5E6	3.0E6
3	10.0E6	8.0E6	14	3.0E6	2.5E6
4	8.0E6	7.5E6	15	2.5E6	2.0E6
5	7.5E6	7.0E6	16	2.0E6	1.5E6
6	7.0E6	6.5E6	17	1.5E6	1.0E6
7	6.5E6	6.0E6	18	1.0E6	4.0E5
8	6.0E6	5.5E6	19	4.0E5	2.0E5
9	5.5E6	5.0E6	20	2.0E5	1.0E5
10	5.0E6	4.5E6	21	1.0E5	1.0E4
11	4.5E6	4.0E6			

TABLE III
CROSS-SECTION REACTION TYPES

Type	Reaction
1	(N,2N)
2	(N,G)
3	(N,P)
4	(N,A)
5	(N,N'P) + (N,D)
6	(N,N'A)
7	(N,ND) + (N,T)
8	(N,3N)
9	(N,HE3)

TABLE IV.2
REACTION CROSS-SECTIONS (35 GROUPS)

INDEX	TARGET NUCLEI	REACTION	NUMBER OF GROUPS	INDEX	TARGET NUCLEI	REACTION	NUMBER OF GROUPS
101	25051	25051	3	154	28063	28063	3
102	25052	25052	4	155	28064	28064	4
103	25053	25053	1	156	28065	28065	1
104	25054	25054	35	157	28066	28066	7
105	25055	25055	15	158	28067	28067	2
106	25056	25056	16	159	28068	28068	3
107	25057	25057	16	160	28069	28069	4
108	25058	25058	5	161	28070	28070	5
109	25059	25059	7	162	28071	28071	6
110	25060	25060	5	163	28072	28072	7
111	25061	25061	4	164	28073	28073	1
112	25062	25062	3	165	28074	28074	2
113	25063	25063	8	166	28075	28075	1
114	25064	25064	10	167	28076	28076	3
115	25065	25065	35	168	28077	28077	4
116	25066	25066	6	169	28078	28078	3
117	25067	25067	3	170	28079	28079	4
118	25068	25068	4	171	28080	28080	1
119	25069	25069	7	172	28081	28081	2
120	25070	25070	3	173	28082	28082	3
121	25071	25071	10	174	28083	28083	4
122	25072	25072	35	175	28084	28084	7
123	25073	25073	6	176	28085	28085	1
124	25074	25074	3	177	28086	28086	2
125	25075	25075	10	178	28087	28087	3
126	25076	25076	3	179	28088	28088	4
127	25077	25077	3	180	28089	28089	4
128	25078	25078	3	181	28090	28090	4
129	25079	25079	3	182	28091	28091	1
130	25080	25080	3	183	28092	28092	2
131	25081	25081	3	184	28093	28093	3
132	25082	25082	3	185	28094	28094	3
133	25083	25083	3	186	28095	28095	4
134	25084	25084	3	187	28096	28096	5
135	25085	25085	3	188	28097	28097	6
136	25086	25086	3	189	28098	28098	7
137	25087	25087	3	190	28099	28099	8
138	25088	25088	3	191	28100	28100	9
139	25089	25089	3	192	28101	28101	10
140	25090	25090	3	193	28102	28102	11
141	25091	25091	3	194	28103	28103	12
142	25092	25092	3	195	28104	28104	13
143	25093	25093	3	196	28105	28105	14
144	25094	25094	3	197	28106	28106	15
145	25095	25095	3	198	28107	28107	16
146	25096	25096	3	199	28108	28108	17
147	25097	25097	3	200	28109	28109	18
148	25098	25098	3	201	28110	28110	19
149	25099	25099	3	202	28111	28111	20
150	25100	25100	3	203	28112	28112	21
151	25101	25101	3	204	28113	28113	22
152	25102	25102	3				
153	25103	25103	3				

TABLE IV.3
REACTION CROSS-SECTIONS IN GROUPS

INDEX	TARGET NUCLEI 2--A	REACTION	NUMBER OF GROUPS	INDEX	TARGET NUCLEI 2--A	REACTION	NUMBER OF GROUPS	INDEX
205	40093	28-93IN, PIV-93	4	254	42094	41-94IN, PIV-94	4	41093
206	40093	28-93IN, AISR-90	4	257	42094	41-94IN, AISR-90	4	41093
207	40093	28-93IN, NP-91V-92	4	258	42094	41-94IN, NP-91V-92	4	41093
208	40093	28-93IN, AISR-90	4	259	42094	41-94IN, AISR-90	4	41093
209	40093	28-93IN, TIV-91	4	260	42094	41-94IN, TIV-91	4	41093
210	40093	28-94IN, 2N12R-93	5	261	42094	41-94IN, 2N12R-93	5	41093
211	40094	28-94IN, PIV-94	6	262	42094	41-94IN, PIV-94	6	41093
212	40094	28-94IN, AISR-91	6	263	42094	41-94IN, AISR-91	6	41093
213	40094	28-94IN, NP-91V-93	6	264	42094	41-94IN, NP-91V-93	6	41093
214	40094	28-94IN, AISR-90	6	265	42094	41-94IN, AISR-90	6	41093
215	40094	28-94IN, TIV-92	6	266	42094	41-94IN, TIV-92	6	41093
216	40094	28-95IN, PIV-95	6	267	42094	41-95IN, PIV-95	6	41093
217	40094	28-95IN, AISR-92	6	268	42094	41-95IN, AISR-92	6	41093
218	40094	28-95IN, NP-91V-94	6	269	42094	41-95IN, NP-91V-94	6	41093
219	40094	28-95IN, AISR-91	6	270	42094	41-95IN, AISR-91	6	41093
220	40094	28-95IN, TIV-93	6	271	42094	41-95IN, TIV-93	6	41093
221	40094	28-96IN, 2N12R-95	6	272	42094	41-96IN, 2N12R-95	6	41093
222	40094	28-96IN, G12R-97	6	273	42094	41-96IN, G12R-97	6	41093
223	40094	28-96IN, PIV-96	6	274	42094	41-96IN, PIV-96	6	41093
224	40094	28-96IN, AISR-93	6	275	42094	41-96IN, AISR-93	6	41093
225	40094	28-96IN, NP-91V-95	6	276	42094	41-96IN, NP-91V-95	6	41093
226	40094	28-96IN, AISR-92	6	277	42094	41-96IN, AISR-92	6	41093
227	40094	28-96IN, TIV-94	6	278	42094	41-96IN, TIV-94	6	41093
228	40094	28-96IN, 2N12R-91	6	279	42094	41-96IN, 2N12R-91	6	41093
229	40094	28-96IN, AISR-90	6	280	42094	41-96IN, AISR-90	6	41093
230	40094	28-96IN, NP-91V-96	6	281	42094	41-96IN, NP-91V-96	6	41093
231	40094	28-96IN, TIV-90	6	282	42094	41-96IN, TIV-90	6	41093
232	40094	28-96IN, G12R-90	6	283	42094	41-96IN, G12R-90	6	41093
233	40094	28-96IN, PIV-90	6	284	42094	41-96IN, PIV-90	6	41093
234	40094	28-96IN, AISR-93	6	285	42094	41-96IN, AISR-93	6	41093
235	40094	28-96IN, NP-91V-90	6	286	42094	41-96IN, NP-91V-90	6	41093
236	40094	28-96IN, AISR-90	6	287	42094	41-96IN, AISR-90	6	41093
237	40094	28-96IN, TIV-91	6	288	42094	41-96IN, TIV-91	6	41093
238	40094	28-96IN, 2N12R-93	6	289	42094	41-96IN, 2N12R-93	6	41093
239	40094	28-96IN, AISR-91	6	290	42094	41-96IN, AISR-91	6	41093
240	40094	28-96IN, NP-91V-93	6	291	42094	41-96IN, NP-91V-93	6	41093
241	40094	28-96IN, AISR-90	6	292	42094	41-96IN, AISR-90	6	41093
242	40094	28-96IN, TIV-91	6	293	42094	41-96IN, TIV-91	6	41093
243	40094	28-96IN, 2N12R-91	6	294	42094	41-96IN, 2N12R-91	6	41093
244	40094	28-96IN, AISR-92	6	295	42094	41-96IN, AISR-92	6	41093
245	40094	28-96IN, NP-91V-90	6	296	42094	41-96IN, NP-91V-90	6	41093
246	40094	28-96IN, AISR-90	6	297	42094	41-96IN, AISR-90	6	41093
247	40094	28-96IN, TIV-90	6	298	42094	41-96IN, TIV-90	6	41093
248	40094	28-96IN, 2N12R-90	6	299	42094	41-96IN, 2N12R-90	6	41093
249	40094	28-96IN, AISR-90	6	300	42094	41-96IN, AISR-90	6	41093
250	40094	28-96IN, NP-91V-90	6	301	42094	41-96IN, NP-91V-90	6	41093
251	40094	28-96IN, AISR-90	6	302	42094	41-96IN, AISR-90	6	41093
252	40094	28-96IN, TIV-90	6	303	42094	41-96IN, TIV-90	6	41093
253	40094	28-96IN, 2N12R-90	6	304	42094	41-96IN, 2N12R-90	6	41093
254	40094	28-96IN, AISR-90	6	305	42094	41-96IN, AISR-90	6	41093
255	40094	28-96IN, NP-91V-90	6	306	42094	41-96IN, NP-91V-90	6	41093

TABLE IV.4
REACTION CROSS-SECTIONS (35 GROUPS)

INDEX	TARGET NUCLEI	REACTION	NUMBER OF GROUPS	INDEX	TARGET NUCLEI	REACTION	NUMBER OF GROUPS	NUMBER OF GROUPS	REACTION	NUMBER OF GROUPS
307	50114	3	3	307	50114	3	3	3	MP-175 (N, 2N)MP-175	3
308	50114	4	4	308	50114	4	4	4	MP-177 (N, 2N)MP-177	4
309	50114	5	5	309	50114	5	5	5	MP-180 (N, 2N)MP-180	5
310	50114	7	7	310	50114	7	7	7	TA-181 (N, 2N)TA-181	7
311	50115	3	3	311	50115	3	3	3	TA-181 (N, 2N)TA-182	3
312	50115	5	5	312	50115	5	5	5	TA-181 (N, 2N)MP-181	5
313	50115	6	6	313	50115	6	6	6	TA-181 (N, 2N)MP-182	6
314	50115	7	7	314	50115	7	7	7	TA-181 (N, 2N)MP-183	7
315	50116	1	1	315	50116	1	1	1	TA-181 (N, 2N)MP-184	1
316	50116	2	2	316	50116	2	2	2	TA-181 (N, 2N)MP-185	2
317	50116	3	3	317	50116	3	3	3	TA-181 (N, 2N)MP-186	3
318	50116	4	4	318	50116	4	4	4	TA-181 (N, 2N)MP-187	4
319	50116	5	5	319	50116	5	5	5	TA-181 (N, 2N)MP-188	5
320	50116	7	7	320	50116	7	7	7	TA-181 (N, 2N)MP-189	7
321	50117	3	3	321	50117	3	3	3	TA-181 (N, 2N)MP-190	3
322	50117	5	5	322	50117	5	5	5	TA-181 (N, 2N)MP-191	5
323	50117	6	6	323	50117	6	6	6	TA-181 (N, 2N)MP-192	6
324	50117	7	7	324	50117	7	7	7	TA-181 (N, 2N)MP-193	7
325	50118	1	1	325	50118	1	1	1	TA-181 (N, 2N)MP-194	1
326	50118	2	2	326	50118	2	2	2	TA-181 (N, 2N)MP-195	2
327	50118	3	3	327	50118	3	3	3	TA-181 (N, 2N)MP-196	3
328	50118	4	4	328	50118	4	4	4	TA-181 (N, 2N)MP-197	4
329	50118	5	5	329	50118	5	5	5	TA-181 (N, 2N)MP-198	5
330	50118	7	7	330	50118	7	7	7	TA-181 (N, 2N)MP-199	7
331	50119	1	1	331	50119	1	1	1	TA-181 (N, 2N)MP-200	1
332	50119	2	2	332	50119	2	2	2	TA-181 (N, 2N)MP-201	2
333	50119	3	3	333	50119	3	3	3	TA-181 (N, 2N)MP-202	3
334	50119	4	4	334	50119	4	4	4	TA-181 (N, 2N)MP-203	4
335	50119	5	5	335	50119	5	5	5	TA-181 (N, 2N)MP-204	5
336	50119	7	7	336	50119	7	7	7	TA-181 (N, 2N)MP-205	7
337	50120	1	1	337	50120	1	1	1	TA-181 (N, 2N)MP-206	1
338	50120	2	2	338	50120	2	2	2	TA-181 (N, 2N)MP-207	2
339	50120	3	3	339	50120	3	3	3	TA-181 (N, 2N)MP-208	3
340	50120	4	4	340	50120	4	4	4	TA-181 (N, 2N)MP-209	4
341	50120	5	5	341	50120	5	5	5	TA-181 (N, 2N)MP-210	5
342	50120	7	7	342	50120	7	7	7	TA-181 (N, 2N)MP-211	7
343	50121	1	1	343	50121	1	1	1	TA-181 (N, 2N)MP-212	1
344	50121	2	2	344	50121	2	2	2	TA-181 (N, 2N)MP-213	2
345	50121	3	3	345	50121	3	3	3	TA-181 (N, 2N)MP-214	3
346	50121	4	4	346	50121	4	4	4	TA-181 (N, 2N)MP-215	4
347	50121	5	5	347	50121	5	5	5	TA-181 (N, 2N)MP-216	5
348	50121	7	7	348	50121	7	7	7	TA-181 (N, 2N)MP-217	7
349	50122	1	1	349	50122	1	1	1	TA-181 (N, 2N)MP-218	1
350	50122	2	2	350	50122	2	2	2	TA-181 (N, 2N)MP-219	2
351	50122	3	3	351	50122	3	3	3	TA-181 (N, 2N)MP-220	3
352	50122	4	4	352	50122	4	4	4	TA-181 (N, 2N)MP-221	4
353	50122	5	5	353	50122	5	5	5	TA-181 (N, 2N)MP-222	5
354	50122	7	7	354	50122	7	7	7	TA-181 (N, 2N)MP-223	7
355	50123	1	1	355	50123	1	1	1	TA-181 (N, 2N)MP-224	1
356	50123	2	2	356	50123	2	2	2	TA-181 (N, 2N)MP-225	2
357	50123	3	3	357	50123	3	3	3	TA-181 (N, 2N)MP-226	3
358	50123	4	4	358	50123	4	4	4	TA-181 (N, 2N)MP-227	4
359	50123	5	5	359	50123	5	5	5	TA-181 (N, 2N)MP-228	5
360	50123	7	7	360	50123	7	7	7	TA-181 (N, 2N)MP-229	7

TABLE V.1
AVAILABLE DECAY DATA SETS BY RESIDUAL ID

INDEX	ID 2--4	HALF-LIFE (SEC)	INTENSITY	NON-ZERO GROUPS	INDEX 2--4	HALF-LIFE (SEC)	INTENSITY	NON-ZERO GROUPS
1	2008	1.220000E-01	6.800000E-01	16 TO 18	51	19042	4.446000E-04	16 TO 19
2	4007	1.300000E-01	1.300000E-01	16 TO 18	52	19043	1.973600E-04	16 TO 22
3	5006	7.761338E-01	2.000000E-01	16 TO 18	53	19044	1.327800E-03	9 TO 19
4	6011	2.041000E-01	2.800000E-02	11 TO 11	54	19045	1.200000E-03	14 TO 20
5	6012	1.222800E-03	1.995199E-01	14 TO 14	55	20039	7.000000E-01	18 TO 19
6	7013	9.978978E-02	1.996427E-01	18 TO 18	56	20047	3.914100E-03	17 TO 18
7	7016	7.120000E-01	7.488999E-01	15 TO 14	57	20049	5.224500E-02	16 TO 18
8	8014	7.059000E-01	2.990779E-01	15 TO 18	58	21041	6.001199E-01	18 TO 18
9	8015	1.222400E-02	1.992700E-01	18 TO 18	59	21042	6.129999E-01	16 TO 18
10	8019	2.409999E-01	1.592899E-01	11 TO 20	60	21042	6.839000E-01	18 TO 18
11	9017	6.641324E-01	2.000000E-01	18 TO 18	61	21043	1.408000E-04	18 TO 19
12	9020	6.384393E-01	1.938000E-01	18 TO 18	62	21043	6.320000E-01	20 TO 20
13	9020	1.103000E-01	1.000000E-01	14 TO 16	63	21044	1.413700E-04	14 TO 18
14	9021	4.328000E-01	7.110000E-01	16 TO 19	64	21044	3.109000E-03	17 TO 19
15	9022	4.230000E-01	2.777999E-01	11 TO 17	65	21046	7.242900E-06	17 TO 18
16	10018	1.669999E-01	2.073600E-01	17 TO 18	66	21046	1.870000E-01	20 TO 20
17	10019	1.139999E-01	2.000000E-01	18 TO 18	67	21047	2.899300E-03	17 TO 21
18	10023	3.723999E-01	3.410100E-01	15 TO 18	68	21048	1.573200E-03	17 TO 21
19	10024	2.028000E-01	1.079000E-01	18 TO 18	69	21049	3.939000E-03	16 TO 18
20	11020	4.460000E-01	2.909999E-01	16 TO 18	70	22043	3.601189E-01	20 TO 21
21	11021	2.354999E-01	2.048999E-01	18 TO 19	71	22044	1.492700E-04	18 TO 18
22	11022	8.211200E-07	2.797399E-01	17 TO 18	72	22045	1.108000E-04	18 TO 18
23	11024	5.409000E-04	1.998010E-01	14 TO 17	73	22051	3.459999E-02	18 TO 19
24	11025	9.999999E-01	3.028199E-01	15 TO 19	74	23046	4.923300E-01	18 TO 18
25	11026	1.087000E-01	1.194902E-01	10 TO 17	75	23046	9.994997E-04	16 TO 16
26	12023	1.136000E-01	2.084499E-01	18 TO 18	76	23047	1.938999E-03	16 TO 20
27	12027	5.677200E-02	1.006000E-01	17 TO 20	77	23048	1.403000E-04	15 TO 18
28	12028	7.327600E-04	2.026999E-01	16 TO 21	78	23052	2.930000E-02	17 TO 17
29	13024	1.300000E-01	1.730329E-01	14 TO 18	79	23053	9.699999E-01	17 TO 19
30	13024	2.044000E-01	4.557000E-01	4 TO 18	80	24048	8.249000E-04	18 TO 20
31	13025	7.730000E-01	2.006199E-01	16 TO 18	81	24049	2.523900E-03	18 TO 21
32	13026	4.346999E-01	1.998400E-01	18 TO 18	82	24051	2.391600E-04	19 TO 19
33	13026	2.394978E-13	2.660999E-01	14 TO 18	83	24055	2.100000E-04	15 TO 20
34	13028	1.344000E-02	1.000000E-01	14 TO 14	84	24056	3.565997E-02	21 TO 21
35	13029	3.939999E-02	9.999999E-01	15 TO 17	85	25050	2.832000E-01	18 TO 18
36	13030	3.064999E-01	1.501198E-01	10 TO 18	86	25050	1.050000E-02	13 TO 18
37	13034	2.300000E-01	2.250799E-01	16 TO 18	87	25051	2.772000E-03	13 TO 18
38	13037	4.169999E-01	2.000299E-01	15 TO 18	88	25052	6.836000E-03	17 TO 19
39	14031	9.431980E-03	7.000000E-04	17 TO 17	89	25052	1.200000E-03	17 TO 19
40	15030	1.497400E-01	1.997199E-01	18 TO 18	90	25054	2.700000E-07	16 TO 18
41	16037	3.042000E-02	9.999999E-01	12 TO 13	91	25056	1.431000E-03	18 TO 18
42	17034	1.200000E-03	2.070000E-01	13 TO 20	92	26052	2.970000E-04	15 TO 20
43	17034	1.006319E-01	2.000000E-01	18 TO 18	93	26053	5.109999E-07	14 TO 19
44	17038	7.160000E-01	9.993300E-01	18 TO 18	94	26053	1.549000E-03	15 TO 18
45	17038	2.332400E-03	7.650000E-01	15 TO 16	95	26059	3.847200E-06	17 TO 20
46	17039	3.336000E-03	1.444999E-01	14 TO 19	96	26061	1.387999E-02	14 TO 20
47	18041	6.377100E-03	9.916000E-01	17 TO 17	97	27055	1.940387E-01	18 TO 18
48	18038	4.501397E-03	2.983399E-01	12 TO 18	98	27055	2.744543E-04	14 TO 21
49	18038	9.268000E-01	2.000000E-01	18 TO 18	99	27056	6.804900E-06	12 TO 18
50	19040	4.438400E-14	1.070000E-01	17 TO 17	100	27057	2.340000E-07	18 TO 21

TABLE V-2
AVAILABLE DECAY DATA SETS BY RESIDUAL ID

INDEX	IP Z--A	HALE-LIFE (SEC)	INTENSITY	NON-ZERO GROUPS	INDEX	ID Z--A	HALE-LIFE (SEC)	INTENSITY	NON-ZERO GROUPS
101	27058	0.117100E 04	1.306239E 00	16 TO 18	131	37086	6.111999E 01	1.000000E 00	18 TO 19
102	27058	3.400000E 04	1.000000E 00	21 TO 21	132	37086	1.619670E 06	8.779999E -07	17 TO 17
103	27060	6.282000E 02	2.324799E -02	17 TO 21	133	37088	1.007999E 03	8.779999E -01	10 TO 18
104	27060	1.463400E 08	1.998819E 00	17 TO 17	134	37089	6.939999E 02	1.807499E 00	12 TO 19
105	27061	5.400000E 03	9.960319E -01	18 TO 21	135	37091	5.801199E 01	1.583999E 00	11 TO 21
106	27062	5.000000E 01	1.157999E 00	11 TO 17	136	38083	4.300000E 03	9.999999E -01	19 TO 20
107	27062	8.345999E 02	2.058999E 00	13 TO 18	137	38085	5.572800E 06	9.979999E -01	18 TO 18
108	28036	3.270399E 05	3.256999E 00	16 TO 20	138	38087	1.011600E 04	1.900000E -01	19 TO 19
109	28037	1.298900E 05	1.931599E 00	14 TO 20	139	38089	4.363200E 06	1.900000E -04	18 TO 18
110	28063	9.072000E 03	4.422314E -01	16 TO 19	140	38090	2.304000E 05	1.600000E -04	16 TO 16
111	29058	3.200639E 00	2.445499E 00	12 TO 21	141	38091	3.451499E 04	7.977999E -01	17 TO 19
112	29062	5.843999E 02	1.953419E 00	17 TO 18	142	38092	9.720000E 03	9.000000E -01	17 TO 17
113	29064	4.572400E 04	3.422832E -01	17 TO 18	143	38097	2.880000E 05	9.979999E -01	18 TO 18
114	29066	3.060000E 02	8.183999E -02	17 TO 18	144	39087	9.244800E 06	1.938270E 00	00 TO 00
115	29067	2.228400E 03	8.869999E -01	19 TO 21	145	39088	1.116000E 06	1.879999E 00	00 TO 00
116	30043	2.280000E 03	3.009000E 00	17 TO 19	146	39090	3.000000E 03	5.800000E -01	18 TO 19
117	30063	2.108160E 07	5.342000E -01	17 TO 18	147	39091	5.097400E 06	2.100000E -03	17 TO 17
118	30064	4.967999E 04	9.500000E -01	18 TO 18	148	39091	5.097400E 06	2.100000E -03	17 TO 17
119	31068	4.097999E 03	1.796499E 00	16 TO 18	149	39093	7.344000E 04	1.792499E -01	15 TO 19
120	31070	1.265999E 03	1.006599E 00	17 TO 20	150	40088	7.344000E 04	9.700000E -01	19 TO 19
121	32069	1.368000E 03	1.024000E 01	15 TO 19	171	40089	2.507999E 02	9.579999E -01	16 TO 18
122	32073	4.800900E 01	3.400000E -01	20 TO 20	172	40089	2.822399E 05	1.466499E 00	00 TO 00
123	32073	4.967999E 03	1.339999E -01	18 TO 21	173	40095	5.572800E 06	9.959999E -01	18 TO 18
124	32077	5.001172E 01	4.373999E -01	18 TO 18	174	40097	6.120000E 04	1.156899E 00	00 TO 00
125	32077	4.067999E 04	2.446196E 00	15 TO 21	175	41090	5.336000E 04	3.026599E 00	00 TO 00
126	32079	4.200830E 01	2.000000E -01	19 TO 19	176	41091	5.336000E 04	3.026599E -02	17 TO 23
127	33074	1.337919E 04	1.388499E 00	18 TO 18	177	41092	8.726000E 11	9.990000E -01	16 TO 18
128	33076	9.467999E 04	6.352499E -01	14 TO 18	178	41094	4.406200E 05	2.000000E 00	00 TO 00
129	33077	1.396799E 05	3.036899E 00	18 TO 21	179	41094	3.799999E 02	4.799999E -03	18 TO 18
130	33078	5.460000E 03	9.648999E -01	13 TO 20	180	41095	3.117600E 05	2.610000E -01	19 TO 19
131	34073	2.340000E 03	7.300000E -01	21 TO 21	181	41095	3.037000E 04	1.000000E 00	00 TO 00
132	34073	2.551999E 04	3.689499E 00	16 TO 21	182	41096	8.404000E 04	3.294799E 00	00 TO 00
133	34075	1.036800E 07	1.752329E 00	18 TO 21	183	41097	6.080000E 01	9.795000E -01	18 TO 18
134	34077	1.750349E 01	5.000000E -01	20 TO 20	184	41097	4.326000E 03	9.876288E -01	16 TO 18
135	34079	2.346000E 02	8.999999E -02	21 TO 21	185	41098	3.000000E 03	2.699999E 00	00 TO 00
136	34083	1.500000E 03	6.239999E 00	15 TO 19	186	41098	2.799999E 00	1.323999E -01	16 TO 18
137	35078	3.900000E 02	1.055079E 00	14 TO 18	187	42091	9.306000E 02	2.468299E 00	00 TO 00
138	35080	3.591196E 04	3.312697E 00	21 TO 21	188	42093	2.468000E 04	2.999999E 00	17 TO 20
139	35082	1.274400E 05	3.312697E 00	16 TO 21	189	42099	2.376000E 05	2.999999E -01	18 TO 21
140	36079	1.256400E 05	2.530198E 00	17 TO 21	190	43093	7.200000E 04	9.699999E -01	17 TO 19
141	36083	1.612799E 04	8.900000E -01	19 TO 20	191	43093	7.200000E 04	9.699999E -01	17 TO 19
142	36085	3.376349E 08	8.099999E -03	18 TO 18	192	43099	2.100000E 04	8.952000E -01	20 TO 20
143	36087	4.680000E 03	8.093088E -01	13 TO 20	193	43101	8.400000E 02	1.009019E 00	00 TO 00
144	36088	1.080000E 04	2.504598E 00	11 TO 21	194	43102	2.509999E 02	2.557299E 00	00 TO 00
145	36089	1.420000E 02	1.919297E 00	11 TO 21	195	44095	5.400000E 03	1.826499E 00	00 TO 00
146	36090	3.200639E 01	3.243399E 00	13 TO 20	196	44097	2.505999E 05	1.000000E 00	00 TO 00
147	36091	7.901571E 00	1.417000E 00	14 TO 20	197	44103	3.421438E 06	9.616499E -01	18 TO 20
148	37083	7.439032E 06	9.473000E -01	18 TO 18	198	44105	1.594799E 04	1.195499E 00	00 TO 00
149	37084	1.200000E 03	1.339999E 00	18 TO 19	199	44105	1.779999E 07	1.052299E 00	00 TO 00
150	37084	2.816638E 06	1.278999E 00	18 TO 19	200	44102	9.145435E 07	4.040000E 00	00 TO 00

TABLE V.3
AVAILABLE DECAY DATA SETS BY RESIDUAL ID

INDEX	ID 2--A	HALF-LIFE (SEC)	INTENSITY	NON-ZERO GROUPS	INDEX	ID 2--A	HALF-LIFE (SEC)	INTENSITY	NON-ZERO GROUPS
201	43103	3.42000E-03	5.59999E-04	21 TO 21	249	52133	7.43999E-02	1.63000E-00	14 TO 19
202	43105	1.27007E-01	2.54460E-01	13 TO 19	250	52134	2.50799E-03	2.27199E-00	18 TO 21
203	43106	3.00060E-01	6.34131E-00	14 TO 19	251	53123	4.75199E-04	8.52829E-01	18 TO 20
204	43109	2.11999E-02	1.00000E-00	20 TO 20	252	53124	3.60287E-04	1.43099E-00	14 TO 18
205	43111	1.98000E-05	7.50000E-01	20 TO 20	253	53126	1.14040E-06	7.72349E-01	17 TO 19
206	43105	3.45600E-06	1.90799E-01	17 TO 21	254	53128	1.30599E-03	1.97740E-01	18 TO 18
207	43106	7.25760E-05	1.58500E-01	16 TO 18	255	53131	6.96339E-03	1.00507E-00	18 TO 21
208	43104	1.44000E-03	7.40000E-00	17 TO 19	256	53132	8.28000E-03	2.93827E-00	14 TO 20
209	43107	4.30844E-01	5.00000E-02	21 TO 21	257	53133	7.30799E-04	1.03947E-00	16 TO 19
210	43108	1.46000E-02	1.02561E-00	16 TO 18	258	53134	3.18000E-03	2.89479E-00	16 TO 21
211	43109	3.42078E-01	5.00000E-02	21 TO 21	259	53135	2.41199E-04	1.72327E-00	15 TO 20
212	43110	2.46400E-07	3.24389E-00	16 TO 18	260	54131	1.02816E-06	1.70000E-02	20 TO 20
213	43111	6.43680E-05	9.43490E-02	18 TO 21	261	54133	1.95239E-03	9.89988E-02	14 TO 19
214	43104	3.46200E-03	1.13379E-00	18 TO 21	262	54135	4.37039E-07	3.60000E-01	21 TO 21
215	43111	2.51599E-03	1.24000E-00	19 TO 20	263	54135	9.35999E-07	8.00000E-01	18 TO 18
216	43115	3.71520E-06	3.22399E-02	17 TO 20	264	54135	3.27599E-04	9.54909E-01	17 TO 20
217	43115	1.90943E-05	3.81519E-01	18 TO 19	265	54137	2.52000E-02	3.38199E-01	12 TO 19
218	43110	1.76398E-04	3.89279E-00	16 TO 20	266	54138	8.70000E-02	1.12329E-00	15 TO 20
219	43111	2.42789E-05	1.83000E-00	19 TO 19	267	55134	1.04400E-04	2.13999E-00	20 TO 21
220	43113	6.22198E-03	6.40000E-01	19 TO 19	268	55134	6.62254E-07	2.25349E-00	17 TO 19
221	43114	4.32000E-06	2.70799E-01	17 TO 20	269	55137	9.46080E-08	8.46000E-01	18 TO 18
222	43114	7.20142E-01	1.70000E-03	17 TO 17	270	55138	1.74000E-02	7.56699E-01	17 TO 21
223	43115	1.58339E-04	4.50000E-01	19 TO 19	271	55138	1.93200E-03	8.03119E-00	12 TO 20
224	43114	3.24000E-03	2.30999E-00	15 TO 20	272	56131	8.75999E-02	1.43000E-00	20 TO 21
225	43117	7.02000E-03	7.84759E-01	17 TO 20	273	56131	1.00240E-06	2.75789E-00	17 TO 21
226	43117	2.40000E-03	2.00699E-00	18 TO 20	274	56133	1.40000E-04	1.16999E-00	19 TO 21
227	43118	8.50169E-00	1.26399E-00	17 TO 20	275	56135	1.03320E-04	1.60000E-01	19 TO 19
228	43118	2.63999E-02	2.76799E-00	15 TO 19	276	56137	1.32999E-02	8.90000E-01	18 TO 18
229	50113	9.93600E-06	1.80000E-02	19 TO 19	277	56139	4.97400E-03	2.77000E-01	17 TO 20
230	50117	1.20960E-06	8.69999E-01	20 TO 19	278	56140	1.10592E-06	5.92479E-01	18 TO 21
231	50123	2.37000E-03	6.40000E-01	20 TO 20	279	57141	1.44720E-03	3.15036E-00	13 TO 21
232	51118	1.53599E-04	3.12919E-00	15 TO 21	280	57141	1.40400E-04	2.00000E-02	17 TO 17
233	51118	7.10000E-02	1.54999E-00	14 TO 18	281	57142	5.03999E-07	1.38149E-00	14 TO 18
234	51120	5.01119E-03	3.65999E-00	17 TO 21	282	58139	5.40107E-01	9.29999E-01	18 TO 18
235	51122	2.32000E-02	6.70000E-01	21 TO 21	283	58139	1.20939E-04	8.00000E-01	20 TO 20
236	51124	3.41919E-05	6.75800E-01	17 TO 18	284	58141	2.79939E-04	4.89999E-01	20 TO 20
237	51124	5.25124E-06	1.87319E-00	15 TO 18	285	58143	1.18349E-01	8.00899E-01	18 TO 21
238	51125	8.73546E-07	9.32327E-01	18 TO 21	286	58144	2.45376E-01	1.15667E-00	15 TO 21
239	51126	1.40000E-03	2.87999E-00	18 TO 18	287	59138	7.20000E-03	3.42299E-00	17 TO 19
240	51124	1.60000E-06	4.44699E-00	18 TO 19	288	59138	9.00000E-01	1.07300E-00	17 TO 19
241	51127	3.56959E-05	1.11000E-00	17 TO 19	289	59139	1.62000E-04	7.13799E-00	16 TO 20
242	52121	1.06800E-06	9.47999E-01	20 TO 21	290	59142	6.91200E-04	3.72499E-02	16 TO 18
243	52123	1.03600E-07	8.30799E-01	20 TO 21	291	59144	4.31999E-02	1.00010E-00	18 TO 21
244	52125	5.01120E-04	7.03599E-02	20 TO 21	292	59144	1.01479E-01	2.02523E-00	14 TO 19
245	52127	9.41740E-06	2.01420E-00	18 TO 21	293	60138	1.81479E-01	1.04900E-00	18 TO 19
246	52127	3.38399E-04	3.60819E-02	18 TO 21	294	60147	9.50400E-03	4.68169E-01	18 TO 21
247	52131	1.03600E-05	2.06699E-00	15 TO 20	295	60149	6.48000E-03	1.21200E-01	18 TO 21
248	52132	2.80800E-05	1.02399E-00	19 TO 21	296	60151	7.80000E-02	7.35199E-00	15 TO 21

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