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Actinide Nuclear Data for Reactor Physics Calculations

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FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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Date Published July 1991

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U S DEPARTMENT OF ENERGY
under contract DE AC05 84OR21400

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ACKNOWLEDGMENTS

This work was funded in part by the Japan/U S Actinides Program (DOE Project No ERD 88 736) directed by S Raman (ORNL) in cooperation with sponsors at the Japan Atomic Energy Research Institute (JAERI) The authors wish to express appreciation for the support and interest in the development and improvement of basic nuclear data exhibited by S Raman as well as T Mukaiyama and other interested parties at JAERI The authors also wish to express their appreciation for the direct technical assistance and communications with B F Rider concerning the fission yield evaluations and D G Madland in regard to the prompt neutron calculations

ABSTRACT

Calculational methodologies and data sources used to predict and recommend fission product yields and delayed neutron and prompt neutron data for a number of actinide nuclides are presented and discussed This compilation of nuclear data is the result of a nearly three year effort under the Japan/U S Actinide Program (JUSAP) at Oak Ridge National Laboratory to provide nuclear data supporting the preliminary design of an actinide burner reactor In this type of reactor minor actinides are the major components of the fuel Nuclear data for these minor actinides are therefore essential in the design of such reactors Fission yield delayed neutron and prompt neutron data are presented in the report for the following nuclides Neptunium 237, Plutonium 238 240 and 242 Americium 241 and 243 and Curium 242 243 244 246 and 248 Additionally prompt neutron data are also presented for these nuclides (except Plutonium 240 242 and Curium 242) and for Curium 245 and 247 As in all compilations of nuclear data the information in this report is subject to change as newer data become available Most of the data presented here are based on calculational methodologies and should be revised as experimental data become available The release of Version VI of the Evaluated Nuclear Data Files (ENDF/B VI) is expected to be completed in 1991 and should replace this evaluation in areas of overlap although no serious discrepancies are expected between this compilation and ENDF/B VI Because of the large amount of data comprising this compilation and limitations in publishing such a voluminous report a complete listing of the explicit data is not included in this report The data are however available from the authors on 5½ in high density (1 2 Mbyte) diskettes The file contents and formats are described in the text and examples are given in the appendices

1 INTRODUCTION

The nuclear data requirements for the design of reactors are numerous and varied Calculations of isotope production and depletion require fission product yields for all nuclides considered calculations of reactor dynamics (or kinetics) require information concerning the production of delayed neutrons and basic reactor physics calculations require detailed data for prompt neutron production (i e prompt neutron yields and spectra) Development of new reactor types such as an actinide burner reactor requires that these data be known or approximated for nuclides not previously of concern

The waste actinide content of reprocessed pressurized water reactor (PWR) fuel (based on a burnup of 33 000 megawatt days per metric ton uranium) is expected to be primarily ^{237}Np (as ordered by weight) with smaller amounts of ^{243}Am ^{241}Am ^{244}Cm ^{239}Pu ^{240}Pu ^{242}Cm ^{241}Pu ^{242}Pu and ^{238}Pu (ref 1) The major emphasis of this work was to compile nuclear data needed for reactor physics calculations for fast fission in ^{237}Np ^{238}Pu ^{241}Am ^{243}Am ^{243}Cm ^{244}Cm ^{246}Cm and ^{248}Cm These data include (1) fission product yields (2) delayed neutron yields group parameters and spectra and (3) prompt neutron yields and spectra The evaluation is based on a literature review to obtain available experimental data and to identify current computational methods to be used in the calculation of unmeasured parameters Unfortunately there are few experimental data available for most of these higher order actinides and therefore this evaluation is based primarily on model calculations The methodologies models and data sources used to produce this compilation of actinide nuclear data are discussed in this text and the recommended nuclear data are presented (where space allows) and described in the the appendices

Specifically data (as indicated) for the fission systems listed in Table 1 are contained in this report (A fission system refers to a combination of fissioning nuclide and incident neutron energy) Several thermal and spontaneous fission systems and one high energy system were evaluated as by products of the methods and formats used in the evaluation of the fission yields For completeness delayed neutron parameters were also calculated for these systems even though they are not of specific interest to the actinide program Prompt neutron yields $\bar{\nu}_p$ were calculated for many thermal and spontaneous fission systems and some fast fission systems [i e ^{235}U(F) ^{238}U(F) ^{239}Pu(F) and ^{240}Pu(F)] in order to utilize measured $\bar{\nu}_p$ data in the validation of key parameters used in the prompt neutron calculations

Table 1 Summary of data presented

Fissioning system[a]	Fission yield data	Delayed neutron data	Prompt neutron spectra	Prompt neutron yield
^{235}U(F)				X
^{238}U(F)				X
^{237}Np(T)	X	X		
^{237}Np(F)	X	X	X	X
^{238}Pu(F)	X	X	X	X
^{239}Pu(F)				X
^{240}Pu(T)	X	X		
^{240}Pu(F)				X
^{242}Pu(T)	X	X		
^{242}Pu(H)	X	X		
^{241}Am(F)	X	X	X	X
^{243}Am(F)	X	X	X	X
^{242}Cm(S)				X
^{242}Cm(F)	X	X		
^{243}Cm(T)	X	X		X
^{243}Cm(F)	X	X	X	X
^{244}Cm(S)				X
^{244}Cm(T)				X
^{244}Cm(F)	X	X	X	X
^{245}Cm(T)				X
^{245}Cm(F)			X	X
^{246}Cm(S)	X	X		X
^{246}Cm(T)				X
^{246}Cm(F)	X	X	X	X
^{247}Cm(T)				X
^{247}Cm(F)			X	X
^{248}Cm(S)				X
^{248}Cm(T)				X
^{248}Cm(F)	X	X	X	X

[a] T F H and S denote thermal fast high energy (~14 MeV) and spontaneous fission respectively

This compilation should be considered preliminary simply because of the evolutionary nature of nuclear data The evaluation of nuclear data is a continuous process, as new experimental data become available theoretical models and model parameters may be modified and in turn suggest new experiments

2. FISSION-PRODUCT YIELD DATA

The direct fission yields in this compilation are the result of the continuing efforts of T R England and B F Rider in producing the U S fission yield evaluations For the actinides of interest in this work, most of the yields are the result of model calculations although experimental yields have been used when available The methodology and models will be described first to more clearly define terms specific to fission product yields and their evaluation

2.1 METHODOLOGY AND MODELS

The evaluation procedure used by England and Rider is described in detail in ref 2 A synopsis will be given here The following definitions are provided to aid the reader

direct (independent) fission yield	—	yield from fission after prompt neutron emission before any radioactive decay
cumulative fission yield	—	direct yield from fission plus indirect yield following decay of radionuclides created by fission
mass chain yield	—	total cumulative yield from fission of all stable isotopes for a given mass number A

The independent (direct) fission yields in this compilation are primarily the product of the methodology outlined below

2.1 1 General

Independent yields are taken from a calculated charge distribution model Large errors are assigned to the model yields as will be discussed later These model yields are merged statistically with weighted averages of measured yields One set of cumulative yields is calculated by adding independent yields starting with the initial nuclide and ending with the chain yield A second set of cumulative yields is calculated by starting with the chain yields and subtracting independent yields ending with the initial nuclide These two sets are averaged using reciprocal variance weighting The first set dominates the initial nuclide yield averages The second set dominates the final chain member yield averages because of the small errors caused by the constraint imposed at 0% and 100% of the chain yield, respectively The powerful and constrained merging technique and resultant error analysis used is that recommended by Spinrad and Wu [3] Other refinements treat delayed neutron emission partition direct yields between metastable and ground state isomers handle isomeric transition and accommodate beta decay branching ratios

2.1.2 Treatment of Data

The original values reported in the literature are tabulated along with the reference value (if any) against which they are determined[2] An updated value is then calculated by using the current recommended value for the fission yield of the reference nuclide from the file All the updated values are readjusted to ensure that the yields will total 100% of the chain yield, except for the small difference between iterations To determine this adjustment the variance of the sum is obtained by summing the variances of each chain yield Any difference in the total chain yield from 100% is apportioned to each yield in the proportion its variance bears to the total variance This method results in a negligible adjustment to any accurately determined absolute yield It ensures that the adjustment is made primarily in the lesser known yields where most of the error lies Yet these lesser known values are modified by only a fraction of their standard deviation or well within their adjusted experimental error

We refer to an adjusted experimental error due to the fact that in many cases the reported experimental errors were judged to be optimistically small and have been adjusted accordingly For example the relative standard deviation is not allowed to be smaller than 0 5% for mass spectrometric measurements or 5% for Ge(Li) era radiochemical measurements made since 1965 A lower limit of 10% is set for sodium iodide era measurements between 1955 and 1965 and 20% for Geiger counter era measurements before 1955 Estimates are generally no better than $\pm 10\%$ and are defaulted at $\pm 30\%$ If no accuracy is reported in the literature, it is assumed to be three times these lower limits Where separate plus and minus errors are reported the smaller value plus two thirds the difference is used For relative values the resultant error is combined statistically with the error in the recommended yield of the reference nuclide from the previous iteration to give an error of the updated value For absolute values a 2% upper limit of conceivable systematic error is combined with the reported random error Average experimental independent yields and experimental cumulative yields are determined for each nuclide The individual values in the average are weighted by the inverse square of the relative standard deviation If more than the above standardized treatment is required a special treatment number is assigned so that these various cases can be individually treated

2 1.3 **Calculated Yields**

For a given mass chain a Gaussian charge distribution is calculated by using the most probable charge (Z_p) and Gaussian width parameter (σ) The Z_p values are verified to be consistent with the chain yields and the atomic number of the compound nucleus undergoing fission Sigma values can vary by mass (or Z_p) but are taken as constant in this evaluation Separate corrections are therefore made for neutron and proton pairing effects The Z_p model [4] modified to account for neutron and proton pairing effects [5] is given in Eq (1) The fractional independent yields FIY(Z A) as a function of charge Z and mass A, are calculated using this basic model The model

$$FIY(Z,A) = \frac{1}{NORM} \int_{Z-\frac{1}{2}}^{Z+\frac{1}{2}} \frac{F_n F_z}{(2\pi\sigma^2)^{\frac{1}{2}}} \exp\left[-\frac{(Z-Z_p)^2}{2\sigma^2}\right] dZ \qquad (1)$$

represents a Gaussian distribution of width σ, about the most probable charge Z_p, for a given mass chain A. Typically the distribution extends 3 or 4 charge units on either side of Z_p (i e $Z_p \pm 3$ or $Z_p \pm 4$) for a given mass The factors F_n and F_z represent corrections for neutron and proton pairing effects[5] and NORM is the factor necessary to renormalize the fractional independent yields to unity for a given mass chain Reference 5 contains a detailed discussion of the pairing effects and also contains data for 11 fissioning nuclides (data for an additional 6 nuclides appear in a supplement to that report)

Equation (1) treats each charge unit along the mass chain separately but does not account for isomeric state fission products Where isomerism occurs the independent yields depend on a nonlinear function of the angular momentum of each isomer Madland[6] finds such a model to predict the isomer split (metastable/ground state) within ±50% The Madland model is used to divide isomeric yields between metastable and ground states in cases where these yields have not been measured Where the angular momentum for each isomer is not known the yield is divided equally between the ground state and a single metastable state

The fractional independent fission yields are scaled to their respective chain yields Mass chain yields for mass numbers 66 through 172 were used to calculate the fission yields in this compilation These mass chain yields are described in ref 7

2.1 4 **Delayed Neutron Emission**

Some thought was given to the method of including delayed neutron emission in the existing format for fission yield evaluations One problem faced is that Pn data (delayed neutron emission probabilities or branching fractions) are given for the precursors but are needed when processing the daughter An iterative procedure was used to determine the amount of yield contributed to the cumulative yield of each nuclide by delayed neutron emission from the next higher mass The independent yields are all before delayed neutron emission The cumulative yields are after delayed neutron emission The chain yield is redefined as the sum of the independent yields plus delayed neutron gains from the A+1 chain minus the delayed neutron decay losses to the A−1 chain In this way the chain yields retain their traditional after delayed neutron emission value as measured by radiochemistry and mass spectrometry A special problem arises for on line mass spectrometers that measure instantaneous yields such as Hiawatha These predelayed neutron chain yields must be corrected to post delayed neutron chain yields manually

2 2 RECOMMENDED YIELDS

The weighted average experimental independent yields the weighted average experimental cumulative yields and the calculated cumulative yields (where no data were available) are combined statistically to form a single self consistent recommended value The following is a summary of the procedure used to obtain the recommended values The calculated charge distribution is used only when no data are available Even then the calculated yield is normalized to the nearest experimentally determined value to ensure the experimental and recommended values will closely agree A large error is assumed for the calculated yields to ensure any respectable data will dominate The contributions of all precursors are added The total precursor contribution is then subtracted from the experimental cumulative yield when available or the normalized calculated yield to obtain an independent yield (Independent yields so obtained that are less than 0 1% are given no weight and negative values are discarded) This independent yield is then averaged with the experimental independent yield (if available) or the calculated independent yield and stored for later use A cumulative yield is then obtained by adding the precursor contribution to the independent yield previously obtained This cumulative yield is averaged with the experimental cumulative yields (if available) or the calculated cumulative yield to obtain a cumulative yield This cumulative yield is stored as input for the next member of the mass chain

After this procedure has been followed for all members of the chain the chain yield is obtained by adding the stored cumulative yields of all stable nuclides The stored independent yields are then normalized so that their total equals the chain yield (after adjustment for delayed neutron emission) The recommended cumulative yields are obtained by adding the independent yield of all precursors to the independent yield of the nuclide The total of the chain yields of each peak is then obtained The difference between 100% and this total is distributed among the chain yields in proportion to their variances This method ensures the reported chain yields will total 100% This procedure preserves the independent yield significance of the differences between the recommended yields It also allows unstable nuclides to affect the chain yields if independent yields have been determined or if the calculated charge distribution shows the yield of the nuclide to be very near the chain yield

There are several simple summation tests that can be performed as a check of the fission yield evaluation [8] These tests are briefly described below and have been performed for all fission systems whose yields have been evaluated Results are given in Table 2 for ^{237}Np ^{238}Pu ^{241}Am ^{243}Am and ^{242}Cm One simple check of the yield evaluation that is usually made is the calculation of the average charge This value may be computed from the independent yields as

$$Z_{avg} = \sum_{i} YI_i \, Z_i \,, \tag{2}$$

where the sum is over all i fission products and YI_i and Z_i are the independent yield and charge of nuclide i Except for small effects due to ternary fission Z_{avg} should be very near the charge of the fissioning nuclide Z_F Table 2 compares these quantities and lists the percentage deviation for five actinides The yield data clearly satisfy this simple check

Table 2 Average charge comparisons

Nuclide	Z_F	Z_{avg}	% deviation
^{237}Np(F)[a]	93	93 00	0 00
^{238}Pu(F)	94	94 00	0 00
^{241}Am(F)	95	94 99	0 01
^{243}Am(F)	95	95 00	0 00
^{242}Cm(F)	96	96 00	0 00

[a](F) denotes fast fission

The average neutron number can be calculated in a similar fashion

$$N_{avg} = \sum_{i} YI_i \, N_i \,, \tag{3}$$

where the sum is over all i fission products and YI_i and N_i are the independent yield and neutron number The average neutron number can be used to calculate the average number of prompt neutrons released per neutron induced fission $\bar{\nu}_p$ This may be done as

$$\bar{\nu}_p = A_F + 1 - (N_{avg} + Z_{avg}) \,, \tag{4}$$

where A_F is the mass number of the fissioning nuclide These values have been calculated and are given in Table 3 in comparison with values from an earlier evaluation [8] The deviations for ^{238}Pu(F) and ^{243}Am(F) are large due to the paucity of experimental data for these nuclides and therefore their heavy reliance on calculated yields Another method for calculating energy dependent prompt neutron yields will be discussed in Sect 4

Table 3 Comparison of prompt neutron yields

Nuclide	$\bar{\nu}$ (ENDF/B V EVAL)	$\bar{\nu}_p$(calc)	% deviation
^{237}Np(F)	2 77	2 696	2 66
^{238}Pu(F)	2 97	2 006	32 46
^{241}Am(F)	3 17	3 045	3 95
^{243}Am(F)	3 36	4 013	19 43
^{242}Cm(F)	3 53	3 604	2 10

A check is also made on the yield normalization to ensure that the sum of the independent yields equals 2 0

2.3 SUMMARY AND DATA FORMATS

The fission product yield data for fast fission of ^{237}Np, ^{238}Pu ^{241}Am ^{243}Am, and ^{242}Cm are provided in the format illustrated in Appendix A and described here The results for Z_{avg}, N_{avg}, $\bar{\nu}_p$ and the sum of direct yields are given for each of the five actinides ^{237}Np(F) ^{238}Pu(F) ^{241}Am(F) ^{243}Am(F) and ^{242}Cm(F) A table of mass chain yields (in percent) are given for mass numbers 66 through 172 for each of these fission systems The column labeled calculated is the result of summing the independent yields for each mass chain and the column labeled evaluated has the evaluated mass chain yields referred to in ref 7 The differences are usually small In some cases where delayed neutrons are important, the coupling between mass chains results in slightly larger differences

A table of independent fission yields is also given In this table the first column represents the chemical symbol, CS of the fission product nuclide Nuclide identifiers ID are given next and are calculated as

$$ID = 10000 * IZ + 10 * IA + IS , \tag{5}$$

where IZ IA, and IS are the nuclide s charge mass number and isomeric state indicator (IS = 0 ground state IS = 1 first isomeric state etc) The next column has half lives HL for nuclides when such data are known standard abbreviations are used (S seconds M minutes H hours etc) An abbreviation L in this column represents units in the common log of years (e g ^{129}I has a half life of 7 201L which is equal to 1 589 x 10^7 years The independent fission yields are given as fractions and their uncertainties are given in percent Each fissioning nuclide has in excess of 1000 fission product yields Recall these yields are for fission induced by fast neutrons (mean energies on the order of 0 5 MeV)

Appendix B illustrates the format used to provide the fission product yield data for ^{237}Np(T) ^{240}Pu(T) ^{242}Pu(T H) ^{243}Cm(T F) ^{244}Cm(F) ^{246}Cm(S F) and ^{248}Cm(F) where T F H and S denote thermal fast (pooled) high energy ($\sim$14 MeV) and spontaneous fission Many users will be familiar with the format in Appendix B in which we list the evaluation results for each of these ten yield sets per mass number per page (mass numbers 66 172) The format is identical to that used in earlier well known reports[8] and is described below

There is an attempt to provide the yield data using four lines per mass number per fission system including the primary decay branchings half lives and Gaussian parameters The nuclide identification is followed by g m or d meaning ground isomeric or delayed neutron Values for delayed neutrons simply show the contribution from the A+1 mass chain and would not be retained in listings of fission yield files such as ENDF/B VI All precursors cannot be listed in this format, but the most important precursors are included in the table and in the evaluation process described above Only the first isomeric state is included in the process of evaluation Exceptions occur in a few cases where second isomeric states are known such as in some indium isotopes As it becomes necessary these are added subsequently to the evaluation by dividing the total (Z A) yield into equal parts or by use of the method described in ref 6 where spins are known Evaluated experimental values for the independent and cumulative yields are given as XI and XC respectively The calculated cumulative yield is designated as CC The rows starting with RI and RC are the recommended independent and cumulative yields Each yield is followed by a letter denoting the uncertainty range as defined in Table 4 The reader should note that the letter P stands for uncertainties greater than 45% In the process of independent yield evaluation, calculated yields <0 5 are assumed to have 100% uncertainty yield values between 0 5 and 1 0 have 64% uncertainty and values >1 0 use 32% uncertainty In general the letter P should warn the reader that the yield is poorly known When the independent yield is very small as on the wings of the mass range and for small values near the beginning of each decay chain the uncertainty could be much larger than 32%, 64% or 100% used in the evaluation process

Table 4 Key to uncertainties of evaluated yields

Letter	Range %	File value stored	Letter	Range %	File value stored
A	<0 35	0 35	I	4 6	6
B	0 35 0 50	0 50	J	6 8	8
C	0 50 0 70	0 70	K	8 11	11
D	0 70 1 00	1 00	L	11 16	16
E	1 00 1 40	1 40	M	16 23	23
F	1 40 2 00	2 00	N	23 32	32
G	2 00 2 80	2 80	O	32 45	45
H	2 80 4 00	4 00	P	45 and up	>64

For the current evaluation there are very few measurements and most of the yields depend on model calculations The majority of tests such as $\bar{\nu}_p$ $\bar{\nu}_d$ that we make for each yield set indicate that the current evaluation is better than we would expect considering the paucity of measured data

3 DELAYED NEUTRON DATA

Delayed neutrons are commonly represented in a six group notation These groups have no physical basis They originated as 6 term 12 parameter fits to experimentally measured delayed neutron activities following fission pulse and saturation irradiation experiments in critical assemblies[9] Few experiments measuring six group parameters and spectra have been made since the late 1960s The more recent delayed neutron measurements have been performed for individual precursor nuclides[10 12] The data presented in this report have been derived from a detailed compilation and evaluation of these individual precursor data [13 15] An outline of the basic methodology for using data of this type is given below

3 1 METHODOLOGY AND MODELS

A principal advantage of an individual precursor data base such as that described in ref 14 is that the single set of precursor data can be used to calculate delayed neutrons for any fissioning system, given the appropriate fission yields The precursor data base includes delayed neutron emission probabilities (Pn values) and spectra for each of 271 individual precursor nuclides

3 1 1 Delayed Neutron Yields

Three methods of evaluating the yield of delayed neutrons from fission are described in order of preference The first is simply the use of experimentally determined $\bar{\nu}_d$ In instances where more than one measurement exists for a given fissioning system an inverse variance weighted average of the measured values is recommended This assumes that the reported yields are in relatively good agreement In the case of discrepant measurements consideration should be given to details of the various measurements in determining the proper weight of each value in calculating the recommended $\bar{\nu}_d$ value Measurements of $\bar{\nu}_d$ are usually reported for a specific incident neutron energy

The second method requires knowledge of the yield from fission and the delayed neutron emission probablity of each individual precursor A simple summation may then be used to calculate the delayed neutron yield per fission $\bar{\nu}_d$ The sum of the product of the delayed neutron emission probability Pn and the cumulative yield from fission YC, for each of 271 precursor nuclides[14] provides the value for $\bar{\nu}_d$ as shown in Eq (6) This equation is dependent on the incident neutron energy only in that the values for the cumulative fission yields are evaluated as a crude function of incident neutron energy for spontaneous thermal fast and high energy ($\sim$14 MeV) fission

$$\bar{\nu}_d = \sum_j Pn^j YC_j \qquad (6)$$

Earlier investigations of the systematics of delayed neutron emission did recommend empirical correlations of $\bar{\nu}_d$ with the charge (Z_c) and mass (A_c) of the compound nucleus which comprise the third method for predicting $\bar{\nu}_d$ More precisely, the fits were versus the parameter ($A_c - 3Z_c$) One such correlation given by Tuttle (1975)[16] was based on 13 experimental data points and a more recent evaluation by Waldo and Karam (1982)[17] included 21 experimental data points (Note that there is an error in Eq (59) of ref 16 it should read $Y = \exp[C + B(A_c\ 3Z)A_c/Z]$) For convenience these empirical correlations are repeated here in a nomenclature consistent with this text The Tuttle expression[16] for the delayed neutron yield is

$$\bar{\nu}_d = \exp[C + B(A_c - 3Z_c)A_c/Z_c] \ , \tag{7}$$

where C = 14 638 and B = 0 1832 Waldo s expression[17] for the delayed neutron yield per 100 fissions is

$$\bar{\nu}_d(100) = \exp(16\,698 - 1\,144 Z_c + 0\,3769 A_c) \tag{8}$$

The uncertainty in these empirical fits is given as approximately 11% in both cases Also note that the effect of incident neutron energy is not considered in these simple models Table 5 compares the calculated results from Eq (6) with those predicted from Eqs (7) and (8) Agreement is considered to be very good except for ^{237}Np(T) The differences for this system are most likely due to inadequate measured fission yield data for the system

Direct measurements of $\bar{\nu}_d$ should be utilized where possible next the summation method is recommended when experimental fission yield data are available and finally in situations where no experimental delayed neutron yields or fission yield data exist the empirical formulae should be used

The energy dependence of $\bar{\nu}_d$ is generally treated as a crude function of energy In most cases where experimental data are available to determine the energy dependence it has been noted that $\bar{\nu}_d$ is relatively constant from thermal energies to approximately 4 MeV where it begins to decrease gradually until it again plateaus out in the region of 7 MeV to 20 MeV The energy dependence of $\bar{\nu}_d$ is an area that has been seriously neglected No energy dependent experimental $\bar{\nu}_d$ data were found for the actinides of interest here and theoretical models were not obtainable Therefore the crude energy dependent function described above was used with the summation $\bar{\nu}_d$ calculated from the fast fission yields representing the first plateau and the 14 MeV value used for the second In some cases, there were no 14 MeV data and no recommendation was made other than the value for fast fission Note that for some actinides the fission reaction is a threshold reaction and in these cases the energy dependent delayed neutron yield should have a zero value from thermal energies to the threshold energy

Table 5 Calculated delayed neutron yield per 100 fissions

Fission[a] system	Present summation	Tuttle fit Eq (7)	Waldo fit Eq (8)
$^{237}Np(T)$	1 632 ± 0 162	1 021	1 008
$^{240}Pu(T)$	1 037 ± 0 106	0 986	0 995
$^{242}Pu(T)$	2 101 ± 0 186	2 166	2 114
$^{242}Pu(H)$	1 526 ± 0 169	2 166	2 114
$^{243}Cm(T)$	0 299 ± 0 043	0 288	0 313
$^{243}Cm(F)$	0 209 ± 0 041	0 288	0 313
$^{244}Cm(F)$	0 366 ± 0 052	0 423	0 456
$^{246}Cm(S)$	0 708 ± 0 084	0 623	0 665
$^{246}Cm(F)$	0 922 ± 0 099	0 921	0 969
$^{248}Cm(F)$	1 939 ± 0 180	2 037	2 059

[a]T F H and S denote thermal fast high energy (~ 14 MeV) and spontaneous fission respectively

3 1 2 Six-Group Parameters

The fission product depletion code, CINDER10 [18] was used to calculate the inventories of all precursor nuclides for various cooling times (to 300 seconds) following a prompt irradiation in each of the fissioning systems These nuclide inventories were weighted with the recently evaluated delayed neutron emission probabilities to determine the delayed neutron activities at the various cooling times

The delayed neutron activity curves can be approximated mathematically by a sum of N exponentials representing N time groups as in Eq (9)

$$n_d(t) = \sum_{i=1}^{N} A_i e^{-\lambda_i t} \tag{9}$$

A nonlinear least squares fitting routine STEPIT [19] was used to determine the parameters

A_i and λ_i The constant λ_i represents an effective decay constant for the i^{th} group of delayed neutron precursors Equation (9) is being used to represent delayed neutron activity following a fission pulse therefore the coefficient A_i represents the initial activity of delayed neutrons and is found as the product of the group decay constant λ_i and the group yield per fission α_i

The six group decay constants are given in Table 6 and the normalized group abundances $a_i = \alpha/\nu_d$ are given in Table 7

Table 6 Six group decay constants (s^{1})

Fission[a] system	Decay group 1	2	3	4	5	6
^{237}Np(T)	1 33E 02[b]	3 17E 02	1 19E 01	3 06E 01	8 71E 01	2 86
^{237}Np(F)	1 33E 02	3 16E 02	1 17E 01	3 01E 01	8 67E 01	2 76
^{238}Pu(F)	1 33E 02	3 12E 02	1 16E 01	2 89E 01	8 56E 01	2 71
^{240}Pu(T)	1 36E 02	3 03E 02	1 14E 01	3 01E 01	8 67E 01	2 87
^{242}Pu(T)	1 40E 02	2 99E 02	1 15E 01	3 16E 01	8 81E 01	3 13
^{242}Pu(H)	1 35E 02	3 11E 02	1 18E 01	3 10E 01	8 90E 01	3 03
^{241}Am(F)	1 33E 02	3 08E 02	1 13E 01	2 87E 01	8 65E 01	2 64
^{243}Am(F)	1 35E 02	2 98E 02	1 14E 01	2 99E 01	8 82E 01	2 81
^{242}Cm(F)	1 30E 02	3 12E 02	1 13E 01	2 78E 01	8 71E 01	2 20
^{243}Cm(T)	1 31E 02	3 03E 02	1 15E 01	2 92E 01	8 58E 01	2 59
^{243}Cm(F)	1 30E 02	2 99E 02	1 08E 01	2 75E 01	8 06E 01	2 15
^{244}Cm(F)	1 32E 02	3 00E 02	1 13E 01	2 90E 01	8 54E 01	2 62
^{246}Cm(S)	1 39E 02	2 92E 02	1 11E 01	3 12E 01	8 57E 01	2 83
^{246}Cm(F)	1 37E 02	2 95E 02	1 13E 01	3 03E 01	8 60E 01	2 93
^{248}Cm(F)	1 47E 02	2 93E 02	1 14E 01	3 20E 01	9 02E 01	3 06

[a]T, F H and S denote thermal fast high-energy (~14 MeV), and spontaneous fission respectively

[b]Read as 1 33 x 10^{2}

Table 7 Normalized six group abundances

Fission[a] system	Decay group 1	2	3	4	5	6
$^{237}Np(T)$	0 0330	0 1957	0 1573	0 3720	0 1730	0 0690
$^{237}Np(F)$	0 0400	0 2162	0 1558	0 3633	0 1659	0 0589
$^{238}Pu(F)$	0 0377	0 2390	0 1577	0 3562	0 1590	0 0504
$^{240}Pu(T)$	0 0236	0 2489	0 1461	0 3379	0 1849	0 0586
$^{242}Pu(T)$	0 0122	0 2027	0 1311	0 3498	0 2270	0 0772
$^{242}Pu(H)$	0 0207	0 1521	0 1369	0 3885	0 2102	0 0916
$^{241}Am(F)$	0 0355	0 2540	0 1563	0 3364	0 1724	0 0454
$^{243}Am(F)$	0 0234	0 2945	0 1537	0 3148	0 1656	0 0480
$^{242}Cm(F)$	0 0763	0 2847	0 1419	0 2833	0 1763	0 0375
$^{243}Cm(T)$	0 0498	0 2994	0 1399	0 2960	0 1777	0 0372
$^{243}Cm(F)$	0 0547	0 3884	0 1477	0 2472	0 1319	0 0300
$^{244}Cm(F)$	0 0369	0 3102	0 1512	0 2991	0 1653	0 0373
$^{246}Cm(S)$	0 0131	0 3577	0 1493	0 2896	0 1579	0 0323
$^{246}Cm(F)$	0 0157	0 2830	0 1513	0 3200	0 1823	0 0476
$^{248}Cm(F)$	0 0070	0 2074	0 1376	0 3423	0 2366	0 0691

[a] T, F, H, and S denote thermal fast high-energy (~14 MeV) and spontaneous fission respectively

3 1 3 Six-Group Energy Spectra

The time dependent behavior of delayed neutrons following a fission pulse can be calculated from Eq (9) using the appropriate six group parameters given in Tables 6 and 7 and the delayed neutron yield per fission In the individual precursor notation the same quantity may be expressed as

$$n_d(t) = \sum_{j=1}^{271} \lambda_j Pn^j YI_j e^{\lambda_j t} , \tag{10}$$

where YI_j is the independent (direct) yield per fission of the j^{th} precursor and λ_j is its decay constant In the previous section it was explained that the six group parameters were determined from a least squares fit to delayed neutron activity following a pulse irradiation as calculated by the fission product depletion code CINDER10 [18] using the individual precursor data Although Eq (10) ignores the coupling between mass chains which is included in the CINDER10 calculations Therefore in the present evaluation it is required that

$$A_i e^{-\lambda_i t} = \sum_k f_{k,i} \lambda_k Pn^k YI_k e^{-\lambda_k t} , \tag{11}$$

where the subscript i represents mathematical group i the summation is over all precursors and $f_{k,}$ is the fraction of delayed neutrons produced by precursor k that contribute to group i It is assumed that a delayed neutron precursor may contribute to either or both of the adjacent mathematical groups as determined by the decay constants as in

$$\lambda_i < \lambda_k < \lambda_{i+1} \tag{12}$$

It is also required that

$$f_{k,i} + f_{k,i\ 1} = 1 \tag{13}$$

The fractions $f_{k,i}$ were determined by requiring that the least squares error

$$\int_0^\infty \{\lambda_k e^{-\lambda_k t} - [f_{k,i} \lambda_i e^{-\lambda_i t} + (1 - f_{k,i}) \lambda_{i+1} e^{-\lambda_{i\ 1} t}]\}^2 dt , \tag{14}$$

be a minimum The equilibrium group spectra $\Phi_i(E)$ were then computed as

$$\phi_i(E) = \sum_k f_{k,i} YC_k Pn^k \phi_k(E) , \tag{15}$$

where $\phi_k(E)$ is the delayed neutron spectrum of precursor k

Using the method described above the group one spectra for most fission nuclides have three primary contributing nuclides The precursor ^{87}Br contributes 100% of its delayed neutrons to group one as would be expected however two additional precursors ^{137}I and ^{141}Cs each contribute about

20% of their delayed neutrons to group one in a ^{235}U fueled system This result allows the group one spectrum to change for different fissioning systems (since the relative yields of ^{87}Br ^{137}I and ^{141}Cs change) as suggested by ENDF/B V data for ^{235}U ^{238}U and ^{239}Pu which are based on experiments

3 2 EXPERIMENTAL DATA

The delayed neutron emission probabilities used in the data base include experimental values for 89 precursor nuclides and values calculated from systematics for the remaining 182 precursors Emission probabilities used in the data base were taken from ref 13 an evaluation by F Mann of Hanford Engineering Development Laboratory The 89 precursors with measured Pn values account for no less than 95 8% of the total delayed neutrons emitted from fast fission in ^{237}Np ^{238}Pu ^{241}Am ^{243}Am and ^{242}Cm

Experimental precursor spectra used in the data base came primarily from three sources K. L Kratz [11] University of Mainz Germany G Rudstam [12] Swedish Research Council s Laboratory at Studsvik Sweden and Greenwood and Caffrey [20] Idaho National Engineering Laboratory Reference 14 gives detailed references by nuclide for each of the 34 precursors with measured delayed neutron spectra The spectra for 30 of these 34 precursors were augmented with model calculations as described in ref 14 The 34 nuclides with measured spectra account for 77 5 85 7% of the total delayed neutrons produced from the fast fission of the five actinides considered in this section Models were used for the 237 precursors with no measured spectra [13]

3.3 SUMMARY AND DATA FORMAT

Recommended values for the delayed neutron yield per fission are given in Table 8 The values for $^{237}Np(F)$, $^{238}Pu(F)$, and $^{241}Am(F)$ are based on the inverse variance weighted average of experimental data from refs 21 and 22 Delayed neutron yields for all other fission systems are based on calculations as described by Eq (6)

Formats used to provide the delayed neutron data for ^{237}Np ^{238}Pu ^{241}Am ^{243}Am and ^{242}Cm are illustrated in Appendix C The yield data are given as pairs of energy (eV) and yield per fission Four points are given for each nuclide and straight line interpolation should be used between points

Next the six group data are given Normalized group fractions (or abundances) are given as well as group decay constants (s^{-1}) The group spectra are given in the 70 energy group structure of the JFS 3 J2 library The spectra are normalized such that they sum to unity Appendix D illustrates the format used to provide the delayed neutron data for $^{237}Np(T)$, $^{240}Pu(T)$, $^{242}Pu(T H)$ $^{243}Cm(T F)$

Table 8 Recommended $\bar{\nu}_d$ values

Nuclide	$\bar{\nu}_d$ per 100 fissions
^{237}Np(T)	1 6320 ± 0 1623
^{237}Np(F)	1 08[a]
^{238}Pu(F)	0 42[a]
^{240}Pu(T)	1 0373 ± 0 1065
^{242}Pu(T)	2 1011 ± 0 1864
^{242}Pu(H)	1 5264 ± 0 1692
^{241}Am(F)	0 43[a]
^{243}Am(F)	0 7951 ± 0 0916
^{242}Cm(F)	0 1361 ± 0 0293
^{243}Cm(T)	0 2990 ± 0 0429
^{243}Cm(F)	0 2093 ± 0 0409
^{244}Cm(F)	0 3663 ± 0 0518
^{246}Cm(S)	0 7081 ± 0 0837
^{246}Cm(F)	0 9219 ± 0 0991
^{248}Cm(F)	1 9386 ± 0 1798

[a]Based on inverse variance weighted average of experimental data from refs 21 and 22

^{244}Cm(F) ^{246}Cm(S F) and ^{248}Cm(F) Basically the same information is presented as in Appendix C although the format is more conducive to computer applications

4 PROMPT NEUTRON DATA

The basic methodology used to calculate prompt neutron yields and spectra is described briefly and specific references to the literature are given For this application only first chance and spontaneous fission are considered

4 1 PROMPT NEUTRON SPECTRA

Prompt neutron spectra are calculated using the methodology described in detail in refs 23 and 24 Multiple chance fission is also discussed in these references but it is not considered in this work

4 1 1 Methodology and Data

The prompt neutron spectrum N(E) is taken to be the average of the prompt neutron spectra for the average light and average heavy fission fragments $N(E,E_f^L)$ and $N(E\ E_f^H)$ respectively as follows

$$N(E) = \tfrac{1}{2}[N(E,E_f^L) + N(E,E_f^H)] \qquad (16)$$

For a given fission fragment, the neutron energy spectrum in the center of mass system can be derived from standard nuclear evaporation theory This expression is then transformed to the laboratory system resulting in the following expression [Eq (17)] for the prompt neutron spectrum of a fission fragment [23]

$$N(E,E_f) = \frac{1}{3[(E_f)(T_m)]^{1/2}}[u_2^{3/2}E_1(u_2) - u_1^{3/2}E_1(u_1) + \gamma(3/2,u_2) - \gamma(3/2,u_1)] \ , \qquad (17)$$

where

$$u_1 = (\sqrt{E} - \sqrt{E_f})^2/T_m$$

$$u_2 = (\sqrt{E} + \sqrt{E_f})^2/T_m,$$

$$\gamma(a\ b) = \int_0^b x^{a-1}\exp(-x)dx$$

and E_1 is the exponential integral The three fundamental quantities that are required in Eqs (16) and (17) are described as follows

E_f^L — the average kinetic energy per nucleon of the average light fission fragment,

E_f^H — the average kinetic energy per nucleon of the average heavy fission fragment,

T_m — maximum temperature of the fission fragment residual nuclear temperature distribution

T_m is a function of incident neutron energy for neutron induced fission but is constant for the case of spontaneous fission Methods to obtain values for these three constants are discussed in ref 23 and in Appendix A of ref 24 The maximum temperature may be found as

$$T_m = \sqrt{(\langle E* \rangle)/a_{eff}} \,, \tag{18}$$

where a_{eff} = A/k (MeV^{1}) A is the mass number of the compound nucleus and k is a constant ranging from 7 5 to 11 0 A value of k = 11 is typically used to represent the level density parameter when comparing with experimental values throughout the periodic table [23] Madland and Nix[23] suggest that a slightly smaller value (k = 10) be used in the case of the constant compound nucleus cross section approximation to adjust the spectrum for this approximation The principal advantage of using this approximation is that it yields a closed form expression for the prompt neutron spectrum based only on the three parameters listed above [24] For the actinides of interest in this work a value of k = 9 4 (recommended from a comparison[25] with experiment for ^{239}Pu) was used except for the curium isotopes where a value of k = 8 5 was used This value of k was based on a comparison of calculated $\bar{\nu}$ with experimental data for curium isotopes A comparison of the calculated level density parameters with measured values[26] for ^{239}Pu ^{242}Am ^{245}Cm reveal differences on the order of 2% The total average fission fragment excitation energy $\langle E \ \rangle$ is given as

$$\langle E \ \rangle = \langle E_r \rangle + B_n + E_n - \langle E_f \rangle_{tot} \,, \tag{19}$$

where

$\langle E_r \rangle$	is the average energy release
B_n	is the neutron separation energy
E_n	is the kinetic energy of the incident neutron
$\langle E_f \rangle_{tot}$	is the total average fission fragment kinetic energy

Data for some actinides are given in Table 1 of ref 23 Values for the neutron separation energy may be found in ref 27 In calculating the average energy release for the fission of the compound nucleus we follow the method used in ref 23 The calculation of $\langle E_r \rangle$ by this method requires identifying the average light and average heavy fission fragments for each case and averaging the energy release as calculated from mass differences for these central fragments and three neighboring fragments on each side of the central fragment The central heavy fission fragment in each case, except ^{237}Np, is taken to be ^{140}Xe and the light fragment is an isotope of molybdenum, calculated from the mass difference of the compound nucleus and the heavy fragment In the case of ^{237}Np the average heavy fragment was taken to be ^{139}Xe The atomic masses used are from the work of

Wapstra Audi and Hoekstra[28] When no measured data are available $\langle E_f \rangle_{tot}$ is calculated using the results of a least squares adjustment by Unik et al [29]

$$\langle E_f \rangle_{tot} = 0\ 13323(Z^2/A^{1/3}) - 11\ 64 \text{ MeV}, \tag{20}$$

where (Z A) refers to the fissioning compound nucleus Average masses are obtained by interpolation of data given in Table I of ref 29 The method given in Appendix A of ref 24 is used to derive values for E_f^L and E_f^H These expressions are derived from conservation of momentum and are given as [23]

$$E_f^L = \frac{A_H}{A_L} \frac{\langle E_f \rangle_{tot}}{A}, \tag{21}$$

$$E_f^H = \frac{A_L}{A_H} \frac{\langle E_f \rangle_{tot}}{A}, \tag{22}$$

where A_L and A_H are the average mass numbers of the light and heavy fragments respectively and A is the mass number of the compound nucleus undergoing fission Tables 9 and 10 summarize the data used in these calculations Data for ^{237}Np were taken from ref 30

Table 9 Quantities used to calculate <E > for neutron induced fission

Nuclide	Average light fragment	Average heavy fragment	$\langle E_r \rangle$	B_n	$\langle E_f \rangle_{tot}$
^{237}Np	^{99}Y	^{139}Xe	193 94	5 488	176 00
^{238}Pu	^{99}Zr	^{140}Xe	198 64	5 647	178 06
^{241}Am	^{102}Nb	^{140}Xe	204 97	6 309	181 31
^{243}Am	^{104}Nb	^{140}Xe	205 14	5 363	180 78
^{243}Cm	^{104}Mo	^{140}Xe	209 72	6 799	184 85
^{244}Cm	^{105}Mo	^{140}Xe	210 43	5 520	184 58
^{245}Cm	^{106}Mo	^{140}Xe	209 94	6 457	184 20
^{246}Cm	^{107}Mo	^{140}Xe	210 58	5 158	184 05
^{247}Cm	^{108}Mo	^{140}Xe	209 88	6 212	183 79
^{248}Cm	^{109}Mo	^{140}Xe	210 77	4 713	183 53

Table 10 Values of A_L A_H E_f^L E_f^H and T_m

Nuclide	A_L	A_H	E_f^L (MeV)	E_f^H (MeV)	T_m
^{237}Np	98 6	138 4	1 0383	0 5267	0 9240
^{238}Pu	99 4	139 6	1 0463	0 5305	1 0250
^{241}Am	102 0	140 0	1 0283	0 5459	1 0880
^{243}Am	103 7	140 3	1 0024	0 5476	1 0790
^{243}Cm	103 7	140 3	1 0250	0 5600	1 0586
^{244}Cm	104 5	140 5	1 0129	0 5603	1 0515
^{245}Cm	105 5	140 5	0 9972	0 5623	1 0629
^{246}Cm	106 5	140 5	0 9830	0 5648	1 0525
^{247}Cm	107 0	141 0	0 9766	0 5624	1 0603
^{248}Cm	107 5	141 5	0 9702	0 5600	1 0525

In Table 10 the values of T_m are based on an incident neutron energy of 0 5 MeV which was chosen as the average energy of a fission neutron For spontaneous fission E_n is taken to be zero

4 1 2 Results and Data Formats

A short FORTRAN program MADNIX FOR was written to calculate prompt neutron spectra and is given in Appendix E as Table E 1 The input file MADNIX DAT used for these calculations is given as Table E 2 The data required by MADNIX FOR include as the first entry the number of energy groups the spectrum is to be generated in Two options are available A value of NG = 70 results in the 70 energy group structure of the JFS 3 J2 library used by JAERI and in the work reported here any other value of NG will default to a 27 group structure Next a title card must be provided The following data card should provide E_n E_f^L E_f^H and T_m in units of eV Additional cases can be executed by providing additional title and data cards for each desired subcase as shown in Table E 2 The calculated spectra are normalized such that they sum to 1 0 The 70 group prompt neutron spectra for the ten cases shown in Table E 2 are given in Table E 3 A complete listing of the contents of Appendix E and the calculated spectra are available from the authors on a 1 2 Mbyte 5¼ in computer diskette

4 2 PROMPT NEUTRON YIELDS

Energy dependent prompt neutron yields for fast fission in ^{237}Np ^{238}Pu ^{241}Am ^{243}Am and ^{243}Cm to ^{248}Cm have been compiled and are described in this section We have also calculated prompt neutron yields for ^{242}Cm ^{244}Cm ^{246}Cm and ^{248}Cm spontaneous fission (sf) These cases serve as a valuable check on the neutron fission calculations since accurate experimental data are available, as will be discussed later The methodology and data sources used for the calculations are described briefly and references are given that will provide additional detail

4.2.1 Methodology

In the previous section of this report we described the calculations for prompt neutron spectra for fast fission The basic method used for the prompt neutron yield calculations is described in detail in ref 23

In order to benchmark our calculations, we have calculated the energy dependent prompt neutron yields for four additional nuclides that were considered in the work by Madland and Nix[23] The nuclides are ^{235}U ^{238}U ^{239}Pu and ^{240}Pu For these cases we use the values given in ref 23 for the input parameters Our results given in Appendix F for these four nuclides are in excellent agreement with the corresponding results by Madland and Nix given in Table III of ref 23

The basic equation[23] for the calculation of the energy dependent $\bar{\nu}_p$ is

$$\bar{\nu}_p(E_n) = \frac{\langle E_r \rangle + B_n + E_n - \langle E_f \rangle_{tot} - \langle E_g \rangle_{tot}}{\langle S_n \rangle + \langle \epsilon \rangle} , \tag{23}$$

where

$\langle E_r \rangle$	is the average energy release
B_n	is the separation energy
E_n	is the kinetic energy of the incident neutron
$\langle E_f \rangle_{tot}$	is the total average fission fragment kinetic energy
$\langle E_g \rangle_{tot}$	is the total average prompt gamma energy
$\langle S_n \rangle$	is the average fission fragment neutron separation energy
$\langle \epsilon \rangle$	is the average center of mass energy of the emitted neutrons

The parameter $\langle \epsilon \rangle$ is calculated as

$$\langle \epsilon \rangle = (4/3)T_m , \tag{24}$$

where the parameter T_m is the maximum temperature of the fission fragment residual nuclear temperature distribution and is calculated as described in Sect 4 1 1 Eqs (18) and (19)

4 2.2 Data Sources and Discussion

In this section, the data sources for the various input parameters will be discussed For the most part these are similar to those presented in Sect 4 1 but are repeated here for the convenience of the reader For some of the input parameters additional details and explanations are included

One of the key parameters in terms of its impact on calculated $\bar{\nu}_p(E_n)$ is the average energy release $<E_r>$ $<E_r>$ is calculated from the mass differences using the method of ref 23 with the experimental masses of Wapstra Audi and Hoekstra (ref 28) The central light and heavy fission fragments for each of the fissionable nuclides are shown in Table 11 For the curium isotopes the central heavy fragment is ^{140}Xe and the central light fragment is an isotope of molybdenum The choice of ^{140}Xe as the central heavy fragment is based on information contained in Unik et al [29]

Table 11 Central light and heavy fission fragments

Nuclide	Central light fragment	Central heavy fragment
^{237}Np	^{99}Y	^{139}Xe
^{238}Pu	^{99}Zr	^{140}Xe
^{241}Am	^{102}Nb	^{140}Xe
^{243}Am	^{104}Nb	^{140}Xe
^{242}Cm (sf)	^{103}Mo	^{140}Xe
^{243}Cm ^{244}Cm (sf)	^{104}Mo	^{140}Xe
^{244}Cm	^{105}Mo	^{140}Xe
^{245}Cm ^{246}Cm (sf)	^{106}Mo	^{140}Xe
^{246}Cm	^{107}Mo	^{140}Xe
^{247}Cm ^{248}Cm (sf)	^{108}Mo	^{140}Xe
^{248}Cm	^{109}Mo	^{140}Xe

Figures 1 and 2 of ref 29 show the primary fragment mass distributions for ^{245}Cm (n f) ^{246}Cm (sf) and ^{248}Cm (sf) In each case the heavy mass peak is very close to A = 140 The choice of (Z_L Z_H) = (42 54) is based on the discussion given on page 27 of ref 29 which states that for curium isotopes this division generally occurs with the highest or nearly the highest yields where Z_L and Z_H refer to the Z numbers for the light and heavy fragments respectively

The separation energy of the neutron inducing fission B_n is obtained as discussed in ref 23 The data of Wapstra and Bos[27] are used in all cases Note that when values are read from the table (in ref 27 Part II) the value of S(N) to be used in each case is that of the compound nucleus B_n for the spontaneous fission cases is zero

The kinetic energy E_n of the neutron inducing fission is usually taken to be 0 5 MeV for fast fission and is set to zero for spontaneous fission cases

The total average fission fragment kinetic energy $<E_f>_{tot}$, has been determined experimentally for ^{245}Cm (n f) and for ^{246}Cm (sf) ^{248}Cm (sf) (see Table I in Unik et al[29]) Unik et al have also performed a least squares fit of the (n,f) data which give a correlation of the (n f) data with the Coulomb repulsion parameter [i e $Z^2/A^{1/3}$ see Eq (20)] which can be used for cases for which an experimental value has not been determined Also for the spontaneous fission cases the calculated or experimental values have been adjusted within uncertainties The rationale for this is taken from Unik et al[29] which states The $<E_f>_{tot}$ values measured for spontaneous fission are in almost all cases less than those measured or interpolated from the (n f) data For ^{246}Cm (sf) and ^{248}Cm (sf) the adjusted values are within uncertainties in the experimental values The values of $<E_f>_{tot}$ for the curium isotopes are summarized in Table 12 In our calculations the adjusted values are used for the (sf) cases and the calculated values are used for the (n f) cases with the exception of ^{245}Cm (n f) for which the experimental value is used For ^{237}Np we use 175 60 (adjusted in this work) The values of $<E_f>_{tot}$ for ^{238}Pu ^{241}Am, and ^{243}Am were shown in Table 9

The total average prompt gamma energy $<E_g>_{tot}$ is calculated using the following expression[31]

$$<E_g>_{tot} = (0\ 028)A + 0\ 09 \qquad (25)$$

The average fission fragment neutron separation energy $<S_n>$ is calculated using the method of ref 23 as one half of the average two neutron separation energy $<S_{2n}>$ This average $<S_{2n}>$ value is calculated similar to average energy release $<E_r>$ as the average of the values for the heavy and light mass peaks The average value for each of the two mass peaks is calculated as the weighted average of the S_2 values for the seven central fragments in each peak (the central fragment being

Table 12 Values of $<E_f>_{tot}$ for curium isotopes

Nuclide	Calculation	Adjustment	Experimental
^{242}Cm (sf)	185 39	184 80	
^{243}Cm	184 85		
^{244}Cm (sf)	184 85	184 35	
^{244}Cm	184 58		
^{245}Cm	184 32		184 20
^{246}Cm (sf)	184 32	183 60	183 90
^{246}Cm	184 05		
^{247}Cm	183 79		
^{248}Cm (sf)	183 79	182 90	182 20[a]
^{248}Cm	183 53		

[a]Error = $\pm$ 0 9 MeV

weighted by a factor of 2) Values for the two neutron separation energies S_{2n} for specific fission fragments are calculated using the masses from ref 28 as

$$S_{2n} = - M(A,Z) + M(A-2,Z) + 2n \tag{26}$$

A small FORTRAN program FISSER has been written which calculates both $<E_r>$ and $<S_n>$ and is listed in Appendix F Table F 1 A sample input to FISSER is also listed in Table F 1 for the case of ^{244}Cm This input file includes the identities and masses of the seven central light and heavy fission fragments and the masses of their A 2 counterparts The compound nucleus and its mass are also included in the input The mass values used here are mass defects relative to the nuclide mass number A and are in units of MeV Appendix G contains tables of mass values for light fission fragments (Table G 1) heavy fission fragments (Table G 2) and compound nuclei (Table G 3) as used in this work This method gives a slightly lower value for the heavy fragment $<S_{2n}>$ as compared with using the $<S_{2n}>$ values from ref 27 and is illustrated in Table 13 for the case of

^{244}Cm The new value for the heavy fragment 9 127 MeV is about 2% smaller than the 9 315 MeV given by Wapstra and Bos[27] The new method has the advantage that both the $<E_r>$ and $<S_{2n}>$ calculations use consistent mass values and have a dependence on the fissioning nucleus The average value for the light fragment is nearly unchanged from that obtained using the $<S_{2n}>$ values from ref 27 The value of $<S_n>$, obtained by taking one half the sum of the two average values is 5 440 MeV and is in good agreement with the previous value[27] of 5 496 MeV

Table 13 ^{244}Cm two neutron separation energies (MeV)

Light fragment	$<S_{2n}>$	Heavy fragment	$<S_{2n}>$
^{102}Nb	12 563	^{143}Cs	9 415
^{103}Nb	12 432	^{142}Cs	9 627
^{104}Mo	12 953	^{141}Xe	8 772
^{105}Mo	12 742	^{140}Xe	9 022
^{106}Mo	12 042	^{139}Xe	9 449
^{107}Tc	12 952	^{138}I	8 882
^{108}Tc	12 632	^{137}I	8 828
Average[a]	12 632	Average[a]	9 127

[a]Central fragments ^{105}Mo and ^{140}Xe are given a double weight

Table 14 summarizes the input data for the energy dependent $\bar{\nu}_p$ calculations

4 2.3 Final Results and Discussion for $\bar{\nu}_p$

The final results for the calculated values of the energy dependent $\bar{\nu}_p$ for the nuclides in Table 14 are given in Appendix F Table F 5 at 13 energies from 0 to 6 MeV in steps of 0 5 MeV The data are included as part of the listing of NUBAR OUT and are given as pairs of energy and $\bar{\nu}_p$ These results were obtained using the program NUBAR FOR with the input NUBAR DAT which are also given in Appendix F For each nuclide a linear fit of the form $A(E_n) + B$ is also provided Considering the accuracy of the calculations it should be adequate to use these linear fits if desired The calculated values for the spontaneous fission cases are compared with the experimental values in Table 15 For the cases where two experimental values were available the values used in Table 15 are taken to be one half of the sum of the measured values (refs 32 and 33)

Table 14 Input data for $\bar{\nu}_p$ calculations[a]

Nuclide	$\langle E_r \rangle$	B_n	$\langle E_f \rangle_{tot}$	$\langle E_g \rangle_{tot}$	$\langle S_n \rangle$
^{237}Np	193 94	5 488	175 60	6 754	5 215
^{238}Pu	198 64	5 647	178 06	6 782	5 274
^{241}Am	204 97	6 309	181 31	6 866	5 414
^{243}Am	205 14	5 363	180 78	6 922	5 295
^{242}Cm (sf)	209 24	0 0	184 80	6 866	5 640
^{243}Cm	209 72	6 799	184 85	6 922	5 524
^{244}Cm (sf)	209 72	0 0	184 35	6 922	5 524
^{244}Cm	210 43	5 520	184 58	6 950	5 440
^{245}Cm	209 94	6 457	184 20	6 978	5 330
^{246}Cm (sf)	209 94	0 0	183 60	6 978	5 330
^{246}Cm	210 58	5 158	184 05	7 006	5 221
^{247}Cm	209 88	6 212	183 79	7 034	5 111
^{248}Cm (sf)	209 88	0 0	182 90	7 034	5 111
^{248}Cm	210 77	4 713	183 53	7 062	5 061

[a]All energies in MeV

Table 15 $\bar{\nu}_p$ for spontaneous fission

Nuclide	Calculation	Experiment[32,33]	C/E
^{242}Cm (sf)	2 556	2 551	1 002
^{244}Cm (sf)	2 722	2 721	1 000
^{246}Cm (sf)	2 933	2 930	1 001
^{248}Cm (sf)	3 120	3 130	0 997

The calculated and experimental values from Table 15 are found to be in excellent agreement To some extent this is due to the use of adjusted values for $\langle E_f \rangle_{tot}$ as discussed in Sect 4 2 2 However the $\langle E_f \rangle_{tot}$ adjustments were both small and reasonable so the good agreement between calculation and experiment tends to increase the confidence in the method used at least for the spontaneous fission cases

The calculated and experimental values of $\bar{\nu}_p$ for thermal fission (corresponding to $E_n \sim 0$ in the calculation) are compared in Table 16

Table 16 $\bar{\nu}_p$ for thermal fission

Nuclide	Calculation	Experiment[32]	C/E
^{243}Cm	3 574	3 43	1 042
^{244}Cm	3 575		
^{245}Cm	3 744	3 75	0 998
^{246}Cm	3 732		
^{247}Cm	3 879	3 80	1 021
^{248}Cm	3 857		

The calculated and experimental values for the odd isotopes are considered to be in good agreement particularly when considering the larger uncertainties in the experimental values relative to those for spontaneous fission For ^{243}Cm the calculated value is higher than the experimental value by just about 1σ For ^{245}Cm and ^{247}Cm the deviations are less than 1σ Experimental values of $\bar{\nu}_p$ are not available for the even isotopes Note that for the even isotopes the calculated $\bar{\nu}_p$ is very close to the value calculated for the odd isotope of mass $(A - 1)$

Experimental energy dependent $\bar{\nu}_p$ data for the curium isotopes is virtually nonexistent It may be of interest to compare the energy dependence obtained from our calculations for ^{235}U ^{238}U ^{239}Pu, and ^{240}Pu included in Table F 5 with the corresponding ENDF/B V evaluations These comparisons are shown in Table 17

The slopes obtained for the curium isotopes do not differ appreciably from those calculated for the uranium and plutonium cases The ^{235}U and ^{238}U calculations are in reasonable agreement with the ENDF/B V evaluations The ^{239}Pu and ^{240}Pu calculated slopes are lower than those obtained from the corresponding ENDF/B V evaluations

The final results for the calculated values of the energy dependent $\bar{\nu}_p$ for the 14 nuclides considered in this section are given in Table F 5 The calculated values at 0 5 MeV from this work are compared with the corresponding ENDF/B V evaluations in Table 18 Generally good agreement

Table 17 Energy dependence (slope) of $\bar{\nu}_p$ by nuclide

Nuclide	Calculation	ENDF/B V
^{235}U	0 1459	0 1487 (1 2 6 MeV)
^{238}U	0 1486	0 1436 (1 5 6 MeV)
^{239}Pu	0 1386	0 1581 (1 5 7 MeV)
^{240}Pu	0 1371	0 1516 (0 0 7 MeV)
^{243}Cm	0 1309	
^{244}Cm	0 1327	
^{245}Cm	0 1342	
^{246}Cm	0 1366	
^{247}Cm	0 1383	
^{248}Cm	0 1396	

Table 18 Comparison of prompt neutron yields (E_n = 0 5 MeV)

Nuclide	ENDF/B V[a]	This calculation	% deviation
^{235}U	2 466	2 482	0 65
^{238}U	2 421	2 423	0 08
^{237}Np	2 773	2 721	1 88
^{238}Pu	2 969	3 003	1 15
^{239}Pu	2 942	3 221	9 48
^{240}Pu	2 870	3 105	8 19
^{241}Am	3 170	3 438	8 45
^{243}Am	3 363	3 460	2 88
^{243}Cm	3 519	3 640	3 45
^{244}Cm	3 552	3 642	2 54
^{245}Cm	3 696	3 819	3 15
^{246}Cm	3 578	3 802	6 25
^{247}Cm	3 679	3 949	7 36
^{248}Cm	3 594	3 928	9 29

[a]The ENDF/B V evaluations for ^{235}U ^{238}U ^{239}Pu ^{240}Pu and ^{245}Cm are for $\bar{\nu}_p$ (at 0 5 MeV) for the other nuclides, the ENDF/B V values are for total $\bar{\nu}$

is seen for five of the first eight nuclides However for ^{239}Pu ^{240}Pu and ^{241}Am the calculations are 8 to 9% high relative to ENDF/B V Plutonium 239 and ^{240}Pu were also calculated by Madland and Nix[23] and the present results are in excellent agreement with the results they obtained Thus it appears reasonable to conclude as they did, that the high values are a result of inaccurate input data It is easy to show that an error of about 1 9 MeV in the numerator of Eq (23) is sufficient to account for a change of about 8% in $\bar{\nu}_p$ Since the numerator of Eq (23) involves the difference of two large terms $<E_r>$ and $<E_f>_{tot}$ a relatively small change in these terms can account for a large change in $\bar{\nu}_p$ Only in the case of ^{237}Np did we make any adjustments in the input parameters (see discussion in Sect 4 2 2) In this case we made a small modification in the value of $<E_f>_{tot}$ from 176 0 to 175 6 MeV in order to obtain agreement with the results of Madland (see ref 30) Note that the experimental data for $\bar{\nu}_p$ of ^{237}Np are discrepant (see ref 30 Fig 35) Also the ENDF/B V evaluation appears to be slightly high relative to the experimental data shown in ref 30 Our result of 2 721 for ^{237}Np at 0 5 MeV is judged to be in excellent agreement with the experimental data

4 3 RECOMMENDATIONS

New ENDF/B VI evaluations are available for the following nuclides ^{235}U ^{238}U ^{237}Np ^{239}Pu ^{240}Pu ^{241}Am and ^{243}Am The ENDF/B V evaluations for ^{238}Pu and the curium isotopes were not revised in ENDF/B VI We would of course recommend using the new ENDF/B VI evaluations when available The $\bar{\nu}_p$ evaluation for ^{243}Am is also unchanged from ENDF/B V It may be of interest to compare the calculated values from Table 18 for ^{237}Np ^{241}Am and ^{243}Am with the corresponding ENDF/B VI evaluations The calculated values for ^{237}Np ^{241}Am and ^{243}Am are 0 8, 4 7 and 3 1% higher respectively We would currently recommend using our calculated values for prompt neutron yields for ^{238}Pu ^{243}Am and the curium isotopes until new experimental data are available All data and program listings given in Appendix F are on computer diskette and may be obtained from the authors

5 CONCLUSIONS

Fission product yield data and delayed neutron yields and six group data including spectra have been evaluated for the fission systems listed in Table 19 These evaluations are based primarily on the calculational methodologies discussed in this report and on experimental data that are also referenced in this document Calculations of prompt neutron yields and spectra were also described and results are available for the fast fission systems listed in Table 19 with the exception of ^{242}Cm(F) and additionally $^{245}Cm(F)$ and $^{247}Cm(F)$ Prompt neutron data for the spontaneous fission of ^{242}Cm ^{244}Cm ^{246}Cm and ^{248}Cm are also included The calculation of the spontaneous fission data was included primarily as a check on the methods used since some experimental data were available for those systems Also as a test of the methodology used to calculate $\bar{\nu}_p(E)$ these data were also calculated for $^{235}U(F)$ $^{238}U(F)$ $^{239}Pu(F)$ and $^{240}Pu(F)$

Table 19 Fission systems evaluated in this report

$^{237}Np(T)^a$	$^{242}Cm(F)$
$^{237}Np(F)$	$^{243}Cm(T)$
$^{238}Pu(F)$	$^{243}Cm(F)$
$^{240}Pu(T)$	$^{244}Cm(F)$
$^{242}Pu(T)$	$^{246}Cm(S)$
$^{242}Pu(H)$	$^{246}Cm(F)$
$^{241}Am(F)$	$^{248}Cm(F)$
$^{243}Am(F)$	

[a]T F H and S denote thermal fast high energy ($\sim$14 MeV) and spontaneous fission, respectively

For the actinides of concern in this report few experimental data are available Comparisons with these experimental data were made when possible and indicate that the calculations presented here are quite acceptable and may be used with confidence until additional experimental data and newer evaluations such as ENDF/B VI become available

The data discussed in the text of this report and presented in an abbreviated form in the appendices are available upon request from the authors on 5¼ in high density (1 2 Mbyte) diskettes The high density diskette is required since one of the yield files (Appendix B) is larger than 650 kbytes

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APPENDIX A

SAMPLE YIELD DATA AND FORMAT
$^{237}Np(F)$, $^{238}Pu(F)$ $^{241,243}Am(F)$, AND $^{242}Cm(F)$

```
1******************** ******************
********************* ******************
**                                    **
**       YIELD SUMMARY FOR NP237F     **
**                                    **
****************************************
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SUM OF YI FOR THE SYSTEM = 2 00

AVERAGE NEUTRON NUMBER = 142 31
AVERAGE PROTON NUMBER = 93 00

NUBAR (CALCULATED) = 2 6963

1**** TABLE OF MASS CHAIN YIELDS (PERCENT) ****

MASS	CHAIN YIELD (CALCULATED)	CHAIN YIELD (EVALUATED)
66	1 875E 07	1 875E 07
67	3 741E 07	3 742E 07
68	1 885E 06	1 885E 06
69	6 909E 08	6 918E 08
70	2 448E 05	2 453E 05
71	6 208E 05	6 207E 05
72	1 510E 04	1 511E 04
73	3 696E 04	3 690E 04
74	6 652E 04	6 649E 04
75	1 323E 03	1 323E 03
76	6 031E 03	6 030E 03
77	1 046E 02	1 046E 02
78	2 443E 02	2 440E 02
79	5 658E 02	5 648E 02
80	1 117E 01	1 107E 01
81	2 361E 01	2 367E 01
82	3 579E 01	3 582E 01
83	4 830E 01	4 823E 01
84	7 646E 01	6 700E 01
85	9 541E 01	1 046E+00
86	1 314E+00	1 277E+00
87	1 727E+00	1 694E+00
88	2 161E+00	2 140E+00
89	2 525E+00	2 539E+00
90	3 343E+00	3 406E+00
91	3 934E+00	3 944E+00
92	4 469E+00	4 432E+00
93	5 119E+00	5 023E+00
94	5 138E+00	5 231E+00
95	5 689E+00	5 719E+00
96	5 490E+00	5 499E+00
97	6 117E+00	6 121E+00
98	6 109E+00	6 078E+00
99	6 115E+00	6 145E+00
100	6 440E+00	6 446E+00

101	6 127E+00	6 127E+00
102	5 773E+00	5 772E+00
103	5 562E+00	5 562E+00
104	4 135E+00	4 125E+00
105	3 159E+00	3 169E+00
106	2 181E+00	2 182E+00
107	1 720E+00	1 720E+00
108	1 301E+00	1 301E+00
109	6 378E 01	6 377E 01
110	2 993E 01	2 994E 01
111	8 982E 02	8 982E 02
112	7 368E 02	7 368E 02
113	5 173E 02	5 173E 02
114	5 301E 02	5 301E 02
115	4 892E 02	4 892E 02
116	4 790E 02	4 790E 02
117	4 313E 02	4 313E 02
118	5 233E 02	5 233E 02
119	5 265E 02	5 265E 02
120	5 241E 02	5 241E 02
121	5 136E 02	5 135E 02
122	5 998E 02	5 997E 02
123	7 482E 02	7 483E 02
124	7 189E 02	7 189E 02
125	1 308E 01	1 308E 01
126	1 635E 01	1 630E 01
127	3 520E 01	3 523E 01
128	1 487E+00	1 485E+00
129	1 733E+00	1 735E+00
130	2 708E+00	2 708E+00
131	3 587E+00	3 587E+00
132	4 910E+00	4 910E+00
133	6 486E+00	6 485E+00
134	7 118E+00	7 103E+00
135	7 282E+00	7 285E+00
136	6 806E+00	6 631E+00
137	6 172E+00	6 301E+00
138	6 113E+00	6 140E+00
139	5 610E+00	5 635E+00
140	5 477E+00	5 479E+00
141	5 316E+00	5 317E+00
142	4 832E+00	4 819E+00
143	4 643E+00	4 650E+00
144	4 130E+00	4 132E+00
145	3 443E+00	3 449E+00
146	2 794E+00	2 794E+00
147	2 243E+00	2 243E+00
148	1 725E+00	1 724E+00
149	1 300E+00	1 301E+00
150	9 922E 01	9 922E 01
151	7 256E 01	7 256E 01
152	4 590E 01	4 590E 01
153	3 658E 01	3 658E 01
154	1 869E 01	1 869E 01
155	1 403E 01	1 403E 01
156	9 868E 02	9 868E 02

157	3 168E 02	3 168E 02
158	1 256E 02	1 256E 02
159	6 382E 03	6 383E 03
160	2 466E 03	2 466E 03
161	7 657E 04	7 653E 04
162	2 980E 04	2 983E 04
163	1 275E 04	1 274E 04
164	5 530E 05	5 531E 05
165	1 902E 05	1 901E 05
166	1 106E 05	1 106E 05
167	1 528E 06	1 527E 06
168	3 918E 07	3 916E 07
169	1 275E 07	1 275E 07
170	4 012E 07	4 010E 07
171	1 190E 07	1 191E 07
172	4 602E 07	4 597E 07

1**** TABLE OF INDEPENDENT (DIRECT) FISSION YIELDS ****

CS	ID	HL	YI	DYI(%)
CR	240660		3 030E 13	64 00
MN	250660		5 400E 11	64 00
FE	260660		9 400E 10	64 00
CO	270660		7 930E 10	64 00
NI	280660	54 6 H	8 740E 11	64 00
CU	290660	5 10 M	3 580E 13	64 00
ZN	300660	STABLE	0 000E+00	0 00
GA	310660	9 5 H	0 000E+00	0 00
GE	320660	2 27H	0 000E+00	0 00
CR	240670		3 180E 14	64 00
MN	250670		1 960E 11	64 00
FE	260670		9 130E 10	64 00
CO	270670		2 190E 09	64 00
NI	280670	18 S	6 110E 10	64 00
CU	290670	61 7 H	8 370E 12	64 00
ZN	300670	STABLE	0 000E+00	0 00
GA	310670	78 26H	0 000E+00	0 00
GE	320670	19 0 M	0 000E+00	0 00
CR	240680		0 000E+00	0 00
MN	250680		1 030E 11	64 00
FE	260680		1 580E 09	64 00
CO	270680		9 420E 09	64 00
NI	280680		7 560E 09	64 00
CU	290681	3 8 M	2 060E 10	64 00
CU	290680	31 S	7 620E 11	64 00
ZN	300680	STABLE	9 880E 13	64 00
GA	310680	68 2 M	0 000E+00	0 00
GE	320680	287 D	0 000E+00	0 00
MN	250690		2 650E 14	64 00
FE	260690		1 180E 11	64 00
CO	270690		2 160E 10	64 00
NI	280690		4 160E 10	64 00
CU	290690	3 0 M	4 750E 11	64 00
ZN	300691	13 9 H	3 990E 13	64 00
ZN	300690	57 M	8 180E 14	64 00
GA	310690	STABLE	0 000E+00	0 00

CE	320690	39 2 H	0 000E+00	0 00
AS	330690	15 M	0 000E+00	0 00
CR	240700		0 000E+00	0 00
MN	250700		3 860E 13	64 00
FE	260700		5 990E 10	64 00
CO	270700		2 990E 08	64 00
NI	280700		1 660E 07	64 00
CU	290701	42 S	3 680E 08	64 00
CU	290700	5 S	1 040E 08	64 00
ZN	300700	STABLE	1 570E 09	64 00
GA	310700	21 1 M	1 740E 12	64 00
GE	320700	STABLE	0 000E+00	0 00
MN	250710		2 890E 14	64 00
FE	260710		1 360E 10	64 00
CO	270710		2 260E 08	64 00
NI	280710		3 180E 07	64 00
CU	290710		2 570E 07	64 00
ZN	300711	3 97 H	1 900E 08	64 00
ZN	300710	2 4 M	3 890E 09	64 00
GA	310710	STABLE	8 780E 11	64 00
GE	320711	11 8 D	1 150E 14	64 00
GE	320710	0 020S	1 150E 14	64 00
AS	330710	64 H	0 000E+00	0 00
FE	260720		2 010E 11	64 00
CO	270720	0 124S	9 810E 09	64 00
NI	280720	3 83 S	4 320E 07	64 00
CU	290720	6 49 S	8 420E 07	64 00
ZN	300720	46 5 H	2 250E 07	64 00
GA	310720	14 10H	2 460E 09	64 00
GE	320720	STABLE	2 300E 12	64 00
AS	330720	26 0H	0 000E+00	0 00
SE	340720	8 5 D	0 000E+00	0 00
FE	260730		1 660E 12	64 00
CO	270730	0 129S	2 870E 09	64 00
NI	280730	0 491S	3 510E 07	64 00
CU	290730	5 11 S	1 990E 06	64 00
ZN	300730	23 5 S	1 300E 06	64 00
GA	310730	4 88H	4 600E 08	64 00
GE	320731	0 53 S	2 180E 11	64 00
GE	320730	STABLE	1 060E 10	64 00
AS	330730	80 3D	1 230E 14	64 00
SE	340731	40 M	0 000E+00	0 00
SE	340730	7 1 H	0 000E+00	0 00
FE	260740		6 730E 14	64 00
CO	270740	0 092S	3 520E 10	64 00
NI	280740	0 900S	1 460E 07	64 00
CU	290740	0 648S	2 150E 06	64 00
ZN	300740	96 S	3 980E 06	64 00
GA	310740	8 2 M	3 690E 07	64 00
GE	320740	STABLE	3 500E 09	64 00
AS	330741	8 0 S	7 500E 13	64 00
AS	330740	17 76D	2 770E 13	64 00
SE	340740	STABLE	0 000E+00	0 00
CO	270750	0 082S	3 380E 11	64 00
NI	280750	0 231S	4 150E 08	64 00
CU	290750	0 927S	1 950E 06	64 00

APPENDIX B

SAMPLE YIELD DATA AND FORMAT ^{237}Np(T), ^{240}Pu(T) ^{242}Pu(T,H) ^{243}Cm(T,F), ^{244}Cm(F), ^{246}Cm(S,F), AND ^{248}Cm(F)

ss nutor 78

per ert yields

nu lide		28 ni g	29 cu g	30 zn g	31 ga d	31 ga g	32 ge d	32 ge g	33 as g	34 se g	35 br g	36 kr g
h lf life		0 132s	0 118s	1 6 s	0 313s	4 9 s	3 0 s	1 45 h	1 515h	stable	6 4 m	stable
lambda		5 251e+00	5 874e+00	4 332e-01	2 215e+00	1 415e-01	2 310e 01	1 328e-04	1 271e-04	0 0	1 805e-03	0 0
7 1 g		100 0000	100 0000	100 0000	0 0	100 0000	0 0	100 0000	100 0000	100 0000	-100 0000	0 0
1 m		0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
7 0 m		0 0	0 0	0 0	1 1460	100 0000	0 0890	100 0000	0 0	0 0	0 0	0 0
cm243t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 031379n	0 0	0 0
zp 31 53	ri	1 06e 09p	3 69e-06p	0 001154p	0 0	0 011758p	0 0	0 017326p	0 001118p	8 03e 06p	1 56e 09p	0 0
sig0 560	cc	1 06e 09p	3 69e-06p	0 001158p	0 0	0 012916p	0 0	0 030242p	0 031360p	0 031368p	1 56e-09p	0 0
	rc	1 06e 09p	3 69e 06p	0 001158p	2 91e 06o	0 012919p	8 67e 06o	0 030254p	0 031372o	0 031380n	1 56e-09p	0 0
cm24(s	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 011747p	0 0	0 0
z| 31 24	ri	(72(09p	) 5e 06p	0 001273p	0 0	0 006015p	0 0	0 00431(p	0 000126p	3 83e 07p	3 03e 11p	0 0
sig0 60	cc	6 72e 09p	) 55e-06p	0 001283p	0 0	0 007298p	0 0	0 011614p	0 011740p	0 011740p	3 03e 11p	0 0
	rc	6 72e 09p	9 55e-06p	0 001283p	3 80e 06o	0 007302p	5 19e-06o	0 011623p	0 011749o	0 011749o	3 03e-11p	0 0
m243f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 020007n	0 0	0 0
z| 31 76	ri	6 14e 11p	4 32e 07p	0 000266p	0 0	0 005057p	0 0	0 013116p	0 001543p	2 16e 05p	8 47e 09p	0 0
sig0 560	cc	6 14e 11p	4 32e-07p	0 000267p	0 0	0 005324p	0 0	0 018439p	0 019983p	0 020004p	8 47e-09p	0 0
	rc	6 14e 11p	4 32e 07p	0 000267p	5 14e-07o	0 005324p	2 91e 06o	0 018443p	0 019986o	0 020008n	8 47e 09p	0 0
cm244f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 015013n	0 0	0 0
zp 31 50	ri	7 16e 10p	2 24e 06p	0 000634p	0 0	0 005899p	0 0	0 007998p	0 000472p	3 07e 06p	5 38e 10p	0 0
sig0 560	cc	7 16e 10p	2 24e-06p	0 000636p	0 0	0 006535p	0 0	0 014533p	0 015004p	0 015008p	5 38e 10p	0 0
	rc	7 16e 10p	2 24e 06p	0 000636p	1 62e-06o	0 006537p	4 39e-06o	0 014539p	0 015010o	0 015014n	5 38e-10p	0 0
cm246f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 009438n	0 0	0 0
z| 31 14	ri	1 34e 08p	1 40e 05p	0 001399p	0 0	0 005101p	0 0	0 002850p	6 32e-05p	1 41e 07p	8 22e 12p	0 0
ig0 60	cc	1 34e 08p	1 40e-05p	0 001413p	0 0	0 006514p	0 0	0 009364p	0 009427p	0 009427p	8 22e 12p	0 0
	rc	1 34 08p	1 40e 0 p	0 001413p	5 54e 06	0 006520p	87 06o	0 009375o	0 009439o	0 009433n	8 22e 12p	0 0
m248f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 004657n	0 0	0 0
zp 30 80	ri	1 10e 07p	4 11e 05p	0 001578p	0 0	0 002443p	0 0	0 000577p	4 88e-06p	3 91e 09p	0 0	0 0
sig0 560	cc	1 10e 07p	4 13e 05p	0 001619p	0 0	0 004062p	0 0	0 004639p	0 004644p	0 004644p	0 0	0 0
	rc	1 10e 07p	4 13e 05p	0 001619p	9 77e 06o	0 004072p	4 64e-06o	0 004653o	0 004658o	0 004658n	0 0	0 0
	242l	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 014 8n	0 0	0 0
z| 30 98	ri	6 60e 08p	5 81e 05p	0 002752p	0 0	0 009125p	0 0	0 002545p	4 92e 05p	5 09e 08p	2 46e 12p	0 0
sig0 560	cc	6 60e 08p	5 82e-05p	0 002810p	0 0	0 011935p	0 0	0 014480p	0 014529p	0 014529p	2 46e-12p	0 0
	rc	6 60e 08p	5 82e 05p	0 002810p	1 71e 05o	0 011952p	1 45e-05o	0 014511p	0 014561o	0 014561n	2 46e-12p	0 0
||237t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 012691n	0 0	0 0
z| 31 10	ri	2 (9e 08p	2 45e 05p	0 002148p	0 0	0 006963p	0 0	0 003469p	6 77e-05p	1 32e 07p	6 65e 12p	0 0
i |0 (0	cc	2 (9e 08p	2 45e 05p	0 002172p	0 0	0 009135p	0 0	0 012604p	0 012671p	0 012671p	6 65e-12p	0 0
	rc	2 69e 08p	2 45e 05p	0 002172p	1 10e 05o	0 009146p	1 04e-05o	0 012625o	0 012693o	0 012693n	6 65e-12p	0 0
|u240t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 016966n	0 0	0 0
z| 31 19	ri	1 54e 08p	1 87e 05p	0 002160p	0 0	0 008960p	0 0	0 005673p	0 000145p	3 77e 07p	2 56e-11p	0 0
sig0 560	cc	1 54e 08p	1 87e 05p	0 002179p	0 0	0 011139p	0 0	0 016812p	0 016956p	0 016957p	2 56e-11p	0 0
	rc	1 54e 08p	1 87e 05p	0 002179p	4 45e-06o	0 011143p	5 35e 06o	0 016821o	0 016966o	0 016966n	2 56e-11p	0 0
|t242t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0064(3n	0 0	0 0
zp 30 87	ri	8 79e 08p	4 07e 05p	0 001901p	0 0	0 003508p	0 0	0 000993p	1 03e-05p	1 02e 08p	0 0	0 0
sig0 560	cc	8 79e 08p	4 08e 05p	0 001942p	0 0	0 005450p	0 0	0 006443p	0 006453p	0 006453p	0 0	0 0
	rc	8 79e 08p	4 08e 0 p	0 001942p	7 16e 06o	0 005457p	3 98e 06o	0 006454o	0 006464o	0 006464n	0 0	0 0

half life of zn-78 from 77ale2 ni cu half lives from ENDF V m ss nu ber 79 percent yield

nuclide		29 cu g	30 z g	31 ga g	32 ge d	32 ge g	33 s g	34 se m	34 se g	35 l m	35 br g	36 kr g	37 rl g
half life		0 135s	0 313s	3 0 s	1 66	43 s	9 0 m	3 89 m	6 5e4y	4 86 s	st ble	34 9 h	23 m
lambda		5 134e+00	2 215e+00	2 310e 01	4 176e 01	1 612e-02	1 284e 03	2 970e 03	3 381e-13	1 426e 01	0 0	5 517e 06	5 023e 04
l i		100 0000	100 0000	98 8540	0 0	99 9110	100 0000	100 0000	0 0	0 0	100 0000	100 0000	-100 0000
l		0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
z 0 m		0 0	0 0	0 0	0 8300	100 0000	0 0	0 0	100 0000	0 0	100 0000	0 0	0 0
m243t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 053781n	0 0	0 0
zp 31 96	ri	2 55e 07p	0 000254p	0 009492p	0 0	0 035884p	0 007951p	2 27e-05p	0 000152p	1 09e-07p	3 26e 08p	7 73e 12p	0 0
ig0 560	cc	2 5 e-07p	0 000254p	0 009743p	0 0	0 045619p	0 053569p	0 053592p	0 053744p	1 09e 07p	0 053744p	7 73e 12p	0 0
	rc	2 55e 07p	0 000254p	0 009743p	3 95e 05o	0 045658p	0 053609p	0 053631o	0 053783o	1 09e 07p	0 053783n	7 73e-12p	0 0
cm246s	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 016989p	0 0	0 0
zp 31 77	ri	7 96 07p	0 000331p	0 00 509p	0 0	0 010073p	0 001054p	1 30e 06p	8 70e-06p	2 58e 09p	7 70e 10p	0 0	0 0
sig0 60	cc	7 96e 07p	0 000331p	0 005837p	0 0	0 015905p	0 016958p	0 016959p	0 016968p	2 58e 09p	0 016968p	0 0	0 0
	rc	7 96e 07p	0 000331p	0 005837p	2 71e-05o	0 015932p	0 016985p	0 016987o	0 016995o	2 58e 09p	0 016995o	0 0	0 0
cm243f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 034013n	0 0	0 0
zp 32 19	ri	2 2 e-08p	4 49e-05p	0 003220p	0 0	0 021804p	0 008579p	4 29e 05p	0 000314p	4 57e 07p	1 22e 07p	6 42e-11p	0 0
sig0 560	cc	2 25e 08p	4 49e 05p	0 003265p	0 0	0 025066p	0 033645p	0 033688p	0 034002p	4 57e 07p	0 034003p	6 42e 11p	0 0
	rc	2 25e 08p	4 49e 05p	0 003265p	1 04e-05o	0 025076p	0 033655p	0 033698o	0 034013o	4 57e 07p	0 034013n	6 42e 11p	0 0
244f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 02 022n	0 0	0 0
zp 31 93	ri	1 57e 07p	0 000141p	0 004790p	0 0	0 016630p	0 003381p	8 75e 06p	5 86e-05p	3 81e 08p	1 14e 08p	2 43e 12p	0 0
i 0 (0	c	1 / 07p	0 000141p	0 004923p	0 0	0 0215 4p	0 024 (p	0 024944p	0 025003p	3 81e 08p	0 02 003p	2 43e 12p	0 0
	r	1 / 07p	0 000141p	0 004929p	2 02e 05o	0 021574p	0 024 (p	0 02496 o	0 025023o	3 81e 08p	0 02 023	2 43e 12p	0 0
246f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	x	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 01(0(4	0 0	0 0
zp 31 57	ri	1 57e 06p	0 000482p	0 006120p	0 0	0 008731p	0 000701p	3 47e-07p	4 61e-06p	1 05e 09p	1 71e 10p	0 0	0 0
sig0 560	cc	1 57e 06p	0 000484p	0 006599p	0 0	0 015324p	0 016025p	0 016025p	0 016030p	1 05e 09p	0 016030p	0 0	0 0
	rc	1 7e 06p	0 000484p	0 006599p	3 77e 05o	0 01 3(2p	0 01(063p	0 016063o	0 016068o	1 05e 09p	0 016068n	0 0	0 0
248f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 008026n	0 0	0 0
zp 31 23	ri	7 40e 06p	0 000845p	0 004371p	0 0	0 002695p	8 63e 05p	2 90e-08p	1 94e-07p	1 48e 11p	4 43e 12p	0 0	0 0
sig0 560	cc	7 40e 06p	0 000852p	0 005213p	0 0	0 007904p	0 007990p	0 007990p	0 007990p	1 48e 11p	0 007990p	0 0	0 0
	rc	7 40e 06p	0 000852p	0 005213p	3 98e 05o	0 007944p	0 008030o	0 008030o	0 008030o	1 48e-11p	0 008030n	0 0	0 0
p 242	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 029218n	0 0	0 0
zp 31 41	ri	9 12e 06p	0 001482p	0 014844p	0 0	0 012032p	0 000762p	3 69e 07p	2 47e-06p	3 99e 10p	1 19e 10p	0 0	0 0
sig0 560	cc	9 12e 06p	0 001491p	0 016318p	0 0	0 028335p	0 029097p	0 029097p	0 029100p	3 99e 10p	0 029100p	0 0	0 0
	rc	9 12e 06p	0 001491p	0 016318p	0 000132o	0 028468p	0 029229o	0 029230o	0 029232o	3 99e-10p	0 029232n	0 0	0 0
np237t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 026358n	0 0	0 0
zp 31 53	ri	3 55e-06p	0 000956p	0 010726p	0 0	0 013668p	0 000971p	7 81e 07p	5 22e-06p	9 88e 10p	2 95e-10p	0 0	0 0
0 560	cc	3 55e 06p	0 000960p	0 011674p	0 0	0 025331p	0 026303p	0 026303p	0 026309p	9 88e 10p	0 026309p	0 0	0 0
	rc	3 55e 06p	0 000960p	0 011674p	5 39e-05o	0 025385p	0 026357o	0 026357o	0 026363o	9 88e 10p	0 026363n	0 0	0 0
pu240t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 015968n	0 0	0 0
zp 31 62	ri	1 08e 06p	0 000387p	0 005625p	0 0	0 009082p	0 000832p	8 87e-07p	5 93e-06p	1 51e-09p	4 50e-10p	0 0	0 0
sig0 560	cc	1 08e 06p	0 000388p	0 006008p	0 0	0 015085p	0 015918p	0 015919p	0 015924p	1 51e 09p	0 015924p	0 0	0 0
	rc	1 08e-06p	0 000388p	0 006008p	4 73e-05o	0 015133p	0 015965p	0 015966o	0 015972o	1 51e-09p	0 015972n	0 0	0 0
242t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 007457n	0 0	0 0
zp 31 30	ri	4 43e 06p	0 000621p	0 003856p	0 0	0 002833p	0 000110p	4 57e 08p	3 06e-07p	2 91e 11p	8 68e 12p	0 0	0 0
sig0 560	cc	4 43e 06p	0 000625p	0 004474p	0 0	0 007303p	0 007413p	0 007413p	0 007413p	2 91e 11p	0 007413p	0 0	0 0
	rc	4 43e 06p	0 000625p	0 004474p	4 97e-05o	0 007352p	0 007463o	0 007463o	0 007463o	2 91e 11p	0 007463n	0 0	0 0

z g cu l lf lives from ENDF V

mass number 80

percent yields

nuclide		28 ni g	29 cu g	30 zn g	31 ga g	32 ge d	32 ge g	33 as g	34 se g	35 br m	35 br g	36 kr g
half life			0 090s	0 487s	1 66 s	1 23s	24 s	16 5 s	stable	4 42 h	17 4 m	stable
lambda		0 0	7 702e+00	1 423e+00	4 176e-01	5 635e-01	2 888e-02	4 201e-02	0 0	4 356e 05	6 639e-04	0 0
z 1 g		100 0000	100 0000	100 0000	100 0000	0 0	99 1700	100 0000	100 0000	0 0	0 0	100 0000
z 1 m		0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
z 0 i		0 0	0 0	0 0	0 0	11 9000	100 0000	0 0	0 0	0 0	100 0000	0 0
m243L	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 089780n	0 0	0 0	0 0
zp 32 35	ri	0 0	1 27e 08p	4 67e-05p	0 004709p	0 0	0 054566p	0 028233p	0 002058p	3 57e-0(p	1 19e 06p	9 76e-10p
sig0 560	cc	0 0	1 27e 08p	4 67e-05p	0 004756p	0 0	0 059282p	0 087515p	0 089574p	3 57e 06p	4 76e-06p	4 76e-06p
	rc	0 0	1 27e 08p	4 67e-05p	0 004756p	0 000219o	0 059502p	0 087735o	0 089793n	3 57e 06p	4 76e 06p	4 76e 06o
cm246s	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 025338p	0 0	0 0	0 0
[illegible] 32 0(	ri	2 7(12p	4 87 08p	7 34e 05p	0 003197p	0 0	0 017449p	0 004372p	0 000142p	1 03e 07p	3 43e 08p	1 14e-11p
sig0 (0	cc	2 7(e 12p	4 87e 08p	7 34e 0 p	0 003271p	0 0	0 020693p	0 025065p	0 025207p	1 03e 07p	1 37e 07p	1 37e-07p
	rc	2 76e 12p	4 87e 08p	7 34e-05p	0 003271p	0 000174o	0 020867p	0 025239p	0 025381o	1 03e 07p	1 37e 07p	1 37e-07p
cm243f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 055020n	0 0	0 0	0 0
zp 32 58	ri	0 0	8 49e 10p	6 28e-06p	0 001241p	0 0	0 026451p	0 024057p	0 003240p	1 15e-05p	3 23e-06p	6 10e 09p
sig0 560	cc	0 0	8 49e 10p	6 28e 06p	0 001247p	0 0	0 027688p	0 051746p	0 054986p	1 15e 05p	1 47e-05p	1 47e-05p
	rc	0 0	8 49e 10p	6 28e-06p	0 001247p	3 67e-05o	0 027725p	0 051782o	0 055023n	1 15e-05p	1 47e 05p	1 47e 05p
cm244f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 041036n	0 0	0 0	0 0
zp 32 32	ri	0 0	7 98e 09p	2 64e 05p	0 002410p	0 0	0 025554p	0 012162p	0 000809p	1 27e 06p	4 22e 07p	3 12e-10p
sig0 560	cc	0 0	7 98e 09p	2 64e-05p	0 002436p	0 0	0 027970p	0 040132p	0 040940p	1 27e 06p	1 69e 06p	1 69e-06p
	rc	0 0	7 98e 09p	2 64e-0 p	0 002436p	0 000102o	0 028071p	0 040233o	0 041042n	1 27e-0(p	1 69e 06p	1 69e 06o
cm246f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 027108n	0 0	0 0	0 0
zp 31 96	ri	9 36e 12p	1 21e 07p	0 000134p	0 004404p	0 0	0 018636p	0 003623p	8 88e-05p	5 38e 08p	9 49e 09p	3 85e-12p
sig0 560	cc	9 36e 12p	1 21e 07p	0 000134p	0 004538p	0 0	0 023136p	0 026759p	0 026848p	5 38e 08p	6 33e-08p	6 33e-08p
	rc	9 36e-12p	1 21e 07p	0 000134p	0 004538p	0 000278o	0 023414p	0 027037o	0 027126n	5 38e-08p	6 33e 08p	6 33e-08p
cm248f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 013871n	0 0	0 0	0 0
zp 31 62	ri	1 91e 10p	8 62e 07p	0 000347p	0 004444p	0 0	0 008077p	0 000653p	6 02e-06p	1 14e-09p	3 80e-10p	0 0
sig0 560	cc	1 91e-10p	8 62e 07p	0 000348p	0 004791p	0 0	0 012829p	0 013482p	0 013488p	1 14e-09p	1 52e-09p	1 52e-09p
	rc	1 91e 10p	8 62e 07p	0 000348p	0 004791p	0 000418o	0 013246p	0 013899o	0 013905n	1 14e 09p	1 52e-09p	1 52e 09p
pu242h	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 055258n	0 0	0 0	0 0
zp 31 80	ri	9 72e 11p	1 05e 06p	0 000537p	0 015408p	0 0	0 032607p	0 005753p	6 67e-05p	3 00e-08p	1 00e-08p	1 11e-12p
sig0 560	cc	9 72e-11p	1 05e 06p	0 000538p	0 015946p	0 0	0 048420p	0 054173p	0 054240p	3 00e-08p	4 00e-08p	4 00e 08p
	rc	9 72e 11p	1 05e 06p	0 000538p	0 015946p	0 001109o	0 049530p	0 055283o	0 055349n	3 00e-08p	4 00e-08p	4 00e 08p
pu237t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 035144n	0 0	0 0	0 0
zp 31 92	ri	2 01e-11p	2 25e 07p	0 000218p	0 006281p	0 0	0 023688p	0 004099p	8 82e-05p	4 10e-08p	1 37e-08p	2 89e-12p
sig0 5(0	cc	2 01e 11p	2 25e 07p	0 000218p	0 006499p	0 0	0 030133p	0 034231p	0 034319p	4 10e-08p	5 47e 08p	5 47e-08p
	r	2 01e 11p	2 25e 07p	0 000218p	0 006499p	0 000884o	0 031017p	0 035116o	0 035204n	4 10e-08p	5 47e-08p	5 47e 08p
pu240t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 038921n	0 0	0 0	0 0
zp 32 01	ri	7 52e-12p	1 14e 07p	0 000147p	0 005551p	0 0	0 026665p	0 005886p	0 000166p	1 03e 07p	3 45e 08p	9 82e-12p
sig0 560	cc	7 52e-12p	1 14e 07p	0 000147p	0 005698p	0 0	0 032315p	0 038201p	0 038367p	1 03e-07p	1 38e 07p	1 38e-07p
	rc	7 52e 12p	1 14e 07p	0 000147p	0 005698p	0 000592o	0 032907p	0 038793o	0 038959n	1 03e-07p	1 38e-07p	1 38e-07p
pu242t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 019886n	0 0	0 0	0 0
zp 31 69	ri	1 30e 10p	7 31e 07p	0 000362p	0 005629p	0 0	0 012177p	0 001184p	1 34e-05p	3 16e 09p	1 05e 09p	0 0
sig0 560	cc	1 30e 10p	7 31e 07p	0 000363p	0 005992p	0 0	0 018119p	0 019304p	0 019317p	3 16e-09p	4 21e 09p	4 21e-09p
	rc	1 30e 10p	7 31e 07p	0 000363p	0 005992p	0 000616o	0 018735p	0 019920o	0 019933n	3 16e 09p	4 21e 09p	4 21e-09p

ga cu zn h lf life from ENDF-V

mass number 81

per cent yields

nuclide		29 cu g	30 zn g	31 ga g	32 ge d	32 ge g	33 as g	34 se m	34 se g	35 br g	36 kr m	36 kr g	37 rb g
half life		0 074s	0 123s	1 23 s	0 60s	10 1 s	32 s	57 3 m	18 5 m	stable	13 3	2 1e5y	4 58 h
lambda		9 367e+00	5 635e+00	5 635e 01	1 155e+00	6 863e 02	2 166e 02	2 016e 04	6 245e 04	0 0	5 212e 02	1 047e 13	4 204e-05
z 1 g		100 0000	100 0000	100 0000	0 0	88 1000	100 0000	0 0	100 0000	100 0000	0 0	-100 0000	-25 0000
z 1 m		0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	75 0000
z 0 m		0 0	0 0	0 0	21 1000	100 0000	0 0	0 0	100 0000	0 0	0 0	100 0000	0 0
243t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 166485t	0 0	0 0	0 0
zp 32 76	ri	4 23e-10p	4 83e-06p	0 001839p	0 0	0 056634p	0 090702p	0 015058p	0 002250p	0 0001 0p	1 24e 08p	8 28e 08p	1 95e 12p
sig0 560	cc	4 23e 10p	4 83e 06p	0 001843p	0 0	0 058258p	0 148960p	0 015058p	0 166268p	0 166418p	1 24e 08p	9 52e-08p	1 95e-12p
	rc	4 23e 10p	4 83e 06p	0 001843p	7 04e 05o	0 058328p	0 149030p	0 015058p	0 166338o	0 166488n	1 24e 08p	9 52e-08p	1 95e 12p
cm24f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 038833t	0 0	0 0	0 0
zp 32 47	ri	1) c 0)p	) 04e 06p	0 001451p	0 0	0 020274p	0 01 808p	0 001217p	0 000182p	5 16e 0(p	1 75e 10p	1 17e 09p	0 0
sig0 560	cc	1 95e 09p	9 04e 06p	0 001460p	0 0	0 021559p	0 037367p	0 001217p	0 038766p	0 038772p	1 75e 10p	1 34e 09p	0 0
	rc	1 95e-09p	9 04e 06p	0 001460p	7 51e 05o	0 021635p	0 037442p	0 001217p	0 038841o	0 038847o	1 75e 10p	1 34e 09p	0 0
cm243f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 087032n	0 0	0 0	0 0
zp 32 99	ri	1 75e 11p	4 06e 07p	0 000308p	0 0	0 017969p	0 051014p	0 015380p	0 002097p	0 000290p	4 45e 08p	3 26e 07p	1 54e-11p
sig0 560	cc	1 75e 11p	4 06e 07p	0 000308p	0 0	0 018241p	0 069255p	0 015380p	0 086733p	0 087024p	4 45e 08p	3 71e 07p	1 54e 11p
		1 7 c 11p	4 06e 07p	0 000308p	8 (2e 06o	0 018250p	0 069264p	0 015380p	0 086742o	0 087033	4 45e 08p	3 71e 07p	1 54e 11p
244f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 066058	0 0	0 0	0 0
zp 32 73	ri	2 41e 10p	2 47e 06p	0 000851p	0 0	0 023891p	0 035185p	0 005350p	0 000799p	4 82e 05p	3 60e 09p	2 41e 08p	0 0
sig0 (0	cc	2 41e 10p	2 47e 0(p	0 000854p	0 0	0 024643p	0 059828p	0 005350p	0 065978p	0 06602(p	3 60e 09p	2 77e 08p	0 0
	rc	2 41e 10p	2 47e 06p	0 000854p	3 36e 05o	0 024677p	0 059861p	0 005350p	0 066011o	0 06605)n	3 60e 09p	2 77e 08p	0 0
cm246f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 043172n	0 0	0 0	0 0
zp 32 37	ri	5 69e 09p	1)4e 05p	0 002319p	0 0	0 024837p	0 01 114p	0 000938p	8 16e 05p	2 79e 06p	3 74e 11p	4 97e-10p	0 0
sig0 60	cc	5 69e-09p	1 94e 05p	0 002339p	0 0	0 026897p	0 042011p	0 000938p	0 043031p	0 043034p	3 74e 11p	5 34e 10p	0 0
	rc	5 69e 09p	1)4e 05p	0 002339p	0 000147o	0 027044p	0 042158p	0 000938p	0 043178o	0 043181n	3 74e 11p	5 34e 10p	0 0
m248f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 022789n	0 0	0 0	0 0
zp 32 03	ri	6 30e 08p	7 63e 05p	0 003433p	0 0	0 015299p	0 003997p	9 17e-0 p	1 37e-05p	1 04e 07p	0 0	6 06e-12p	0 0
sig0 560	cc	6 30e 08p	7 64e 05p	0 003509p	0 0	0 018391p	0 022388p	9 17e 05p	0 022493p	0 022493p	0 0	6 97e 12p	0 0
	rc	6 30e 08p	7 64e 05p	0 003509p	0 000316o	0 018707p	0 022704p	9 17e-0 p	0 022809o	0 022809n	0 0	6 97e 12p	0 0
pu242f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 091858n	0 0	0 0	0 0
zp 32 21	ri	5 73e 08p	0 000101p	0 009220p	0 0	0 054861p	0 027167p	0 000868p	0 000130p	2 06e-06p	2 63e 11p	1 76e-10p	0 0
sig0 560	cc	5 73e 08p	0 000101p	0 009321p	0 0	0 063073p	0 090240p	0 000868p	0 091238p	0 091240p	2 63e-11p	2 02e 10p	0 0
	rc	5 73e 08p	0 000101p	0 009321p	0 000661o	0 063734p	0 090901p	0 000868p	0 091898o	0 091900n	2 63e 11p	2 02e-10p	0 0
1231t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	x	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 11714	0 0	0 0	0 0
zp 32 33	ri	2 37e 08p	7 04e 05p	0 007362p	0 0	0 069906p	0 037387p	0 001969p	0 000294p	5 41e 0(p	1 17e 10p	7 81e 10p	0 0
sig0 (0	c	2 37 08p	7 04e 0 p	0 007432p	0 0	0 07(453p	0 114441p	0 001969p	0 116703p	0 1167()p	1 17e 10p	8 98e 10p	0 0
	r	2 37e 08p	7 04e 0 p	0 007432p	0 000464o	0 076918p	0 114905p	0 001969p	0 117168o	0 117173	1 17e 10p	8 98e 10p	0 0
pu240t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 109777n	0 0	0 0	0 0
zp 32 42	ri	8 97e 09p	3 57e 05p	0 004938p	0 0	0 060385p	0 041593p	0 002797p	0 000418p	1 02e 05p	2 97e 10p	1 98e 09p	0 0
sig0 5(0	cc	8 97e-09p	3 57e 05p	0 004974p	0 0	0 064767p	0 10(360p	0 002797p	0 109575p	0 109585p	2 97e-10p	2 28e-09p	0 0
	rc	8 97e-09p	3 57e 05p	0 004974p	0 000203o	0 064970p	0 106563p	0 002797p	0 109778o	0 109789n	2 97e 10p	2 28e 09p	0 0
p 242t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 040767n	0 0	0 0	0 0
zp 32 10	ri	6 16e-08p	9 25e 05p	0 005083p	0 0	0 027105p	0 008453p	0 000236p	3 53e 05p	3 33e 07p	3 60e 12p	2 41e 11p	0 0
sig0 560	cc	6 16e-08p	9 25e 05p	0 005176p	0 0	0 031665p	0 040119p	0 000236p	0 040390p	0 040391p	3 60e 12p	2 77e 11p	0 0
	rc	6 16e 08p	9 25e 05p	0 005176p	0 000402o	0 032067p	0 040521p	0 000236p	0 040792o	0 040793	3 60e 12p	2 77e 11p	0 0

cu zn ga ge half lives from ENDF-V

mass number 82

percent yields

nuclide		28 ni g	29 cu g	30 zn g	31 ga g	32 ge d	32 ge g	33 as m	33 as g	34 se g	35 br m	35 br g	36 kr g
h lf life				0 127s	0 60s	0 31 s	4 60 s	13 0 s	21 0 s	stable	6 1 m	35 4 h	stable
l mtd		0 0	0 0	5 458e+00	1 155e+00	2 236e+00	1 50/e-01	5 332e 02	3 301e-02	0 0	1 894e 03	5 439e 06	0 0
7 1 q		100 0000	100 0000	100 0000	100 0000	0 0	78 9000	0 0	100 0000	100 0000	0 0	0 0	100 0000
/ 1 m		0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	100 0000	0 0	0 0	2 4000
7 0 m		0 0	0 0	0 0	0 0	56 2000	100 0000	0 0240	0 0	0 0	0 0	97 6000	0 0
n243t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 255393n	0 0	0 0	0 0
zi 33 16	ri	0 0	6 68e-12p	2 97e 07p	0 000333p	0 0	0 035605p	0 068925p	0 068925p	0 081654p	0 000580p	0 001353p	4 64e-06p
sij0 560	cc	0 0	6 68e-12p	2 97e 07p	0 000334p	0 0	0 035868p	0 068925p	0 104793p	0 255373p	0 000580p	0 001919p	0 001937p
	rc	0 0	6 68e 12p	2 97e-07p	0 000334p	1 96e 05o	0 035888p	0 068928p	0 104813p	0 255395n	0 000580p	0 001919p	0 001937p
cm246s	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	x	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 056404p	0 0	0 0	0 0
zi 32 87	ri	0 0	4 26e 11p	7 64e 07p	0 000355p	0 0	0 016617p	0 015376p	0 015376p	0 008729p	2 72e-05p	6 36e 05p	9 04e 08p
ig0 560	cc	0 0	4 26e 11p	7 64c-07p	0 000356p	0 0	0 016898p	0 015376p	0 032274p	0 056379p	2 72e-05p	9 01e 05p	9 09e 0
	rc	0 0	4 26e 11p	7 64e 07p	0 000356p	3 12c 05o	0 016929p	0 015378p	0 032305p	0 056417o	2 72e 05p	9 01e 05p	9 09e-0 p
cm243f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 130048n	0 0	0 0	0 0
zi 33 39	ri	0 0	0 0	1 81e-08p	4 08e-05p	0 0	0 008465p	0 029730p	0 029730p	0 062088p	0 000743p	0 002010p	1 31e 05p
sig0 560	cc	0 0	0 0	1 81e 08p	4 09e 05p	0 0	0 008497p	0 029730p	0 038227p	0 13004(p	0 000743p	0 002735p	0 00276(
	rc	0 0	0 0	1 81e 08p	4 09e 05p	1 93e 06o	0 008499p	0 029731p	0 038229p	0 130048n	0 000743p	0 002735p	0 002766p
cm244f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 100087n	0 0	0 0	0 0
zi 33 13	ri	0 0	3 93e 12p	1 57e-07p	0 000159p	0 0	0 015418p	0 027367p	0 027367p	0 029797p	0 000193p	0 000449p	1 39e-0(p
j0 (0	c	0 0	3 93e 12p	1 5/e 0/p	0 000159p	0 0	0 01 544p	0 02736/p	0 042911p	0 1000/(p	0 000193p	0 000637p	0 000(43p
	rc	0 0	3)3e 12p	1 57e-0/p	0 000159p	1 09e-05o	0 01 555p	0 027369p	0 042922p	0 100089n	0 000193p	0 000637p	0 000643p
cn246f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0682/2n	0 0	0 0	0 0
32 //	ri	0 0	1 53e-10p	2 02e 06p	0 000693p	0 0	0 024546p	0 017681p	0 017681p	0 007750p	1 09e-05p	4 95e-05p	4 43e-08p
sig0 560	cc	0 0	1 53e-10p	2 02e 06p	0 000695p	0 0	0 02 094p	0 017681p	0 042776p	0 068207p	1 09e-05p	6 01e-05p	6 04e 05p
	rc	0 0	1 53e 10p	2 02e-06p	0 000695p	6 98e 05o	0 025164p	0 017684p	0 042846p	0 068280n	1 09e-05p	6 01e-05p	6 04e 05p
cm248f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 036(60n	0 0	0 0	0 0
zp 32 43	ri	0 0	2 56e 09p	1 18e 05p	0 001486p	0 0	0 020999p	0 006539p	0 006539p	0 001169p	1 01e-06p	2 36e-06p	8 73e 10p
sig0 560	cc	0 0	2 56e-09p	1 18e-05p	0 001498p	0 0	0 022181p	0 006539p	0 028720p	0 036427p	1 01e-06p	3 35e-06p	3 37e-06p
	rc	0 0	2 56e-09p	1 18e-05p	0 001498p	0 000251o	0 022432p	0 006543p	0 028971p	0 036682n	1 01e-06p	3 35e-06p	3 37e-06p
p 242f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	x	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 134301n	0 0	0 0	0 0
zp 32 (1	ri	0 0	1 /8e-09p	1 07e 05p	0 003120p	0 0	0 053286p	0 035289p	0 035289p	0 007603p	1 53e 05p	3 57e-05p	1 71e-08p
sig0 560	cc	0 0	1 /8e-09p	1 07e-05p	0 003131p	0 0	0 055756p	0 035289p	0 091045p	0 133936p	1 53e 05p	5 06e-05p	5 09e 05p
	rc	0 0	1 /8e 09p	1 07e-05p	0 003131p	0 000398o	0 056154p	0 035298p	0 091443p	0 134343n	1 53e-05p	5 06e-05p	5 09e-05p
237t	xl	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 175718n	0 0	0 0	0 0
zp 32 /3	ri	0 0	6 42e 10p	7 32e-06p	0 002194p	0 0	0 068488p	0 044034p	0 044034p	0 017136p	3 51e-05p	8 19e-05p	7 46e-08p
j0 5(0	cc	0 0	(42e 10p	7 32e 06p	0 002201p	0 0	0 070225p	0 044034p	0 114259p	0 175429p	3 51e-05p	0 000116p	0 000117p
	rc	0 0	6 42e-10p	/ 32e-06p	0 002201p	0 000312o	0 070537p	0 044046p	0 114571p	0 175752	3 51e 05p	0 000116p	0 000117p
p 240t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 119756n	0 0	0 0	0 0
zp 32 82	ri	0 0	1 57e-10p	2 40e-06p	0 000961p	0 0	0 039110p	0 031920p	0 031920p	0 015926p	4 30e-05p	0 000100p	1 23e-07p
sig0 560	cc	0 0	1 57e-10p	2 40e 06p	0 000964p	0 0	0 039870p	0 031920p	0 071790p	0 119636p	4 30e-05p	0 000142p	0 000144p
	rc	0 0	1 57e-10p	2 40e-06p	0 000964p	0 000129o	0 039998p	0 031926p	0 071918p	0 119771n	4 30e-05p	0 000142p	0 000144p
pu242t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 060654n	0 0	0 0	0 0
zi 32 50	ri	0 0	2 14e-09p	1 22e 05p	0 001893p	0 0	0 032266p	0 011954p	0 011954p	0 002581p	2 75e 06p	6 42e-06p	2 95e-09p
sig0 560	cc	0 0	2 14e-09p	1 22e-05p	0 001905p	0 0	0 033769p	0 011954p	0 045723p	0 060258p	2 75e 06p	9 11e-06p	9 18e-06p
	rc	0 0	2 14e-09p	1 22e 05p	0 001905p	0 000427o	0 034195p	0 011963p	0 046149p	0 060693n	2 75e-06p	9 11e-06p	9 18e-06p

1 ge a l lf li es est ated by FNDI V

mass number 83 perce t yields

nuclide		30 zn g	31 ga g	32 ge g	33 as d	33 as g	34 se m	34 se g	35 br g	36 kr m	36 kr g	37 rb g	38 sr g
h lf life		0 084s	0 31s	1 9 s	1 2 s	13 5 s	70 s	22 5m	2 40h	1 86 h	stable	83 d	32 4 h
l mbda		8 252e+00	2 236e+00	3 648e-01	5 776e-01	5 134e-02	9 902e-03	5 134e-04	8 023e-05	1 03 e 04	0 0	9 666e-08	5 943e 06
7 1 g		100 0000	100 0000	43 8000	0 0	99 9760	64 0000	36 0000	100 0000	100 0000	0 0	23 0000	100 0000
7 1 m		0 0	0 0	0 0	0 0	0 0	0 0	0 0	100 0000	0 0	0 0	77 0000	0 0
0 ı		0 0	0 0	0 0	2060	100 0000	0 0860	0 0	0 0	0 0	100 0000	0 0	0 0
m243t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 367334n	0 0	0 0
z[33 7	ri	7 89e-09p	3 49e-05p	0 010878p	0 0	0 139339p	0 038110p	0 162465p	0 016250p	2 21e 05p	9 41e 05p	2 89e 08p	0 0
sig0 560	cc	7 88e-09p	3 50e-05p	0 010892p	0 0	0 150246p	0 134264p	0 216542p	0 367054p	0 367076p	0 367170p	2 89e 08p	0 0
	rc	7 89e 09p	3 50e 05p	0 010893p	9 92e 05o	0 150329p	0 134320o	0 216583p	0 367153o	0 367175n	0 367269m	2 83e-08p	0 0
m24(s	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 082 60p	0 0	0 0
7[33 28	ri	3 06e 08p	5 55e 05p	0 007348p	0 0	0 043482p	0 005793p	0 024695p	0 001126p	6 46e 07p	2 75e 06p	3 44e 10p	0 0
sig0 560	cc	3 0(e 08p	5 55e 05p	0 007373p	0 0	0 050853p	0 038339p	0 043002p	0 082466p	0 082467p	0 082470p	3 44e-10p	0 0
	rc	3 06e-08p	5 55e 05p	0 007373p	8 35e 05o	0 050937p	0 038392p	0 043032p	0 082550o	0 082550o	0 082553n	3 44e-10p	0 0
cm243[	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 200053n	0 0	0 0
7p 33 80	ri	3 82e-10p	3 43e 06p	0 002111p	0 0	0 050565p	0 021792p	0 106394p	0 018883p	4 46e 05p	0 000218p	1 31e-07p	4 36e 12p
sig0 560	cc	3 82e 10p	3 43e 06p	0 002113p	0 0	0 052677p	0 055505p	0 125358p	0 199746p	0 199791p	0 200009p	1 31e 07p	4 36e 12[
	rc	3 82e 10p	3 43e 06p	0 002113p	1 89e 05o	0 052696p	0 055517p	0 125365p	0 199765o	0 199810n	0 200028m	1 31e 07p	4 36e 12[
m244[	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 160099n	0 0	0 0
7p 33 54	ri	4 85e-09p	1 94e 05p	0 005453p	0 0	0 063788p	0 016047p	0 068413p	0 006255p	7 69e 06p	3 28e 0 p	9 08e 09p	0 0
si j0 560	cc	4 85e 09p	1 94e 05p	0 005461p	0 0	0 069248[	0 060366p	0 093342p	0 159963p	0 159971p	0 160004p	9 08e 09p	0 0
	rc	4 85e 09p	1 94e 05p	0 005461p	6 08 05o	0 069309p	0 060405p	0 093364p	0 160024o	0 160032n	0 160065m	9 08e 09p	0 0
cn246[	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	x	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 100283n	0 0	0 0
7[33 18	ri	9 31e 08p	0 000124p	0 012311p	0 0	0 056153p	0 003374p	0 027300p	0 000858p	2 11e 07p	1 71e 0(p	1 42e 10p	0 0
sig0 560	cc	) 31e 08p	0 000124p	0 012366p	0 0	0 068516p	0 047224p	0 051966p	0 100048p	0 100049p	0 100050p	1 42e-10p	0 0
	rc	9 31e 08p	0 000124p	0 01236(p	0 000203o	0 068719p	0 047354p	0 052039p	0 100251o	0 1002 1n	0 100253m	1 42e 10p	0 0
cm248[	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 057623n	0 0	0 0
7[32 84	i	9 33e 07p	0 00044 p	0 016891p	0 0	0 032613p	0 00143 p	0 006119p	8 10e-05p	1 23e 08p	5 25e 08p	1 67e 12p	0 0
s g0 560	c	9 33e 07p	0 000446p	0 017087p	0 0	0 049695p	0 033240p	0 024009p	0 057330p	0 057330p	0 057330p	1 68e 12p	0 0
	rc	9 33e-07p	0 000446p	0 017087p	0 000299o	0 049994p	0 033432p	0 024117o	0 057629n	0 057629n	0 057629m	1 68e 12p	0 0
pu242h	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 218831n	0 0	0 0
z[33 02	ri	7 11e 07p	0 000707p	0 037463p	0 0	0 137212p	0 008051p	0 034321p	0 000918p	2 03e 07p	8 66e 07p	5 86e 11p	0 0
si j0 560	cc	7 11e 07p	0 000707p	0 037743p	0 0	0 175011p	0 120051[	0 097298p	0 218266p	0 2182(6p	0 2182(7p	5 85e 11p	0 0
	rc	7 11e-07p	0 000708p	0 037773p	0 000495o	0 175472p	0 120353o	0 097491o	0 218761n	0 218762n	0 218762m	5 86e 11p	0 0
[237t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	x	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 342127m	0 0	0 0
7p 33 14	ri	4 78e 07p	0 000555p	0 048201p	0 0	0 195257p	0 018094p	0 077137p	0 002346p	8 68e 07p	3 70e-06p	2 94e-10p	0 0
g0 5(0	cc	4 78e 07p	0 000555p	0 048417p	0 0	0 243743p	0 174079p	0 1(4842p	0 341266p	0 3412(7p	0 341270p	2 94e 10p	0 0
	r	4 78e 07p	0 000555p	0 048444p	0 000727o	0 244416p	0 174520o	0 165127p	0 341993n	0 3419)3m	0 3419971	2 94e 10p	0 0
pu240t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 249641	0 0	0 0
zp 33 23	ri	1 47e 07p	0 000229p	0 026196p	0 0	0 135901p	0 015996p	0 068193p	0 002707p	1 34e 06p	5 69e-06p	6 10e-10p	0 0
sig0 560	cc	1 47e-07p	0 000229p	0 026283p	0 0	0 162235p	0 119818p	0 126563p	0 249087p	0 249088p	0 249094p	6 09e-10p	0 0
	rc	1 47e 07p	0 000229p	0 026296p	0 000462o	0 162653p	0 120094o	0 126748p	0 249549n	0 249550n	0 249556m	6 10e-10p	0 0
[u242t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 139438n	0 0	0 0
7[32 91	ri	1 28e-06p	0 000758p	0 034991p	0 0	0 080587p	0 004248p	0 018109p	0 000293p	5 53e 08p	2 36e 07p	9 36e-12p	0 0
sig0 560	cc	1 28e 06p	0 000759p	0 035324p	0 0	0 115903p	0 078425p	0 059834p	0 138553p	0 138553p	0 138553p	9 36e-12p	0 0
	rc	1 28e 06p	0 000759p	0 035324p	0 000892o	0 116795p	0 078397p	0 060155p	0 139445o	0 139445n	0 139445m	9 36e-12p	0 0

t se bt ichl g to [it d t ga ge l lf li e [rom ENDF V mass n be 84 percent yields

nuclide		30 zn g	31 ga g	32 ge g	33 as d	33 as g	34 e d	34 se g	35 br m	35 lr g	36 kr g	37 rb g	38 sr j
h lf life			0 098s	1 2 s	0 250s	0 3 s	2 03 s	3 3 m	6 0 m	31 8 m	stable	34 d	stable
l mbda		0 0	7 073e+00	5 776e-01	2 773e+00	2 310e+00	3 415e-01	3 501e-03	1 925e 03	3 633e 04	0 0	2 360e-07	0 0
/] j		100 0000	100 0000	100 0000	0 0	94 7940	0 0	99 9140	0 0	100 0000	100 0000	-97 0000	3 0000
l n		0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	100 0000	0 0	0 0
7 0 m		0 0	0 0	0 0	16 4540	100 0000	70 9250	100 0000	0 0	0 0	0 0	0 0	0 0
m243t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 441054n	0 0	0 0
zp 33 98	ri	1 15e 10p	1 59e 06p	0 001903p	0 0	0 066673p	0 0	0 295016p	0 039525p	0 022233p	0 001618p	1 24e-06p	8 11e-11p
sig0 560	cc	1 14e-10p	1 58e 06p	0 001886p	0 0	0 067790p	0 0	0 364074p	0 039128p	0 386083p	0 426815p	1 22e-06p	3 68e-08p
	rc	1 15e 10p	1 59e-06p	0 001905p	2 76e 05o	0 068506p	0 015325o	0 378788p	0 039525p	0 401021o	0 442166n	1 24e-06p	3 72e-08p
cm246s	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	c	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 096402p	0 0	0 0
j 33 ()	rl	5 72 10p	3 22e 0(p	0 001601p	0 0	0 024951p	0 0	0 054131p	0 003380p	0 001901p	6 00e-05p	1 89e 08p	0 0
sig0 560	cc	5 72e 10p	3 22e 06p	0 001604p	0 0	0 026472p	0 0	0 080580p	0 003380p	0 082481p	0 085920p	1 89e 08p	5 67e-10p
	rc	5 72e-10p	3 22e-06p	0 001604p	6 42e-05o	0 026536p	0 015473o	0 096116p	0 003380p	0 098017p	0 101457o	1 89e-08p	5 67e-10p
cm243f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 300111n	0 0	0 0
zp 34 21	ri	35e 12p	1 52e 07p	0 000362p	0 0	0 024368p	0 0	0 194314p	0 048832p	0 022980p	0 003569p	5 43e-06p	7 24e-10p
sij0 60	cc	32e 12p	1 51e 07p	0 000360p	0 0	0 024555p	0 0	0 219481p	0 048524p	0 242316p	0 294392p	5 40e-06p	1 63e-07p
	rc	5 35e 12p	1 52e 07p	0 000362p	70e 06o	0 024717p	0 006188o	0 225198p	0 048832p	0 248178o	0 300585n	5 43e-06p	1 64e-07p
c 244f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 230201n	0 0	0 0
zp 33 95	ri	8 66e 11p	1 08e 06p	0 001166p	0 0	0 037145p	0 0	0 149674p	0 018561p	0 010441p	0 000690p	4 77e 07p	2 81e-11p
ij0 (0		8 2e 11p	1 07e 0(p	0 001149p	0 0	0 037(0p	0 0	0 188362p	0 0182(9p	0 198(38p	0 217 87p	4 69e-07p	1 41e-08p
	r	8 66 11p	1 08e 0(p	0 001167p	2 71 0 o	0 038273p	0 013(21	0 201 41p	0 018561p	0 211381o	0 231234n	4 77e 07p	1 43e 08p
cm246f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 160640n	0 0	0 0
zp 33 9	ri	2 5e 09p	1 05e 05p	0 003883p	0 0	0 046043p	0 0	0 077930p	0 004553p	0 001284p	4 94e 05p	1 14e 08p	0 0
sig0 560	cc	2 55e 09p	1 05e-05p	0 003894p	0 0	0 049734p	0 0	0 127622p	0 004553p	0 128906p	0 133508p	1 14e-08p	3 44e-10p
	rc	2 55e 09p	1 05e-05p	0 003894p	0 000167o	0 049901p	0 030391o	0 158179p	0 004553p	0 159463o	0 164066n	1 14e-08p	3 44e 10p
cf248f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 088183n	0 0	0 0
zp 33 25	ri	2 87e 08p	4 18e 05p	0 005709p	0 0	0 027535p	0 0	0 020153p	0 000386p	0 000217p	1 87e 06p	1 52e-10p	0 0
sig0 560	cc	2 87e 08p	4 19e 05p	0 005751p	0 0	0 032986p	0 0	0 053111p	0 000386p	0 053328p	0 053717p	1 52e-10p	4 56e 12p
	rc	2 87e 08p	4 19e 05p	0 005751p	0 000576o	0 033562p	0 042084o	0 095770p	0 000386p	0 095388o	0 096376n	1 52e 10p	4 56e 12p
pu242l	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 326014n	0 0	0 0
zp 33 43	ri	1 59e 08p	5 50e-05p	0 009462p	0 0	0 099711p	0 0	0 085071p	0 003637p	0 002046p	2 25e-05p	4 36e-09p	0 0
sig0 560	cc	1 59e 08p	5 49e-05p	0 009507p	0 0	0 108828p	0 0	0 193717p	0 003633p	0 195761p	0 199416p	4 35e-09p	1 31e-10p
	rc	1 59e 08p	5 50e-05p	0 009517p	0 001117o	0 109850p	0 158024o	0 352851p	0 003637p	0 354897o	0 358556n	4 36e-09p	1 31e-10p
p237t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 497868n	0 0	0 0
zp 33 5	ri	1 21e 08p	4 32e 05p	0 013922p	0 0	0 145684p	0 0	0 209785p	0 009362p	0 005266p	0 000108p	2 18e-08p	0 0
j0 (0	cc	1 17e 08p	4 20e 05p	0 013578p	0 0	0 154711p	0 0	0 369002p	0 009103p	0 374123p	0 383331p	2 12e-08p	6 36e-10p
	rc	1 21e 08p	4 32e 05p	0 013965p	0 000818o	0 159741p	0 131312o	0 500700p	0 009362p	0 505966o	0 515437n	2 18e-08p	6 54e-10p
pu240t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 419148n	0 0	0 0
zp 33 (4	i	4 29e 09p	2 07e 05p	0 008858p	0 0	0 120265p	0 0	0 222485p	0 012616p	0 007097p	0 000193p	5 22e-08p	1 18e-12p
ig0 560	cc	4 20e 09p	2 02e 05p	0 008688p	0 0	0 125995p	0 0	0 351494p	0 012346p	0 358433p	0 370974p	5 11e-08p	1 53e-09p
	rc	4 29e 09p	2 07e 05p	0 008879p	0 000255o	0 128937p	0 053402o	0 404713p	0 012616p	0 411809o	0 424619n	5 22e-08p	1 57e-09p
pu242t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 278410n	0 0	0 0
zp 33 32	ri	5 64e 08p	0 000102p	0 017042p	0 0	0 098558p	0 0	0 086084p	0 002002p	0 001126p	1 20e 05p	1 21e 09p	0 0
sij0 560	cc	63e 08p	0 000102p	0 017126p	0 0	0 114902p	0 0	0 200798p	0 002000p	0 201923p	0 203935p	1 21e-09p	3 63e 11p
	rc	5 64e 08p	0 000102p	0 017143p	0 001029o	0 115838p	0 090400o	0 292222p	0 002002p	0 293348o	0 295362n	1 21e-09p	3 63e-11p

j j l lf ll es from LNDI V

mass number	85									percent yields			
nuclide		31 ga g	32 ge g	33 as d	33 as g	34 se m	34 se g	35 br g	36 kr m	36 kr g	37 rb g	38 sr g	39 y g
half life		0 087s	0 250s	0 247s	2 03 s	19 s	39 s	2 87ı	4 48 h	10 73y	stable	65 2 d	5 0 h
l mbdı		7 967e+00	2 773e+00	2 806e+00	3 415e-01	3 648e 02	1 777e 02	4 025e-03	4 298e-05	2 048e 09	0 0	1 230e-07	3 851e 05
/ 1 g		100 0000	100 0000	0 0	83 5460	0 0	29 0750	100 0000	100 0000	0 0	100 0000	100 0000	-100 0000
/ 1 m		0 0	0 0	0 0	0 0	0 0	0 0	100 0000	0 0	0 0	80 0210	0 0	0 0
7 0 m		0 0	0 0	15 2150	100 0000	8 5030	0 0	0 0	0 0	19 9790	0 0	0 0	0 0
cm243t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 420070n	0 0	0 0
zı 34 39	ri	4 58e 08p	0 000168p	0 0	0 021467p	0 122088p	0 122284p	0 157676p	0 002155p	0 009186p	3 33e-05p	6 85e 09p	0 0
sig0 560	cc	4 57e-08p	0 000168p	0 0	0 021596p	0 122272p	0 128501p	0 408344p	0 410498p	0 091195p	0 419712p	6 84e 09p	0 0
	rc	4 58e-08p	0 000168p	1 79e-06o	0 021609p	0 122480p	0 128566p	0 408723o	0 410878n	0 091275n	0 420097m	6 85e-09p	0 0
cm246	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 158657p	0 0	0 0
zı 34 10	ri	2 59e 07p	0 000390p	0 0	0 021485p	0 057448p	0 057448p	0 035935p	0 000220p	0 000938p	1 42e-06p	1 19e-10p	0 0
sig0 560	cc	2 59e-07p	0 000390p	0 0	0 021811p	0 057448p	0 063790p	0 157173p	0 157393p	0 032384p	0 158333p	1 19e-10p	0 0
	rc	2 59e-07p	0 000390p	4 70e 06o	0 021815p	0 057883p	0 063791p	0 157609o	0 157829o	0 032471o	0 158768n	1 19e 10p	0 0
cm243f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 420110n	0 0	0 0
zı 34 62	ri	4 67e 09p	3 46e 05p	0 0	0 008695p	0 091376p	0 091376p	0 207112p	0 004665p	0 022774p	0 000158p	6 56e-08p	0 0
sig0 560	cc	4 67e 09p	3 46e-05p	0 0	0 008724p	0 091373p	0 093909p	0 392401p	0 397066p	0 102103p	0 419997p	6 56e-08p	0 0
	rc	4 67e-09p	3 46e 05p	2 88e 07o	0 008725ı	0 091501p	0 093912p	0 392526p	0 397191o	0 102129o	0 420123m	6 56e-08p	0 0
c 244f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 330204	0 0	0 0
zı 34 36	ri	4 98e 08p	0 000164p	0 0	0 019065p	0 099347p	0 099347p	0 117843p	0 001469p	0 006264p	2 05e 05p	3 80e-09p	0 0
ı0 560	cc	4 97e 08p	0 000164ı	0 0	0 019201p	0 099341p	0 104924p	0 322121p	0 323590p	0 070913p	0 329874p	3 80e-09p	0 0
	ı	4 98 08p	0 000164ı	1 89e 06o	0 019204ı	0 099722ı	0 104331ı	0 32249 o	0 323964o	0 070389n	0 330249ı	3 80e 09p	0 0
m246f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 230650n	0 0	0 0
zı 34 00	ri	9 13e 07p	0 001013p	0 0	0 041986ı	0 086970p	0 086970p	0 042247p	0 000113p	0 000914p	9 32e-07p	5 69e-11p	0 0
sig0 560	cc	9 13e 07p	0 001014p	0 0	0 042833p	0 086970p	0 099424p	0 228640p	0 228753p	0 046616p	0 229668p	5 69e-11p	0 0
	rc	9 13e 07p	0 001014p	1 63e 0 o	0 042849p	0 088093p	0 099428p	0 229768o	0 229881n	0 046841n	0 230796m	5 69e-11p	0 0
c 248f	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 129156n	0 0	0 0
zp 33 66	ri	8 71e-06p	0 003491p	0 0	0 056339p	0 050013p	0 050013p	0 010141p	1 77e-05p	7 53e 05p	3 00e 08p	0 0	0 0
sig0 560	cc	8 71e-06p	0 003500p	0 0	0 059263p	0 050013p	0 067244p	0 127398p	0 127416p	0 025532p	0 127491p	0 0	0 0
	rc	8 71e-06p	0 003500p	7 30e 05o	0 059336p	0 051917p	0 067265p	0 129324o	0 129341n	0 025916n	0 129416m	0 0	0 0
pu242h	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 674994j	0 0	0 674994j	0 0	0 0
zı 33 84	ri	1 17e 05p	0 006776p	0 0	0 217042p	0 250784p	0 253664p	0 099174p	0 000245p	0 001045p	8 73e 07p	2 74e-11p	0 0
sıg0 560	cc	1 17e 05p	0 006764p	0 0	0 221963p	0 252777p	0 317313p	0 668916p	0 669160p	0 134732p	0 670202p	2 73e-11p	0 0
	rc	1 17e 05p	0 006787p	9 95e 05o	0 222812p	0 256674p	0 318447p	0 6742951	0 674540j	0 135811j	0 675585ı	2 74e-11p	0 0
ı237ı	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 033815j	0 0	0 758703m	0 0	0 0
zı 33 36	ri	5 14e 06p	0 004968p	0 0	0 180910p	0 331277p	0 333890p	0 277651p	0 000586p	0 002436p	2 43e 06p	1 29e 10p	0 0
ı0 60	c	81e 06p	0 00 672p	0 0	0 209235p	0 377441p	0 43827(ı	0 978975p	0 979637p	0 198544p	0 982462p	1 46e-10p	0 0
	rc	14e-06p	0 004973p	7 67e 05o	0 185142p	0 335900p	0 387721p	1 0012711	1 001857j	0 202(57j	1 004355j	1 29e 10p	0 0
pu240t	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 469326n	0 0	0 0
zı 34 05	ri	1 20e 06p	0 001 48p	0 0	0 073975p	0 173037p	0 174019p	0 095940p	0 000510p	0 0021/ p	2 84e 06p	2 02e-10p	0 0
s g0 60	cc	1 20e-06p	0 001546p	0 0	0 07 127p	0 173692p	0 195535p	0 464987p	0 465496p	0 0951/3p	0 467670p	2 02e-10p	0 0
	rc	1 20e-06p	0 001549p	2 49e 05o	0 075294p	0 175023p	0 195910p	0 466873o	0 467383n	0 095554n	0 469562m	2 02e-10p	0 0
ı 242ı	xi	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	xc	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 328675n	0 0	0 0
zp 33 73	ri	1 26e-05p	0 006241p	0 0	0 122103p	0 127092p	0 129097p	0 031470p	6 72e-05p	0 000287p	1 42e 07p	3 74e 12p	0 0
sig0 560	cc	1 26e-05p	0 006223p	0 0	0 126744p	0 128467p	0 165318p	0 325101p	0 325168p	0 06 2 1p	0 325453p	3 72e-12p	0 0
	rc	1 26e 05p	0 006254p	0 000130o	0 127458p	0 131229p	0 166155p	0 328855o	0 328922n	0 066002n	0 329209m	3 74e-12p	0 0

kr l ıching to fit data ga as ge half li es from ENDF V

APPENDIX C

SAMPLE DELAYED NEUTRON DATA AND FORMAT
$^{237}Np(F)$ $^{238}Pu(F)$ $^{241,243}Am(\Gamma)$ AND $^{242}Cm(\Gamma)$

1
NP 237 (F)
0
DELAYED NEUTRON YIELD PER FISSION

1 00000E 05	1 08100E 02
4 00000E+06	1 08100E 02
7 00000E+06	6 48600E 03
2 00000E+07	6 48600E 03

0
DATA BY DECAY GROUP

GROUP 1

GROUP FRACTION = 3 99831E 02 GROUP DECAY CONSTANT (1/S) = 1 32520E 02

GROUP SPECTRUM (NORMALIZATION SUM=1 0)

UPPER ENERGY BOUND (EV)	SPECTRUM
0 0E+00	0 0000
0 4E+00	0 0000
0 5E+00	0 0000
0 7E+00	0 0000
0 9E+00	0 0000
0 1E+01	0 0000
0 1E+01	0 0000
0 2E+01	0 0000
0 2E+01	0 0000
0 3E+01	0 0000
0 4E+01	0 0000
0 5E+01	0 0000
0 6E+01	0 0000
0 8E+01	0 0000
0 1E+02	0 0000
0 1E+02	0 0000
0 2E+02	0 0000
0 2E+02	0 0000
0 3E+02	0 0000
0 4E+02	0 0000
0 5E+02	0 0000
0 6E+02	0 0000
0 8E+02	0 0000
0 1E+03	0 0000
0 1E+03	0 0000
0 2E+03	0 0000
0 2E+03	0 0000
0 3E+03	0 0000
0 4E+03	0 0000
0 5E+03	0 0000
0 6E+03	0 0000
0 7E+03	0 0000
0 1E+04	0 0001
0 1E+04	0 0001
0 2E+04	0 0001
0 2E+04	0 0001
0 3E+04	0 0001
0 3E+04	0 0002

0 4E+04	0 0002
0 6E+04	0 0003
0 7E+04	0 0004
0 9E+04	0 0005
0 1E+05	0 0041
0 2E+05	0 0075
0 2E+05	0 0096
0 2E+05	0 0136
0 3E+05	0 0147
0 4E+05	0 0085
0 5E+05	0 0212
0 7E+05	0 0314
0 9E+05	0 0369
0 1E+06	0 0252
0 1E+06	0 0566
0 2E+06	0 0735
0 2E+06	0 0792
0 3E+06	0 1246
0 4E+06	0 0919
0 5E+06	0 1142
0 6E+06	0 0960
0 8E+06	0 0644
0 1E+07	0 0717
0 1E+07	0 0436
0 2E+07	0 0092
0 2E+07	0 0000
0 3E+07	0 0000
0 4E+07	0 0000
0 5E+07	0 0000
0 6E+07	0 0000
0 8E+07	0 0000
0 1E+08	0 0000

0

GROUP 2

GROUP FRACTION = 2 16180E 01 GROUP DECAY CONSTANT (1/S) = 3 16030E 02

GROUP SPECTRUM (NORMALIZATION SUM=1 0)

UPPER ENERGY BOUND (EV)	SPECTRUM
0 0E+00	0 0000
0 4E+00	0 0000
0 5E+00	0 0000
0 7E+00	0 0000
0 9E+00	0 0000
0 1E+01	0 0000
0 1E+01	0 0000
0 2E+01	0 0000
0 2E+01	0 0000
0 3E+01	0 0000
0 4E+01	0 0000
0 5E+01	0 0000
0 6E+01	0 0000
0 8E+01	0 0000
0 1E+02	0 0000
0 1E+02	0 0000

0 2E+02	0 0000
0 2E+02	0 0000
0 3E+02	0 0000
0 4E+02	0 0000
0 5E+02	0 0000
0 6E+02	0 0000
0 8E+02	0 0000
0 1E+03	0 0000
0 1E+03	0 0000
0 2E+03	0 0000
0 2E+03	0 0000
0 3E+03	0 0000
0 4E+03	0 0001
0 5E+03	0 0001
0 6E+03	0 0001
0 7E+03	0 0001
0 1E+04	0 0002
0 1E+04	0 0002
0 2E+04	0 0003
0 2E+04	0 0004
0 3E+04	0 0005
0 3E+04	0 0006
0 4E+04	0 0008
0 6E+04	0 0010
0 7E+04	0 0012
0 9E+04	0 0016
0 1E+05	0 0021
0 2E+05	0 0027
0 2E+05	0 0035
0 2E+05	0 0045
0 3E+05	0 0058
0 4E+05	0 0074
0 5E+05	0 0095
0 7E+05	0 0124
0 9E+05	0 0234
0 1E+06	0 0309
0 1E+06	0 0316
0 2E+06	0 0344
0 2E+06	0 0401
0 3E+06	0 0750
0 4E+06	0 1199
0 5E+06	0 1528
0 6E+06	0 1446
0 8E+06	0 0989
0 1E+07	0 1099
0 1E+07	0 0689
0 2E+07	0 0144
0 2E+07	0 0002
0 3E+07	0 0000
0 4E+07	0 0000
0 5E+07	0 0000
0 6E+07	0 0000
0 8E+07	0 0000
0 1E+08	0 0000

0

GROUP 3

GROUP FRACTION = 1 55803E 01 GROUP DECAY CONSTANT (1/S) = 1 16790E 01

GROUP SPECTRUM (NORMALIZATION SUM=1 0)

UPPER ENERGY BOUND (EV)	SPECTRUM
0 0E+00	0 0000
0 4E+00	0 0000
0 5E+00	0 0000
0 7E+00	0 0000
0 9E+00	0 0000
0 1E+01	0 0000
0 1E+01	0 0000
0 2E+01	0 0000
0 2E+01	0 0000
0 3E+01	0 0000
0 4E+01	0 0000
0 5E+01	0 0000
0 6E+01	0 0000
0 8E+01	0 0000
0 1E+02	0 0000
0 1E+02	0 0000
0 2E+02	0 0000
0 2E+02	0 0000
0 3E+02	0 0000
0 4E+02	0 0000
0 5E+02	0 0000
0 6E+02	0 0000
0 8E+02	0 0000
0 1E+03	0 0000
0 1E+03	0 0000
0 2E+03	0 0000
0 2E+03	0 0000
0 3E+03	0 0000
0 4E+03	0 0001
0 5E+03	0 0001
0 6E+03	0 0001
0 7E+03	0 0001
0 1E+04	0 0002
0 1E+04	0 0002
0 2E+04	0 0003
0 2E+04	0 0004
0 3E+04	0 0005
0 3E+04	0 0006
0 4E+04	0 0008
0 6E+04	0 0010
0 7E+04	0 0013
0 9E+04	0 0016
0 1E+05	0 0028
0 2E+05	0 0041
0 2E+05	0 0052
0 2E+05	0 0067
0 3E+05	0 0086
0 4E+05	0 0109
0 5E+05	0 0136
0 7E+05	0 0175

0 9E+05	0 0222
0 1E+06	0 0374
0 1E+06	0 0537
0 2E+06	0 0598
0 2E+06	0 0752
0 3E+06	0 0963
0 4E+06	0 1155
0 5E+06	0 1169
0 6E+06	0 1254
0 8E+06	0 1226
0 1E+07	0 0563
0 1E+07	0 0265
0 2E+07	0 0119
0 2E+07	0 0031
0 3E+07	0 0003
0 4E+07	0 0000
0 5E+07	0 0000
0 6E+07	0 0000
0 8E+07	0 0000
0 1E+08	0 0000

0

GROUP 4

GROUP FRACTION - 3 63301E 01 GROUP DECAY CONSTANT (1/S) - 3 00650E 01

GROUP SPECTRUM (NORMALIZATION SUM-1 0)

UPPER ENERGY BOUND (EV)	SPECTRUM
0 0E+00	0 0000
0 4E+00	0 0000
0 5E+00	0 0000
0 7E+00	0 0000
0 9E+00	0 0000
0 1E+01	0 0000
0 1E+01	0 0000
0 2E+01	0 0000
0 2E+01	0 0000
0 3E+01	0 0000
0 4E+01	0 0000
0 5E+01	0 0000
0 6E+01	0 0000
0 8E+01	0 0000
0 1E+02	0 0000
0 1E+02	0 0000
0 2E+02	0 0000
0 2E+02	0 0000
0 3E+02	0 0000
0 4E+02	0 0000
0 5E+02	0 0000
0 6E+02	0 0000
0 8E+02	0 0000
0 1E+03	0 0000
0 1E+03	0 0000
0 2E+03	0 0000
0 2E+03	0 0000
0 3E+03	0 0000

0 4E+03	0 0000
0 5E+03	0 0000
0 6E+03	0 0001
0 7E+03	0 0001
0 1E+04	0 0001
0 1E+04	0 0001
0 2E+04	0 0002
0 2E+04	0 0002
0 3E+04	0 0003
0 3E+04	0 0003
0 4E+04	0 0004
0 6E+04	0 0005
0 7E+04	0 0007
0 9E+04	0 0009
0 1E+05	0 0021
0 2E+05	0 0033
0 2E+05	0 0042
0 2E+05	0 0055
0 3E+05	0 0068
0 4E+05	0 0081
0 5E+05	0 0101
0 7E+05	0 0133
0 9E+05	0 0194
0 1E+06	0 0266
0 1E+06	0 0394
0 2E+06	0 0559
0 2E+06	0 0655
0 3E+06	0 0838
0 4E+06	0 1039
0 5E+06	0 1144
0 6E+06	0 1247
0 8E+06	0 1036
0 1E+07	0 0913
0 1E+07	0 0602
0 2E+07	0 0366
0 2E+07	0 0132
0 3E+07	0 0037
0 4E+07	0 0003
0 5E+07	0 0000
0 6E+07	0 0000
0 8E+07	0 0000
0 1E+08	0 0000

0

GROUP 5

GROUP FRACTION = 1 65862E 01 GROUP DECAY CONSTANT (1/S) = 8 66690E 01

GROUP SPECTRUM (\ORMALIZATION SUM=1 0)

UPPER ENERGY BOU\D (EV)	SPECTRUM
0 0E+00	0 0000
0 4E+00	0 0000
0 5E+00	0 0000
0 7E+00	0 0000
0 9E+00	0 0000
0 1E+01	0 0000

0 1E+01	0 0000
0 2E+01	0 0000
0 2E+01	0 0000
0 3E+01	0 0000
0 4E+01	0 0000
0 5E+01	0 0000
0 6E+01	0 0000
0 8E+01	0 0000
0 1E+02	0 0000
0 1E+02	0 0000
0 2E+02	0 0000
0 2E+02	0 0000
0 3E+02	0 0000
0 4E+02	0 0000
0 5E+02	0 0000
0 6E+02	0 0000
0 8E+02	0 0000
0 1E+03	0 0000
0 1E+03	0 0000
0 2E+03	0 0000
0 2E+03	0 0000
0 3E+03	0 0000
0 4E+03	0 0000
0 5E+03	0 0000
0 6E+03	0 0000
0 7E+03	0 0000
0 1E+04	0 0001
0 1E+04	0 0001
0 2E+04	0 0001
0 2E+04	0 0001
0 3E+04	0 0002
0 3E+04	0 0002
0 4E+04	0 0003
0 6E+04	0 0003
0 7E+04	0 0004
0 9E+04	0 0006
0 1E+05	0 0027
0 2E+05	0 0047
0 2E+05	0 0060
0 2E+05	0 0053
0 3E+05	0 0062
0 4E+05	0 0074
0 5E+05	0 0112
0 7E+05	0 0162
0 9E+05	0 0246
0 1E+06	0 0333
0 1E+06	0 0457
0 2E+06	0 0615
0 2E+06	0 0797
0 3E+06	0 0940
0 4E+06	0 1082
0 5E+06	0 1161
0 6E+06	0 1190
0 8E+06	0 0931
0 1E+07	0 0678
0 1E+07	0 0447

0 2E+07	0 0283
0 2E+07	0 0144
0 3E+07	0 0068
0 4E+07	0 0007
0 5E+07	0 0000
0 6E+07	0 0000
0 8E+07	0 0000
0 1E+08	0 0000

0

GROUP 6

GROUP FRACTION = 5 88701E 02 GROUP DECAY CONSTANT (1/S) = 2 76000E+00

GROUP SPECTRUM (NORMALIZATION SUM=1 0)

UPPER ENERGY BOUND (EV)	SPECTRUM
0 0E+00	0 0000
0 4E+00	0 0000
0 5E+00	0 0000
0 7E+00	0 0000
0 9E+00	0 0000
0 1E+01	0 0000
0 1E+01	0 0000
0 2E+01	0 0000
0 2E+01	0 0000
0 3E+01	0 0000
0 4E+01	0 0000
0 5E+01	0 0000
0 6E+01	0 0000
0 8E+01	0 0000
0 1E+02	0 0000
0 1E+02	0 0000
0 2E+02	0 0000
0 2E+02	0 0000
0 3E+02	0 0000
0 4E+02	0 0000
0 5E+02	0 0000
0 6E+02	0 0000
0 8E+02	0 0000
0 1E+03	0 0000
0 1E+03	0 0000
0 2E+03	0 0000
0 2E+03	0 0000
0 3E+03	0 0000
0 4E+03	0 0000
0 5E+03	0 0000
0 6E+03	0 0000
0 7E+03	0 0000
0 1E+04	0 0001
0 1E+04	0 0001
0 2E+04	0 0001
0 2E+04	0 0001
0 3E+04	0 0001
0 3E+04	0 0002
0 4E+04	0 0002
0 6E+04	0 0003

0 7E+04	0 0004
0 9E+04	0 0005
0 1E+05	0 0056
0 2E+05	0 0105
0 2E+05	0 0136
0 2E+05	0 0082
0 3E+05	0 0079
0 4E+05	0 0076
0 5E+05	0 0127
0 7E+05	0 0149
0 9E+05	0 0263
0 1E+06	0 0344
0 1E+06	0 0398
0 2E+06	0 0552
0 2E+06	0 0719
0 3E+06	0 0845
0 4E+06	0 0991
0 5E+06	0 1013
0 6E+06	0 1162
0 8E+06	0 0984
0 1E+07	0 0676
0 1E+07	0 0474
0 2E+07	0 0346
0 2E+07	0 0233
0 3E+07	0 0150
0 4E+07	0 0017
0 5E+07	0 0000
0 6E+07	0 0000
0 8E+07	0 0000
0 1E+08	0 0000

APPENDIX D

SAMPLE DELAYED NEUTRON DATA AND FORMAT ^{237}Np(T) ^{240}Pu(T) ^{242}Pu(T H) ^{243}Cm(T F) ^{244}Cm(F) ^{246}Cm(S F) AND ^{248}Cm(F)

***************** ******************************* ************ * * *

Cm 243(T) 8 28 89

Group 1 yield per fission 4 9761e 02 decay constant (per sec) 1 3090e 02
Group 2 yield per fission 2 9936e 01 decay constant (per sec) 3 0317e 02
Group 3 yield per fission 1 3994e 01 decay constant (per sec) 1 1498e 01
Group 4 yield per fission 2 9603e 01 decay constant (per sec) 2 9189e 01
Group 5 yield per fission 1 7772e 01 decay constant (per sec) 8 5756e 01
Group 6 yield per fission 3 7178e 02 decay constant (per sec) 2 5917e+00

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
7 8805e 08	1 5462e 07	2 7404e 07	1 1994e 07	6 1416e 08	7 5551e 08
2 2381e 08	4 3913e 08	7 7828e 08	3 4065e 08	1 7443e 08	2 1457e 08
2 8741e 08	5 6391e 08	9 9944e 08	4 3745e 08	2 2399e 08	2 7554e 08
3 6902e 08	7 2404e 08	1 2832e 07	5 6167e 08	2 8759e 08	3 5378e 08
4 7383e 08	9 2968e 08	1 6477e 07	7 2119e 08	3 6927e 08	4 5426e 08
6 0855e 08	1 1940e 07	2 1162e 07	9 2624e 08	4 7427e 08	5 8342e 08
7 8116e 08	1 5327e 07	2 7164e 07	1 1890e 07	6 0879e 08	7 4890e 08
1 0031e 07	1 9681e 07	3 4881e 07	1 5267e 07	7 8175e 08	9 6167e 08
1 2881e 07	2 5273e 07	4 4791e 07	1 9605e 07	1 0038e 07	1 2349e 07
1 6537e 07	3 2447e 07	5 7506e 07	2 5170e 07	1 2888e 07	1 5854e 07
2 1237e 07	4 1669e 07	7 3851e 07	3 2324e 07	1 6551e 07	2 0361e 07
2 7267e 07	5 3500e 07	9 4818e 07	4 1502e 07	2 1250e 07	2 6141e 07
3 5013e 07	6 8697e 07	1 2175e 06	5 3291e 07	2 7287e 07	3 3567e 07
4 4956e 07	8 8206e 07	1 5633e 06	6 8424e 07	3 5036e 07	4 3099e 07
5 7724e 07	1 1326e 06	2 0073e 06	8 7858e 07	4 4987e 07	5 5341e 07
7 4132e 07	1 4545e 06	2 5778e 06	1 1283e 06	5 7774e 07	7 1071e 07
9 5152e 07	1 8669e 06	3 3088e 06	1 4482e 06	7 4155e 07	9 1223e 07
1 2221e 06	2 3978e 06	4 2497e 06	1 8601e 06	9 5242e 07	1 1716e 06
1 5692e 06	3 0788e 06	5 4566e 06	2 3883e 06	1 2229e 06	1 5044e 06
2 0150e 06	3 9535e 06	7 0068e 06	3 0669e 06	1 5703e 06	1 9318e 06
2 5869e 06	5 0757e 06	8 9957e 06	3 9374e 06	2 0161e 06	2 4801e 06
3 3219e 06	6 5177e 06	1 1551e 05	5 0560e 06	2 5889e 06	3 1847e 06
4 2653e 06	8 3688e 06	1 4832e 05	6 4920e 06	3 3241e 06	4 0892e 06
5 4767e 06	1 0746e 05	1 9044e 05	8 3357e 06	4 2682e 06	5 2505e 06
7 0319e 06	1 3797e 05	2 4453e 05	1 0703e 05	5 4802e 06	6 7415e 06
9 0312e 06	1 7720e 05	3 1405e 05	1 3746e 05	7 0384e 06	8 6583e 06
1 1593e 05	2 2746e 05	4 0312e 05	1 7645e 05	9 0346e 06	1 1114e 05
1 4887e 05	2 9210e 05	5 1769e 05	2 2659e 05	1 1602e 05	1 4273e 05
1 9118e 05	3 7511e 05	6 6482e 05	2 9099e 05	1 4900e 05	1 8329e 05
2 4544e 05	4 8157e 05	8 5350e 05	3 7358e 05	1 9128e 05	2 3531e 05
3 1518e 05	6 1839e 05	1 0960e 04	4 7971e 05	2 4563e 05	3 0216e 05
4 0468e 05	7 9401e 05	1 4072e 04	6 1594e 05	3 1538e 05	3 8797e 05
5 1963e 05	1 0195e 04	1 8070e 04	7 9090e 05	4 0497e 05	4 9818e 05
6 6721e 05	1 3091e 04	2 3201e 04	1 0155e 04	5 1998e 05	6 3966e 05
8 5668e 05	1 6809e 04	2 9790e 04	1 3039e 04	6 6765e 05	8 2131e 05
1 1001e 04	2 1585e 04	3 8255e 04	1 6744e 04	8 5737e 05	1 0547e 04
1 4125e 04	2 7714e 04	4 9118e 04	2 1499e 04	1 1008e 04	1 3542e 04
1 8136e 04	3 5583e 04	6 3065e 04	2 7603e 04	1 4134e 04	1 7387e 04
2 3288e 04	4 5693e 04	8 0982e 04	3 5445e 04	1 8149e 04	2 2327e 04
2 9902e 04	5 8669e 04	1 0398e 03	4 5512e 04	2 3304e 04	2 8667e 04
3 8396e 04	7 5334e 04	1 3352e 03	5 8470e 04	2 9923e 04	3 6810e 04

4 9302e 04	9 6732e 04	1 7144e 03	7 5039e 04	3 8422e 04	4 7266e 04
3 9549e 03	1 2949e 03	2 8306e 03	1 9937e 03	1 8414e 03	5 6168e 03
7 2755e 03	1 6971e 03	4 0500e 03	3 2410e 03	3 2560e 03	1 0526e 02
9 3454e 03	2 1800e 03	5 2022e 03	4 1631e 03	4 1823e 03	1 3521e 02
1 3245e 02	2 9068e 03	6 8177e 03	5 6267e 03	4 5311e 03	8 0905e 03
1 4318e 02	3 7687e 03	8 7762e 03	7 1244e 03	5 6812e 03	7 8791e 03
8 3454e 03	4 9075e 03	1 1232e 02	8 6026e 03	7 5059e 03	7 5455e 03
2 0740e 02	6 4347e 03	1 4283e 02	1 1052e 02	1 1580e 02	1 2815e 02
3 0719e 02	8 6553e 03	1 8322e 02	1 4671e 02	1 7058e 02	1 5298e 02
3 6353e 02	1 9401e 02	2 3144e 02	2 1724e 02	2 5651e 02	2 5998e 02
2 4891e 02	2 2584e 02	3 9006e 02	3 0260e 02	3 6497e 02	3 6000e 02
5 5362e 02	2 2663e 02	5 5609e 02	4 4320e 02	5 0234e 02	4 2428e 02
7 2042e 02	2 7009e 02	6 1789e 02	6 1256e 02	6 8457e 02	5 9231e 02
7 7573e 02	3 0344e 02	7 7011e 02	7 3139e 02	8 7985e 02	7 6924e 02
1 2316e 01	7 1344e 02	9 6883e 02	9 2030e 02	1 0499e 01	8 9609e 02
9 2846e 02	1 2315e 01	1 1485e 01	1 1104e 01	1 1815e 01	1 0277e 01
1 1563e 01	1 5773e 01	1 1614e 01	1 1654e 01	1 2301e 01	1 0612e 01
9 7954e 02	1 5605e 01	1 2354e 01	1 2137e 01	1 1684e 01	1 1713e 01
6 5917e 02	1 0983e 01	1 1869e 01	1 0065e 01	8 8939e 02	9 5633e 02
7 3695e 02	1 2683e 01	5 4187e 02	7 9752e 02	5 9434e 02	6 1284e 02
4 4912e 02	8 0117e 02	2 5459e 02	4 8729e 02	3 3501e 02	3 9601e 02
9 4884e 03	1 6589e 02	1 1316e 02	2 7189e 02	1 7239e 02	2 7479e 02
6 4428e 06	1 3907e 04	2 8243e 03	9 1695e 03	7 1269e 03	1 7444e 02
0 0000e+00	0 0000e+00	2 8136e 04	2 5345e 03	2 8619e 03	1 0438e 02
0 0000e+00	0 0000e+00	8 2354e 06	4 2371e 04	1 1282e 03	5 3727e 03
0 0000e+00	0 0000e+00	0 0000e+00	1 2125e 05	4 2049e 04	2 2399e 03
0 0000e+00	0 0000e+00	0 0000e+00	1 2666e 08	1 3895e 04	7 6226e 04
0 0000e+00	0 0000e+00	0 0000e+00	2 9773e 10	1 6783e 05	1 0578e 04
0 0000e+00	0 0000e+00	0 0000e+00	0 0000e+00	4 8629e 08	3 3056e 07

APPENDIX E

PROMPT NEUTRON SPECTRAL DATA

APPENDIX E. PROMPT NEUTRON SPECTRAL DATA

In this Appendix we include a listing of the program used to calculate the 70 group spectra along with the input and output files The program used MADNIX FOR (Table E 1) is written in FORTRAN 77 and runs on a VAX VMS system The main subroutine MADNIX, is taken from subroutine ANASED of the NJOY code system [34] The user should be cautioned that the modified version used here is valid only for the LF = 12 option The program uses two functions DGAMI and DE1 double precision versions of the incomplete gamma function and the exponential integral respectively These two functions must be linked from an external library The equations solved by MADNIX FOR are given in ref 24 pp 12 14 The input file MADNIX DAT corresponding to the cases described in Sect 4 1 of this report, is given in Table E 2

Table E 1 Program MADNIX FOR

```
c
c**** main program to call subroutine madnix (lf=12)
C     TO LINK THIS PROGRAM ON THE STC VAX USE
C     LINK MADNIX SYS$LIBRARY SLATEC/LIB
c
      implicit real*8 (a h o z)
      character*4 title(15)
      dimension ebnd(28) eb70(71)
      dimension fns(70 20)
      common /mainio/nsysi nsyso nshort
      data nsysi nsyso nshort /5 6,0/
c**   data ebnd/3 00e+00 1 0e+01 3 0e+01 1 0e+02 5 5e+02 3 0e+03
c**  &1 7e+04 1 0e+05 4 0e+05 9 0e+05 1 4e+06 1 85e+06 3 0e+06
c**  &6 434e+06 2 0e+07/
      data ebnd/1 0d 5,1 0d 2 3 0d 2 5 0d 2 0 1 0 225 0 325 0 4
     * 0 8 1 0 1 13 1 3,1 77,3 0,10 0,30 0,100 0,550 0 3 0d+3,
     * 1 7d+4,1 0d+5 4 0d+5 9 0d+5 1 4d+6,1 85d+6 3 0d+6,
     * 6 434d+6 2 0d+7/
c***  the following two statements are for the cray version
c**     call link( unit5=(infile open text)//' )
c**     call link( unit6=(outfile,create,text)//' )
      read(5 4) ng
      ng1=ng+1
      if(ng ne 70) go to 15
      ehi=1 0d+07
      unow=0 0
      ng=70
      do 25 n=1 ng
      j=72 n
      eb70(j)=ehi*dexp(unow)
      unow=unow 0 25
```

```
   25 continue
      eb70(1)=1 0d 05
      nmat=0
   15 read(5 5 end=20) title
      read(5 2 end=20) e efl efh templ
      nmat=nmat+1
      if(nmat gt 20) go to 20
C     write(nsyso 1) e efl efh templ
C     write(nsyso 6) title
      do 10 i=1 ng
      if(ng ne 70) go to 16
      n=71 i
      ep1=eb70(n)
      ep2=eb70(n+1)
      go to 18
   16 n=ng1 i
      ep1=ebnd(n)
      ep2=ebnd(n+1)
   18 call madnix(g e enext idis ep1 ep2 templ efl efh)
      fns(i nmat)=g
   10 continue
      go to 15
   20 continue
      j1=1
   26 j2=j1+4
      do 30 i=1 ng
      n=71 i
      ep1=eb70(n)
      ep2=eb70(n+1)
      write(nsyso 3) i ep2 (fns(i j) j=j1 j2)
   30 continue
      write(nsyso,3) ng1 ep1
      j1=j1+5
      if(j1 lt 7) go to 26
      stop
    1 format(///3x 1p4e12 4 //)
    2 format(4e12 4)
    3 format(i3 1p6e12 4)
    4 format(i3)
    5 format(15a4)
    6 format(3x 15a4 /)
      end
      subroutine madnix(g e enext idis ep1,ep2 templ,efl efh)
c**** subroutine anased(g,e enext idis,ep1,ep2 a,ip,ir)                   gro
c     ******************************************************             gro
c     analytic secondary energy distributions   compute the integral     gro
```

```
c    between sink energies epl and eph for source energy e  the        gro
c    parameters are in a in packed endf format  laws 5 7, 9            gro
c    11 and 12 only                                                    gro
c    gami is the incomplete gamma function (law 12 only)               gro
c    e1 is the first order exponential integral function (law 12 only) gro
c    *****************************************************             gro
cibm                                                                   gro
     implicit real*8 (a h o z)
c    real*8 rc rh rl,xc,xlo,xhi,rp4 bot,top,xmin                       gro
c    real*8 h r1 r2 r3 r4,de,t1 t2,epl eph theta                       gro
c    real*8 expa expb,expc r,rerfc z                                   gro
c    real*8 a0 a1 a2 a3 a4 a5                                          gro
cibm                                                                   gro
     common/mainio/nsysi nsyso,nshort                                  gro
     data brk/ 01/                                                     gro
ccdc                                                                   gro
     data xmin/1 d 4/ rp4/ 88622693/                                   gro
     data a0 a1 a2 a3 a4 a5/ 3275911 254829592  284496736              gro
    1  1 421413741  1 453152027 1 061405429/                           gro
ccdc                                                                   gro
cibm                                                                   gro
c    data xmin/1 d 4/ rp4/ 88622693d0/                                 gro
c    data a0 a1 a2 a3 a4 a5/ 3275911d0, 254829592d0                    gro
c   1   284496736d0 1 421413741d0  1 453152027d0 1 061405429d0/        gro
cibm                                                                   gro
     r(z)=1 /(1 +a0*z)                                                 gro
     rerfc(z)=r(z)*(a1+r(z)*(a2+r(z)*(a3+r(z)*(a4+a5*r(z)))))          gro
     epl=ep1                                                           gro
     eph=ep2                                                           gro
     new=0                                                             gro
     if (ep1 lt 1 1e 5) new=1                                          gro
c                                                                      gro
c    check limit on integration                                        gro
     enext=1d+10                                                       gro
     idis=0                                                            gro
     g=0                                                               gro
     lf=12
     if (lf eq 12) go to 110                                           gro
     t1=e                                                              gro
     t2=u                                                              gro
     de=t1 t2                                                          gro
     if (epl gt de) return                                             gro
c                                                                      gro
c    ***retrieve theta by interpolation                                gro
 110 continue                                                          gro
     theta=temp1
```

```
c     write(nsyso 1) t1 epl eph theta efl efh
  1  format(3x 1p6e12 4)
     if (new eq 0) go to 115                                    gro
     ip2=2                                                      gro
     ir2=1                                                      gro
     theta=temp1                                                gro
     xc=de/theta                                                gro
     if (en lt enext) idis=idisc                                gro
     if (en lt enext) enext=en                                  gro
 115 continue                                                   gro
     if (lf eq 12) go to 210                                    gro
c                                                               gro
c     ***law 12                                                 gro
 210 ef=efl
     i=0                                                        gro
ccdc                                                            gro
c     alpha=sqrt(theta)                                         gro
c     sa=sqrt(epl)                                              gro
c     sb=sqrt(eph)                                              gro
ccdc                                                            gro
cibm                                                            gro
     alpha=dsqrt(theta)                                         gro
     sa=dsqrt(epl)                                              gro
     sb=dsqrt(eph)                                              gro
cibm                                                            gro
 220 beta=dsqrt(ef)                                             gro
     aa=(sa+beta)*(sa+beta)/theta                               gro
     bb=(sb+beta)*(sb+beta)/theta                               gro
     ab=alpha*beta                                              gro
     fact=1 /(3 *ab)                                            gro
     ap=(sa beta)*(sa beta)/theta                               gro
     bp=(sb beta)*(sb beta)/theta                               gro
     if (epl ge ef and eph gt ef) go to 230                     gro
     if (epl lt ef and eph le ef) go to 240                     gro
     if (epl lt ef and eph gt ef) go to 250                     gro
c     region i                                                  gro
 230 ans=fact*((( 4*theta*bb**2 5  5*ab*bb*bb)*del(bb)          gro
    1    ( 4*theta*aa**2 5  5*ab*aa*aa)*del(aa))                gro
    2  (( 4*theta*bp**2 5+ 5*ab*bp*bp)*del(bp)                  gro
    3    ( 4*theta*ap**2 5+ 5*ab*ap*ap)*del(ap))+               gro
    4  ((theta*bb 2 *ab*sqrt(bb))*dgami(1 5 bb)                 gro
    5    (theta*aa 2 *ab*sqrt(aa))*dgami(1 5 aa))               gro
    6  ((theta*bp+2 *ab*sqrt(bp))*dgami(1 5 bp)                 gro
    7    (theta*ap+2 *ab*sqrt(ap))*dgami(1 5 ap))               gro
    8  ( 6*theta*(dgami(2 5 bb) dgami(2 5 aa) dgami(2 5 bp)    gro
    *  +dgami(2 5 ap)))                                         gro
```

Table E 1 (contınued)

```
     9  (1 5*ab*(exp( bb)*(1 +bb) exp( aa)*(1 +aa)+                      gro
     a    exp( bp)*(1 +bp) exp( ap)*(1 +ap))))                            gro
        go to 270                                                         gro
c       regıon ıı                                                         gro
  240 ans=fact*((( 4*theta*bb**2 5  5*ab*bb*bb)*del(bb)                   gro
     1    ( 4*theta*aa**2 5  5*ab*aa*aa)*del(aa))                         gro
     2  (( 4*theta*bp**2 5  5*ab*bp*bp)*del(bp)                           gro
     3    ( 4*theta*ap**2 5  5*ab*ap*ap)*del(ap))+                        gro
     4  ((theta*bb 2 *ab*sqrt(bb))*dgamı(1 5 bb)                          gro
     5    (theta*aa 2 *ab*sqrt(aa))*dgamı(1 5 aa))                        gro
     6  ((theta*bp 2 *ab*sqrt(bp))*dgamı(1 5 bp)                          gro
     7    (theta*ap 2 *ab*sqrt(ap))*dgamı(1 5 ap))                        gro
     8  ( 6*theta*(dgamı(2 5 bb) dgamı(2 5 aa) dgamı(2 5 bp)              gro
     *  +dgamı(2 5 ap)))                                                  gro
     9  (1 5*ab*(exp( bb)*(1 +bb) exp( aa)*(1 +aa)                        gro
     a    exp( bp)*(1 +bp)+exp( ap)*(1 +ap))))                            gro
        go to 270                                                         gro
c       regıon ııı                                                        gro
  250 ans=fact*((( 4*theta*bb**2 5  5*ab*bb*bb)*del(bb)                   gro
     1    ( 4*theta*aa**2 5  5*ab*aa*aa)*del(aa))                         gro
     2  (( 4*theta*bp**2 5+ 5*ab*bp*bp)*del(bp)                           gro
     3    ( 4*theta*ap**2 5  5*ab*ap*ap)*del(ap))+                        gro
     4  ((theta*bb 2 *ab*sqrt(bb))*dgamı(1 5 bb)                          gro
     5    (theta*aa 2 *ab*sqrt(aa))*dgamı(1 5 aa))                        gro
     6  ((theta*bp+2 *ab*sqrt(bp))*dgamı(1 5 bp)                          gro
     7    (theta*ap 2 *ab*sqrt(ap))*dgamı(1 5 ap))                        gro
     8  ( 6*theta*(dgamı(2 5 bb) dgamı(2 5 aa) dgamı(2 5 bp)              gro
     *  +dgamı(2 5 ap)))                                                  gro
     9  (1 5*ab*(exp( bb)*(1 +bb) exp( aa)*(1 +aa)+exp( bp)*(1 +bp)+      gro
     a    exp( ap)*(1 +ap) 2 )))                                          gro
  270 contınue
c       wrıte(nsyso 1) g ans
        g=g+ans
        ı=ı+1                                                             gro
        ıf (ı eq 2) go to 280                                             gro
        ef=efh
        go to 220                                                         gro
  280 contınue                                                            gro
        g=g*0 5                                                           gro
        return                                                            gro
c                                                                         gro
c       ***error message                                                  gro
  900 wrıte(nsyso 10)                                                     gro
c       ıf (nshort gt 0) wrıte(nshort 10)                                 gro
c**** call error                                                          gro
        return                                                            gro
```

Table E 1 (continued)

```
c                                                          gro
 10 format(/33h ***error in anased***illegal lf )          gro
   end                                                     gro
```

Table E 2 MADNIX.DAT

```
70
   70 GROUP FISSION SPECTRUM FOR Np 237
 5 0000E+05  1 0383E+06  0 5267E+06  0 9240E+06
   70 GROUP FISSION SPECTRUM FOR Pu 238
 5 0000E+05  1 0463E+06  0 5305E+06  1 0250E+06
   70 GROUP FISSION SPECTRUM FOR Am 241
 5 0000E+05  1 0283E+06  0 5459E+06  1 0880E+06
   70 GROUP FISSION SPECTRUM FOR Am 243
 5 0000E+05  1 0024E+06  0 5476E+06  1 0790E+06
   70 GROUP FISSION SPECTRUM FOR Cm 243
 5 0000E+05  1 0250E+06  0 5600E+06  1 0586E+06
   70 GROUP FISSION SPECTRUM FOR Cm 244
 5 0000E+05  1 0129E+06  0 5603E+06  1 0515E+06
   70 GROUP FISSION SPECTRUM FOR Cm 245
 5 0000E+05  0 9972E+06  0 5623E+06  1 0629E+06
   70 GROUP FISSION SPECTRUM FOR Cm 246
 5 0000E+05  0 9830E+06  0 5648E+06  1 0525E+06
   70 GROUP FISSION SPECTRUM FOR Cm 247
 5 0000E+05  0 9766E+06  0 5624E+06  1 0603E+06
   70 GROUP FISSION SPECTRUM FOR Cm 248
 5 0000E+05  0 9702E+06  0 5600E+06  1 0525E+06
```

Table E 3 Prompt neutron spectral data

70 GROUP FISSION NEUTRON SPECTRA

	EHI(EV)	Np 237	Pu 238	Am 241	Am 243	Cm 243
1	1 0000E+07	4 9791E 03	7 5492E 03	9 2804E 03	8 7951E 03	8 4649E 03
2	7 7880E+06	1 6932E 02	2 2488E 02	2 5877E 02	2 4917E 02	2 4362E 02
3	6 0653E+06	3 9889E 02	4 7934E 02	5 2470E 02	5 1160E 02	5 0572E 02
4	4 7237E+06	7 0571E 02	7 8671E 02	8 2944E 02	8 1670E 02	8 1329E 02
5	3 6788E+06	9 9833E 02	1 0526E 01	1 0791E 01	1 0707E 01	1 0712E 01
6	2 8650E+06	1 1857E 01	1 2000E 01	1 2052E 01	1 2030E 01	1 2066E 01
7	2 2313E+06	1 2282E 01	1 2070E 01	1 1941E 01	1 1976E 01	1 2023E 01
8	1 7377E+06	1 1438E 01	1 1012E 01	1 0778E 01	1 0848E 01	1 0890E 01
9	1 3534E+06	9 8290E 02	9 3341E 02	9 0644E 02	9 1450E 02	9 1752E 02
10	1 0540E+06	7 9939E 02	7 5231E 02	7 2619E 02	7 3340E 02	7 3561E 02
11	8 2085E+05	6 2464E 02	5 8436E 02	5 6195E 02	5 6817E 02	5 6946E 02
12	6 3928E+05	4 7261E 02	4 4064E 02	4 2301E 02	4 2820E 02	4 2888E 02
13	4 9787E+05	3 5074E 02	3 2634E 02	3 1302E 02	3 1717E 02	3 1751E 02
14	3 8774E+05	2 5640E 02	2 3822E 02	2 2828E 02	2 3145E 02	2 3152E 02
15	3 0197E+05	1 8481E 02	1 7158E 02	1 6428E 02	1 6664E 02	1 6656E 02
16	2 3518E+05	1 3171E 02	1 2224E 02	1 1698E 02	1 1870E 02	1 1855E 02
17	1 8316E+05	9 3058E 03	8 6366E 03	8 2615E 03	8 3845E 03	8 3687E 03
18	1 4264E+05	6 5320E 03	6 0627E 03	5 7979E 03	5 8851E 03	5 8709E 03
19	1 1109E+05	4 5623E 03	4 2351E 03	4 0494E 03	4 1107E 03	4 0991E 03
20	8 6517E+04	3 1746E 03	2 9474E 03	2 8178E 03	2 8607E 03	2 8517E 03
21	6 7379E+04	2 2027E 03	2 0454E 03	1 9553E 03	1 9852E 03	1 9783E 03
22	5 2475E+04	1 5250E 03	1 4163E 03	1 3538E 03	1 3746E 03	1 3696E 03
23	4 0868E+04	1 0541E 03	9 7905E 04	9 3581E 04	9 5021E 04	9 4657E 04
24	3 1828E+04	7 2765E 04	6 7591E 04	6 4604E 04	6 5600E 04	6 5340E 04
25	2 4788E+04	5 0181E 04	4 6617E 04	4 4555E 04	4 5243E 04	4 5059E 04
26	1 9305E+04	3 4579E 04	3 2126E 04	3 0705E 04	3 1179E 04	3 1049E 04
27	1 5034E+04	2 3815E 04	2 2126E 04	2 1147E 04	2 1474E 04	2 1383E 04
28	1 1709E+04	1 6394E 04	1 5232E 04	1 4558E 04	1 4783E 04	1 4720E 04
29	9 1188E+03	1 1281E 04	1 0482E 04	1 0018E 04	1 0173E 04	1 0129E 04
30	7 1017E+03	7 7608E 05	7 2112E 05	6 8920E 05	6 9987E 05	6 9683E 05
31	5 5308E+03	5 3379E 05	4 9600E 05	4 7404E 05	4 8138E 05	4 7928E 05
32	4 3074E+03	3 6708E 05	3 4110E 05	3 2600E 05	3 3105E 05	3 2960E 05
33	3 3546E+03	2 5241E 05	2 3454E 05	2 2416E 05	2 2763E 05	2 2663E 05
34	2 6126E+03	1 7354E 05	1 6126E 05	1 5412E 05	1 5650E 05	1 5581E 05
35	2 0347E+03	1 1930E 05	1 1086E 05	1 0595E 05	1 0759E 05	1 0712E 05
36	1 5846E+03	8 2013E 06	7 6211E 06	7 2836E 06	7 3965E 06	7 3637E 06
37	1 2341E+03	5 6376E 06	5 2388E 06	5 0068E 06	5 0844E 06	5 0619E 06
38	9 6112E+02	3 8752E 06	3 6010E 06	3 4416E 06	3 4949E 06	3 4794E 06
39	7 4852E+02	2 6636E 06	2 4752E 06	2 3656E 06	2 4023E 06	2 3916E 06
40	5 8295E+02	1 8308E 06	1 7013E 06	1 6260E 06	1 6512E 06	1 6439E 06
41	4 5400E+02	1 2584E 06	1 1694E 06	1 1176E 06	1 1349E 06	1 1299E 06
42	3 5358E+02	8 6492E 07	8 0374E 07	7 6815E 07	7 8006E 07	7 7659E 07

Table E 3 (continued)

70 GROUP FISSION NEUTRON SPECTRA

	EHI(EV)	Np 237	Pu 238	Am 241	Am 243	Cm 243
43	2 7536E+02	5 9447E 07	5 5243E 07	5 2796E 07	5 3615E 07	5 3376E 07
44	2 1445E+02	4 0859E 07	3 7969E 07	3 6287E 07	3 6850E 07	3 6686E 07
45	1 6702E+02	2 8082E 07	2 6096E 07	2 4941E 07	2 5327E 07	2 5215E 07
46	1 3007E+02	1 9301E 07	1 7936E 07	1 7142E 07	1 7408E 07	1 7330E 07
47	1 0130E+02	1 3266E 07	1 2328E 07	1 1782E 07	1 1964E 07	1 1911E 07
48	7 8893E+01	9 1175E 08	8 4728E 08	8 0976E 08	8 2232E 08	8 1866E 08
49	6 1442E+01	6 2665E 08	5 8234E 08	5 5655E 08	5 6518E 08	5 6267E 08
50	4 7851E+01	4 3070E 08	4 0024E 08	3 8252E 08	3 8846E 08	3 8673E 08
51	3 7267E+01	2 9602E 08	2 7509E 08	2 6291E 08	2 6699E 08	2 6580E 08
52	2 9023E+01	2 0345E 08	1 8907E 08	1 8070E 08	1 8351E 08	1 8269E 08
53	2 2603E+01	1 3984E 08	1 2995E 08	1 2420E 08	1 2613E 08	1 2556E 08
54	1 7603E+01	9 6110E 09	8 9319E 09	8 5367E 09	8 6691E 09	8 6303E 09
55	1 3710E+01	6 6058E 09	6 1391E 09	5 8676E 09	5 9586E 09	5 9319E 09
56	1 0677E+01	4 5403E 09	4 2197E 09	4 0331E 09	4 0956E 09	4 0773E 09
57	8 3153E+00	3 1207E 09	2 9004E 09	2 7722E 09	2 8152E 09	2 8026E 09
58	6 4760E+00	2 1450E 09	1 9936E 09	1 9056E 09	1 9352E 09	1 9264E 09
59	5 0435E+00	1 4744E 09	1 3704E 09	1 3099E 09	1 3303E 09	1 3243E 09
60	3 9279E+00	1 0134E 09	9 4206E 10	9 0052E 10	9 1450E 10	9 1035E 10
61	3 0590E+00	6 9664E 10	6 4763E 10	6 1911E 10	6 2872E 10	6 2585E 10
62	2 3824E+00	4 7889E 10	4 4525E 10	4 2567E 10	4 3229E 10	4 3030E 10
63	1 8554E+00	3 2923E 10	3 0614E 10	2 9271E 10	2 9726E 10	2 9588E 10
64	1 4450E+00	2 2635E 10	2 1052E 10	2 0131E 10	2 0444E 10	2 0348E 10
65	1 1254E+00	1 5564E 10	1 4478E 10	1 3847E 10	1 4063E 10	1 3995E 10
66	8 7642E 01	1 0703E 10	9 9594E 11	9 5271E 11	9 6757E 11	9 6284E 11
67	6 8256E 01	7 3611E 11	6 8526E 11	6 5568E 11	6 6592E 11	6 6259E 11
68	5 3158E 01	5 0639E 11	4 7164E 11	4 5143E 11	4 5850E 11	4 5613E 11
69	4 1399E 01	3 4845E 11	3 2474E 11	3 1096E 11	3 1584E 11	3 1415E 11
70	3 2242E 01	7 7564E 11	7 2781E 11	7 0007E 11	7 1137E 11	7 0605E 11
71	1 0000E 05					

Table E 3 (continued)

	70 GROUP FISSION NEUTRON SPECTRA					
	EHI(EV)	Cm 244	Cm 245	Cm 246	Cm 247	Cm 248
1	1 0000E+07	8 1617E 03	8 3667E 03	7 9688E 03	8 1229E 03	7 8402E 03
2	7 7880E+06	2 3750E 02	2 4130E 02	2 3332E 02	2 3617E 02	2 3039E 02
3	6 0653E+06	4 9726E 02	5 0197E 02	4 9103E 02	4 9452E 02	4 8642E 02
4	4 7237E+06	8 0500E 02	8 0891E 02	7 9835E 02	8 0115E 02	7 9306E 02
5	3 6788E+06	1 0657E 01	1 0675E 01	1 0608E 01	1 0619E 01	1 0564E 01
6	2 8650E+06	1 2052E 01	1 2048E 01	1 2033E 01	1 2026E 01	1 2010E 01
7	2 2313E+06	1 2046E 01	1 2026E 01	1 2058E 01	1 2040E 01	1 2059E 01
8	1 7377E+06	1 0935E 01	1 0909E 01	1 0969E 01	1 0947E 01	1 0989E 01
9	1 3534E+06	9 2272E 02	9 2009E 02	9 2680E 02	9 2484E 02	9 2983E 02
10	1 0540E+06	7 4034E 02	7 3774E 02	7 4376E 02	7 4207E 02	7 4682E 02
11	8 2085E+05	5 7354E 02	5 7141E 02	5 7651E 02	5 7519E 02	5 7932E 02
12	6 3928E+05	4 3223E 02	4 3073E 02	4 3491E 02	4 3396E 02	4 3732E 02
13	4 9787E+05	3 2016E 02	3 1913E 02	3 2243E 02	3 2176E 02	3 2438E 02
14	3 8774E+05	2 3353E 02	2 3282E 02	2 3531E 02	2 3487E 02	2 3686E 02
15	3 0197E+05	1 6804E 02	1 6756E 02	1 6939E 02	1 6910E 02	1 7058E 02
16	2 3518E+05	1 1963E 02	1 1929E 02	1 2061E 02	1 2043E 02	1 2151E 02
17	1 8316E+05	8 4458E 03	8 4233E 03	8 5171E 03	8 5053E 03	8 5830E 03
18	1 4264E+05	5 9255E 03	5 9103E 03	5 9763E 03	5 9688E 03	6 0240E 03
19	1 1109E+05	4 1374E 03	4 1271E 03	4 1734E 03	4 1686E 03	4 2075E 03
20	8 6517E+04	2 8784E 03	2 8715E 03	2 9036E 03	2 9006E 03	2 9278E 03
21	6 7379E+04	1 9970E 03	1 9922E 03	2 0146E 03	2 0126E 03	2 0316E 03
22	5 2475E+04	1 3825E 03	1 3793E 03	1 3947E 03	1 3934E 03	1 4066E 03
23	4 0868E+04	9 5552E 04	9 5332E 04	9 6402E 04	9 6316E 04	9 7232E 04
24	3 1828E+04	6 5958E 04	6 5808E 04	6 6547E 04	6 6490E 04	6 7123E 04
25	2 4788E+04	4 5486E 04	4 5383E 04	4 5892E 04	4 5855E 04	4 6292E 04
26	1 9305E+04	3 1344E 04	3 1274E 04	3 1625E 04	3 1599E 04	3 1901E 04
27	1 5034E+04	2 1586E 04	2 1538E 04	2 1780E 04	2 1763E 04	2 1971E 04
28	1 1709E+04	1 4859E 04	1 4827E 04	1 4993E 04	1 4981E 04	1 5125E 04
29	9 1188E+03	1 0225E 04	1 0203E 04	1 0317E 04	1 0309E 04	1 0408E 04
30	7 1017E+03	7 0345E 05	7 0190E 05	7 0978E 05	7 0924E 05	7 1603E 05
31	5 5308E+03	4 8383E 05	4 8277E 05	4 8819E 05	4 8782E 05	4 9250E 05
32	4 3074E+03	3 3273E 05	3 3200E 05	3 3572E 05	3 3547E 05	3 3869E 05
33	3 3546E+03	2 2878E 05	2 2828E 05	2 3084E 05	2 3067E 05	2 3288E 05
34	2 6126E+03	1 5729E 05	1 5695E 05	1 5871E 05	1 5859E 05	1 6012E 05
35	2 0347E+03	1 0814E 05	1 0790E 05	1 0911E 05	1 0903E 05	1 1008E 05
36	1 5846E+03	7 4337E 06	7 4175E 06	7 5007E 06	7 4952E 06	7 5671E 06
37	1 2341E+03	5 1100E 06	5 0988E 06	5 1560E 06	5 1522E 06	5 2017E 06
38	9 6112E+02	3 5125E 06	3 5048E 06	3 5441E 06	3 5415E 06	3 5755E 06
39	7 4852E+02	2 4143E 06	2 4091E 06	2 4361E 06	2 4343E 06	2 4577E 06
40	5 8295E+02	1 6595E 06	1 6559E 06	1 6744E 06	1 6732E 06	1 6893E 06
41	4 5400E+02	1 1406E 06	1 1381E 06	1 1509E 06	1 1501E 06	1 1611E 06

Table E 3 (continued)

70 GROUP FISSION NEUTRON SPECTRA

	EHI(EV)	Cm 244	Cm 245	Cm 246	Cm 247	Cm 248
42	3 5358E+02	7 8397E 07	7 8226E 07	7 9104E 07	7 9046E 07	7 9804E 07
43	2 7536E+02	5 3884E 07	5 3766E 07	5 4369E 07	5 4330E 07	5 4851E 07
44	2 1445E+02	3 7035E 07	3 6954E 07	3 7369E 07	3 7342E 07	3 7700E 07
45	1 6702E+02	2 5454E 07	2 5399E 07	2 5684E 07	2 5665E 07	2 5911E 07
46	1 3007E+02	1 7495E 07	1 7457E 07	1 7653E 07	1 7640E 07	1 7809E 07
47	1 0130E+02	1 2024E 07	1 1998E 07	1 2133E 07	1 2124E 07	1 2240E 07
48	7 8893E+01	8 2644E 08	8 2464E 08	8 3389E 08	8 3328E 08	8 4128E 08
49	6 1442E+01	5 6801E 08	5 6678E 08	5 7314E 08	5 7272E 08	5 7822E 08
50	4 7851E+01	3 9040E 08	3 8955E 08	3 9392E 08	3 9364E 08	3 9741E 08
51	3 7267E+01	2 6833E 08	2 6774E 08	2 7075E 08	2 7055E 08	2 7315E 08
52	2 9023E+01	1 8442E 08	1 8402E 08	1 8609E 08	1 8595E 08	1 8774E 08
53	2 2603E+01	1 2676E 08	1 2648E 08	1 2790E 08	1 2781E 08	1 2904E 08
54	1 7603E+01	8 7124E 09	8 6935E 09	8 7910E 09	8 7847E 09	8 8689E 09
55	1 3710E+01	5 9883E 09	5 9754E 09	6 0424E 09	6 0380E 09	6 0960E 09
56	1 0677E+01	4 1160E 09	4 1072E 09	4 1532E 09	4 1503E 09	4 1901E 09
57	8 3153E+00	2 8292E 09	2 8231E 09	2 8548E 09	2 8528E 09	2 8801E 09
58	6 4760E+00	1 9447E 09	1 9406E 09	1 9623E 09	1 9610E 09	1 9798E 09
59	5 0435E+00	1 3368E 09	1 3340E 09	1 3489E 09	1 3480E 09	1 3609E 09
60	3 9279E+00	9 1900E 10	9 1705E 10	9 2733E 10	9 2669E 10	9 3557E 10
61	3 0590E+00	6 3180E 10	6 3047E 10	6 3754E 10	6 3710E 10	6 4321E 10
62	2 3824E+00	4 3439E 10	4 3348E 10	4 3834E 10	4 3805E 10	4 4224E 10
63	1 8554E+00	2 9869E 10	2 9808E 10	3 0142E 10	3 0122E 10	3 0410E 10
64	1 4450E+00	2 0541E 10	2 0500E 10	2 0729E 10	2 0716E 10	2 0914E 10
65	1 1254E+00	1 4128E 10	1 4101E 10	1 4259E 10	1 4250E 10	1 4386E 10
66	8 7642E 01	9 7200E 11	9 7014E 11	9 8100E 11	9 8043E 11	9 8980E 11
67	6 8256E 01	6 6889E 11	6 6766E 11	6 7514E 11	6 7477E 11	6 8121E 11
68	5 3158E 01	4 6047E 11	4 5967E 11	4 6481E 11	4 6459E 11	4 6901E 11
69	4 1399E 01	3 1714E 11	3 1663E 11	3 2016E 11	3 2003E 11	3 2307E 11
70	3 2242E 01	7 1280E 11	7 1256E 11	7 2044E 11	7 2066E 11	7 2736E 11
71	1 0000E 05					

APPENDIX F

PROMPT NEUTRON YIELD DATA

APPENDIX F PROMPT NEUTRON YIELD DATA

In this Appendix FORTRAN and data files used in the calculation of the energy dependent prompt neutron yield are given The FISSER FOR code was used to preprocess some of the parameters needed in the prompt neutron calculations as described in Sect 4 2 2 Table F 1 contains a listing of both the FORTRAN source and a sample input file The FISSER input data correspond to ^{244}Cm neutron fission The output quantities are 210 43 MeV and 5 44 MeV corresponding to $<E_r>$ and $S_n>$ respectively, as shown in Table 14 Details of the $<S_n>$ calculation for ^{244}Cm (n f) are given in Sect 4 2 2 Table 13 We briefly describe the program NUBAR FOR used to calculate the prompt neutron yield in Table F 2 Listings of the program (Table F 3) the input file NUBAR DAT (Table F 4) and the output file NUBAR OUT (Table F 5) are also given

Table F 1 Listing and input data for FISSER FOR

```
      IMPLICIT REAL*8 (A H O Z)
      DIMENSION AL(7) AH(7) CN(4)
      DIMENSION S2L(7),S2H(7)
      FC=1 0/931 50
      DN=16 142
   15 CONTINUE
      DO 25 N=1 7
C***  READ ML(Z A) DML(Z A) MH(Z A) DMH(Z A) DML(Z A 2) DMH(Z A 2)
C***  DML AND DMH ARE THE MASS DEFECTS REATIVE TO  A
C***  GO TO STATEMENT 20  IF NO MORE DATA, RUN FINISHED
      READ(1,2 END=20) ML DML MH DMH D1 D2
C***  CALCULATE MASSES IN ATOMIC MASS UNITS FOR THE LIGHT AND
C***  AND HEAVY FRAGMENTS
      AL(N)=FC*DML+DFLOAT(ML)
      AH(N)=FC*DMH+DFLOAT(MH)
C***  CALCULATE THE TWO NEUTRON SEPARATION ENERGIES FOR THE
C***  LIGHT AND HEAVY FRAGEMENTS
      S2L(N)= DML+D1+DN
      S2H(N)= DMH+D2+DN
C***  WRITE OUT THE MASSES IN AMU FOR THE LIGHT AND HEAVY FRAG
      WRITE(6,1) AL(N),AH(N)
   25 CONTINUE
C***  READ MCN AND DCM FOR THE COMPOUND NUCLEUS
      READ(1 2 END=20) MCN DCM
C***  CALCULATE THE MASS OF THE COUPOUND NUCLEUS
      CN(1)=FC*DCM+DFLOAT(MCN)
      K=1
C*** WRITE OUT THE MASS OF THE COMPOUND NUCLEUS
      WRITE(6 1) CN(K)
      ERSUM=0 0
C***  CALCULATE ER AVE
      DO 10 N=1 7
      SUM=AH(N)+AL(N)
      DIFF=CN(K) SUM
      ER=931 50*DIFF
```

Table F 1 (contınued)

```
      WRITE(2 3) N,AL(N) AH(N) SUM,DIFF ER
C***  THE CENTRAL FRAGMENTS RECEIVE A DOUBLE WEIGHT
      IF(N EQ 4) ERSUM=ERSUM+ER
      ERSUM=ERSUM+ER
   10 CONTINUE
C***  ER AVE = ERSUM/8 0
      ERAVE=ERSUM/8 0
C***  WRITE OUT ER AVE
      WRITE(2 4) ERAVE
      SUM1=0 0
      SUM2=0 0
C***  CALCULATE THE TWO NEUTRON SEPARATION ENERGIES
      DO 30 N=1 7
C***  CENTRAL FRAGMENTS RECEIVE A DOUBLE WEIGHT
      IF(N EQ 4) SUM1=SUM1+S2L(N)
      IF(N EQ 4) SUM2=SUM2+S2H(N)
      SUM1=SUM1+S2L(N)
      SUM2=SUM2+S2H(N)
      WRITE(2 3) N S2L(N) S2H(N)
   30 CONTINUE
C***  CALCULATE THE AVE  TWO NEUTRON SEPARATION ENERGIES
      SUM1=SUM1/8 0
      SUM2=SUM2/8 0
C***  SN IS THE AVERAGE FISSION FRAG  NEUTRON SEPARATION ENERGY
      SN=0 25*(SUM1+SUM2)
      WRITE(2 5) SUM1 SUM2
      WRITE(2 6) SN
C***  GO TO STATEMENT 15 TO READ INPUT FOR NEXT CASE
      GO TO 15
   20 STOP
    1 FORMAT(2X 4F14 7)
    2 FORMAT(2(5X I3 F12 3) 2F10 3)
    3 FORMAT(I4 3F12 5 F10 5 F10 3)
    4 FORMAT(// 5X  ER AVE =  F9 3)
    5 FORMAT(// 5X  S2NL =  F7 3 3X  S2NH =  F7 3)
    6 FORMAT(// 5X  SN  =  F7 3)
      END
```

Nb 102	76 350	Cs 143	67 745	79 929	74 472
Nb 103	75 240	Cs 142	70 538	78 950	77 053
Mo 104	80 370	Xe 141	68 320	83 559	75 690
Mo 105	77 360	Xe 140	72 990	80 760	80 110
Mo 106	76 270	Xe 139	75 690	80 370	82 383
Tc 107	79 160	I 138	72 290	82 350	79 550
Tc 108	76 280	I 137	76 507	79 790	83 821
Cm 245	60 998				

Table F 2 Documentation for NUBAR FOR

1	Read ER BN EFTOT EGTOT SN and ZA
2	Compute AC NZ = ZA/1000 0 AC = ZA 1000 0*FLOAT(NZ)
3	Compute a eff
4	Compute ESTAR, TM AND EPS
5	Compute NUBAR(E)
6	Linear fit is done using NUBAR(E) at 0 5 and 6 0 Mev

Table F 3 Listing of NUBAR FOR

```
      DIMENSION EN(13) XNU(13) FNU(13)
      CHARACTER*4 TITLE(18)
      DATA EN /0 0 0 5,1 0 1 5,2 0 2 5,3 0 3 5,4 0 4 5,5 0 5 5 6 0/
    1 CONTINUE
      READ(1 15 END=30) TITLE
      READ(1 10 END=30) ER BN EFTOT EGTOT SN ZA
      NZ=ZA/1000 0
      AC=ZA 1000 0*FLOAT(NZ)
      C=AC/9 40
      IF(NZ EQ 93) C=AC/8 5
      IF(NZ EQ 96) C=AC/8 5
      NP=13
      DO 20 N=1,NP
      ESTAR=ER+BN+EN(N) EFTOT
      TM=SQRT(ESTAR/C)
      EPS=4 0*TM/3 0
      T1=ESTAR EGTOT
      XNU(N)=T1/(SN+EPS)
   20 CONTINUE
      WRITE(2 16) TITLE
      WRITE(2 17) ER BN EFTOT EGTOT SN AC
      WRITE(2 13)
      WRITE(2 11) (EN(N) XNU(N) N=1 NP)
      A=(XNU(13) XNU(2))/5 5
      B=XNU(2) 0 5*A
      DO 25 N=1 NP
      FNU(N)=A*EN(N)+B
   25 CONTINUE
      WRITE(2 12) A,B
      WRITE(2 11) (EN(N) FNU(N) N=1 NP)
      GO TO 1
   30 STOP
   10 FORMAT(6F10 5)
   11 FORMAT(1P6E12 5)
   12 FORMAT(//10X, LINEAR FIT A =  1PE12 5 5X B =  E12 5 //)
   13 FORMAT(/1H )
   15 FORMAT(18A4)
   16 FORMAT(// 18A4)
   17 FORMAT(6F10 4)
      END
```

Table F 4 Listing of NUBAR DAT

```
                  PROMPT NUBAR  URANIUM 235
186 980  6 546   171 8    6 71    4 998   92236 0
                  PROMPT NUBAR  URANIUM 238
186 436  4 806   170 07   6 782   4 915   92239 0
                  PROMPT NUBAR  NEPTUNIUM 237
193 937  5 488   175 60   6 754   5 215   93238 0
                  PROMPT NUBAR  PLUTONIUM 238
198 64   5 647   178 06   6 782   5 274   94239 0
                  PROMPT NUBAR  PLUTONIUM 239
198 154  6 534   177 1    6 77    5 220   94240 0
                  PROMPT NUBAR  PLUTONIUM 240
199 179  5 241   177 53   6 838   5 241   94241 0
                  PROMPT NUBAR  AMERICIUM 241
204 97   6 309   181 31   6 866   5 414   95242 0
                  PROMPT NUBAR  AMERICIUM 243
205 14   5 363   180 78   6 922   5 295   95244 0
                  PROMPT NUBAR  CURIUM 242(SF)
209 24   0 0     184 80   6 866   5 640   96242 0
                  PROMPT NUBAR  CURIUM 243
209 72   6 799   184 85   6 922   5 524   96244 0
                  PROMPT NUBAR  CURIUM 244(SF)
209 72   0 0     184 35   6 922   5 524   96244 0
                  PROMPT NUBAR  CURIUM 244
210 43   5 520   184 58   6 950   5 440   96245 0
                  PROMPT NUBAR  CURIUM 245
209 94   6 457   184 20   6 978   5 330   96246 0
                  PROMPT NUBAR  CURIUM 246(SF)
209 94   0 0     183 60   6 978   5 330   96246 0
                  PROMPT NUBAR  CURIUM 246
210 58   5 158   184 05   7 006   5 221   96247 0
                  PROMPT NUBAR  CURIUM 247
209 88   6 212   183 79   7 034   5 111   96248 0
                  PROMPT NUBAR  CURIUM 248(SF)
209 88   0 0     182 90   7 034   5 111   96248 0
                  PROMPT NUBAR  CURIUM 248
210 77   4 713   183 53   7 062   5 061   96249 0
```

Table F 5 Listing of NUBAR OUT

```
          PROMPT NUBAR  URANIUM 235
   186 9800    6 5460  171 8000    6 7100    4 9980  236 0000

0 00000E+00 2 40705E+00 5 00000E-01 2 48156E+00 1 00000E+00 2 55579E+00
1 50000E+00 2 62976E+00 2 00000E+00 2 70346E+00 2 50000E+00 2 77690E+00
3 00000E+00 2 85009E+00 3 50000E+00 2 92304E+00 4 00000E+00 2 99574E+00
4 50000E+00 3 06820E+00 5 00000E+00 3 14042E+00 5 50000E+00 3 21241E+00
6 00000E+00 3 28418E+00


       LINEAR FIT  A =  1 45930E 01     B =  2 40859E+00

0 00000E+00 2 40859E+00 5 00000E-01 2 48156E+00 1 00000E+00 2 55452E+00
1 50000E+00 2 62749E+00 2 00000E+00 2 70046E+00 2 50000E+00 2 77342E+00
3 00000E+00 2 84639E+00 3 50000E+00 2 91935E+00 4 00000E+00 2 99232E+00
4 50000E+00 3 06528E+00 5 00000E+00 3 13825E+00 5 50000E+00 3 21121E+00
6 00000E+00 3 28418E+00


          PROMPT NUBAR  URANIUM 238
   186 4360    4 8060  170 0700    6 7820    4 9150  239 0000

0 00000E+00 2 34682E+00 5 00000E-01 2 42272E+00 1 00000E+00 2 49833E+00
1 50000E+00 2 57367E+00 2 00000E+00 2 64873E+00 2 50000E+00 2 72352E+00
3 00000E+00 2 79805E+00 3 50000E+00 2 87231E+00 4 00000E+00 2 94633E+00
4 50000E+00 3 02009E+00 5 00000E+00 3 09361E+00 5 50000E+00 3 16688E+00
6 00000E+00 3 23992E+00


       LINEAR FIT  A =  1 48582E 01     B =  2 34843E+00

0 00000E+00 2 34843E+00 5 00000E-01 2 42272E+00 1 00000E+00 2 49701E+00
1 50000E+00 2 57130E+00 2 00000E+00 2 64559E+00 2 50000E+00 2 71988E+00
3 00000E+00 2 79417E+00 3 50000E+00 2 86846E+00 4 00000E+00 2 94276E+00
4 50000E+00 3 01705E+00 5 00000E+00 3 09134E+00 5 50000E+00 3 16563E+00
6 00000E+00 3 23992E+00
```

PROMPT NUBAR NEPTUNIUM 237

193 9370 5 4880 175 6000 6 7540 5 2150 238 0000

0 00000E+00 2 64875E+00 5 00000E−01 2 72091E+00 1 00000E+00 2 79284E+00
1 50000E+00 2 86455E+00 2 00000E+00 2 93603E+00 2 50000E+00 3 00730E+00
3 00000E+00 3 07835E+00 3 50000E+00 3 14919E+00 4 00000E+00 3 21982E+00
4 50000E+00 3 29024E+00 5 00000E+00 3 36047E+00 5 50000E+00 3 43049E+00
6 00000E+00 3 50033E+00

LINEAR FIT A = 1 41711E 01 B = 2 65006E+00

0 00000E+00 2 65006E+00 5 00000E−01 2 72091E+00 1 00000E+00 2 79177E+00
1 50000E+00 2 86262E+00 2 00000E+00 2 93348E+00 2 50000E+00 3 00434E+00
3 00000E+00 3 07519E+00 3 50000E+00 3 14605E+00 4 00000E+00 3 21690E+00
4 50000E+00 3 28776E+00 5 00000E+00 3 35861E+00 5 50000E+00 3 42947E+00
6 00000E+00 3 50033E+00

PROMPT NUBAR PLUTONIUM 238

198 6400 5 6470 178 0600 6 7820 5 2740 239 0000

0 00000E+00 2 93368E+00 5 00000E−01 3 00330E+00 1 00000E+00 3 07270E+00
1 50000E+00 3 14189E+00 2 00000E+00 3 21087E+00 2 50000E+00 3 27965E+00
3 00000E+00 3 34823E+00 3 50000E+00 3 41661E+00 4 00000E+00 3 48480E+00
4 50000E+00 3 55280E+00 5 00000E+00 3 62060E+00 5 50000E+00 3 68822E+00
6 00000E+00 3 75566E+00

LINEAR FIT A = 1 36792E 01 B = 2 93490E+00

0 00000E+00 2 93490E+00 5 00000E−01 3 00330E+00 1 00000E+00 3 07169E+00
1 50000E+00 3 14009E+00 2 00000E+00 3 20849E+00 2 50000E+00 3 27688E+00
3 00000E+00 3 34528E+00 3 50000E+00 3 41368E+00 4 00000E+00 3 48207E+00
4 50000E+00 3 55047E+00 5 00000E+00 3 61886E+00 5 50000E+00 3 68726E+00
6 00000E+00 3 75566E+00

PROMPT NUBAR PLUTONIUM 239

198 1540 6 5340 177 1000 6 7700 5 2200 240 0000

0 00000E+00	3 15139E+00	5 00000E−01	3 22098E+00	1 00000E+00	3 29036E+00
1 50000E+00	3 35955E+00	2 00000E+00	3 42852E+00	2 50000E+00	3 49731E+00
3 00000E+00	3 56589E+00	3 50000E+00	3 63429E+00	4 00000E+00	3 70249E+00
4 50000E+00	3 77051E+00	5 00000E+00	3 83834E+00	5 50000E+00	3 90599E+00
6 00000E+00	3 97346E+00				

LINEAR FIT A = 1 36814E 01 B = 3 15257E+00

0 00000E+00	3 15257E+00	5 00000E−01	3 22098E+00	1 00000E+00	3 28939E+00
1 50000E+00	3 35779E+00	2 00000E+00	3 42620E+00	2 50000E+00	3 49461E+00
3 00000E+00	3 56301E+00	3 50000E+00	3 63142E+00	4 00000E+00	3 69983E+00
4 50000E+00	3 76823E+00	5 00000E+00	3 83664E+00	5 50000E+00	3 90505E+00
6 00000E+00	3 97346E+00				

PROMPT NUBAR PLUTONIUM 240

199 1790 5 2410 177 5300 6 8380 5 2410 241 0000

0 00000E+00	3 03520E+00	5 00000E−01	3 10494E+00	1 00000E+00	3 17447E+00
1 50000E+00	3 24380E+00	2 00000E+00	3 31292E+00	2 50000E+00	3 38184E+00
3 00000E+00	3 45056E+00	3 50000E+00	3 51909E+00	4 00000E+00	3 58742E+00
4 50000E+00	3 65557E+00	5 00000E+00	3 72352E+00	5 50000E+00	3 79130E+00
6 00000E+00	3 85889E+00				

LINEAR FIT A = 1 37081E 01 B = 3 03640E+00

0 00000E+00	3 03640E+00	5 00000E−01	3 10494E+00	1 00000E+00	3 17348E+00
1 50000E+00	3 24202E+00	2 00000E+00	3 31056E+00	2 50000E+00	3 37910E+00
3 00000E+00	3 44764E+00	3 50000E+00	3 51618E+00	4 00000E+00	3 58472E+00
4 50000E+00	3 65326E+00	5 00000E+00	3 72180E+00	5 50000E+00	3 79035E+00
6 00000E+00	3 85889E+00				

PROMPT NUBAR AMERICIUM 241
204 9700 6 3090 181 3100 6 8660 5 4140 242 0000

0 00000E+00 3 37144E+00 5 00000E−01 3 43841E+00 1 00000E+00 3 50519E+00
1 50000E+00 3 57180E+00 2 00000E+00 3 63822E+00 2 50000E+00 3 70448E+00
3 00000E+00 3 77056E+00 3 50000E+00 3 83646E+00 4 00000E+00 3 90220E+00
4 50000E+00 3 96777E+00 5 00000E+00 4 03318E+00 5 50000E+00 4 09843E+00
6 00000E+00 4 16351E+00

LINEAR FIT A = 1 31838E 01 B = 3 37249E+00

0 00000E+00 3 37249E+00 5 00000E−01 3 43841E+00 1 00000E+00 3 50432E+00
1 50000E+00 3 57024E+00 2 00000E+00 3 63616E+00 2 50000E+00 3 70208E+00
3 00000E+00 3 76800E+00 3 50000E+00 3 83392E+00 4 00000E+00 3 89984E+00
4 50000E+00 3 96576E+00 5 00000E+00 4 03168E+00 5 50000E+00 4 09760E+00
6 00000E+00 4 16351E+00

PROMPT NUBAR AMERICIUM 243
205 1400 5 3630 180 7800 6 9220 5 2950 244 0000

0 00000E+00 3 39211E+00 5 00000E−01 3 46035E+00 1 00000E+00 3 52839E+00
1 50000E+00 3 59624E+00 2 00000E+00 3 66391E+00 2 50000E+00 3 73140E+00
3 00000E+00 3 79871E+00 3 50000E+00 3 86584E+00 4 00000E+00 3 93280E+00
4 50000E+00 3 99958E+00 5 00000E+00 4 06619E+00 5 50000E+00 4 13263E+00
6 00000E+00 4 19891E+00

LINEAR FIT A = 1 34284E 01 B = 3 39320E+00

0 00000E+00 3 39320E+00 5 00000E−01 3 46035E+00 1 00000E+00 3 52749E+00
1 50000E+00 3 59463E+00 2 00000E+00 3 66177E+00 2 50000E+00 3 72891E+00
3 00000E+00 3 79606E+00 3 50000E+00 3 86320E+00 4 00000E+00 3 93034E+00
4 50000E+00 3 99748E+00 5 00000E+00 4 06463E+00 5 50000E+00 4 13177E+00
6 00000E+00 4 19891E+00

PROMPT NUBAR CURIUM 243
209 7200 6 7990 184 8500 6 9220 5 5240 244 0000

0 00000E+00 3 57385E+00 5 00000E−01 3 64027E+00 1 00000E+00 3 70652E+00
1 50000E+00 3 77261E+00 2 00000E+00 3 83854E+00 2 50000E+00 3 90432E+00
3 00000E+00 3 96993E+00 3 50000E+00 4 03539E+00 4 00000E+00 4 10069E+00
4 50000E+00 4 16585E+00 5 00000E+00 4 23086E+00 5 50000E+00 4 29571E+00
6 00000E+00 4 36043E+00

Table F 5 (contınued)

LINEAR FIT A = 1 30937E 01 B = 3 57480E+00

0 00000E+00	3 57480E+00	5 00000E−01	3 64027E+00	1 00000E+00	3 70574E+00
1 50000E+00	3 77121E+00	2 00000E+00	3 83668E+00	2 50000E+00	3 90215E+00
3 00000E+00	3 96761E+00	3 50000E+00	4 03308E+00	4 00000E+00	4 09855E+00
4 50000E+00	4 16402E+00	5 00000E+00	4 22949E+00	5 50000E+00	4 29496E+00
6 00000E+00	4 36043E+00				

PROMPT NUBAR CURIUM 244

210 4300	5 5200	184 5800	6 9500	5 4400	245 0000

0 00000E+00	3 57489E+00	5 00000E−01	3 64220E+00	1 00000E+00	3 70933E+00
1 50000E+00	3 77630E+00	2 00000E+00	3 84311E+00	2 50000E+00	3 90975E+00
3 00000E+00	3 97623E+00	3 50000E+00	4 04255E+00	4 00000E+00	4 10871E+00
4 50000E+00	4 17472E+00	5 00000E+00	4 24057E+00	5 50000E+00	4 30627E+00
6 00000E+00	4 37182E+00				

LINEAR FIT A = 1 32660E 01 B = 3 57587E+00

0 00000E+00	3 57587E+00	5 00000E−01	3 64220E+00	1 00000E+00	3 70853E+00
1 50000E+00	3 77486E+00	2 00000E+00	3 84119E+00	2 50000E+00	3 90752E+00
3 00000E+00	3 97385E+00	3 50000E+00	4 04017E+00	4 00000E+00	4 10650E+00
4 50000E+00	4 17283E+00	5 00000E+00	4 23916E+00	5 50000E+00	4 30549E+00
6 00000E+00	4 37182E+00				

PROMPT NUBAR CURIUM 245

209 9400	6 4570	184 2000	6 9780	5 3300	246 0000

0 00000E+00	3 74373E+00	5 00000E−01	3 81180E+00	1 00000E+00	3 87970E+00
1 50000E+00	3 94742E+00	2 00000E+00	4 01498E+00	2 50000E+00	4 08238E+00
3 00000E+00	4 14961E+00	3 50000E+00	4 21669E+00	4 00000E+00	4 28360E+00
4 50000E+00	4 35035E+00	5 00000E+00	4 41695E+00	5 50000E+00	4 48340E+00
6 00000E+00	4 54970E+00				

LINEAR FIT A = 1 34164E 01 B = 3 74472E+00

0 00000E+00	3 74472E+00	5 00000E−01	3 81180E+00	1 00000E+00	3 87888E+00
1 50000E+00	3 94596E+00	2 00000E+00	4 01304E+00	2 50000E+00	4 08012E+00
3 00000E+00	4 14721E+00	3 50000E+00	4 21429E+00	4 00000E+00	4 28137E+00
4 50000E+00	4 34845E+00	5 00000E+00	4 41553E+00	5 50000E+00	4 48262E+00
6 00000E+00	4 54970E+00				

PROMPT NUBAR CURIUM 246

210 5800 5 1580 184 0500 7 0060 5 2210 247 0000

0 00000E+00	3 73215E+00	5 00000E−01	3 80147E+00	1 00000E+00	3 87060E+00
1 50000E+00	3 93956E+00	2 00000E+00	4 00835E+00	2 50000E+00	4 07696E+00
3 00000E+00	4 14540E+00	3 50000E+00	4 21367E+00	4 00000E+00	4 28178E+00
4 50000E+00	4 34973E+00	5 00000E+00	4 41751E+00	5 50000E+00	4 48513E+00
6 00000E+00	4 55260E+00				

LINEAR FIT A = 1 36569E 01 B = 3 73318E+00

0 00000E+00	3 73318E+00	5 00000E−01	3 80147E+00	1 00000E+00	3 86975E+00
1 50000E+00	3 93803E+00	2 00000E+00	4 00632E+00	2 50000E+00	4 07460E+00
3 00000E+00	4 14289E+00	3 50000E+00	4 21117E+00	4 00000E+00	4 27946E+00
4 50000E+00	4 34774E+00	5 00000E+00	4 41603E+00	5 50000E+00	4 48431E+00
6 00000E+00	4 55260E+00				

PROMPT NUBAR CURIUM 247

209 8800 6 2120 183 7900 7 0340 5 1110 248 0000

0 00000E+00	3 87907E+00	5 00000E−01	3 94927E+00	1 00000E+00	4 01929E+00
1 50000E+00	4 08913E+00	2 00000E+00	4 15879E+00	2 50000E+00	4 22828E+00
3 00000E+00	4 29760E+00	3 50000E+00	4 36674E+00	4 00000E+00	4 43572E+00
4 50000E+00	4 50452E+00	5 00000E+00	4 57317E+00	5 50000E+00	4 64165E+00
6 00000E+00	4 70997E+00				

LINEAR FIT A = 1 38309E 01 B = 3 88012E+00

0 00000E+00	3 88012E+00	5 00000E−01	3 94927E+00	1 00000E+00	4 01843E+00
1 50000E+00	4 08758E+00	2 00000E+00	4 15674E+00	2 50000E+00	4 22589E+00
3 00000E+00	4 29505E+00	3 50000E+00	4 36420E+00	4 00000E+00	4 43335E+00
4 50000E+00	4 50251E+00	5 00000E+00	4 57166E+00	5 50000E+00	4 64082E+00
6 00000E+00	4 70997E+00				

PROMPT NUBAR CURIUM 248

210 7700 4 7130 183 5300 7 0620 5 0610 249 0000

0 00000E+00	3 85696E+00	5 00000E−01	3 92783E+00	1 00000E+00	3 99852E+00
1 50000E+00	4 06902E+00	2 00000E+00	4 13934E+00	2 50000E+00	4 20948E+00
3 00000E+00	4 27945E+00	3 50000E+00	4 34924E+00	4 00000E+00	4 41885E+00
4 50000E+00	4 48830E+00	5 00000E+00	4 55758E+00	5 50000E+00	4 62670E+00
6 00000E+00	4 69564E+00				

Table F 5 (continued)

LINEAR FIT A = 1 39602E 01 B = 3 85803E+00

0 00000E+00	3 85803E+00	5 00000E−01	3 92783E+00	1 00000E+00	3 99763E+00
1 50000E+00	4 06743E+00	2 00000E+00	4 13724E+00	2 50000E+00	4 20704E+00
3 00000E+00	4 27684E+00	3 50000E+00	4 34664E+00	4 00000E+00	4 41644E+00
4 50000E+00	4 48624E+00	5 00000E+00	4 55604E+00	5 50000E+00	4 62584E+00
6 00000E+00	4 69564E+00				

APPENDIX G

ATOMIC MASS VALUES

APPENDIX G ATOMIC MASS VALUES

Mass differences are given in ref 28 The values are given in MeV relative to the A number of the nuclide For example the value for Zr 96 in Table G 1 is −85 442 MeV The mass in atomic mass units (a m u) for Zr 96 is

$$96\ 00000 + (\ 85\ 442/931\ 50) = 95\ 908275$$

Values are not given in the Wapstra Audi and Hoekstra evaluation (ref 28) for the following nuclides

Nb 107 Mo 109 Mo 110 Tc 111 Tc 112 I 141 and I 142

We recommend a value of −60 840 MeV for I 141 The other six nuclides have been left blank in Tables G 1 and G 2 For these cases a choice can be made from one of the other 8 10 evaluations given in ref 28

Table G 1 Light fragments

Sr 94	78 836	Nb 97	85 608
Sr 95	75 050	Nb 98	83 528
Sr 96	72 880	Nb 99	82 328
Sr 97	68 810	Nb 100	79 929
Sr 98	66 380	Nb 101	78 950
Sr 99	62 150	Nb 102	76 350
Sr 100	60 200	Nb 103	75 240
		Nb 104	72 260
		Nb 105	70 940
		Nb 106	67 290
		Nb 107	
Y 94	82 348	Mo 100	86 186
Y 95	81 214	Mo 101	83 513
Y 96	78 300	Mo 102	83 559
Y 97	76 270	Mo 103	80 760
Y 98	72 520	Mo 104	80 370
Y 99	70 170	Mo 105	77 360
Y 100	67 290	Mo 106	76 270
Y 101	64 650	Mo 107	72 910
Y 102	61 450	Mo 108	71 460
		Mo 109	
		Mo 110	
Zr 95	85 659	Tc 105	82 350
Zr 96	85 442	Tc 106	79 790
Zr 97	82 950	Tc 107	79 160
Zr 98	81 283	Tc 108	76 280
Zr 99	77 790	Tc 109	74 920
Zr 100	76 590	Tc 110	71 640
Zr 101	73 380	Tc 111	
Zr 102	71 770	Tc 112	
Zr 103	68 290		
Zr 104	66 260		

Table G 2 Heavy fragments

Te 133	82 970	Xe 136	86 429
Te 134	82 430	Xe 137	82 383
Te 135	77 870	Xe 138	80 110
Te 136	74 460	Xe 139	75 690
Te 137	69 480	Xe 140	72 990
Te 138	66 110	Xe 141	68 320
		Xe 142	65 500
I 134	83 990	Cs 139	80 710
I 135	83 821	Cs 140	77 053
I 136	79 550	Cs 141	74 472
I 137	76 507	Cs 142	70 538
I 138	72 290	Cs 143	67 745
I 139	68 880	Cs 144	63 370
I 140	64 250		
I 141	60 840		
I 142			

Table G 3 Compound nucleus

Np 238	47 451	Cm 242	54 800
		Cm 243	57 177
Pu 238	46 160	Cm 244	58 449
Pu 239	48 584	Cm 245	60 998
Pu 240	50 122	Cm 246	62 614
Pu 241	52 952	Cm 247	65 528
Pu 242	54 713	Cm 248	67 388
		Cm 249	70 746
Am 242	55 463		
Am 243	57 169		
Am 244	59 877		

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