LA-9362-MS

C.3

Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36.

Application of Adjusted Data in Calculating Fission-Product Decay Energies and Spectra

Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

This work was supported by the US Department of Energy, Office of Nuclear Energy, Office of Reactor Research and Technology.

LA-9362-MS

UC-34c
Issued: June 1982

Application of Adjusted Data in Calculating Fission-Product Decay Energies and Spectra

D. C. George
R. J. LaBauve
T. R. England

Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

APPLICATION OF ADJUSTED DATA IN CALCULATING FISSION-PRODUCT DECAY ENERGIES AND SPECTRA

by

D. C. George, R. J. LaBauve, and T. R. England

ABSTRACT

The code ADENA, which approximately calculates fission-product beta and gamma decay energies and spectra in 19 or fewer energy groups from a mixture of ^{235}U and ^{239}Pu fuels, is described. The calculation uses aggregate, adjusted data derived from a combination of several experiments and summation results based on the ENDF/B-V fission-product file. The method used to obtain these adjusted data and the method used by ADENA to calculate fission-product decay energy with an absorption correction are described, and an estimate of the uncertainty of the ADENA results is given.

Comparisons of this approximate method are made to experimental measurements, to the ANSI/ANS 5.1-1979 standard, and to other calculational methods. A listing of the complete computer code (ADENA) is contained in an appendix. Included in the listing are data statements containing the adjusted data in the form of parameters to be used in simple analytic functions. These fitted parameters can be abstracted for other uses such as in spatial neutron depletion or thermal hydraulics codes.

I. INTRODUCTION

Summation calculations of fission product decay energy based on four different fission-product data files were compared with several experiments,[1,2,3,4,5] and the results were reported in Ref. 6. The conclusions drawn from these comparisons include

(1) The experimental spectral data are consistent.

(2) Aggregate beta and gamma spectral decay energies calculated from any of the four fission product files do not agree well with experiment for short irradiation and cooling times below ~1000 s.

(3) It is likely that some data in ENDF/B-V (Mod 0)[7], probably the experimental decay energies for some individual, high-Q nuclides, are deficient.

These conclusions imply that better estimates of decay spectra will result from calculations that use aggregate data derived, where possible, from experiments rather than data derived entirely from the fission-product files. However, because such experimental data are available only in the region 2.2 s - 2 x 10^5 s for gamma decay energy and 2.2 s-10^4 s for beta decay energy, information based on ENDF/B-V summation calculations was incorporated to extend the range of the calculated decay-energy cooling times from 10^4-10^9 s. The method used to prepare the adjusted data base is described in Section II.

The code ADENA uses these adjusted data to calculate fission-product decay-energy spectra from any mixture of thermally irradiated ^{235}U and ^{239}Pu fuels at user specified cooling times. A correction for neutron absorption in the fission products is included. Section III contains a description of the code, and Appendix A contains a full listing and a sample problem input and output. The spectra, but not the absorption correction, should be almost as accurate for the fissions induced by fast energy neutrons as it is for thermal neutrons.

Section IV contains the results of three applications of the code ADENA. First, the ADENA results for a finite irradiation problem including the effects of neutron absorption are compared with CINDER-10 (Ref. 8) calculations. Second, sample calculations of both the Oak Ridge and Los Alamos experiments are compared with the experiments. Third, a calculational comparison of the summed spectra with the ANSI/ANS-5.1-1979 standard[9] is made.

Finally, Section V contains the authors' estimate of the reliability of ADENA results. Appendix B clarifies the procedure used to obtain this estimate and includes in tabular form the detailed data upon which the estimate is based.

II. PREPARATION OF ADJUSTED DATA

The adjusted data base used by ADENA is derived from a combination of experimental data and the ENDF/B-V fission-product data file. The experiments, whose results were incorporated into the data base, were conducted at Los Alamos and Oak Ridge; nuclear fuel samples were irradiated with thermal neutrons and the decay-energy and beta-ray and/or gamma-ray spectra of the resulting fission products measured. Results of these experiments were included in formulating the ANSI/ANS-5.1 Decay Power Standard. A brief summary of the experimental range of data follows.

- Oak Ridge spectral experiments[1,2] in which ^{235}U and ^{239}Pu fuels were irradiated with thermal neutrons for times of 1, 10, (5 for ^{239}Pu), and 100 s, and both aggregate fission-product gamma-ray and beta-ray decay-energy spectra were measured for a range of average cooling times from 2.2 (for the 1-s irradiation time) to 12 000 s (for the 100-s irradiation time). There were similar measurements for ^{241}Pu.
- Los Alamos calorimetric experiments[3,4] in which ^{233}U, ^{235}U, and ^{239}Pu were irradiated with thermal neutrons for 20 000 s and total decay heat (gamma plus beta) measured for a range of cooling times from 29-190 000 s.
- Los Alamos spectral experiments[5] in which fuels, irradiation time, and cooling time ranges were the same as for the calorimetric experiments, but aggregate fission-product gamma-ray decay-energy spectra were measured.

The ENDF/B-V fission-product data file contains data for 877 nuclides, of which 264 have spectra, and there are 20 yield sets. These data for individual nuclides were input to the summation code CINDER-10,[8] and the associated code system described in Refs. 10 and 11 was used to produce calculated decay energies and spectra. The aggregate experimental and summation code results were combined to produce the adjusted data base using the procedure described below.

Step 1: Use ENDF/B-V based summation results to calculate points from 10^4 s (beta) or 2×10^5 s (gamma) to 10^9 s following a fission pulse. (As noted below, caclulations for shorter times were included in the detailed procedure.)

Step 2: Use the shape of the ENDF/B-V derived decay-energy curves below 2 s cooling time shifted to coincide with the experimental data having the shortest cooling times to calculate points below 2 s.

Step 3: Combine points from steps one and two with experimental data points. Use this set of combined points as input to FITPULS[11] to calculate a set of parametric pairs, which represents a fit for a combined adjusted equivalent pulse.

A more detailed description of the procedure outlined in these three steps follows.

ENDF/B-V Calculation - Preliminary

Methods described in Refs. 10 and 11 were used to create sets of alpha (α), lambda (λ) parameter pairs which represent least squares fits to the aggregate ENDF/B-V pulse data by fitting the data with the equation,

$$f(t) = \sum_{i=1}^{n} \alpha_i e^{-\lambda_i t} \quad \text{(MeV/fis-s)} \quad . \tag{1}$$

These sets of parameter pairs were obtained for beta- and gamma-ray decay, for both ^{235}U and ^{239}Pu fuels, for all decay-energy groups, over the full cooling time range of 10^{-4}-10^9 s. The generation of these sets was a necessary preliminary step to obtaining the adjusted data base, and the sets are used in each of the three steps previously outlined.

Long Cooling Times - Step 1

The sets of parameters from the ENDF/B-V calculation were used in Eq. (1) to compute the beta- and gamma-ray decay energy at four cooling times per decade from the longest experimental cooling time (10^4 s for beta-ray decay and 2×10^5 s for gamma-ray decay) up to 10^9 s for each decay energy group for both fuels. Because of large experimental errors, ENDF/B-V data were used to calculate points from 10^3-10^9 s for some of the higher energy groups.

Cooling Times Less Than Two Seconds - Step 2

Because there is often a large difference between the decay energy for short cooling times calculated from the ENDF/B-V fits and the experimentally measured values, we used the shape of the ENDF/B-V data shifted to coincide with the equivalent experimental short cooling time points. [The derivation of "equivalent experimental points" (pulse values) is discussed below.] The shift was accomplished by first plotting the ENDF/B-V fit and the equivalent experimental pulse points having a cooling time less than 10 s. Figure 1 is an example of one of these plots. The ENDF/B-V curve was then shifted manually to coincide with the equivalent experimental points, and values for cooling times of 0.01, 0.03, 0.1, 0.3, and 1.0 seconds were read off the graph. (Figure 2 shows the resulting adjusted fit for cooling times less than 10 s after the procedures described in Steps 1-3 have been completed.)

It is important to note that the equivalent experimental points plotted on Figs. 1-3 are produced from the original data in the following manner. The original experimental points are measured beta- or gamma-ray decay energies at cooling times of t seconds after an irradiation period of T seconds. In order

Fig. 1. Beta-ray fission-product decay energy for Group 5 (0.6-0.8 MeV) calculated from ENDF/B-V data and "equivalent pulse" experimental points.

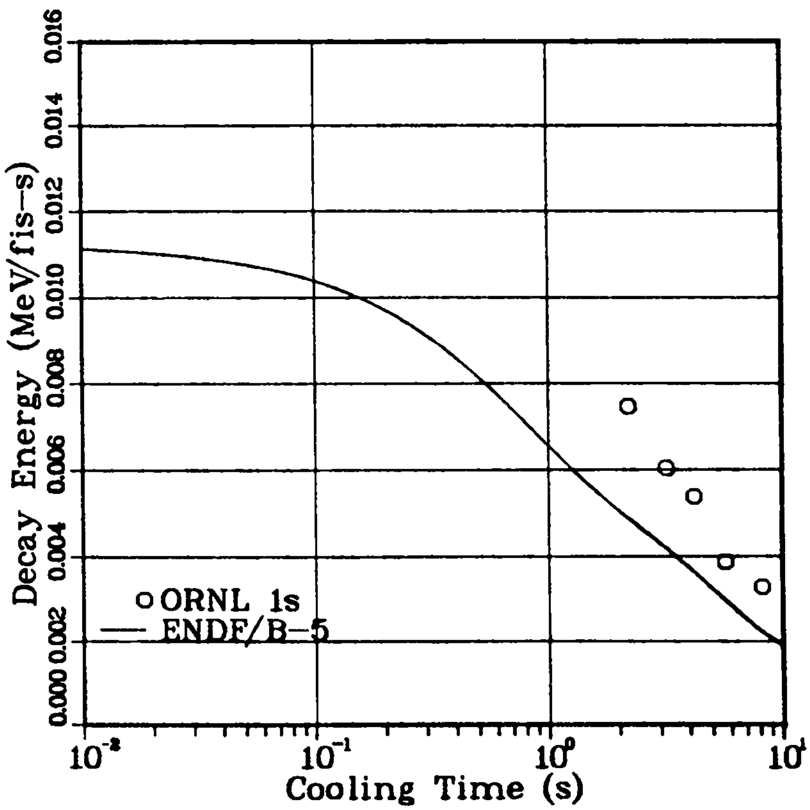
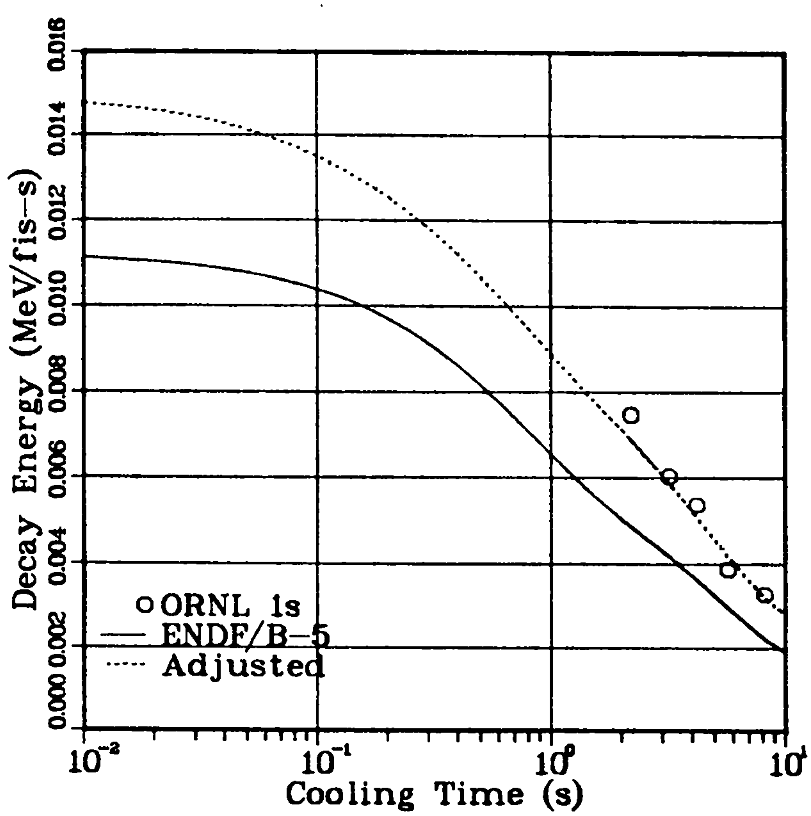


Fig. 2. Beta-ray fission-product decay energy for Group 5 (0.6-0.8 MeV). Adjusted curve shows the result of shifting the ENDF/B-V curve to coincide with the "equivalent pulse" experimental points.



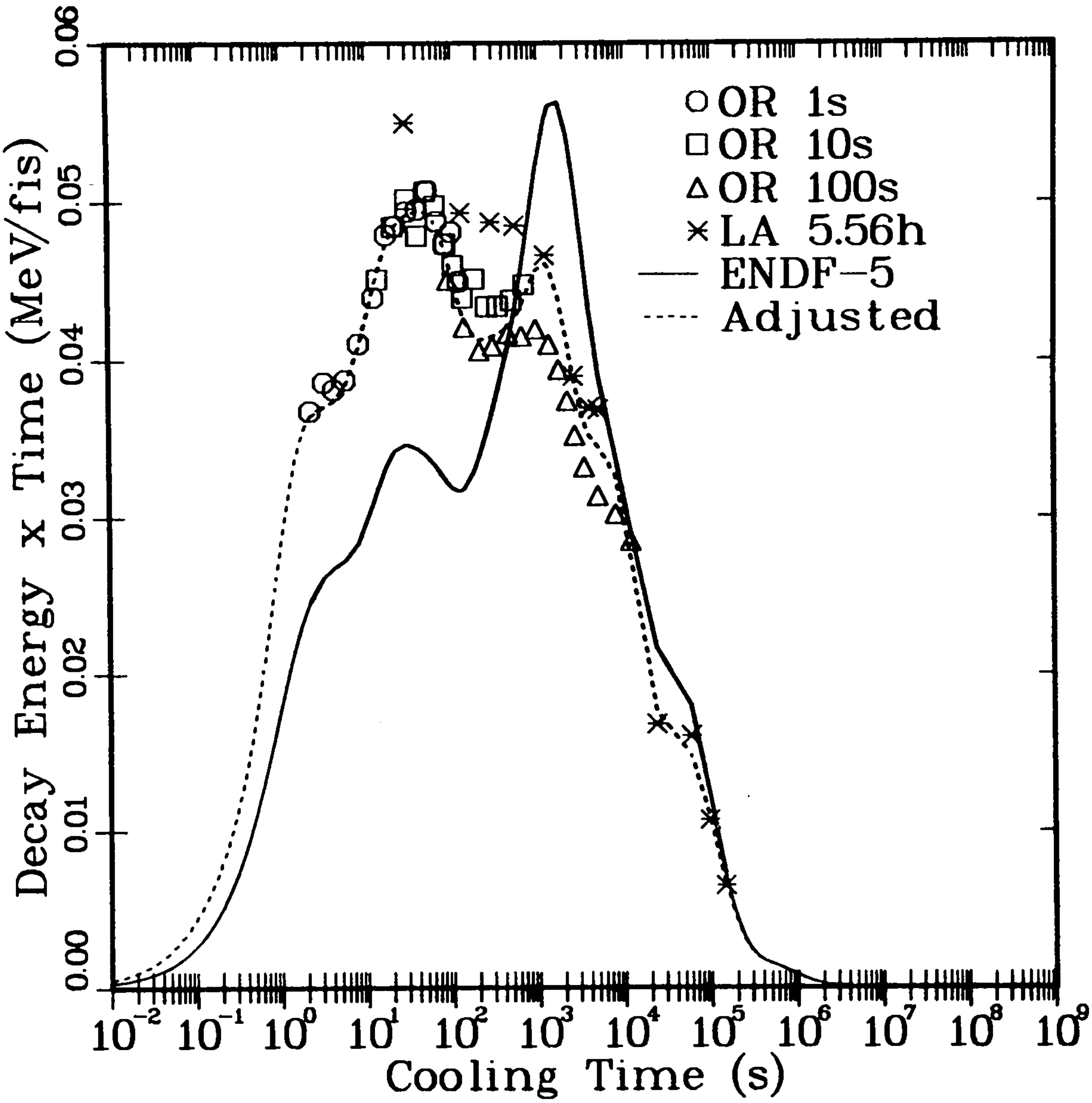


Fig. 3. Gamma-ray decay energy for Group 7 (1.0-1.2 MeV) showing "equivalent pulse" experimental points, ENDF/B-V fit, and adjusted fit.

to intercompare experiments with different irradiation times and to compare these experiments to calculations, it is desirable to reduce the experimental data to equivalent pulse data that are independent of irradiation time. The code FITPULS can generate a set of alphas and lambdas by fitting the original experimental data with an integration of Eq. (1) over T for a unit fission rate producing functions of the form,

$$F(T,t) = \sum_{i=1}^{n} \frac{\alpha_i}{\lambda_i} e^{-\lambda_i t}\left(1-e^{-\lambda_i T}\right)(\mathrm{MeV/fis}) \quad . \tag{2}$$

The set of alpha, lambda parameter pairs derived by FITPULS using Eq. (2) from the combination of all experimental data points constitute the experimental pulse fit. See Appendix D of Ref. 10 for a detailed treatment of this subject. During this fitting process, the percent differences of the original experimental data points to the fitted results as calculated by Eq. (2) are computed and saved. These percent differences can be applied to the experimental pulse by evaluating Eq. (1) at the cooling times of the original experimental points and adding the percent differences to generate equivalent experimental pulse data points. Because the fitting procedure involves a nonlinear least squares algorithm, neither the experimental pulse fits nor the equivalent experimental pulse points are unique. For graphical comparisons, the equivalent experimental pulse values are an excellent representation of the experiments because deviations are emphasized. The actual fitting process of Step 3 (below) uses the original experimental data points, not the equivalent points.

Final Parameters Representing the Adjusted Data - Step 3

Points from Step 1 computed directly using the ENDF/BV pulse parameters in Eq. (1) for long cooling times, points from Step 2 derived from the shifted ENDF/BV pulse fit for short cooling times, and the original experimental data points for the middle cooling time region were combined. The combination was input along with the ENDF/BV pulse parameters to FITPULS, which produced sets of alpha, lambda parameter pairs constituting the adjusted equivalent pulse fits. FITPULS uses a nonlinear least squares procedure to fit the input to Eq. (1) (for the pulse points from Steps 1 and 2) and Eq. (2) (for the original experimental finite-irradiation data points) using the ENDF/B-V pulse parameters as the starting values for the fitting process. Thus, the adjusted fits reflect the basic shape of the ENDF fit, as can be seen in Fig. 3, which shows the original ENDF fit, the final adjusted fit, and the equivalent pulse experimental data points for each experiment. The fitting procedure allows for weights to be assigned to the data points (experimental data or points created by the methods described in Steps 1 and 2). By looking at graphs of the equivalent experimental points and the ENDF fits, it can be determined which points should be given light weights and which should be given heavy weights. Heavy weights will force the final fit to adhere closely to those points, whereas light weights will allow the fit to wander quite far from the data points.

These adjusted fits were obtained in the 19-energy group structure given in Table I for ^{235}U beta- and gamma-ray decay-energy spectra and for ^{239}Pu beta- and gamma-ray decay-energy spectra. Note that for cooling times outside the range of the experiments, only ENDF/B-V data were used for FITPULS input; thus the adjusted fits for cooling times greater than 10^4 s for betas and 2×10^5 s for gammas are just fits to the calculated ENDF/B-V summation data. Because the experimental error at cooling times greater than 1000 s for energies greater than 4 MeV is very large for groups 17 and 18, those experimental points were ignored and the ENDF/B-V data were used instead. Thus, for these groups the adjusted fits are the ENDF/B-V fits for cooling times greater than 1000 s. There are no experimental data for group 19, therefore the adjusted fit for group 19 is based on the ENDF/B-V fit for all cooling times.

III. DESCRIPTION OF ADENA

The program ADENA was written to approximate the fission product decay-energy spectra with an absorption correction for fuel mixtures of ^{235}U and ^{239}Pu. The adjusted fits produced by the procedure given in Sec. II were incorporated into the code, which uses these parameters in Eq. (2) to calculate the fission product decay energy for a finite irradiation time without absorption. A description of the input to ADENA is given in Table II.

For many applications involving long irradiation times, a correction to the adjusted fits is needed to account for the effects of neutron absorption. (Appendix D of Ref. 10 gives the general equations to calculate absorption effects; however, the simplified method developed in Ref. 12 was used in ADENA.) Several limiting assumptions are made in order to simplify the absorption calculations. The power history must be reduced to the associated

TABLE I

ENERGY GROUP STRUCTURE

Group	E-Lo(MeV)	E-Hi(MeV)
1	0.0	0.1
2*	0.1	0.2
3	0.2	0.4
4	0.4	0.6
5	0.6	0.8
6	0.8	1.0
7	1.0	1.2
8	1.2	1.4
9	1.4	1.6
10	1.6	1.8
11	1.8	2.0
12	2.0	2.2
13	2.2	2.4
14	2.4	2.6
15	2.6	3.0
16	3.0	4.0
17	4.0	5.0
18	5.0	6.0
19	6.0	7.5

*Due to lack of experimental data, Groups 1 and 2 were combined for the beta-ray calculations.

average thermal and epithermal fluxes. The requested group structure must be a subset of the group structure given in Table I. Only the two most important chains ^{155}Eu - ^{156}Eu and ^{133}Cs - ^{134}Cs are considered; these have a net positive effect on heating and spectra. The correction is given by the equation

$$\Delta F(t,T,\phi) = \Delta N(T,\phi)\ \lambda \omega e^{-\lambda t} \quad (3)$$

where,

T is the irradiation time

t is the cooling time

ϕ is the neutron flux (thermal and epithermal)

λ is the decay constant of the second nuclide in the chain

ω is the average photon decay energy for a given group for the second nuclide

$\Delta N(T,\phi)$ is the change in atom density of the nuclide resulting from its radiative capture and capture in its precursor.

TABLE II

ADENA INPUT SPECIFICATIONS[a]

Card	Variable	Comment
1	UFRAC	Fraction of ^{235}U in fuel
	TFLUX	Average thermal flux ($n/cm^2/s$)
	ETFLUX	Average epithermal flux ($n/cm^2/s$)
	OTIME	Operating time (seconds) (use OTIME = 0 for pulse case)
	NGI	Number of energy groups
	NTSP	Number of cooling times
	IPLT	Plotting flag; flag = 1 for plots, = 0 for no plots
	IST	If = 1, calculate ANSI Standard, 0 otherwise
2	EI(I),I=1,NGI+1	If NGI > 0 energy bounds (MeV); energy bounds must be a subset of bounds given in Table I. If NGI $\leq$ 0, card 2 is omitted If NGI = 0, energy bounds of Table I are used If NGI = -6, the energy bounds 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 7.5 will be used If NGI = -12, the energy bounds 0.0, 0.4, 0.8, 1.0, 1.4, 1.8, 2.2, 2.6, 3.0, 4.0, 5.0, 6.0, 7.5 will be used
3	TMIN,TMAX	Only if NTSP = 0 or NTSP = -1 If NTSP = 0, results will be calculated for cooling times at each decade and half decade from TMIN to TMAX If NTSP = -1, results will be calculated for cooling times at each decade from TMIN to TMAX
	T(I),I=1,NTSP	Only if NTSP > 0, cooling times
4	UFG,UFB,PUFG,PUFB	Multiplication factor for increasing confidence limits of ADENA calculation for ^{235}U gamma energies, ^{235}U beta energies, ^{239}Pu gamma energies, and ^{239}Pu beta energies, in that order. Set = 1 for no effect

[a]All input is free field; values or commas must be supplied for all variables.

Results are generated for each requested cooling time by group and for the sum over all groups. Beta-ray, gamma-ray, and the sum of beta- and gamma-ray decay energies are printed and plotted for each category.

The ADENA code also has the capability of calculating the decay energy after a pulse (specify OTIME = 0) and of performing calculations of the total beta plus gamma decay energy based on the ANSI/ANS-5.1-1979 Standard (specify IST =1), as described in Table II.

IV. COMPARISONS

To check the data fits used in ADENA, three types of comparisons were made. The first comparison involved using ADENA to calculate the gammaray decay energy at three cooling times (1, 10^6, and 10^8 s) for a ^{235}U-fueled thermal reactor with an average thermal flux of 10^{14} n/cm^2/s for an operating time of 20 000 hours. The ADENA results were then compared with the results of a CINDER-10 (Ref. 8) calculation of the same problem. The ADENA calculation used the adjusted data base derived from experiment and ENDF/B-V, whereas the CINDER calculation used ENDF/B-IV data. The results of both calculations are given in Table III. The biggest differences occur at the shortest cooling time, 1 s, in the lowest energy group. This observation is supported by the results of the data testing study[6] that indicates that the calculated gamma-ray decay energies are relatively high for early cooling times and small gamma-ray energies. Maximum absorption effects in the calculations are at 10^6 s cooling time for the europium chain and 10^8 s for the cesium chain. As can be seen from the tabulations in Table III, ADENA agrees well with CINDER at these times.

The second type of comparison involved using ADENA to calculate the Oak Ridge (ORNL) and Los Alamos experiments, and plotting the calculation with the experimental data. Examples of these graphical comparisons for the ORNL 100-s irradiation experiment[1] are given in Figs. 4-6 for three cooling times (90, 950, and 11 950 s) and for the Los Alamos 5.56-h experiment[3] in Figs. 7-9 for three cooling times (128, 1218, and 14 650 s). As can be seen in the figures, the calculation agrees quite well with the experiment. Note that for long cooling times and high gamma-ray energies, the experimental error is very large.

A final comparison is made with the 1979 ANSI/ANS-5.1 Standard. This standard is believed to provide the best estimate of total (beta plus gamma)

TABLE III

COMPARISON OF GAMMA-RAY ENERGY CALCULATED BY ADENA AND CINDER

Group	Energy Bounds (MeV)	Cooling Time 1 s Gamma Decay Energy (MeV/fis)		Cooling Time 10^6 s Gamma Decay Energy (MeV/fis)		Cooling Time 10^8 s Gamma Decay Energy (MeV/fis)	
		CINDER	ADENA	CINDER	ADENA	CINDER	ADENA
1	0.0-1.0	2.681	2.258	0.180	0.181	0.0079	0.0077
2	1.0-2.0	2.061	1.971	0.073	0.067	0.0003	0.0003
3	2.0-3.0	0.838	0.968	0.008	0.009	0.0001	0.0000
4	3.0-4.0	0.306	0.421	0.001	0.000	0.0000	0.0000
5	4.0-5.0	0.166	0.179	0.001	0.000	0.0000	0.0000
6	5.0-6.0	0.042	0.057	0.000	0.000	0.0000	0.0000
Total		6.095	5.856	0.261	0.257	0.0083	0.0081

Fuel	^{235}U
Thermal Flux	10^{14} n/cm^2/s
Epithermal Flux	5 x 10^{14} n/cm^2 s
Operating Time	20 000 hr

decay heating, but it does not provide a resolution into the beta and gamma components or spectra. The primary intent of this report is to provide a simple code that will calculate our best estimate of these components, particularly their spectra on a few-energy group basis. The total heating closely matches values from the standard, as shown in Fig. 10 for ^{235}U and Fig. 11 for ^{239}Pu, but is not normalized to the standard. The ADENA results are within 10% of the standard at all times. In terms of the small assigned uncertainties of the standard, the ADENA results are all within a two-sigma uncertainty of the standard for ^{239}Pu. The uncertainties in the standard are much smaller for ^{235}U (<2%), and 14 of the 46 points are further than 2 sigma from the standard (all are within 10%), 4 points are further than 3 sigma, and all are within 4 sigma uncertainty of the standard. Note that the standard is based on five experiments and ENDF/B-IV data, whereas our adjusted fits are based on only three experiments and ENDF/B-V data.

V. ESTIMATE OF ACCURACY OF CALCULATIONS USING THE ADENA CODE

As described in Sec. III, the user has the option of assigning values to four input parameters in ADENA, namely, UFG, UFB, PUFG, and PUFB, which will raise or lower the results of the calculation by a certain percentage and thus increase the level of confidence in the calculation. It is the intent of this

Fig. 4. Gamma-ray decay energy after a cooling time of 90 s from the Oak Ridge National Laboratory ^{235}U 100-s irradiation experiment compared with the ADENA calculation.

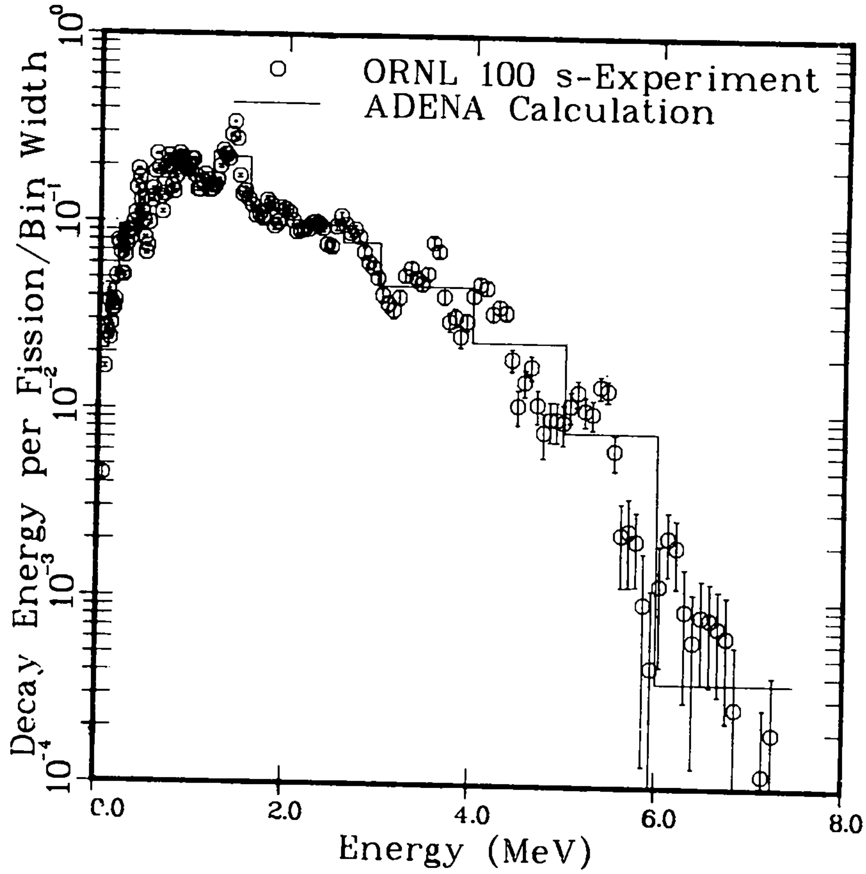


Fig. 5. Gamma-ray decay energy after a cooling time of 950 s from the Oak Ridge National Laboratory ^{235}U 100-s irradiation experiment compared with the ADENA calculation.

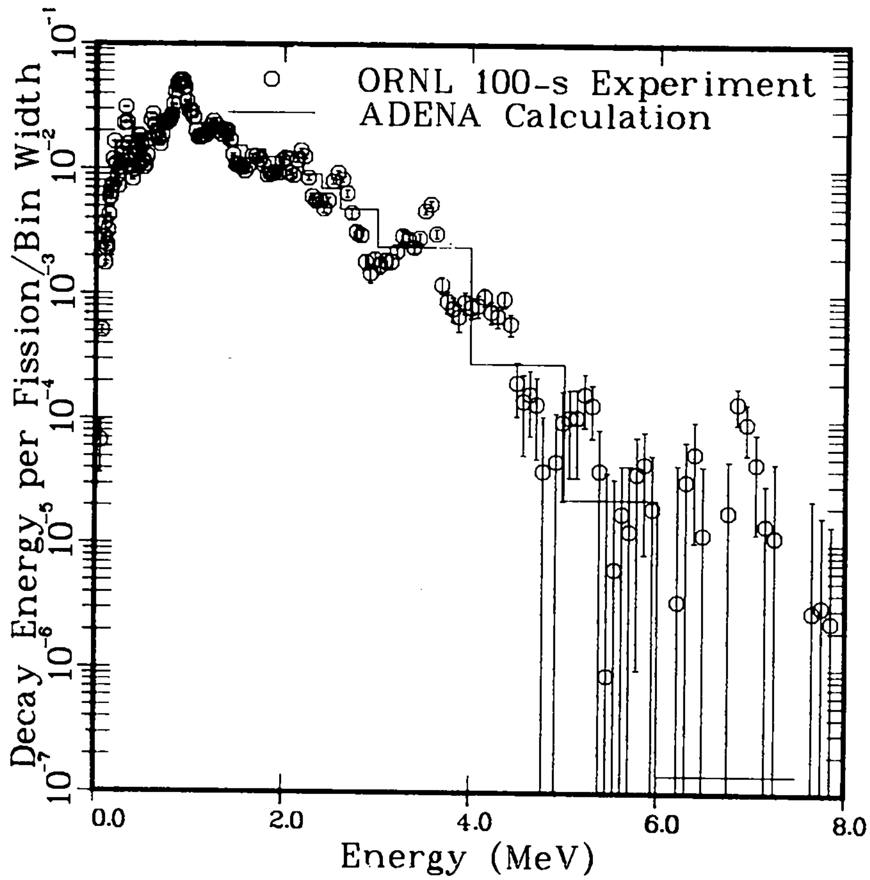


Fig. 6. Gamma-ray decay energy after a cooling time of 11 950 s from the Oak Ridge National Laboratory ^{235}U 100-s irradiation experiment compared with the ADENA calculation.

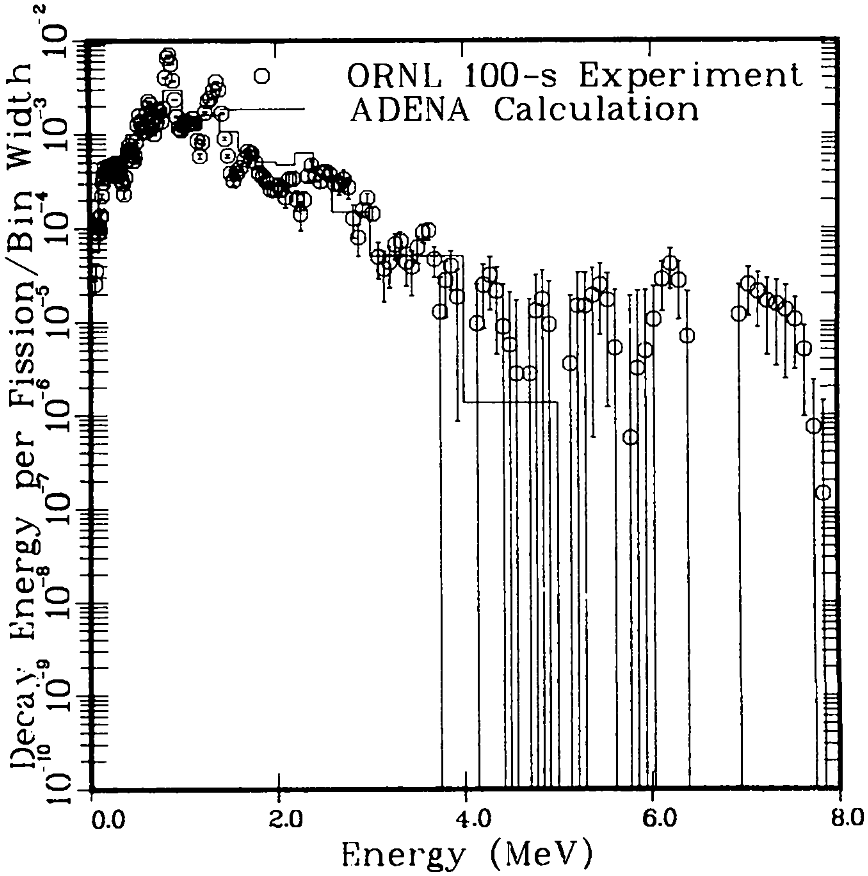


Fig. 7. Gamma-ray decay energy after a cooling time of 128 s from the Los Alamos ^{235}U 5.56-h irradiation experiment compared to the ADENA calculation.

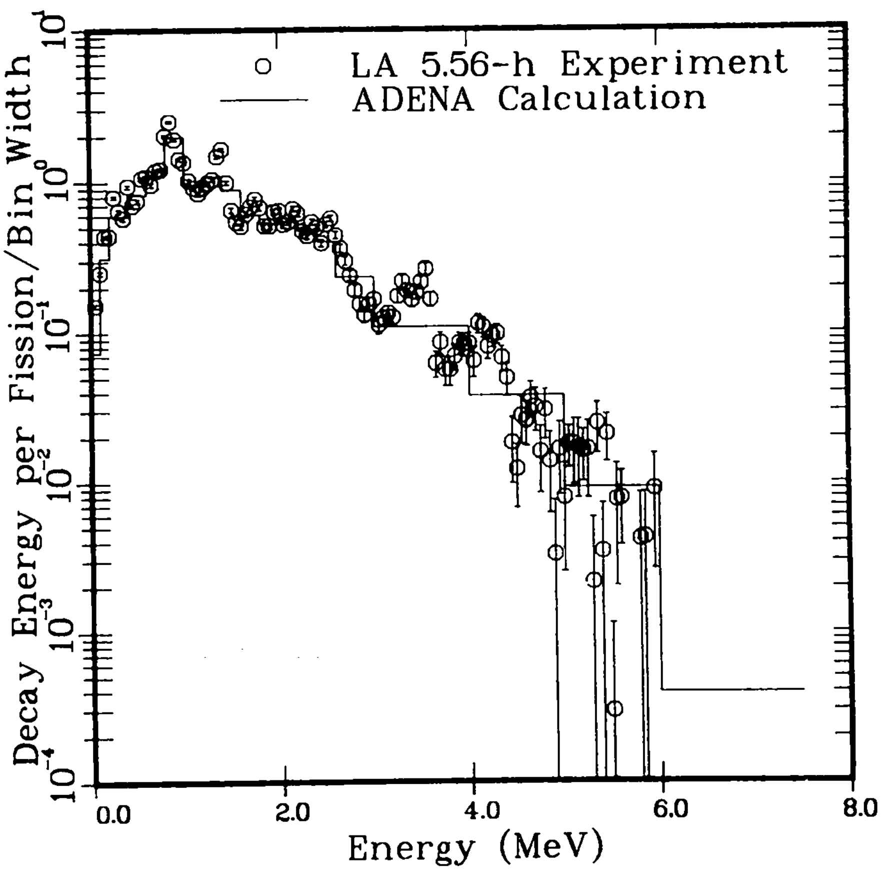


Fig. 8. Gamma-ray decay energy after a cooling time of 1218 s from the Los Alamos ^{235}U 5.56-h irradiation experiment compared to the ADENA calculation.

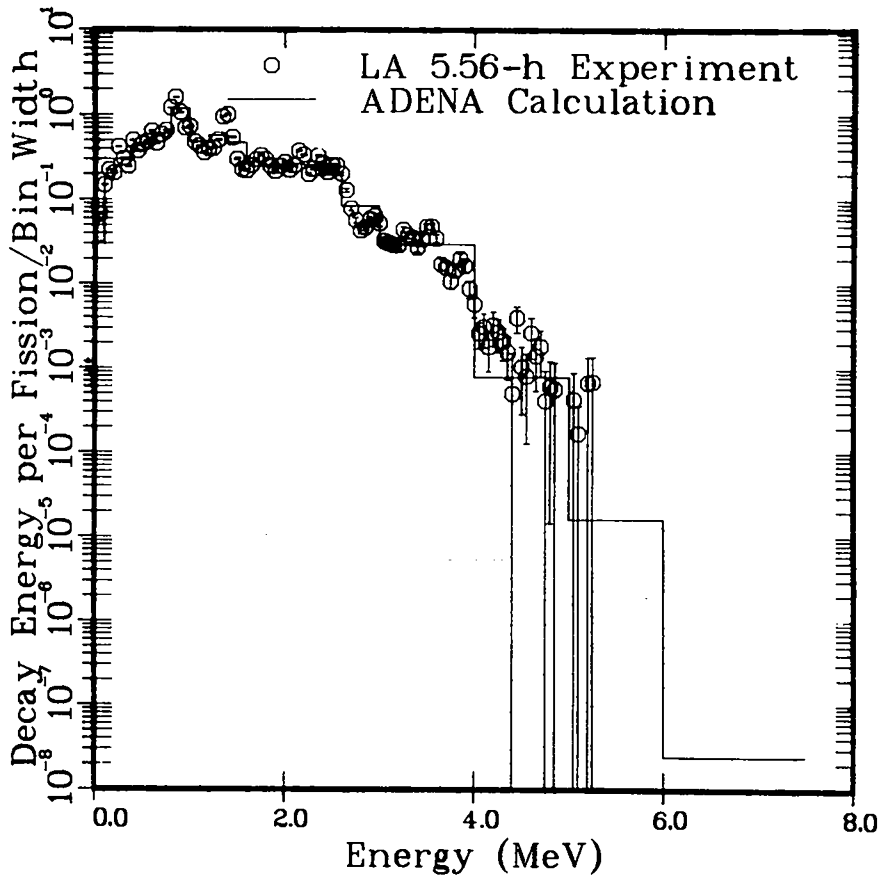


Fig. 9. Gamma-ray decay energy after a cooling time of 14 650 s from the Los Alamos ^{235}U 5.56-h irradiation experiment compared to the ADENA calculation.

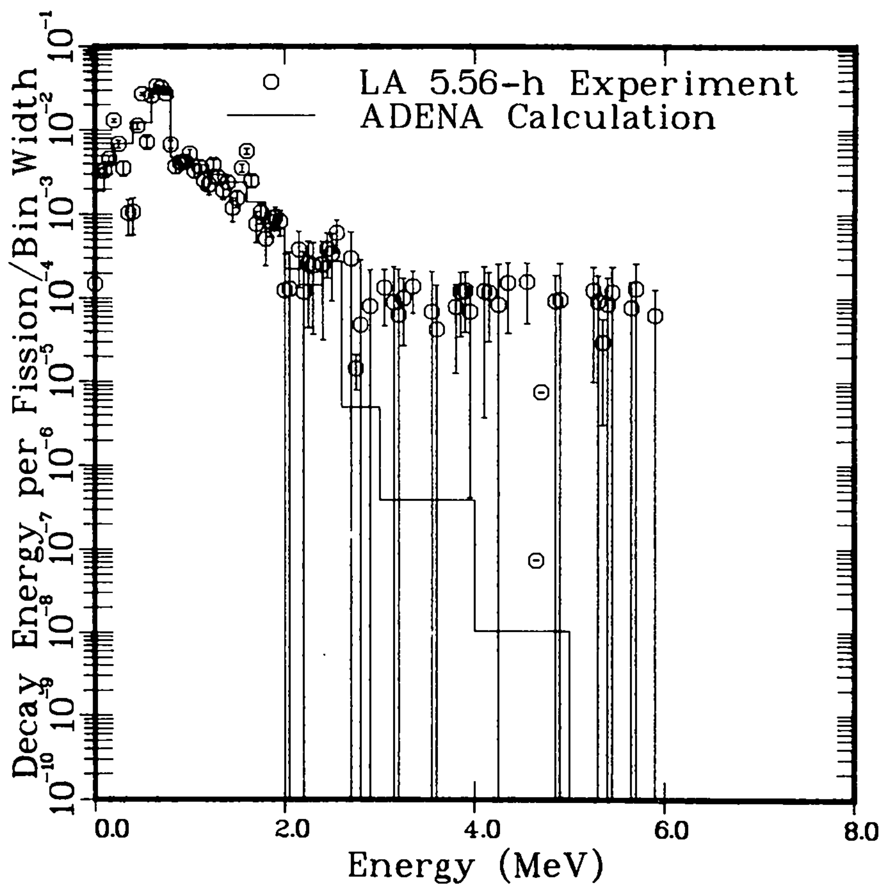


Fig. 10. Comparison of ANSI/ANS-5.1-1979 standard for ^{235}U thermal pulse fission of to the ADENA calculation.

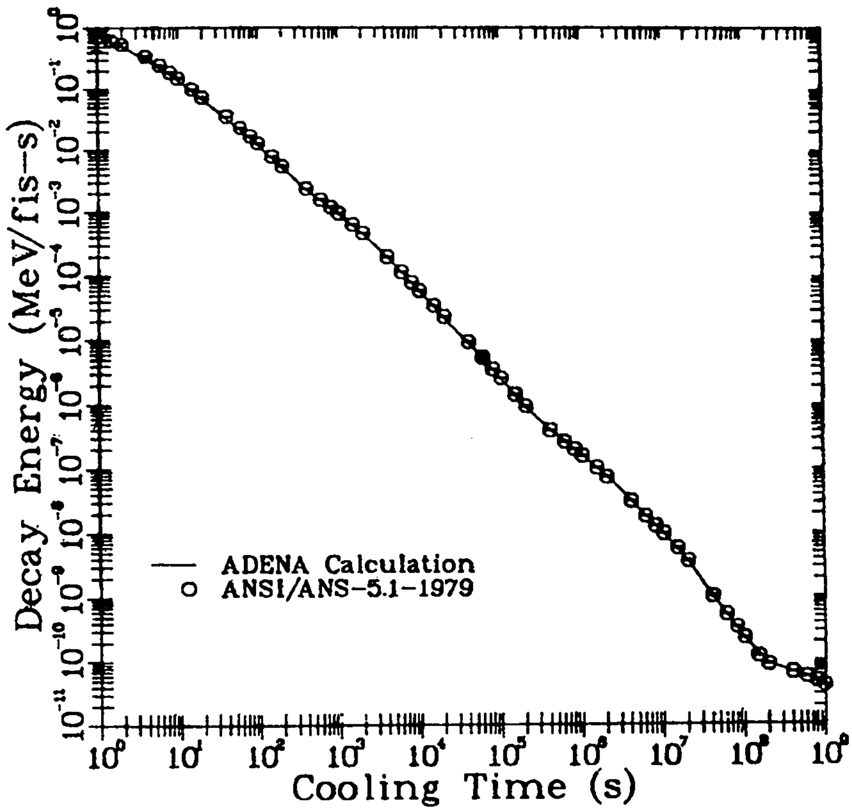
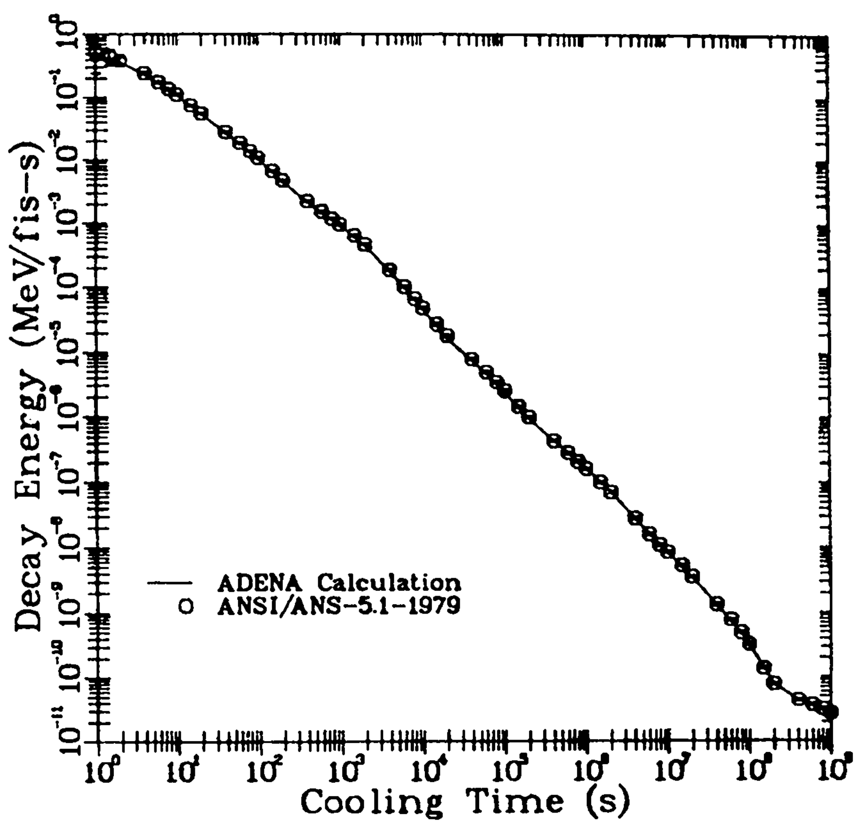


Fig. 11. Comparison of ANSI/ANS-5.1-1979 standard for ^{239}Pu thermal pulse fission of to the ADENA calculation.



section to provide the user with some guidance in assigning values to these parameters. Overall reliability of calculations with ADENA depends upon (a) the accuracy of the adjusted spectral fits and (b) the accuracy of the neutron absorption approximation. Some indication of the accuracy of the fits is obtained by the calculation of the standard noted in Sec. IV. Note, however, that this is for the decay energy from combined beta- and gamma-ray decay for the aggregate of the fission products and summed over all energy groups.

Results given in Sec. IV show that the values calculated by ADENA are all within the 2-sigma error quoted for the ^{239}Pu standard, but that 14 were outside the small 2-sigma error quoted for ^{235}U. These 14 values are shown as a function of cooling time in Table IV. Note that 9 of the 14 values occur for cooling times of 100 s or less. We therefore suggest that for problems involving totals over energy (i.e., nonspectral) and total beta- plus gamma-decay energy, an average uncertainty value of 7.5% be assumed for cooling times of 100 s or less, and an average of 4.0% be assumed for longer cooling times.

Uncertainties assigned for spectral calculations using the adjusted fits are considerably greater, however, and are more dependent on cooling-time ranges as well as being dependent upon spectral energy ranges. A rather detailed discussion of the deviations of calculations with the adjusted fits from aggregate values from summation calculations using ENDF/B-V and the deviations of adjusted fit calculations from experimental data are given in Appendix B. On the basis of the results of the analysis in this appendix, we recommend that the uncertainties given in Table V be used over the energy and cooling-time ranges given in the table for both beta- and gamma-ray decay energies and for both ^{235}U and ^{239}Pu fuels. We further suggest that the user can easily modify this table according to his needs by referring to Appendix B.

Finally, Table III is a good example of the accuracy of the two-chain approximation that the ADENA code uses to calculate neutron absorption effects for cooling times above 10^5 s. As can be seen from the table, deviations from the summation calculations do not exceed 2% for those cooling-time ranges where the absorption correction is significant. For shorter cooling times, uncertainties in spectral values calculated with the adjusted fits are considerably greater than the deviation due to absorption effects. Consequently, as a "rule of thumb," we suggest that a minimum uncertainty of 10% be assigned in Table V for ADENA calculations with significant absorption effect, i.e., large fluence and long cooling times. Neutron absorption is discussed more fully in Refs. 10 and 12.

TABLE IV

ADENA CALCULATIONS OUTSIDE 2-SIGMA OF ^{235}U STANDARD

Cooling Time (s)	1-Sigma Uncertainty in Standard (%)	Deviation of ADENA Calculation from Standard (%)
4.0E+00	4.3	10.0
6.0E+00	3.5	8.9
8.0E+00	3.1	7.6
1.0E+01	3.2	6.7
2.0E+01	2.4	6.3
4.0E+01	2.0	8.1
6.0E+01	1.9	7.5
8.0E+01	1.9	6.5
1.0E+02	1.8	5.7
2.0E+02	1.9	4.8
4.0E+02	1.9	4.5
2.0E+03	1.8	3.9
2.0E+04	1.4	4.2
4.0E+04	1.4	3.3

TABLE V

PERCENT ACCURACY OF ADJUSTED SPECTRAL FITS

Energy Ranges (MeV)	Cooling-Time Ranges (s)			
	1.0E-02-1.0E+00	1.0E+00-1.0E+04	1.0E+04-1.0E+06	1.0E+06-1.0E+09
0.0-0.6	22.8	15.3	8.2	5.0
0.6-1.6	6.9	5.8	8.4	5.0
1.6-3.0	27.2	16.5	17.0	5.0
3.0-7.5	40.5	22.3	7.8	5.0

VI. SUMMARY

A method for creating an adjusted fission-product decay-energy data base from a combination of experimental data and the ENDF/B-V fission-product data file has been described. The code ADENA, which uses the adjusted data base in calculating fission-product decay-energy spectra (including the major effects of neutron absorption) for fuel mixtures of ^{235}U and ^{239}Pu, has also been described. The code can be used for a wide variety of reactor operational and safety related computations where aggregate fission-product decay spectra are needed. This avoids the need for the large data base and code systems[10-12] we have used to produce this end product, assuming the user requires only aggregate, rather than individual nuclide, results. We have, in addition, incorporated the important experimental spectra available for short cooling times.

Several examples of the application of the ADENA code are also given, including a comparison to the ANSI/ANS 5.1-1979 Standard. A section is included from which the user can obtain an indication of the reliability of ADENA calculational results.

The adjusted parameters can be abstracted from the code listing and used directly in Eqs. (1) or (2) or the more general equations in the appendix of Ref. 10 by those users requiring spectral calculations in various spatial codes.

ACKNOWLEDGMENTS

For two fuels, the pulse functions described in this report and the associated ADENA code are the culmination of a series of related reports and codes. The need for and general utility of such functions was originally suggested by J. Lewellen and P. Hemmig (Department of Energy). Along the way, we have enjoyed discussions contributing to our work with R. Schenter, F. Schmittroth, and F. Mann (Hanford Engineering Development Lab); A. Tobias and colleagues (Central Electricity Board, U.K.); and T. Yoshida and colleagues (Nippon Atomic Industry Group Nuclear Research Laboratory, Japan). The experimental data provided by J. K. Dickens (Oak Ridge), and J. Yarnell and E. Jurney (Los Alamos) contributed vitally to this work and to earlier comparisons.

REFERENCES

1. J. K. Dickens, T. A. Love, J. W. McConnell, J. F. Emery, K. J. Northcutt, and R. W. Peelle, "Delayed Beta- and Gamma-Ray Production Due to Thermal-Neutron Fission of ^{235}U, Spectral Distributions for Times After Fission Between 2 and 14 000 sec: Tabular and Graphical Data," Oak Ridge National Laboratory report NUREG/CR-0162, ORNL/NUREG-39 (August 1978).

2. J. K. Dickens, T. R. England, T. A. Love, J. W. McConnell, J. F. Emery, K. J. Northcutt, and R. W. Peelle, "Delayed Beta- and Gamma-Ray Production Due to Thermal-Neutron Fission of ^{239}Pu: Tabular and Graphical Spectral Distributions for Times After Fission Between 2 and 14 000 sec," Oak Ridge National Laboratory report NUREG/CR-1172, ORNL/NUREG-66 (January 1980).

3. J. L. Yarnell and P. J. Bendt, "Decay Heat from Products of ^{235}U Thermal Fission by Fast-Response Boil-Off Calorimetry," Los Alamos Scientific Laboratory report LA-NUREG-6713 (September 1977).

4. J. L. Yarnell and P. J. Bendt, "Calorimetric Fission Decay Heat Measurements for ^{239}Pu, ^{233}U, and ^{235}U," Los Alamos Scientific Laboratory report NUREG/CR-0349, LA-7542-MS (September 1978).

5. E. T. Jurney, P. J. Bendt, and T. R. England, "Fission Product Gamma Spectra," Los Alamos Scientific Laboratory report LA-7620-MS (January 1979).

6. R. J. LaBauve, T. R. England, and D. C. George, "Integral Data Testing of ENDF/B Fission Product Data and Comparisons of ENDF/B with Other Fission Product Data Files," Los Alamos National Laboratory report LA-9090-MS (December 1981).

7. Fission-Product Decay Library of the Evaluated Nuclear Data File, Version V (ENDF/B-V). [Available from and maintained by the National Nuclear Data Center (NNDC) at Brookhaven National Laboratory]. NOTE: Spectral files in these compilations are based on data evaluated at INEL.

8. T. R. England, R. Wilczynski, and N. L. Whittemore, "CINDER-7: An Interim Report for Users," Los Alamos Scientific Laboratory report LA-5885-MS (April 1976). [CINDER-10, the version used in this report is unpublished. It is described in "Applied Nuclear Data Research and Development, January 1 - March 31, 1976," Los Alamos Scientific Laboratory report LA-6472-PR, p. 60 (1976), and in "Applied Nuclear Data Research and Development, October 1 - December 31, 1975," Los Alamos Scientific Laboratory report LA-6266-PR, p. 13 (1976).]

9. "American National Standard for Decay Heat Power in Light Water Reactors," prepared by the American Nuclear Society Standards Committee Working Group ANS-5.1, ANSI/ANS-5.1 (1979).

10. R. J. LaBauve, T. R. England, D. C. George, and M. G. Stamatelatos, "The Application of a Library of Processed ENDF/B-IV Fission-Product Aggregate Decay Data in the Calculation of Decay-Energy Spectra," Los Alamos Scientific Laboratory report LA-7483-MS (September 1978).

11. R. J. LaBauve, D. C. George, and T. R. England, "FITPULS, A Code for Obtaining Analytic Fits to Aggregate Fission-Product Decay-Energy Spectra," Los Alamos Scientific Laboratory report LA-8277-MS (March 1980).

12. R. J. LaBauve, T. R. England, D. C. George, and C. W. Maynard, "Fission Product Analytic Impulse Source Functions," Nucl. Tec. 56, 322 (February 1982).

APPENDIX A

A full listing of the computer code ADENA is contained in this appendix. The adjusted fits can be abstracted from the block data routine and used in other applications. The fits are in the order ^{235}U betas, ^{235}U gammas, ^{239}Pu betas, and ^{239}Pu gammas. For the beta fit, groups 1 and 2 have been combined; thus, in order to retrieve the fits for group 8 betas, one must abstract the seventh set of parameters. For nonspectral calculations of the total (beta plus gamma) decay energy, the fits to the standard have been included; see subroutine STNDRD.

Input and output listings of a sample problem have been included following the listing of the code. This problem calculates the decay-energy spectra in 12 groups (see Table II), at 2 cooling times (10^6 and 10^8 s), from a reactor whose operating time was 7.2×10^7 s, with a thermal flux of 10^{14} n/cm^2/s, an epithermal flux of 5×10^{14} n/cm^2/s, and with a fuel mixture 75% ^{235}U and 25% ^{239}Pu.

```
      PROGRAM  ADENA(INPUT,TAPE5=INPUT,TAPE6,OUTPUT,TAPE1)
C    PROGRAM TO APPROXIMATE FISSION PRODUCT DECAY ENERGY WITH
C    ABSORPTION FOR MIXTURES OF PU-239 AND U-235.
C    RESULTS IN 19 GROUP GAMMA 18 GROUP BETA STRUCTURE
C    ABSORPTION CORRECTION FROM CS, EU CHAINS.
      REAL ABCOR(2),AC(50,19,2,2),W(19,3,2),BET(19),GAM(19),TOT(19)
      REAL AAC(3800)
      EQUIVALENCE (AC(1,1,1,1),AAC(1))
      COMMON /VAR/NGI,EI(20),NTSP,T(50),UFRAC,TFLUX,ETFLUX,DTIME,UFG,
     2 UFB,PUFG,PUFB,IPLT,IST
      COMMON /ABSP/DC,YU,YPU,PEPXS,FEPXS,PTXS,FTXS
      COMMON /FITS/XLAM(20,19,4),XALP(20,19,4),KTRM(19,4)
C     FITS IN ORDER U-BETA U-GAMMA PU-BETA PU-GAMMA SEE BLOCK DATA
C   W IS THE AVERAGE  DECAY ENERGY FOR SECOND
C   NUCLIDE BY GROUPS..
      DATA (W(I,1,1),I=1,19)/.0180922,.0281686,.0768595,.0417469,
     1 .000791733,.0000108118,.618985E-7,1.84582E-6,2.28177E-8,
     2  10*0./
      DATA (W(I,1,2),I=1,19)/.000148678,0.,.0000980157,.141983,1.26973,
     1 .0700032,.0314065,.0415000,11*0./
      DATA (W(I,2,1),I=1,19)/.0390261,.0296386,.0490872,.0327957,
     1 .0398798,.0423082,.0407609,.0398081,.0376028,.0315247,
     2 .0222194,.0116397,.00297791,.0000319913,5*0./
      DATA (W(I,2,2),I=1,19)/.0141238,.00160603,.000450942,
     1 .0169239,.0964488,.142209,.276996,.255532,0.,.00553968,
     2 ,161764,.303278,.0524688,6*0./
      DATA (W(I,3,1),I=1,18)/.0191422,.0426199,.0647785,.017627,
     1 .00236877,.00046317,4.35695E-7,11*0./
      DATA (W(I,3,2),I=1,18)/.00749719,.00259804,.0487936,.751278,
     1 .822712,.171198,.204923,11*0./
      CALL FILEREP
      IF(IPLT.EQ.1) CALL GPLOT(1HU,5HPLOTA,5)
C     READ INPUT - FREE FIELD
C     CARD 1-FRACTION OF U-235 IN FUEL(UFRAC), AVERAGE THERMAL FLUX
C        (TFLUX), AVERAGE EPITHREMAL FLUX(ETFLUX), OPERATING TIME
C        (DTIME), NUMBER OF ENERGY GROUPS(NGI), NUMBER OF COOLING
C        TIMES(NTSP), PLOTTING FLAG=1 FOR PLOTS; 0 OTHERWISE(IPLT),
C      STANDARD FLAG =1 TO CALCULATE STANDARD (IST); 0 OTHERWISE
C        USE DTIME=1 FOR BURST CASE
C    CARD 2-IF NGI>0 EI(I),I=1,NGI+1, ENERGY BOUNDS
C          -IF NGI=0 USE STANDARD 19 GAMMA 18 BETA GROUPS
C          -IF NGI=-6 STANDARD 6 GROUP 0.,1.,2.,3.,4.,5.,7.5
C          -IF NGI=-12 BUILT IN 12GRP 0,.4,.8,1,1.4,1.8,2.2,2.6,3,4,5,7.5
C    CARD 3-IF NTSP=0 THEN TMIN, TMAX, RESULTS WILL BE AT EACH DECADE
C              AND HALF DECADE FROM TMIN TO TMAX
C          - IF NTSP=-1 THEN TMIN, TMAX , RESULTS WILL BE AT EACH DECADE
C              FROM TMIN TO TMAX
C          - IF NTSP>0 THEN T(1),...T(NTSP) MAXIMUM OF 50 TIMES
C    CARD 4-ADJUST FACTORS- PERCENT TO BE ADDED TO U,PU DECAY ENERGY
C        (BETA,GAMMA FOR EACH) UFG,UFB,PUFG,PUFB
       CALL READSUB
C   ACCUMULATE ABSORPTION CORRECTION
C   CONSIDER ONLY CS 133-134 AND EU 155-156 CHAINS
C   USE AC(I,J,K,L) I=COOLING TIME, J=GROUP, K=FUEL, L=BETA OR GAMMA
      NG=19
      NBG=2
      NFUEL=2
      NCHN=2
      DO 30 I=1,3800
   30 AAC(I)=0.
C   USE PULSE EQNS IF DTIME=0.
      IF(DTIME.EQ.0.) GO TO 101
C   ABSORPTION CORRECTIONS RETURNED IN ABCOR(1) FOR URANIUM ABCOR(2) FOR
C   PLUTONIUM
```

```
      DO 100 N=1,NCHN
      CALL EVAL(N,ABCDR)
C  LOOP OVER TIME STEPS (I) AND GROUPS (J) TO GET CORRECTIONS
C  K INDEX TO NUMBER OF FUELS
C  L INDEX TO BETA OR GAMMA CORRECTION
      DO 90 L=1,NBG
      DO 90 K=1,NFUEL
      DO 90 I=1,NTSP
      DO 90 J=1,NG
   90 AC(I,J,K,L)=AC(I,J,K,L)+ABCDR(K)*DC*EXP(-DC*T(I))*W(J,N,L)
  100 CONTINUE
C  CHECK FOR STANDARD CALCULATION
101   IF(IST.EQ.1) CALL STNDRD(AC)
C  FINAL ACCUMULATION IS BY COOLING TIME
C  FOR EACH TIME CALCULATED BETA, GAMMA AND TOTAL DECAY ENERGY FOR
C  EACH GROUP
C  TAKE APPROPRIATE FRACTION FOR EACH FUEL AND SUM
      DO 200 I=1,NTSP
      BTOT=GTOT=STOT=0.
      DO 150 J=1,NG
      BET(J)=0.
      GAM(J)=0.
      TOT(J)=0.
C  BETA INDICES ARE 1 FOR URANIUM AND 3 FOR PLUTONIUM
      IF(J.EQ.19) GO TO 190
      KU=KTRM(J,1)
      KPU=KTRM(J,3)
C  U-BETAS
      DO 110 K=1,KU
      XA=XALP(K,J,1)
      XL=XLAM(K,J,1)
      IF(DTIME.NE.0.)BET(J)=BET(J)+XA/XL*EXP(-XL*T(I))*(1-EXP(-XL
     1    *DTIME))
      IF(DTIME.EQ.0.) BET(J)=BET(J)+XA*EXP(-XL*T(I))
  110 CONTINUE
      BET(J)=BET(J)+AC(I,J,1,1)
      IF(UFB.LE.0.) UFB=1.
      BET(J)=BET(J)*UFB
C PU-BETAS
      TEMP=0.
      DO 120 K=1,KPU
      XA=XALP(K,J,3)
      XL=XLAM(K,J,3)
      IF(DTIME.NE.0.) TEMP=TEMP+XA/XL*EXP(-XL*T(I))*(1-EXP(-XL*DTIME))
      IF(DTIME.EQ.0.) TEMP=TEMP+XA*EXP(-XL*T(I))
  120 CONTINUE
      TEMP=TEMP+AC(I,J,2,1)
      IF(PUFB.LE.0.) PUFB=1.
      TEMP=TEMP*PUFB
C  GET FRACTIONS
      BET(J)=UFRAC*BET(J)+(1-UFRAC)*TEMP
      IF(BET(J).LT.1.0E-10) BET(J)=0.0
C  GAMMAS INDICES ARE 2,4
190   KU=KTRM(J,2)
      KPU=KTRM(J,4)
C  U-GAMMAS
      DO 130 K=1,KU
      XA=XALP(K,J,2)
      XL=XLAM(K,J,2)
      IF(DTIME.NE.0) GAM(J)=GAM(J)+XA/XL*EXP(-XL*T(I))*(1-EXP(-XL
     1    *DTIME))
      IF(DTIME.EQ.0.) GAM(J)=GAM(J)+XA*EXP(-XL*T(I))
130   CONTINUE
      GAM(J)=GAM(J)+AC(I,J,1,2)
```

```
      IF(UFG.LE.O.) UFG=1.
      GAM(J)=GAM(J)*UFG
C  PU-GAMMAS
      TEMP=O.
      DO 140 K=1,KPU
      XA=XALP(K,J,4)
      XL=XLAM(K,J,4)
      IF(DTIME.NE.O.)TEMP=TEMP+XA/XL*EXP(-XL*T(I))*(1-EXP(-XL*DTIME))
      IF(DTIME.EQ.O.) TEMP=TEMP+XA*EXP(-XL*T(I))
140   CONTINUE
      TEMP=TEMP+AC(I,J,2,2)
      IF(PUFG.LE.O.) PUFG=1.
      TEMP=TEMP*PUFG
      GAM(J)=UFRAC*GAM(J)+(1-UFRAC)*TEMP
      IF(GAM(J).LT.1.E-10) GAM(J)=0.0
C  ACCUMULATE TOTALS
      TOT(J)=GAM(J)
      IF(J.NE.1) TOT(J)=TOT(J)+BET(J-1)
      BTOT=BTOT+BET(J)
      GTOT=GTOT+GAM(J)
      STOT=STOT+TOT(J)
  150 CONTINUE
C  REGROUP IF NECESSARY
      CALL REGROUP(BET,GAM,TOT)
C  OUTPUT SECTION
      WRITE (6,151)
  151 FORMAT(1H1,T20,"FISSION PRODUCT DECAY ENERGY FOR A MIXTURE OF U-23
     15 AND PU-239")
      TEMP=(1.-UFRAC)*100.
      TEMP1=UFRAC*100.
      WRITE (6,152) TEMP1,TEMP,TFLUX,ETFLUX,DTIME,T(I)
  152 FORMAT(T30,"PERCENT U-235",T50,1PE11.4/
     1  T30,"PERCENT PU-239",T50,1PE11.4/
     2  T30,"THERMAL FLUX",T50,1PE11.4," N/CM**2-S"/
     3  T30,"EPITHERMAL FLUX",T50,1PE11.4," N/CM**2-S"/
     4  T30,"OPERATING TIME",T50,1PE11.4," SECONDS"/
     5  T30,"COOLING TIME",T50,1PE11.4," SECONDS")
      WRITE (6,160)
  160 FORMAT(1HO,T10,
     2 " GRP    ELO     EHI     BETA DECAY ENERGY    GAMMA DECAY ENERGY
     1 TOTAL DECAY ENERGY")
      WRITE (6,161)
  161 FORMAT(T10,7X,"(MEV)  (MEV)",7X,"(MEV/FIS)",12X,"(MEV/FIS)",12
     1X,"(MEV/FIS)")
      WRITE(6,162) (J,EI(J),EI(J+1),BET(J),GAM(J),TOT(J),J=1,NGI)
  162 FORMAT(T10,I4,4X,OPF3.1,4X,OPF3.1,6X,1PE13.5,8X,1PE13.5,8X,1PE13.5
     1 )
      WRITE(6,164) BTOT,GTOT,STOT
  164 FORMAT(/T10," TOTALS OVER GROUPS   ",3X,1PE13.5,8X,1PE13.5,8X,
     1     1PE13.5)
      IF(IPLT.EQ.O) GO TO 200
      CALL PLOTIT(TOT,1,I)
      CALL PLOTIT(BET,2,I)
      CALL PLOTIT(GAM,3,I)
  200 CONTINUE
      IF(IPLT.EQ.O) GO TO 250
      CALL DONEPL
      CALL GDONE
 250  STOP
      END
      SUBROUTINE REGROUP(BET,GAM,TOT)
      COMMON /VAR/NGI,EI(20),NTSP,T(50),UFRAC,TFLUX,ETFLUX,DTIME,UFG,
     2 UFB,PUFG,PUFB,IPLT,IST
      REAL E(20),BET(2),GAM(2),TOT(2),E1(7),E2(13)
```

```
      DATA E/0.,.1,.2,.4,.6,.8,1.,1.2,1.4,1.6,1.8,2.,2.2,2.4,
     1 2.6,3.,4.,5.,6.,7.5/
      DATA E1/0.,1.,2.,3.,4.,5.,7.5/
      DATA E2/0.,.4,.8,1.,1.4,1.8,2.2,2.6,3.,4.,5.,6.,7.5/
C  SHIFT BETA GROUPS DOWN SO GROUP 1 IS EMPTY
      DO 2 I=1,18
2     BET(19-I+1)=BET(19-I)
      BET(1)=0.
C  STANDARD 19 GROUPS
      IF(NGI.NE.19) GO TO 5
      DO 3 I=1,20
    3 EI(I)=E(I)
      RETURN
C  LOOK FOR STANDARD 6 AND 12 GROUPS
5       IF(NGI.GT.0) GO TO 9
      IF(NGI.NE.-6) GO TO 7
      NGI=6
      DO 6 I=1,7
6     EI(I)=E1(I)
      GO TO 9
7     NGI=12
      DO 8 I=1,13
8     EI(I)=E2(I)
9     NG=20
      JSTART=1
      DO 100 I=1,NGI
      DO 10 J=JSTART,NG
C  FIND HOW MANY GROUPS TO COMBINE
      IF(EI(I+1).EQ.E(J)) GO TO 20
   10 CONTINUE
      WRITE(6,15)
   15 FORMAT (" ILLEGAL ENERGY BOUNDS SPECIFIED")
      STOP
   20 T1=0.
      T2=0.
      T3=0.
      JEND=J-1
      DO 30 K=JSTART,JEND
      T1=T1+BET(K)
      T2=T2+GAM(K)
   30 T3=T3+TOT(K)
      BET(I)=T1
      GAM(I)=T2
      TOT(I)=T3
      JSTART=J
  100 CONTINUE
      RETURN
      END
      SUBROUTINE  READSUB
      COMMON /VAR/NGI,EI(20),NTSP,T(50),UFRAC,TFLUX,ETFLUX,DTIME,UFG,
     2 UFB,PUFG,PUFB,IPLT,IST
      READ *,UFRAC,TFLUX,ETFLUX,DTIME,NGI,NTSP,IPLT,IST
      NG1=NGI+1
      IF(NG1.LT.21) GO  TO 10
      WRITE(6,8)
    8 FORMAT(" MAX OF 20 GROUPS")
      STOP
   10 IF(NGI.GT.0) READ *,(EI(I),I=1,NG1)
      IF(NGI.EQ.0) NGI=19
      IF(NTSP.GT.0) GO TO 30
      READ *, TMIN,TMAX
      IF(TMIN.NE.TMAX) GO TO 15
      NTSP=1
      T(1)=TMIN
```

```
      GO TO 40
   15 L=IFIX(ALOG10(TMIN))
      IF(L.LT.0) L=L-1
      M=IFIX(ALOG10(TMAX)+.99)
      IF(NTSP.EQ.-1) GO TO 20
      NTSP=2*(M-L)+1
      J=1
      DO 18 I=1,NTSP,2
      T(I)=10.**(L+J-1)
      T(I+1)=5.*T(I)
      J=J+1
   18 CONTINUE
      GO TO 40
   20 NTSP=(M-L)+1
      DO 22 I=1,NTSP
   22 T(I)=10.**(L+I-1)
      GO TO 40
   30 IF(NTSP.LE.50) GO TO 35
      WRITE(6,32)
32    FORMAT(" MAX OF 50 TIME STEPS")
      STOP
   35 READ *,(T(I),I=1,NTSP)
   40 READ *,UFG,UFB,PUFG,PUFB
      RETURN
      END
      SUBROUTINE EVAL(NCID,ABCOR)
      COMMON /VAR/NGI,EI(20),NTSP,T(50),UFRAC,TFLUX,ETFLUX,DTIME,UFG,
     2 UFB,PUFG,PUFB,IPLT,IST
      COMMON /ABSP/DC,YU,YPU,PEPXS,FEPXS,PTXS,FTXS
      REAL ABCOR (2),K
C  NCID- NUCLIDE ID 1 FOR CS 2 FOR EU
C  DC DECAY CONSTANT
C  YU CUMULATIVE YIELD FRACTION FROM THERMAL FISSION U-235
C  YPU CUMULATIVE YIELD FRACTION FROM THERMAL FISSION PU-239
C  PEPXS(N,GAM) XS OF PRECURSOR EPITHERMAL
C  FEPXS(N,GAM) XS OF SECOND NUCLIDE
C  PTXS(N,GAM)  XS OF PRECURSOR THERMAL
C  FTXS(N,GAM)  XS OF SECOND NUCLIDE
C  K CONSTANT
C  EVALUATE ADDITIONAL ATOM DENSITY OF NUCLIDE 2 RESULTING
C  FROM RADIATIVE CAPTURE IN NUCLIDE 1.
C  THIS TERM IS INDEPENDENT OF GROUP OR COOLING TIME.
C  ABCOR(1) FOR U    ABCOR(2) FOR PU
C  Y*A*/K(1/(A*B)-(EXP(-A*DTIME)/(A*(B-A)))+(EXP(-B*DTIME)/(B*(B-A))))
C  A=PTXS*TFLUX+PEPXS*ETFLUX
C  B=DC+FTXS*TFLUX+FEPXS*ETFLUX
      K=1.0
      IF(NCID.EQ.1) CALL CSCHN
      IF(NCID.EQ.2) CALL EUCHN
      A=(PTXS*TFLUX+PEPXS*ETFLUX)*1.E-24
      B=DC+(FTXS*TFLUX+FEPXS*ETFLUX)*1.E-24
      ABCOR(1)=A*K*(1/(A*B)-(EXP(-A*DTIME)/(A*(B-A)))+
     1  (EXP(-B*DTIME)/(B*(B-A))))
      ABCOR(2)=ABCOR(1)*YPU
      ABCOR(1)=ABCOR(1)*YU
      RETURN
      END
      SUBROUTINE CSCHN
      COMMON /ABSP/X(7)
      REAL AR(7)
      DATA AR/1.06523E-8,.06779,0.06957,34.12,20.454,30.162,140.67/
C  FILL ABSP COMMON WITH VALUES FOR CS CHAIN
      DO 10 I=1,7
   10 X(I)=AR(I)
```

```
      RETURN
      END
      SUBROUTINE EUCHN
      COMMON /VAR/NGI,EI(20),NTSP,T(50),UFRAC,TFLUX,ETFLUX,DTIME,UFG,
     2 UFB,PUFG,PUFB,IPLT,IST
      COMMON /ABSP/X(7)
C  FILL IN ABSP COMMON WITH VALUES FOR EU CHAIN
      REAL AR(7)
      DATA AR/5.28152E-7,.00033,.00170,153.59,129.52,4059.8,484.94/
      DO 10 I=1,7
   10 X(I)=AR(I)
C  CORRECT CUMULATIVE YIELD
C  F IS FLUENCE
      F=TFLUX*DTIME*1.E-21
      FLOG=ALOG(F)
      IF(F.GT.3.0) GO TO 20
      Y=EXP(1.688*FLOG-6.565)
      GO TO 30
   20 Y=EXP(-0.1827*FLOG**2+1.47*FLOG-6.105)
   30 X(2)=X(2)+Y
      X(3)=X(3)+Y
      RETURN
      END
      SUBROUTINE PLOTIT(DT,NT,I)
      REAL X(50),Y(50),DT(2)
      INTEGER XL(2),YL(5),TL(5)
      COMMON /VAR/NGI,EI(20),NTSP,T(50),UFRAC,TFLUX,ETFLUX,DTIME,UFG,
     2 UFB,PUFG,PUFB,IPLT,IST
C  MAKE PLOTS OF DECAY ENERGY /BIN VS ENERGY FOR EACH COOLING TIME -
C  NT=1 FOR TOTAL BETA +GAMMA
C  NT=2 FOR BETA PLOT
C  NT=3 FOR GAMMA PLOT
      DATA XL,YL/10HE<NERGY> (,10HM<E>V)$     ,10HD<ECAY >E<,
     1  10HNERGY PER , 10H>F<ISSION/, 10H>B<IN >W<I, 10HDTH$
      IF(NT.NE.1) GO TO 15
      TL(1)=10H T<OTAL> E
      TL(2)=10H<NERGY FOR
      TL(3)=10H >C<OOLING
      TL(4)=10H> T<IME
      ENCODE(9,10,TL(5)) T(I)
10    FORMAT(1PE9.3)
15    IF(NT.EQ.2) TL(1)=10H  B<ETA >E
      IF(NT.EQ.3) TL(1)=10H G<AMMA >E
      NP=NGI*2
      X(1)=EI(1)
      K=2
      DO 20 J=2,NP,2
      X(J)=EI(K)
      X(J+1)=X(J)
20    K=K+1
      K=1
      DO 30 J=1,NP,2
      Y(J)=DT(K)/(EI(K+1)-EI(K))
      IF(Y(J).LE.0.0) Y(J)=1.E-10
      Y(J+1)=Y(J)
30    K=K+1
      CALL SETUP(X,Y,NP,TL,50,XL,100,YL,100,2,0,0,2)
      CALL ENDPL(0)
      RETURN
      END
      SUBROUTINE STNDRD(AC)
C CALCULATE TOTAL DECAY HEAT USING ANSI/ANS-5.1 STANDARD
      COMMON /VAR/NGI,EI(20),NTSP,T(50),UFRAC,TFLUX,ETFLUX,DTIME,UFG,
     1  UFB,PUFG,PUFB,IPLT
```

```
      REAL STL(23,2),STA(23,2),ST(50),AC(50,19,2,2)
C  U-235 ALPHAS
      DATA (STA(I,1),I=1,23)/.65057,.51264,.24384,.13850,.055440,.022225
     X,3.3088E-3,9.3015E-4,8.0943E-4,1.9567E-4,3.2535E-5,7.5595E-6,
     X 2.5232E-6,4.9948E-7,1.8531E-7,2.6608E-8,2.2398E-9,8.1641E-12,
     X 8.7797E-11,2.5131E-14,3.2176E-16,4.5038E-17,7.4791E-17/
C  U-235 LAMBDAS
      DATA (STL(I,1),I=1,23)/22.138,.51587,.19594,.10314,.033656,.011681
     X ,.0035870,.0013930,6.2630E-4,1.8906E-4,5.4988E-5,2.0958E-5,
     X 1.001E-5,2.5438E-6,6.6361E-7,1.2290E-7,2.7213E-8,4.3714E-9,
     X 7.5780E-10,2.4786E-10,
     X 2.2384E-13,2.46E-14,1.5699E-14/
C  PU-239 ALPHAS
      DATA (STA(I,2),I=1,23)/.2083,.3853,.2213,.09460,.03531,.02292,
     X .003946,.001317,7.052E-4,1.432E-4,1.765E-5,7.347E-6,
     X 1.747E-6,5.481E-7,1.671E-7,2.112E-8,2.996E-9,5.107E-11,5.730E-11,
     X 4.138E-14,1.088E-15,2.454E-17,7.557E-17/
C  PU-239 LAMBDAS
      DATA (STL(I,2),I=1,23)/10.02,.6433,.2186,.1004,.03728,.01435,
     X .004549,.001328,5.356E-4,1.73E-4,4.881E-5,2.006E-5,
     X 8.319E-6,2.358E-6,6.450E-7,1.278E-7,2.466E-8,9.378E-9,
     X 7.45E-10,2.426E-10,2.21E-13,2.64E-14,1.38E-14/
C  STANDARD FDR TDTALS DNLY
      DD 100 I=1,NTSP
      ST(I)=O.
      DD 90 J=1,2
      S=O.
C LDDP THRU URANIUM THEN PLUTDNIUM CALC
C SEE IF BURST DR FINITE IRRADIATIDN CALC
      IF(DTIME.NE.O.) GD TD 20
      DD 10 K=1,23
   10 S=S+STA(K,J)*EXP(-STL(K,J)*T(I))
      GD TD 80
   20 DD 22 K=1,23
   22 S=S+STA(K,J)/STL(K,J)*EXP(-STL(K,J)*T(I))*(1-EXP(-STL(K,J)*DTIME))
C  ADD IN ALL ABSDRPTIDN CDRRECTIDNS
      DD 30 K=1,2
      DD 30 L=1,19
   30 S=S+AC(I,L,J,K)
C FIGURE PER CENT FDR U AND PU
   80 IF(J.EQ.1) ST(I)=UFRAC*S
      IF(J.EQ.2) ST(I)=ST(I)+(1-UFRAC)*S
   90 CDNTINUE
  100 CDNTINUE
C  PRINT RESULTS
      TEMP1=UFRAC*100.
      TEMP=100.-TEMP1
      WRITE(6,150)
  150 FDRMAT(1H1,T20,"CALCULATIDN DF ANSI/ANS-5.1 STANDARD")
      WRITE (6,152) TEMP1,TEMP,TFLUX,ETFLUX,DTIME
  152 FDRMAT(T30,"PERCENT U-235",T50,1PE11.4/
     1  T30,"PERCENT PU-239",T50,1PE11.4/
     2  T30,"THERMAL FLUX",T50,1PE11.4," N/CM""2-S"/
     3  T30,"EPITHERMAL FLUX",T50,1PE11.4," N/CM""2-S"/
     4  T30,"DPERATING TIME",T50,1PE11.4," SECDNDS")
      WRITE(6,154)
  154 FDRMAT(//T10,"CDDLING TIME",T40,"TDTAL DECAY ENERGY"/
     1 T15,"(SEC)",T45,"(MEV/FIS)")
      WRITE(6,156) (T(I),ST(I),I=1,NTSP)
  156 FDRMAT (T12,1PE12.5,T42,1PE12.5)
      STDP
      RETURN
      END
      BLDCK DATA
```

```
      COMMON /FITS/ XLAM(20,19,4),XALP(20,19,4),KTRM(19,4)                DATA
C     FITS FOR U-235 BETAS                                                DATA
      DATA (XALP(K, 1,1),K=1,20)/                                         DATA
     X .6434E-11, .1913E-10, .1578E-09, .2530E-08, .1708E-07, .4206E-07,DATA
     X .1834E-06, .5005E-06, .2179E-05, .8087E-05, .2306E-04, .9554E-04,DATA
     X .5491E-03, .1982E-02, .1696E-02,-.6758E-03, .6054E-03,-.2326E-03,DATA
     XO.        ,O.        /                                              DATA
      DATA (XLAM(K, 1,1),K=1,20)/                                         DATA
     X .7896E-09, .9474E-08, .3256E-07, .1501E-06, .9199E-06, .3307E-05,DATA
     X .1780E-04, .7042E-04, .1454E-03, .4018E-03, .1345E-02, .7228E-02,DATA
     X .3395E-01, .1833E+00, .6551E+00, .8562E+00, .8475E+01, .4550E+01,DATA
     XO.        ,O.        /                                              DATA
      DATA (XALP(K, 2,1),K=1,20)/                                         DATA
     X .1062E-10, .1890E-11, .6351E-10, .2015E-08, .1576E-07, .5459E-07,DATA
     X .6061E-06, .9710E-06, .3984E-05, .1727E-04, .5401E-04, .2774E-03,DATA
     X .8341E-03, .9005E-03, .5944E-02,-.2499E-01, .2153E-01, .1110E-01,DATA
     X-.1126E-01,O.        /                                              DATA
      DATA (XLAM(K, 2,1),K=1,20)/                                         DATA
     X .7807E-09, .1148E-07, .3184E-07, .1585E-06, .6529E-06, .3463E-05,DATA
     X .1731E-04, .6245E-04, .1701E-03, .4936E-03, .1393E-02, .9581E-02,DATA
     X .3740E-01, .1121E+00, .4593E+00, .7693E+00, .8770E+00, .1010E+02,DATA
     X .9788E+01,O.        /                                              DATA
      DATA (XALP(K, 3,1),K=1,20)/                                         DATA
     X .4750E-11, .2357E-11, .7888E-10, .2391E-08, .1854E-07, .8220E-07,DATA
     X .6783E-06, .1340E-05, .9950E-05, .6032E-04, .3861E-03, .1226E-02,DATA
     X .2435E-02, .2601E-02, .5654E-02, .5239E-02,-.8991E-02,-.1611E-05,DATA
     XO.        ,O.        /                                              DATA
      DATA (XLAM(K, 3,1),K=1,20)/                                         DATA
     X .7805E-09, .1191E-07, .3140E-07, .1698E-06, .7808E-06, .4453E-05,DATA
     X .1624E-04, .6349E-04, .1951E-03, .9275E-03, .7555E-02, .3455E-01,DATA
     X .1381E+00, .3703E+00, .1792E+01, .5809E+01, .3458E+01, .1178E-03,DATA
     XO.        ,O.        /                                              DATA
      DATA (XALP(K, 4,1),K=1,20)/                                         DATA
     X .4883E-11, .1903E-10, .9872E-10, .4300E-08, .1432E-07, .1350E-06,DATA
     X .9369E-06, .5395E-05, .7592E-04, .1308E-02, .2671E-02, .9315E-02,DATA
     X .7551E-03,-.7696E-02, .9081E-02,-.5847E-03,-.7231E-04, .8844E-04,DATA
     X-.1824E-08,O.        /                                              DATA
      DATA (XLAM(K, 4,1),K=1,20)/                                         DATA
     X .7499E-09, .2138E-07, .3127E-07, .1626E-06, .7559E-06, .5469E-05,DATA
     X .2151E-04, .1349E-03, .5565E-03, .9635E-02, .4599E-01, .3322E+00,DATA
     X .1206E+02, .8495E+00, .1442E+01, .9493E-02, .6678E-03, .1281E-02,DATA
     X .1742E-06,O.        /                                              DATA
      DATA (XALP(K, 5,1),K=1,20)/                                         DATA
     X .6292E-11, .1042E-09, .6666E-10, .2504E-08, .1152E-07, .6957E-06,DATA
     X .1044E-04, .6635E-04, .1760E-01, .2071E-01,-.2346E-01,-.1872E-01,DATA
     X .3231E-02, .6294E-02, .1352E-01,-.5361E-06, .1231E-05,O.         ,DATA
     XO.        ,O.        /                                              DATA
      DATA (XLAM(K, 5,1),K=1,20)/                                         DATA
     X .7685E-09, .2614E-07, .3809E-07, .1591E-06, .1020E-05, .8643E-05,DATA
     X .1924E-03, .9142E-03, .1071E-01, .4203E+01, .3437E+01, .1116E-01,DATA
     X .1991E-01, .1267E+00, .1096E+01, .9227E-05, .3095E-04,O.         ,DATA
     XO.        ,O.        /                                              DATA
      DATA (XALP(K, 6,1),K=1,20)/                                         DATA
     X .7112E-11, .1540E-09, .6938E-10, .2156E-08, .5464E-08, .6190E-07,DATA
     X .4927E-06, .2253E-05, .1857E-04, .6168E-04, .2965E-03, .1574E-02,DATA
     X .3578E+00,-.3686E+00, .2491E-01, .7847E-02,-.2409E-02,-.4072E-09,DATA
     XO.        ,O.        /                                              DATA
      DATA (XLAM(K, 6,1),K=1,20)/                                         DATA
     X .7706E-09, .2641E-07, .4577E-07, .1623E-06, .9591E-06, .7049E-05,DATA
     X .2044E-04, .6548E-04, .3281E-03, .1229E-02, .6261E-02, .1967E-01,DATA
     X .1663E+00, .1708E+00, .2903E+00, .3439E+01, .1017E+02, .1777E-06,DATA
     XO.        ,O.        /                                              DATA
      DATA (XALP(K, 7,1),K=1,20)/                                         DATA
     X .7264E-11, .1605E-09, .8736E-10, .8811E-09, .3714E-08, .1754E-06,DATA
```

```
X .1339E-05, .2520E-05, .1466E-04, .4227E-04, .1311E-03, .8081E-03,DATA 650
X .1912E-02, .5576E-02, .3570E-02, .2204E-01,-.1461E-01, .8132E-02,DATA 660
X-.4068E-10,0.          /                                          DATA 670
 DATA (XLAM(K, 7,1),K=1,20)/                                       DATA 680
X .7709E-09, .2619E-07, .3811E-07, .1811E-06, .1336E-05, .1290E-04,DATA 690
X .3986E-04, .1399E-03, .3666E-03, .1039E-02, .4132E-02, .1239E-01,DATA 700
X .3473E-01, .1258E+00, .1675E+00, .9831E+00, .1783E+01, .4127E+01,DATA 710
X .2837E-05,0.          /                                          DATA 720
 DATA (XALP(K, 8,1),K=1,20)/                                       DATA 730
X .6463E-11, .1825E-09, .8885E-10, .3097E-09, .8137E-09, .2905E-08,DATA 740
X .1905E-06, .1107E-05, .1110E-05, .1731E-04, .4208E-04, .9869E-04,DATA 750
X .8968E-03, .2568E-02, .5091E-02, .1612E-01, .3812E-01,-.3097E-01,DATA 760
X0.        ,0.          /                                          DATA 770
 DATA (XLAM(K, 8,1),K=1,20)/                                       DATA 780
X .7583E-09, .2675E-07, .3901E-07, .3983E-06, .9840E-06, .3216E-05,DATA 790
X .1486E-04, .4059E-04, .8726E-04, .3789E-03, .1079E-02, .3565E-02,DATA 800
X .1219E-01, .4522E-01, .1086E+00, .3837E+00, .3853E+01, .4879E+01,DATA 810
X0.        ,0.          /                                          DATA 820
 DATA (XALP(K, 9,1),K=1,20)/                                       DATA 830
X .4849E-11, .2136E-09, .6448E-10, .1028E-08, .6465E-07, .1052E-05,DATA 840
X .2872E-05, .2114E-02, .1843E-01,-.7584E-02, .2210E-01,-.2356E-02,DATA 850
X .3988E-03, .1578E-02,-.1751E-10,0.         ,0.         ,0.         ,DATA 860
X0.        ,0.          /                                          DATA 870
 DATA (XLAM(K, 9,1),K=1,20)/                                       DATA 880
X .7314E-09, .2655E-07, .5161E-07, .1138E-05, .1148E-04, .3500E-04,DATA 890
X .1536E-03, .1078E-02, .1263E+00, .1502E+00, .7820E+00, .1131E-02,DATA 900
X .1823E-02, .1764E-01, .4980E-07,0.         ,0.         ,0.         ,DATA 910
X0.        ,0.          /                                          DATA 920
 DATA (XALP(K,10,1),K=1,20)/                                       DATA 930
X .2949E-11, .1980E-09, .6559E-10, .5338E-09, .8019E-07, .1207E-05,DATA 940
X .2281E-04, .5828E-04, .4859E-03, .9572E-02, .1438E-01, .2216E-01,DATA 950
X-.6902E-02,-.9159E-07,-.2522E-10,0.         ,0.         ,0.         ,DATA 960
X0.        ,0.          /                                          DATA 970
 DATA (XLAM(K,10,1),K=1,20)/                                       DATA 980
X .7714E-09, .2751E-07, .3731E-07, .1322E-05, .1422E-04, .4057E-04,DATA 990
X .4868E-03, .1670E-02, .8908E-02, .4377E-01, .1733E+00, .1193E+01,DATA1000
X .4579E-01, .2355E-02, .4412E-07,0.         ,0.         ,0.         ,DATA1010
X0.        ,0.          /                                          DATA1020
 DATA (XALP(K,11,1),K=1,20)/                                       DATA1030
X .1020E-11, .1452E-09, .7995E-10, .2193E-09, .2169E-06, .1707E-05,DATA1040
X .2067E-04, .7755E-04, .6905E-03, .2517E-02, .1233E-01, .2177E-01,DATA1050
X .4179E-02,-.1870E-03,-.8830E-06,-.1946E-10,0.         ,0.         ,DATA1060
X0.        ,0.          /                                          DATA1070
 DATA (XLAM(K,11,1),K=1,20)/                                       DATA1080
X .7529E-09, .2621E-07, .3554E-07, .2239E-05, .2054E-04, .5446E-04,DATA1090
X .5119E-03, .2029E-02, .1264E-01, .4546E-01, .1633E+00, .7341E+00,DATA1100
X .8797E+01, .6310E-01, .6605E-04, .3456E-07,0.         ,0.         ,DATA1110
X0.        ,0.          /                                          DATA1120
 DATA (XALP(K,12,1),K=1,20)/                                       DATA1130
X .1903E-12, .1072E-09, .5483E-10, .1553E-09, .1454E-06, .1201E-05,DATA1140
X .1695E-04, .5651E-04, .3952E-03, .4120E-02, .7799E-02, .1116E-01,DATA1150
X .2257E-01,-.2236E-02,-.1368E-05,-.6888E-11,0.         ,0.         ,DATA1160
X0.        ,0.          /                                          DATA1170
 DATA (XLAM(K,12,1),K=1,20)/                                       DATA1180
X .7383E-09, .2529E-07, .3435E-07, .2998E-05, .2031E-04, .5467E-04,DATA1190
X .4681E-03, .1594E-02, .9282E-02, .4844E-01, .1677E+00, .2477E+00,DATA1200
X .1378E+01, .8750E-01, .1320E-03, .2175E-07,0.         ,0.         ,DATA1210
X0.        ,0.          /                                          DATA1220
 DATA (XALP(K,13,1),K=1,20)/                                       DATA1230
X .1537E-12, .8363E-10, .2375E-10, .4104E-07, .6387E-06, .2477E-04,DATA1240
X .1345E-02, .7314E-03, .4027E-02, .3552E-01,-.2066E-01, .2439E-01,DATA1250
X-.1287E-02,-.6659E-11, .7127E-10,0.         ,0.         ,0.         ,DATA1260
X0.        ,0.          /                                          DATA1270
 DATA (XLAM(K,13,1),K=1,20)/                                       DATA1280
```

```
     X .7277E-09, .2623E-07, .4445E-07, .1752E-04, .4300E-04, .6432E-03,DATA1290
     X .3340E-02, .1420E-01, .6944E-01, .2643E+00, .2914E+00, .1245E+01,DATA1300
     X .3420E-02, .4485E-07, .2409E-05,0.        ,0.        ,0.        ,DATA1310
     X0.        ,0.        /                                            DATA1320
      DATA (XALP(K,14,1),K=1,20)/                                       DATA1330
     X .2727E-12, .4138E-10, .1706E-10, .1045E-10, .1495E-09, .1240E-07,DATA1340
     X .1340E-05, .2917E-04, .5145E-04, .4355E-03, .1236E-01, .4517E-01,DATA1350
     X .4570E-01,-.2425E-01,-.2114E-01, .2968E-01,-.4287E-06,0.        ,DATA1360
     X0.        ,0.        /                                            DATA1370
      DATA (XLAM(K,14,1),K=1,20)/                                       DATA1380
     X .7243E-09, .2441E-07, .3570E-07, .2328E-06, .3553E-05, .1636E-04,DATA1390
     X .4797E-04, .5905E-03, .1357E-02, .6814E-02, .4479E-01, .6053E+00,DATA1400
     X .3446E+01, .4152E+01, .6306E-01, .1055E+00, .8224E-04,0.        ,DATA1410
     X0.        ,0.        /                                            DATA1420
      DATA (XALP(K,15,1),K=1,20)/                                       DATA1430
     X .4153E-12, .3579E-11, .1346E-11, .1425E-10, .3418E-09, .8996E-06,DATA1440
     X .2150E-05, .4837E-04, .9929E-04, .3157E-03, .2987E-02, .3174E-01,DATA1450
     X .1002E+00, .4835E-03,-.3577E-01, .9453E-01,-.1804E-05,0.        ,DATA1460
     X0.        ,0.        /                                            DATA1470
      DATA (XLAM(K,15,1),K=1,20)/                                       DATA1480
     X .7098E-09, .2083E-07, .6657E-07, .2455E-06, .5361E-05, .3918E-04,DATA1490
     X .5184E-04, .6238E-03, .1948E-02, .6540E-02, .2109E-01, .1171E+00,DATA1500
     X .4571E+00, .3940E+01, .4790E+00, .1663E+01, .4392E-04,0.        ,DATA1510
     X0.        ,0.        /                                            DATA1520
      DATA (XALP(K,16,1),K=1,20)/                                       DATA1530
     X .1360E-12, .2872E-11, .3918E-09, .1941E-06, .5200E-05, .4277E-04,DATA1540
     X .3132E-03, .1951E+00,-.4793E+00, .3067E+00, .7505E-01, .4923E-01,DATA1550
     X-.2039E-01,-.8067E-12, .5015E-11,0.        ,0.        ,0.        ,DATA1560
     X0.        ,0.        /                                            DATA1570
      DATA (XLAM(K,16,1),K=1,20)/                                       DATA1580
     X .7006E-09, .2105E-06, .9443E-05, .4775E-04, .5230E-03, .3298E-02,DATA1590
     X .9846E-02, .7072E-01, .7851E-01, .8639E-01, .6381E+00, .1712E+01,DATA1600
     X .7458E+00, .4439E-06, .1375E-05,0.        ,0.        ,0.        ,DATA1610
     X0.        ,0.        /                                            DATA1620
      DATA (XALP(K,17,1),K=1,20)/                                       DATA1630
     X .3393E-13, .5026E-13, .1891E-12, .1251E-09, .7343E-09, .2219E-07,DATA1640
     X .1196E-05, .2789E-04, .1550E-03, .1477E-01, .2050E-01,-.1423E-01,DATA1650
     X .2480E-01,-.1599E-01,-.5153E-08,0.        ,0.        ,0.        ,DATA1660
     X0.        ,0.        /                                            DATA1670
      DATA (XLAM(K,17,1),K=1,20)/                                       DATA1680
     X .6959E-09, .2317E-06, .1891E-05, .1121E-04, .3562E-04, .7610E-04,DATA1690
     X .4750E-02, .4628E-02, .2096E-01, .1399E+00, .6032E+00, .5545E+00,DATA1700
     X .2415E+01, .3674E+01, .7165E-04,0.        ,0.        ,0.        ,DATA1710
     X0.        ,0.        /                                            DATA1720
      DATA (XALP(K,18,1),K=1,20)/                                       DATA1730
     X 1.90934E-15, 5.36465E-14, 2.33181E-11, 2.77998E-10,4.54551E-8,   DATA1740
     X 1.93885E-6, 8.71837E-5, 2.22677E-3, 5.98149E-3, 8.85817E-3,      DATA1750
     X 1.61727E-3,-2.36961E-10,-4.45492E-14, 7*0./                      DATA1760
      DATA (XLAM(K,18,1),K=1,20)/                                       DATA1770
     X 7.06343E-10, 8.33849E-7, 1.16847E-5, 6.74779E-5, 1.36779E-3,    DATA1780
     X 4.87554E-3, 2.05905E-2, 7.64181E-2, 1.98977E-1, 1.04123,         DATA1790
     X 5.21095, 7.60620E-5, 9.28661E-7, 7*0./                           DATA1800
      DATA (XALP(K,19,1),K=1,20)/                                       DATA1810
     X0.        ,0.        ,0.        ,0.        ,0.        ,0.        ,DATA1820
     X0.        ,0.        ,0.        ,0.        ,0.        ,0.        ,DATA1830
     X0.        ,0.        ,0.        ,0.        ,0.        ,0.        ,DATA1840
     X0.        ,0.        /                                            DATA1850
      DATA (XLAM(K,19,1),K=1,20)/                                       DATA1860
     X0.        ,0.        ,0.        ,0.        ,0.        ,0.        ,DATA1870
     X0.        ,0.        ,0.        ,0.        ,0.        ,0.        ,DATA1880
     X0.        ,0.        ,0.        ,0.        ,0.        ,0.        ,DATA1890
     X0.        ,0.        /                                            DATA1900
C  FITS FOR U-235 GAMMAS GROUPS 1 THROUGH 19                            DATA1905
      DATA (XALP(K, 1,2),K=1,20)/                                       DATA1910
```

```
X .1228E-12, .4447E-12, .9405E-11, .3022E-09, .6528E-08, .3318E-07,DATA1920
X .9476E-06, .7533E-05, .6507E-04, .4818E-03, .8863E-03,-.2132E-03,DATA1930
X-.3858E-05,-.3226E-07, .4742E-07,0.         ,0.         ,0.        ,DATA1940
X0.         ,0.         /                                           DATA1950
 DATA (XLAM(K, 1,2),K=1,20)/                                         DATA1960
X .8579E-09, .1275E-07, .3172E-07, .3403E-06, .1314E-05, .5054E-05,DATA1970
X .3283E-03, .1426E-02, .1041E-01, .4514E-01, .3187E+00, .4561E-01,DATA1980
X .1425E-02, .6742E-05, .3695E-04,0.         ,0.         ,0.        ,DATA1990
X0.         ,0.         /                                           DATA2000
 DATA (XALP(K, 2,2),K=1,20)/                                         DATA2010
X .4090E-13, .2485E-11, .2304E-10, .1295E-08, .2774E-07, .4529E-07,DATA2020
X .6728E-06, .5744E-05, .9158E-05, .1127E-04, .1192E-03, .7323E-03,DATA2030
X .1619E-02, .9440E-02, .2279E-03,-.4288E-08,0.         ,0.        ,DATA2040
X0.         ,0.         /                                           DATA2050
 DATA (XLAM(K, 2,2),K=1,20)/                                         DATA2060
X .4802E-08, .2080E-07, .3117E-07, .2722E-06, .2963E-05, .1461E-04,DATA2070
X .9231E-04, .4102E-03, .1158E-02, .3266E-02, .1323E-01, .4193E-01,DATA2080
X .1259E+00, .7269E+00, .1045E+02, .4334E-05,0.         ,0.        ,DATA2090
X0.         ,0.         /                                           DATA2100
 DATA (XALP(K, 3,2),K=1,20)/                                         DATA2110
X .4262E-14, .1991E-13, .3188E-15, .6465E-11, .5067E-08, .1193E-07,DATA2120
X .5075E-07, .1227E-06, .1918E-06, .1984E-04, .5503E-04, .1187E-03,DATA2130
X .9778E-03, .3131E-02, .1475E-01, .2059E-03,-.7574E-02, .1270E-01,DATA2140
X0.         ,0.         /                                           DATA2150
 DATA (XLAM(K, 3,2),K=1,20)/                                         DATA2160
X .6144E-08, .9623E-08, .1542E-06, .1262E-06, .6485E-06, .1179E-05,DATA2170
X .3726E-05, .2662E-04, .1312E-04, .3288E-03, .1102E-02, .7011E-02,DATA2180
X .1899E-01, .9157E-01, .3912E+00, .1463E+02, .4043E+00, .1026E+01,DATA2190
X0.         ,0.         /                                           DATA2200
 DATA (XALP(K, 4,2),K=1,20)/                                         DATA2210
X .2064E-13, .8636E-12, .9578E-11, .3139E-08, .3769E-07, .5032E-06,DATA2220
X .1039E-05, .2068E-04, .8651E-04, .1204E-02, .7462E-02, .1001E+00,DATA2230
X-.8124E-01, .1455E+00,-.1232E+00,-.1243E-07,0.         ,0.        ,DATA2240
X0.         ,0.         /                                           DATA2250
 DATA (XLAM(K, 4,2),K=1,20)/                                         DATA2260
X .2121E-08, .9932E-08, .2363E-07, .2110E-06, .7255E-06, .1045E-04,DATA2270
X .4414E-04, .2598E-03, .1443E-02, .1353E-01, .7951E-01, .4185E+00,DATA2280
X .4654E+00, .2092E+01, .2209E+01, .7486E-06,0.         ,0.        ,DATA2290
X0.         ,0.         /                                           DATA2300
 DATA (XALP(K, 5,2),K=1,20)/                                         DATA2310
X .2574E-10, .7418E-11, .2867E-10, .1984E-07, .2611E-06, .1350E-05,DATA2320
X .1972E-04, .7089E-04, .3109E-03, .2301E-02, .8318E-02, .1851E+01,DATA2330
X-.1906E+01, .1591E+00,-.6489E-01,-.1156E-07,0.         ,0.        ,DATA2340
X0.         ,0.         /                                           DATA2350
 DATA (XLAM(K, 5,2),K=1,20)/                                         DATA2360
X .7376E-09, .1713E-07, .4871E-07, .1228E-06, .2894E-05, .1485E-04,DATA2370
X .1964E-03, .1152E-02, .4265E-02, .2561E-01, .1481E+00, .1395E+01,DATA2380
X .1437E+01, .3249E+01, .4622E+01, .1979E-06,0.         ,0.        ,DATA2390
X0.         ,0.         /                                           DATA2400
 DATA (XALP(K, 6,2),K=1,20)/                                         DATA2410
X .1259E-16, .2938E-12, .9255E-13, .7414E-08, .1273E-07, .4374E-07,DATA2420
X .1052E-05, .2150E-04, .2559E-04, .2235E-03, .8837E-03, .3410E-02,DATA2430
X .1101E-01, .4631E-01, .2531E-01,0.         ,0.         ,0.        ,DATA2440
X0.         ,0.         /                                           DATA2450
 DATA (XLAM(K, 6,2),K=1,20)/                                         DATA2460
X .5695E-09, .2122E-07, .3302E-07, .5605E-06, .8313E-06, .4035E-05,DATA2470
X .3179E-04, .1608E-03, .2116E-03, .1521E-02, .1108E-01, .4970E-01,DATA2480
X .2147E+00, .9452E+00, .4542E+01,0.         ,0.         ,0.        ,DATA2490
X0.         ,0.         /                                           DATA2500
 DATA (XALP(K, 7,2),K=1,20)/                                         DATA2510
X .9554E-17, .180[illegible]-11, .2164E-13, .1910E-10, .3362E-09, .1093E-07,DATA2520
X .2442E-06, .7977E-06, .1458E-04, .1037E-03, .3971E-03, .2181E-02,DATA2530
X .5714E-02, .1870E-01, .3736E-01,-.6221E-01, .4891E-01,0.        ,DATA2540
X0.         ,0.         /                                           DATA2550
```

```
      DATA (XLAM(K, 7,2),K=1,20)/
     X .7047E-09, .2167E-07, .2207E-07, .3623E-06, .8302E-06, .2815E-05,
     X .1497E-04, .2924E-04, .1891E-03, .1162E-02, .6912E-02, .2700E-01,
     X .1068E+00, .4804E+00, .1129E+01, .2848E+01, .4440E+01,0.        ,
     X0.        ,0.        /
      DATA (XALP(K, 8,2),K=1,20)/
     X .2433E-16, .3457E-13, .1720E-12, .3215E-10, .3094E-08, .2218E-07,
     X .8842E-07, .3442E-05, .1351E-04, .1040E-03, .2014E-02, .7000E-02,
     X .1128E+00,-.3390E-01, .5434E+00,-.5846E+00,-.1887E-03,0.        ,
     X0.        ,0.        /
      DATA (XLAM(K, 8,2),K=1,20)/
     X .1824E-08, .2029E-07, .3403E-07, .1420E-06, .1775E-05, .2891E-05,
     X .1268E-04, .5066E-04, .2003E-03, .1186E-02, .1179E-01, .9864E-01,
     X .8032E+00, .7183E+00, .2027E+01, .1897E+01, .1082E-01,0.        ,
     X0.        ,0.        /
      DATA (XALP(K, 9,2),K=1,20)/
     X .2657E-17, .4743E-11, .2442E-11, .1499E-06, .1019E-04, .1913E-03,
     X .1784E-02, .8929E-02, .1433E-01,-.6409E-02, .8391E-02,-.2153E-03,
     X .1150E-03,-.2028E-06, .1274E-06,-.1911E-06, .7048E-06,0.        ,
     X0.        ,0.        /
      DATA (XLAM(K, 9,2),K=1,20)/
     X .4328E-09, .2620E-07, .3741E-07, .6916E-06, .1507E-03, .6732E-03,
     X .1162E-01, .2082E+00, .1520E+01, .3379E-01, .3717E-01, .8070E-03,
     X .1756E-02, .8980E-06, .1065E-05, .8004E-05, .2568E-04,0.        ,
     X0.        ,0.        /
      DATA (XALP(K,10,2),K=1,20)/
     X .2671E-18, .1056E-12, .4417E-13, .1072E-11, .1159E-08, .1388E-08,
     X .4823E-06, .3281E-05, .1291E-04, .4864E-03, .3784E-02, .1598E-01,
     X-.1040E+00, .1049E+00,-.2317E-05,-.4039E-03, .5889E-03, .2100E-02,
     X0.        ,0.        /
      DATA (XLAM(K,10,2),K=1,20)/
     X .6182E-10, .2175E-07, .2117E-06, .8332E-06, .2418E-05, .5228E-05,
     X .2323E-04, .1063E-03, .4402E-03, .1501E-02, .1246E+00, .4091E+00,
     X .1520E+01, .1693E+01, .4745E+02, .1485E-02, .1012E-01, .3991E-01,
     X0.        ,0.        /
      DATA (XALP(K,11,2),K=1,20)/
     X .2024E-18, .5844E-13, .6540E-10, .1507E-08, .2069E-08, .2169E-07,
     X .2723E-06, .2706E-05, .1521E-04, .5338E-04, .1569E-03, .6287E-03,
     X .1160E-02, .6638E-02, .1869E-01, .2948E-01,0.        ,0.        ,
     X0.        ,0.        /
      DATA (XLAM(K,11,2),K=1,20)/
     X .9974E-10, .2208E-07, .5904E-06, .2846E-05, .2872E-05, .2110E-04,
     X .2734E-04, .1085E-03, .4563E-03, .1452E-02, .6788E-02, .1403E-01,
     X .3474E-01, .1469E+00, .6451E+00, .1739E+01,0.        ,0.        ,
     X0.        ,0.        /
      DATA (XALP(K,12,2),K=1,20)/
     X .2671E-12, .3418E-10, .2562E-08, .3248E-09, .3678E-06, .2663E-05,
     X .2568E-04, .8103E-04, .1192E-02, .4033E-02, .8527E-02, .1476E+00,
     X-.1415E+00,-.1026E-10,0.        ,0.        ,0.        ,0.        ,
     X0.        ,0.        /
      DATA (XLAM(K,12,2),K=1,20)/
     X .2274E-07, .2879E-07, .2204E-05, .2203E-05, .4780E-04, .1152E-03,
     X .4940E-03, .2200E-02, .1736E-01, .9531E-01, .3754E+00, .4271E+01,
     X .4296E+01, .2996E-07,0.        ,0.        ,0.        ,0.        ,
     X0.        ,0.        /
      DATA (XALP(K,13,2),K=1,20)/
     X .8784E-13, .1050E-16, .1016E-15, .4116E-11, .9380E-09, .4627E-09,
     X .1670E-06, .2679E-05, .1391E-04, ..6762E-04, .1035E-02, .5141E-02,
     X .1035E+00, .2306E-01,-.1034E+00,0.        ,0.        ,0.        ,
     X0.        ,0.        /
      DATA (XLAM(K,13,2),K=1,20)/
     X .2174E-07, .1889E-07, .3614E-06, .4137E-06, .6352E-06, .2476E-05,
     X .4117E-04, .8088E-04, .3708E-03, .2403E-02, .1483E-01, .1085E+00,
     X .1296E+01, .3206E+01, .1609E+01,0.        ,0.        ,0.        ,
```

```
     XO.         ,O.        /                                            DATA3200
      DATA (XALP(K,14,2),K=1,20)/                                        DATA3210
     X .4550E-13, .2863E-14, .3774E-09, .4319E-08, .4902E-06, .2073E-05,DATA3220
     X .5159E-04, .1950E-03, .1111E-02, .3164E-02, .6179E-02, .1502E-04,DATA3230
     X-.3600E-04,-.2081E-08,O.         ,O.         ,O.         ,O.         ,DATA3240
     XO.         ,O.        /                                            DATA3250
      DATA (XLAM(K,14,2),K=1,20)/                                        DATA3260
     X .2174E-07, .8104E-07, .9897E-06, .6300E-06, .5834E-04, .9839E-04,DATA3270
     X .6065E-03, .4739E-02, .2031E-01, .9459E-01, .3370E+00, .1394E+02,DATA3280
     X .6874E-03, .2182E-05,O.         ,O.         ,O.         ,O.         ,DATA3290
     XO.         ,O.        /                                            DATA3300
      DATA (XALP(K,15,2),K=1,20)/                                        DATA3310
     X .2495E-13, .7280E-14, .7767E-10, .3281E-06, .3060E-05, .7557E-05,DATA3320
     X .1161E-03, .1366E-02, .3349E-02, .1577E-01, .1207E-02,-.3044E-01,DATA3330
     X .3383E-01,-.5577E-04, O., O., O., O.,                             DATA3340
     XO.         ,O.        /                                            DATA3350
      DATA (XLAM(K,15,2),K=1,20)/                                        DATA3360
     X .2173E-07, .2794E-07, .6198E-06, .5951E-04, .2018E-03, .3211E-03,DATA3370
     X .2357E-02, .1367E-01, .5757E-01, .2826E+00, .4177E+01, .1392E+01,DATA3380
     X .1657E+01, .3513E+01, O., O., O., O.,                             DATA3390
     XO.         ,O.        /                                            DATA3400
      DATA (XALP(K,16,2),K=1,20)/                                        DATA3410
     X .6504E-14, 2.669E-18, 5.395E-13, 4.068E-11, 2.719E-07, 3.819E-06,DATA3420
     X 5.467E-05, 2.832E-05, 1.781E-03, 5.359E-03, 1.624E-02, 2.948E-02,DATA3430
     X-1.603E-02, 7.184E-03,-2.691E-12,-3.153E-11, O., O.,               DATA3440
     XO.         ,O.        /                                            DATA3450
      DATA (XLAM(K,16,2),K=1,20)/                                        DATA3460
     X .2173E-07, 2.188E-08, 4.266E-07, 6.412E-07, 7.441E-05, 1.887E-04,DATA3470
     X 1.244E-03, 1.767E-03, 1.124E-02, 5.813E-02, 1.825E-01, 6.914E-01,DATA3480
     X 1.777E+00, 4.474E+00, 6.246E-07, 3.729E-06, O., O.,               DATA3490
     XO.         ,O.        /                                            DATA3500
      DATA (XALP(K,17,2),K=1,20)/                                        DATA3510
     X 2.168E-19, 6.995E-09, 2.267E-08, 1.791E-07, 5.588E-05, 2.432E-04,DATA3520
     X 1.063E-03, 6.520E-03, 2.135E-02, 3.497E-03,-1.341E-03,-6.313E-09,DATA3530
     X 8.807E-03,-9.967E-03,O.         ,O.         ,O.         ,O.         ,DATA3540
     XO.         ,O.        /                                            DATA3550
      DATA (XLAM(K,17,2),K=1,20)/                                        DATA3560
     X 4.141E-06, 6.319E-05, 7.671E-05, 4.034E-04, 3.650E-03, 5.320E-03,DATA3570
     X 1.907E-02, 9.760E-02, 5.200E-01, 1.119E+01, 1.931E-01, 3.985E-04,DATA3580
     X 9.947E-02, 9.387E-02,O.         ,O.         ,O.         ,O.         ,DATA3590
     XO.         ,O.        /                                            DATA3600
      DATA (XALP(K,18,2),K=1,20)/                                        DATA3610
     X 8.816E-20, 2.179E-15, 2.465E-13, 1.821E-07, 3.242E-05, 2.858E-04,DATA3620
     X 2.039E-01,-2.012E-01, 4.292E-03,-2.908E-03, 9.703E-04,-5.322E-04,DATA3630
     X-6.367E-20, 2.267E-03,-1.939E-03, .1000E-20,O.         ,O.         ,DATA3640
     XO.         ,O.        /                                            DATA3650
      DATA (XLAM(K,18,2),K=1,20)/                                        DATA3660
     X 5.758E-06, 2.011E-04, 6.372E-04, 2.754E-03, 5.036E-03, 1.138E-02,DATA3670
     X 2.014E-01, 2.022E-01, 4.014E-01, 4.045E-01, 1.201E+00, 1.824E+00,DATA3680
     X 7.043E-06, 4.107E-02, 4.044E-02, .1000E-05,O.         ,O.         ,DATA3690
     XO.         ,O.        /                                            DATA3700
      DATA (XALP(K,19,2),K=1,20)/                                        DATA3710
     X 3.44840E-21, 8.39004E-21,3.62256E-19, 4.63223E-17, 4.49234E-9,    DATA3720
     X 1.07130E-5, 1.31924E-5, 2.51500E-4, -1.57334E-4, 8.27934E-5,      DATA3730
     X -1.63636E-5, -9.44376E-21,8*0./                                   DATA3740
      DATA (XLAM(K,19,2),K=1,20)/                                        DATA3750
     X 4.26783E-6, 2.10226E-5, 2.05656E-4, 6.05335E-4, 5.32009E-3,       DATA3760
     X 8.59635E-3, 1.35035E-2, .187459, .325807, .956266, 1.13647,       DATA3770
     X 2.15828E-5,8*0./                                                  DATA3780
C  FITS FOR PU-239 BETAS  GROUPS 1 AND 2 COMBINED INTO 1                 DATA3785
      DATA (XALP(K, 1,3),K=1,20)/                                        DATA3790
     X .5119E-11, .5897E-10, .7550E-09, .3890E-08, .3120E-07, .8983E-07,DATA3800
     X .2280E-06, .4645E-05, .2900E-04, .4929E-04, .2540E-03, .8475E-03,DATA3810
     X .4021E-04, .3211E-04, .3215E-05,O.         ,O.         ,O.         ,DATA3820
```

```
XO.         ,O.        /                                              DATA3830
 DATA (XLAM(K, 1,3),K=1,20)/                                          DATA3840
X .8882E-09, .1583E-07, .8552E-07, .2910E-06, .1431E-05, .6194E-05,DATA3850
X .2573E-04, .1800E-03, .8218E-03, .4258E-02, .1513E-01, .8165E-01,DATA3860
X .1433E+00, .4597E+00, .9689E+01,O.          ,O.          ,O.          ,DATA3870
XO.         ,O.        /                                              DATA3880
 DATA (XALP(K, 2,3),K=1,20)/                                          DATA3890
X .6815E-11, .5074E-10, .8639E-09, .6740E-08, .2546E-07, .2057E-06,DATA3900
X .1088E-05, .7335E-05, .6070E-04, .1277E-03, .5421E-03, .1033E-02,DATA3910
X .8253E-03, .5389E-03, .6076E-04,O.          ,O.          ,O.          ,DATA3920
XO.         ,O.        /                                              DATA3930
 DATA (XLAM(K, 2,3),K=1,20)/                                          DATA3940
X .7591E-09, .2618E-07, .1405E-06, .4525E-06, .1392E-05, .7443E-05,DATA3950
X .3189E-04, .1980E-03, .8686E-03, .5066E-02, .1791E-01, .5746E-01,DATA3960
X .2753E+00, .9173E+00, .4599E+01,O.          ,O.          ,O.          ,DATA3970
XO.         ,O.        /                                              DATA3980
 DATA (XALP(K, 3,3),K=1,20)/                                          DATA3990
X .2331E-11, .6773E-10, .4448E-09, .6469E-08, .2265E-07, .1876E-06,DATA4000
X .9492E-06, .2378E-05, .2535E-04, .8596E-04, .4259E-03, .1130E-02,DATA4010
X .1605E-02, .2016E-02, .4068E-03,O.          ,O.          ,O.          ,DATA4020
XO.         ,O.        /                                              DATA4030
 DATA (XLAM(K, 3,3),K=1,20)/                                          DATA4040
X .7847E-09, .2413E-07, .1174E-06, .4460E-06, .1391E-05, .7015E-05,DATA4050
X .2461E-04, .1012E-03, .3937E-03, .1494E-02, .8519E-02, .3219E-01,DATA4060
X .8691E-01, .5182E+00, .2517E+01,O.          ,O.          ,O.          ,DATA4070
XO.         ,O.        /                                              DATA4080
 DATA (XALP(K, 4,3),K=1,20)/                                          DATA4090
X .2049E-11, .1108E-09, .5264E-09, .4655E-08, .2002E-07, .1850E-06,DATA4100
X .8825E-06, .3569E-05, .3391E-04, .6498E-04, .4854E-03, .1538E-02,DATA4110
X .3867E-02, .1255E-02, .7133E-05,O.          ,O.          ,O.          ,DATA4120
XO.         ,O.        /                                              DATA4130
 DATA (XLAM(K, 4,3),K=1,20)/                                          DATA4140
X .7507E-09, .2418E-07, .1156E-06, .4219E-06, .1460E-05, .7192E-05,DATA4150
X .2458E-04, .1158E-03, .4870E-03, .1587E-02, .7846E-02, .2731E-01,DATA4160
X .1339E+00, .3199E+00, .6246E+00,O.          ,O.          ,O.          ,DATA4170
XO.         ,O.        /                                              DATA4180
 DATA (XALP(K, 5,3),K=1,20)/                                          DATA4190
X .2439E-11, .1568E-09, .4441E-09, .2337E-08, .1279E-07, .1047E-06,DATA4200
X .4656E-06, .2064E-05, .2006E-04, .7338E-04, .5369E-03, .1655E-02,DATA4210
X .2997E-02, .6525E-02, .1815E-02,O.          ,O.          ,O.          ,DATA4220
XO.         ,O.        /                                              DATA4230
 DATA (XLAM(K, 5,3),K=1,20)/                                          DATA4240
X .7504E-09, .2410E-07, .1074E-06, .3520E-06, .1432E-05, .6781E-05,DATA4250
X .1957E-04, .7239E-04, .3514E-03, .1307E-02, .7554E-02, .2869E-01,DATA4260
X .1045E+00, .4012E+00, .1983E+01,O.          ,O.          ,O.          ,DATA4270
XO.         ,O.        /                                              DATA4280
 DATA (XALP(K, 6,3),K=1,20)/                                          DATA4290
X .2630E-11, .2006E-09, .2809E-09, .1345E-08, .6247E-08, .4608E-07,DATA4300
X .3230E-06, .1579E-05, .1667E-04, .6838E-04, .5111E-03, .1826E-02,DATA4310
X .3938E-02, .6417E-02, .1507E-02,O.          ,O.          ,O.          ,DATA4320
XO.         ,O.        /                                              DATA4330
 DATA (XLAM(K, 6,3),K=1,20)/                                          DATA4340
X .7524E-09, .2402E-07, .9519E-07, .3138E-06, .1343E-05, .6853E-05,DATA4350
X .1819E-04, .6169E-04, .3381E-03, .1311E-02, .7685E-02, .2827E-01,DATA4360
X .1140E+00, .4672E+00, .2453E+01,O.          ,O.          ,O.          ,DATA4370
XO.         ,O.        /                                              DATA4380
 DATA (XALP(K, 7,3),K=1,20)/                                          DATA4390
X .2669E-11, .2368E-09, .1117E-09, .6499E-09, .3244E-08, .2113E-07,DATA4400
X .2830E-06, .1318E-05, .1476E-04, .6597E-04, .4800E-03, .1977E-02,DATA4410
X .5113E-02, .8198E-02, .1718E-02,O.          ,O.          ,O.          ,DATA4420
XO.         ,O.        /                                              DATA4430
 DATA (XLAM(K, 7,3),K=1,20)/                                          DATA4440
X .7529E-09, .2395E-07, .7533E-07, .3016E-06, .1357E-05, .6895E-05,DATA4450
X .1905E-04, .5995E-04, .3314E-03, .1306E-02, .7605E-02, .2859E-01,DATA4460
```

```
X .1199E+00, .4470E+00, .3161E+01,0.        ,0.        ,0.        ,DATA4470
X0.        ,0.        /                                             DATA4480
 DATA (XALP(K, 8,3),K=1,20)/                                         DATA4490
X .2420E-11, .2604E-09, .3715E-10, .3381E-09, .1968E-08, .1364E-07,DATA4500
X .2439E-06, .1116E-05, .1347E-04, .6335E-04, .4102E-03, .1905E-02,DATA4510
X .7426E-02, .1102E-01, .2431E-02,0.        ,0.        ,0.        ,DATA4520
X0.        ,0.        /                                             DATA4530
 DATA (XLAM(K, 8,3),K=1,20)/                                         DATA4540
X .7532E-09, .2386E-07, .5222E-07, .3842E-06, .1474E-05, .7069E-05,DATA4550
X .1943E-04, .5450E-04, .3417E-03, .1313E-02, .7243E-02, .2757E-01,DATA4560
X .1317E+00, .5374E+00, .1742E+01,0.        ,0.        ,0.        ,DATA4570
X0.        ,0.        /                                             DATA4580
 DATA (XALP(K, 9,3),K=1,20)/                                         DATA4590
X .1878E-11, .2680E-09, .3369E-10, .1866E-09, .1196E-08, .6570E-08,DATA4600
X .1778E-06, .8040E-06, .1244E-04, .6067E-04, .3749E-03, .1892E-02,DATA4610
X .7177E-02, .1117E-01, .2441E-02,0.        ,0.        ,0.        ,DATA4620
X0.        ,0.        /                                             DATA4630
 DATA (XLAM(K, 9,3),K=1,20)/                                         DATA4640
X .7537E-09, .2377E-07, .5089E-07, .4034E-06, .1600E-05, .6887E-05,DATA4650
X .1972E-04, .4704E-04, .3563E-03, .1310E-02, .7270E-02, .2882E-01,DATA4660
X .1275E+00, .4606E+00, .2457E+01,0.        ,0.        ,0.        ,DATA4670
X0.        ,0.        /                                             DATA4680
 DATA (XALP(K,10,3),K=1,20)/                                         DATA4690
X .1158E-11, .2582E-09, .3229E-10, .9044E-10, .5239E-09, .3076E-08,DATA4700
X .1604E-06, .6059E-06, .1017E-04, .5633E-04, .3146E-03, .1642E-02,DATA4710
X .7810E-02, .1161E-01, .4786E-02,0.        ,0.        ,0.        ,DATA4720
X0.        ,0.        /                                             DATA4730
 DATA (XLAM(K,10,3),K=1,20)/                                         DATA4740
X .7549E-09, .2362E-07, .4904E-07, .3593E-06, .1570E-05, .6889E-05,DATA4750
X .2091E-04, .4810E-04, .3897E-03, .1238E-02, .7345E-02, .2806E-01,DATA4760
X .1257E+00, .4593E+00, .4158E+01,0.        ,0.        ,0.        ,DATA4770
X0.        ,0.        /                                             DATA4780
 DATA (XALP(K,11,3),K=1,20)/                                         DATA4790
X .4893E-12, .2324E-09, .2848E-10, .3249E-10, .1059E-09, .2470E-08,DATA4800
X .1398E-06, .4286E-06, .9132E-05, .5456E-04, .2526E-03, .1547E-02,DATA4810
X .8177E-02, .1284E-01, .4237E-02,0.        ,0.        ,0.        ,DATA4820
X0.        ,0.        /                                             DATA4830
 DATA (XLAM(K,11,3),K=1,20)/                                         DATA4840
X .7587E-09, .2344E-07, .4668E-07, .2829E-06, .1664E-05, .8128E-05,DATA4850
X .2152E-04, .4695E-04, .4246E-03, .1236E-02, .7192E-02, .2789E-01,DATA4860
X .1323E+00, .4483E+00, .4122E+01,0.        ,0.        ,0.        ,DATA4870
X0.        ,0.        /                                             DATA4880
 DATA (XALP(K,12,3),K=1,20)/                                         DATA4890
X .1915E-12, .1950E-09, .2300E-10, .2236E-10, .2488E-09, .3744E-07,DATA4900
X .3702E-06, .8964E-05, .5010E-04, .1958E-03, .1476E-02, .7887E-02,DATA4910
X .1339E-01, .4395E-02,0.        ,0.        ,0.        ,0.        ,DATA4920
X0.        ,0.        /                                             DATA4930
 DATA (XLAM(K,12,3),K=1,20)/                                         DATA4940
X .7652E-09, .2320E-07, .5096E-07, .3528E-06, .3786E-05, .1540E-04,DATA4950
X .3900E-04, .4644E-03, .1274E-02, .6800E-02, .2764E-01, .1371E+00,DATA4960
X .4143E+00, .3473E+01,0.        ,0.        ,0.        ,0.        ,DATA4970
X0.        ,0.        /                                             DATA4980
 DATA (XALP(K,13,3),K=1,20)/                                         DATA4990
X .1704E-12, .1474E-09, .1561E-10, .1592E-10, .1887E-09, .2041E-07,DATA5000
X .3010E-06, .9338E-05, .4301E-04, .1146E-03, .1512E-02, .7586E-02,DATA5010
X .1418E-01, .4085E-02,0.        ,0.        ,0.        ,0.        ,DATA5020
X0.        ,0.        /                                             DATA5030
 DATA (XLAM(K,13,3),K=1,20)/                                         DATA5040
X .7606E-09, .2289E-07, .4910E-07, .2551E-06, .4225E-05, .1492E-04,DATA5050
X .4040E-04, .5009E-03, .1338E-02, .5592E-02, .2749E-01, .1422E+00,DATA5060
X .4899E+00, .3028E+01,0.        ,0.        ,0.        ,0.        ,DATA5070
X0.        ,0.        /                                             DATA5080
 DATA (XALP(K,14,3),K=1,20)/                                         DATA5090
X .3008E-12, .1551E-09, .1037E-10, .2433E-10, .2786E-09, .9032E-08,DATA5100
```

```
     X .4663E-06, .1672E-04, .6538E-04, .2303E-03, .2097E-02, .1452E-01,DATA5110
     X .2618E-01, .9535E-02,0.        ,0.        ,0.        ,0.        ,DATA5120
     X0.        ,0.        /                                            DATA5130
      DATA (XLAM(K,14,3),K=1,20)/                                       DATA5140
     X .7514E-09, .2224E-07, .4785E-07, .2477E-06, .4257E-05, .1270E-04,DATA5150
     X .4199E-04, .5579E-03, .1284E-02, .6216E-02, .2640E-01, .1376E+00,DATA5160
     X .4918E+00, .3000E+01,0.        ,0.        ,0.        ,0.        ,DATA5170
     X0.        ,0.        /                                            DATA5180
      DATA (XALP(K,15,3),K=1,20)/                                       DATA5190
     X .4543E-12, .3983E-10, .8334E-11, .2808E-10, .1169E-09, .6576E-08,DATA5200
     X .5397E-06, .2329E-04, .8706E-04, .4345E-03, .3394E-02, .3286E-01,DATA5210
     X .5802E-01, .1363E-01,0.        ,0.        ,0.        ,0.        ,DATA5220
     X0.        ,0.        /                                            DATA5230
      DATA (XLAM(K,15,3),K=1,20)/                                       DATA5240
     X .7371E-09, .2121E-07, .9686E-07, .2722E-06, .3451E-05, .1211E-04,DATA5250
     X .5192E-04, .5555E-03, .1414E-02, .7911E-02, .3107E-01, .1565E+00,DATA5260
     X .7539E+00, .1432E+01,0.        ,0.        ,0.        ,0.        ,DATA5270
     X0.        ,0.        /                                            DATA5280
      DATA (XALP(K,16,3),K=1,20)/                                       DATA5290
     X 1.453E-13, 6.189E-12, 6.941E-12, 3.335E-10, 3.960E-09, 2.716E-07,DATA5300
     X 1.927E-06, 4.636E-06, 7.133E-05, 5.462E-04, 1.437E-02,           DATA5310
     X 4.122E-02, 1.510E-02,0.        ,0.        ,0.        ,0.        ,DATA5320
     X0.        ,0.        ,0.        /                                 DATA5330
      DATA (XLAM(K,16,3),K=1,20)/                                       DATA5340
     X 6.892E-10, 2.079E-07, 1.675E-06, 8.784E-06, 2.069E-05, 7.051E-05,DATA5350
     X 4.956E-04, 1.579E-03, 7.532E-03, 2.272E-02, 1.325E-01, 6.950E-01,DATA5360
     X 1.797E+00,0.0        ,0.        ,0.        ,0.        ,0.        ,DATA5370
     X0.        ,0.        /                                            DATA5380
      DATA (XALP(K,17,3),K=1,20)/                                       DATA5390
     X 3.722E-14, 8.313E-13, 4.292E-10, 1.992E-08, 1.150E-06, 2.139E-05,DATA5400
     X 9.618E-05, 1.830E-03, 1.120E-02, 3.234E-02,-1.431E-02, 7.555E-03,DATA5410
     X-4.665E-03,-1.395E-08,-1.568E-12, 1.454E-12,0.        ,0.        ,DATA5420
     X0.        ,0.        /                                            DATA5430
      DATA (XLAM(K,17,3),K=1,20)/                                       DATA5440
     X 7.203E-10, 3.787E-07, 1.307E-05, 6.274E-05, 1.595E-03, 8.367E-03,DATA5450
     X 3.223E-02, 9.089E-02, 2.464E-01, 1.048E+00, 6.151E-01, 5.771E+00,DATA5460
     X 2.811E+00, 6.510E-05, 5.143E-07, 6.850E-07,0.        ,0.        ,DATA5470
     X0.        ,0.        /                                            DATA5480
      DATA (XALP(K,18,3),K=1,20)/                                       DATA5490
     X 2.02247E-15,4.26636E-13, 8.99431E-10, 5.76412E-8, 2.47780E-6,    DATA5500
     X 5.85628E-5, 1.03751E-3, 3.19925E-3, 1.15261E-2, -6.31111E-3,     DATA5510
     X 2.85479E-3,-1.53200E-3,-9.53371E-10, 4.09241E-10, -2.67547E-13,  DATA5520
     X 5*0./                                                            DATA5530
      DATA (XLAM(K,18,3),K=1,20)/                                       DATA5540
     X 6.81882E-10,6.30735E-7,1.63083E-5, 1.52073E-3, 6.16627E-3,       DATA5550
     X 1.97103E-2, 7.39598E-2, 1.74214E-1, .793894, .890645,            DATA5560
     X 2.87581, 3.57001, 1.75916E-5, 3.26377E-5, 6.3666E-7,5*0./        DATA5570
      DATA (XALP(K,19,3),K=1,20)/                                       DATA5580
     X0.        ,0.        ,0.        ,0.        ,0.        ,0.        ,DATA5590
     X0.        ,0.        ,0.        ,0.        ,0.        ,0.        ,DATA5600
     X0.        ,0.        ,0.        ,0.        ,0.        ,0.        ,DATA5610
     X0.        ,0.        /                                            DATA5620
      DATA (XLAM(K,19,3),K=1,20)/                                       DATA5630
     X0.        ,0.        ,0.        ,0.        ,0.        ,0.        ,DATA5640
     X0.        ,0.        ,0.        ,0.        ,0.        ,0.        ,DATA5650
     X0.        ,0.        ,0.        ,0.        ,0.        ,0.        ,DATA5660
     X0.        ,0.        /                                            DATA5670
C   FITS FOR PU-239 GAMMAS GROUPS 1 THROUGH 19                          DATA5675
      DATA (XALP(K, 1,4),K=1,20)/                                       DATA5680
     X .1675E-12, .5868E-12, .6533E-11, .1563E-09, .2942E-08, .1025E-07,DATA5690
     X .7436E-08, .3483E-07, .9955E-06, .4669E-05, .2706E-04, .1908E-03,DATA5700
     X .5654E-03, .6856E-01,-.7029E-01, .4682E-02,-.2124E-02,0.        ,DATA5710
     X0.        ,0.        /                                            DATA5720
      DATA (XLAM(K, 1,4),K=1,20)/                                       DATA5730
```

```
X .1053E-08, .7491E-08, .3193E-07, .2533E-06, .9501E-06, .2326E-05,DATA5740
X .9554E-05, .9956E-04, .3260E-03, .1420E-02, .6438E-02, .1786E-01,DATA5750
X .9085E-01, .1582E+01, .1659E+01, .4954E+01, .7501E+01,0.         ,DATA5760
X0.         ,0.         /                                           DATA5770
  DATA (XALP(K, 2,4),K=1,20)/                                       DATA5780
X .1895E-12, .7624E-12, .1603E-10, .1104E-08, .2778E-07, .5213E-07,DATA5790
X .7963E-06, .5556E-05, .1684E-04, .8240E-04, .8442E-03, .2436E-02,DATA5800
X .2005E-01,-.8527E-02,-.4437E-08,0.         ,0.         ,0.         ,DATA5810
X0.         ,0.         /                                           DATA5820
  DATA (XLAM(K, 2,4),K=1,20)/                                       DATA5830
X .4578E-08, .1647E-07, .2997E-07, .2627E-06, .2903E-05, .1534E-04,DATA5840
X .1357E-03, .4019E-03, .1534E-02, .7615E-02, .4544E-01, .2401E+00,DATA5850
X .1396E+01, .1596E+01, .5917E.-05,0.         ,0.         ,0.         ,DATA5860
X0.         ,0.         /                                           DATA5870
  DATA (XALP(K, 3,4),K=1,20)/                                       DATA5880
X .1904E-13, .8134E-13, .7531E-13, .1019E-10, .5421E-08, .1798E-07,DATA5890
X .6339E-07, .3285E-06, .2898E-06, .2682E-04, .4978E-04, .5306E-03,DATA5900
X .1899E-01, .1015E+00,-.1124E+00,-.2311E-01, .1205E-01, .1644E-01,DATA5910
X0.         ,0.         /                                           DATA5920
  DATA (XLAM(K, 3,4),K=1,20)/                                       DATA5930
X .6098E-08, .1012E-07, .3884E-07, .1499E-06, .6605E-06, .1235E-05,DATA5940
X .4014E-05, .1366E-04, .3175E-04, .4061E-03, .8420E-03, .9422E-02,DATA5950
X .8051E-01, .7403E+01, .6864E+01, .9396E-01, .1646E+00, .2363E+01,DATA5960
X0.         ,0.         /                                           DATA5970
  DATA (XALP(K, 4,4),K=1,20)/                                       DATA5980
X .1580E-12, .1981E-10, .1081E-09, .7883E-08, .3127E-07, .4183E-06,DATA5990
X .1132E-05, .1938E-04, .4860E-04, .1030E-03, .5790E-03, .6223E-03,DATA6000
X .1028E-01, .3843E-01,-.1548E-01, .4805E-02,-.2382E-02,-.5746E-08,DATA6010
X0.         ,0.         /                                           DATA6020
  DATA (XLAM(K, 4,4),K=1,20)/                                       DATA6030
X .4501E-08, .1410E-07, .2817E-07, .2249E-06, .8420E-06, .1010E-04,DATA6040
X .4560E-04, .2835E-03, .9431E-03, .3519E-02, .1204E-01, .2756E-01,DATA6050
X .1147E+00, .5050E+00, .5633E+00, .2563E+01, .4641E+01, .7773E-06,DATA6060
X0.         ,0.         /                                           DATA6070
  DATA (XALP(K, 5,4),K=1,20)/                                       DATA6080
X .2743E-10, .1232E-10, .7873E-10, .1462E-07, .3050E-06, .8594E-06,DATA6090
X .2487E-05, .2047E-04, .3840E-04, .1538E-03, .4903E-03, .2285E-02,DATA6100
X .1239E-01, .5805E-01,-.1241E+00, .7718E-01,-.4958E-03,-.7299E-08,DATA6110
X0.         ,0.         /                                           DATA6120
  DATA (XLAM(K, 5,4),K=1,20)/                                       DATA6130
X .7278E-09, .1087E-07, .2966E-07, .1240E-06, .2826E-05, .1520E-04,DATA6140
X .6046E-04, .2516E-03, .9024E-03, .2905E-02, .1092E-01, .4341E-01,DATA6150
X .2716E+00, .2337E+01, .4393E+01, .5731E+01, .2642E+00, .1969E-06,DATA6160
X0.         ,0.         /                                           DATA6170
  DATA (XALP(K, 6,4),K=1,20)/                                       DATA6180
X .6121E-15, .3415E-11, .3061E-11, .1473E-07, .4877E-07, .4367E-06,DATA6190
X .2233E-04, .3467E-04, .1332E-03, .3924E-03, .7549E-02, .2176E-01,DATA6200
X .2077E-01,-.1701E-01, .1686E-01,0.         ,0.         ,0.         ,DATA6210
X0.         ,0.         /                                           DATA6220
  DATA (XLAM(K, 6,4),K=1,20)/                                       DATA6230
X .2209E-08, .2162E-07, .1876E-06, .6308E-06, .2943E-05, .2015E-04,DATA6240
X .1506E-03, .3421E-03, .1381E-02, .6926E-02, .4757E-01, .5772E+00,DATA6250
X .3649E+01, .6936E-01, .9324E-01,0.         ,0.         ,0.         ,DATA6260
X0.         ,0.         /                                           DATA6270
  DATA (XALP(K, 7,4),K=1,20)/                                       DATA6280
X .3386E-15, .1891E-10, .1015E-11, .5966E-09, .1488E-08, .1405E-07,DATA6290
X .9464E-07, .9313E-06, .1396E-04, .7180E-04, .1907E-03, .1327E-02,DATA6300
X .4988E-02, .2417E-01,-.1155E-01, .3024E-02,-.6802E-04,0.         ,DATA6310
X0.         ,0.         /                                           DATA6320
  DATA (XLAM(K, 7,4),K=1,20)/                                       DATA6330
X .1872E-08, .2159E-07, .3497E-07, .5608E-06, .1414E-05, .3147E-05,DATA6340
X .1136E-04, .3355E-04, .2250E-03, .9838E-03, .4337E-02, .2133E-01,DATA6350
X .1000E+00, .5331E+00, .1364E+01, .2902E+01, .3011E-01,0.         ,DATA6360
X0.         ,0.         /                                           DATA6370
```

```
 DATA (XALP(K, 8,4),K=1,20)/                                        DATA6380
X .1035E-14, .1086E-12, .3401E-12, .1555E-10, .3557E-09, .2170E-07,DATA6390
X .2566E-07, .1673E-05, .9010E-05, .4957E-04, .1260E-03, .1326E-02,DATA6400
X .2244E-02, .9506E-02, .1301E-01, .1261E-03,0.         ,0.         ,DATA6410
X0.        ,0.        /                                             DATA6420
 DATA (XLAM(K, 8,4),K=1,20)/                                        DATA6430
X .2421E-08, .1670E-07, .3130E-07, .1495E-06, .6177E-06, .2425E-05,DATA6440
X .5153E-05, .4161E-04, .1913E-03, .7425E-03, .2879E-02, .1422E-01,DATA6450
X .6297E-01, .2560E+00, .8232E+00, .1514E+02,0.         ,0.         ,DATA6460
X0.        ,0.        /                                             DATA6470
 DATA (XALP(K, 9,4),K=1,20)/                                        DATA6480
X .6011E-16, .3490E-11, .3876E-11, .6253E-06, .7373E-04, .1356E-02,DATA6490
X .1885E-02, .6279E-02, .1381E-01,-.7309E-02, .2441E-02,-.4071E-02,DATA6500
X-.2959E-04, .1626E-03,-.1617E-05, .9953E-06, .8030E-06, .2093E-06,DATA6510
X-.1985E-06,0.        /                                             DATA6520
 DATA (XLAM(K, 9,4),K=1,20)/                                        DATA6530
X .1414E-08, .2207E-07, .3063E-07, .7440E-06, .3949E-03, .1522E-01,DATA6540
X .7589E-01, .2278E+00, .7323E+00, .5955E+00, .1533E+01, .2331E+01,DATA6550
X .4123E-03, .3979E-02, .8158E-06, .8456E-06, .4587E-04, .1344E-05,DATA6560
X .1894E-05,0.        /                                             DATA6570
 DATA (XALP(K,10,4),K=1,20)/                                        DATA6580
X .1420E-17, .1126E-11, .2791E-12, .8436E-11, .1764E-08, .2082E-07,DATA6590
X .4911E-06, .4814E-05, .1441E-04, .5855E-04, .2359E-03, .1169E-02,DATA6600
X .1270E-01,-.8152E-02, .8864E-D2,-.5294E-02, .2934E-02,-.1143E-02,DATA6610
X0.        ,0.        /                                             DATA6620
 DATA (XLAM(K,10,4),K=1,20)/                                        DATA6630
X .1549E-09, .2180E-07, .2003E-06, .7512E-06, .2556E-05, .1121E-04,DATA6640
X .2763E-04, .1758E-03, .5645E-03, .1182E-02, .7098E-02, .2469E-01,DATA6650
X .1117E+00, .1193E+00, .3794E+00, .1297E+01, .4467E+01, .3307E+01,DATA6660
X0.        ,0.        /                                             DATA6670
 DATA (XALP(K,11,4),K=1,20)/                                        DATA6680
X .9696E-18, .6832E-12, .1720E-09, .3996E-08, .4361E-07, .6644E-06,DATA6690
X .7149E-05, .4754E-04, .1041E-03, .7792E-03, .1092E-02, .4851E-02,DATA6700
X .1016E-01,-.4740E-02, .3880E-02,0.         ,0.         ,0.         ,DATA6710
X0.        ,0.        /                                             DATA6720
 DATA (XLAM(K,11,4),K=1,20)/                                        DATA6730
X .9565E-10, .2180E-07, .5658E-06, .2702E-05, .1756E-04, .6416E-04,DATA6740
X .2874E-03, .1009E-02, .4623E-02, .1667E-01, .3861E-01, .1740E+00,DATA6750
X .5496E+00, .1163E+01, .2173E+01,0.         ,0.         ,0.         ,DATA6760
X0.        ,0.        /                                             DATA6770
 DATA (XALP(K,12,4),K=1,20)/                                        DATA6780
X .9394E-11, .5163E-15, .1838E-11, .9985E-10, .5056E-11, .3573E-08,DATA6790
X .3964E-06, .9300E-05, .4799E-04, .1216E-03, .1386E-02, .5089E-02,DATA6800
X .3932E-02, .4930E-02,-.6688E-02,-.3144E-05,0.         ,0.         ,DATA6810
X0.        ,0.        /                                             DATA6820
 DATA (XLAM(K,12,4),K=1,20)/                                        DATA6830
X .2465E-07, .3071E-07, .9914E-07, .3122E-06, .1260E-05, .2072E-05,DATA6840
X .5483E-04, .2280E-03, .8095E-03, .4200E-02, .2219E-01, .1688E+00,DATA6850
X .5132E+00, .3755E+01, .2049E+01, .1940E-03,0.         ,0.         ,DATA6860
X0.        ,0.        /                                             DATA6870
 DATA (XALP(K,13,4),K=1,20)/                                        DATA6880
X .9396E-12, .2560E-15, .1045E-11, .8002E-09, .2344E-09, .1830E-08,DATA6890
X .7367E-06, .9824E-05, .3303E-04, .2582E-03, .1420E-02, .5593E-02,DATA6900
X .4160E-02, .4263E-02,-.5712E-02,-.4260E-05,0.         ,0.         ,DATA6910
X0.        ,0.        /                                             DATA6920
 DATA (XLAM(K,13,4),K=1,20)/                                        DATA6930
X .2179E-07, .3071E-07, .3544E-06, .6192E-06, .1211E-05, .5411E-05,DATA6940
X .5950E-04, .2018E-03, .9124E-03, .7439E-02, .2534E-01, .2142E+00,DATA6950
X .6752E+00, .4459E+01, .2545E+01, .1683E-03,0.         ,0.         ,DATA6960
X0.        ,0.        /                                             DATA6970
 DATA (XALP(K,14,4),K=1,20)/                                        DATA6980
X .4848E-12, .1252E-14, .3612E-15, .3374E-08, .1407E-06, .4232E-05,DATA6990
X .4572E-04, .5981E-03, .7497E-03, .4713E-02, .3493E-02,-.1039E-02,DATA7000
X .6771E-03,-.5645E-03,-.1469E-04, .1990E-06,-.2004E-06,0.         ,DATA7010
```

```
XO,          .O.         /
 DATA (XLAM(K,14,4),K=1,20)/
X .2178E-07, .2263E-07, .2264E-07, .6139E-06, .4253E-04, .1602E-03,
X .8998E-03, .1206E-01, .4243E-01, .2018E+00, .7063E+00, .1277E+01,
X .2275E+01, .3738E+01, .7934E-03, .1692E-05, .1705E-05,0.         ,
XO.          .O.         /
 DATA (XALP(K,15,4),K=1,20)/
X .2680E-12, .4346E-14, .7312E-10, .2684E-12, .6776E-08, .1388E-05,
X .6886E-05, .4367E-04, .1070E-01,-.1098E-01, .2709E-02, .5040E-02,
X .1087E-01,-.5809E-02, .1904E-03,0.         ,O.         ,O.         ,
XO,          .O.         /
 DATA (XLAM(K,15,4),K=1,20)/
X .2179E-07, .2553E-07, .6240E-06, .6835E-05, .1993E-04, .1158E-03,
X .3099E-03, .1240E-02, .1038E-01, .1074E-01, .2116E-01, .1682E+00,
X .5767E+00, .1301E+01, .1162E+02,0.         ,O.         ,O.         ,
XO,          .O.         /
 DATA (XALP(K,16,4),K=1,20)/
X .6976E-13, .6465E-16, .3321E-10, .1827E-06, .1733E-05, .3355E-04,
X .1392E-03, .2059E-02, .3501E-02, .1461E-01,-.1852E-10,0.         ,
XO.          .O.         ,O.         .O.         .O.         .O.         ,
XO.          .O.         /
 DATA (XLAM(K,16,4),K=1,20)/
X .2179E-07, .3507E-07, .6308E-06, .9524E-04, .1474E-03, .7336E-03,
X .3629E-02, .1808E-01, .8523E-01, .2323E+00, .3354E-05,0.         ,
XO.          .O.         ,O.         .O.         .O,         .O.         ,
XO,          .O.         /
 DATA (XALP(K,17,4),K=1,20)/
X 7.781E-19, 8.311E-09, 2.357E-08, 1.956E-07, 1.681E-06, 1.591E-04,
X 7.875E-04, 1.763E-03, 4.693E-03, 4.702E-05, 2.463E-05, 0.0        ,
XO.          .O.         ,O.         .O.         .O.         .O.         ,
XO.          .O.         /
 DATA (XLAM(K,17,4),K=1,20)/
X 4.142E-06, 6.800E-05, 1.478E-04, 6.896E-04, 5.208E-03, 5.207E-03,
X 2.489E-02, 1.236E-01, .2862E+00, .9943E+00, .1620E+02,0.         ,
XO.          .O.         ,O.         .O.         .O.         .O.         ,
XO,          .O.         /
 DATA (XALP(K,18,4),K=1,20)/
X 1.200E-19,3.004E-15,1.191E-12,2.959E-7,2.493E-5,2.012E-4,
X 9.907E-6,1.325E-3,1.418E-3,-1.811E-20,0.0,0.0,
XO,          .O.         ,O.         .O.         .O.         .O.         ,
XO,          .O.         /
 DATA (XLAM(K,18,4),K=1,20)/
X 4.289E-06, 2.022E-04, 6.552E-04, 3.006E-03, 6.336E-03, 1.921E 02
X 3.258E-02, 1.539E-01, 9.212E-01, 5.945E-06, 0.0       , 0.0        ,
XO.          .O.         ,O.         .O.         .O.         .O.         ,
XO,          .O.         /
 DATA (XALP(K,19,4),K=1,20)/
X 1.85545E-20,3.30519E-17,5.72023E-16,3.86898E-6,1.02786E-5,
X 1.23228E-4,-4.42133E-5,2.57210E-5,-6.96988E-6,-2.50522E-6,
X -7.29476E-21,2.15247E-20,8*0./
 DATA (XLAM(K,19,4),K=1,20)/
X 4.57245E-6,4.41793E-4,8.97811E-4,8.03833E-3,1.22545E-2,
X 1.99914E-1,2.53015E-1,1.11151,2.76967,1.33733E-2,
X 6.83542E-6, 6.22339E-5,8*0./
 DATA KTRM/
X18,19,18,19,17,18,19,18,15,15,16,16,15,17,17,15,15,13,0,15,16,
X18,16,16,15,17,17,17,18,16,14,15,14,14,16,14,16,12,15,15,15,15,
X15,15,15,15,15,15,15,14,14,13,14,13,16,15,0,17,15,18,18,18,15,
X17,16,19,18,15,16,16,17,15,11,11,10,12/
 END
 SUBROUTINE SETUP (X1,Y1,L1,TL,NT,XL,NX,YL,NY,ITYPE,IMK,ICDN,IGRD)
 REAL X1(L1),Y1(L1)
 INTEGER TL(2), XL(2), YL(2)
 DATA XPAGE, YPAGE /6.,6./
```

```
      CALL BGNPL (-1)
      CALL NDBRDR
      CALL PAGE (XPAGE,YPAGE)
      XG=XPAGE-1.7
      YG=YPAGE-1.7
      HITE=.03*YG
      CALL HEIGHT (HITE)
      CALL SCMPLX
      CALL MX1ALF(5HSTAND,1H>)
      CALL MX2ALF(5HL/CST,1H<)
      CALL MX3ALF(5HINSTR,1H#)
      XLEFT=XRIGHT=X1(1)
      YTDP=YBDT=Y1(1)
      DD 5 I=2,L1
      IF(X1(I).LT.XLEFT) XLEFT=X1(I)
      IF(X1(I).GT.XRIGHT) XRIGHT=X1(I)
      IF(Y1(I).LT.YBDT) YBDT=Y1(I)
      IF(Y1(I).GT.YTDP) YTDP=Y1(I)
5     CDNTINUE
      IF(ITYPE.LT.3) GD TD 6
      TDP=ALDG10(XRIGHT)
      IF(TDP.GE.0.) XRIGHT=10.**IFIX(TDP+.99)
      IF(TDP.LT.0.) XRIGHT=10.**IFIX(TDP)
      IF(XLEFT.NE.0.0) GD TD 6
      XLEFT=10.**IFIX(TDP-15.)
6     IF(ITYPE.NE.2.AND.ITYPE.NE.4) GD TD 7
      TDP=ALDG10(YTDP)
      IF(TDP.GE.0.) YTDP=10.**IFIX(TDP+.99)
      IF(TDP.LT.0.) YTDP=10.**IFIX(TDP)
      IF(YBDT.GT.0.0) GD TD 7
      YBDT=10.**IFIX(TDP-15.)
7     IF (ITYPE.NE.1) GD TD 10
      CALL AXSPLT (YBDT,YTDP,YG,YDRIG,YSTEP,YAXIS)
      YTDP=IFIX((YTDP+YSTEP)/YSTEP)*YSTEP
      CALL AXSPLT (XLEFT,XRIGHT,XG,XDRIG,XSTEP,XAXIS)
C     XRIGHT=IFIX((XRIGHT+XSTEP)/XSTEP)*XSTEP
      CALL TITLE (0,0,XL,NX,YL,NY,XG,YG)
      CALL GRAF (XDRIG,XSTEP,XRIGHT,YDRIG,YSTEP,YTDP)
      GD TD 40
   10 IF (ITYPE.NE.2) GD TD 20
      CALL AXSPLT (XLEFT,XRIGHT,XG,XDRIG,XSTEP,XAXIS)
      XRIGHT=IFIX((XRIGHT+XSTEP)/XSTEP)*XSTEP
      CALL ALGPLT (YBDT,YTDP,YG,YDRIG,YCYCLE)
      CALL TITLE (0,0,0,0,YL,NY,XG,YG)
      CALL YLDG (0.,1.,YDRIG,YCYCLE)
      CALL XGRAXS (XDRIG,XSTEP,XRIGHT,XG,XL,NX,0.,0.)
      GD TD 40
   20 CALL ALGPLT (XLEFT,XRIGHT,XG,XDRIG,XCYCLE)
      IF (ITYPE.NE.3) GD TD 30
      CALL AXSPLT (YBDT,YTDP,YG,YDRIG,YSTEP,YAXIS)
      YTDP=IFIX((YTDP+YSTEP)/YSTEP)*YSTEP
      CALL TITLE (0,0,XL,NX,0,0,XG,YG)
      CALL XLDG (XDRIG,XCYCLE,0.,1.)
      CALL YGRAXS (YDRIG,YSTEP,YTDP,YG,YL,NY,0.,0.)
      GD TD 40
   30 CALL ALGPLT (YBDT,YTDP,YG,YDRIG,YCYCLE)
      CALL TITLE (0,0,XL,NX,YL,NY,XG,YG)
      CALL LOGLDG (XDRIG,XCYCLE,YDRIG,YCYCLE)
   40 CALL FRAME
      IF(IGRD.EQ.1) CALL GRID(1,1)
      IF(IGRD.NE.2) GD TD 41
      CALL BLNK1(.13,XG-.13,0.,YG,0)
      CALL GRID(0,1)
      CALL RESET(5HBLNK1)
      CALL BLNK1(0.,XG,.13,YG-.13,0)
      CALL GRID(1,0)
      CALL RESET(5HBLNK1)
41    IF(ICDN.NE.0) CALL MARKER(IMK)
      CALL CURVE (X1,Y1,L1,ICON)
      IF(NT.GT.0)CALL MESSAG(TL,NT,-.5,YPAGE-1.)
      RETURN
      END
```

SAMPLE PROBLEM INPUT

```
.75,1.E+14,5.E+14,7.2E+7,-12,2,0,0
1.E+6,1.E+8
1.,1.,1.,1.
```

SAMPLE PROBLEM OUTPUT

FISSION PRODUCT DECAY ENERGY FOR A MIXTURE OF U-235 AND PU-239

PERCENT U-235	7.5000E+01
PERCENT PU-239	2.5000E+01
THERMAL FLUX	1.0000E+14 N/CM**2-S
EPITHERMAL FLUX	5.0000E+14 N/CM**2-S
OPERATING TIME	7.2000E+07 SECONDS
COOLING TIME	1.0000E+06 SECONDS

0

GRP	ELO (MEV)	EHI (MEV)	BETA DECAY ENERGY (MEV/FIS)	GAMMA DECAY ENERGY (MEV/FIS)	TOTAL DECAY ENERGY (MEV/FIS)
1	0.0	.4	5.40222E-02	1.50357E-02	6.90579E-02
2	.4	.8	5.05763E-02	1.48899E-01	1.99475E-01
3	.8	1.0	2.15015E-02	1.64012E-02	3.79027E-02
4	1.0	1.4	3.02747E-02	7.98657E-03	3.82613E-02
5	1.4	1.8	1.88445E-02	5.68778E-02	7.57223E-02
6	1.8	2.2	1.52776E-02	5.67523E-03	2.09528E-02
7	2.2	2.6	9.02947E-03	4.91520E-03	1.39447E-02
8	2.6	3.0	2.82435E-03	6.95132E-05	2.89386E-03
9	3.0	4.0	5.75426E-04	3.15467E-05	6.06973E-04
10	4.0	5.0	2.40575E-05	0.	2.40575E-05
11	5.0	6.0	2.76628E-06	0.	2.76628E-06
12	6.0	7.5	1.77129E-07	0.	1.77129E-07
TOTALS OVER GROUPS			2.02953E-01	2.55891E-01	4.58844E-01

1

FISSION PRODUCT DECAY ENERGY FOR A MIXTURE OF U-235 AND PU-239

PERCENT U-235	7.5000E+01
PERCENT PU-239	2.5000E+01
THERMAL FLUX	1.0000E+14 N/CM**2-S
EPITHERMAL FLUX	5.0000E+14 N/CM**2-S
OPERATING TIME	7.2000E+07 SECONDS
COOLING TIME	1.0000E+08 SECONDS

0

GRP	ELO (MEV)	EHI (MEV)	BETA DECAY ENERGY (MEV/FIS)	GAMMA DECAY ENERGY (MEV/FIS)	TOTAL DECAY ENERGY (MEV/FIS)
1	0.0	.4	1.85958E-03	7.00323E-05	1.92961E-03
2	.4	.8	1.40169E-03	7.59423E-03	8.99592E-03
3	.8	1.0	6.82085E-04	2.83293E-04	9.65378E-04
4	1.0	1.4	1.72243E-03	3.16643E-04	2.03907E-03
5	1.4	1.8	1.74267E-03	1.57313E-05	1.75840E-03
6	1.8	2.2	1.23715E-03	4.07158E-05	1.27787E-03
7	2.2	2.6	7.00417E-04	1.88010E-06	7.02297E-04
8	2.6	3.0	2.70177E-04	3.66127E-07	2.70543E-04
9	3.0	4.0	8.43223E-05	9.19320E-08	8.44143E-05
10	4.0	5.0	9.05890E-06	0.	9.05890E-06
11	5.0	6.0	2.27445E-06	0.	2.27445E-06
12	6.0	7.5	1.26854E-07	0.	1.26854E-07
TOTALS OVER GROUPS			9.71198E-03	8.32299E-03	1.80350E-02

APPENDIX B

ACCURACY ESTIMATE OF ADJUSTED SPECTRAL FITS

As an aid in estimating the accuracy of the adjusted spectral fits, calculations made with the adjusted fits were separately compared to both aggregate spectral summation results calculated using the CINDER code and ENDF/B-V data and also with the experimental results. Examples of these comparisons are shown graphically in Figs. B-1 through B-5 for the aggregate gamma-ray decay energy from fission products resulting from a pulse irradiation (1 x 10^{-4} s) of ^{239}Pu with thermal neutrons. (Note that although in figures comparing calculated decay energies with experiment, the experimental points have been reduced to a pulse; those figures showing the deviations take into consideration the actual irradiation times used in the experiments.) The comparisons shown in these figures are for a low-energy group (0.1-0.2 MeV) in Fig. B-1, for two intermediate-energy groups (0.8-1.0 MeV and 1.4-1.6 MeV) in Figs. B-2 and B-3, respectively, and two high-energy groups (2.2-2.4 MeV and 4.0-5.0 MeV) in Figs. B-4 and B-5, respectively. As demonstrated by these figures, the adjusted fits most closely follow the experimental data in the cooling-time range of the experiments, the ENDF/B-V aggregate data for cooling times greater than the range of the experiments, and are extrapolations of the experimental data with and ENDF/B-V "shape" for very early cooling times. Note, however, as can be seen in Fig. B-4, that for high beta- and gamma-ray energies, and for long cooling times, the dispersion of the experimental data is so great that the adjusted fits have been forced to fit the ENDF/B-V aggregate data. Also, for the highest energy group (6.0-7.5 MeV), no experimental data were available and the adjusted fits are entirely ENDF/B-V.

As a first step in estimating the reliability of the adjusted fits, we divide the cooling-time range into bins having widths of one decade, except that the last bin is understood to extend to the end of the cooling-time range (1 x 10^{9} s). Averages of deviations of points calculated using the adjusted fits from the aggregate ENDF/B-V pulse points and from the experimental points are next tabulated separately for each energy group and cooling-time decade for the aggregate betas and gammas from each fissioning nuclide (^{235}U and ^{239}Pu) as shown in Tables B-I through B-IV. Combined "accuracy" estimates are then made as follows.

- For cooling times less than 1 s (i.e., below the experimental range), the combined estimate is taken to be one-half the average deviation for ENDF/B-V.
- For cooling times in the range of 1 s-1 x 10^4 s, where it is believed that the experimental data are the most accurate, the combined estimate is taken as one-fourth the absolute value of the average deviation for ENDF/B-V plus the average deviation for the experiment.
- For cooling times above 1.0E+04 s, but within the range of the experiments, it is assumed that ENDF/B-V data are as valid as the experimental data so the combined estimate is the absolute value of the average deviation for ENDF/B-V plus the absolute value of the experimental deviation. Exceptions to this are the highest energy groups for which the deviations for the experimental data are essentially ignored above 1000 s. (See Fig. B-4.)
- For cooling times above the experimental range, the combined estimate is just the absolute value of the average deviations from the ENDF/B-V data, as the adjusted fits in this time domain are just fits to the aggregate ENDF/B-V pulse data.
- The minimum combined estimate is taken to be 5%, as this is judged to be the "accuracy" of the ENDF/B-V fits, i.e., no point calculated with the ENDF/B-V fits deviates more than 5% from an aggregate ENDF/B-V data point.
- The multigroup energy can be rebinned into broader groups for purposes of making uncertainty estimates, as it is generally noted that the experimental gamma-ray decay energy data are lower than the aggregate summation calculations using ENDF/B-V data for low energies, are in fair agreement for intermediate energies, and are high for high energies. (The opposite is more or less the case for the betas.) Similarly, wider cooling-time bins can also be assigned.

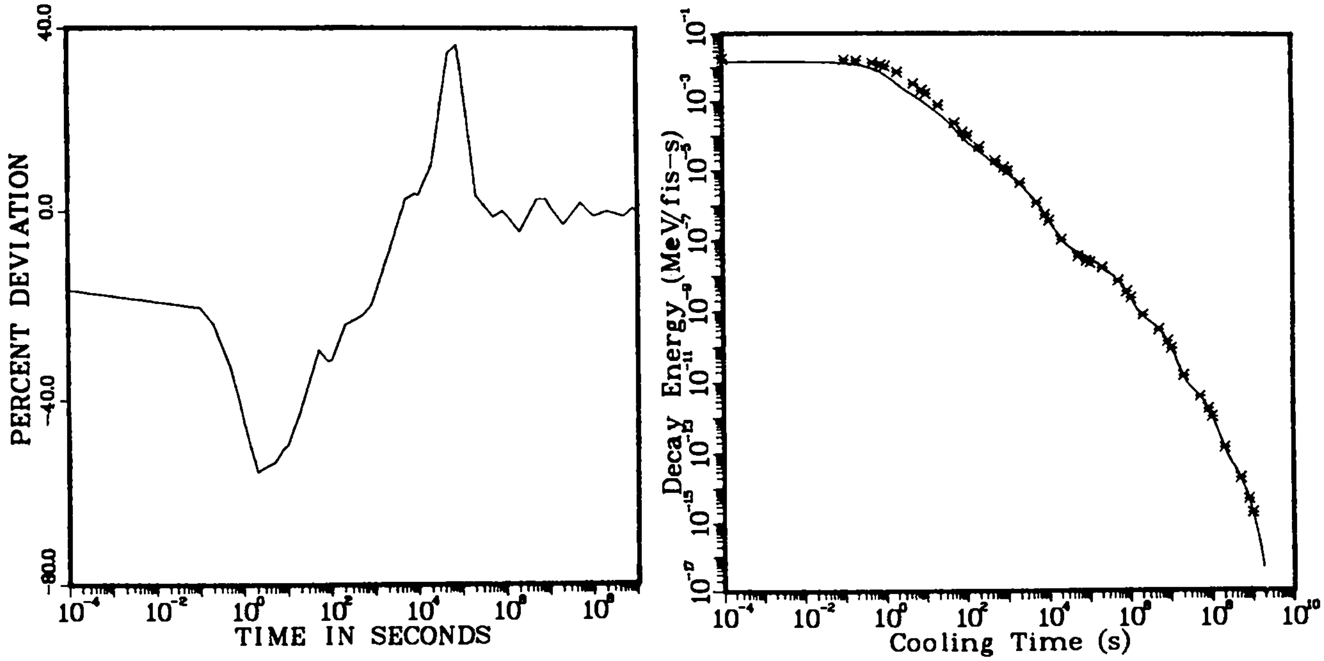
In accordance with the above, absolute averages of the average deviations were taken over four energy and four cooling-time ranges. The results are displayed in Tables B-V through B-VIII, which also give the bounds of energy and cooling-time ranges as well as the absolute averages of the deviations.

First, note in comparing Tables B-V through B-VIII that the deviations for the gammas are generally higher than those for the betas. This is not surprising since only one experiment (the ORNL) was included in obtaining the adjusted beta fits. The deviations in Table B-V and B-VII, therefore, are considered somewhat optimistic.

On the other hand, the large deviations seen in Tables B-VI and B-VIII for the gammas for short cooling times and high energies seem overly pessimistic when examining the numbers in Tables B-II and B-IV. Note in these latter tables that the adjusted fits are extrapolations of closely followed experimental data. As discussed in Ref. 6, we believe that the experimental data are correct for this energy-cooling time domain, and that the data in the ENDF/B-V file are deficient for those nuclides contributing to the decay energy in this domain.

Because of the foregoing, it does not seem unreasonable to make a single estimate of "one-sigma" uncertainties for the adjusted fits for both the beta- and gamma-ray decay energies resulting from the thermal pulse irradiation of both ^{235}U and ^{239}Pu. This is done by taking simple averages of the deviations in each energy and cooling-time range in Tables B-V through B-VIII. The resulting table appears in Sec. V of the main body of this report. Note that a user may be dissatisfied with the final result of this analysis and may wish to reestimate the uncertainties according to his own needs. If so, Tables B-I through B-IV are available for this task.

Comparison with ENDF/B-V aggregate data.



Comparison with experimental data.

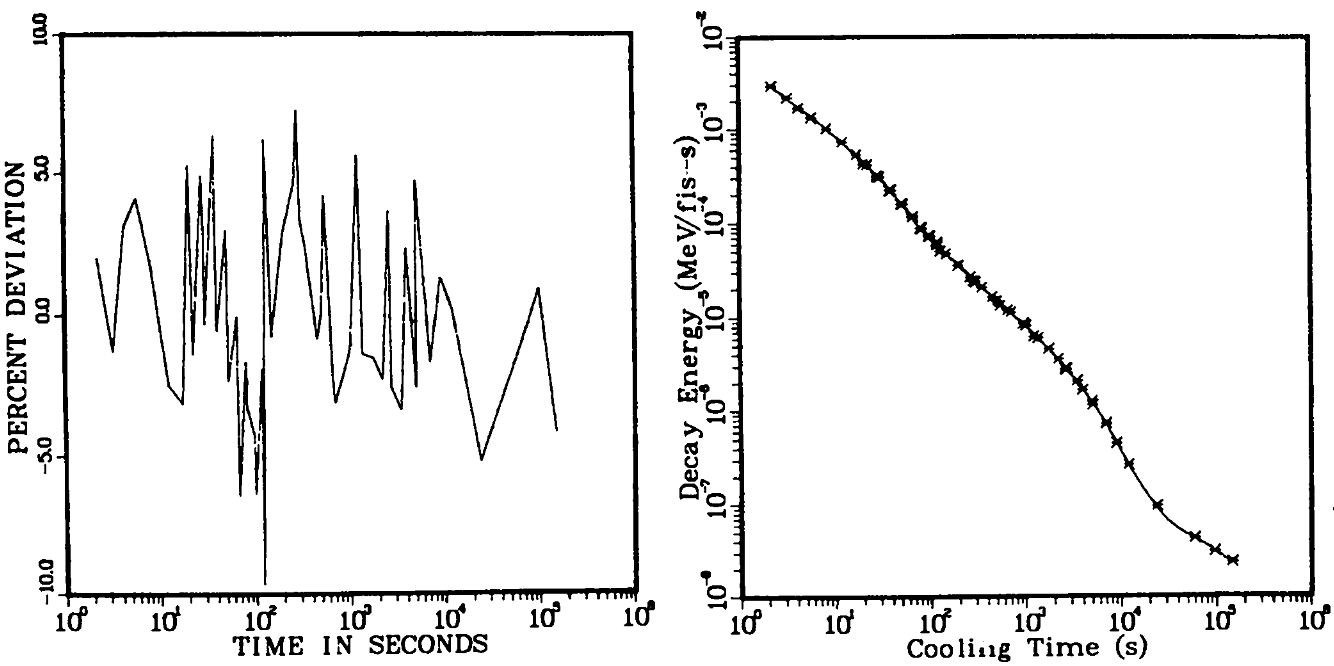
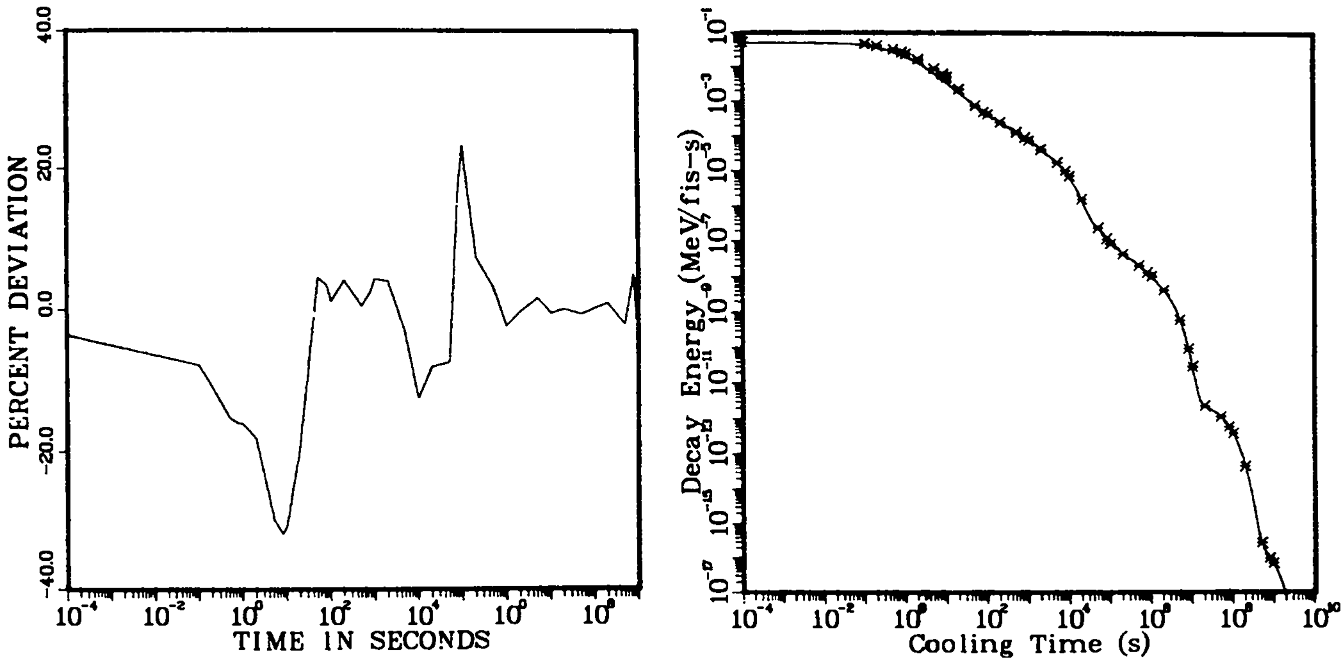


Fig. B-1. Comparisons of adjusted fits for Group 2 (0.1-0.2 MeV)

Comparison with ENDF/B-V aggregate data.



Comparison with experimental data.

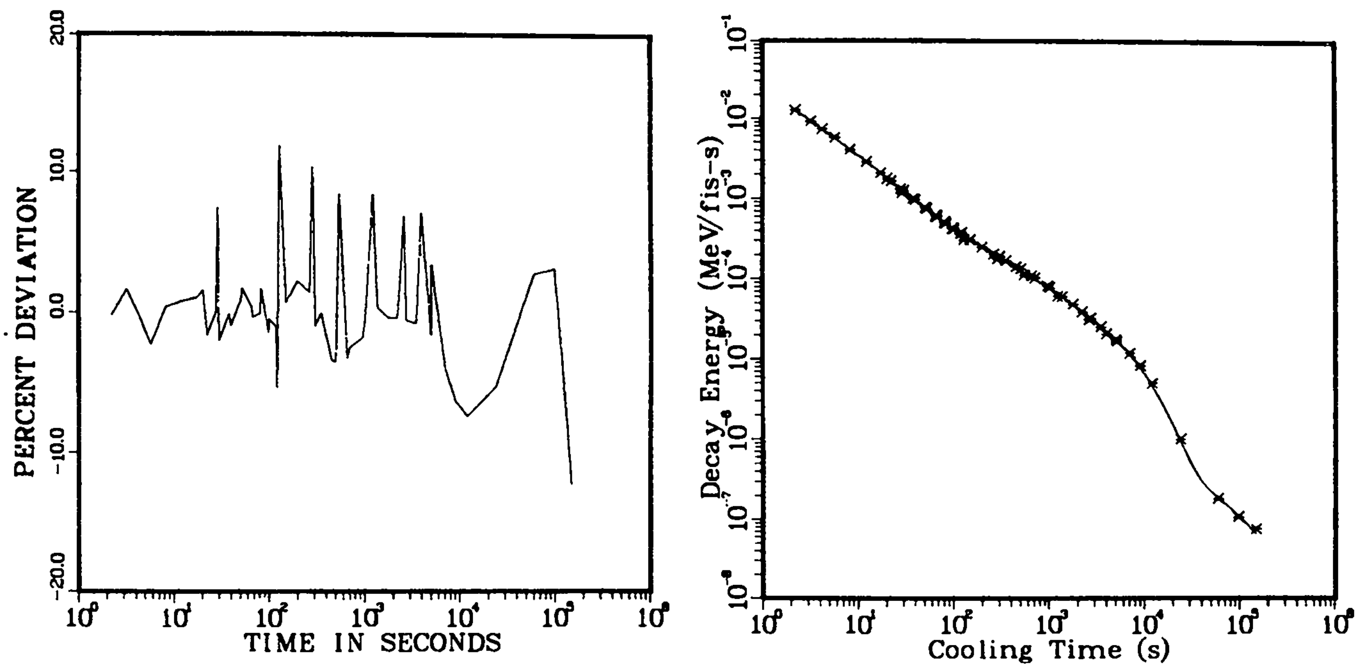
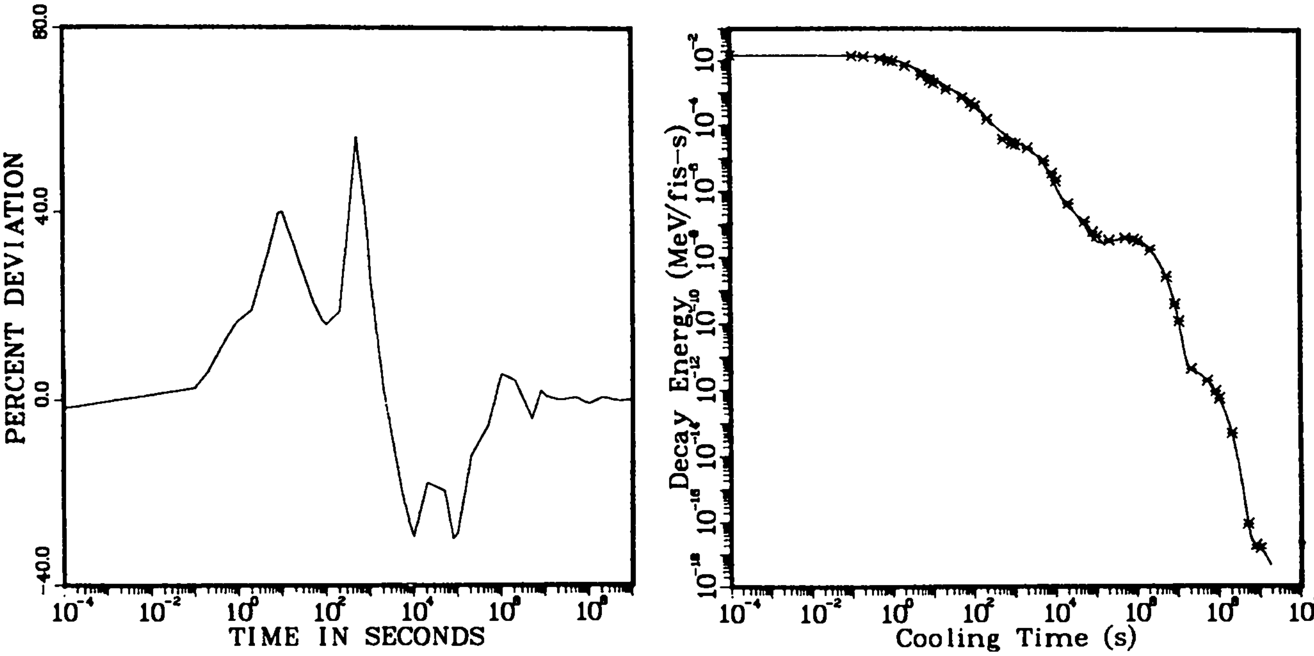


Fig. B-2. Comparisons of adjusted fits for Group 6 (0.8-1.0 MeV).

Comparison with ENDF/B-V aggregate data.



Comparison with experimental data,

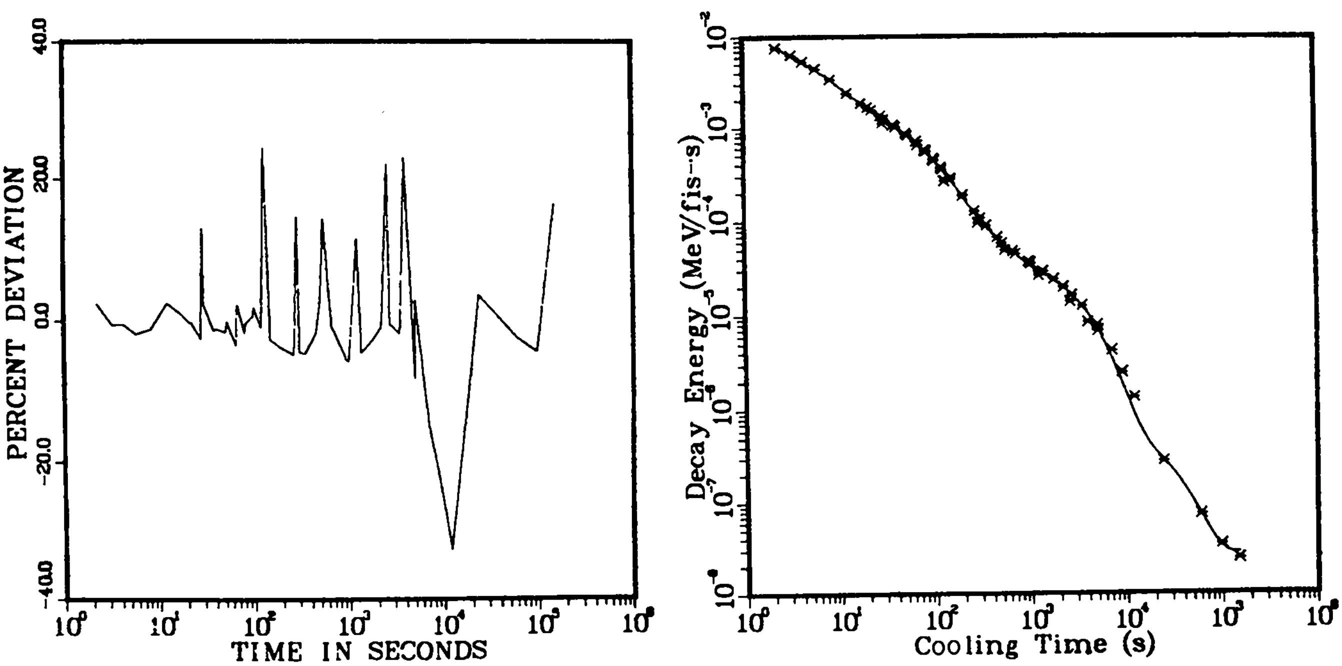
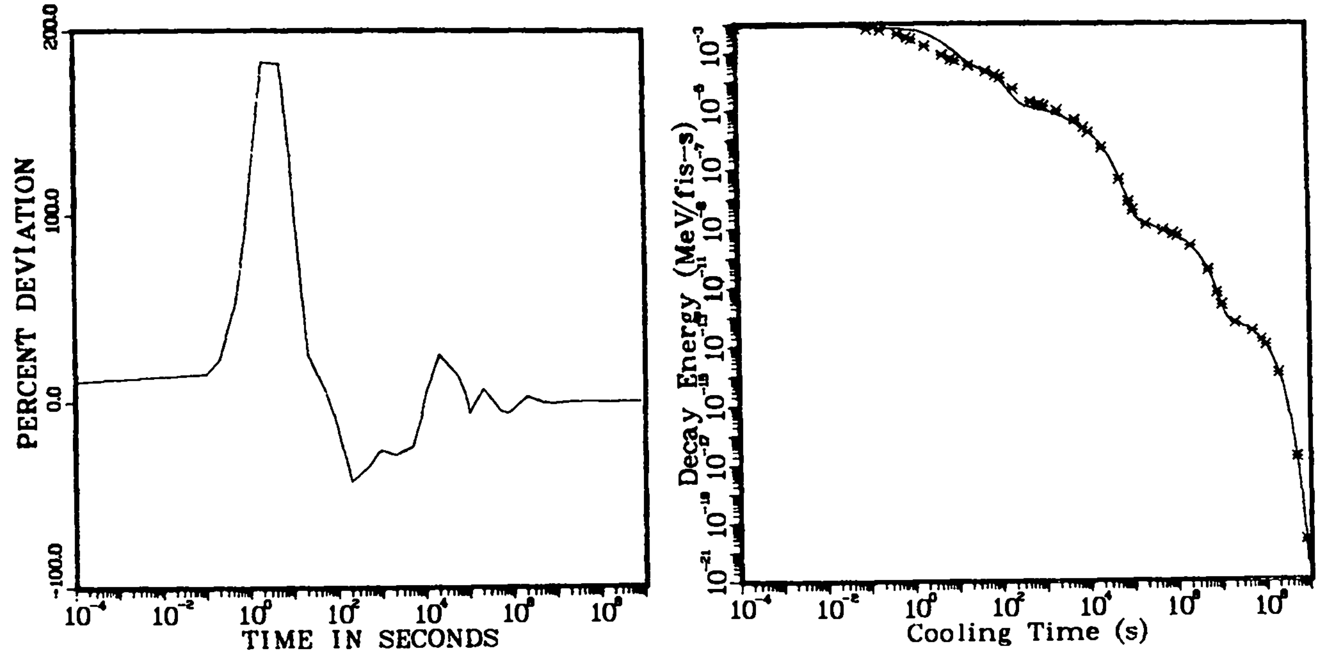


Fig. B-3. Comparisons of adjusted fits for Group 9 (1.4-1.6 MeV).

Comparison with ENDF/B-V aggregate data.



Comparison with experimental data.

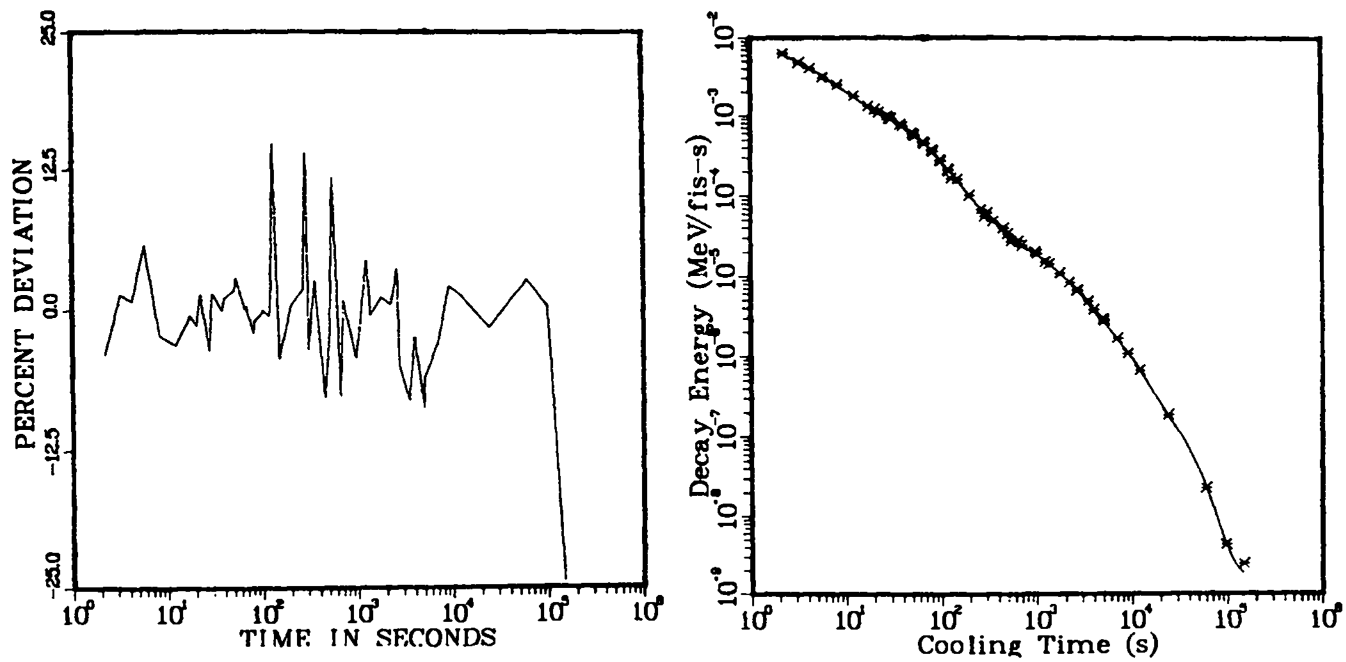
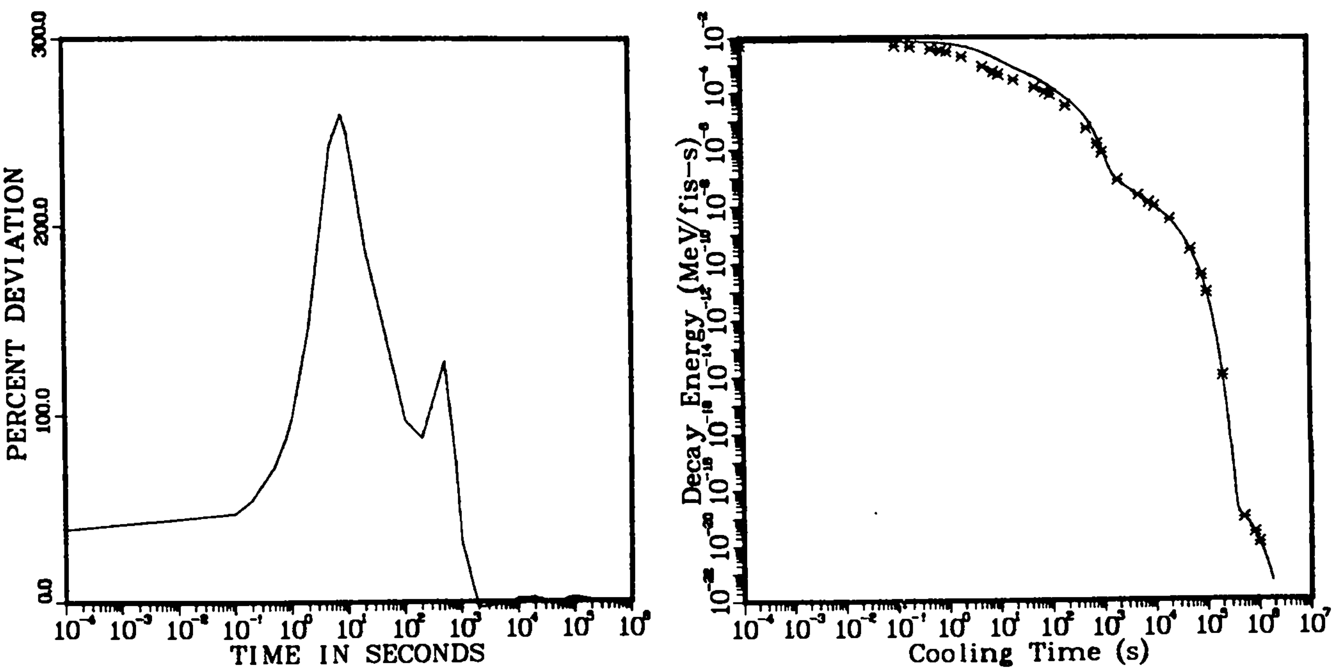


Fig. B-4. Comparisons of adjusted fits for Group 13 (2.1-1.4 MeV).

Comparison with ENDF/B-V aggregate data.



Comparison with experimental data.

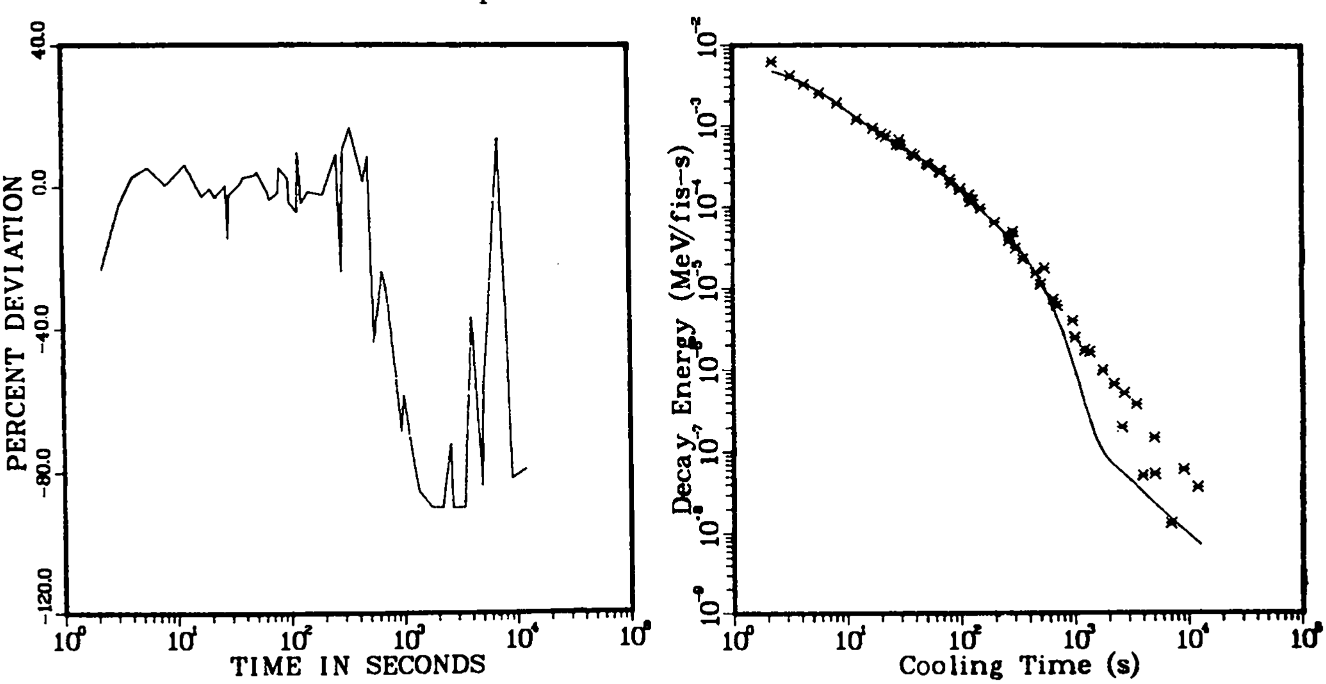


Fig. B-5. Comparisons of adjusted fits for Group 17 (4.0-5.0 MeV).

TABLE B-I

AVERAGE PERCENT DEVIATIONS OF ADJUSTED FITS FROM ENDF/B-V AND EXPERIMENTAL DATA FOR U-235 BETAS

COOL TIME	GROUP 1		GROUP 2		GROUP 3		GROUP 4		GROUP 5		GROUP 6		GROUP 7		GROUP 8		GROUP 9	
DECADE	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP
.1E-01-.1E+00	128.9	0.0	40.5	0.0	30.1	0.0	34.3	0.0	.7	0.0	-.9	0.0	1.7	0.0	-10.6	0.0	-4.9	0.0
.1E+00-.1E+01	141.4	0.0	49.7	0.0	38.7	0.0	30.9	0.0	-.0	0.0	1.1	0.0	1.7	0.0	-6.5	0.0	2.2	0.0
.1E+01-.1E+02	178.0	-7.6	79.4	-9.9	56.5	-.2	40.5	-.3	15.1	-1.1	12.5	-.6	8.5	-2.1	-11.9	.1	3.6	-1.9
.1E+02-.1E+03	109.0	-.3	85.8	-.4	51.0	-4.4	48.2	-.6	27.8	1.0	17.4	-.9	8.9	-.9	-8.5	.5	-2.3	-.8
.1E+03-.1E+04	68.6	-1.9	51.5	3.2	28.4	-1.2	27.3	.7	15.7	.1	11.0	-.5	.9	-2.8	-.6	-.1	-4.5	.5
.1E+04-.1E+05	66.6	-1.7	24.3	-.1	9.2	-1.0	8.5	-.0	5.8	.7	2.6	.6	-5.1	-1.6	-5.1	-.1	-11.5	-1.2
.1E+05-.1E+06	18.9	0.0	8.2	0.0	2.5	0.0	1.3	0.0	.0	0.0	-1.0	0.0	-1.8	0.0	-2.8	0.0	-3.6	0.0
.1E+06-.1E+07	-1.3	0.0	-2.6	0.0	.1	0.0	-.6	0.0	-1.2	0.0	-.2	0.0	-.5	0.0	.0	0.0	.5	0.0

COOL TIME	GROUP 10		GROUP 11		GROUP 12		GROUP 13		GROUP 14		GROUP 15		GROUP 16		GROUP 17	
DECADE	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP
.1E-01-.1E+00	-.4	0.0	-2.6	0.0	-.5	0.0	-1.5	0.0	-.4	0.0	-.1	0.0	.5	0.0	-46.3	0.0
.1E+00-.1E+01	1.5	0.0	-1.2	0.0	.8	0.0	.9	0.0	-1.0	0.0	-1.6	0.0	-1.1	0.0	-41.4	0.0
.1E+01-.1E+02	1.2	-.1	1.0	-3.0	-.8	.5	-3.3	-1.2	-5.6	-1.6	-11.3	-.1	-18.2	2.7	-33.7	.8
.1E+02-.1E+03	-10.5	-1.5	-13.4	.1	-18.5	-1.4	-22.5	-.6	-26.7	-.8	-30.0	-.3	-34.6	-.6	-50.1	-5.4
.1E+03-.1E+04	-12.3	.9	-14.3	-1.7	-17.6	.3	-18.3	.4	-25.7	-.1	-26.4	.2	-35.7	.4	-50.5	-4.5
.1E+04-.1E+05	-10.9	-.0	-11.8	-2.3	-10.1	-.7	-14.4	-1.6	-14.0	2.4	-10.8	-1.0	-16.9	-2.1	-20.3	-4.2
.1E+05-.1E+06	-5.0	0.0	-6.7	0.0	-6.8	0.0	-9.8	0.0	-8.5	0.0	-15.1	0.0	-25.9	0.0	4.8	0.0
.1E+06-.1E+07	-.0	0.0	-.1	0.0	-.1	0.0	.9	0.0	2.4	0.0	3.8	0.0	20.5	0.0	1.9	0.0

TABLE B-II

AVERAGE PERCENT DEVIATIONS OF ADJUSTED FITS FROM ENDF/B-V AND EXPERIMENTAL DATA FOR U-235 GAMMAS

COOL TIME	GROUP 1		GROUP 2		GROUP 3		GROUP 4		GROUP 5		GROUP 6		GROUP 7		GROUP 8		GROUP 9	
DECADE	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP
.1E-01-.1E+00	-1.4	0.0	-39.4	0.0	-67.9	0.0	-7.6	0.0	-40.0	0.0	.7	0.0	80.6	0.0	-1.6	0.0	-.1	0.0
.1E+00-.1E+01	14.1	0.0	-35.9	0.0	-63.6	0.0	-12.2	0.0	-42.9	0.0	.1	0.0	58.7	0.0	-8.4	0.0	-3.0	0.0
.1E+01-.1E+02	31.1	-.8	-36.6	-.9	-56.8	.6	-29.1	.0	-40.9	.4	-17.9	-.9	47.3	-1.7	-7.7	3.1	2.7	-2.4
.1E+02-.1E+03	-25.2	-.3	-11.5	.0	-37.4	-.0	-9.5	-.2	-37.5	-.6	-1.1	-.1	43.4	-1.3	9.3	-.9	7.2	.0
.1E+03-.1E+04	-30.2	-.5	-4.9	2.1	-7.1	2.5	-7.5	4.1	-4.9	1.1	9.0	.7	11.9	-2.1	5.5	1.6	8.9	5.4
.1E+04-.1E+05	.1	.2	-.9	4.2	19.9	6.2	-12.2	11.3	-2.7	2.1	.7	-1.8	-13.9	6.0	4.5	-1.7	-10.7	25.6
.1E+05-.1E+06	1.4	-4.0	28.6	4.4	-6.5	-4.8	-9.9	1.5	-4.6	.2	2.0	-4.9	-13.9	-1.7	-10.7	-9.2	7.7	9.6
.1E+06-.1E+07	-6.6	0.0	8.5	0.0	-8.3	0.0	-2.6	0.0	-1.7	0.0	3.6	0.0	-4.0	0.0	-7.0	0.0	-9.8	0.0

COOL TIME	GROUP 10		GROUP 11		GROUP 12		GROUP 13		GROUP 14		GROUP 15		GROUP 16		GROUP 17		GROUP 18	
DECADE	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP
.1E-01-.1E+00	141.2	0.0	70.3	0.0	111.6	0.0	64.0	0.0	62.2	0.0	118.2	0.0	81.5	0.0	214.5	0.0	253.7	0.0
.1E+00-.1E+01	110.5	0.0	71.0	0.0	125.3	0.0	87.3	0.0	110.9	0.0	100.7	0.0	77.1	0.0	245.2	0.0	262.4	0.0
.1E+01-.1E+02	97.8	.7	75.4	.7	234.4	-1.4	215.8	-3.6	203.3	-1.6	130.8	.6	76.6	-.8	224.7	-4.2	204.9	-2.2
.1E+02-.1E+03	60.7	-.6	96.4	-1.1	157.1	-1.5	164.8	-.8	108.3	-.1	91.7	-.4	88.9	-.4	109.2	-1.7	124.6	-.9
.1E+03-.1E+04	31.0	5.8	64.9	7.4	21.3	6.5	43.4	5.4	25.7	4.5	13.6	5.9	28.4	9.8	61.8	9.1	105.7	3.5
.1E+04-.1E+05	6.3	11.0	19.7	19.5	-15.3	23.3	-20.3	27.2	-6.4	5.8	-2.7	8.8	-4.3	3.7	8.2	-24.9	9.0	-61.3
.1E+05-.1E+06	2.6	7.1	19.6	15.6	-29.3	8.8	-27.7	34.2	44.3	3.9	58.4	-34.0	10.1	0.0	-.3	0.0	-.3	0.0
.1E+06-.1E+07	7.4	0.0	24.6	0.0	-18.7	0.0	-.2	0.0	3.2	0.0	63.2	0.0	20.4	0.0	-1.0	0.0	0.0	0.0

TABLE B-III

AVERAGE PERCENT DEVIATIONS OF ADJUSTED FITS FROM ENDF/B-V AND EXPERIMENTAL DATA FOR PU-239 BETAS

COOL TIME	GROUP 1		GROUP 2		GROUP 3		GROUP 4		GROUP 5		GROUP 6		GROUP 7		GROUP 8		GROUP 9	
DECADE	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP
.1E-01-.1E+00	15.4	0.0	51.6	0.0	28.5	0.0	-1.7	0.0	.6	0.0	.7	0.0	.1	0.0	-.2	0.0	.4	0.0
.1E+00-.1E+01	31.7	0.0	58.8	0.0	32.6	0.0	9.8	0.0	4.8	0.0	1.8	0.0	1.3	0.0	-.4	0.0	2.3	0.0
.1E+01-.1E+02	108.8	-17.9	99.7	-10.8	61.8	-8.1	52.1	.8	27.1	-.8	11.7	-5.9	11.4	-2.9	-4.9	1.9	9.2	-.3
.1E+02-.1E+03	143.3	.5	134.9	8.0	90.7	5.8	70.2	-.0	41.0	1.7	23.3	1.7	14.4	1.6	-2.6	-1.0	.8	.6
.1E+03-.1E+04	115.8	-.4	80.7	1.1	55.4	1.6	37.0	-.2	25.3	3.0	10.7	.0	1.6	-.3	-5.7	-.3	-11.1	-.5
.1E+04-.1E+05	92.2	-.4	42.4	-2.1	26.2	-1.2	11.1	-.0	3.0	.5	-5.5	.3	-8.5	2.1	-11.8	2.0	-14.0	2.0
.1E+05-.1E+06	15.9	0.0	15.6	0.0	7.4	0.0	1.7	0.0	-2.1	0.0	-3.8	0.0	-5.2	0.0	-1.7	0.0	-2.3	0.0
.1E+06-.1E+07	.6	0.0	-2.7	0.0	-2.4	0.0	-.4	0.0	.2	0.0	.8	0.0	.0	0.0	.2	0.0	-.9	0.0

COOL TIME	GROUP 10		GROUP 11		GROUP 12		GROUP 13		GROUP 14		GROUP 15		GROUP 16		GROUP 17	
DECADE	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP	ENDF	EXP
.1E-01-.1E+00	5.4	0.0	3.8	0.0	2.5	0.0	3.0	0.0	2.2	0.0	-.5	0.0	.4	0.0	3.8	0.0
.1E+00-.1E+01	.0	0.0	1.0	0.0	1.2	0.0	1.9	0.0	-.0	0.0	.4	0.0	-3.9	0.0	-15.1	0.0
.1E+01-.1E+02	6.7	-.5	7.5	-.3	7.4	-.4	1.7	-2.3	-.6	-.3	-6.8	.2	-21.6	-.4	-36.5	-2.0
.1E+02-.1E+03	-5.0	.6	-10.2	.5	-15.3	1.0	-20.1	1.4	-27.1	.4	-35.2	.1	-48.3	.7	-63.0	-.3
.1E+03-.1E+04	-17.2	-1.1	-19.9	-.2	-23.1	-.5	-27.8	-2.6	-31.4	-.9	-36.5	-.3	-60.6	-2.2	-65.5	-7.5
.1E+04-.1E+05	-17.9	.7	-17.3	1.1	-18.0	.8	-19.1	1.0	-21.9	.8	-19.4	-.1	-21.0	-3.5	-13.6	9.8
.1E+05-.1E+06	-7.0	0.0	-7.2	0.0	-5.7	0.0	-8.4	0.0	-7.7	0.0	-13.4	0.0	1.0	0.0	1.1	0.0
.1E+06-.1E+07	-.7	0.0	-1.2	0.0	3.3	0.0	1.9	0.0	5.1	0.0	-.1	0.0	2.4	0.0	-1.0	0.0

TABLE B-IV

AVERAGE PERCENT DEVIATIONS OF ADJUSTED FITS FROM ENDF/B-V AND EXPERIMENTAL DATA FOR PU-239 GAMMAS

COOL TIME DECADE	GROUP 1 ENDF	GROUP 1 EXP	GROUP 2 ENDF	GROUP 2 EXP	GROUP 3 ENDF	GROUP 3 EXP	GROUP 4 ENDF	GROUP 4 EXP	GROUP 5 ENDF	GROUP 5 EXP	GROUP 6 ENDF	GROUP 6 EXP	GROUP 7 ENDF	GROUP 7 EXP	GROUP 8 ENDF	GROUP 8 EXP	GROUP 9 ENDF	GROUP 9 EXP
.1E-01-.1E+00	65.0	0.0	-16.8	0.0	-68.4	0.0	-11.2	0.0	-36.6	0.0	-3.6	0.0	7.5	0.0	.1	0.0	-1.7	0.0
.1E+00-.1E+01	81.0	0.0	-29.6	0.0	-65.0	0.0	-13.7	0.0	-29.1	0.0	-12.5	0.0	15.4	0.0	-1.0	0.0	9.3	0.0
.1E+01-.1E+02	48.6	-2.8	-50.8	1.9	-55.1	1.1	-26.4	-.3	-32.8	.9	-24.0	-.1	46.0	-.3	1.3	.5	27.1	-.3
.1E+02-.1E+03	-32.2	2.5	-38.1	-.6	-47.7	-2.4	-18.6	-1.6	-41.8	-.5	-10.5	.5	58.5	.3	12.8	-.1	27.5	.7
.1E+03-.1E+04	-26.7	-.4	-24.4	.6	-16.6	-.5	-14.5	-.9	-11.4	1.0	2.0	.8	22.7	.4	17.9	.4	32.5	1.4
.1E+04-.1E+05	3.0	.1	-5.0	.2	8.8	.5	-13.4	.8	-4.9	-.2	-1.2	1.0	-11.5	-.7	17.1	-.7	-4.0	.3
.1E+05-.1E+06	-12.7	0.0	21.1	-1.4	5.4	.2	-11.7	3.1	-15.3	-2.3	-2.9	-1.7	-21.9	-4.0	-19.1	-2.1	-24.0	-9.0
.1E+06-.1E+07	-.1	0.0	7.9	0.0	-1.7	0.0	-4.2	0.0	-6.9	0.0	8.3	0.0	-6.7	0.0	-12.3	0.0	-10.8	0.0

COOL TIME DECADE	GROUP 10 ENDF	GROUP 10 EXP	GROUP 11 ENDF	GROUP 11 EXP	GROUP 12 ENDF	GROUP 12 EXP	GROUP 13 ENDF	GROUP 13 EXP	GROUP 14 ENDF	GROUP 14 EXP	GROUP 15 ENDF	GROUP 15 EXP	GROUP 16 ENDF	GROUP 16 EXP	GROUP 17 ENDF	GROUP 17 EXP	GROUP 18 ENDF	GROUP 18 EXP
.1E-01-.1E+00	72.8	0.0	2.9	0.0	119.4	0.0	35.0	0.0	191.9	0.0	82.8	0.0	27.1	0.0	39.6	0.0	261.2	0.0
.1E+00-.1E+01	78.4	0.0	17.5	0.0	163.3	0.0	82.7	0.0	239.2	0.0	107.5	0.0	31.3	0.0	66.2	0.0	234.4	0.0
.1E+01-.1E+02	94.5	-.4	85.1	-.0	349.9	-.7	273.7	.3	329.5	3.9	180.1	.0	76.7	-.8	186.5	-3.5	181.1	-4.4
.1E+02-.1E+03	76.3	.1	155.2	-.0	242.8	.1	214.4	-.1	174.1	-1.4	167.0	-.1	152.5	-.1	171.5	-.6	154.1	-2.3
.1E+03-.1E+04	47.5	.7	103.9	.1	61.3	.0	79.6	.9	57.6	-.0	30.4	1.2	73.2	.8	96.7	1.3	78.7	-23.2
.1E+04-.1E+05	4.6	-2.0	25.4	-.2	-1.1	-1.2	-12.6	-1.8	18.9	-.3	7.9	-6.7	21.4	-2.0	7.2	-20.0	4.2	-86.0
.1E+05-.1E+06	-21.0	-.7	-6.8	-.0	-40.3	-5.1	-24.5	.7	5.3	-2.7	36.5	-21.4	-34.5	0.0	1.2	0.0	-.3	0.0
.1E+06-.1E+07	-3.8	0.0	4.3	0.0	-23.9	0.0	3.4	0.0	1.0	0.0	89.3	0.0	-10.4	0.0	.8	0.0	0.0	0.0

TABLE B-V

PERCENT ESTIMATE OF ACCURACY OF ADJUSTED FITS FOR U-235 BETAS

ENERGY RANGES (MEV)	COOLING TIME RANGES (S) 1.0E-02-1.0E+00	1.0E+00-1.0E+04	1.0E+04-1.0E+06	1.0E+06-1.0E+09
0.0- .6	35.8	19.5	5.6	5.0
.6-1.6	5.0	5.0	5.0	5.0
1.6-3.0	5.0	5.0	5.0	5.0
3.0-7.5	7.6	8.9	12.0	5.0

TABLE B-VI

PERCENT ESTIMATE OF ACCURACY OF ADJUSTED FITS FOR U-235 GAMMAS

ENERGY RANGES (MEV)	COOLING TIME RANGES (S) 1.0E-02-1.0E+00	1.0E+00-1.0E+04	1.0E+04-1.0E+06	1.0E+06-1.0E+09
0.0- .6	15.1	7.1	10.9	5.0
.6-1.6	11.8	6.6	9.0	5.0
1.6-3.0	48.9	25.9	33.6	5.0
3.0-7.5	94.5	32.0	5.4	5.0

TABLE B-VII

PERCENT ESTIMATE OF ACCURACY OF ADJUSTED FITS FOR PU-239 BETAS

ENERGY RANGES (MEV)	COOLING TIME RANGES (S) 1.0E-02-1.0E+00	1.0E+00-1.0E+04	1.0E+04-1.0E+06	1.0E+06-1.0E+09
0.0- .6	18.2	26.7	7.4	5.0
.6-1.6	5.0	6.1	5.0	5.0
1.6-3.0	5.0	5.0	5.0	5.0
3.0-7.5	5.0	11.2	5.0	5.0

TABLE B-VIII

PERCENT ESTIMATE OF ACCURACY OF ADJUSTED FITS FOR PU-239 GAMMAS

ENERGY RANGES (MEV)	COOLING TIME RANGES (S) 1.0E-02-1.0E+00	1.0E+00-1.0E+04	1.0E+04-1.0E+06	1.0E+06-1.0E+09
0.0- .6	21.9	7.8	8.7	5.0
.6-1.6	5.8	5.6	14.7	5.0
1.6-3.0	49.7	30.0	24.2	5.0
3.0-7.5	55.0	37.2	7.9	5.0

Printed in the United States of America
Available from
National Technical Information Service
US Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

Microfiche (A01)

Page Range	NTIS Price Code	Page Range	NTIS Price Code	Page Range	NTIS Price Code	Page Range	NTIS Price Code
001-025	A02	151-175	A08	301-325	A14	451-475	A20
026-050	A03	176-200	A09	326-350	A15	476-500	A21
051-075	A04	201-225	A10	351-375	A16	501-525	A22
076-100	A05	226-250	A11	376-400	A17	526-550	A23
101-125	A06	251-275	A12	401-425	A18	551-575	A24
126-150	A07	276-300	A13	426-450	A19	576-600	A25
						601-up*	A99

*Contact NTIS for a price quote.

Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36.

Los Alamos National Laboratory
Los Alamos, New Mexico 87545