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A COMPUTER CODE FOR STANDARDIZING NEUTRON SPECTRA

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A COMPUTER CODE FOR STANDARDIZING NEUTRON SPECTRA

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ABSTRACT

The DPSC code is written for comparison and evaluation of neutron spectra computed or measured by different techniques. The code calculates the spectra in 48 predetermined points independently from the original interval distribution of the input spectra. The code computes kerma and rem-dose spectra as well as dose fraction from the standardized neutron spectra. The calculated spectra are written on a library tape and drawn by an off-line plotter.

KIVONAT

A DPSC program lehetővé teszi különböző módon számitott és mért neutron spektrumok összehasonlitását és kiértékelését azáltal, hogy függvény--interpolációk segitségével a spektrumokat egységesen 48 energia-intervallumban adja meg. A program a standardizált neutron spektrumokból kerma és rem-dózis spektrumokat, valamint dózishányadokat számol. A spektrumokat könyvtárszalagon rögziti és plotteren kirajzolja.

РЕЗЮМЕ

Программа DPSC делает возможным сравнение и оценку нейтронных спектров, вычисленных и измеренных разными методами. Спектры с помощью интерполяции приводятся к одному виду в 48 интервалах энергии. Из стандартизованных нейтронных спектров программа вычисляет спектры керма и бэр поглощенной дозы, а также вклад дозы в спектр. Спектры записываются на магнитных лентах и на самописце.

I. Introduction

Neutron spectra calculated or measured by the different methods described in the literature often can only with difficulty be compared with each other and used for evaluation of dosimeters, because they refer to different values; for instance, $\Psi/E/$ or $E.\Psi/E/$, etc.

The DPSC code, designed to simplify work with the spectra, makes a neutron spectrum library by standardizing neutron spectra from either $\Psi/E/$ or $E.\Psi/E/$ input spectra. The code also calculates dose and kerma spectra and dose fractions and has the standardized spectra drawn on a plotter.

II. Description of the program

The first task is to make a standardized spectrum from the input spectrum. This is done by Lagrange and linear interpolation. The program determined both interpolations, compares the results, and the result which approximates the input function the better is used for the further calculation.

Lagrange interpolation

The function which is to be approximated, denoted by $f/x/$, is defined in the interval $\left[x_1 ; x_n\right]$. If $x_1,\ldots,x_n$ are different optional base points then the Lagrange polynomial is

$$P/x/ = \sum_{k=1}^{n} f/x_k/ \cdot \prod_{\substack{i=1 \\ i\neq k}}^{n} \frac{x - x_i}{x_k - x_i} \qquad 1/$$

Generally it is not necessary to know the $P/x/$ polynomial in its explicit form $a_o + a_1x + a_2x + \ldots + a_{n-1}x^{n-1}$; the knowledge of its values at m discrete points $(\xi_1, \xi_2, \ldots \xi_m)$ is enough. An algorithm for computer calculation of the $P/X/$ values /here called $A/$ is given in [1].

In 1/ P/x/ is a Lagrange polynomial of degree /n-1/ interval and has /n-2/ extremes. The positions of these extremes may all be inside the $\left[x_1 ; x_n \right]$ interval. In that case, if f/x/ has less than /n-2/ extremes the interpolating polynomial is not a good approximation to the original function but oscillates. This happens, often, especially when f/x/ is monotonous in a large interval within $\left[x_1 ; x_n \right]$. The oscillation increases when the value of $\left| \max f/x/ - \min f/x/ \right|$ in an energy interval $\left[x_1 ; x_n \right]$ - or the energy interval itself - is large. Sometimes the value of P/x/ will be less than 0, despite the fact that $x_1 > 0$ and $f/x/ > 0$ in the whole $\left[x_1 ; x_n \right]$ interval.

Linear interpolation

$$L/x/ = f/x_i/ + \frac{\left(f/x_n/ - f/x_i/ \right) . /x - x_i/}{x_k - x_i} \qquad 2/$$

where $x_i \quad x \quad x_k$

This interpolation results in large error when an extreme lies between x_i and x_k, but gives a good approximation if the function is monotonous and changing only slowly.

The standardizing procedure

To avoid the difficulties which have been mentioned above the following procedure is utilized.

Let f/x/ represent an input spectrum $E.\varphi /E/$. If the input spectrum is $\varphi /E/$, then it is converted by the code to $E.\varphi /E/$. As a result the value of $\left| \max f/x/ - \min f/x/ \right|$ will be small, and $x_i = \log_{10} E_i$ is used instead of E_i to decrease the length of the $\left[x_1 ; x_n \right]$ interval.

The standardized output spectrum $(E.\varphi /E/)$ is denoted by g/x/. This is a combination of three different approximate functions:

a/ $g_1/x/$ computed by algorithm A using six base points. These points are chosen on the basis of the conditions:

$$|x_{k+5} - x| \geq |x - x_i| \qquad i = k,\ldots,k+4 \quad \text{or}$$
$$|x_k - x| \geq |x - x_i| \qquad i = k+1,\ldots,k+5$$

$$x \in [x_k ; x_{k+5}] \; ; \; x_k, x_{k+5} \in [x_1 ; x_n]$$

b/ $g_2/x/$ calculated also by algorithm A but for four base points, with

$$|x_{k+3} - x| \geq |x - x_i| \qquad i = k, k+1, k+2 \quad \text{or}$$
$$|x_k - x| \geq |x - x_i| \qquad i = k+1, k+2, k+3$$

$$x \in [x_k ; x_{k+3}] \; ; \qquad x_k, x_{k+3} \in [x_1 ; x_n]$$

c/ $g_3/x/$ computed by linear interpolation.

Generally $g_1/x/$ is the best approximation of $f/x/$. But at some points the P_6 approximation may be deficient and the code therefore replaces values of $g_1/x/$ with values of $g_2/x/$ or $g_3/x/$, such that at points where $g_1/x/ < 0$, then $g_1/x/ = g_2/x/$, while points where $g_2/x/ < 0$, the value of $g_3/x/$ is used instead of $g_2/x/$. Consequently $g_1/x/$ will be greater than 0 in the whole $[x_1 ; x_n]$ interval.

This optimalization is carried out with the expression

$$\left| \left(\sum_{i=1}^{k-1} f(x_i)(x_{i+1} - x_i) - C_1 + C_2 \right) - \sum_{\ell=1}^{j} g_1(\xi_\ell)(\xi_{\ell+1} - \xi_\ell) \right|$$

$$\left(C_1 = f(x_1) \cdot (\xi_1 - x_1) \quad ; \quad C_2 = f(x_{k-1}) \cdot (\xi_{j+1} - x_k) \right) \qquad 3/$$

which is put equal to D_1.

In the approximation the values of $g_1(\xi_i)$ /i increases from 1 until m/ are tested for each i.

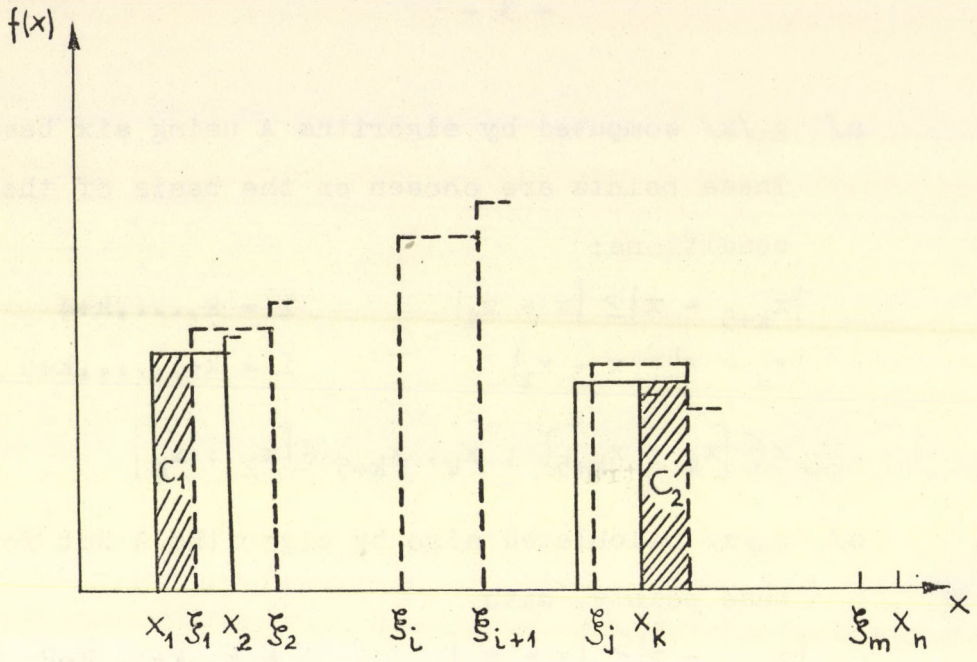


Fig. 1.

In Fig. 1 x_k is the nearest to ξ_j and

if $0 < i < 4$ then $j = 4$

if $4 \leq i$ then $j = i+1$ and

if $i = m$ then $j = m$

When $g_1(\xi_i)$ in 3/ is replacedby $g_2(\xi_i)$ or by $g_3(\xi_i)$, we get the different values D_2 and D_3.

If D_1 is the smaller quantity among D_1, D_2 and D_3, then $g_1(\xi_i)$ will not be changed; if D_2 is minimum, then let $g_1(\xi_i) = g_2(\xi_i)$; and if D_3 is minimum, then $g_1(\xi_i)$ will be equal to $g_3(\xi_i)$. In the next step /when $g_1(\xi_{i+1})$ is tested/ the changed value of $g_1(\xi_{i+1})$ is taken. Finally let g/x/ be equal to g_1/x/. In this procedure the code uses uncorrected values for calculation of $g(\xi_1)$ and $g(\xi_2)$. Although this may result in an error, the error is not significant when f/x/ is a neutron spectrum /since the function in the low energy range is smooth/. The difference of the limits of summarizing also gives an error. The total error of interpolation is, in fact, less than the error which may derive from the measurement of calculation of the input neutron spectrum.

Further calculations

From the calculated E.Υ /E/ spectrum the Υ /E/ spectrum can be recorded. Kerma and rem-dose spectra are computed from this by applying conversion factors obtained by graphical interpolation from [2] and [3], /see Appendix 8/. After this the E.Υ /E/ kerma and rem-dose spectra are normalized to unit area as follows. If h/x/ denotes the spectra to be normalized and $\overline{h/x/}$ denotes the normalized spectra then

$$\overline{h_i/x/} = \frac{h_i/x/}{\sum_{i=1}^{m} h_i/x/} \qquad i=1,.....,m \qquad 4/$$

The dose fractions are computed by the expression 5/

$$D_j = \frac{\sum_{i=k}^{k+L} dosis_i\ /E/.E_i.leth_i}{\sum_{i=1}^{m} dosis_i\ /E/.E_i.leth_i} \qquad 5/$$

Where $leth_i$ equals the length of the lethargy interval. The boundaries of standard energy intervals, /E/ the energy base points $/\sqrt{E_j.E_k}/$, the length of the lethargy intervals and the energy intervals in which the dose fractions are calculated are given in Appendix 2 and 3.

III. Users' manual

Program name: DPSC

Program language: ICL-1900 FORTRAN

Peripherials: 1 tape reader
1 line printer
3 magnetic tapes: DPSC- LIBRARY
PLOTTER tape
Scratch tape
1 off-line plotter

A core of 19,000 words is needed.

The running time for the preparation of a spectrum is about two minutes.

Input data

The input data must be given in records.

1./ The first record contains a variable ICARD /format 10A8/ defining the mode of operation. ICARD may contain the following characters, written into the first character positions of the record /the rest character positions are left blank/:

- RUN The input spectrum is standardized and the output is given on the line printer and on the plotter.
- ADD As in RUN mode but the input and output spectra are also written into the library.
- EDIT Prints the input and output spectra requested from the library.
- LIST Lists the contents of the library from a given identification number.
- DELETE Deletes the spectrum identified below.
- PLOT Output on the line printer as in EDIT mode and the output spectrum is also plotted. /Description of the plotter code is given in /4//.
- ENDEND Terminates the program.
- NEWTAPE Deletes the whole library tape.

The mode of operation determines the content of the other records.

2./ In EDIT, LIST, PLOT and DELETE modes the second record contains the spectrum identification number in A8 format. No further record is needed in these cases.

3./ In RUN and ADD modes the second record is the same as 2. Information about the spectrum may be placed in the next five records 3-7 /format 10A8/.

Record 8: N, K1, KN /format 3I0/

N: Number of input points $6 \leq N \leq 200$

K1, KN: Serial numbers of the standardized energy points. The interpolation begins from K1 and is terminated by KN. An arbitrary value may be given to K1 and KN in the input list, provided the condition $1 \leq K1 \leq KN \leq 48$ is fulfilled. If ESTAND /K1/ < EIN/1/, then the current value of K1 is increased by 1 until ESTAND/K1/ < EIN/1/. Similary, if ESTAND/KN/ > EIN/N/, then KN is decremented by 1 until ESTAND/KN/ $\leq$ EIN/N/.

If ESTAND/K1/ > EIN/1/ and ESTAND/KN/ < EIN/N/, then the calculations described above are made in the energy interval ESTAND/K1/ $\div$ ESTAND/KN/.

Record 9: ZZ /format F0.0/. If ZZ > 0, then both EIN/I/ and F/I/ must be given in the input list. If ZZ < 0, then only F/I/ must be specified; in this case the previous set of EIN/I/ will be used in the calculations. Variable EIN/I/ gives the energy base points of the input spectrum /in eV/ in increasing order $(6 \leq I \leq N \leq 200)$. Variable F/I/ gives the input spectrum, which may be either Ψ/E/, E.Ψ /E/ or flux per GY length lethargy interval $(6 \leq I \leq N \leq 200)$. If ZZ is greater than 0, then

Record 10:	EIN/1/	/format F0.0/
11:	EIN/2/	"
.....		
Record N+9:	EIN/N/	"
N+10:	F/1/	"
N+11:	F/2/	"
.....		
Record 2N+9:	F/N/	"
2N+10:	Z	"

If $Z>0$, then F/I/ is identical with E.Υ /E/ ; if $Z<0$, then F/I/ is identical with Υ /E/;

Record 2N+11:	GY	/format F0.0/

GY is the length of the lethargy interval in which the input spectrum is given. If the form of the input spectrum (F/I/) is Υ /E/, then GY value is arbitrary, if (F/I/) is E.Υ /E/, then GY=1.0

Record 2N+12:	KU,KUK	/format 2I0/

KU respectively KUK may be equal to 1,2,3,4,5,6 or 7 correspond to this the first grades of linear E.Υ /E/ and E.KER/E/ axises may be either 0.2, 0.1, 0.05, 0.04, 0.025, 0.02 or 0.01
If KU=0, then the code chooses the appropriate grade of axises out. If ZZ is less than 0, then

Record 10:	F/1/	/format F0.0/
11:	F/2/	"
.....		
Record N+9:	F/N/	"
N+10:	Z	"
N+11:	GY	"
N+12:	KU, KUK	/format 2I0/

In RUN and ADD modes no further record is needed. The modes mentioned under points 2 and 3 may follow each other in any order.

4./ It should be noted that:

The input list should begin with NEWTAPE if it is necessary to delete the whole library or to begin a new library tape. In every case the input list must finish with ENDEND. A sample input list is given in Appendix 7.

When there is a mistake in the input list, then the code writes the following text: "Error in input date" and writes out the faulty data, too. The program is continued from the next operation defined by the variable ICARD.

Output data

We demonstrate a complete processing of a spectrum by DPSC code in Appendix 1-11. The presented sample spectrum is published in [6].

In RUN mode the output data are printed on line printer /see Appendix 1, 2 and 3/.

In ADD mode the output data are printed on line printer, as in RUN mode, and the following data are written on the library tape: identification number and comments about the input spectrum, the input spectrum in its native form and the standardized spectrum obtained from it. /see Appendix 5 and 6/. Beside these data E.Ψ /E/, kerma and rem-dose spectra are drawn on an off-line operated plotter. /see Appendix 9, 10 and 11./

In EDIT and PLOT modes the data are read from the library tape and written by line printer. /see Appendix 5 and 6/.

In PLOT mode the E.Ψ /E/ spectrum is drawn. /see Appendix 9/.

In LIST mode the content of the library is printed /see Appendix 4/.

Notes

The identification number of the DPSC-library is 1677. The tape was opened on 15th Jan, 1972.

Time of the preservation is 3 years.

The program language is ICL-1900 FORTRAN, this differs from ANSI-FORTRAN.

The DPSC code used the following differences: /see [5]/

- Names with up to 32 characters.
- Subscripts formed from any INTEGER expression.
- Named common blocks differing in size in different segments.
- Text constans in DATA statements initializing several array elements.
- Operators +,-,. and / combining elements of type:
  INTEGER and REAL
- Zero statement labels in computed GO TO and arithmetic IF.
- INTEGER expressions as the parameters of a DO statement.
- TEXT constans as actual arguments replacing dummy arrays.
- TEXT constans as actual arguments of external function references.
- A MASTER statement is required.
- FORMAT of READ and WRITE may be IO and FO.0 .
- Four spetial segments for handling of characters and data
  COMP8 compare two strings of eight characters for equality.
  COPY8 copy eight characters.
  DATA writing of data.
  TIME writing of time.

References

[1] I.N. Bronstein, K.A. Semendiaev: Mathematical Handbook MK. Budapest, 1963. pp. 723-724. /in Hungarian/

[2] J.A. Dennis, H.J. Delafield, P.D. Holt, S.J. Boot: AERE-R 6498, June, 1970.

[3] D. Nachtigall, F. Rohloff: Jül-213-ST /1964/.

[4] ICT 1900 Series, Graph Plotter, Technical Publication 4087, ICT, Letchworth, Hertfordshire, Great Britain, 1968.

[5] Technical Publication 4261, ICL Printing Service, at Letchworth, Hertfordshire.

[6] ORNL-RSIC-29. pp. 42-57.

Appendix 1

NEUTRON SPECTRUM TRANSFORMATION

```
00000012
     ORNL-RSIC-29.P.S1.
     REACTOR SPECTRUM,FE,D=90CM
     POKER CODE (A.W.R.E.)(PINK)
     INPUT SPECTRUM:E*PHI(E)
     **
```

INPUT DATA

NUMBER OF THE INPUT ENERGY GROUPS: 33

	ENERGY EV	ENERGY*FLUX
1	0.17320E 00	0.18000000E 07
2	0.54770E 00	0.14000000E 08
3	0.22360E 01	0.50000000E 08
4	0.74160E 01	0.90000000E 08
5	0.18170E 02	0.12000000E 09
6	0.42430E 02	0.16000000E 09
7	0.94870E 02	0.17000000E 09
8	0.24490E 03	0.18000000E 09
9	0.63250E 03	0.21000000E 09
10	0.12250E 04	0.28000000E 09
11	0.17320E 04	0.32000000E 09
12	0.28280E 04	0.40000000E 09
13	0.48990E 04	0.44000000E 09
14	0.77460E 04	0.18000000E 09
15	0.11400E 05	0.40000000E 09
16	0.16120E 05	0.60000000E 09
17	0.22360E 05	0.16000000E 10
18	0.27390E 05	0.60000000E 08
19	0.42430E 05	0.18000000E 09
20	0.69280E 05	0.20000000E 09
21	0.89440E 05	0.14000000E 09
22	0.11400E 06	0.26000000E 09
23	0.13960E 06	0.18000000E 09
24	0.16430E 06	0.17000000E 09
25	0.22450E 06	0.65000000E 08
26	0.37420E 06	0.16000000E 08
27	0.70710E 06	0.30000000E 07
28	0.12650E 07	0.12000000E 06
29	0.21910E 07	0.16000000E 05
30	0.42430E 07	0.20000000E 04
31	0.62050E 07	0.00000000E 00
32	0.79370E 07	0.00000000E 00
33	0.11220E 08	0.00000000E 00

Appendix 2

CALCULATED DATA

NUMBER OF THE STANDARD ENERGY GROUPS: 48

	STANDARD ENERGY EV	LIMITS OF THE ENERGY GROUPS E EV		LETHARGY INTERVALS	FLUX OUT	E*PHI(E)
1	0.21701E 00	0.18845E 00	0.25000E 00	0.2710	0.11947E 08	0.25926E 07
2	0.35356E 00	0.25000E 00	0.50000E 00	0.6930	0.20052E 08	0.70847E 07
3	0.70715E 00	0.50000E 00	0.10000E 01	0.6930	0.24604E 08	0.17400E 08
4	0.14663E 01	0.10000E 01	0.21500E 01	0.7460	0.22904E 08	0.33588E 08
5	0.31619E 01	0.21500E 01	0.46500E 01	0.7460	0.18075E 08	0.57150E 08
6	0.68191E 01	0.46500E 01	0.10000E 02	0.7460	0.12522E 08	0.85391E 08
7	0.14663E 02	0.10000E 02	0.21500E 02	0.7460	0.75167E 07	0.11022E 09
8	0.31619E 02	0.21500E 02	0.46500E 02	0.7460	0.44965E 07	0.14217E 09
9	0.68191E 02	0.46500E 02	0.10000E 03	0.7460	0.26418E 07	0.16491E 09
10	0.14663E 03	0.10000E 03	0.21500E 03	0.7460	0.11824E 07	0.17345E 09
11	0.31619E 03	0.21500E 03	0.46500E 03	0.7460	0.58673E 06	0.18552E 09
12	0.68191E 03	0.46500E 03	0.10000E 04	0.7460	0.31652E 06	0.21584E 09
13	0.14663E 04	0.10000E 04	0.21500E 04	0.7460	0.20394E 06	0.29904E 09
14	0.31619E 04	0.21500E 04	0.46500E 04	0.7460	0.12855E 06	0.40645E 09
15	0.68191E 04	0.46500E 04	0.10000E 05	0.7460	0.38810E 05	0.26465E 09
16	0.11220E 05	0.10000E 05	0.12589E 05	0.2300	0.34685E 05	0.38916E 09
17	0.14125E 05	0.12589E 05	0.15848E 05	0.2300	0.36493E 05	0.51547E 09
18	0.17816E 05	0.15848E 05	0.19951E 05	0.2300	0.48933E 05	0.87179E 09
19	0.22385E 05	0.19951E 05	0.25117E 05	0.2300	0.71135E 05	0.15923E 10
20	0.28182E 05	0.25117E 05	0.31620E 05	0.2300	0.23532E 04	0.66319E 08
21	0.35478E 05	0.31620E 05	0.39805E 05	0.2300	0.35101E 04	0.12453E 09
22	0.44663E 05	0.39805E 05	0.50112E 05	0.2300	0.40674E 04	0.18186E 09
23	0.56226E 05	0.50112E 05	0.63086E 05	0.2300	0.33841E 04	0.19028E 09
24	0.70782E 05	0.63086E 05	0.79418E 05	0.2300	0.27624E 04	0.19553E 09
25	0.89117E 05	0.79418E 05	0.10000E 06	0.2300	0.15818E 04	0.14096E 09
26	0.11220E 06	0.10000E 06	0.12589E 06	0.2300	0.22389E 04	0.25121E 09
27	0.14125E 06	0.12589E 06	0.15848E 06	0.2300	0.12694E 04	0.17933E 09
28	0.17816E 06	0.15848E 06	0.19951E 06	0.2300	0.81851E 03	0.14583E 09
29	0.22385E 06	0.19951E 06	0.25117E 06	0.2300	0.29544E 03	0.66134E 08
30	0.28182E 06	0.25117E 06	0.31620E 06	0.2300	0.16407E 03	0.46258E 08
31	0.35478E 06	0.31620E 06	0.39806E 06	0.2300	0.63015E 02	0.22357E 08
32	0.44663E 06	0.39806E 06	0.50112E 06	0.2300	0.29491E 02	0.13172E 08
33	0.56226E 06	0.50112E 06	0.63086E 06	0.2300	0.15395E 02	0.86561E 07
34	0.70782E 06	0.63086E 06	0.79418E 06	0.2300	0.42331E 01	0.29963E 07
35	0.89117E 06	0.79418E 06	0.10000E 07	0.2300	0.23001E 01	0.20498E 07
36	0.11220E 07	0.10000E 07	0.12589E 07	0.2300	0.76488E 00	0.85820E 06
37	0.14125E 07	0.12589E 07	0.15848E 07	0.2300	0.73228E-01	0.10343E 06
38	0.17816E 07	0.15848E 07	0.19951E 07	0.2300	0.34789E-01	0.61980E 05
39	0.22385E 07	0.19951E 07	0.25117E 07	0.2300	0.70029E-02	0.15676E 05
40	0.28182E 07	0.25117E 07	0.31620E 07	0.2300	0.41590E-02	0.11721E 05
41	0.35478E 07	0.31620E 07	0.39806E 07	0.2300	0.19004E-02	0.67431E 04
42	0.44663E 07	0.39806E 07	0.50112E 07	0.2300	0.39683E-03	0.17724E 04
43	0.56226E 07	0.50112E 07	0.63086E 07	0.2300	0.10559E-03	0.59358E 03
44	0.70782E 07	0.63086E 07	0.79418E 07	0.2300	0.00000E 00	0.00000E 00
45	0.89117E 07	0.79418E 07	0.10000E 08	0.2300	0.00000E 00	0.00000E 00
46	0.11220E 08	0.10000E 08	0.12589E 08	0.2300	0.00000E 00	0.00000E 00
47	0.14125E 08	0.12589E 08	0.15848E 08	0.2300	0.00000E 00	0.00000E 00
48	0.17816E 08	0.15848E 08	0.19951E 08	0.2300	0.00000E 00	0.00000E 00

Appendix 3

	KERMA(E)	REMDOSE(E)
1	0.83510E-04	0.13345E-01
2	0.11089E-03	0.22960E-01
3	0.95963E-04	0.38518E-01
4	0.62305E-04	0.27808E-01
5	0.33980E-04	0.22430E-01
6	0.16154E-04	0.15891E-01
7	0.74415E-05	0.99520E-02
8	0.40468E-05	0.60163E-02
9	0.24360E-05	0.33350E-02
10	0.20701E-05	0.15993E-02
11	0.19362E-05	0.76861E-03
12	0.21207E-05	0.41053E-03
13	0.29979E-05	0.25309E-03
14	0.40620E-05	0.15605E-03
15	0.26003E-05	0.47115E-04
16	0.38847E-05	0.55010E-04
17	0.51090E-05	0.68461E-04
18	0.83187E-05	0.11069E-03
19	0.14938E-04	0.18836E-03
20	0.58831E-06	0.75304E-05
21	0.10706E-05	0.13170E-04
22	0.14846E-05	0.18291E-04
23	0.14552E-05	0.18203E-04
24	0.14365E-05	0.17602E-04
25	0.96487E-06	0.12130E-04
26	0.15896E-05	0.20381E-04
27	0.10411E-05	0.13940E-04
28	0.77758E-06	0.10547E-04
29	0.32203E-06	0.44818E-05
30	0.20180E-06	0.30320E-05
31	0.88221E-07	0.13473E-05
32	0.46891E-07	0.74848E-06
33	0.27557E-07	0.45016E-06
34	0.84662E-08	0.13080E-06
35	0.50602E-08	0.83747E-07
36	0.18204E-08	0.29540E-07
37	0.18307E-09	0.29291E-08
38	0.10089E-09	0.14204E-08
39	0.21709E-10	0.28978E-09
40	0.14141E-10	0.17326E-09
41	0.79827E-11	0.79181E-10
42	0.16667E-11	0.16639E-10
43	0.47515E-12	0.44421E-11
44	0.00000E 00	0.00000E 00
45	0.00000E 00	0.00000E 00
46	0.00000E 00	0.00000E 00
47	0.00000E 00	0.00000E 00
48	0.00000E 00	0.00000E 00

SPECTRA NORMALIZED TO UNIT AREA

	E*PHI(E)	E*KERMA(E)	E*REMDOSE(E)
1	0.36147E-03	0.10656E-04	0.11749E-03
2	0.98845E-03	0.23054E-04	0.32935E-03
3	0.24259E-02	0.39903E-04	0.81819E-03
4	0.46828E-02	0.53720E-04	0.16543E-02
5	0.79679E-02	0.63178E-04	0.28775E-02
6	0.11905E-01	0.64772E-04	0.43964E-02
7	0.15366E-01	0.64161E-04	0.59205E-02
8	0.19822E-01	0.75241E-04	0.77179E-02
9	0.22992E-01	0.10570E-03	0.92266E-02
10	0.24183E-01	0.12849E-03	0.95142E-02
11	0.25865E-01	0.35990E-03	0.98401E-02
12	0.30092E-01	0.85034E-03	0.11358E-01
13	0.41692E-01	0.25848E-02	0.15056E-01
14	0.56667E-01	0.75524E-02	0.20019E-01
15	0.36897E-01	0.10424E-01	0.13035E-01
16	0.54257E-01	0.25429E-01	0.25041E-01
17	0.71867E-01	0.42434E-01	0.39233E-01
18	0.12155E 00	0.87147E-01	0.80007E-01
19	0.22201E 00	0.19663E 00	0.17107E 00
20	0.92463E-02	0.97492E-02	0.86102E-02
21	0.17362E-01	0.22336E-01	0.18957E-01
22	0.25328E-01	0.38990E-01	0.33145E-01
23	0.24523E-01	0.48111E-01	0.41525E-01
24	0.27261E-01	0.59787E-01	0.50569E-01
25	0.19653E-01	0.50582E-01	0.43859E-01
26	0.35023E-01	0.10488E 00	0.92776E-01
27	0.25003E-01	0.84469E-01	0.79888E-01
28	0.20331E-01	0.81461E-01	0.76381E-01
29	0.92204E-02	0.42388E-01	0.40703E-01
30	0.64465E-02	0.33442E-01	0.34668E-01
31	0.31170E-02	0.18404E-01	0.19393E-01
32	0.18364E-02	0.12315E-01	0.13563E-01
33	0.12068E-02	0.91110E-02	0.10269E-01
34	0.41774E-03	0.35237E-02	0.37543E-02
35	0.23578E-03	0.26517E-02	0.30280E-02
36	0.11965E-03	0.12010E-02	0.13447E-02
37	0.14421E-04	0.15205E-03	0.16786E-03
38	0.84413E-05	0.10569E-03	0.10267E-03
39	0.21856E-05	0.28575E-04	0.26318E-04
40	0.16341E-05	0.23433E-04	0.19811E-04
41	0.94013E-06	0.16653E-04	0.11397E-04
42	0.24711E-06	0.43772E-05	0.30151E-05
43	0.82771E-07	0.15709E-05	0.10133E-05
44	0.00000E 00	0.00000E 00	0.00000E 00
45	0.00000E 00	0.00000E 00	0.00000E 00
46	0.00000E 00	0.00000E 00	0.00000E 00
47	0.00000E 00	0.00000E 00	0.00000E 00
48	0.00000E 00	0.00000E 00	0.00000E 00

NORMALIZING FACTOR TO UNIT AREA OF E*PHI(E) SPECTRUM 7.17253E 00
FACTOR TO E*KER(E) 1.70063E 00
FACTOR TO E*REM(E) 2.46478E 01

DOSE FRACTIONS

0.5EV-1.0EV	0.00196
1.0EV-10.0KEV	0.29240
10.0KEV-0.1MEV	0.40630
0.1MEV-0.5MEV	0.28359
0.5MEV-0.794MEV	0.01113
0.794MEV-1.0MEV	0.00240
1.0MEV-1.58MEV	0.00120
1.58MEV-2.51MEV	0.00010
2.51MEV-15.8MEV	0.00003

END

CONTENT OF THE DPSC-LIBRARY

Appendix 4

```
IDENTIFICATION NUMBER          00000004
NUMBER OF INPUT POINTS            32
NUMBER OF OUTPUT POINTS           48
     00000004
          31-05-72
          MELEKES,1969,PROB.ZASCS.6.P.154
          REACTOR SPECTRUM
          POLYTHEN D=21CM
          INPUT DTA ARE READ FROM THE CURVE IN RELATIVE UNIT,PHI(E)


IDENTIFICATION NUMBER          00000005
NUMBER OF INPUT POINTS            25
NUMBER OF OUTPUT POINTS           48
     00000005
      12-06-72.
      FISSION NEUTRON SPECTRUM,FE,D=50CM
       CALCULATED BY VERTES,1968.IX.
      THERMAL NEUTRON FLUXUS:1.597E-06
      INPUT E*PHI(E) IN 0.77 LETHARGY INTERVAL


IDENTIFICATION NUMBER          00000005
NUMBER OF INPUT POINTS            25
NUMBER OF OUTPUT POINTS           48
     00000005
      12-06-72.
      FISSION NEUTRON SPECTRUM,FE,D=50CM
       CALCULATED BY VERTES,1968.IX.
      THERMAL NEUTRON FLUXUS:1.597E-06
      INPUT E*PHI(E) IN 0.77 LETHARGY INTERVAL


IDENTIFICATION NUMBER          00000012
NUMBER OF INPUT POINTS            33
NUMBER OF OUTPUT POINTS           48
     00000012
          ORNL-RSIC-29.P.51.
          REACTOR SPECTRUM,FE,D=90CM
          POKER CODE (A.W.R.F.)(PINK)
          INPUT SPECTRUM:E*PHI(E)
          **
ENDEND
```

Appendix 5

```
IDENTIFICATION NUMBER          00000012
NUMBER OF INPUT POINTS            33
NUMBER OF OUTPUT POINTS           48
    00000012
         ORNL-RSIC-29,P.51,
         REACTOR SPECTRUM,FE,D=90CM
         POKER CODE (A.W.R.E.)(PINK)
         INPUT SPECTRUM:E*PHI(E)
         **
```

INPUT SPECTRUM

	ENERGY EV	
1	1.73200E-01	1.80000E 06
2	5.47700E-01	1.40000E 07
3	2.23600E 00	5.00000E 07
4	7.41600E 00	9.00000E 07
5	1.81700E 01	1.20000E 08
6	4.24300E 01	1.60000E 08
7	9.48700E 01	1.70000E 08
8	2.44900E 02	1.80000E 08
9	6.32500E 02	2.10000E 08
10	1.22500E 03	2.80000E 08
11	1.73200E 03	3.20000E 08
12	2.82800E 03	4.00000E 08
13	4.89900E 03	4.40000E 08
14	7.74600E 03	1.80000E 08
15	1.14000E 04	4.00000E 08
16	1.61200E 04	6.00000E 08
17	2.23600E 04	1.60000E 09
18	2.73900E 04	6.00000E 07
19	4.24300E 04	1.80000E 08
20	6.92800E 04	2.00000E 08
21	8.94400E 04	1.40000E 08
22	1.14000E 05	2.60000E 08
23	1.39600E 05	1.80000E 08
24	1.64300E 05	1.70000E 08
25	2.24500E 05	6.50000E 07
26	3.74200E 05	1.60000E 07
27	7.07100E 05	3.00000E 06
28	1.26500E 06	1.20000E 05
29	2.19100E 06	1.60000E 04
30	4.24300E 06	2.00000E 03
31	6.20500E 06	0.00000E-01
32	7.93700E 06	0.00000E-01
33	1.12200E 07	0.00000E-01

Appendix 6

OUTPUT SPECTRUM

E*PHI(E) SPESTRUM IS NORMALIZED TO UNIT AREA

	ENERGY EV	
1	2.17010E-01	3.61465E-04
2	3.53560E-01	9.88448E-04
3	7.07150E-01	2.42592E-03
4	1.46630E 00	4.68280E-03
5	3.16190E 00	7.96787E-03
6	6.81910E 00	1.19052E-02
7	1.46630E 01	1.53665E-02
8	3.16190E 01	1.98221E-02
9	6.81910E 01	2.29922E-02
10	1.46630E 02	2.41825E-02
11	3.16190E 02	2.58650E-02
12	6.81910E 02	3.00922E-02
13	1.46630E 03	4.16920E-02
14	3.16190E 03	5.66675E-02
15	6.81910E 03	3.68975E-02
16	1.12200E 04	5.42574E-02
17	1.41250E 04	7.18667E-02
18	1.78160E 04	1.21546E-01
19	2.23850E 04	2.22006E-01
20	2.81820E 04	9.24627E-03
21	3.54780E 04	1.73623E-02
22	4.46630E 04	2.53276E-02
23	5.62260E 04	2.65285E-02
24	7.07820E 04	2.72609E-02
25	8.91170E 04	1.96529E-02
26	1.12200E 05	3.50232E-02
27	1.41250E 05	2.50026E-02
28	1.78160E 05	2.03311E-02
29	2.23850E 05	9.22042E-03
30	2.81820E 05	6.44653E-03
31	3.54780E 05	3.11697E-03
32	4.46630E 05	1.83639E-03
33	5.62260E 05	1.20684E-03
34	7.07820E 05	4.17744E-04
35	8.91170E 05	2.85784E-04
36	1.12200E 06	1.19650E-04
37	1.41250E 06	1.44209E-05
38	1.78160E 06	8.64132E-06
39	2.23850E 06	2.18555E-06
40	2.81820E 06	1.63413E-06
41	3.54780E 06	9.40126E-07
42	4.46630E 06	2.47106E-07
43	5.62260E 06	8.27713E-08
44	7.07820E 06	0.00000E-01
45	8.91170E 06	0.00000E-01
46	1.12200E 07	0.00000E-01
47	1.41250E 07	0.00000E-01
48	1.78160E 07	0.00000E-01

NORMALIZING FACTOR TO UNIT AREA OF E*PHI(E) SPECTRUM 7.17253E 09

22/01/36

* * * * #XFAM USED ON 19/09/72 AT 22/02/54

Appendix 7

```
ADD
00000012
     ORNL-RSIC-29.P.51.
     REACTOR SPECTRUM,FE,D=90CM
     POKER CODE (A.W.R.E.)(PINK)
     INPUT SPECTRUM:E*PHI(E)
     **
33  1  48
0.15
0.1732
0.5477
2.236
7.416
18.17
42.43
94.87
244.9
632.5
1225.0
1732.0
2828.0
4899.0
7746.0
1.14E 04
1.612E 04
2.236E 04
2.739E 04
4.243E 04
6.928E 04
8.944E 04
1.14E 05
1.396E 05
1.643E 05
2.245E 05
3.742E 05
7.071E 05
1.265E 06
2.191E 06
4.243E 06
6.205E 06
7.937E 06
1.122E 07
```

Continuing in the
secund column.

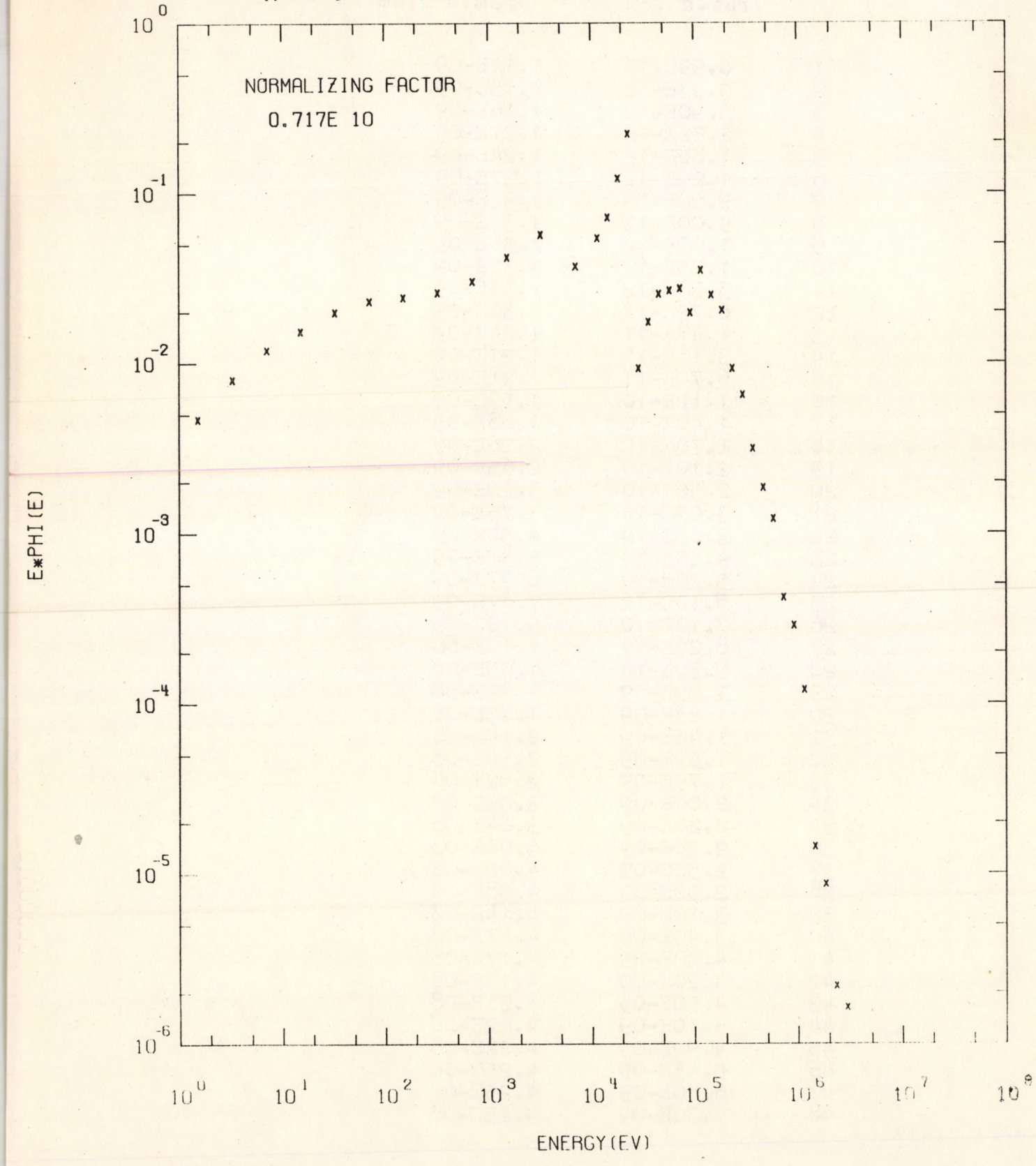
```
1.8E 06
1.4E 07
5.0E 07
9.0E 07
1.2E 08
1.6E 08
1.7E 08
1.8E 08
2.1E 08
2.8E 08
3.2E 08
4.0E 08
4.4E 08
1.8E 08
4.0E 08
6.0E 08
1.6E 09
6.0E 07
1.8E 08
2.0E 08
1.4E 08
2.6E 08
1.8E 08
1.7E 08
6.5E 07
1.6E 07
3.0E 06
1.2E 05
1.6E 04
2.0E 03
0.0
0.0
0.0
0.15
1.0
0  0
EDIT
00000012
DELETE
00000012
ENDEND
****
```

Appendix 8

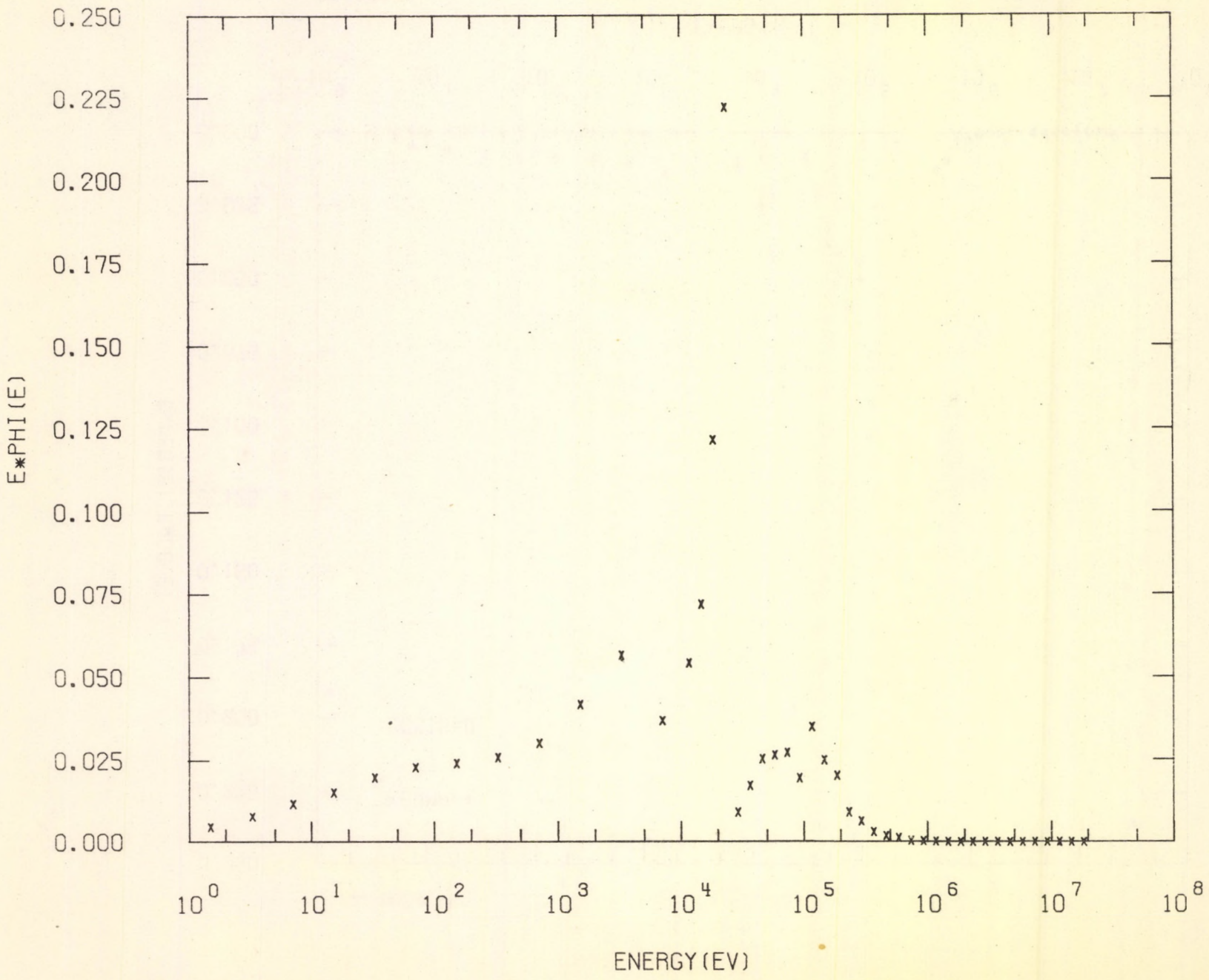
Conversion factors

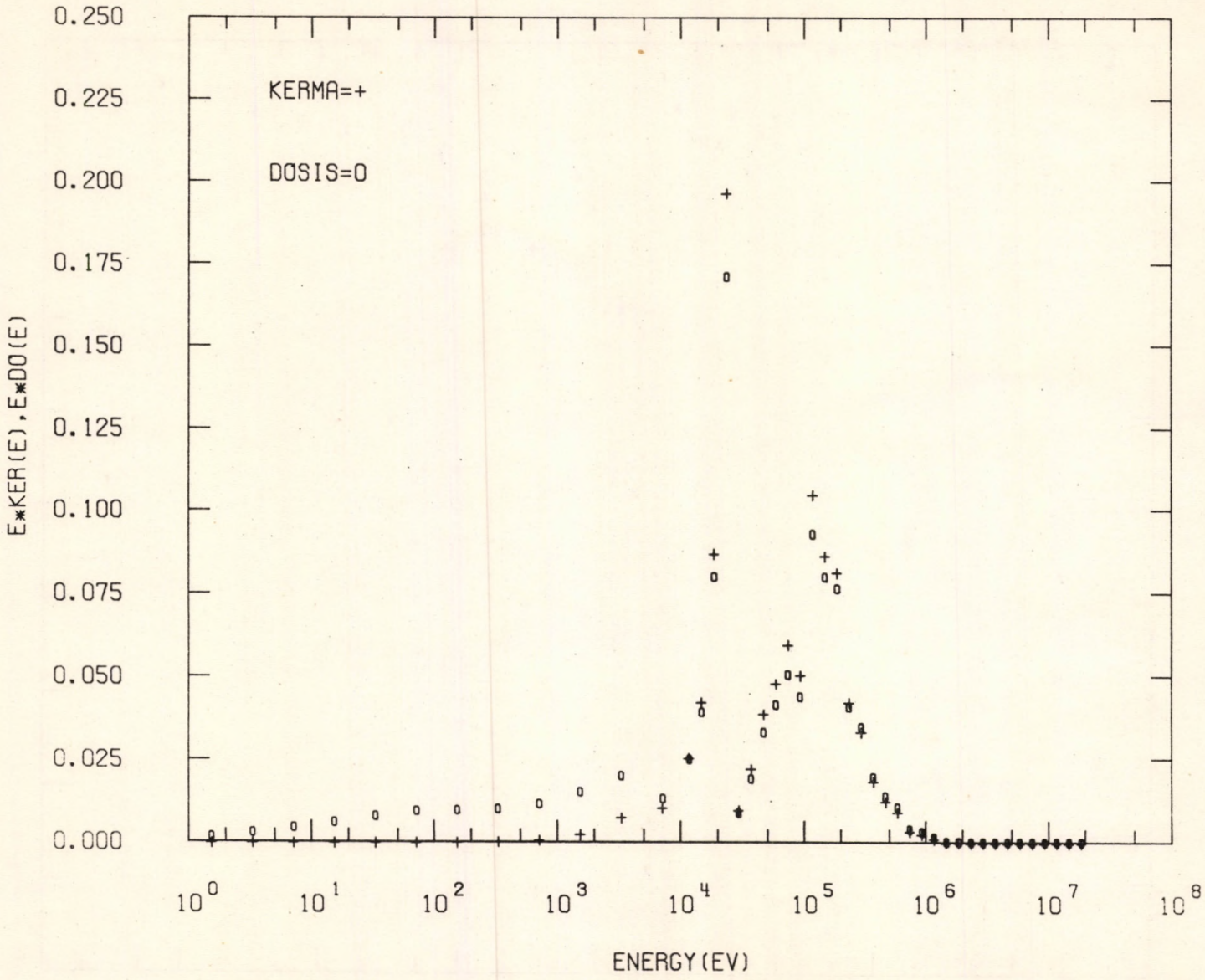
No.	Kerma /rad.n^{-1}.cm^2/	rem-dose /rem.n^{-1}.cm^2/
1	6.99E-12	1.12E-09
2	5.53E-12	1.15E-09
3	3.90E-12	1.16E-09
4	2.72E-12	1.21E-09
5	1.88E-12	1.24E-09
6	1.29E-12	1.27E-09
7	9.90E-13	1.32E-09
8	9.00E-13	1.34E-09
9	1.09E-12	1.38E-09
10	1.75E-12	1.35E-09
11	3.30E-12	1.31E-09
12	6.70E-12	1.30E-09
13	1.47E-11	1.24E-09
14	3.16E-11	1.21E-09
15	6.70E-11	1.21E-09
16	1.12E-10	1.59E-09
17	1.40E-10	1.88E-09
18	1.70E-10	2.26E-09
19	2.10E-10	2.65E-09
20	2.50E-10	3.20E-09
21	3.05E-10	3.75E-09
22	3.65E-10	4.50E-09
23	4.30E-10	5.38E-09
24	5.20E-10	6.37E-09
25	6.10E-10	7.67E-09
26	7.10E-10	9.10E-09
27	8.20E-10	1.10E-08
28	9.50E-10	1.29E-08
29	1.09E-09	1.52E-08
30	1.23E-09	1.85E-08
31	1.40E-09	2.14E-08
32	1.59E-09	2.54E-08
33	1.79E-09	2.92E-08
34	2.00E-09	3.09E-08
35	2.20E-09	3.64E-08
36	2.38E-09	3.86E-08
37	2.50E-09	4.00E-08
38	2.90E-09	4.08E-08
39	3.10E-09	4.14E-08
40	3.40E-09	4.17E-08
41	4.20E-09	4.17E-08
42	4.20E-09	4.19E-08
43	4.50E-09	4.21E-08
44	5.10E-09	4.22E-08
45	4.90E-09	4.22E-08
46	5.45E-09	4.25E-08
47	6.80E-09	4.25E-08
48	7.30E-09	4.25E-08

Appendix 9

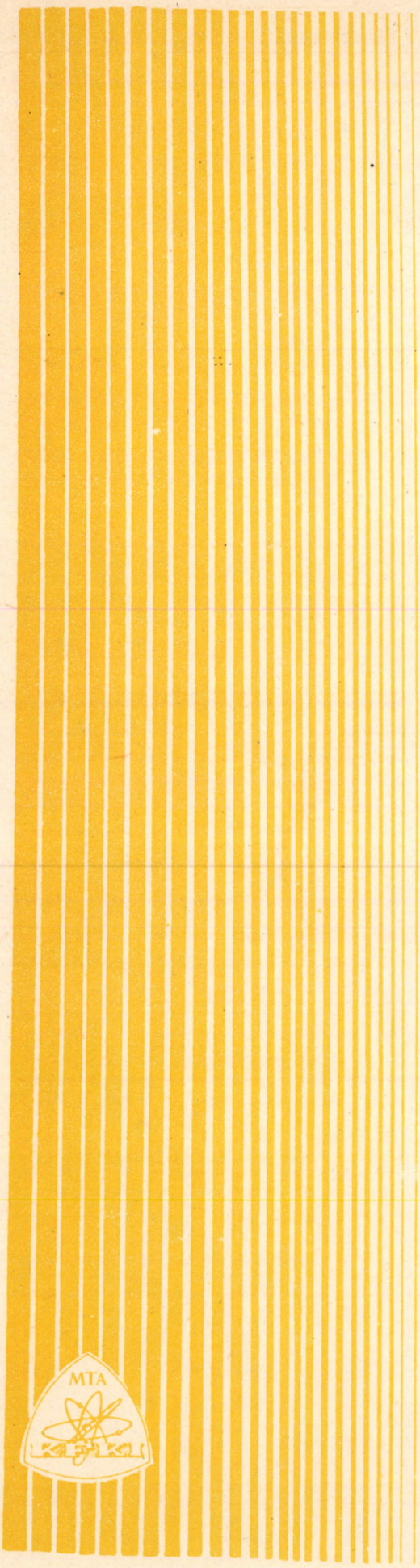


Appendix 10


0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
E*PHI(E)
10^0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
ENERGY(EV)


KERMA=+
DOSIS=0
E*KER(E), E*DO(E)
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
10^0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
ENERGY(EV)

00000012



Kiadja a Központi Fizikai Kutató Intézet
Felelős kiadó: Szabó Ferenc, a KFKI
Reaktor Kutatási Tanácsának elnöke
Szakmai lektor: Kulcsár Katalin
Koblinger László
Nyelvi lektor: T. Wilkinson
Példányszám: 205 Törzsszám: 72-7457
Készült a KFKI sokszorositó üzemében,
Budapest, 1972. október hó