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ASIYAD,

A fission-product yield data library

by A.F. Grashin et a1

Nov. 1993

Summary by H.D. Lemmel

Abstract: This document describes a nuclear data library of neutron-induced fission-product yield data by A.F. Grashin et al. The data file is available on magnetic tape from the IAEA Nuclear Data Section, cost free, upon request.

Revised by P.K.McLaughlin IAEA/NDS Jan. 2005

The file was revised to conform with ENDF/B format standards.. The merged file was corrected for format errors and processed through the code CHECKR to ensure, as far as possible, format compatibility.

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ASIYAD

A fission-product yield data library for neutron-induced fission by A.F. Grashin, A.D. Efinenko, et al, Engineering Physics Institute, Moscow, Russia.

The work was reported by A.D. Efimenko, A.F. Grashin, E.A. Kudryavtseva at the International Conference on Nuclear Data for Science and Technology in Mito, Japan, 1988, and published in the proceedings, pages 971-974. This paper is attached to the present document. (The reference quoted in the free-text section of the data library has a mistake in the page numbering.) The data library was converted to ENDF-6 format by the Russian Nuclear Data Centre, Obninsk, and installed on the V AX computer of the IAEA Nuclear Data Section by A.I. Blokhin, Obninsk, in Sept. 1992.

The data library includes independent yield data for thermal and 20 fast fissile systems. It is available on magnetic tape from the IAEA Nuclear Data Section, cost free, upon request.

Independent fission-yield data of the following fissile systems have been included:

nuclide	indicent neutrons		
92-U-232	thermal	fast	
233		fast	1)
234		fast	
235	thermal	fast	
236		fast	
237	thermal	fast	
238		fast	
239		fast	
93-Np-236		fast	
237		fast	
238	thermal	fast	
239		fast	
94-Pu-236	thermal	fast	
239	thermal	fast	
240		fast	
241	thermal	fast	
242		fast	
243	thermal	fast	
95-Am-241	thermal		2)
242	thermal	fast	
243		fast	
96-Cm-245	thermal		
98-Cf-249			3)

1) The Mito paper includes also U-233 thermal which, however, does not exist in the available file.

2) The Mito paper gives data for Am-241 fast only, whereas the available file has data for Am-241 thermal only.

3) The Mito paper mentions Cf-249 thermal which, however, does not exist in the available file.

Nuclear Data for Science and Technology (1988 MITO), 971- 974, Copyright © 1988 JAERI.

THE ASIND-MEPhI FISSION PRODUCT YIELD DATA-BASE

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Abstract: The ASIND-MEPhI(Automatized System of Information on Nuclear Data in Moscow Engineering Physics Institute) Data-Base, containing independent yields of fission products, has been organized on the basis of a thermodynamical model. The number of yield sets is significantly larger in comparison with the ENDF/B-5, some of the sets being virtual. For example, yields of photofission products are included in the ASIND-MEPhI Data-Base. The use of the theoretical model made it possible to raise accurasy of predictions for poorly explored fission reactions. In total, the accuracy of data from ASIND-MEPhI file is not inferior to that of ENDF/B.

(independent yield, thermodynamical model, experimental data, calculated value)

For many reactor physics calculations and measurement applications it is necessary to expand the fission-product-yield nomenclature being available in known files. For this purpose, the ASIND-MEPhI(Automatized System of Information on Nuclear Data in Moscow Engineering Physics Institute) Data-Base has been organized according to the earlier suggested conception /1,2/. The Data-Base consists of independent yield sets Y(A,Z) for fission-product mass $70 \leqslant A \leqslant 170$ in the wide range of fissile nuclides from Th-232 to Fm-257 with excitation energies $U \leqslant 20$ MeV. Each version of the yield file is completed with the experimental data taking priority. The experimental yields are extremely sparse, however, and they are complemented with values calculated on the basis of a thermodynamical fission model /3-5/. Yield sets are normalized to 200% and put on a magnetic tape.

The data sets will be renewed periodically as additional experimental yields become available. Together with a current version of the file we keep the version, containing calculated yields alone (ASIND-MEPhI-0 version). To operate with the Data-Base the procedures of tape handling, information generation and retrieval are elaborated.

The only adjustable parameter in our calculating model is the temperature T. For temperature prognozing it is possible to adopt the expression

$$U = a_{eff}\,(T^2 - T_0^2)\,.$$

Here, for example, a_{eff} = 16.07, 14.74, 15.38, 15.99 and 21.89 MeV^{-1}, T_0=1.79, 1.78, 1.79, 1.81 and 1.87 MeV for the compound nuclei Th-233, U-234, 236, 239 and Pu-240 respectively. More precise values of T may be obtained from experimental mass chain yields with an error $T \approx 0.01$ MeV. The temperature T increases with the charge of fissioning system for a given fission type, being approximately constant for fissioning isotopes.

It is of interest to compare ASIND-MEPhI data with ENDF/B-5 data. The quality of a file is characterized mainly by the accurasy of data prediction. We can check the files by comparing the average changes $\bar{Z}(A)$ and widths $\sigma(A)$ with the Pu-239(n_{th},f) experimental data /6/, these data being the only large set obtained after the files have been completed. We calculated the mean deviations

$$\overline{\Delta Z} = \left\{ \frac{1}{n} \sum_{i=1}^{n} \left[\bar{Z}_{exp}(A_i) - \bar{Z}_{file}(A_i) \right]^2 \right\}^{1/2},$$

$$\overline{\Delta \sigma} = \left\{ \frac{1}{n} \sum_{i=1}^{n} \left[\sigma_{exp}(A_i) - \sigma_{file}(A_i) \right]^2 \right\}^{1/2}$$

and obtained the same values $\overline{\Delta Z}$=0.11, $\overline{\Delta\sigma}$ =0.05 for both the files. The mean value

$$\frac{1}{n} \sum_{i=1}^{n} \left| \ln Y_{exp}(A_i, Z_i) - \ln Y_{file}(A_i, Z_i) \right|$$

proved to be $\ln$ 1.5 for both the files.

It is noteworthy we do not assume the width to be a constant, that has been done in ENDF/B-5 and can produce large errors for fission-product-yields Y(A,Z) with $|Z(A)-\bar{Z}(A)| > 1.5$ /7/. Our model supplies a width σ(A) varying with A and fission type, therefore ASIND-MEPhI yields have to be more reliable far from the most probable charge where data have not been obtained yet.

Examples of calculated values are given in tables 1, 2. In tables 3 and 4 some calculated yields are compared with yields from the Rider-Meek /9/ and JAERI /10/ files along with experimental data /6,8,11/. Note that our yield of Nb-94

Table 1. Independent yields of some fission products from ASIND-MEPhI file
(T - for the thermal fission, F - for the reactor-neutron-induced fission)

Nuclide	Fission type	Kr-85G	Sr-90	I-131	Cs-137
U-232	T	1.11(25)E-1	3.76(90)E-1	1.20(60)E-1	1.10(27)
	F	1.12(24)E-1	3.56(78)E-1	1.97(85)E-1	1.36(29)
U-233	T	5.85(115)E-2	2.39(53)E-1	6.2(33)E-2	5.8(16)E-1
	F	6.3(11)E-2	2.28(45)E-1	9.8(46)E-2	7.3(17)E-1
U-234	F	2.87(65)E-2	1.02(22)E-1	4.5(20)E-2	4.2(10)E-1
U-235	T	2.35(81)E-2	5.3(17)E-2	1.14(65)E-2	1.29(30)E-1
	F	1.55(31)E-2	5.8(11)E-2	1.76(92)E-2	1.72(56)E-1
U-236	F	8.1(17)E-3	2.67(55)E-2	6.9(39)E-3	8.0(31)E-2
U-237	T	2.29(68)E-3	9.7(25)E-3	1.59(95)E-3	2.3(10)E-2
	F	2.81(80)E-3	1.03(27)E-2	3.0(16)E-3	3.8(14)E-2
U-238	F	1.65(41)E-3	5.1(13)E-3	8.1(53)E-4	1.04(61)E-2
U-239	F	4.9(17)E-4	1.65(56)E-3	3.0(18)E-4	4.0(21)E-3
Np-236	F	2.37(53)E-2	1.01(21)E-1	8.9(40)E-2	7.4(17)E-1
Np-237	F	1.52(29)E-2	5.9(11)E-2	3.3(17)E-2	3.26(95)E-1
Np-238	T	4.6(12)E-3	2.25(54)E-2	9.5(53)E-3	1.36(44)E-1
	F	5.7(14)E-3	2.42(57)E-2	1.64(82)E-2	1.88(53)E-1
Np-239	F	2.78(76)E-3	1.15(32)E-2	5.9(32)E-3	8.3(27)E-2
Pu-236	T	9.3(17)E-2	3.78(73)E-1	5.7(25)E-1	2.72(52)
	F	9.8(18)E-2	3.71(69)E-1	8.4(42)E-1	2.90(48)
Pu-239	T	1.51(28)E-2	1.06(9)E-1	6.3(31)E-2	5.2(13)E-1
	F	1.70(30)E-2	7.7(13)E-2	8.5(39)E-2	5.9(14)E-1
Pu-240	F	9.3(17)E-3	4.12(77)E-2	3.8(18)E-2	3.07(81)E-1
Pu-241	T	3.51(75)E-3	1.92(40)E-2	1.09(61)E-2	1.16(40)E-1
	F	4.43(89)E-3	2.08(41)E-2	1.83(92)E-2	1.55(46)E-1
Pu-242	F	1.93(44)E-3	9.7(22)E-3	5.3(30)E-3	5.5(22)E-2
Pu-243	T	6.0(19)E-4	3.3(10)E-3	2.2(12)E-3	2.30(91)E-2
	F	8.1(24)E-4	3.8(11)E-3	3.7(19)E-3	3.5(12)E-2
Am-241	F	1.37(28)E-2	6.6(12)E-2	2.04(75)E-1	1.19(23)
Am-242	T	6.3(14)E-3	3.43(70)E-2	8.3(35)E-2	6.4(14)E-1
	F	7.2(16)E-3	3.57(70)E-2	1.11(42)E-1	7.2(14)E-1
Am-243	F	3.92(91)E-3	1.85(40)E-2	5.3(21)E-2	3.83(84)E-1
Cm-245	T	3.62(87)E-3	1.93(40)E-2	6.6(28)E-2	4.8(11)E-1
Cf-249	T	4.02(90)E-3	2.09(40)E-2	1.92(80)E-1	1.08(23)

Table 2. Average charges $\bar{Z}(A)$ for some types of fission, $74 \leq A \leq 163$

A	Am-241(F)	Cm-245(T)	Cf-249(T)	A	Am-241(F)	Cm-245(T)	Cf-249(T)
74	30.27	30.05	30.23	119	47.50	46.90	47.14
75	30.68	30.45	30.65	120	47.89	47.46	47.54
76	30.95	30.74	30.93	121	48.28	47.83	47.83
77	31.34	31.07	31.30	122	48.63	48.18	48.27
78	31.83	31.52	31.79	123	48.91	48.62	48.69
79	32.18	31.93	32.12	124	49.25	48.94	49.11
80	32.50	32.22	32.41	125	49.71	49.35	49.65
81	32.89	32.65	32.84	126	50.05	49.83	50.03
82	33.21	32.97	33.18	127	50.40	50.10	50.40
83	33.63	33.38	33.62	128	50.70	50.38	50.79
84	34.03	33.93	34.06	129	50.92	50.72	51.06
85	34.34	34.24	34.41	130	51.17	50.96	51.41
86	34.70	34.60	34.85	131	51.56	51.20	51.76
87	35.03	34.99	35.25	132	51.94	51.62	52.05
88	35.59	35.39	35.78	133	52.32	51.99	52.39
89	36.07	35.80	36.13	134	52.72	52.29	52.76
90	36.45	36.11	36.44	135	53.12	52.80	53.19
91	36.90	36.49	36.86	136.	53.65	53.24	53.74
92	37.29	36.90	37.21	137	54.08	53.76	54.11
93	37.79	37.47	37.64	138	54.54	54.13	54.50
94	38.15	37.97	38.02	139	54.94	54.57	54.93
95	38.55	38.31	38.38	140	55.40	54.96	55.41
96	38.88	38.69	38.80	141	55.83	55.44	55.82
97	39.29	39.09	39.32	142	56.22	55.86	56.14
98	39.77	39.58	39.84	143	56.59	56.20	56.51
99	40.13	39.94	40.19	144	56.95	56.52	56.87
100	40.49	40.25	40.52	145	57.39	56.93	57.35
101	40.83	40.59	40.86	146	57.80	57.43	57.76
102	41.24	40.90	41.28	147	58.21	57.81	58.13
103	41.68	41.36	41.71	148	58.58	58.17	58.48
104	42.04	41.82	42.03	149	58.98	58.53	58.90
105	42.42	42.15	42.37	150	59.42	58.96	59.39
106	42.71	42.46	42,66	151	59.85	59.45	59.80
107	43.07	42.79	43.03	152	60.23	59.85	60.14
108	43.55	43.24	43.53	153	60.56	60.20	60.47
109	43.84	43.67	43.88	154	60.87	60.50	60.81
110	44.16	43.97	44.20	155	61.24	60.87	61.27
111	44.45	44.32	44.53	156	61.59	61.32	61.66
112	44.65	44.56	44.81	157	61.93	61.66	61.98
113	45.06	44.87	45.20	158	62.28	61.98	62.30
114	45.56	45.32	45.67	159	62.63	62.26	62.65
115	45.96	45.56	45.93	160	63.03	62.56	63.07
116	46.34	45.81	46.23	161	63.43	62.98	63.49
117	46.67	46.10	46.52	162	63.85	63.42	63.84
118	47.03	46.44	46.76	163	64.26	63.79	64.15

Table 3. $^{235}U(n_{th},f)$ independent yields

Fission product	Experimental data Lang/8/	Stritmatter/11/	Rider/9/	JAERI/10/	ASIND-MEPhI-0
Br-91	5.4(24)E-2	7.1(20)E-2	2.45(15)E-1	2.45E-1	8.7(19)E-2
Nb-96	1.9(12)E-2		5.6(3)E-4	6.1E-4	1.2(5)E-2
Y-98	2.139(86)	2.670(46)	2.91(37)	2.23	2.3(4)
Y-100	3.12(49)E-1	8.30(30)E-1	5.21(57)E-1	5.38E-1	4.6(11)E-1
Y-101	1.30(25)E-1	2.94(20)E-1	4.01(64)E-1	4.01E-1	1.4(4)E-1
Y-102		7.4(16)E-2	2.59(60)E-1	2.58E-1	2.5(8)E-2
Y-103			8.0(36)E-2	8.0E-2	5.0(17)E-3
Mo-103	1.189(43)	8.39(58)E-1	7.23(58)E-1	7.19E-1	8.4(33)E-1

Table 4. $^{239}Pu(n_{th},f)$ independent yields

Fission product	Schmitt/6/	Rider/9/	JAERI/10/	ASIND-MEPhI-0
Rb-86	2.3(8)E-3	6.51(52)E-5	6.52E-5	8.4(22)E-3
Br-90	6.2(9)E-2	2.31(18)E-1	2.29E-1	5.2(8)E-2
Rb-94	5.84(23)E-1	7.88(31)E-1	7.88E-1	4.2(7)E-1
Nb-94		8.7(40)E-6	8.6E-6	2.4(11)E-3
Tc-104	8.59(34)E-1	4.04(180)E-1	4.06E-1	7.6(16)E-1
Tc-105	1.808(55)	1.18(19)	1.198	1.9(4)
Rh-109	5.1(23)E-2	3.1(20)E-1	2.76E-1	2.9(16)E-2

differs by a factor of 360 from the Rider-Meek and JAERI yields.

The ASIND-MEPhI Data-Base gains the major advantage with the data set number having been increased as compared not only with ENDF/B-5, but also with ENDF/B-6. The current version of the ASIND-MEPhI file contains data sets for the thermal fission of U-232, 233, 235, 237, Np-238, Pu-236, 239, 241, 243, Am-242, Cm-245, Cf-249, the reactor-neutron-induced fission of Th-232, U-232-239, Np-236-239, Pu-236, 239-243, Am-241-243 and for the fission of Th-232, U-233, 235, 238, Pu-239 by 14-MeV neutrons. In addition to the real sets we have also virtual sets, being generated with a computer program.

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