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Documentation for WIMSD-formatted libraries based on ENDF/B-VII.1 evaluated nuclear data files with extended actinide burn-up chains and cross section data up to 2000 K for fuel materials.

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Contents

Tables:

1. Introduction

In the frame of WIMS Library Update Project [1] the WIMSD-IAEA-69 and WIMSD-IAEA-172 libraries were prepared and made available at the Nuclear Data Section (NDS) of the International Atomic Energy Agency (IAEA). The main libraries were prepared from different sources of evaluated nuclear data that were available before December 2003. Also others WIMSD libraries were prepared from the major evaluated nuclear data libraries and made available at http://www-nds.iaea.org/wimsd. During the last ten years new libraries have been prepared every time that a major version of an evaluated nuclear data library has been released, namely JEFF-3.1 and ENDF/B-VII.0.

Recently, end-users have requested to extend the temperature ranges of fuel materials included in the libraries and also to extend the burn-up chains to higher actinides up to Cf-254. The inclusion of new structural materials, like bismuth, has been also considered. Therefore, new WIMSD-formatted libraries in the 69- and 172-energy structure have been prepared with more materials, extended actinides burn-up chains and higher temperatures in thermal and resonance range.

2. Source of data

A new WIMSD-formatted library was generated from the ENDF/B-VII.1 evaluated nuclear data library [2] at the Nuclear Data Section (NDS) of the International Atomic Energy Agency (IAEA). Particularly, reaction data for incident neutrons, decay constants and thermal scattering laws were retrieved from the ENDF/B-VII.1 evaluated nuclear data library for all materials included in the WIMSD libraries.

Fission product yields induced by neutrons were also taken from the ENDF/B-VII.1 library for most actinides, but in case of lack of data the values were adopted from the TENDL-2009 evaluated nuclear data library [3], if available. It was the case for six minor actinides, namely Np-239, Cm-247, Bk-249, Cf-251, Cf-252 and Cf-253.

The dosimetry materials included in the WIMSD-formatted library were also updated from the IRDFF-v.1.05 evaluated nuclear data files [4]. For those dosimetry reactions that were not available in the IRDFF-v.1.05 evaluated nuclear data library, the ENDF/B-VII.1 data were applied.

3. New materials

The bismuth (Bi-209) was added as a new structural material and the actinide burn-up chains were extended to higher actinides from Cm-245 up to Cf-254.

The library based on ENDF/B-VII.1 data, includes eleven new minor actinides compared to the previous versions of WIMSD-formatted libraries prepared at the IAEA. They are Cm-245, Cm-246, Cm-247, Cm-248, Bk-249, Cf-249, Cf-250, Cf-251, Cf-252, Cf-253 and Cf-254. Table 1 summarizes the number of materials in the libraries.

Table 1: Number of material in the WIMSD libraries

Item	ENDF/B-VII.1-WIMSD	IAEA-WIMSD
Total of materials	185	173
Moderators	5	5
Actinides	35	24
Fission products	57	57
Dosimetry reactions	37	37
Structural materials	41	40
Other materials	10	10
Resonant materials	28	28

4. Extended temperature range

The temperature range was extended up to 2000 K for all actinides. For the major actinides the cross section data are available at 293 K, 600 K, 900 K, 1200 K, 1600 K and 2000 K. Data for the minor actinides are given at 293 K, 700 K, 1100 K, 1500 K and 2000 K.

For graphite, silicon and zirconium, that could be used in some fuel design, the temperature range was also extended up to 2000 K. The same was applied to burnable absorber materials such as gadolinium, erbium, hafnium, dysprosium and holmium as well as to the resonant fission products technetium, silver and cesium.

5. Actinide and fission product burn-up chains.

The actinide burn-up chains were extended including minor actinides from Cm-245 up to Cf-254. Table 2 shows the burn-up and decay data for actinides. Actinides explicitly included in the burn-up chains decay with a half-life greater than 51 hours, except Am-242 that is important in the production mechanism of curium 242. If the half-life is greater than 33 000 years, then the nuclide was considered stable.

The burn-up chains for fission products were not modified or extended compared to the original WIMSD-IAEA libraries [1]. For the sake of completeness, Figure 1 and 2 show the actinide and fission product burn-up chains.

Table 2: Burn-up and decay data for actinides

Nuclide	Half life [1/s]	Decay Product (DP)	Capture branching ratio (BR)	Capture Product (CP)	Notes
Th-232	Stable*	-	1.00	Pa-233	- Th-233 is assumed to produce instantly Pa-233 by β^- decay. The production of Th-231 from (n, 2n) is modeled by means of a pseudo fission product, which produce instantly Pa-231 by β^- decay. The fission yield is equal to the ratio (n,2n)/(n,f). A value of 0.185 was adopted.
Pa-231	6.7047-13	Null	1.00	U -232	Pa-232 is assumed to produce instantly U-232 by β^- decay.
Pa-233	2.9741-07	U-233	1.00	U -234	Pa-234 is assumed to produce instantly U-234 by β^- decay.
U -232	3.1879-10	Null	1.00	U -233	
U -233	Stable*	-	1.00	U -234	The production of U-232 from (n, 2n) was simulated by means of a pseudo fission product, which decay instantly to U-232. The fission yield is equal to the ratio (n,2n)/(n,f). This ratio is spectrum dependent. A value of 0.0000075 was chosen.
U -234	Stable*	-	1.00	U -235	
U -235	Stable*	-	1.00	U -236	
U -236	Stable*	-	1.00	U -237	
U -237	1.1885-06	Np-237	1.00	U -238	
U -238	Stable*	-	1.00	Np-239	U-239 is assumed to produce instantly Np-239 by β^- decay. The production of U-237 from (n, 2n) was simulated by means of a pseudo fission product, which decay instantly to U-237. The fission yield is equal to the ratio (n,2n)/(n,f). This ratio is spectrum dependent. A value of 0.06 was chosen.
Np-237	Stable*	-	1.00	Pu-238	Np-238 is assumed to produce instantly Pu-238 by β^- decay.

Nuclide	Half life [1/s]	Decay Product (DP)	Capture branching ratio (BR)	Capture Product (CP)	Notes
Np-239	3.4052-06	Pu-239	1.00	Pu-240	Np-240 is assumed to produce instantly Pu-240 by β^- decay.
Pu-238	2.5045-10	U -234	1.00	Pu-239	
Pu-239	9.1101-13	U- 235	1.00	Pu-240	
Pu-240	3.3477-12	U -236	1.00	Pu-241	
Pu-241	1.5371-09	Am-241	1.00	Pu-242	β^- decay branching ratio equal to 99.998%, 100% implicitly assumed.
Pu-242	Stable*	-	1.00	Am-243	Pu-243 is assumed to produce instantly Am-243 by β^- decay.
Am-241	5.0773-11	Np-237	0.12	Am-242m	Capture in Am-241 results in Am-242m with a branching ratio of 0.12. Actually, the branching ratio is spectrum dependent. Calculations performed under the WIMSD Library Update Project produce values ranging from 0.132 for plutonium recycling benchmark to 0.109 for metal uranium lattices.
Am-242m	1.5578-10	Am-242g	1.00	Am-243	Am-242m decays by isomeric transition (IT) to Am-242g (99.55%). Unfortunately, due to WIMSD library limitations a branching ratio cannot be specified for decays. IT=100% is implicitly assumed.

Nuclide	Half life [1/s]	Decay Product (DP)	Capture branching ratio (BR)	Capture Product (CP)	Notes
Am-242g	1.2019-05	Cm-242	0.80	Am-243	Reduced Am-242g is produced from Am-241 capture. Since only one nuclide can be specified as the capture product (Am-242m was previously chosen with $T_{1/2}$=141 years), then Am-242g is treated as a fission product of Am-241 with an effective yield proportional to the capture to fission rate (c/f). The effective yield is calculated by the expression: $Y^1_{Am242g}=(c/f)(1-0.12)0.827$ Where, 0.12 is the capture branching ratio for Am-242m production. The value 0.827 is the branching decay ratio to produce Cm-242 from Am-242g by β^- emission. It is the way used to overcome the limitations of WIMSD library format. The (c/f) ratio depends strongly on lattice spectrum. Calculations performed under WIMSD Library Update Project produce values of (c/f) ranging from 42 for plutonium recycling benchmark to 124 metal uranium lattices. A value of (c/f)=92 was adopted, it implied that $Y^1_{Am242g} \approx 67$ atoms/fission. Additionally, as Am-241 is not an important contributor to fission events, the fission cross section of Am-241 is forced to be proportional to the absorption cross section, normalized to conserve the selected (c/f) ratio. A branching ratio of 0.80 was assumed to produce Am-243 by neutron capture.
Am-243	2.9803-12	Np-239	1.00	Cm-244	Am-244 is assumed to produce instantly Cm-244 by β^- decay.
Cm-242	4.9236-08	Pu-238	1.00	Cm-243	
Cm-243	7.5479-10	Pu-239	1.00	Cm-244	α decay branching ratio equal to 99.71%, 100% implicitly assumed.

Nuclide	Half life [1/s]	Decay Product (DP)	Capture branching ratio (BR)	Capture Product (CP)	Notes
Cm-244	1.2128-09	Pu-240	1.00	Cm-245	
Cm-245	2.5841-12	Pu-241	1.00	Cm-246	
Cm-246	4.6144-12	Pu-242	1.00	Cm-247	α decay branching ratio equal to 99.9785%, 100% implicitly assumed.
Cm-247	Stable*	-	1.00	Cm-248	
Cm-248	Stable*	-	1.00	Bk-249	Cm-249 is assumed to produce instantly Bk-249 by β^- decay.
Bk-249	2.5070-08	Cf-249	1.00	Cf-250	β^- decay branching ratio equal to 99.9985%, 100% implicitly assumed. Bk-250 is assumed to produce instantly Cf-250 by β^- decay.
Cf-249	6.2577-11	Cm-245	1.00	Cf-250	
Cf-250	1.6792-09	Cm-246	1.00	Cf-251	α decay branching ratio equal to 99.923%, 100% implicitly assumed.
Cf-251	2.4459-11	Cm-247	1.00	Cf-252	
Cf-252	8.3043-09	Cm-248	1.00	Cf-253	α decay = 96.908%. Spontaneous fission = 3.092%. 100% α decay assumed.
Cf-253	4.5045-07	Null	1.00	Cf-254	
Cf-254	1.3260-07	Null	1.00	Null	

*Stable means half-life > 33000 years

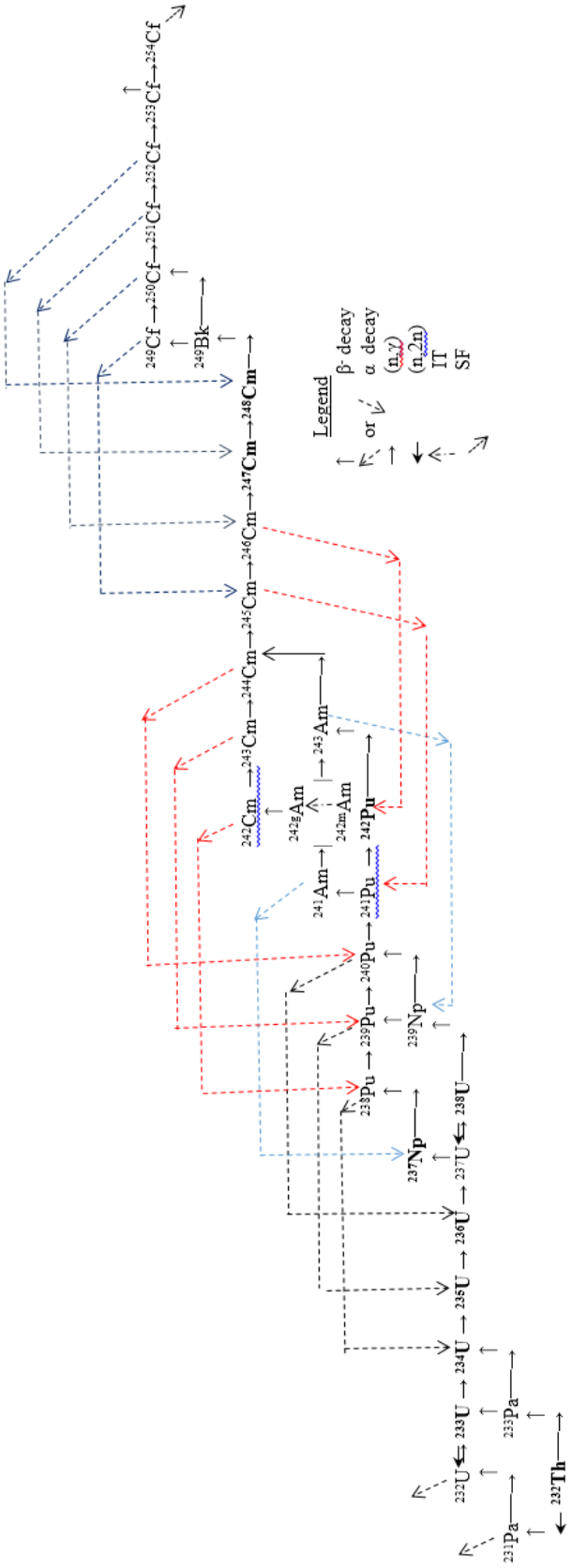

Figure 1: Actinide burn-up chains

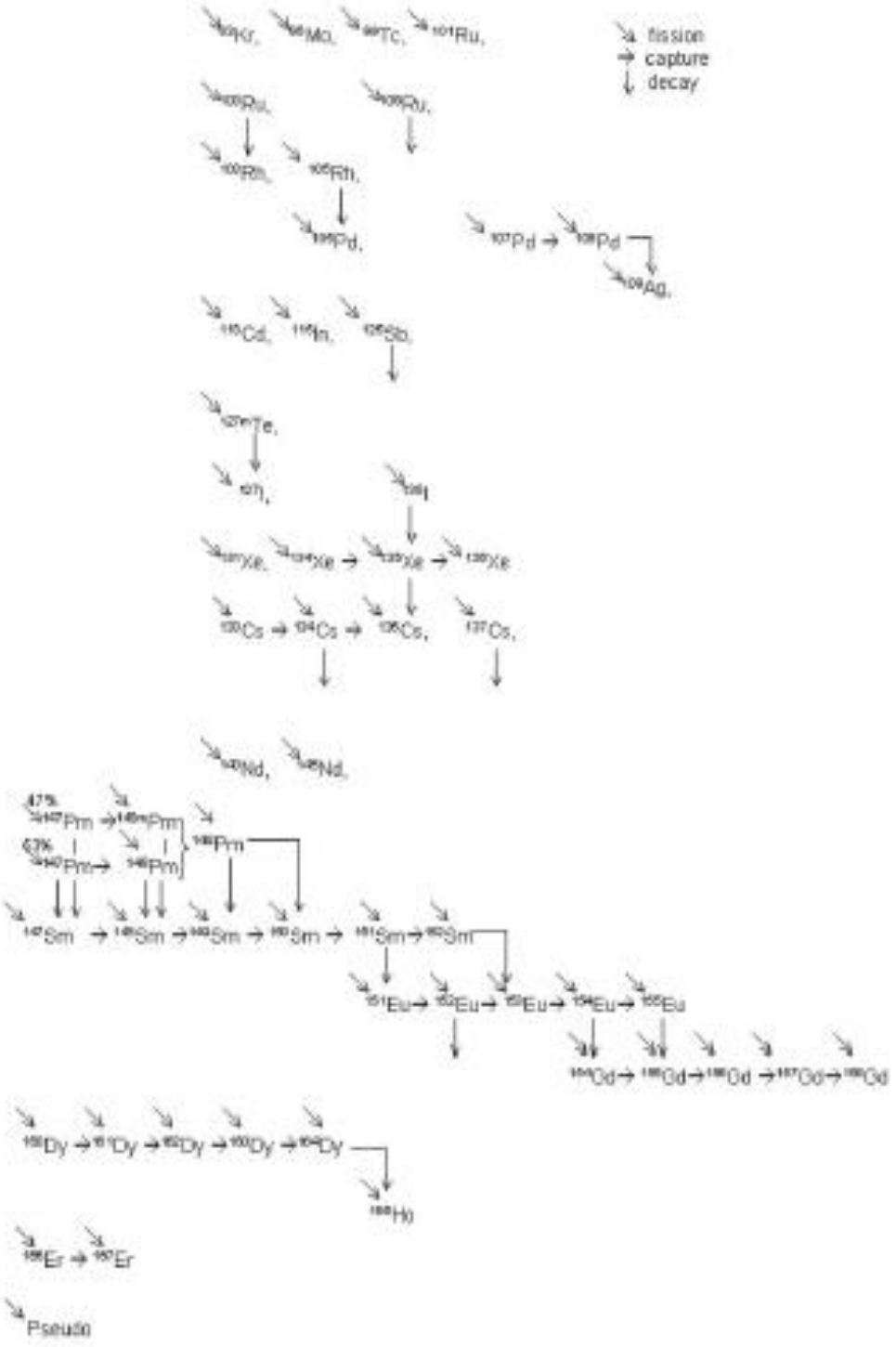

Figure 2: Fission product chains

6. Processing methods

The evaluated nuclear data files for all materials were processed using the NJOY-99.396 modular system [4]. The input options were similar to those developed in the frame of WIMS Library Update Project and described in reference [1]. In the case of chlorine 35 it was necessary to pre-process the evaluated data file using the PREPRO-2012 code system (https://www-nds.iaea.org/public/endf/prepro/) [5], because the processing of R-Matrix limited format (LRF=7) for the resonance data is not implemented in this version of NJOY.

For the added minor actinides the processing options are similar to the ones used for Cm-242, Cm-243 and Cm-244 in the original WIMSD-IAEA libraries. Similarly, for bismuth the processing was performed in the same way that for lead isotopes.

All the processing inputs, data, procedures and auxiliary programs applied to generate the new library are freely available on http://www-nds.iaea.org/wimsd/ hosting by the Nuclear Data Section.

7. Running benchmarks

More than 200 benchmarks analyzed in the frame of the WIMS Library Update Project were calculated using the new libraries based on ENDF/B-VII.1 evaluated nuclear data files. The results and plots are published on http://www-nds.iaea.org/wimsd/ web site.

8. End-user information

The libraries in the 69- and 172-energy group structures are available on the website of the WIMS Library Update Project (http://www-nds.iaea.org/wimsd/). Tables 3 to Table 11 summarize the information to use the WIMSD libraries based on ENDF/B-VII.1 evaluated nuclear data files, namely:

- Table 3: General data for materials included in the WIMSD-formatted library
- Table 4: Resonance data
- Table 5. Materials with P1 matrices
- Table 6: Energy release per fission for fissionable materials
- Table 7: Burn-up and decay data
- Table 8. Fission spectrum of the 69-group library
- Table 9: Fission spectrum of the 172-group library
- Table 10: Fission product yields for Th-232, U-233, U-235 and U-238
- Table 11: Fission product yields for Pu-239, Pu-240, Pu-241 and Pu-242

As was mentioned above, the libraries include new materials, extended actinide burn-up chains and higher temperatures for the most important nuclides. The conventions and symbols follows the definitions of reference [1].

To use the library:

1. Download the WIMSD-formatted libraries from the WLUP web page.
    a. endfb7.lib with 69 energy groups (WIMS energy structure)
    b. endfb7gx.lib with 172 energy groups (XMAS energy structure)
2. Download the code WILLIE.FOR included in the for.src package.
3. Prepare a WILLIE executable
4. Prepare a WIMSD binary library using the option FOBI of WILLIE.

A binary library in 69- or 172-groups should be ready for use with the WIMSD-family of lattice codes.

References

[1] Leszczynski**,** F., Lopez Aldama, D., Trkov, A. (Eds), "WIMS-D library update: final report of a coordinated research project", STI/PUB/1264, ISBN 92–0–105006–2, IAEA, Vienna.

[2] Chadwick, M.B., et al., "ENDF/B-VII.1 Nuclear Data for Science and Technology: Cross Sections, Covariances, Fission Product Yields and Decay Data", Nuclear Data Sheets 112 (2011) 2887-2996.

[3] Koning, A.J., Rochman, D., "TENDL-2009: TALYS-based evaluated nuclear data library", November 2013.

[4] MacFarlane, R.E., Muir, D.M., "NJOY-99.0: Code System for Producing Pointwise and Multigroup Neutron and Photon Cross Sections from ENDF/B Data", Technical Report PSR-480, Los Alamos National Laboratory, 2000.

[5] Cullen D.E, "PREPRO 2010: ENDF/B Pre-processing Codes", report IAEA-NDS-39, Rev. 14, 2010.

Table 3: General data for materials included in the WIMSD-formatted library

Material	ID	At.Wt.	NF	T[K]	Typ	σ_0	Description	Data Source
1-H –H2O	3001	1.00783	0	293.6 350 400 450 500 550 600 650 800	M	∞.	Hydrogen bound in water	ENDF/B-VII.1
1-H –ZrH	5001	1.00783	0	296 400 500 600 700 800 1000 1200	M	10.0	Hydrogen bound in ZrH	ENDF/B-VII.1
1-D –D2O	3002	2.0141	0	293.6 350 400 450 500 550 600 650	M	∞.	Deuterium bound in D2O. HWR spectrum	ENDF/B-VII.1
2-He- 3	3	3.01493	0	900	S	∞.	Helium-3	ENDF/B-VII.1
2-He- 4	4	4.03617	0	900	S	∞.	Helium-4	ENDF/B-VII.1
3-Li- 6	6	6.01507	0	600	S	∞.	Lithium-6	ENDF/B-VII.1
3-Li- 7	7	7.01601	0	600	S	∞	Lithium-7	ENDF/B-VII.1
4-Be-nat	9	9.0122	0	296 400 500 600 700 800 1000 1200	S	∞	Beryllium	ENDF/B-VII.1
5-B – 10	10	10.0129	0	300	B	1000.0	Boron-10 (burnable)	ENDF/B-VII.1
5-B – 10	1010	10.0129	0	300	S	1000.0	Boron-10 (unburnable)	ENDF/B-VII.1
5-B – 11	11	10.0129	0	300	B	300.0	Boron-11 (burnable)	ENDF/B-VII.1
5-B –nat	1011	10.811	0	300	S	*	Natural boron (unburnable)	ENDF/B-VII.1 (From isotopes)

Material	ID	At.Wt.	NF	T[K]	Typ	σ_0	Description	Data Source
6-C –nat	2012	12.0011	0	296 400 500 600 700 800 1000 1200 1600 2000	M	∞	Graphite	ENDF/B-VII.1
7-N –nat	14	14.0067	0	900	S	∞	Nitrogen	ENDF/B-VII.1 (From isotopes)
8-O –nat	6016	15.9905	0	293 450 600 900 1200 1600 2000	S	∞ (included elastic scatt.)	Oxygen	ENDF/B-VII.1
9-F –nat	19	18.9982	0	600	S	∞	Fluorine	ENDF/B-VII.1
11-Na-nat	23	22.9895	0	600	S	∞	Sodium	ENDF/B-VII.1
12-Mg-nat	24	24.3051	0	293 600 900	S		Magnesium	ENDF/B-VII.1 (From isotopes)
13-Al-nat	27	26.9815	0	293	S	∞	Aluminium	ENDF/B-VII.1
14-Si-nat	29	28.0859	0	293 600 900 1200 1600 2000	S		Silicon	ENDF/B-VII.1 (From isotopes)
15-P –nat	31	30.9741	0	293 900	S	2.0E5	Phosphorus	ENDF/B-VII.1
16-S –nat	32	32.0637	0	293 900	S	*	Sulphur	ENDF/B-VII.1 (From isotopes)
17-Cl-nat	35	35.4526	0	300	S	∞.	Chlorine	ENDF/B-VII.1 (From isotopes)
20-Ca-nat	40	40.0803	0	300	S	∞	Calcium	ENDF/B-VII.1 (From isotopes)
22-Ti-nat	48	47.8789	0	293 900	S	*	Titanium	ENDF/B-VII.1 (From isotopes)
23-V –nat	51	50.9416	0	293 900	S	*	Vanadium	ENDF/B-VII.1 (From isotopes)
24-Cr-nat	52	51.9959	0	293 600 900	S	*	Chromium	ENDF/B-VII.1 (From isotopes)
25-Mn-nat	55	54.9381	0	293 900	S	1.5E4	Manganese	ENDF/B-VII.1
26-Fe-nat	2056	55.8464	0	293 600 900	S	*	Iron	ENDF/B-VII.1 (From isotopes)
28-Ni-nat	58	58.6936	0	293 600 900	S	*	Nickel	ENDF/B-VII.1 (From isotopes)

Material	ID	At.Wt.	NF	T[K]	Typ	σ_0	Description	Data Source
27-Co- 59	1059	58.9332	0	293 900	S	2.5E5	Cobalt	ENDF/B-VII.1
29-Cu-nat	3063	63.5456	0	293 900	S	*	Copper	ENDF/B-VII.1 (From isotopes)
40-Zr-nat	91	91.2196	0	293 600 900 1200 1600 2000	S	*	Zirconium	ENDF/B-VII.1 (From isotopes)
41-Nb- 93	93	92.9032	0	293 900	S	3.0E4	Niobium	ENDF/B-VII.1
42-Mo-nat	96	95.9402	0	293 900	S	*	Molybdenum	ENDF/B-VII.1 (From isotopes)
47-Ag-nat	3109	107.868	0	293 600 900	S	*	Silver (control rod material)	ENDF/B-VII.1 (From isotopes)
48-Cd-nat	2113	112.411	0	300 600 900	S	*	Cadmium (control rod material)	ENDF/B-VII.1 (From isotopes)
49-In-nat	2115	114.82	0	300 600 900	S	*	Indium (control rod material)	ENDF/B-VII.1 (From isotopes)
50-Sn-nat	118	117.241	0	293 600 900	S	*	Tin	ENDF/B-VII.1 (From isotopes)
51-Sb-121	121	120.904	1	293 600 900	S	500	Antimony-121	ENDF/B-VII.1
51-Sb-123	123	122.904	1	293 600 900	S	500	Antimony-123	ENDF/B-VII.1
63-Eu-nat	152	151.965	0	293 600 900	S	*	Europium (control rod material)	ENDF/B-VII.1 (From isotopes)
64-Gd-154	2154	153.921	1	293 700 1100 1500 2000	B/FP	5.0E4	Gadolinium-154 (burnable absorber)	ENDF/B-VII.1
64-Gd-155	2155	154.923	1	293 700 1100 1500 2000	B/FP	1.0E4	Gadolinium-155 (burnable absorber)	ENDF/B-VII.1
64-Gd-156	2156	155.923	1	293 700 1100 1500 2000	B/FP	1.0E4	Gadolinium-156 (burnable absorber)	ENDF/B-VII.1

Material	ID	At.Wt.	NF	T[K]	Typ	σ_0	Description	Data Source
64-Gd-157	2157	156.924	1	293 700 1100 1500 2000	B/FP	1.0E4	Gadolinium-157 (burnable absorber)	ENDF/B-VII.1
64-Gd-158	2158	157.924	1	293 700 1100 1500 2000	B/FP	5.0E3	Gadolinium-158 (burnable absorber)	ENDF/B-VII.1
66-Dy-160	160	159.925	0	293 700 1100 1500 2000	B/FP	2.0E5	Dysprosium-160	ENDF/B-VII.1
66-Dy-161	161	160.927	0	293 700 1100 1500 2000	B/FP	2.0E5	Dysprosium-161	ENDF/B-VII.1
66-Dy-162	162	161.927	0	293 700 1100 1500 2000	B/FP	2.0E5	Dysprosium-162	ENDF/B-VII.1
66-Dy-163	163	162.929	0	293 700 1100 1500 2000	B/FP	2.0E5	Dysprosium-163	ENDF/B-VII.1
66-Dy-164	164	163.928	0	293 700 1100 1500 2000	B/FP	2.0E5	Dysprosium-164	ENDF/B-VII.1
67-Ho-165	165	164.93	0	293 700 1100 1500 2000	B/FP	2.0E5	Holmium-165	ENDF/B-VII.1
68-Er-166	2166	165.93	1	293 700 1100 1500 2000	B	500	Erbium-166 (burnable absorber)	ENDF/B-VII.1
68-Er-167	2167	166.932	1	293 700 1100 1500 2000	B	500	Erbium-167 (burnable absorber)	ENDF/B-VII.1

Material	ID	At.Wt.	NF	T[K]	Typ	σ_0	Description	Data Source
72-Hf-176	2176	175.941	1	293 700 1100 1600 2000	B	1000	Hafnium-176 (burnable absorber)	ENDF/B-VII.1
72-Hf-177	2177	176.943	1	293 700 1100 1600 2000	B	1000	Hafnium-177 (burnable absorber)	ENDF/B-VII.1
72-Hf-178	2178	177.944	1	293 700 1100 1600 2000	B	500	Hafnium-178 (burnable absorber)	ENDF/B-VII.1
72-Hf-179	2179	178.946	1	293 700 1100 1600 2000	B	1000	Hafnium-179 (burnable absorber)	ENDF/B-VII.1
72-Hf-180	2180	179.947	1	293 700 1100 1600 2000	B	500	Hafnium-180 (burnable absorber)	ENDF/B-VII.1
72-Hf-nat	178	178.487	0	293 600 900	S	*	Natural Hafnium (unburnable)	ENDF/B-VII.1 (From isotopes)
73-Ta-nat	181	180.955	0	293 600 900	S	500	Tantalum Ta-181 isotope (99.998 %)	ENDF/B-VII.1
74-W –nat	183	183.856	0	293 600 900	S	*	Tungsten W-182, W-183 W-184, W-186	ENDF/B-VII.1 (From isotopes)
82-Pb-nat	207	207.262	0	600	S	∞	Lead Pb-204, Pb-206, Pb- 207, Pb-208	ENDF/B-VII.1 (From isotopes)
83-Bi-nat	209	208.980	0	600	S	∞	Bismuth (Bi-209)	ENDF/B-VII.1
36-Kr- 83	4083	82.9141	0	700	FP	5.E5	Krypton-83	ENDF/B-VII.1
42-Mo- 95	4095	94.9059	0	700	FP	3.E4	Molybdenum-95	ENDF/B-VII.1
43-Tc- 99	4099	99.0005	1	293 700 1100 1500 2000	FP	3.E4	Technetium-99	ENDF/B-VII.1
44-Ru-101	4101	100.906	0	700	FP	2.5E4	Ruthenium-101	ENDF/B-VII.1
44-Ru-103	5103	102.906	0	700	FP	1.2E6	Ruthenium-103	ENDF/B-VII.1
44-Ru-106	4106	105.908	0	700	FP	1.0E6	Ruthenium-106	ENDF/B-VII.1
45-Rh-103	4103	102.905	0	700	FP	5.5E4	Rhodium-103	ENDF/B-VII.1
45-Rh-105	4105	104.906	0	700	FP	4.5E7	Rhodium-105	ENDF/B-VII.1
46-Pd-105	5105	104.905	0	700	FP	8.0E4	Palladium-105	ENDF/B-VII.1
46-Pd-107	4107	106.905	0	700	FP	2.0E5	Palladium-107	ENDF/B-VII.1

Material	ID	At.Wt.	NF	T[K]	Typ	σ_0	Description	Data Source
46-Pd-108	4108	107.904	0	700	FP	2.0E5	Palladium-108	ENDF/B-VII.1
47-Ag-109	4109	108.905	1	293 700 1100 1500 2000	FP	5.0E5	Silver-109	ENDF/B-VII.1
48-Cd-113	4113	112.9	0	700	FP	2.0E8	Cadmium-113	ENDF/B-VII.1
49-In-115	4115	114.82	0	700	FP	3.0E7	Indium-115	ENDF/B-VII.1
51-Sb-125	4125	124.905	0	700	FP	5.0E7	Antimony-125	ENDF/B-VII.1
52-Te-127m	5127	126.905	0	700	FP	5.0E7	Tellurium-127m	ENDF/B-VII.1
53-I –127	4127	126.905	0	700	FP	7.0E5	Iodine-127	ENDF/B-VII.1
54-Xe-131	4131	130.906	0	700	FP	7.0E5	Xenon-131	ENDF/B-VII.1
55-Cs-133	4133	132.906	1	293 700 1100 1500 2000	FP	2.5E4	Cesium-133	ENDF/B-VII.1
55-Cs-134	4134	133.907	0	700	FP	5.0E5	Cesium-134	ENDF/B-VII.1
55-Cs-137	4137	136.907	0	700	FP	5.0E4	Cesium-137	ENDF/B-VII.1
53-I –135	6135	134.91	0	700	FP	1.5E8	Iodine-135	ENDF/B-VII.1
54-Xe-134	5134	133.905	0	700	FP	1.0E5	Xenon-134	ENDF/B-VII.1
54-Xe-135	4135	134.907	0	700	FP	2.5E8	Xenon-135	ENDF/B-VII.1
55-Cs-135	5135	134.906	0	700	FP	5.0E4	Cesium-135	ENDF/B-VII.1
54-Xe-136	4136	135.908	0	700	FP	1.0E5	Xenon-136	ENDF/B-VII.1
60-Nd-143	4143	142.91	0	700	FP	3.5E4	Neodymium-143	ENDF/B-VII.1
60-Nd-145	4145	144.913	0	700	FP	4.5E4	Neodymium-145	ENDF/B-VII.1
61-Pm-147	4147	146.915	0	700	FP	5.0E5	Promethium-147 (n, γ) Pm-148	ENDF/B-VII.1
61-Pm-147	5147	146.915	0	700	FP	5.0E5	Promethium-147 (n, γ) Pm-148m	ENDF/B-VII.1
62-Sm-147	6147	146.915	0	700	FP	4.5E5	Samarium-147	ENDF/B-VII.1
61-Pm-148m	4148	147.918	0	700	FP	3.0E7	Promethium-148m	ENDF/B-VII.1
61-Pm-148	5148	147.918	0	700	FP	8.0E7	Promethium-148	ENDF/B-VII.1
62-Sm-148	6148	147.915	0	700	FP	1.0E6	Samarium-148	ENDF/B-VII.1
61-Pm-149	5149	148.918	0	700	FP	6.5E7	Promethium-149	ENDF/B-VII.1
62-Sm-149	4149	148.917	0	700	FP	2.0E7	Samarium-149	ENDF/B-VII.1
62-Sm-150	4150	149.917	0	700	FP	1.0E5	Samarium-150	ENDF/B-VII.1
62-Sm-151	4151	150.92	0	700	FP	5.0E6	Samarium-151	ENDF/B-VII.1
62-Sm-152	4152	151.92	0	700	FP	1.0E6	Samarium-152	ENDF/B-VII.1
63-Eu-151	5151	150.92	0	700	FP	∞	Europium-151	ENDF/B-VI.8
63-Eu-152	5152	151.925	0	700	FP	∞	Europium-152	ENDF/B-VII.1
63-Eu-153	4153	152.922	0	700	FP	3.0E5	Europium-153	ENDF/B-VI.8
63-Eu-154	4154	153.922	0	700	FP	1.5E6	Europium-154	ENDF/B-VII.1
63-Eu-155	4155	154.923	0	700	FP	1.0E7	Europium-155	ENDF/B-VII.1
Pseudo FP	4902	114.675	0	700	FP	-	Lumped fission product	ENDF/B-VII.1
90-Th-232	2232	232.033	2	293 600 900 1200 1600 2000	A	28.0	Thorium-232	ENDF/B-VII.1

Material	ID	At.Wt.	NF	T[K]	Typ	σ_0	Description	Data Source
92-U –232	4232	232.033	0		FP	-	Pseudo fission product U-232(n,2n)U-231	N/A
92-U –232	232	232.033	4	293 700 1100 1500 2000	A	1.0E5	Uranium-232	ENDF/B-VII.1
92-U –233	9233	233.045	3	293 600 900 1200 1600 2000	A	800.0	Uranium-233	ENDF/B-VII.1
91-Pa-231	1231	231.035	0	293 700 1100 1500 2000	FP	1.0E5	Protactinium-231 (non-fissile FP)	ENDF/B-VII.1
91-Pa-233	1233	233.04	4	293 700 1100 1500 2000	A	5.5E5	Protactinium-233	ENDF/B-VII.1 (no fission yields)
92-U –234	234	234.041	2	293 700 1100 1500 2000	A	1.0E5	Uranium-234	ENDF/B-VII.1
92-U –235	2235	235.044	3	293 600 900 1200 1600 2000	A	800.0	Uranium-235	ENDF/B-VII.1
92-U –236	236	236.046	2	293 700 1100 1500 2000	A	1.0E4	Uranium-236	ENDF/B-VII.1
92-U –237	4927	237.049	0		FP	-	Pseudo fission product U-238(n,2n)U-237	N/A
92-U –237	927	237.048	4	293 700 1100 1500 2000	A	1.5E7	Uranium-237	ENDF/B-VII.1
92-U –238	8238	238.051	2	293 600 900 1200 1600 2000	A	28.0	Uranium-238	ENDF/B-VII.1

Material	ID	At.Wt.	NF	T[K]	Typ	σ_0	Description	Data Source
93-Np-237	937	237.048	4	293 700 1100 1500 2000	A	1.0E5	Neptunium-237	ENDF/B-VII.1
93-Np-239	1939	239.053	4	293 700 1100 1500 2000	A	1.0E6	Neptunium-239	ENDF/B-VII.1 (Fission product yields from TENDL-2009)
94-Pu-238	948	238.05	4	293 700 1100 1500 2000	A	3.0E4	Plutonium-238	ENDF/B-VII.1
94-Pu-239	6239	239.052	3	293 600 900 1200 1600 2000	A	700.0	Plutonium-239	ENDF/B-VII.1
94-Pu-240	1240	240.054	2	293 600 900 1200 1600 2000	A	2.0E3	Plutonium-240	ENDF/B-VII.1
94-Pu-241	1241	241.049	3	293 600 900 1200 1600 2000	A	1.0E4	Plutonium-241	ENDF/B-VII.1
94-Pu-242	242	242.058	2	293 700 1100 1500 2000	A	1.0E5	Plutonium-242 (high self-shielding)	ENDF/B-VII.1
94-Pu-242	1242	242.058	2	293 700 1100 1500 2000	A	1.0E3	Plutonium-242 (low self-shielding)	ENDF/B-VII.1
95-Am-241	951	241.057	4	293 700 1100 1500 2000	A	5.0E4	Americium-241	ENDF/B-VII.1

Material	ID	At.Wt.	NF	T[K]	Typ	σ_0	Description	Data Source
95-Am-242	1952	242.059	0	293 700 1100 1500 2000	FP	5.0E6	Americium-242 (non-fissile fp)	ENDF/B-VII.1
95-Am242m	952	242.059	4	293 700 1100 1500 2000	A	1.0E6	Americium-242m	ENDF/B-VII.1
95-Am-243	953	243.061	4	293 700 1100 1500 2000	A	5.0E5	Americium-243	ENDF/B-VII.1
96-Cm-242	962	242.058	4	293 700 1100 1500 2000	A	1.0E6	Curium-242	ENDF/B-VII.1
96-Cm-243	963	243.061	4	293 700 1100 1500 2000	A	1.0E6	Curium-243	ENDF/B-VII.1
96-Cm-244	964	244.063	4	293 700 1100 1500 2000	A	1.0E6	Curium-244	ENDF/B-VII.1
96-Cm-245	965	245.065	4	293 700 1100 1500 2000	A	1.0E6	Curium-245	ENDF/B-VII.1
96-Cm-246	966	246.067	4	293 700 1100 1500 2000	A	1.0E6	Curium-246	ENDF/B-VII.1
96-Cm-247	967	247.070	4	293 700 1100 1500 2000	A	1.0E6	Curium-247	ENDF/B-VII.1 (Fission product yields from TENDL-2009)
96-Cm-248	968	248.072	4	293 700 1100 1500 2000	A	1.0E6	Curium-248	ENDF/B-VII.1

Material	ID	At.Wt.	NF	T[K]	Typ	σ_0	Description	Data Source
97-Bk-249	9749	249.075	4	293 700 1100 1500 2000	A	1.0E6	Berkelium-249	ENDF/B-VII.1 (Fission product yields from TENDL-2009)
98-Cf-249	9849	249.075	4	293 700 1100 1500 2000	A	1.0E6	Californium-249	ENDF/B-VII.1
98-Cf-250	9850	250.076	4	293 700 1100 1500 2000	A	1.0E6	Californium-250	ENDF/B-VII.1 (Fission product yields from TENDL-2009)
98-Cf-251	9851	251.080	4	293 700 1100 1500 2000	A	1.0E6	Californium-251	ENDF/B-VII.1
98-Cf-252	9852	252.081	4	293 700 1100 1500 2000	A	1.0E6	Californium-252	ENDF/B-VII.1 (Fission product yields from TENDL-2009)
98-Cf-253	9853	253.085	4	293 700 1100 1500 2000	A	1.0E6	Californium-253	ENDF/B-VII.1 (Fission product yields from TENDL-2009)
98-Cf-254	9854	254.088	4	293 700 1100 1500 2000	A	1.0E6	Californium-254	ENDF/B-VII.1 (Fission product yields adopted from Cf-252)
1/v	1000	1	0	300	D	-	1/v absorber	N/A
Res.(1/v)	1999	1	0	300	D	-	Resonance part of 1/v absorber	N/A
-1/v	2000	1	0	300	D	-	-1/v absorber	N/A
abs	3000	1	0	300	D	-	Pure absorber (1 barn)	N/A
1/Δu	4000	1	0	300	D	-	Inverse lethargy intervals	N/A
6-C - 0	2212	12.0011	0	300	D	∞	Graphite damage	ENDF/B-VI.7
40-Zr- 0	1091	91.2196	0	300	D	∞	Zr damage	ENDF/B-VI.7
25-Mn- 55	1055	54.938	0	300	D	∞	Mn-55(n,g)Mn-56	IRDFF-v.1.05
26-Fe- 54	1054	53.9396	0	300	D	∞	Fe-54(n,p)Mn-54	IRDFF-v.1.05
26-Fe- 58	3058	57.9333	0	300	D	∞	Fe-58(n,g)Fe-59	IRDFF-v.1.05
27-Co- 59	2059	58.9332	0	300	D	∞	Co-59(n,g)Co-60	IRDFF-v.1.05
28-Ni- 58	1058	57.9354	0	300	D	∞	Ni-58(n,p)Co-58	IRDFF-v.1.05
29-Cu- 63	1063	62.9296	0	300	D	∞	Cu-63(n,g)Cu-64	IRDFF-v.1.05
36-Kr- 84	84	83.9114	0	300	D	∞	Kr-84(n,g)Kr-85	ENDF/B-VII.1
45-Rh-103	2103	102.904	0	300	D	∞	Rh-103(n,n')Rh-103m	IRDFF-v.1.05

Material	ID	At.Wt.	NF	T[K]	Typ	σ_0	Description	Data Source
49-In-115	1115	114.904	0	300	D	∞	In-115(n,n')In-115m	IRDFF-v.1.05
49-In-115	3115	114.904	0	300	D	∞	In-115(n,g)In-116m	IRDFF-v.1.05
63-Eu-151	1151	150.92	0	300	D	∞	Eu-151(n,g)Eu-152	ENDF/B-VII.1
66-Dy-164	1164	163.928	0	300	D	∞	Dy-164(n,g)Dy-165	ENDF/B-VII.1
71-Lu-176	176	175.941	0	300	D	∞	Lu-176(n,g)Lu-177	ENDF/B-VII.1
79-Au-197	197	196.967	0	300	D	∞	Au-197(n,g)Au-198	IRDFF-v.1.05
90-Th-232	1232	232.038	0	300	D	∞	Th-232(n,g)Th-233	IRDFF-v.1.05
90-Th-232	3232	232.038	0	300	D	∞	Th-232(n,f)	IRDFF-v.1.05
92-U -235	1235	235.044	0	300	D	∞	U-235(n,g)U-236	IRDFF-v.1.05
92-U -235	1003	235.044	0	300	D	∞	U-235(n,f)	IRDFF-v.1.05
92-U -238	1238	238.051	0	300	D	∞	U-238(n,g)U-239	IRDFF-v.1.05
92-U -238	3238	238.051	0	300	D	∞	U-238(n,f)	IRDFF-v.1.05
93-Np-237	1237	237.048	0	300	D	∞	Np-237(n,f)	IRDFF-v.1.05
94-Pu-239	1239	239.053	0	300	D	∞	Pu-239(n,f)	IRDFF-v.1.05
90-Th-232	1632	232.033	0	300	D	∞	Th-232(n,2n)	ENDF/B-VII.1
92-U –233	1633	233.045	0	300	D	∞	U-233(n,2n)	ENDF/B-VII.1
92-U –235	1635	235.044	0	300	D	∞	U-235(n,2n)	ENDF/B-VII.1
92-U –238	1638	238.051	0	300	D	∞	U-238(n,2n)	IRDFF-v.1.05
94-Pu-239	1639	239.052	0	300	D	∞	Pu-239(n,2n)	ENDF/B-VII.1
94-Pu-240	1640	240.054	0	300	D	∞	Pu-240(n,2n)	ENDF/B-VII.1
94-Pu-241	1641	241.049	0	300	D	∞	Pu-241(n,2n)	ENDF/B-VII.1
94-Pu-242	1642	242.058	0	300	D	∞	Pu-242(n,2n)	ENDF/B-VII.1

Material: Material identification
ID**:** WIMSD identification number
At. Wt.: Atomic weight [amu]
NF: WIMSD resonance trigger (0-4)
0: Material has no resonance tables.
1: Material is non-fissile with absorption resonance integral tables.
2: Material is fissile with absorption resonance integral tables.
3: Material is fissile with absorption and fission resonance integral tables.
4: Material is fissile without resonance integral tables.
T: Temperature in thermal range [K]
Typ: Type of material (M, S, D, FP, A, B)
M: Moderators.
S: Structural materials and other components
D: Dosimetry reactions (to calculate reaction rates only).
FP: Fission products.
A: Actinides.
B: Burnable materials.
σ_0: Reference Bondarenko background cross section. The value defines the dilution at which the cross-section data are tabulated, and corresponds to the dilution commonly encountered in practical problems for this material. An asterisk means that the material was prepared from isotope data and the isotopes were self-shielded individually.

Table 4: Resonance data

Material	ID_r	NF	T_{res}	λ	σ_{pot}	σ_{0res}
51-Sb-121	121.0	1	293 600 900	0.29	4.9381	1.0E10 5.0E5 5.0E4 1.0E4 1.0E3 5.0E2 1.0E2 10.
51-Sb-123	123.0	1	293 600 900	0.29	4.3701	1.0E10 5.0E5 5.0E4 1.0E4 1.0E3 5.0E2 1.0E2 10.
64-Gd-154	2154.0	1	293 700 1100 1500 2000	0.24	6.6723	1.0E10 5.0E6 5.0E5 1.0E5 5.0E4 1.0E4 5.0E3 1.0E3 5.0E2 50.
64-Gd-155	2155.0	1	293 700 1100 1500 2000	0.24	6.3376	1.0E10 5.0E6 5.0E5 1.0E5 5.0E4 1.0E4 5.0E3 1.0E3 5.0E2 50.
64-Gd-156	2156.0	1	293 700 1100 1500 2000	0.24	7.3792	1.0E10 5.0E6 5.0E5 1.0E5 5.0E4 1.0E4 5.0E3 1.0E3 5.0E2 50.
64-Gd-157	2157.0	1	293 700 1100 1500 2000	0.24	7.8427	1.0E10 5.0E6 5.0E5 1.0E5 5.0E4 1.0E4 5.0E3 1.0E3 5.0E2 50.
64-Gd-158	2158.0	1	293 700 1100 1500 2000	0.24	7.6454	1.0E10 5.0E6 5.0E5 1.0E5 5.0E4 1.0E4 5.0E3 1.0E3 5.0E2 50.
68-Er-166	2166.0	1	293 700 1100 1500 2000	0.23	8.2448	1.0E10 5.0E6 5.0E5 1.0E5 5.0E4 1.0E4 5.0E3 1.0E3 5.0E2 50.
68-Er-167	2167.0	1	293 700 1100 1500 2000	0.23	7.9704	1.0E10 5.0E6 5.0E5 1.0E5 5.0E4 1.0E4 5.0E3 1.0E3 5.0E2 50.
72-Hf-176	2176.0	1	293 700 1100 1600 2000	0.22	7.8720	1.0E10 5.0E6 5.0E5 1.0E5 5.0E4 1.0E4 5.0E3 1.0E3 5.0E2 50.
72-Hf-177	2177.0	1	293 700 1100 1600 2000	0.22	6.3780	1.0E10 5.0E6 5.0E5 1.0E5 5.0E4 1.0E4 5.0E3 1.0E3 5.0E2 50.

Material	ID_r	NF	T_{res}	λ	σ_{pot}	σ_{0res}
72-Hf-178	2178.0	1	293 700 1100 1600 2000	0.22	7.9154	1.0E10 5.0E6 5.0E5 1.0E5 5.0E4 1.0E4 5.0E3 1.0E3 5.0E2 50.
72-Hf-179	2179.0	1	293 700 1100 1600 2000	0.22	7.5973	1.0E10 5.0E6 5.0E5 1.0E5 5.0E4 1.0E4 5.0E3 1.0E3 5.0E2 50.
72-Hf-180	2180.0	1	293 700 1100 1600 2000	0.22	8.1241	1.0E10 5.0E6 5.0E5 1.0E5 5.0E4 1.0E4 5.0E3 1.0E3 5.0E2 50.
43-Tc- 99	4099.0	1	293 700 1100 1500 2000	0.35	6.4242	1E10, 1E6, 5E5, 1E5, 3E4, 1E4, 1E3, 500
47-Ag-109	4109.0	1	293 700 1100 1500 2000	0.32	5.5051	1.0E10 1.0E6 5.0E5 1.0E5 5.0E4 1.0E4 1.0E3 5.0E2
55-Cs-133	4133.0	1	293 700 1100 1500 2000	0.27	3.5299	1.0E10 1.0E6 5.0E5 1.0E5 2.5E4 1.0E4 1.0E3 5.0E2
90-Th-232	2232.1	2	293 600 900 1200 1600 2000	0.20	11.8194	1.E10 2.E4 3600. 1000. 260. 140. 64. 46. 28. 10.
92-U -233	9233.0	3	293 600 900 1200 1600 2000	0.20	11.7185	1.E10 3.E4 8000. 4500. 2800. 1800. 1200. 800. 500. 200.
92-U -234	234.0	2	293 700 1100 1500 2000	0.20	10.0210	1.E10 5.E5 3.E5 1.E5 5.E4 1.E4 5.E3 1.E3
92-U -235	2235.0	3	293 600 900 1200 1600 2000	0.20	11.6137	1.E10 3.E4 8000. 4500. 2800. 1800. 1200. 800. 500. 200.

Material	ID_r	NF	T_{res}	λ	σ_{pot}	σ_{0res}
92-U -236	236.0	2	293 700 1100 1500 2000	0.20	10.9954	1.E10 5.E5 3.E5 1.E5 5.E4 1.E4 5.E3 1.E3
92-U -238	8238.0	2	293 600 900 1200 1600 2000	0.20	11.2934	1E10, 2E4, 3.6E3, 1E3, 260, 140, 64, 52, 28, 10
94-Pu-239	6239.0	3	293 600 900 1200 1600 2000	0.20	11.1471	1.E10 3.E4 7000. 5000. 3000. 1800. 1200. 700. 450. 175.
94-Pu-240	1240.0	2	293 600 900 1200 1600 2000	0.20	9.9091	1.E10 5.E5 3.E5 1.E5 5.E4 1.E4 5.E3 2.E3 1.E3 5.E2
94-Pu-241	1241.0	3	293 600 900 1200 1600 2000	0.20	11.2156	1.E10 5.E5 3.E5 1.E5 5.E4 1.E4 5.E3 3.E3 1.E3 5.E2
94-Pu-242 (High self-shielding)	242.0	2	293 700 1100 1500 2000	0.20	11.9459	1.E10 5.E5 3.E5 1.E5 5.E4 1.E4 8.E3 5.E3 1.E3 5.E2
94-Pu-242 (Low self-shielding)	1242.0	2	293 700 1100 1500 2000	0.20	11.9459	1.E10 5.E5 3.E5 1.E5 5.E4 1.E4 8.E3 5.E3 1.E3 5.E2

Material: Material identification

IDr**:** WIMSD identification number for resonance data (real number)

NF: WIMSD resonance trigger (1-3)

1: Material is non-fissile with absorption resonance integral tables.

2: Material is fissile with absorption resonance integral tables.

3: Material is fissile with absorption and fission resonance integral tables.

T_{res}: Temperature list in the resonance range [K]

λ: Intermediate resonance parameter

σ_{pot}: Potencial cross section in the resonance range ($\sigma_b = \lambda\ \sigma_{pot} + \sigma_{0res}$)

σ_{0res}: List of Bondarenko background cross section.

$\sigma_{b:}$ WIMS background cross section

Table 5. Material with P1 matrices

Order	Material	WIMS ID	Temperature [K]	Description	Data Source
1	1-H –H2O	3001	293.6	Hydrogen bound in water; PWR spectrum	ENDF/B-VII.1
2	1-D –D2O	3002	293.6	Deuterium bound in D_2O; HWR spectrum	ENDF/B-VII.1
3	6-C –nat	2012	296.	Graphite; PWR spectrum	ENDF/B-VII.1
4	8-O –nat	6016	293.	Oxygen; PWR spectrum	ENDF/B-VII.1

Table 6: Energy release per fission for fissionable materials ($\mathbf{E_{fiss}}$)

Nuclide	**WIMS ID**	$\mathbf{E_{fiss}}$ [J/mole]
90-Th-232	2232	1.9260E-11
91-Pa-233(*)	1233	1.9186E-11
92-U –232	232	1.8692E-11
92-U –233	9233	1.9312E-11
92-U –234	234	1.9619E-11
92-U –235	2235	1.9511E-11
92-U –236	236	1.9836E-11
92-U –237	927	1.9096E-11
92-U –238	8238	2.0434E-11
93-Np-237	937	2.0278E-11
93-Np-239	1939	1.9667E-11
94-Pu-238	948	2.0528E-11
94-Pu-239	6239	2.0292E-11
94-Pu-240	1240	2.0645E-11
94-Pu-241	1241	2.0637E-11
94-Pu-242	242,1242	2.1041E-11
95-Am-241	951	2.0933E-11
95-Am242m	952	2.1180E-11
95-Am-243	953	2.1431E-11
96-Cm-242	962	2.0610E-11
96-Cm-243	963	2.0568E-11
96-Cm-244	964	2.1084E-11
96-Cm-245	965	2.0683E-11
96-Cm-246	966	2.1292E-11
96-Cm-247	967	2.1083E-11
96-Cm-248	968	2.1434E-11
97-Bk-249	9749	2.1616E-11
98-Cf-249	9849	2.1311E-11
98-Cf-250	9850	2.2121E-11
98-Cf-251	9851	2.1471E-11
98-Cf-252	9852	2.2172E-11
98-Cf-253	9853	2.2208E-11
98-Cf-254	9854	2.2205E-11

(*) No fission product yields
Pa-231 and Am-242 are treated as fission products

Table 7: Burn-up and decay data

Nuclide	WIMSD ID	Decay constant [1/s]	Decay product (DP)	Capture product (CP)	Capture branching ratio (BR)
5-B – 10	10	Stable	-	B-11 (11)	1.0
5-B – 11	11	Stable	-	-	-
64-Gd-154	2154	Stable	-	Gd-155 (2155)	1.0
64-Gd-155	2155	Stable	-	Gd-156 (2156)	1.0
64-Gd-156	2156	Stable	-	Gd-157 (2157)	1.0
64-Gd-157	2157	Stable	-	Gd-158 (2158)	1.0
64-Gd-158	2158	Stable	-	-	-
66-Dy-160	160	Stable	-	Dy-161 (161)	1.0
66-Dy-161	161	Stable	-	Dy-162 (162)	1.0
66-Dy-162	162	Stable	-	Dy-163 (163)	1.0
66-Dy-163	163	Stable	-	Dy-164 (164)	1.0
66-Dy-164	164	Stable	-	Ho-165 (165)	1.0
67-Ho-165	165	Stable	-	-	-
68-Er-166	2166	Stable	-	Er-167 (2167)	1.0
68-Er-167	2167	Stable	-	-	-
72-Hf-176	2176	Stable	-	Hf-177 (2177)	1.0
72-Hf-177	2177	Stable	-	Hf-178 (2178)	1.0
72-Hf-178	2178	Stable	-	Hf-179 (2179)	1.0
72-Hf-179	2179	Stable	-	Hf-180 (2180)	1.0
72-Hf-180	2180	Stable	-	-	-
36-Kr- 83	4083	Stable	-	-	-
42-Mo- 95	4095	Stable	-	-	-
43-Tc- 99	4099	Stable	-	-	-
44-Ru-101	4101	Stable	-	-	-
44-Ru-103	5103	2.0441E-07	Rh-103 (4103)	-	-
44-Ru-106	4106	2.1578E-08	-	-	-
45-Rh-103	4103	Stable	-	-	-
45-Rh-105	4105	5.4452E-06	Pd-105 (5105)	-	-
46-Pd-105	5105	Stable	-	-	-
46-Pd-107	4107	Stable	-	Pd-108 (4108)	1.0
46-Pd-108	4108	Stable	-	Ag-109 (4109)	1.0
47-Ag-109	4109	Stable	-	-	-
48-Cd-113	4113	Stable	-	-	
49-In-115	4115	Stable	-	-	
51-Sb-125	4125	7.9623E-09	-	-	
52-Te-127m	5127	7.3601E-08	I-127 (4127)	-	
53-I –127	4127	Stable	-	-	
54-Xe-131	4131	Stable	-	-	
55-Cs-133	4133	Stable	-	Cs-134 (4134)	1.0
55-Cs-134	4134	1.0636E-08	-	Cs-135 (5135)	1.0
55-Cs-137	4137	7.3020E-10	-	-	
53-I –135	6135	2.9306E-5	Xe-135 (4135)	-	
54-Xe-134	5134	Stable	-	Xe-135 (4135)	1.0
54-Xe-135	4135	2.1066E-05	Cs-135 (5135)	Xe-136 (4136)	1.0
55-Cs-135	5135	Stable	-	-	

Nuclide	WIMSD ID	Decay constant [1/s]	Decay product (DP)	Capture product (CP)	Capture branching ratio (BR)
54-Xe-136	4136	Stable	-	-	
60-Nd-143	4143	Stable	-	-	
60-Nd-145	4145	Stable	-	-	
61-Pm-147	4147	8.3725E-09	Sm-147 (6147)	Pm-148m (4148)	1.0 (1)
61-Pm-147	5147	8.3725E-09	Sm-147 (6147)	Pm-148 (5148)	1.0 (1)
62-Sm-147	6147	Stable	-	Sm-148 (6148)	1.0
61-Pm-148m	4148	1.9430E-07	Sm-148 (6148)	Pm-149 (5149)	1.0
61-Pm-148	5148	1.4945E-06	Sm-148 (6148)	Pm-149 (5149)	1.0
62-Sm-148	6148	Stable	-	Sm-149 (4149)	1.0
61-Pm-149	5149	3.6274E-06	Sm-149 (4149)	Sm-150 (1450)	1.0
62-Sm-149	4149	Stable	-	Sm-150 (4150)	1.0
62-Sm-150	4150	Stable	-	Sm-151 (4151)	1.0
62-Sm-151	4151	2.4405E-10	Eu-151 (5151)	Sm-152 (4152)	1.0
62-Sm-152	4152	Stable	-	Eu-153 (4153)	1.0 (2)
63-Eu-151	5151	Stable	-	Eu-152 (5152)	1.0
63-Eu-152	5152	1.6226E-09	(3)	Eu-153 (4153)	1.0
63-Eu-153	4153	Stable	-	Eu-154 (4154)	1.0
63-Eu-154	4154	2.5537E-09	Gd-154 (2154)	Eu-155 (4155)	1.0
63-Eu-155	4155	4.6212E-09	Gd-155 (2155)	-	
Pseudo FP.	4902	Stable	-	-	
90-Th-232	2232	Stable	-	Pa-233 (1233)	1.0
92-U-232	232	3.1879E-10	-	U-233 (9233)	1.0
92-U -233	9233	Stable	-	U-234 (234)	1.0
91-Pa-231	1231	6.7047E-13	-	U-232 (232)	1.0
91-Pa-233	1233	2.9741E-07	U-233 (9233)	U-234 (234)	1.0
92-U -234	234	Stable	-	U-235 (2235)	1.0
92-U -235	2235	Stable	-	U-236 (236)	1.0
92-U -236	236	Stable	-	U-237 (927)	1.0
92-U -237	927	1.1885E-06	Np-237 (937)	U-238 (8238)	1.0
92-U -238	8238	Stable	-	Np-239 (1939)	1.0
93-Np-237	937	Stable	-	Pu-238 (948)	1.0
93-Np-239	1939	3.4052E-06	Pu-239 (6239)	Pu-240 (1240)	1.0
94-Pu-238	948	2.5045E-10	U-234 (234)	Pu-239 (6239)	1.0
94-Pu-239	6239	9.1101E-13	U-235 (2235)	Pu-240 (1240)	1.0
94-Pu-240	1240	3.3477E-12	U-236 (236)	Pu-241 (1241)	1.0
94-Pu-241	1241	1.5371E-09	Am-241 (951)	Pu-242 (1242)	1.0
94-Pu-242	242	Stable	-	Am-243 (953)	1.0
94-Pu-242	1242	Stable	-	Am-243 (953)	1.0
95-Am-241	951	5.0773E-11	Np-237 (937)	Am-242m (952)	0.12
95-Am-242	1952	1.2019E-05	Cm-242 (962)	Am-242 (953)	0.80
95-Am-242m	952	1.5578E-10	Am-242 (1952)	Am-243 (953)	1.0
95-Am-243	953	2.9803E-12	Np-239 (1939)	Cm-244 (964)	1.0
96-Cm-242	962	4.9236E-08	Pu-238 (948)	Cm-243 (963)	1.0
96-Cm-243	963	7.5479E-10	Pu-239 (6239)	Cm-244 (964)	1.0
96-Cm-244	964	1.2128E-09	Pu-240 (1240)	Cm-245 (965)	1.0
96-Cm-245	965	2.5841E-12	Pu-241(1241)	Cm-246 (966)	1.0
96-Cm-246	966	4.6144E-12	Pu-242(1242)	Cm-247 (967)	1.0

Nuclide	WIMSD ID	Decay constant [1/s]	Decay product (DP)	Capture product (CP)	Capture branching ratio (BR)
96-Cm-247	967	Stable	-	Cm-248 (968)	1.0
96-Cm-248	968	Stable	-	Bk-249 (9749)	1.0
97-Bk-249	9749	2.5070E-08	Cf-249 (5849)	Cf-250 (9850)	1.0
98-Cf-249	9849	6.2577E-11	Cm-245 (965)	Cf-250 (9850)	1.0
98-Cf-250	9850	1.6792E-09	Cm-246 (966)	Cf-251 (9851)	1.0
98-Cf-251	9851	2.4459E-11	Cm-247(967)	Cf-252 (9852)	1.0
98-Cf-252	9852	8.3043E-11	Cm-248(968)	Cf-253 (9853)	1.0
98-Cf-253	9853	4.5045E-07	(4)	Cf-254 (9854)	1.0
98-Cf-254	9854	1.3260E-07	(5)	-	(5)

(1) Pm-147 + n → Pm-148m Mat 4147
→Pm-148 Mat 5147

(2) Sm-152 +n → [Sm-153] → Eu-153

(3) Eu-152 decays into void (ignore 72.08% Sm-152 and 27.92 % Gd-152)

(4) Cf-253 decays into void

(5) Cf-254 decay and capture products are void

Table 8. Fission spectrum of the 69-group library

Group	Fission Spectrum
1	2.7155E-02
2	1.1348E-01
3	2.1581E-01
4	2.3289E-01
5	1.7578E-01
6	1.1040E-01
7	6.2441E-02
8	3.1854E-02
9	1.5632E-02
10	7.5740E-03
11	3.6242E-03
12	1.7394E-03
13	8.4624E-04
14	4.0858E-04
15	1.8690E-04
16	8.3818E-05
17	4.3405E-05
18	2.2574E-05
19	1.1801E-05
20	9.4982E-06
21	2.7058E-06
22	6.8004E-07
23	2.1249E-07
24	1.3763E-07
25	6.9403E-08
26	3.2289E-08
27	2.6470E-08
sum	1.0000E+00

Table 9: Fission spectrum of the 172-group library

Group	Fission Spectrum	Group	Fission Spectrum	Group	Fission Spectrum
1	5.4366E-06	32	1.3352E-02	63	1.2407E-06
2	3.0151E-05	33	2.2999E-03	64	6.0053E-07
3	4.6129E-05	34	5.1939E-03	65	1.1988E-07
4	3.6377E-04	35	2.3912E-03	66	4.2185E-07
5	1.0609E-03	36	1.7753E-03	67	1.3563E-07
6	4.2858E-03	37	1.8526E-03	68	6.2924E-08
7	1.1374E-02	38	4.5624E-04	69	9.5335E-08
8	9.9939E-03	39	8.3687E-04	70	2.9881E-08
9	1.3719E-02	40	1.9225E-04	71	2.4257E-08
10	4.0475E-02	41	2.5538E-04	72	1.9597E-08
11	5.9306E-02	42	7.2186E-04	73	3.7407E-08
12	7.7123E-02	43	1.2468E-04	74	1.9764E-08
13	9.0501E-02	44	2.8184E-04	75	2.3610E-08
14	4.8103E-02	45	1.2699E-04	76	2.0828E-08
15	4.8690E-02	46	9.1430E-05	77	1.8387E-08
16	9.5545E-02	47	9.5464E-05	78	1.6241E-08
17	8.8608E-02	48	2.3573E-05	79	1.4355E-08
18	4.0651E-02	49	5.9994E-05	80	1.8485E-08
19	3.7989E-02	50	6.3356E-06	81	1.9935E-08
20	3.5199E-02	51	3.7064E-05	82	1.2090E-08
21	3.2434E-02	52	6.3669E-06	83	1.3087E-08
22	2.9670E-02	53	1.4414E-05	84	6.7340E-09
23	7.3557E-02	54	1.8536E-06	85	3.5601E-09
24	1.9817E-02	55	4.8264E-06	86	4.2240E-09
25	1.7688E-02	56	5.0179E-06	87	3.7027E-09
26	1.5710E-02	57	2.0210E-06	88	6.1156E-09
27	1.3851E-02	58	3.2750E-06	89	3.4881E-09
28	3.2319E-02	59	1.3210E-06	90	1.2680E-09
29	8.1900E-03	60	3.7631E-06	91	3.7259E-09
30	7.1535E-03	61	1.2250E-06	92	5.1452E-10
31	1.6320E-02	62	9.2828E-07	sum	1.0000E+00

Table 10: Fission product yields for Th-232, U-233, U-235 and U-238

Fission product	WIMS ID	Th-232	U-233	U-235	U-238
Kr-83	4083	2.1836E-02	1.0155E-02	5.4016E-03	3.9992E-03
Mo-95	4095	5.6503E-02	6.3490E-02	6.5007E-02	5.1362E-02
Tc-99	4099	2.9503E-02	4.9131E-02	6.1233E-02	6.1844E-02
Ru-101	4101	7.1204E-03	3.1711E-02	5.1789E-02	6.2049E-02
Ru-103	5103	1.5511E-03	1.5733E-02	3.0353E-02	6.2652E-02
Ru-106	4106	4.8494E-04	2.4620E-03	4.0380E-03	2.4773E-02
Rh-103	4103	1.0164E-20	1.7922E-10	4.8418E-12	8.9286E-14
Rh-105	4105	5.3416E-04	4.9663E-03	9.7199E-03	4.0850E-02
Pd-105	5105	0.0000E+00	0.0000E+00	0.0000E+00	3.7500E-09
Pd-107	4107	5.0256E-04	1.1451E-03	1.4926E-03	1.4383E-02
Pd-108	4108	6.1395E-04	7.5788E-04	5.5825E-04	6.0057E-03
Ag-109	4109	6.4521E-04	3.3341E-04	3.1149E-04	2.5104E-03
Cd-113	4113	7.7159E-04	1.3452E-04	1.4415E-04	4.5601E-04
In-115	4115	7.3378E-04	1.4309E-04	1.2405E-04	3.5773E-04
Sb-125	4125	3.2952E-04	1.1699E-03	3.4717E-04	4.8519E-04
Te-127	5127	1.6701E-04	9.1565E-04	2.6420E-04	2.2457E-04
I-127	4127	8.4638E-04	4.6404E-03	1.3390E-03	1.1381E-03
I-135	6135	5.5061E-02	5.0326E-02	6.2807E-02	6.9321E-02
Xe-131	4131	1.6205E-02	3.6046E-02	2.8886E-02	3.2911E-02
Xe-134	5134	5.3767E-02	6.3050E-02	7.8636E-02	7.6277E-02
Xe-135	4135	1.0181E-04	1.2244E-02	2.5710E-03	2.6817E-04
Xe-136	4136	5.5950E-02	6.7764E-02	6.3657E-02	6.9684E-02
Cs-133	4133	4.0713E-02	5.9533E-02	6.7104E-02	6.7968E-02
Cs-134	4134	3.0400E-10	2.6826E-06	7.6546E-08	6.4600E-09
Cs-135	5135	2.5812E-07	8.3154E-05	1.0200E-05	8.4230E-07
Cs-137	4137	5.8274E-02	6.7514E-02	6.1312E-02	6.0156E-02
Nd-143	4143	6.3040E-02	5.9630E-02	5.9252E-02	4.4078E-02
Nd-145	4145	5.3287E-02	3.4435E-02	3.9294E-02	3.8034E-02
Pm-147	4147	1.2290E-02	6.6862E-03	8.5794E-03	8.4290E-03
Pm-147*	5147	1.3858E-02	7.5398E-03	9.6746E-03	9.5050E-03
Pm-148	5148	1.9600E-13	3.1256E-09	4.6171E-11	6.1300E-12
Pm-148m	4148	5.2999E-13	9.8878E-09	8.6334E-11	1.6600E-11
Pm-149	5149	1.0838E-02	7.7800E-03	1.0807E-02	1.6272E-02
Sm-147	6147	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Sm-148	6148	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Sm-149	4149	0.0000E+00	1.2541E-10	1.6865E-12	1.5703E-14
Sm-150	4150	1.4500E-09	4.3812E-06	2.9909E-07	3.2902E-08
Sm-151	4151	3.6252E-03	3.1570E-03	4.1857E-03	7.9736E-03
Sm-152	4152	7.5505E-04	2.1361E-03	2.6700E-03	5.3013E-03
Eu-151	5151	0.0000E+00	3.8358E-12	2.6348E-12	0.0000E+00
Eu-152	5152	0.0000E+00	7.6428E-11	1.7888E-12	2.9200E-14

Fission product	WIMS ID	Th-232	U-233	U-235	U-238
Eu-153	4153	3.0993E-04	1.0368E-03	1.5847E-03	4.1458E-03
Eu-154	4154	2.2000E-13	2.0854E-08	1.9128E-09	8.2500E-11
Eu-155	4155	3.6169E-05	2.1430E-04	3.2285E-04	1.4150E-03
Gd-154	2154	0.0000E+00	6.1092E-12	1.1022E-13	0.0000E+00
Gd-155	2155	0.0000E+00	1.3556E-10	4.0232E-12	8.0401E-14
Gd-156	2156	2.6901E-05	1.2799E-04	1.4964E-04	7.6021E-04
Gd-157	2157	9.3169E-06	6.3065E-05	6.2417E-05	4.1344E-04
Gd-158	2158	4.6406E-06	2.0561E-05	3.3511E-05	1.8481E-04
Dy-160	160	4.8699E-14	1.3734E-09	2.8047E-10	1.8900E-11
Dy-161	161	1.4485E-07	1.2155E-06	9.0384E-07	1.2150E-05
Dy-162	162	7.9749E-08	1.2592E-07	1.6722E-07	3.4046E-06
Dy-163	163	4.6512E-08	5.9312E-08	6.1743E-08	2.0420E-06
Dy-164	164	2.0314E-08	1.9531E-08	1.9617E-08	1.2476E-06
Ho-165	165	3.5330E-09	6.3259E-09	9.7921E-09	7.6592E-07
Er-166	2166	1.3835E-09	3.6772E-09	3.7473E-09	5.6491E-07
Er-167	2167	9.7640E-10	5.0880E-10	2.4995E-09	4.3504E-07
pseudo	4902	1.2809E+00	1.1533E+00	1.0682E+00	9.5381E-01

Table 11: Fission product yields for Pu-239, Pu-240, Pu-241 and Pu-242

Fission product	WIMS ID	Pu-239	Pu-240	Pu-241	Pu-242
Kr-83	4083	2.9851E-03	2.3241E-03	2.3241E-03	1.7810E-03
Mo-95	4095	4.8184E-02	4.5032E-02	4.5032E-02	3.6289E-02
Tc-99	4099	6.2143E-02	5.9470E-02	5.9470E-02	5.4689E-02
Ru-101	4101	6.0294E-02	6.3326E-02	6.3326E-02	5.9902E-02
Ru-103	5103	6.9859E-02	6.4442E-02	6.4442E-02	6.5307E-02
Ru-106	4106	4.3476E-02	5.1332E-02	5.1332E-02	5.7524E-02
Rh-103	4103	2.5625E-09	2.1682E-10	2.1682E-10	8.8132E-12
Rh-105	4105	5.6375E-02	5.6146E-02	5.6146E-02	6.9646E-02
Pd-105	5105	2.4422E-10	1.8380E-11	1.8380E-11	7.6369E-13
Pd-107	4107	3.3265E-02	3.9964E-02	3.9964E-02	5.0364E-02
Pd-108	4108	2.1603E-02	2.9187E-02	2.9187E-02	4.3980E-02
Ag-109	4109	9.3569E-03	1.1922E-02	1.1922E-02	2.5650E-02
Cd-113	4113	8.2317E-04	1.3774E-03	1.3774E-03	3.1216E-03
In-115	4115	4.1878E-04	6.0516E-04	6.0516E-04	1.0434E-03
Sb-125	4125	1.1377E-03	8.1814E-04	8.1814E-04	1.2607E-03
Te-127	5127	8.3520E-04	6.6253E-04	6.6253E-04	4.5252E-04
I-127	4127	4.2327E-03	3.3577E-03	3.3577E-03	2.2934E-03
I-135	6135	6.5190E-02	6.8499E-02	6.8499E-02	6.8627E-02
Xe-131	4131	3.8556E-02	3.4731E-02	3.4731E-02	3.0874E-02
Xe-134	5134	7.6601E-02	7.5207E-02	7.5207E-02	7.4304E-02
Xe-135	4135	1.0784E-02	5.3232E-03	5.3232E-03	1.4784E-03
Xe-136	4136	7.0417E-02	6.7260E-02	6.7260E-02	6.8852E-02
Cs-133	4133	7.0160E-02	6.8747E-02	6.8747E-02	6.6400E-02
Cs-134	4134	6.6982E-06	1.1138E-06	1.1138E-06	1.0145E-07
Cs-135	5135	1.4880E-04	4.2887E-05	4.2887E-05	7.1050E-06
Cs-137	4137	6.6007E-02	6.5528E-02	6.5528E-02	6.3220E-02
Nd-143	4143	4.4029E-02	4.4352E-02	4.4352E-02	4.4726E-02
Nd-145	4145	2.9866E-02	3.0734E-02	3.0734E-02	3.3701E-02
Pm-147	4147	5.9427E-03	6.2524E-03	6.2524E-03	6.4935E-03
Pm-147*	5147	6.7013E-03	7.0506E-03	7.0506E-03	7.3225E-03
Pm-148	5148	1.3309E-08	4.2982E-09	4.2982E-09	3.7195E-10
Pm-148m	4148	4.6655E-08	1.1256E-08	1.1256E-08	1.0086E-09
Pm-149	5149	1.2197E-02	1.3506E-02	1.3506E-02	1.5749E-02
Sm-147	6147	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Sm-148	6148	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Sm-149	4149	8.2205E-10	4.4663E-11	4.4663E-11	2.4188E-12
Sm-150	4150	1.1793E-05	4.1831E-06	4.1831E-06	7.5841E-07
Sm-151	4151	7.4165E-03	8.5148E-03	8.5148E-03	9.8875E-03
Sm-152	4152	5.7944E-03	6.5236E-03	6.5236E-03	7.9079E-03
Eu-151	5151	4.6053E-11	2.3742E-12	2.3742E-12	1.2373E-13
Eu-152	5152	9.1886E-10	6.9698E-11	6.9698E-11	5.6156E-12

Fission product	WIMS ID	Pu-239	Pu-240	Pu-241	Pu-242
Eu-153	4153	3.6428E-03	4.9960E-03	4.9960E-03	6.2340E-03
Eu-154	4154	2.8474E-07	5.0316E-08	5.0316E-08	9.1112E-09
Eu-155	4155	1.6762E-03	2.4149E-03	2.4149E-03	3.2771E-03
Gd-154	2154	9.5301E-11	6.9660E-12	6.9660E-12	5.4274E-13
Gd-155	2155	1.7484E-09	3.1147E-10	3.1147E-10	2.8369E-11
Gd-156	2156	1.2545E-03	1.6483E-03	1.6483E-03	2.3702E-03
Gd-157	2157	7.5439E-04	1.2219E-03	1.2219E-03	1.6423E-03
Gd-158	2158	4.2369E-04	7.6414E-04	7.6414E-04	1.0975E-03
Dy-160	160	6.5772E-08	3.9359E-08	3.9359E-08	8.2707E-09
Dy-161	161	4.9889E-05	1.1102E-04	1.1102E-04	2.3740E-04
Dy-162	162	2.3352E-05	5.3408E-05	5.3408E-05	1.2594E-04
Dy-163	163	9.9398E-06	1.8389E-05	1.8389E-05	5.4107E-05
Dy-164	164	3.7916E-06	9.4215E-06	9.4215E-06	1.3716E-05
Ho-165	165	1.6025E-06	4.4949E-06	4.4949E-06	9.1246E-06
Er-166	2166	8.5972E-07	2.4083E-06	2.4083E-06	4.4353E-06
Er-167	2167	2.3783E-07	1.4052E-06	1.4052E-06	1.7658E-06
pseudo	4902	8.6512E-01	8.5131E-01	8.5131E-01	8.1985E-01

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