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ECNJEF1

A JEF1 based 219-group neutron cross-section library: User's Manual

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Abstract

This manual describes the contents of the ECNJEF1 library. The ECNJEF1 library is a JEF1.1 based 219-group AMPX-Master library for reactor calculations with the AMPX/SCALE-3 system, e.g. the PASC-3 system as implemented at ECN-Petten. The group cross-section data were generated with NJOY and NPTXS/XLACS-2 from the AMPX system.

The data on the ECNJEF1 library allows resolved-resonance treatment by NITAWL and/or unresolved resonance self-shielding by BONAMI. These codes are based upon the Nordheim and Bondarenko methods, respectively.

Contents

1. The ECNJEF1 library

At present one of the best basic nuclear data libraries is the Joint Evaluated File (JEF) which has been developed and benchmarked in Europe. The ECNJEF1 library is a JEF1.1 based 219-group AMPX-Master library for reactor calculations with the AMPX/SCALE-3 system [1], e.g. the PASC-3 system [2] as implemented at ECN-Petten. The group cross-section data were generated with NJOY87.0 [3], NJOY89.62/NSLINK [4], and NPTXS/XLACS-2 from the AMPX/SCALE system.

The data on the ECNJEF1 library allow Nordheim resolved-resonance treatment by NITAWL (l=0 only) and/or unresolved resonance self shielding by BONAMI. Bondarenko treatment of resolved p-wave resonances is included for the most important isotopes of U and Pu.

The data on the ECNJEF1 library have been checked extensively by detailed graphical comparisons with experimental data and with a number of benchmark calculations such as the ORNL (experimental) [5], EPRI (calculational) [6], TRX (experimental) [7] and other calculational benchmarks [8].

The data are stored on 19 files indicated by ECNJEF1_FILExx.

The pseudo fission products given on ECNJEF1_FILE14 were taken from the ENDF/B-III library. The materials $^{11}_{5}$B, $^{0}_{6}$C, $^{19}_{9}$F, $^{238}_{94}$Pu, $^{242}_{94}$Pu, $^{241}_{95}$Am were taken from the BOL-JEF1 219-group AMPX-M library [9]. A more detailed description of the production of the ECNJEF1 library with NJOY87.0 can be found in reference [10].

2. Parameters used in the generation of the group constants

1. The energy-group boundaries of the 219 group set are listed in table 3.6.
2. The weighting spectrum used in the group averaging is Maxwellian + $1/E$ + Fission.
3. The nuclides have been divided into 6 classes. For each class of nuclides data are available at a certain set of temperatures and σ_0 values (see table 2.1).
4. The Legendre order used for elastic- and inelastic scattering and (n,2n), (n,3n) and (n,4n) is P3.
5. Thermal scattering treatment (free gas) is applied in the thermal range up to 3.05 eV for all classes. A special thermal scattering treatment is given for H_2O and D_2O.
6. A Bondarenko treatment in the unresolved-resonance range is applied for the most important nuclides for which unresolved resonances are given on the JEF1.1 library (classes 3 and 6).

Table 2.1: Available temperatures and σ_0 values for each class of nuclides. The class numbers correspond to the numbers in column 2 of tables 3.1 to 3.5.

Class 1	Materials for which no resonance treatment is possible with this data file; data processed with NJOY; thermal scattering matrix calculated with free-gas scattering model. T =300 K σ_0 =∞
Class 2	Water and heavy water; processed with NJOY for all temperatures as given on JEF1.1 thermal scattering law data file: T_{i,H_2O}=293.6, 323.6, 373.6, 423.6, 473.6, 523.6, 573.6, 623.6 K T_{i,D_2O}=293.6, 323.6, 373.6, 423.6, 473.6, 523.6, 573.6, 673.6 K σ_0 =∞
Class 3	Resonance materials; processed with NPTXS/XLACS-2. The σ_0 values refer to the Bondarenko treatment in the unresolved range. Thermal scattering matrix calculated with free-gas scattering model. For these materials resolved s-wave resonance parameters are present on the library to allow Nordheim resolved resonance treatment. T =300 K σ_0 =∞ or 1000 b
Class 4	Light materials; processed with NJOY. Thermal scattering matrix calculated with free-gas scattering model ($^{10}_{5}$B, $^{14}_{7}$N, $^{16}_{8}$O). T =293.16 K σ_0 =∞
Class 5	Light materials; processed with NJOY. Temperature values refer to the Doppler broadening and thermal scattering matrices calculated with free-gas scattering model ($^{27}_{13}$Al only). T_i =300, 600, 900, 1000, 1200, 1500, 2000, 3000 K σ_0 =∞
Class 6	U and Pu resonance materials; processed with NJOY. Temperatures and σ_0 values refer to the Doppler broadening in the thermal range and the Bondarenko treatment in unresolved range and (approximately) for p-wave resonances in the resolved range. The temperatures were also used to generate thermal scattering matrices with free-gas scattering model. For these materials resolved s-wave resonance parameters are present on the library to allow Nordheim resolved resonance treatment. T_i =293.16, 600, 900, 1000, 1200, 1500, 2000, 3000 K σ_{0j} =∞, 10^4, 10^3, 500, 200, 100, 10, 1 b

3. Contents of the ECNJEF1 library

Tables 3.1 to 3.5 show the contents of the ECNJEF1 library.

Column 1 gives the nuclide, where A=0 indicates natural element.

Column 2 gives the classification of the nuclides. The class numbers correspond to the classes given in table 2.1.

Column 3 shows the material identification number (ID) on the ECNJEF1 library.

Column 4 shows the temperatures for which the data are present on the library (Doppler broadening and thermal scattering). For the nuclides in classes 5 and 6 this column shows only the base temperature of the data. The other temperatures for which the data is available are shown in table 2.1.

Column 5 shows the value of σ_0 for which the unresolved self-shielding is performed. For all classes except 3 and 6 only infinitely diluted (σ_0=∞) cross sections are available. For the nuclides in class 3 for which the JEF1.1 evaluation contains unresolved resonance parameters, self-shielded cross sections in the unresolved region at σ_0 = 1000 b are available. For class 6, self-shielded unresolved cross-section data for a series of values of σ_0 and temperatures as given in table 2.1 are available.

Column 6 shows the number of the file on which the data for the nuclides is given.

Columns 7 and 8 show whether Nordheim resolved resonance treatment (with NITAWL) and/or Bondarenko unresolved resonance treatment (with BONAMI) is possible or not. This depends on whether resonance parameters and/or Bondarenko factors are present on the library or not.

Table 3.1: Contents of ECNJEF1 , light elements.

Nuclide	Class	ECNJEF1 id	T (K)	σ_0	File	Nord	Bond
H in H_2O	2	100100	293.6	∞	23		
H in H_2O	2	40112	323.6	∞	11		
H in H_2O	2	40113	373.6	∞	11		
H in H_2O	2	40114	423.6	∞	11		
H in H_2O	2	40115	473.6	∞	11		
H in H_2O	2	40116	523.6	∞	11		
H in H_2O	2	4011	573.6	∞	24		
H in H_2O	2	40118	623.6	∞	11		
1-D free	1	4012	300	∞	1		
D in D_2O	2	40121	293.6	∞	12		
D in D_2O	2	40122	323.6	∞	12		
D in D_2O	2	40123	373.6	∞	12		
D in D_2O	2	40124	423.6	∞	12		
D in D_2O	2	40125	473.6	∞	12		
D in D_2O	2	40126	523.6	∞	12		
D in D_2O	2	40127	573.6	∞	12		
D in D_2O	2	40128	673.6	∞	12		
1-T-3	1	4013	300	∞	1		
2-He-3	1	4023	300	∞	1		
2-He-4	1	4024	300	∞	1		
3-Li-6	1	4036	300	∞	1		
3-Li-7	1	4037	300	∞	1		
4-Be-9	1	4049	300	∞	1		
5-B-10	1	501000	300	∞	23		
5-B-11	1	4051	300	∞	17		
6-C-0	1	4060	300	∞	17		
7-N-14	1	701400	300	∞	23		
8-O-16	1	801600	300	∞	23		
9-F-19	1	40990	300	∞	17		
11-Na-22	1	4112	300	∞	1		
11-Na-23	1	41130	300	∞	14	+	
12-Mg-0	1	4120	300	∞	1		

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Contents of ECNJEF1, light elements continued							
Nuclide	Class	ECNJEF1 id	T (K)	σ_0	File	Nord	Bond
13-Al-27	5	13027	300,...	∞	27		
14-Si-0	1	4140	300	∞	1		
17-Cl-0	1	4170	300	∞	1		
18-Ar-40	1	4180	300	∞	1		
18-Ar-36	1	4186	300	∞	1		
18-Ar-38	1	4188	300	∞	1		
19-K-0	1	4190	300	∞	1		
20-Ca-0	1	4200	300	∞	1		

Table 3.2: Contents of ECNJEF1, structural elements.

Nuclide	Class	ECNJEF1 id	T (K)	σ_0	File	Nord	Bond
22-Ti-0	1	4220	300	∞	1		
23-V-0	1	4230	300	∞	1		
24-Cr-0	3	42400	300	∞	14	+	
24-Cr-50	1	4241	300	∞	2		
25-Mn-55	1	42550	300	∞	14	+	
26-Fe-0	1	4260	300	∞	14	+	
26-Fe-54	1	4264	300	∞	2		
27-Co-58g	1	4277	300	∞	2		
27-Co-58m	1	4278	300	∞	2		
27-Co-59	1	4279	300	∞	2		
28-Ni-0	3	4280	300	∞	14	+	
28-Ni-62	1	4282	300	∞	2		
28-Ni-64	1	4284	300	∞	2		
28-Ni-58	1	4288	300	∞	2		
29-Cu-0	1	4290	300	∞	2		
30-Zn-64	1	4304	300	∞	2		

Table 3.3: Contents of ECNJEF1, fission products.

Nuclide	Class	ECNJEF1 id	T (K)	σ_0	File	Nord	Bord
31-Ga-0	1	4310	300	∞	3		
32-Ge-72	1	4322	300	∞	3		
32-Ge-73	1	4323	300	∞	3		
32-Ge-74	1	4324	300	∞	3		
32-Ge-76	1	4326	300	∞	3		
33-As-75	1	4335	300	∞	3		
34-Se-80	1	4340	300	∞	3		
34-Se-82	1	4342	300	∞	3		
34-Se-74	1	4344	300	∞	3		
34-Se-76	1	4346	300	∞	3		
34-Se-77	1	4347	300	∞	3		
34-Se-78	1	4348	300	∞	3		
35-Br-81	1	4351	300	∞	3		
35-Br-79	1	4359	300	∞	3		
36-Kr-80	1	4360	300	∞	3		
36-Kr-82	1	4362	300	∞	3		
36-Kr-83	1	4363	300	∞	3		
36-Kr-84	1	4364	300	∞	3		
36-Kr-85	1	4365	300	∞	3		
36-Kr-86	1	4366	300	∞	3		
36-Kr-78	1	4368	300	∞	3		
37-Rb-85	1	4375	300	∞	3		
37-Rb-86	1	4376	300	∞	3		
37-Rb-87	1	4377	300	∞	3		
38-Sr-90	1	4380	300	∞	3		
38-Sr-84	1	4384	300	∞	3		
38-Sr-86	1	4386	300	∞	3		
38-Sr-87	1	4387	300	∞	3		
38-Sr-88	1	4388	300	∞	3		
38-Sr-89	1	4389	300	∞	3		
39-Y-90	1	4390	300	∞	3		
39-Y-91	1	4391	300	∞	3		

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Contents of ECNJEF1, fission products continued

Nuclide	Class	ECNJEF1 id	T (K)	σ_0	File	Nord	Bond
39-Y-89	1	4399	300	∞	3		
40-Zr-0	1	4409	300	∞	3		
40-Zr-90	3	44000	300	1000	14	+	
40-Zr-91	3	44010	300	1000	14	+	
40-Zr-92	3	44020	300	1000	14	+	
40-Zr-93	3	44030	300	1000	14	+	
40-Zr-94	3	44040	300	1000	14	+	
40-Zr-95	3	44050	300	1000	14	+	
40-Zr-96	3	44060	300	1000	14	+	
41-Nb-93	1	4413	300	∞	3		
41-Nb-94	1	4414	300	∞	3		
41-Nb-95	1	4415	300	∞	3		
42-Mo-0	3	44200	300	∞	13	+	
42-Mo-100	3	44210	300	1000	13	+	
42-Mo-92	3	44220	300	∞	13	+	
42-Mo-94	3	44240	300	∞	13	+	
42-Mo-95	3	44250	300	∞	13	+	
42-Mo-96	3	44260	300	∞	13	+	
42-Mo-97	3	44270	300	∞	13	+	
42-Mo-98	3	44280	300	1000	13	+	
42-Mo-99	3	44290	300	∞	13	+	
43-Tc-99	3	44390	300	1000	14	+	
44-Ru-100	1	4440	300	∞	4		
44-Ru-101	1	4441	300	∞	4		
44-Ru-102	1	4442	300	∞	4		
44-Ru-103	1	4443	300	∞	4		
44-Ru-104	1	4444	300	∞	4		
44-Ru-105	1	4445	300	∞	4		
44-Ru-106	1	4446	300	∞	4		
44-Ru-96	1	4447	300	∞	4		
44-Ru-98	1	4448	300	∞	4		
44-Ru-99	1	4449	300	∞	4		
45-Rh-103	3	44530	300	1000	14	+	

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Contents of ECNJEF1, fission products continued							
Nuclide	Class	ECNJEF1 id	T (K)	σ_0	File	Nord	Bond
45-Rh-105	1	4455	300	∞	4		
46-Pd-110	1	4460	300	∞	4		
46-Pd-102	1	4462	300	∞	4		
46-Pd-104	1	4464	300	∞	4		
46-Pd-105	1	4465	300	∞	4		
46-Pd-106	1	4466	300	∞	4		
46-Pd-107	1	4467	300	∞	4		
46-Pd-108	1	4468	300	∞	4		
47-Ag-107	1	4477	300	∞	4		
47-Ag-109	3	44790	300	1000	14	+	
47-Ag-111	1	4471	300	∞	4		
48-Cd-0	1	4480	300	∞	5		
48-Cd-106	1	4481	300	∞	5		
48-Cd-108	1	4482	300	∞	5		
48-Cd-110	1	4483	300	∞	5		
48-Cd-111	1	4484	300	∞	5		
48-Cd-112	1	4485	300	∞	5		
48-Cd-113	3	44860	300	∞	14	+	
48-Cd-114	1	4487	300	∞	5		
48-Cd-115m	1	4488	300	∞	5		
48-Cd-116	1	4489	300	∞	5		
49-In-113	1	4493	300	∞	5		
49-In-115	1	4495	300	∞	5		
50-Sn-112	1	4500	300	∞	5		
50-Sn-114	1	4501	300	∞	5		
50-Sn-115	1	4502	300	∞	5		
50-Sn-116	1	4503	300	∞	5		
50-Sn-117	1	4504	300	∞	5		
50-Sn-118	1	4505	300	∞	5		
50-Sn-119	1	4506	300	∞	5		
50-Sn-120	1	4507	300	∞	5		
50-Sn-122	1	4508	300	∞	5		
50-Sn-123	1	4509	300	∞	5		

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Contents of ECNJEF1, fission products continued

Nuclide	Class	ECNJEF1 id	T (K)	σ_0	File	Nord	Bond
50-Sn-124	1	4510	300	∞	5		
50-Sn-125	1	4511	300	∞	5		
50-Sn-126	1	4512	300	∞	5		
51-Sb-121	1	4513	300	∞	5		
51-Sb-123	1	4514	300	∞	5		
51-Sb-124	1	4515	300	∞	5		
51-Sb-125	1	4516	300	∞	5		
51-Sb-126	1	4517	300	∞	5		
52-Te-120	1	4520	300	∞	5		
52-Te-122	1	4521	300	∞	5		
52-Te-123	1	4522	300	∞	5		
52-Te-124	1	4523	300	∞	5		
52-Te-125	1	4524	300	∞	5		
52-Te-126	1	4525	300	∞	5		
52-Te-127m	1	4526	300	∞	5		
52-Te-128	1	4527	300	∞	5		
52-Te-129m	1	4528	300	∞	5		
52-Te-130	1	4529	300	∞	5		
52-Te-132	1	4530	300	∞	5		
53-I-127	1	4533	300	∞	6		
53-I-129	1	4534	300	∞	6		
53-I-130	1	4535	300	∞	6		
53-I-131	1	4536	300	∞	6		
53-I-135	1	4537	300	∞	6		
54-Xe-124	1	4540	300	∞	6		
54-Xe-126	1	4541	300	∞	6		
54-Xe-128	1	4542	300	∞	6		
54-Xe-129	1	4543	300	∞	6		
54-Xe-130	1	4544	300	∞	6		
54-Xe-131	1	4545	300	∞	6		
54-Xe-132	1	4546	300	∞	6		
54-Xe-133	1	4547	300	∞	6		
54-Xe-134	1	4548	300	∞	6		

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Contents of ECNJEF1, fission products continued							
Nuclide	Class	ECNJEF1 id	T (K)	σ_0	File	Nord	Bond
54-Xe-135	1	4549	300	∞	6		
54-Xe-136	1	4551	300	∞	6		
55-Cs-133	3	45530	300	1000	14	+	
55-Cs-134	1	4554	300	∞	6		
55-Cs-135	3	45550	300	1000	14	+	
55-Cs-136	1	4556	300	∞	6		
55-Cs-137	1	4557	300	∞	6		
56-Ba-140	1	4560	300	∞	6		
56-Ba-134	1	4564	300	∞	6		
56-Ba-135	1	4565	300	∞	6		
56-Ba-136	1	4566	300	∞	6		
56-Ba-137	1	4567	300	∞	6		
56-Ba-138	1	4568	300	∞	6		
57-La-140	1	4570	300	∞	6		
57-La-139	1	4579	300	∞	6		
58-Ce-140	1	4580	300	∞	6		
58-Ce-141	1	4581	300	∞	6		
58-Ce-142	1	4582	300	∞	6		
58-Ce-143	1	4583	300	∞	6		
58-Ce-144	1	4584	300	∞	6		
59-Pr-141	1	4591	300	∞	6		
59-Pr-142	1	4592	300	∞	6		
59-Pr-143	1	4593	300	∞	6		
60-Nd-150	1	4600	300	∞	7		
60-Nd-142	1	4602	300	∞	7		
60-Nd-143	1	4603	300	∞	7		
60-Nd-144	1	4604	300	∞	7		
60-Nd-145	1	4605	300	∞	7		
60-Nd-146	1	4606	300	∞	7		
60-Nd-147	1	4607	300	∞	7		
60-Nd-148	1	4608	300	∞	7		
61-Pm-147	1	4611	300	∞	7		
61-Pm-148g	1	4612	300	∞	7		
see next page							

Contents of ECNJEF1, fission products continued							
Nuclide	Class	ECNJEF1 id	T (K)	σ_0	File	Nord	Bond
61-Pm-148m	1	4613	300	∞	7		
61-Pm-149	1	4614	300	∞	7		
61-Pm-151	1	4615	300	∞	7		
62-Sm-150	1	4620	300	∞	7		
62-Sm-151	1	4621	300	∞	7		
62-Sm-152	1	4622	300	∞	7		
62-Sm-153	1	4623	300	∞	7		
62-Sm-154	1	4624	300	∞	7		
62-Sm-144	1	4626	300	∞	7		
62-Sm-147	1	4627	300	∞	7		
62-Sm-148	1	4628	300	∞	7		
62-Sm-149	3	46290	300	1000	15	+	
63-Eu-151	3	46310	300	1000	15	+	
63-Eu-152	1	4632	300	∞	7		
63-Eu-153	3	46330	300	1000	15	+	
63-Eu-154	1	4634	300	∞	7		
63-Eu-155	1	4635	300	∞	7		
63-Eu-156	1	4636	300	∞	7		
63-Eu-157	1	4637	300	∞	7		
64-Gd-0	1	4649	300	∞	7		
64-Gd-154	3	46440	300	∞	15	+	
64-Gd-155	3	46450	300	∞	15	+	
64-Gd-156	3	46460	300	1000	15	+	
64-Gd-157	3	46470	300	∞	15	+	
64-Gd-158	3	46480	300	∞	15	+	
64-Gd-160	3	46400	300	∞	15	+	
65-Tb-160	1	4650	300	∞	7		
65-Tb-159	1	4659	300	∞	7		
66-Dy-160	1	4660	300	∞	8		
66-Dy-161	1	4661	300	∞	8		
66-Dy-162	1	4662	300	∞	8		
66-Dy-163	1	4663	300	∞	8		
66-Dy-164	1	4664	300	∞	8		

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Contents of ECNJEF1, fission products continued							
Nuclide	Class	ECNJEF1 id	T (K)	σ_0	File	Nord	Bond
67-Ho-165	1	4675	300	∞	8		
68-Er-166	1	4686	300	∞	8		
68-Er-167	1	4687	300	∞	8		
71-Lu-175	1	4715	300	∞	8		
71-Lu-176	1	4716	300	∞	8		
72-Hf-0	1	4721	300	∞	8		
72-Hf-174	3	47240	300	∞	15	+	
72-Hf-176	3	47260	300	∞	15	+	
72-Hf-177	3	47270	300	∞	15	+	
72-Hf-178	3	47280	300	∞	15	+	
72-Hf-179	3	47290	300	∞	15	+	
73-Ta-182	1	4732	300	∞	8		
74-W-182	1	4742	300	∞	8		
74-W-183	1	4743	300	∞	8		
74-W-184	1	4744	300	∞	8		
74-W-186	1	4746	300	∞	8		
75-Re-185	1	4755	300	∞	8		
75-Re-187	1	4757	300	∞	8		
79-Au-197	1	4797	300	∞	8		
82-Pb-0	1	4820	300	∞	8		
83-Bi-209	1	4839	300	∞	8		

Table 3.4: Contents of ECNJEF1, actinides.

Nuclide	Class	ECNJEF1 id	T (K)	σ_0	File	Nord	Bond
90-Th-230	1	4900	300	∞	9		
90-Th-232	3	49020	300	1000	15	+	
91-Pa-231	1	4911	300	∞	9		
91-Pa-233	1	4913	300	∞	9		
92-U-232	1	4922	300	∞	9		
92-U-233	1	4923	300	∞	9		
92-U-234	6	92234	293,...	∞,...	26	+	+
92-U-235	6	92235	293,...	∞,...	26	+	+
92-U-236	6	92236	293,...	∞,...	26	+	+
92-U-237	1	4927	300	∞	9		
92-U-238	6	92238	293,...	∞,...	26	+	+
93-Np-237	1	4937	300	∞	9		
93-Np-238	1	4938	300	∞	9		
93-Np-239	1	4939	300	∞	9		
94-Pu-236	1	4946	300	∞	9		
94-Pu-237	1	4947	300	∞	9		
94-Pu-238	3	49480	300	1000	17	+	
94-Pu-239	6	94239	300,...	∞,...	26	+	+
94-Pu-240	6	4940	293,...	∞,...	26	+	+
94-Pu-241	6	4941	293,...	∞,...	26	+	+
94-Pu-242	3	4942	300	1000	17	+	
94-Pu-243	1	4943	300	∞	9		
94-Pu-244	1	4944	300	∞	9		
95-Am-241	3	4951	300	1000	17	+	
95-Am-242g	1	4952	300	∞	9		
95-Am-242m	1	4953	300	∞	9		
95-Am-243	1	4954	300	∞	9		
96-Cm-241	1	4961	300	∞	9		
96-Cm-242	1	4962	300	∞	9		
96-Cm-243	1	4963	300	∞	9		
96-Cm-244	1	4964	300	∞	9		
96-Cm-245	1	4965	300	∞	9		

see next page

Contents of ECNJEF1, actinides continued							
Nuclide	Class	ECNJEF1 id	T (K)	σ_0	File	Nord	Bond
96-Cm-246	1	4966	300	∞	9		
96-Cm-247	1	4967	300	∞	9		
96-Cm-248	1	4968	300	∞	9		
97-Bk-249	1	4969	300	∞	9		
98-Cf-250	1	4980	300	∞	9		
98-Cf-251	1	4981	300	∞	9		
98-Cf-252	1	4982	300	∞	9		
98-Cf-253	1	4983	300	∞	9		
98-Cf-249	1	4989	300	∞	9		
99-Es-253	1	4993	300	∞	9		

Table 3.5: Contents of ECNJEF1, pseudo fission products generated from ENDF/B-III for fission products of $^{233}_{92}U$, $^{235}_{92}U$ and $^{239}_{94}Pu$.
RSFP = Rapid Saturating Fission Product,
SSFP = Slowly Saturating Fission Product,
NSFP = Non Saturating Fission Product.

Nuclide	Class	ECNJEF1 id	T (K)	σ_0	File	Nord	Bond
92-U-233RSFP	1	1042	300	∞	14		
92-U-235RSFP	1	1045	300	∞	14		
94-Pu-239RSFP	1	1052	300	∞	14		
92-U-233SSFP	1	1066	300	∞	14		
92-U-235SSFP	1	1068	300	∞	14		
94-Pu-239SSFP	1	1070	300	∞	14		
92-U-233NSFP	1	1067	300	∞	14		
92-U-235NSFP	1	1069	300	∞	14		
94-Pu-239NSFP	1	1071	300	∞	14		

Table 3.6: The upper limits of the groups in the 219-group structure set.

g	E_{high}	g	E_{high}	g	E_{high}	g	E_{high}	g	E_{high}
1	2.00000E+07	2	6.43400E+06	3	4.80000E+06	4	4.30400E+06	5	3.00000E+06
6	2.47900E+06	7	2.35400E+06	8	1.85000E+06	9	1.50000E+06	10	1.40000E+06
11	1.35600E+06	12	1.31700E+06	13	1.25000E+06	14	1.20000E+06	15	1.10000E+06
16	1.01000E+06	17	9.20000E+05	18	9.00000E+05	19	8.75000E+05	20	8.61100E+05
21	8.20000E+05	22	8.00000E+05	23	7.50000E+05	24	6.79000E+05	25	6.70000E+05
26	6.00000E+05	27	5.73000E+05	28	5.50000E+05	29	4.99520E+05	30	4.70000E+05
31	4.40000E+05	32	4.20000E+05	33	4.00000E+05	34	3.30000E+05	35	2.70000E+05
36	2.00000E+05	37	1.50000E+05	38	1.28300E+05	39	1.00000E+05	40	8.50000E+04
41	8.20000E+04	42	7.50000E+04	43	7.30000E+04	44	6.00000E+04	45	5.20000E+04
46	5.00000E+04	47	4.50000E+04	48	3.00000E+04	49	2.50000E+04	50	1.70000E+04
51	1.30000E+04	52	9.50000E+03	53	8.03000E+03	54	6.00000E+03	55	3.50000E+03
56	3.74000E+03	57	3.00000E+03	58	2.58000E+03	59	2.29000E+03	60	2.20000E+03
61	1.80000E+03	62	1.55000E+03	63	1.50000E+03	64	1.15000E+03	65	9.50000E+02
66	6.83000E+02	67	6.70000E+02	68	5.50000E+02	69	3.05000E+02	70	2.85000E+02
71	2.40000E+02	72	2.10000E+02	73	2.07500E+02	74	1.92500E+02	75	1.86000E+02
76	1.22000E+02	77	1.19000E+02	78	1.15000E+02	79	1.08000E+02	80	1.00000E+02
81	9.00000E+01	82	8.20000E+01	83	8.00000E+01	84	7.60000E+01	85	7.20000E+01
86	6.75000E+01	87	6.50000E+01	88	6.10000E+01	89	5.90000E+01	90	5.34000E+01
91	5.20000E+01	92	5.06000E+01	93	4.92000E+01	94	4.83000E+01	95	4.70000E+01
96	4.52000E+01	97	4.40000E+01	98	4.24000E+01	99	4.10000E+01	100	3.96000E+01
101	3.91000E+01	102	3.80000E+01	103	3.70000E+01	104	3.55000E+01	105	3.46000E+01
106	3.37500E+01	107	3.32500E+01	108	3.17500E+01	109	3.12500E+01	110	3.00000E+01
111	2.75000E+01	112	2.50000E+01	113	2.25000E+01	114	2.10000E+01	115	2.00000E+01
116	1.90000E+01	117	1.85000E+01	118	1.70000E+01	119	1.60000E+01	120	1.51000E+01
121	1.44000E+01	122	1.37500E+01	123	1.29000E+01	124	1.19000E+01	125	1.15000E+01
126	1.00000E+01	127	9.10000E+00	128	8.10000E+00	129	7.15000E+00	130	7.00000E+00
131	6.75000E+00	132	6.50000E+00	133	6.25000E+00	134	6.00000E+00	135	5.40000E+00
136	5.00000E+00	137	4.75000E+00	138	4.00000E+00	139	3.73000E+00	140	3.50000E+00
141	3.15000E+00	142	3.05000E+00	143	3.00000E+00	144	2.97000E+00	145	2.87000E+00
146	2.77000E+00	147	2.67000E+00	148	2.57000E+00	149	2.47000E+00	150	2.38000E+00
151	2.30000E+00	152	2.21000E+00	153	2.12000E+00	154	2.00000E+00	155	1.94000E+00
156	1.86000E+00	157	1.77000E+00	158	1.68000E+00	159	1.59000E+00	160	1.50000E+00
161	1.45000E+00	162	1.40000E+00	163	1.35000E+00	164	1.30000E+00	165	1.25000E+00
166	1.22500E+00	167	1.20000E+00	168	1.17500E+00	169	1.15000E+00	170	1.14000E+00
171	1.13000E+00	172	1.12000E+00	173	1.11000E+00	174	1.10000E+00	175	1.09000E+00
176	1.08000E+00	177	1.07000E+00	178	1.06000E+00	179	1.05000E+00	180	1.04000E+00
181	1.03000E+00	182	1.02000E+00	183	1.01000E+00	184	1.00000E+00	185	9.75000E-01
186	9.50000E-01	187	9.25000E-01	188	9.00000E-01	189	8.50000E-01	190	8.00000E-01
191	7.50000E-01	192	7.00000E-01	193	6.50000E-01	194	6.00000E-01	195	5.50000E-01
196	5.00000E-01	197	4.50000E-01	198	4.00000E-01	199	3.75000E-01	200	3.50000E-01
201	3.25000E-01	202	3.00000E-01	203	2.75000E-01	204	2.50000E-01	205	2.25000E-01
206	2.00000E-01	207	1.75000E-01	208	1.50000E-01	209	1.25000E-01	210	1.00000E-01
211	9.00000E-02	212	8.00000E-02	213	7.00000E-02	214	6.00000E-02	215	5.00000E-02
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