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WIMKAL-88

The 1988 Version of WIMS-KAERI Library

Summary Report

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Abstract: The WIMS-KAERI Library is a nuclear data library for thermal reactor neutronics calculations. It contains neutron reaction data in 69 groups of neutron energies for more than 130 materials. A magnetic tape copy of the library is available, free of charge.

August 1990

Informal Note

WIMKAL-88

The 1988 Version of WIMS-KAERI Library

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Attached : "Generation and Benchmarking of a 69-group Cross Section Library for Thermal Reactor Applications", Journal of the Korean Nuclear Society, Vol.21, No.4, Dec. 1989.

WIMKAL-88 : The 1988 Version of WIMS-KAERI Library

A new version of 69-group neutron cross section library for thermal reactor design analysis has been generated with the NJOY processing system and with various evaluated nuclear data available from the IAEA Nuclear Data Section. This note summarizes the contents of the library. The library format is described in Appendix. For more details, refer to the attached paper.

1. Energy Group

The energy group structure is 69 groups with energy boundaries corresponding to those of the original WIMS library. The energy boundaries of 69-group are listed in Table 1.

2. Source of Basic Nuclear Data

Most of the evaluated nuclear data were taken from the ENDF/B-V or IV, but some data, not available from the released ENDF/B files, were taken from the JENDL-2 (Rev.1) and ENDL-84.

3. Fission Spectra

Fission spectra of U-235 were generated from Watt spectrum data of ENDF/B-V and the result is listed in Table 2.

4. Data Processing Routines

The NJOY routines and an auxilliary routine, WIMSLIC, were used to generate 69-group data of the WIMS-KAERI library format. The processing path is shown in Fig.1.

5. Burnup Chains

The isotopes B10, Co-59, Er-166, Er-167, and the hafnium isotopes are burnable in addition to actinide nuclides and fission products. The burnup chains are listed in Table 3. For details, refer to figures in the attached paper. The energy release per fission for each of actinides are given in Table 4. And the fission product yield data derived from ENDF/B-V are summarized in Table 5. Yield values for actinides not included in ENDF/B-V were selected from actinide data having similar fission cross sections.

6. Resonance Data

The Goldstein-Cohen parameters used in resonance calculation were taken from the reported data without critical evaluation and listed in Table 6, and resonance tabulations for self-shielding are given in Table 7.

7. Materials Included in the Library

More than 130 materials including reactor fuel, moderator, absorber, structure materials, fission products and actinide nuclides were processed. The list of nuclides included in the WIMKAL-88 library is given in Table 8.

8. Benchmarking

An extensive benchmarking of the WIMKAL-88 library by means of the WIMS-KAERI code, which is a KAERI version of WIMS-D/4, was carried out by comparing results of pin-cell calculations with those of experimentally determined criticalities and depletions. Detailed contents and results are described in the attached paper.

Remark

The WIMKAL-88 library can be used with the WIMS-D/4 code available from the NEA DATA BANK.

Table 1. Energy Boundaries for WIMS 69-Group Libraries

Group	Energy			Energy Width
	MeV			
1	10.0	-	6.0655	3.9345
2	6.0655	-	3.679	2.3865
3	3.679	-	2.231	1.448
4	2.231	-	1.353	0.878
5	1.353	-	0.821	0.532
6	0.821	-	0.500	0.321
7	0.500	-	0.3025	0.1975
8	0.3025	-	0.183	0.1195
9	0.183	-	0.1110	0.072
10	0.1110	-	0.06734	0.04366
11	0.06734	-	0.04085	0.02649
12	0.04085	-	0.02478	0.01607
13	0.02478	-	0.01503	0.00975
14	0.01503	-	0.009118	0.005912
	eV			
15	9118.0	-	5530.0	3588.0
16	5530.0	-	3519.1	2010.9
17	3519.1	-	2239.85	1279.65
18	2239.45	-	1425.1	814.35
19	1425.1	-	906.898	518.202
20	906.898	-	367.262	539.636
21	367.262	-	148.728	218.534
22	148.728	-	75.5014	73.2266
23	75.5014	-	48.052	27.4494
24	48.052	-	27.700	20.352
25	27.700	-	15.968	11.732
26	15.968	-	9.877	6.091
27	9.877	-	4.00	5.877

Group	Energy			Energy Width
	eV			
28	4.00	-	3.30	0.700
29	3.30	-	2.60	0.700
30	2.60	-	2.10	0.500
31	2.10	-	1.50	0.600
32	1.50	-	1.30	0.200
33	1.30	-	1.15	0.150
34	1.15	-	1.123	0.027
35	1.123	-	1.097	0.026
36	1.097	-	1.071	0.026
37	1.071	-	1.045	0.026
38	1.045	-	1.020	0.025
39	1.020	-	0.996	0.024
40	0.996	-	0.972	0.024
41	0.972	-	0.950	0.022
42	0.950	-	0.910	0.040
43	0.910	-	0.850	0.060
44	0.850	-	0.780	0.070
45	0.780	-	0.625	0.155
46	0.625	-	0.500	0.125
47	0.500	-	0.400	0.100
48	0.400	-	0.350	0.050
49	0.350	-	0.320	0.030
50	0.320	-	0.300	0.020
51	0.300	-	0.280	0.020
52	0.280	-	0.250	0.030
53	0.250	-	0.220	0.030
54	0.220	-	0.180	0.040
55	0.180	-	0.140	0.040
56	0.140	-	0.100	0.040
57	0.100	-	0.080	0.020
58	0.080	-	0.067	0.013
59	0.067	-	0.058	0.009
60	0.058	-	0.050	0.008
61	0.050	-	0.042	0.008
62	0.042	-	0.035	0.007
63	0.035	-	0.030	0.005
64	0.030	-	0.025	0.005
65	0.025	-	0.020	0.005
66	0.020	-	0.015	0.005
67	0.015	-	0.010	0.005
68	0.010	-	0.005	0.005
69	0.005	-	0.	0.005

Table 2. Fission Spectra for 69-Group

69-Group Library	
Group	Spectrum
1	2.595E-2
2	1.139E-1
3	2.138E-1
4	2.300E-1
5	1.768E-1
6	1.111E-1
7	6.330E-2
8	3.307E-2
9	1.651E-2
10	8.094E-3
11	3.913E-3
12	1.874E-3
13	8.931E-4
14	4.239E-4
15	2.010E-4
16	8.872E-5
17	4.508E-5
18	2.290E-5
19	1.163E-5
20	2.670E-6
Total	1.0

Table 3. Burn-up Data

Nuclide	ID NO.	Capture Product	Decay Product	Half Life (sec)	Decay Constant (sec^{-1})
B-10	5010	-			
Co-59	27059	-			
Er-166	68166	68167			
Er-167	68167	-			
Hf-174	72174	-			
Hf-176	72176	72177			
Hf-177	72177	72178			
Hf-178	72178	72179			
Hf-179	72179	72180			
Hf-180	72180	-			
Th-232	90232	91233			
Pa-233	91233	92234	92233	2.3328E+6	2.9713E-7
U -233	92233	92234			
U -234	92234	92235			
U -235	92235	92236			
U -236	92236	92237			
U -237	92237	92238	93237	5.8320E+5	1.1885E-6
Np-237	93237	93238			
U -238	92238	93239			
Np-238	93238	93239	94238	1.8291E+5	3.7896E-6
Pu-238	94238	94239			
Np-239	93239	94240	94239	2.0339E+5	3.4080E-6
Pu-239	94239	94240			
Pu-240	94240	94241			
Pu-241	94241	94242	95241	4.6389E+8	1.4942E-9
Am-241	95241	95342			
Pu-242	94242	95243			
Am-242g	95242	95243	96242	5.7636E+4	1.2026E-5
Am-242m	95342	95243			
Cm-242	6242	96243		1.4075E+7	4.9247E-8
Am-243	95243	96244			
Cm-243	96243	96244			
Cm-244	96244				

Table 3. (continued)

Nuclide	ID NO.	Capture Product	Decay Product	Half Life (sec)	Decay Constant (sec^{-1})
Kr-83	36083				
Mo-95	42095				
Tc-99	43099				
Ru-101	44101				
Ru-103	44103		45103	3.3938E+6	2.0424E-7
Rh-103	45103				
Rh-105	45105		461 05	1.2730E+5	5.4450E-6
Pd-105	46105				
Pd-108	46108	47109			
Ag-109	109				
Cd-113	48113				
In-115	115				
I-127	53127				
I-135	53135		54135	2.3796E+4	2.9129E-5
Xe-131	54131				
Xe-135	54135		55135	3.2724E+4	2.1182E-5
Cs-133	55133	55134			
Cs-134	55134	55135		6.5070E+7	1.0652E-8
Cs-135	55135				
Nd-143	60143				
Nd-145	60145				
Pm-147*	61147	61148	62147	8.2786E+7	8.3728E-9
Pm-147	61347	61348	62147	8.2786E+7	8.3728E-9
Pm-148g	61148	61149	62148	4.5397E+5	1.4939E-6
Pm-148m	61348	61149	62148	3.5683E+6	1.9425E-7
Pm-149	61149	62150	62149	1.9109E+5	3.6273E-6
Sm-147	62147	62148			
Sm-148	62148	62149			
Sm-149	62149	62150			
Sm-150	62150	62151			
Sm-151	62151	62152			
Sm-152	62152	63153			
Eu-153	63153	63154			
Eu-154	63154	63155			
Eu-155	63155				
Gd-157	64157				
Pseudo	902				
Dummy	237		92237	0.693	1.0

* Pm-147(61147) —53%→ Pm-148 (61148)
(61347) —47%→ Pm-148m(61348)

Table 4. Energy Release per Fission Including Contribution from Capture

Nuclide	Energy Release per Fission	
	MeV	Joules/mole x 10^{-24}
Th-232	189.76	1.8309E-11
Pa-233	181.71	1.7532E-11
U -233	199.74	1.9272E-11
U -234	199.48	1.9247E-11
U -235	201.74	1.9465E-11
U -236	201.79	1.9469E-11
U -237	189.10	1.8245E-11
U -238	203.89	1.9672E-11
Np-237	206.50	1.9924E-11
Np-238	210.11	2.0272E-11
Np-239	201.29	1.9421E-11
Pu-238	208.09	2.0077E-11
Pu-239	210.60	2.0320E-11
Pu-240	207.07	1.9979E-11
Pu-241	213.05	2.0556E-11
Pu-242	212.10	2.0464E-11
Am-241	213.77	2.0625E-11
Am-242m	215.10	2.0754E-11
Am-243	216.33	2.0872E-11
Cm-244	218.55	2.1087E-11

Table 5. Fission Product Yield Data

Nuclide	Nuclide ID NO.	Fission Yield		
		Th-232	U-233	U-235
KR-83	36083	2.22272E-02	1.01797E-02	5.36047E-03
MO-95	95	5.37418E-02	6.19043E-02	6.49490E-02
TC-99	43099	2.87561E-02	4.87389E-02	6.11911E-02
RU-101	44101	7.30503E-03	3.23116E-02	5.07374E-02
RU-103	44103	1.52769E-03	1.66930E-02	3.04185E-02
RH-103	45103	0.	0.	0.
RH-105	45105	4.61732E-04	4.82949E-03	9.67387E-03
PD-105	46105	0.	0.	0.
PD-108	46108	6.26151E-04	6.31809E-04	6.70610E-04
AG-109	109	6.09107E-04	4.41868E-04	3.44293E-04
CD-113	48113	8.49075E-04	1.34345E-04	1.60694E-04
IN-115	115	6.92447E-04	1.18251E-04	1.07886E-04
I-127	53127	9.07700E-04	5.51717E-03	1.25602E-03
I-135	53135	5.35142E-02	4.91300E-02	6.29661E-02
XE-131	54131	1.62119E-02	3.60597E-02	2.88306E-02
XE-135	54135	3.08900E-04	1.28300E-02	2.41920E-03
CS-133	55133	3.96380E-02	6.02230E-02	6.70172E-02
CS-134	55134	4.22102E-09	1.32045E-05	1.26972E-07
CS-135	55135	2.00000E-07	1.85500E-04	2.08000E-05
ND-143	60143	6.51899E-02	5.89179E-02	5.93726E-02
ND-145	60145	5.28346E-02	3.39175E-02	3.91741E-02
PM-147*	61147	1.59600E-02	9.27479E-03	1.19428E-02
PM-147	61347	1.41532E-02	8.22481E-03	1.05908E-02
PM-148g	61148	4.49109E-11	3.53854E-09	4.05910E-11
PM-148m	61348	1.08026E-10	9.80595E-09	7.44834E-11
PM-149	61149	8.83247E-03	7.77062E-03	1.06662E-02
SM-147	62147	0.	0.	0.
SM-148	62148	0.	0.	0.
SM-149	62149	0.	0.	0.
SM-150	62150	3.70090E-08	2.80184E-05	3.03932E-07
SM-151	62151	3.14161E-03	3.15328E-03	4.18395E-03
SM-152	62152	7.59054E-04	2.13551E-03	2.67834E-03
EU-153	63153	3.32460E-04	1.04782E-03	1.61350E-03
EU-154	63154	2.11051E-11	2.27906E-07	2.68940E-08
EU-155	63155	3.82793E-05	2.17930E-04	3.20479E-04
GD-157	64157	9.56231E-06	6.32739E-05	6.15363E-05
PSEUDO	902	3.07000E-01	3.17000E-01	3.04000E-01
DUMMY	237	0.	0.	0.

* Two identical nuclides, Pm147, are included to model the branching ratio to Pm148m and Pm148g.

Table 5. (continued)

Nuclide	Nuclide ID NO.	Fission Yield		
		U-236	U-238	Np-237
KR-83	36083	5.24215E-03	3.93454E-03	4.81512E-03
MO-95	95	6.40997E-02	5.10515E-02	5.69875E-02
TC-99	43099	5.91164E-02	6.24788E-02	6.19157E-02
RU-101	44101	5.29346E-02	6.08435E-02	6.17895E-02
RU-103	44103	4.20658E-02	6.22897E-02	5.58421E-02
RH-103	45103	0.	0.	0.
RH-105	45105	2.47029E-02	3.97489E-02	3.17882E-02
PD-105	46105	0.	0.	0.
PD-108	46108	3.45685F-03	6.01109E-03	9.53713E-03
AG-109	109	1.43111E-03	2.67089E-03	4.46214E-03
CD-113	48113	3.75146E-04	5.18167E-04	5.08817E-04
IN-115	115	5.12365E-04	3.38487E-04	4.89097E-04
I-127	53127	2.26471E-03	1.29954E-03	3.58632E-03
I-135	53135	5.63072E-02	6.83489E-02	6.66004E-02
XE-131	54131	3.03390E-02	3.23266E-02	3.69670E-02
XE-135	54135	1.58470E-03	2.79500E-04	8.82930E-03
CS-133	55133	7.02632E-02	6.61965E-02	6.63938E-02
CS-134	55134	1.70998E-07	3.14368E-09	3.11004E-06
CS-135	55135	4.30000E-06	2.00000E-07	6.05000E-05
ND-143	60143	6.08466E-02	4.55850E-02	4.70258E-02
ND-145	60145	3.66786E-02	3.75491E-02	3.48214E-02
PM-147*	61147	1.24053E-02	1.34120E-02	1.17171E-02
PM-147	61347	1.10010E-02	1.18937E-02	1.03906E-02
PM-148g	61148	1.24999E-09	2.45287E-11	2.88004E-08
PM-148m	61348	2.99997E-09	5.88690E-11	6.91010E-08
PM-149	61149	1.36911E-02	1.61003E-02	1.27463E-02
SM-147	62147	0.	0.	0.
SM-148	62148	0.	0.	0.
SM-149	62149	0.	0.	0.
SM-150	62150	1.24999E-06	8.00938E-08	1.65502E-05
SM-151	62151	4.22682E-03	8.01067E-03	7.13773E-03
SM-152	62152	3.87746E-03	5.20746E-03	4.56314E-03
EU-153	63153	2.55329E-03	4.10947E-03	3.59421E-03
EU-154	63154	8.72991E-09	3.44404E-10	1.99003E-07
EU-155	63155	9.23191E-04	1.32803E-03	1.19214E-03
GD-157	64157	2.30798E-04	3.87184E-04	3.33005E-04
PSEUDO	902	3.05000E-01	3.07000E-01	3.06000E-01
DUMMY	237	0.	5.07500E-02	0.

Table 5. (continued)

Nuclide	Nuclide ID NO.	Fission Yield		
		Pu-239	Pu-240	Pu-241
KR-83	36083	2.95103E-03	3.03097E-03	2.12726E-03
MO-95	95	4.89429E-02	4.39602E-02	4.07359E-02
TC-99	43099	6.15613E-02	5.99595E-02	6.27018E-02
RU-101	44101	5.89887E-02	6.05317E-02	6.00612E-02
RU-103	44103	6.94980E-02	6.71258E-02	6.15095E-02
RH-103	45103	0.	0.	0.
RH-105	45105	5.36227E-02	5.54896E-02	6.14640E-02
PD-105	46105	0.	0.	0.
PD-108	46108	2.17260E-02	3.03572E-02	3.93759E-02
AG-109	109	1.87613E-02	1.79176E-02	2.25404E-02
CD-113	48113	6.40757E-04	1.57070E-03	1.43542E-03
IN-115	115	3.57286E-04	6.63816E-04	4.22419E-04
I-127	53127	4.89307E-03	4.18768E-03	2.29386E-03
I-135	53135	6.44939E-02	6.74761E-02	7.06975E-02
XE-131	54131	3.84640E-02	3.54415E-02	2.84278E-02
XE-135	54135	1.15238E-02	6.98430E-03	2.31400E-03
CS-133	55133	6.97542E-02	7.00541E-02	6.76991E-02
CS-134	55134	9.89320E-06	1.82018E-06	1.85052E-07
CS-135	55135	1.58900E-04	4.41000E-05	6.70000E-06
ND-143	60143	4.42815E-02	4.72014E-02	4.70421E-02
ND-145	60145	2.99151E-02	3.27715E-02	3.34353E-02
PM-147*	61147	1.08270E-02	1.13360E-02	1.25489E-02
PM-147	61347	9.60135E-03	1.04961E-02	1.11283E-02
PM-148g	61148	1.12036E-07	1.48015E-08	2.22062E-09
PM-148m	61348	2.36076E-07	3.55035E-08	4.68132E-09
PM-149	61149	1.23930E-02	1.36947E-02	1.52403E-02
SM-147	62147	0.	0.	0.
SM-148	62148	0.	0.	0.
SM-149	62149	0.	0.	0.
SM-150	62150	1.15838E-05	1.14011E-05	2.78078E-06
SM-151	62151	7.72062E-03	8.43189E-03	9.36900E-03
SM-152	62152	5.85171E-03	6.57575E-03	7.46591E-03
EU-153	63153	3.63693E-03	5.79670E-03	5.48158E-03
EU-154	63154	9.22299E-07	1.74017E-07	3.62102E-08
EU-155	63155	1.65477E-03	2.47628E-03	2.41746E-03
GD-157	64157	7.40970E-04	1.30401E-03	1.37162E-03
PSEUDO	902	3.29000E-01	3.19000E-01	3.09000E-01
DUMMY	237	0.	0.	0.

Table 5. (continued)

Nuclide	Nuclide ID NO.	Fission Yield Pu-242
KR-83	36083	2.40604E-03
MO-95	95	4.02190E-02
TC-99	43099	5.38580E-02
RU-101	44101	5.88605E-02
RU-103	44103	5.88250E-02
RH-103	45103	0.
RH-105	45105	5.67325E-02
PD-105	46105	0.
PD-108	46108	4.23064E-02
AG-109	109	3.24758E-02
CD-113	48113	3.02846E-03
IN-115	115	1.02439E-03
I-127	53127	3.04358E-03
I-135	53135	6.90005E-02
XE-131	54131	3.18479E-02
XE-135	54135	2.64430E-03
CS-133	55133	6.59281E-02
CS-134	55134	1.48002E-07
CS-135	55135	5.80000E-06
ND-143	60143	4.67754E-02
ND-145	60145	3.46662E-02
PM-147*	61147	1.28223E-02
PM-147	61347	1.13707E-02
PM-148g	61148	1.11002E-09
PM-148m	61348	2.68004E-09
PM-149	61149	1.61523E-02
SM-147	62147	0.
SM-148	62148	0.
SM-149	62149	0.
SM-150	62150	1.80002E-06
SM-151	62151	1.02476E-02
SM-152	62152	8.34761E-03
EU-153	63153	6.55417E-03
EU-154	63154	2.28003E-08
EU-155	63155	3.67832E-03
GD-157	64157	1.83918E-03
PSEUDO	902	3.00000E-01
DUMMY	237	0.

Table 6. Goldstein-Cohen Parameters used in the '88' Library

Nuclide	ID NO.	λ-Value	Nuclide	ID NO.	λ-Value
H	1001	1.0	In-113	49113	0.5
H in H2O	1011	1.0	In-115	49115	0.5
H in ZrH	1021	1.0	Sn	50000	0.5
D	1002	1.0	Gd	64000	0.28
H in D2O	1012	1.0	Dy-164	66164	0.28
He-3	2003	0.98	Er-166	68166	0.28
He-4	2004	0.98	Er-167	68167	0.28
Li-6	3006	0.98	Lu-176	71176	0.28
Li-7	3007	0.98	Hf	72000	0.28
Be-9	4009	0.98	Ta-181	73181	0.25
B -10	10	0.98	Au-197	79197	0.25
B -11	5011	0.98	Pb	82000	0.22
C	6000	0.98	F.P.	-	0.5
N -14	7014	0.98	Th-232	90232	0.2
O -16	8016	0.94	Pd-233	91233	0.2
F	9019	0.85	U -233	92233	0.2
Na-23	11023	0.85	U -234	92234	0.2
Al-27	13027	0.85	U -235	92235	0.2
Si	14000	0.85	U -236	92236	0.2
P -31	15031	0.8	U -237	92237	0.2
S -32	16032	0.8	Np-237	93237	0.2
K	19000	0.7	U -238	92238	0.2
Ti	22000	0.7	Np-239	93239	0.2
V	23000	0.6	Pu-238	94238	0.2
Cr	24000	0.6	Np-239	93239	0.2
Mn-55	25055	0.5	Pu-239	94239	0.2
Fe	26000	0.5	Pu-240	94240	0.2
Co-59	27059	0.5	Pu-241	94241	0.2
Ni	28000	0.5	Am-241	95241	0.2
Cu	29000	0.5	Pu-242	94242	0.2
Cu-63	29063	0.5	Am-242g	95242	0.2
Zr	40000	0.5	Am-242m	95342	0.2
Nb-93	41093	0.5	Cm-242	96242	0.2
Mo	42000	0.5	Am-243	95243	0.2
Ag-107	47107	0.5	Cm-243	96243	0.2
Ag-109	47109	0.5	Cm-244	96244	0.2
Cd	48000	0.5			

Table 7. Resonance Tabulations for Self-Shielding

Nuclide	ID NO.	Temp °K	σ_o Barns						
Hf-176	72176	300 600	5.0×10^{1}	5.0×10^{2}	5.0×10^{3}	5.0×10^{4}	5.0×10^{5}	1.0×10^{10}	
Hf-177	72177	"			"				
Hf-178	72178	"			"				
Hf-179	72179	"			"				
Hf-180	72180	"			"				
Th-232	90232	300 600 900	1.0×10^{1}	5.0×10^{1}	1.0×10^{2}	3.0×10^{2}	1.0×10^{3}	1.0×10^{4}	1.0×10^{10}
Pa-233	91233	"	1.0×10^{2}	1.0×10^{3}	1.0×10^{4}	1.0×10^{5}	1.0×10^{10}		
U -233	92233	"	3.0×10^{2}	1.0×10^{3}	3.0×10^{3}	1.0×10^{4}	1.0×10^{5}	1.0×10^{10}	
U -234	92234	"	3.0×10^{2}	1.0×10^{3}	5.0×10^{3}	1.0×10^{4}	1.0×10^{5}	5.0×10^{5}	1.0×10^{10}
U -235	92235	"	5.0×10^{2}	1.0×10^{3}	2.0×10^{3}	3.0×10^{3}	6.0×10^{3}	1.0×10^{4}	1.0×10^{5}
			1.0×10^{10}						
U -236	92236	"	3.0×10^{3}	1.0×10^{4}	5.0×10^{4}	1.0×10^{5}	1.0×10^{6}	1.0×10^{10}	
U -238	92238	"	1.0×10^{1}	5.0×10^{1}	1.0×10^{2}	1.5×10^{2}	3.0×10^{2}	1.0×10^{3}	1.0×10^{4}
			1.0×10^{10}						
Np-237	93237	"	1.0×10^{2}	3.0×10^{2}	1.0×10^{4}	1.0×10^{5}	1.0×10^{10}		
Np-239	93239	"			"				
Pu-238	94238	"			"				
Pu-239	94239	"	1.0×10^{2}	3.0×10^{2}	7.0×10^{2}	1.5×10^{3}	3.0×10^{3}	5.0×10^{3}	1.0×10^{4}
			1.0×10^{10}						
Pu-240	94240	"	1.0×10^{2}	1.0×10^{3}	1.0×10^{4}	1.0×10^{5}	1.0×10^{10}		
Pu-241	94241	"			"				
Pu-242	94242	"			"				
Am-241	95241	"	1.0×10^{2}	1.0×10^{3}	1.0×10^{4}	1.0×10^{10}			
Am-242g	95242	"		"					
Am-242m	95242	"		"					
Am-243	95243	"		"					
Cm-242	96242	"		"					
Cm-243	96243	"		"					
Cm-244	96244	"		"					

Table 8. List of Nuclides in the Library

Nuclide	Nuclide ID No.	Source Data (MAT No.)	Thermal Scattering		Resonance Tabulation
			Model	Temp. °K	
Hydrogen	1001	ENDF/B-V (1301)	Free Gas	300	
H bound in H2O	1011	ENDF/B-V, III (1301, 1002)	S(α, β)	296, 350 400, 450 500, 600	
H bound in ZrH	1021	" (1301, 1097)	S(α, β)	296, 400 500, 600 800, 1200	
H bound in H2O	1111	UKNDL	Nelkin	293, 333 373, 423 473	
Deuterium	1002	ENDF/B-IV (1120)	Free Gas	300	
D bound in D2O	1012	ENDF/B-IV, III (1120, 1004)	S(α, β)	296, 350 400, 450 500, 600	
D bound in D2O	1222	UKNDL	Effective Width	293, 450 600	
Helium - 3	2003	ENDF/B-V (1146)	Free Gas	300	
Helium - 4	2004	ENDF/B-V (IV) (1270)	"	"	
Lithium - 6	3006	ENDF/B-V (1303)	"	"	
Lithium - 7	3007	ENDF/B-V (IV) (1272)	"	"	
Beryllium - 9	4009	" (1287)	"	"	

Table 8. (Continued)

Nuclide	Nuclide ID No.	Source Data (MAT No.)	Thermal Scattering		Resonance Tabulation
			Model	Temp. °K	
Boron - 10	10	ENDF/B-V (1305)	Free Gas	300	
Boron - 10 *	5010	" (1305)	"	"	
Boron - 11	5011	ENDF/B-V (IV) (1160)	"	"	
Carbon	6000	ENDF/B-V (1306)	"	296	
Graphite	6001	ENDF/B-V, III (1303, 1065)	S(α, β)	296, 400 500, 600 800, 1200	
Nitrogen - 14	7014	ENDF/B-V (IV) (1275)	Free Gas	300	
Oxygen - 16	8016	" (1276)	"	296, 350 400, 450 500, 600	
Fluorine	9019	ENDF/B-IV (1277)	"	300	
Sodium	11023	" (1156)	"	"	
Aluminium	13027	" (1193)	"	300, 600 900	
Silicon	14000	" (1194)	"	"	
Phosphorus - 31	15031	ENDL-84 (7821)	"	300	
Sulfur - 32	16032	" (7822)	"	"	

* Burnable

Table 8. (Continued)

Nuclide	Nuclide ID No.	Source Data (MAT No.)	Thermal Scattering		Resonance Tabulation
			Model	Temp. °K	
Potassium	19000	ENDF/B-V (IV) (1150)	Free Gas	300	
Titan	22000	ENDF/B-IV (1286)	"	"	
Vanadium	23000	" (1136)	"	"	
Chromium	24000	" (1191)	"	300, 600 900	
Manganese - 55	25055	" (1197)	"	"	
Iron	26000	" (1192)	"	"	
Cobalt - 59	27059	" (1199)	"	300	
Nickel	28000	" (1190)	"	300, 600 900	
Copper	29000	" (1295)	"	300	
Copper - 63	29063	JENDL-2 (2291)	"	"	
Zirconium	40000	ENDL-84 (7841)	"	300, 600 900	
Zircaloy - 2	40002	ENDF/B-IV (1284)	"	"	
Niobium - 93	41093	ENDF/B-V (IV) (1189)	"	"	

Table 8. (Continued)

Nuclide	Nuclide ID No.	Source Data (MAT No.)	Thermal Scattering		Resonance Tabulation
			Model	Temp. °K	
Molybdenum	42000	ENDF/B-IV (1287)	Free Gas	300	
Molybdenum - 92	42092	ENDF/B-V (9278)	"	"	
Molybdenum - 94	42094	" (9281)	"	"	
Molybdenum - 95	42095	" (9282)	"	"	
Molybdenum - 96	42096	" (9283)	"	"	
Molybdenum - 97	42097	" (9284)	"	"	
Molybdenum - 98	42098	" (9285)	"	"	
Molybdenum - 99	42099	" (9286)	"	"	
Molybdenum - 100	42100	" (9287)	"	"	
Silver - 107	47107	" (1407)	"	"	
Silver - 109	47109	" (1409)	"	"	
Cadmium	48000	ENDF/B-V (IV) (1281)	"	"	
Indium - 113	49113	ENDF/B-V (9473)	"	"	

Table 8. (Continued)

Nuclide	Nuclide ID No.	Source Data (MAT No.)	Thermal Scattering		Resonance Tabulation
			Model	Temp. °K	
Indium - 115	49115	ENDF/B-V (9477)	Free Gas	300	
Tin	50000	ENDL-84 (7850)	"	"	
Gadolinium	64000	ENDF/B-IV (1030)	"	"	
Dysprosium - 164	66164	ENDF/B-V (IV) (1031)	"	"	
Erbium - 166	68166	ENDF/B-V (9875)	"	"	
Erbium - 167	68167	" (9876)	"	"	
Lutetium - 176	71176	ENDF/B-V (IV) (1033)	"	"	
Hafnium	72000	ENDL-84 (8305)	"	"	
Hafnium - 174	72174	JENDL-2 (2721)	"	300, 600	
Hafnium - 176	72176	" (2722)	"	"	72176.0
Hafnium - 177	72177	" (2723)	"	"	72177.0
Hafnium - 178	72178	" (2724)	"	"	72178.0
Hafnium - 179	72179	" (2725)	"	"	72179.0

Table 8. (Continued)

Nuclide	Nuclide ID No.	Source Data (MAT No.)	Thermal Scattering		Resonance Tabulation
			Model	Temp. °K	
Hafnium - 180	72180	JENDL-2 (2726)	Free Gas	300, 600	72180.0
Tantal - 181	73181	ENDF/B-V (IV) (1285)	"	300	
Gold - 197	79197	ENDF/B-V (1379)	"	"	
Lead	82000	ENDF/B-IV (1288)	"	"	

Fission Product

Nuclide	Nuclide ID No.	Source Data (MAT No.)	Thermal Scattering		Resonance Tabulation
			Model	Temp. °K	
Krypton - 83	36083	ENDF/B-V (1333)	Free Gas	600	
Molybdenum - 95	95	" (9282)	"	"	
Technetium - 99	43099	" (1308)	"	"	
Ruthenium - 101	44101	" (9330)	"	"	
Ruthenium - 103	44103	" (9332)	"	"	
Rhodium - 103	45103	" (1310)	"	"	
Rhodium - 105	45105	" (9355)	"	"	

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Table 8. (Continued)

Nuclide	Nuclide ID No.	Source Data (MAT No.)	Thermal Scattering		Resonance Tabulation
			Model	Temp. °K	
Palladium - 105	46105	ENDF/B-V (9382)	Free Gas	600	
Palladium - 108	46108	" (9386)	"	"	
Silver - 109	109	" (1409)	"	"	
Cadmium - 113	48113	" (1318)	"	"	
Indium - 115	115	" (9477)	"	"	
Iodine - 127	53127	" (9606)	"	"	
Iodine - 135	53135	" (9618)	"	"	
Xenon - 131	54131	" (1351)	"	"	
Xenon - 135	54135	" (1294)	"	"	
Cesium - 133	55133	" (1355)	"	"	
Cesium - 134	55134	" (9663)	"	"	
Cesium - 135	55135	" (9665)	"	"	
Neodymium - 143	60143	" (9764)	"	"	

Table 8. (Continued)

Nuclide	Nuclide ID No.	Source Data (MAT No.)	Thermal Scattering		Resonance Tabulation
			Model	Temp. °K	
Neodymium - 145	60145	ENDF/B-V (9766)	Free Gas	600	
Promethium -147*	61147	" (9783)	"	"	
Promethium -147	61347	" (9783)	"	"	
Promethium -148g	61148	" (9784)	"	"	
Promethium -148m	61348	" (9785)	"	"	
Promethium -149	61149	" (9786)	"	"	
Samarium - 147	62147	" (9806)	"	"	
Samarium - 148	62148	" (9807)	"	"	
Samarium - 149	62149	" (1319)	"	"	
Samarium - 150	62150	" (9809)	"	"	
Samarium - 151	62151	" (9810)	"	"	
Samarium - 152	62152	" (9811)	"	"	

* Two identical nuclides ,Pm-147, are included to model the branching ratio to Pm-148m and Pm-148g.

Table 8. (Continued)

Nuclide	Nuclide ID No.	Source Data (MAT No.)	Thermal Scattering		Resonance Tabulation
			Model	Temp. °K	
Europium - 153	63153	ENDF/B-V (1359)	Free Gas	600	
Europium - 154	63154	" (1293)	"	"	
Europium - 155	63155	" (9832)	"	"	
Gadolinium -157	64157	EVDF/B-IV (794)	"	"	
Pseudo F.P	902	Original WIMS			
Dummy	237	$\sigma a = 1.0 \times 10^{-8}$ barns			

Actinide

Nuclide	Nuclide ID No.	Source Data (MAT No.)	Thermal Scattering		Resonance Tabulation
			Model	Temp. °K	
Thorium - 232	90232	ENDF/B-IV + V (1296, 6390)	Free Gas	300, 600 900	90232.0
Thorium - 232	90332	ENDF/B-IV (1296)	"	"	90332.0
Protactinium-233	91232	ENDF/B-V (1391)	"	"	91233.0
Uranium - 233	92233	ENDF/B-IV (1260)	"	"	92233.0
Uranium - 234	92234	ENDF/B-V (1394)	"	"	92234.0

Table 8. (Continued)

Nuclide	Nuclide ID No.	Source Data (MAT No.)	Thermal Scattering		Resonance Tabulation
			Model	Temp. °K	
Uranium - 235	92235	ENDF/B-V (1395)	Free gas	300, 600 900	92235.0
Uranium - 236	92236	" (1396)	"	"	92236.0
Uranium - 237	92237	" (8237)	"	"	
Neptunium - 237	93237	" (1337)	"	"	93237.0
Uranium - 238	92238	ENDF/B-IV + V (1262, 6298)	"	"	92238.0
Uranium - 238	92338	ENDF/B-IV (1262)	"	"	92338.0
Neptunium - 238	93238	ENDF/B-V (8338)	"	"	
Plutonium - 238	94238	" (1338)	"	"	94238.0
Neptunium - 239	93239	JENDL-2 (2932)	"	"	93239.0
Plutonium - 239	94239	ENDF/B-IV (1264)	"	"	94239.0
Plutonium - 240	94240	" (1265)	"	"	94240.0
Plutonium - 241	94241	" (1266)	"	"	94241.0
Americium - 241	95241	ENDF/B-V (1361)	"	"	95241.0

Table 8. (Continued)

Nuclide	Nuclide ID No.	Source Data (MAT No.)	Thermal Scattering		Resonance
			Model	Temp. °K	Tabulation
Plutonium - 242	94242	ENDF/B-V (1342)	Free Gas	300, 600 900	94242.0
Americium - 242g	95242	" (8542)	"	"	95242.0
Americium - 242m	95342	JENDL-2 (2953)	"	"	95342.0
Curium - 242	96242	" (8642)	"	"	96242.0
Americium - 243	95243	JENDL-2 (2954)	"	"	95243.0
Curium - 243	96243	" (1343)	"	"	96243.0
Curium - 244	96244	" (1344)	"	"	96244.0
1/v absorber	1000				

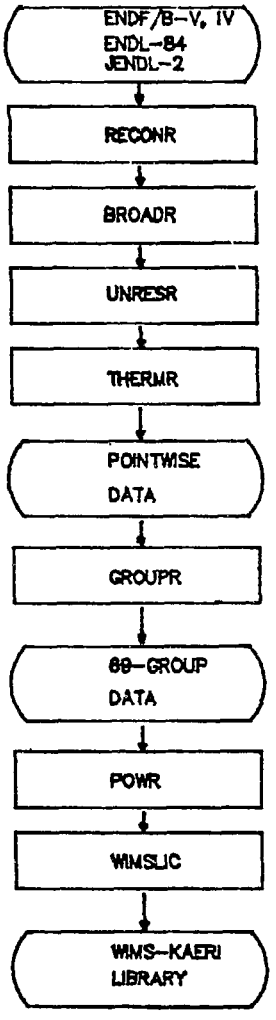

Fig. 1. NJOY PROCESSING PATH FOR THE WIMS-KAERI LIBRARY

Appendix

WIMS-KAERI Library Format

I. General Index File

The first file on the tape contains the following general information :

Record 1 : L, N, NO, N1, N2, N3, NNF, NNFP
- Number of nuclides on this library tape.
- Total number of groups (= N1+N2+N3).
- Number of groups into which there is a fission source.
- Numbers of fast, resonance and thermal groups.
- Numbers of fissile and fission product nuclides.

Record 2 : (NIN(I), I=1, L)
- Nuclide identification numbers for the L nuclides on the tape ; these form an index to the nuclide files.

Record 3 : (GB(J), J=1, N+1)
- Energy group boundaries - in order of decreasing energy.

Record 4 : (FS(J), J=1, NO)
- Fission source spectrum, sums to 1.0.

Record 5, to L+4 : JC, JB, (AA(k), JJ(k), K=1, JA) where JA=JC/2-1 and may differ for each record

A record for each nuclide describing all nuclides produced by burnup of this nuclide. This record contains :
- Length of record (JC), NIN(JB).
- Yield (normally 1.0) and NIN of nuclide formed by neutron capture in nuclide JB.
- Decay constant of nuclide JB and NIN of nuclide formed by decay.
- Fission energy yield and indicator NFA (see below).
- Pairs of numbers giving yield and NIN of fission products produced by fission of JB.
- Pairs of numbers 0.0 and NIN of any nuclides formed only indirectly from JB (e.g., U238 + n + n → Pu240, Sm149 + n → Sm150, requiring specification of Pu240, Sm150 respectively).

The indicator NFA is equal to NF for nuclide JB unless nuclide JB is a fission product ; in this case NFA is -1 if nuclide JB does not have a resonance

tabulation associated with it, and -2 if it does. If yield and NIN of nuclide formed by capture in nuclide JB are both set to zero, no capture product will be assumed in any subsequent calculation of burnup.

File Mark

II. Nuclide Files

For each of the nuclides specified in record 2 of the general index file, there is a file of data containing the following information :

Record 1 : J, AW, IAN, NF, NT, NZZ
- NIN, atomic weight, atomic number, trigger (see below), number of temperatures at which thermal data tabulated, number of resonance tabulations associated with this nuclides.

NF is the fissile and resonance trigger, and may take the following values :

0 - non-fissile, no resonance tabulation
1 - non-fissile, resonance absorption tabulation
2 - fissile, tabulation of resonance absorption only
3 - fissile, tabulation of resonance absorption and fission
4 - fissile, no resonance tabulation

Note that the atomic weight should be exact because it is used in WIMS for calculating number densities from physical densities.

Record 2 : (PSCAT(J), J=1, N=2)
- Potential scattering cross section, for resonance groups.

(XISS(J), J=1, N2)
- Slowing down power divided by lethargy width, for resonance groups.

(TR(J), J=1, N1+N2)
- Transport cross section for fast and resonance groups.

(ABS(J), J=1, N1+N2)
- Absorption cross section for fast and resonance groups.

(CHI(J), J=1, N2)
- Not used.

(ALAMDA(J), J=1, N2)
- Goldstein-Cohen parameter, for resonance groups.

Record 3 : (XNUFIS(J), J=1, N1+N2), (FIS(J), J=1, N1+N2)
- Fission yield and fission cross sections for fast and resonance groups.

Record 3 is present only for fissile nuclides (i.e., NF ≥ 2). For nuclides with resonance tabulation(s), the resonance group cross sections are 'infinitely dilute' (i.e., no resonance shielding). Note that these cross sections can in general be consistent only with one resonance tabulation.

Record 4 : K, (AA(I), I=1, K)
- Condensed scattering matrix for scattering from fast and resonance groups.

The vector AA(I) may be split into N1+N2 blocks of the form

AS, AL, (VECTOR(I), I=1, L),

where the numbers in VECTOR are the non-zero scattering cross sections from a group, L=AL is the number of these cross sections, and AS is the position of the self-scatter term in the array VECTOR. Note that AS=1 if there is no upscatter.

Record 5 : (TEMP(J), J=1, NT)
- Temperatures(K) at which thermal data is tabulated, in ascending order. (If NT=1 there is one thermal data tabulation, which is then used for all temperatures in WIMS : in this case TEMP(1) is usually arbitrarily set equal to 300 K).

Following this record, there are three records for each temperature as follows :

Record 6 : (TR(J), J=N1+N2+1, N), (ABS(J), J=N1+N2+1, N)
- Transport and absorption cross sections for thermal groups (for the appropriate temperature).

Record 7 : (XNUFIS(J), J=N1+N2+1, N), (FIS(J), J=N1+N2+1, N)
- Fission yield and fission cross sections for thermal groups.

Record 7 is present only for fissile nuclides (i.e., NF ≥ 2).

Record 8 : KA, (AA(I), (I=1, KA)

- Condensed scattering matrix for scattering from thermal groups. The data are stored as described for record 4.

After the thermal data for all temperatures specified in record 5, data for this nuclide are terminated.

File Mark.

This concludes the description of the L nuclide files 2 to L+1.

III. Resonance Data Files

The resonance data are contained in N2 files, one for each resonance group. Each file contains one (absorption) or two (absorption and fission yield) records for each resonance tabulation, depending on the trigger NF in the nuclide data of the nuclide to which the tabulation refers. The records are in the order of the NIN's in the index (Record 2, General Index File). The records contain :

RIN, M1, M2, (T(JB), JB=1, M1), (SIGP(JD), JD=1, M2), ((RSIG(JD, JB), JD=1, M2), JB=1, M1)

- Resonance identification number, number of temperatures and σ_0's, temperatures, σ_0's, and resonance cross sections ordered σ_0 within temperature.

Note that the upper value of σ_0 in the tabulation is ignored and replaced by 'infinity' when WIMS interpolates in the RSIG table. Following the records for each resonance identification number, the data for each group are terminated by

One record : 0.0, 1, 1, 0.0, 0.0, 0.0

File Mark.

IV. P1 Scattering Matrices

The P1 scattering matrix data consist of a single P1 matrix for hydrogen, deuterium, oxygen and carbon in that order. The matrices are written to tape one row at a time ; thus the P1 scattering matrix file consists of 4N records,

System EOF Mark

Attachment

Jung-Do, Jong Tai Lee, Choong-Sup Gil, Hark Rho Kim, Generation and Benchmarking of a 69-group Corss Section Library for Thermal Reactor Applications. Journal of the Korean Nuclear Society, v.21(4) p. 245-258 (December 1989). (Not Microfiched)