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FENDL-3.0:
Processing the evaluated nuclear data library for fusion applications

Summary documentation prepared by

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December 2011

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Abstract

A description of the work undertaken towards the development of a new version of the neutron-induced part of the Fusion Evaluated Nuclear Data Library (FENDL) for applications is summarized. The main issues related to the selection and processing of evaluated nuclear data files using the NJOY-99 and PREPRO-2010 processing systems are described. The new version of FENDL for applications, termed FENDL-3.0, includes the evaluated nuclear data files in ENDF-6 format, the continuous-energy cross section files in ACE format for the MCNP family of Monte Carlo codes and the multi-group data library in MATXS format for deterministic transport calculations up to 55 MeV for 180 isotopes. Further, additional data are supplied in GENDF format for sensitivity studies. The library is freely available from the Nuclear Data Section at the International Atomic Energy Agency.

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Introduction

As a result of the Coordinated Research Program entitled "Nuclear Reaction Data for Advances Systems – Fusion Devices" the third version of the Fusion Evaluated Nuclear Data Library FENDL-3.0 has been developed. It represents a substantial extension of the presently available FENDL-2.1 library [1] toward higher energies for fusion applications such as IFMIF and also for design studies of DEMO, which represent the next generation devices beyond ITER. The present report deals only with the neutron-induced general purpose files. Details of the other data in FENDL-3 will be available in the final report of the Coordinated Research Project (CRP) on Nuclear Data Libraries for Advanced Systems – Fusion Devices (FENDL-3).

In order to produce nuclear-application libraries for advanced fusion systems, the IAEA Nuclear Data Section supported the generation of the FENDL/MC-3.0 library - point-wise continuous-energy cross section data in ACE format for Monte Carlo calculations - and the FENDL/MG-3.0 library – multi-group cross section data up to 55 MeV for deterministic transport codes - under a Special Service Agreement to D. López Aldama. The FENDL/MC-3.0 and FENDL/MG-3.0 libraries will be freely available from the Nuclear Data Section webpage (http://www-nds.iaea.org). The package ACEDOP [2], which allows Doppler broadening of ACE-formatted cross sections files in the resolved resonance range, is also available as for FENDL-2.1.

The work carried out to produce FENDL-3.0 application libraries is described in this report. The evaluated nuclear data files are available from FENDL-3.0. The continuous-energy cross section data files in ACE format and the multi-group cross section data in MATXS format were produced by NJOY-99.364+ [3] at IAEA-NDS. Point-wise cross section data files in ENDF-6 format were generated using PREPRO-2010 code package [4]. A qualitative verification of processed files was also performed and the main findings and recommendations are reported.

It should be noted that this report details processing work carried out on a preliminary version of FENDL-3, further work based on this experience was subsequently carried out for the final version.

1. FENDL-3.0 Evaluated Nuclear Data Files (FENDL/E-3.0)

The evaluated nuclear data files for neutrons were taken from the test version of FENDL-3.0 evaluations, dated October 24, 2011. The general information of each evaluated nuclear data file is presented in Table 1. Note the extension to higher energies of the upper energy limit (E_{max}) compared to 20 MeV in the FENDL-2.1 evaluated nuclear data library.

The evaluated data files were analyzed using the preprocessing packages PREPRO [4] and ENDF utilities [5] to check the general compliance with ENDF-6 format rules [6]. The main findings that affect reaction data processing are listed below:

1. Derived cross section data from MT=200-208 were found for all the isotopes of titanium (Ti), bromine (Br), zirconium (Zr), niobium (Nb), molybdenum (Mo) and hafnium (Hf). It is not recommended to include these derived data into primary evaluations, therefore the derived reactions from MT=200 up to MT=450 were deleted.

2. Partial fission reactions (MT=19, 20, 21 and 38) are not consistent with the total fission (MT=18) reaction data for U-235 and U-238. To solve this problem the partial fission reactions were removed from the primary evaluation
3. It was noted that the transition probability data in the case of Nb-93 were missing for MT = 51 in File 12 (MF=12). The data were included using the code chmf35 [7].

Table 1: FENDL-3.0 evaluated nuclear data files

No.	Isotope	MAT	Library	E_{max} [MeV]	Filename [*.txt]
1	1-H-1	125	ENDF/B-VII	150	n_0125_1-H-1
2	1-H-2	128	ENDF/B-VII	150	n_0128_1-H-2
3	1-H-3	131	ENDF/B-VII	60	n_0131_1-H-3
4	2-He-3	225	JENDL-4.0	60	n_0225_2-He-3
5	2-He-4	228	ENDF/B-VII	60	n_0228_2-He-4
6	3-Li-6	325	ENDF/B-VII	200	n_0325_3-Li-6
7	3-Li-7	328	ENDF/B-VII	200	n_0328_3-Li-7
8	4-Be-9	425	ENDF/B-VII	200	n_0425_4-Be-9
9	5-B-10	525	ENDF/B-VII	200	n_0525_5-B-10
10	5-B-11	528	ENDF/B-VII	200	n_0528_5-B-11
11	6-C-12	625	JENDL-4.0	150	n_0625_6-C-12
12	6-C-13	628	TENDL-2010	200	n_0628_6-C-13
13	7-N-14	725	JENDL-4.0	200	n_0725_7-N-14
14	7-N-15	728	RUSFOND	200	n_0728_7-N-15
15	8-O-16	825	ENDF/B-VII	150	n_0825_8-O-16
16	8-O-17	828	TENDL-2010	200	n_0828_8-O-17
17	8-O-18	831	TENDL-2010	200	n_0831_8-O-18
18	9-F-19	925	ENDF/B-VII	150	n_0925_9-F-19
19	11-Na-23	1125	JENDL-4.0	150	n_1125_11-Na-23
20	12-Mg-24	1225	JENDL-4.0	150	n_1225_12-Mg-24
21	12-Mg-25	1228	JENDL-4.0	150	n_1228_12-Mg-25
22	12-Mg-26	1231	JENDL-4.0	150	n_1231_12-Mg-26
23	13-Al-27	1325	JEFF-311	150	n_1325_13-Al-27
24	14-Si-28	1425	ENDF/B-VII	150	n_1425_14-Si-28
25	14-Si-29	1428	ENDF/B-VII	150	n_1428_14-Si-29
26	14-Si-30	1431	ENDF/B-VII	150	n_1431_14-Si-30
27	15-P-31	1525	TENDL-2010	200	n_1525_15-P-31
28	16-S-32	1625	TENDL-2010	200	n_1625_16-S-32
29	16-S-33	1628	TENDL-2010	200	n_1628_16-S-33
30	16-S-34	1631	TENDL-2010	200	n_1631_16-S-34
31	16-S-36	1637	TENDL-2010	200	n_1637_16-S-36
32	17-Cl-35	1725	ENDF/B-VII	200	n_1725_17-Cl-35
33	17-Cl-37	1731	ENDF/B-VII	150	n_1731_17-Cl-37
34	18-Ar-36	1825	JENDL-4.0	150	n_1825_18-Ar-36
35	18-Ar-38	1831	JENDL-4.0	150	n_1831_18-Ar-38
36	18-Ar-40	1837	JENDL-4.0	150	n_1837_18-Ar-40
37	19-K-39	1925	TENDL-2010	150	n_1925_19-K-39
38	19-K-40	1928	TENDL-2010	150	n_1928_19-K-40
39	19-K-41	1931	TENDL-2010	150	n_1931_19-K-41
40	20-Ca-40	2025	JENDL-4.0	150	n_2025_20-Ca-40
41	20-Ca-42	2031	JENDL-4.0	150	n_2031_20-Ca-42
42	20-Ca-43	2034	JENDL-4.0	150	n_2034_20-Ca-43
43	20-Ca-44	2037	JENDL-4.0	150	n_2037_20-Ca-44
44	20-Ca-46	2043	JENDL-4.0	150	n_2043_20-Ca-46
45	20-Ca-48	2049	JENDL-4.0	150	n_2049_20-Ca-48

No.	Isotope	MAT	Library	E_{max} [MeV]	Filename [*.txt]
46	21-Sc-45	2125	JEFF-3.1.1	200	n_2125_21-Sc-45
47	22-Ti-46	2225	ENDF/B-VII	150	n_2225_22-Ti-46
48	22-Ti-47	2228	ENDF/B-VII	150	n_2228_22-Ti-47
49	22-Ti-48	2231	ENDF/B-VII	150	n_2231_22-Ti-48
50	22-Ti-49	2234	ENDF/B-VII	150	n_2234_22-Ti-49
51	22-Ti-50	2237	ENDF/B-VII	150	n_2237_22-Ti-50
52	23-V-50	2325	JENDL-4.0	150	n_2325_23-V-50
53	23-V-51	2328	JENDL-4.0	150	n_2328_23-V-51
54	24-Cr-50	2425	KIT-2010	200	n_2425_24-Cr-50
55	24-Cr-52	2431	ENDF/A-1	150	n_2431_24-Cr-52
56	24-Cr-53	2434	KIT-2010	200	n_2434_24-Cr-53
57	24-Cr-54	2437	KIT-2010	200	n_2437_24-Cr-54
58	25-Mn-55	2525	INDL/V-3	60	n_2525_25-Mn-55
59	26-Fe-54	2625	ENDF/B-VII	150	n_2625_26-Fe-54
60	26-Fe-56	2631	JEFF-3.1.1	200	n_2631_26-Fe-56
61	26-Fe-57	2634	ENDF/B-VII	150	n_2634_26-Fe-57
62	26-Fe-58	2637	JEFF-3.1.1	200	n_2637_26-Fe-58
63	27-Co-59	2725	ENDF/B-VII	150	n_2725_27-Co-59
64	28-Ni-58	2825	ENDF/B-VII	150	n_2825_28-Ni-58
65	28-Ni-60	2831	ENDF/B-VII	150	n_2831_28-Ni-60
66	28-Ni-61	2834	ENDF/B-VII	150	n_2834_28-Ni-61
67	28-Ni-62	2837	ENDF/B-VII	150	n_2837_28-Ni-62
68	28-Ni-64	2843	ENDF/B-VII	150	n_2843_28-Ni-64
69	29-Cu-63	2925	ENDF/B-VII	150	n_2925_29-Cu-63
70	29-Cu-65	2931	ENDF/B-VII	150	n_2931_29-Cu-65
71	30-Zn-64	3025	JENDL-4.0	150	n_3025_30-Zn-64
72	30-Zn-66	3031	JENDL-4.0	150	n_3031_30-Zn-66
73	30-Zn-67	3034	JENDL-4.0	150	n_3034_30-Zn-67
74	30-Zn-68	3037	JENDL-4.0	150	n_3037_30-Zn-68
75	30-Zn-70	3043	JENDL-4.0	150	n_3043_30-Zn-70
76	31-Ga-69	3125	JENDL-4.0	150	n_3125_31-Ga-69
77	31-Ga-71	3131	JENDL-4.0	150	n_3131_31-Ga-71
78	32-Ge-70	3225	JEFF-3.1.1	200	n_3225_32-Ge-70
79	32-Ge-72	3231	JEFF-3.1.1	200	n_3231_32-Ge-72
80	32-Ge-73	3234	JEFF-3.1.1	200	n_3234_32-Ge-73
81	32-Ge-74	3237	JEFF-3.1.1	200	n_3237_32-Ge-74
82	32-Ge-76	3243	JEFF-3.1.1	200	n_3243_32-Ge-76
83	35-Br-79	3525	JENDL-4.0	200	n_3525_35-Br-79
84	35-Br-81	3531	JENDL-4.0	200	n_3531_35-Br-81
85	39-Y-89	3925	ENDF/B-VII	200	n_3925_39-Y-89
86	40-Zr-90	4025	JENDL-4.0	150	n_4025_40-Zr-90
87	40-Zr-91	4028	ENDF/B-VII	150	n_4028_40-Zr-91
88	40-Zr-92	4031	ENDF/B-VII	150	n_4031_40-Zr-92
89	40-Zr-94	4037	ENDF/B-VII	150	n_4037_40-Zr-94
90	40-Zr-96	4043	ENDF/B-VII	150	n_4043_40-Zr-96
91	41-Nb-93	4125	ENDF/B-VII	150	n_4125_41-Nb-93
92	42-Mo-92	4225	JENDL-3	150	n_4225_42-Mo-92
93	42-Mo-94	4231	JENDL-3	150	n_4231_42-Mo-94
94	42-Mo-95	4234	JENDL-3	150	n_4234_42-Mo-95
95	42-Mo-96	4237	JENDL-3	150	n_4237_42-Mo-96
96	42-Mo-97	4240	JENDL-3	150	n_4240_42-Mo-97
97	42-Mo-98	4243	JENDL-3	150	n_4243_42-Mo-98

No.	Isotope	MAT	Library	E_{max} [MeV]	Filename [*.txt]
98	42-Mo-100	4249	JENDL-3	150	n_4249_42-Mo-100
99	45-Rh-103	4525	JEFF-311	200	n_4525_45-Rh-103
100	47-Ag-107	4725	ENDF/B-VII	200	n_4725_47-Ag-107
101	47-Ag-109	4731	ENDF/B-VII	200	n_4731_47-Ag-109
102	48-Cd-106	4825	ENDF/B-VII	200	n_4825_48-Cd-106
103	48-Cd-108	4831	ENDF/B-VII	200	n_4831_48-Cd-108
104	48-Cd-110	4837	ENDF/B-VII	200	n_4837_48-Cd-110
105	48-Cd-111	4840	ENDF/B-VII	200	n_4840_48-Cd-111
106	48-Cd-112	4843	ENDF/B-VII	200	n_4843_48-Cd-112
107	48-Cd-113	4846	ENDF/B-VII	200	n_4846_48-Cd-113
108	48-Cd-114	4849	ENDF/B-VII	200	n_4849_48-Cd-114
109	48-Cd-116	4855	ENDF/B-VII	200	n_4855_48-Cd-116
110	50-Sn-112	5025	JENDL-4.0	200	n_5025_50-Sn-112
111	50-Sn-114	5031	JENDL-4.0	200	n_5031_50-Sn-114
112	50-Sn-115	5034	JENDL-4.0	200	n_5034_50-Sn-115
113	50-Sn-116	5037	JENDL-4.0	200	n_5037_50-Sn-116
114	50-Sn-117	5040	JENDL-4.0	200	n_5040_50-Sn-117
115	50-Sn-118	5043	JENDL-4.0	200	n_5043_50-Sn-118
116	50-Sn-119	5046	JENDL-4.0	200	n_5046_50-Sn-119
117	50-Sn-120	5049	JENDL-4.0	200	n_5049_50-Sn-120
118	50-Sn-122	5055	JENDL-4.0	200	n_5055_50-Sn-122
119	50-Sn-124	5061	JENDL-4.0	200	n_5061_50-Sn-124
120	51-Sb-121	5125	ENDF/B-VII	200	n_5125_51-Sb-121
121	51-Sb-123	5131	ENDF/B-VII	200	n_5131_51-Sb-123
122	53-I-127	5325	ENDF/B-VII	200	n_5325_53-I-127
123	55-Cs-133	5525	JENDL-4.0	200	n_5525_55-Cs-133
124	56-Ba-130	5625	ENDF/B-VII	200	n_5625_56-Ba-130
125	56-Ba-132	5631	ENDF/B-VII	200	n_5631_56-Ba-132
126	56-Ba-134	5637	ENDF/B-VII	200	n_5637_56-Ba-134
127	56-Ba-135	5640	ENDF/B-VII	200	n_5640_56-Ba-135
128	56-Ba-136	5643	ENDF/B-VII	200	n_5643_56-Ba-136
129	56-Ba-137	5646	ENDF/B-VII	200	n_5646_56-Ba-137
130	56-Ba-138	5649	ENDF/B-VII	200	n_5649_56-Ba-138
131	57-La-138	5725	TENDL-2010	200	n_5725_57-La-138
132	57-La-139	5728	TENDL-2010	200	n_5728_57-La-139
133	58-Ce-136	5825	ENDF/B-VII	200	n_5825_58-Ce-136
134	58-Ce-138	5831	ENDF/B-VII	200	n_5831_58-Ce-138
135	58-Ce-140	5837	ENDF/B-VII	200	n_5837_58-Ce-140
136	58-Ce-142	5843	ENDF/B-VII	200	n_5843_58-Ce-142
137	64-Gd-152	6425	JENDL-4.0	200	n_6425_64-Gd-152
138	64-Gd-154	6431	JENDL-4.0	200	n_6431_64-Gd-154
139	64-Gd-155	6434	JENDL-4.0	200	n_6434_64-Gd-155
140	64-Gd-156	6437	JENDL-4.0	200	n_6437_64-Gd-156
141	64-Gd-157	6440	JENDL-4.0	200	n_6440_64-Gd-157
142	64-Gd-158	6443	JENDL-4.0	200	n_6443_64-Gd-158
143	64-Gd-160	6449	JENDL-4.0	200	n_6449_64-Gd-160
144	68-Er-162	6825	ENDF/B-VII	200	n_6825_68-Er-162
145	68-Er-164	6831	ENDF/B-VII	200	n_6831_68-Er-164
146	68-Er-166	6837	ENDF/B-VII	200	n_6837_68-Er-166
147	68-Er-167	6840	ENDF/B-VII	200	n_6840_68-Er-167
148	68-Er-168	6843	ENDF/B-VII	200	n_6843_68-Er-168
149	68-Er-170	6849	ENDF/B-VII	200	n_6849_68-Er-170

No.	Isotope	MAT	Library	E_{max} [MeV]	Filename [*.txt]
150	71-Lu-175	7125	TENDL-2010	200	n_7125_71-Lu-175
151	71-Lu-176	7128	TENDL-2010	200	n_7128_71-Lu-176
152	72-Hf-174	7225	JENDL-4.0	200	n_7225_72-Hf-174
153	72-Hf-176	7231	JENDL-4.0	200	n_7231_72-Hf-176
154	72-Hf-177	7234	JENDL-4.0	200	n_7234_72-Hf-177
155	72-Hf-178	7237	JENDL-4.0	200	n_7237_72-Hf-178
156	72-Hf-179	7240	JENDL-4.0	200	n_7240_72-Hf-179
157	72-Hf-180	7243	JENDL-4.0	200	n_7243_72-Hf-180
158	73-Ta-181	7328	JENDL-4.0	150	n_7328_73-Ta-181
159	74-W-180	7425	INDL/V-3	150	n_7425_74-W-180
160	74-W-182	7431	INDL/V-3	150	n_7431_74-W-182
161	74-W-183	7434	INDL/V-3	150	n_7434_74-W-183
162	74-W-184	7437	INDL/V-3	150	n_7437_74-W-184
163	74-W-186	7443	INDL/V-3	150	n_7443_74-W-186
164	75-Re-185	7525	TENDL-2010	200	n_7525_75-Re-185
165	75-Re-187	7531	TENDL-2010	200	n_7531_75-Re-187
166	78-Pt-190	7825	TENDL-2010	200	n_7825_78-Pt-190
167	78-Pt-192	7831	TENDL-2010	200	n_7831_78-Pt-192
168	78-Pt-194	7837	TENDL-2010	200	n_7837_78-Pt-194
169	78-Pt-195	7840	TENDL-2010	200	n_7840_78-Pt-195
170	78-Pt-196	7843	TENDL-2010	200	n_7843_78-Pt-196
171	78-Pt-198	7849	TENDL-2010	200	n_7849_78-Pt-198
172	79-Au-197	7925	ENDF/B-VII	150	n_7925_79-Au-197
173	82-Pb-204	8225	JEFF-3.1.1	200	n_8225_82-Pb-204
174	82-Pb-206	8231	JEFF-3.1.1	200	n_8231_82-Pb-206
175	82-Pb-207	8234	JEFF-3.1.1	200	n_8234_82-Pb-207
176	82-Pb-208	8237	JEFF-3.1.1	200	n_8237_82-Pb-208
177	83-Bi-209	8325	JEFF-3.1.1	200	n_8325_83-Bi-209
178	90-Th-232	9040	ENDF/B-VII.1	60	n_9040_90-Th-232
179	92-U-235	9228	ENDF/B-VII	150	n_9228_92-U-235
180	92-U-238	9237	ENDF/B-VII	150	n_9237_92-U-238

The number of elements included in the FENDL-3.0 library has been increased from 36 to 59 and all the evaluations contain isotopic data, therefore the number of materials has been increased from 71 in FENDL-2.1 up to 180 in FENDL-3.0.

As in FENDL-2.1 the photo atomic evaluated data were taken from ENDF/B-VI.8 (EDPL-97) for all the elements. General information of photo-atomic data is presented in Table 2.

Table 2: Photo-atomic evaluated data for FENDL-3.0

No.	Element	MAT	Isotopes	Library	Filename [*.txt]
1	H	100	1-H-1	ENDF/B-VI.8	ph_0100_1-H
			1-H-2		
			1-H-3		
2	He	200	2-He-3	ENDF/B-VI.8	ph_0200_2-He
			2-He-4		
3	Li	300	3-Li-6	ENDF/B-VI.8	ph_0300_3-Li
			3-Li-7		
4	Be	400	4-Be-9	ENDF/B-VI.8	ph_0400_4-Be
5	B	500	5-B-10	ENDF/B-VI.8	ph_0500_5-B
			5-B-11		

No.	Element	MAT	Isotopes	Library	Filename [*.txt]
6	C	600	6-C-12	ENDF/B-VI.8	ph_0600_6-C
			6-C-13		
7	N	700	7-N-15	ENDF/B-VI.8	ph_0700_7-N
			7-N-14		
8	O	800	8-O-16	ENDF/B-VI.8	ph_0800_8-O
			8-O-17		
			8-O-18		
9	F	900	9-F-19	ENDF/B-VI.8	ph_0900_9-F
10	Na	1100	11-Na-23	ENDF/B-VI.8	ph_1100_11-Na
11	Mg	1200	12-Mg-24	ENDF/B-VI.8	ph_1200_12-Mg
			12-Mg-25		
			12-Mg-26		
12	Al	1300	13-Al-27	ENDF/B-VI.8	ph_1300_13-Al
13	Si	1400	14-Si-28	ENDF/B-VI.8	ph_1400_14-Si
			14-Si-29		
			14-Si-30		
14	P	1500	15-P-31	ENDF/B-VI.8	ph_1500_15-P
15	S	1600	16-S-32	ENDF/B-VI.8	ph_1600_16-S
			16-S-33		
			16-S-34		
			16-S-36		
16	Cl	1700	17-Cl-35	ENDF/B-VI.8	ph_1700_17-Cl
			17-Cl-37		
17	Ar	1800	18-Ar-36	ENDF/B-VI.8	ph_1800_18-Ar
			18-Ar-38		
			18-Ar-40		
18	K	1900	19-K-39	ENDF/B-VI.8	ph_1900_19-K
			19-K-40		
			19-K-41		
19	Ca	2000	20-Ca-40	ENDF/B-VI.8	ph_2000_20-Ca
			20-Ca-42		
			20-Ca-43		
			20-Ca-44		
			20-Ca-46		
			20-Ca-48		
20	Sc	2100	21-Sc-45	ENDF/B-VI.8	ph_2100_21-Sc
21	Ti	2200	22-Ti-46	ENDF/B-VI.8	ph_2200_22-Ti
			22-Ti-47		
			22-Ti-48		
			22-Ti-49		
			22-TI-50		
22	V	2300	23-V-50	ENDF/B-VI.8	ph_2300_23-V
			23-V-51		
23	Cr	2400	24-Cr-50	ENDF/B-VI.8	ph_2400_24-Cr
			24-Cr-52		
			24-Cr-53		
			24-Cr-54		
24	Mn	2500	25-Mn-55	ENDF/B-VI.8	ph_2500_25-Mn
25	Fe	2600	26-Fe-54	ENDF/B-VI.8	ph_2600_26-Fe
			26-Fe-56		
			26-Fe-57		
			26-Fe-58		

No.	Element	MAT	Isotopes	Library	Filename [*.txt]
26	Co	2700	27-Co-59	ENDF/B-VI.8	ph_2700_27-Co
27	Ni	2800	28-Ni-58	ENDF/B-VI.8	ph_2800_28-Ni
			28-Ni-60		
			28-Ni-61		
			28-Ni-62		
			28-Ni-64		
28	Cu	2900	29-Cu-63	ENDF/B-VI.8	ph_2900_29-Cu
			29-Cu-65		
29	Zn	3000	30-Zn-64	ENDF/B-VI.8	ph_3000_30-Zn
			30-Zn-66		
			30-Zn-67		
			30-Zn-68		
			30-Zn-70		
30	Ga	3100	31-Ga-69	ENDF/B-VI.8	ph_3100_31-Ga
			31-Ga-71		
31	Ge	3200	32-Ge-70	ENDF/B-VI.8	ph_3200_32-Ge
			32-Ge-72		
			32-Ge-73		
			32-Ge-74		
			32-Ge-76		
32	Br	3500	35-Br-79	ENDF/B-VI.8	ph_3500_35-Br
			35-Br-81		
33	Y	3900	39-Y-89	ENDF/B-VI.8	ph_3900_39-Y
34	Zr	4000	40-Zr-90	ENDF/B-VI.8	ph_4000_40-Zr
			40-Zr-91		
			40-Zr-92		
			40-Zr-94		
			40-Zr-96		
35	Nb	4100	41-Nb-93	ENDF/B-VI.8	ph_4100_41-Nb
36	Mo	4200	42-Mo-92	ENDF/B-VI.8	ph_4200_42-Mo
			42-Mo-94		
			42-Mo-95		
			42-Mo-96		
			42-Mo-97		
			42-Mo-98		
			42-Mo-100		
37	Rh	4500	45-Rh-103	ENDF/B-VI.8	ph_4500_45-Rh
38	Ag	4700	47-Ag-107	ENDF/B-VI.8	ph_4700_47-Ag
			47-Ag-109		
39	Cd	4800	48-Cd-106	ENDF/B-VI.8	ph_4800_48-Cd
			48-Cd-108		
			48-Cd-110		
			48-Cd-111		
			48-Cd-112		
			48-Cd-113		
			48-Cd-114		
			48-Cd-116		
40	Sn	5000	50-Sn-112	ENDF/B-VI.8	ph_5000_50-Sn
			50-Sn-114		
			50-Sn-115		
			50-Sn-116		
			50-Sn-117		

No.	Element	MAT	Isotopes	Library	Filename [*.txt]
			50-Sn-118		
			50-Sn-119		
			50-Sn-120		
			50-Sn-122		
			50-Sn-124		
41	Sb	5100	51-Sb-121	ENDF/B-VI.8	ph_5100_51-Sb
			51-Sb-123		
42	I	5300	53-I-127	ENDF/B-VI.8	ph_5300_53-I
43	Cs	5500	55-Cs-133	ENDF/B-VI.8	ph_5500_55-Cs
44	Ba	5600	56-Ba-130	ENDF/B-VI.8	ph_5600_56-Ba
			56-Ba-132		
			56-Ba-134		
			56-Ba-135		
			56-Ba-136		
			56-Ba-137		
			56-Ba-138		
45	La	5700	57-La-138	ENDF/B-VI.8	ph_5700_57-La
			57-La-139		
46	Ce	5800	58-Ce-136	ENDF/B-VI.8	ph_5800_58-Ce
			58-Ce-138		
			58-Ce-140		
			58-Ce-142		
47	Gd	6400	64-Gd-152	ENDF/B-VI.8	ph_6400_64-Gd
			64-Gd-154		
			64-Gd-155		
			64-Gd-156		
			64-Gd-157		
			64-Gd-158		
			64-Gd-160		
48	Er	6800	68-Er-162	ENDF/B-VI.8	ph_6800_68-Er
			68-Er-164		
			68-Er-166		
			68-Er-167		
			68-Er-168		
			68-Er-170		
49	Lu	7100	71-Lu-175	ENDF/B-VI.8	ph_7100_71-Lu
			71-Lu-176		
50	Hf	7200	72-Hf-174	ENDF/B-VI.8	ph_7200_72-Hf
			72-Hf-176		
			72-Hf-177		
			72-Hf-178		
			72-Hf-179		
			72-Hf-180		
51	Ta	7300	73-Ta-181	ENDF/B-VI.8	ph_7300_73-Ta
52	W	7400	74-W-180	ENDF/B-VI.8	ph_7400_74-W
			74-W-182		
			74-W-183		
			74-W-184		
			74-W-186		
53	Re	7500	75-Re-185	ENDF/B-VI.8	ph_7500_75-Re
			75-Re-187		
54	Pt	7800	78-Pt-190	ENDF/B-VI.8	ph_7800_78-Pt

No.	Element	MAT	Isotopes	Library	Filename [*.txt]
			78-Pt-192		
			78-Pt-194		
			78-Pt-195		
			78-Pt-196		
			78-Pt-198		
55	Au	7900	79-Au-197	ENDF/B-VI.8	ph_7900_79-Au
56	Pb	8200	82-Pb-204	ENDF/B-VI.8	ph_8200_82-Pb
			82-Pb-206		
			82-Pb-207		
			82-Pb-208		
57	Bi	8300	83-Bi-209	ENDF/B-VI.8	ph_8300_83-Bi
58	Th	9000	90-Th-232	ENDF/B-VI.8	ph_9000_90-Th
59	U	9200	92-U-235 92-U-238	ENDF/B-VI.8	ph_9200_92-U

2. Processing FENDL/E-3.0 data for fusion applications

The FENDL/E-3.0 evaluated nuclear data files were processed using the NJOY-99.364 modular code system with local updates at IAEA-NDS. Particularly, two additional updates were required to successfully process the FENDL-3.0 evaluations, the first one for ACER and the second one for HEATR (Appendix 1). The update of ACER is a correction to the update up360 included in the official release of NJOY-99.364. On the other hand, the update of HEATR allows the processing of large sections for angular distributions in File 4 (MF4) as found in some FENDL-3.0 evaluations.

The processing sequence for generating the FENDL/MC-3.0 and FENDL/MG-3.0 libraries is shown in Figure 1. FENDL/MC-3.0 is an ACE-formatted library suitable for use by the MCNP family of Monte-Carlo codes [8]. FENDL/MG-3.0 is a multi-group-formatted library, intended for use in deterministic transport codes like DORT and TORT [9].

The main processing options and their specifications are given in Refs. [1,10,11]. A summary of the main processing options is presented below for completeness:

- Reconstruction tolerance in RECONR: 0.1%.
- Resonance-integral-check tolerance in RECONR: 0.2%.
- Maximum resonance integral error in RECONR: 5.0E-08 (default for 0.1%).
- Temperature: 300K = 2.5852E-08 MeV.
- Thinning tolerance in BROADR: 0.1%.
- Integral criterion tolerance in BROADR: 0.2%.
- Integral thinning tolerance in BROADR: 5.0E-0.8 (default for 0.1%).
- Maximum energy in BROADR: 20 MeV.
- Number of probability bins in PURR: 20.
- Number of resonance ladders: 100.
- Bondarenko σ_0 values: 10^{10}, 10^5, 10^4, 10^3, 300, 100, 30, 10, 3, 1, 0.3, 0.1, 0.001 barns, not more than 10 out of this list (Table 3).
- No thermal data.
- No thinning in ACER.
- ACE-type 1 file.
- Suffix for zaid in ACER: .30
- New cumulative angle distributions in ACER.

- Detailed photon calculation in ACER.
- Neutron groups: 211 energy groups, 175 group Vitamin-J structure + 36 1 MeV bins up to 55 MeV (Appendix 2)
- Gamma groups: 42 in Vitamin-J structure.
- Neutron weight function: VITAMIN-E (IWT=11 in NJOY).
- Gamma weight function: 1/E with roll-offs (IWT=3 in NJOY).
- Legendre order: P-6 for transport correction to P-5.
- Reactions included: all reactions contained in the evaluated FENDL/E-3.0 file plus total kerma (MT = 301), partial kermas (MT=302, 304, 404), total kinematic kerma (MT = 443), total damage (MT = 444) and gas production (MT=200s). For multi-group calculations, MT = 251 (μ), MT = 252 (χ), MT = 253 (γ) and MT = 259 (1/v) are also included.

Comparing to the FENDL-2.1 processing options there are some changes:

- Tighter integral resonance criterion in RECONR and BROADR (0.2% instead of 0.3%)
- Higher upper energy limit in BROADR for Doppler broadening (20 instead of 2 MeV)
- 211-group energy structure up to 55 MeV instead of the 175-group Vitamin J energy structure up to 19.6403 MeV in GROUPR, GAMINR and MATXSR.
- Calculation of more partial kinematic kermas in HEATR

It should be noted, that the plotting options of HEATR and ACER were used for quality assurance issues. Some examples of NJOY input options are given in Appendix 3. A complete set of NJOY inputs is available on the IAEA-NDS webpage.

All the evaluated data files were processed and the continuous energy cross section library FENDL/MC-3.0 and the FENDL/MG-3.0 multi-group library were generated for fusion applications.

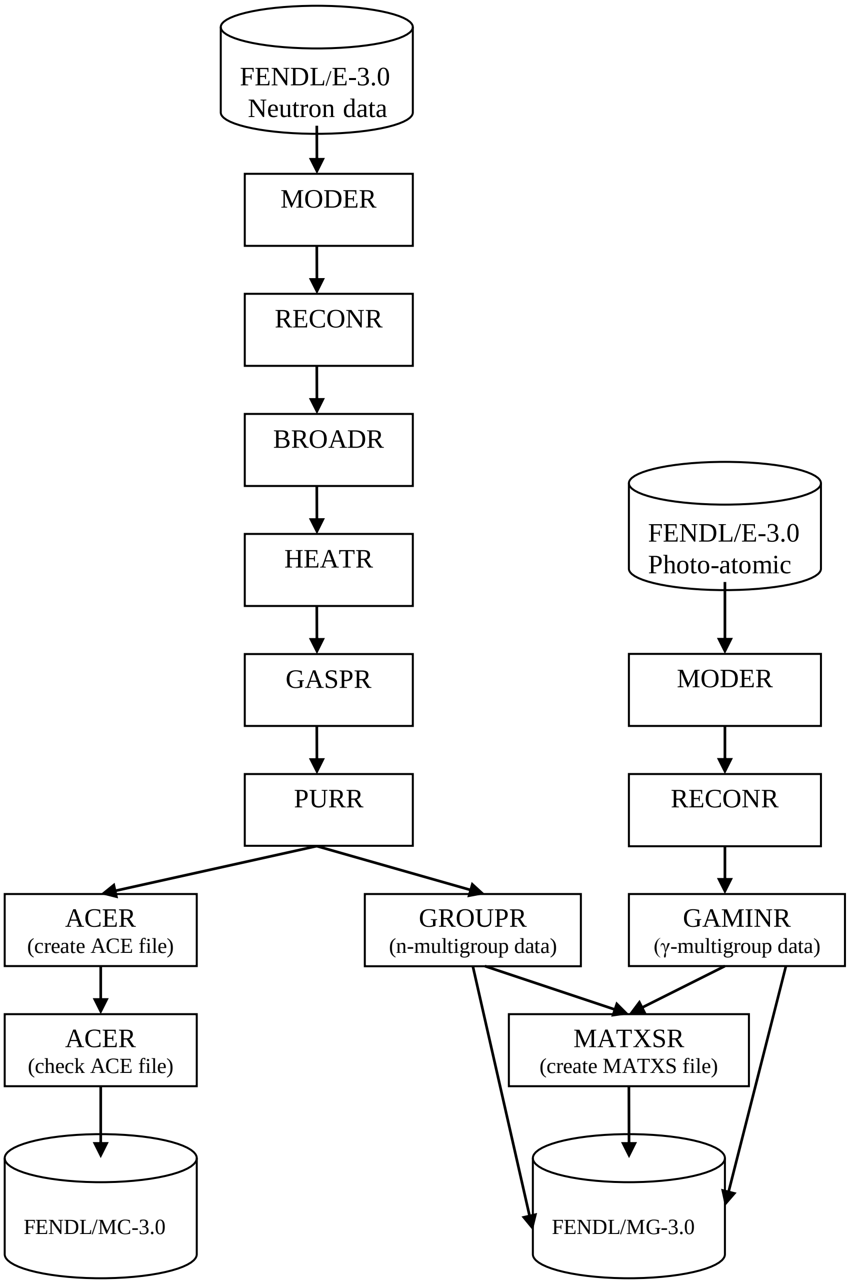

Fig. 1: NJOY processing sequence for FENDL/MC-3.0 and FENDL/MG-3.0.

Table 3: Bondarenko σ_0 values for the multi-group data files.

Material	**10^{10}**	**10^5**	**10^4**	**310^3**	**10^3**	**300.**	**100.**	**30.**	**10.**	**3.**	**1.**	**0.3**	**0.1**	**.001**
1-H-1	X													
1-H-2	X		X		X		X		X		X			
1-H-3	X													
2-He-3	X													
2-He-4	X													
3-Li-6	X													
3-Li-7	X													
4-Be-9	X		X		X	X	X	X	X		X		X	X
5-B-10	X													
5-B-11	X													
6-C-12	X		X		X	X	X	X	X		X		X	X
6-C-13	X		X		X	X	X	X	X		X		X	X
7-N-14	X		X		X	X	X	X	X		X		X	X
7-N-15	X													
8-O-16	X		X		X	X	X	X	X		X		X	X
8-O-17	X		X		X	X	X	X	X		X		X	X
8-O-18	X		X		X	X	X	X	X		X		X	X
9-F-19	X													
11-Na-23	X													
12-Mg-24	X													
12-Mg-25	X													
12-Mg-26	X													
13-Al-27	X													
14-Si-28	X						X		X		X			
14-Si-29	X						X		X		X			
14-Si-30	X						X		X		X			
15-P-31	X													
16-S-32	X				X	X	X	X	X					
16-S-33	X				X	X	X	X	X					
16-S-34	X				X	X	X	X	X					
16-S-36	X				X	X	X	X	X					
17-Cl-35	X				X	X	X	X	X					
17-Cl-37	X				X	X	X	X	X					
18-Ar-36	X				X	X	X	X	X					
18-Ar-38	X				X	X	X	X	X					
18-Ar-40	X				X	X	X	X	X					
19-K-39	X				X	X	X	X	X					
19-K-40	X				X	X	X	X	X					
19-K-41	X				X	X	X	X	X					
20-Ca-40	X				X	X	X	X	X	X	X			
20-Ca-42	X				X	X	X	X	X	X	X			
20-Ca-43	X				X	X	X	X	X	X	X			
20-Ca-44	X				X	X	X	X	X	X	X			
20-Ca-46	X				X	X	X	X	X	X	X			
20-Ca-48	X				X	X	X	X	X	X	X			
21-Sc-45	X		X		X	X	X	X	X	X	X			
22-Ti-46	X		X		X	X	X	X	X	X	X			
22-Ti-47	X		X		X	X	X	X	X	X	X			
22-Ti-48	X		X		X	X	X	X	X	X	X			
22-Ti-49	X		X		X	X	X	X	X	X	X			
22-Ti-50	X		X		X	X	X	X	X	X	X			

Material	**10^{10}**	**10^{5}**	**10^{4}**	**310^{3}**	**10^{3}**	**300.**	**100.**	**30.**	**10.**	**3.**	**1.**	**0.3**	**0.1**	**.001**
23-V-50	X		X		X	X	X	X	X		X		X	X
23-V-50	X		X		X	X	X	X	X		X		X	X
24-Cr-50	X				X	X	X	X	X	X	X			
24-Cr-52	X				X	X	X	X	X	X	X			
24-Cr-53	X				X	X	X	X	X	X	X			
24-Cr-54	X				X	X	X	X	X	X	X			
25-Mn-55	X	X			X		X		X		X			
26-Fe-54	X	X	X		X		X		X					
26-Fe-56	X	X	X		X		X		X	X	X	X	X	
26-Fe-57	X	X	X		X		X		X					
26-Fe-58	X	X	X		X		X		X					
27-Co-59	X	X	X		X		X		X					
28-Ni-58	X				X	X	X	X	X	X	X			
28-Ni-60	X				X	X	X	X	X	X	X			
28-Ni-61	X				X	X	X	X	X	X	X			
28-Ni-62	X				X	X	X	X	X	X	X			
28-Ni-64	X				X	X	X	X	X	X	X			
29-Cu-63	X		X			X	X	X	X		X		X	
29-Cu-65	X		X			X	X	X	X		X		X	
30-Zn-64	X		X			X	X	X	X		X		X	
30-Zn-66	X		X			X	X	X	X		X		X	
30-Zn-67	X		X			X	X	X	X		X		X	
30-Zn-68	X		X			X	X	X	X		X		X	
30-Zn-70	X		X			X	X	X	X		X		X	
31-Ga-69	X		X		X	X	X	X	X		X		X	X
31-Ga-71	X		X		X	X	X	X	X		X		X	X
32-Ge-70	X		X		X	X	X	X	X		X		X	X
32-Ge-72	X		X		X	X	X	X	X		X		X	X
32-Ge-73	X		X		X	X	X	X	X		X		X	X
32-Ge-74	X		X		X	X	X	X	X		X		X	X
32-Ge-76	X		X		X	X	X	X	X		X		X	X
35-Br-79	X		X		X	X	X	X	X		X		X	X
35-Br-81	X		X		X	X	X	X	X		X		X	X
39-Y-89	X		X		X	X	X	X	X		X		X	X
40-Zr-90	X		X		X	X	X	X	X		X		X	X
40-Zr-91	X		X		X	X	X	X	X		X		X	X
40-Zr-92	X		X		X	X	X	X	X		X		X	X
40-Zr-94	X		X		X	X	X	X	X		X		X	X
40-Zr-96	X		X		X	X	X	X	X		X		X	X
41-Nb-93	X		X		X	X	X	X	X		X		X	X
42-Mo-92	X		X		X	X	X	X	X		X		X	X
42-Mo-94	X		X		X	X	X	X	X		X		X	X
42-Mo-95	X		X		X	X	X	X	X		X		X	X
42-Mo-96	X		X		X	X	X	X	X		X		X	X
42-Mo-97	X		X		X	X	X	X	X		X		X	X
42-Mo-98	X		X		X	X	X	X	X		X		X	X
42-Mo-100	X		X		X	X	X	X	X		X		X	X
45-Rh-103	X		X		X	X	X	X	X		X		X	X
47-Ag-107	X		X		X	X	X	X	X		X		X	X
47-Ag-109	X		X		X	X	X	X	X		X		X	X
48-Cd-106	X		X		X	X	X	X	X		X		X	X
48-Cd-108	X		X		X	X	X	X	X		X		X	X

Material	10^{10}	10^5	10^4	310^3	10^3	300.	100.	30.	10.	3.	1.	0.3	0.1	.001
48-Cd-110	X		X		X	X	X	X	X		X		X	X
48-Cd-111	X		X		X	X	X	X	X		X		X	X
48-Cd-112	X		X		X	X	X	X	X		X		X	X
48-Cd-113	X		X		X	X	X	X	X		X		X	X
48-Cd-114	X		X		X	X	X	X	X		X		X	X
48-Cd-116	X		X		X	X	X	X	X		X		X	X
50-Sn-112	X		X		X	X	X	X	X		X		X	X
50-Sn-114	X		X		X	X	X	X	X		X		X	X
50-Sn-115	X		X		X	X	X	X	X		X		X	X
50-Sn-116	X		X		X	X	X	X	X		X		X	X
50-Sn-117	X		X		X	X	X	X	X		X		X	X
50-Sn-118	X		X		X	X	X	X	X		X		X	X
50-Sn-119	X		X		X	X	X	X	X		X		X	X
50-Sn-120	X		X		X	X	X	X	X		X		X	X
50-Sn-122	X		X		X	X	X	X	X		X		X	X
50-Sn-124	X		X		X	X	X	X	X		X		X	X
51-Sb-121	X		X		X	X	X	X	X		X		X	X
51-Sb-123	X		X		X	X	X	X	X		X		X	X
53-I-127	X		X		X	X	X	X	X		X		X	X
55-Cs-133	X		X		X	X	X	X	X		X		X	X
56-Ba-130	X		X		X	X	X	X	X		X		X	X
56-Ba-132	X		X		X	X	X	X	X		X		X	X
56-Ba-134	X		X		X	X	X	X	X		X		X	X
56-Ba-135	X		X		X	X	X	X	X		X		X	X
56-Ba-136	X		X		X	X	X	X	X		X		X	X
56-Ba-137	X		X		X	X	X	X	X		X		X	X
56-Ba-138	X		X		X	X	X	X	X		X		X	X
57-La-138	X		X		X	X	X	X	X		X		X	X
57-La-139	X		X		X	X	X	X	X		X		X	X
58-Ce-136	X		X		X	X	X	X	X		X		X	X
58-Ce-138	X		X		X	X	X	X	X		X		X	X
58-Ce-140	X		X		X	X	X	X	X		X		X	X
58-Ce-142	X		X		X	X	X	X	X		X		X	X
64-Gd-152	X		X		X	X	X	X	X		X		X	X
64-Gd-154	X		X		X	X	X	X	X		X		X	X
64-Gd-155	X		X		X	X	X	X	X		X		X	X
64-Gd-156	X		X		X	X	X	X	X		X		X	X
64-Gd-157	X		X		X	X	X	X	X		X		X	X
64-Gd-158	X		X		X	X	X	X	X		X		X	X
64-Gd-160	X		X		X	X	X	X	X		X		X	X
68-Er-162	X		X		X	X	X	X	X		X		X	X
68-Er-164	X		X		X	X	X	X	X		X		X	X
68-Er-166	X		X		X	X	X	X	X		X		X	X
68-Er-167	X		X		X	X	X	X	X		X		X	X
68-Er-168	X		X		X	X	X	X	X		X		X	X
68-Er-170	X		X		X	X	X	X	X		X		X	X
71-Lu-175	X		X		X	X	X	X	X		X		X	X
71-Lu-176	X		X		X	X	X	X	X		X		X	X
72-Hf-174	X		X		X	X	X	X	X		X		X	X
72-Hf-176	X		X		X	X	X	X	X		X		X	X
72-Hf-177	X		X		X	X	X	X	X		X		X	X
72-Hf-178	X		X		X	X	X	X	X		X		X	X

Material	**10^{10}**	**10^5**	**10^4**	**310^3**	**10^3**	**300.**	**100.**	**30.**	**10.**	**3.**	**1.**	**0.3**	**0.1**	**.001**
72-Hf-180	X		X		X	X	X	X	X		X		X	X
73-Ta-181	X		X		X		X		X					
W-182	X		X		X	X	X	X	X		X		X	X
W-183	X		X		X	X	X	X	X		X		X	X
W-184	X		X		X	X	X	X	X		X		X	X
W-186	X		X		X	X	X	X	X		X		X	X
75-Re-185	X		X		X	X	X	X	X		X		X	X
75-Re-187	X		X		X	X	X	X	X		X		X	X
78-Pt-190	X		X		X	X	X	X	X		X		X	X
78-Pt-192	X		X		X	X	X	X	X		X		X	X
78-Pt-194	X		X		X	X	X	X	X		X		X	X
78-Pt-195	X		X		X	X	X	X	X		X		X	X
78-Pt-196	X		X		X	X	X	X	X		X		X	X
78-Pt-198	X		X		X	X	X	X	X		X		X	X
79-Au-197	X		X		X	X	X	X	X		X			
82-Pb-204	X				X		X		X		X			
82-Pb-206	X				X		X		X		X			
82-Pb-207	X				X		X		X		X			
82-Pb-208	X				X		X		X		X			
83-Bi-209	X		X		X		X		X					
90-Th-232	X		X		X		X	X	X	X	X		X	X
92-U-235	X		X	X	X	X	X	X	X	X	X			
92-U-238	X		X		X		X	X	X	X	X		X	X

3. Continuous-energy data library FENDL/MC-3.0 for MCNP

FENDL/MC-3.0 contains point-wise cross section data files for use in the Monte Carlo code MCNP. Two files are given for each material: one with extension "`.ace`" for the cross section data file in ACE type 1 (ASCII) format and the second one with extension "`.xdr`" with the information required by the XSDIR file from MCNP code system. Both files are prepared by the ACER module of NJOY-99. The `.xdr` files were rewritten by the UpdXSDIR code to give the correct ACE filename and to update the route to 0. Table 4 summarizes the information on the FENDL/MC-3.0 library. All the files were created at 300K, and probability tables (PT) were generated for those materials containing unresolved resonance data.

Table 4: FENDL/MC-3.0 library-summary.

No.	MATERIAL	ZAID	E_{max} [MeV]	PT	Filenames [*.ace],[*.xdr]
1	1-H-1	1001.30c	150		01H_001
2	1-H-2	1002.30c	150		01H_002
3	1-H-3	1003.30c	60		01H_003
4	2-He-3	2003.30c	60		02He003
5	2-He-4	2004.30c	60		02He004
6	3-Li-6	3006.30c	200		03Li006
7	3-Li-7	3007.30c	200		03Li007
8	4-Be-9	4009.30c	200		04Be009
9	5-B-10	5010.30c	200		05B_010
10	5-B-11	5011.30c	200		05B_011
11	6-C-12	6012.30c	150		06C_012
12	6-C-13	6013.30c	200		06C_013

No.	MATERIAL	ZAID	E_{max} [MeV]	PT	Filenames [*.ace],[*.xdr]
13	7-N-14	7014.30c	200		07N_014
14	7-N-15	7015.30c	200		07N_015
15	8-O-16	8016.30c	150		08O_016
16	8-O-17	8017.30c	200		08O_017
17	8-O-18	8018.30c	200		08O_018
18	9-F-19	9019.30c	150		09F_019
19	11-Na-23	11023.30c	150		11Na023
20	12-Mg-24	12024.30c	150		12Mg024
21	12-Mg-25	12025.30c	150		12Mg025
22	12-Mg-26	12026.30c	150		12Mg026
23	13-Al-27	13027.30c	150		13Al027
24	14-Si-28	14028.30c	150		14Si028
25	14-Si-29	14029.30c	150		14Si029
26	14-Si-30	14030.30c	150		14Si030
27	15-P-31	15031.30c	200		15P_031
28	16-S-32	16032.30c	200		16S_032
29	16-S-33	16033.30c	200		16S_033
30	16-S-34	16034.30c	200		16S_034
31	16-S-36	16036.30c	200		16S_036
32	17-Cl-35	17035.30c	200		17Cl035
33	17-Cl-37	17037.30c	150		17Cl037
34	18-Ar-36	18036.30c	150		18Ar036
35	18-Ar-38	18038.30c	150		18Ar038
36	18-Ar-40	18040.30c	150		18Ar040
37	19-K-39	19039.30c	150		19K_039
38	19-K-40	19040.30c	150		19K_040
39	19-K-41	19041.30c	150		19K_041
40	20-Ca-40	20040.30c	150		20Ca040
41	20-Ca-42	20042.30c	150		20Ca042
42	20-Ca-43	20043.30c	150		20Ca043
43	20-Ca-44	20044.30c	150		20Ca044
44	20-Ca-46	20046.30c	150		20Ca046
45	20-Ca-48	20048.30c	150		20Ca048
46	21-Sc-45	21045.30c	200		21Sc045
47	22-Ti-46	22046.30c	150		22Ti046
48	22-Ti-47	22047.30c	150		22Ti047
49	22-Ti-48	22048.30c	150		22Ti048
50	22-Ti-49	22049.30c	150		22Ti049
51	22-Ti-50	22050.30c	150		22Ti050
52	23-V-50	23050.30c	150		23V_050
53	23-V-51	23051.30c	150		23V_051
54	24-Cr-50	24050.30c	200		24Cr050
55	24-Cr-52	24052.30c	150		24Cr052
56	24-Cr-53	24053.30c	200		24Cr053
57	24-Cr-54	24054.30c	200		24Cr054
58	25-Mn-55	25055.30c	60	X	25Mn055
59	26-Fe-54	26054.30c	150		26Fe054
60	26-Fe-56	26056.30c	200		26Fe056
61	26-Fe-57	26057.30c	150		26Fe057
62	26-Fe-58	26058.30c	200	X	26Fe058
63	27-Co-59	27059.30c	150		27Co059

No.	MATERIAL	ZAID	E_{max} [MeV]	PT	Filenames [*.ace],[*.xdr]
64	28-Ni-58	28058.30c	150		28Ni058
65	28-Ni-60	28060.30c	150		28Ni060
66	28-Ni-61	28061.30c	150		28Ni061
67	28-Ni-62	28062.30c	150		28Ni062
68	28-Ni-64	28064.30c	150		28Ni064
69	29-Cu-63	29063.30c	150		29Cu063
70	29-Cu-65	29065.30c	150		29Cu065
71	30-Zn-64	30064.30c	150	X	30Zn064
72	30-Zn-66	30066.30c	150	X	30Zn066
73	30-Zn-67	30067.30c	150	X	30Zn067
74	30-Zn-68	30068.30c	150	X	30Zn068
75	30-Zn-70	30070.30c	150	X	30Zn070
76	31-Ga-69	31069.30c	150	X	31Ga069
77	31-Ga-71	31071.30c	150	X	31Ga071
78	32-Ge-70	32070.30c	200		32Ge070
79	32-Ge-72	32072.30c	200		32Ge072
80	32-Ge-73	32073.30c	200		32Ge073
81	32-Ge-74	32074.30c	200		32Ge074
82	32-Ge-76	32076.30c	200		32Ge076
83	35-Br-79	35079.30c	200	X	35Br079
84	35-Br-81	35081.30c	200	X	35Br081
85	39-Y-89	39089.30c	200		39Y_089
86	40-Zr-90	40090.30c	150	X	40Zr090
87	40-Zr-91	40091.30c	150	X	40Zr091
88	40-Zr-92	40092.30c	150	X	40Zr092
89	40-Zr-94	40094.30c	150	X	40Zr094
90	40-Zr-96	40096.30c	150	X	40Zr096
91	41-Nb-93	41093.30c	150	X	41Nb093
92	42-Mo-92	42092.30c	150	X	42Mo092
93	42-Mo-94	42094.30c	150	X	42Mo094
94	42-Mo-95	42095.30c	150	X	42Mo095
95	42-Mo-96	42096.30c	150	X	42Mo096
96	42-Mo-97	42097.30c	150	X	42Mo097
97	42-Mo-98	42098.30c	150	X	42Mo098
98	42-Mo-100	42100.30c	150	X	42Mo100
99	45-Rh-103	45103.30c	200	X	45Rh103
100	47-Ag-107	47107.30c	200	X	47Ag107
101	47-Ag-109	47109.30c	200	X	47Ag109
102	48-Cd-106	48106.30c	200	X	48Cd106
103	48-Cd-108	48108.30c	200	X	48Cd108
104	48-Cd-110	48110.30c	200	X	48Cd110
105	48-Cd-111	48111.30c	200	X	48Cd111
106	48-Cd-112	48112.30c	200	X	48Cd112
107	48-Cd-113	48113.30c	200	X	48Cd113
108	48-Cd-114	48114.30c	200	X	48Cd114
109	48-Cd-116	48116.30c	200	X	48Cd116
110	50-Sn-112	50112.30c	200	X	50Sn112
111	50-Sn-114	50114.30c	200	X	50Sn114
112	50-Sn-115	50115.30c	200	X	50Sn115
113	50-Sn-116	50116.30c	200	X	50Sn116
114	50-Sn-117	50117.30c	200	X	50Sn117

No.	MATERIAL	ZAID	E_{max} [MeV]	PT	Filenames [*.ace],[*.xdr]
115	50-Sn-118	50118.30c	200	X	50Sn118
116	50-Sn-119	50119.30c	200	X	50Sn119
117	50-Sn-120	50120.30c	200	X	50Sn120
118	50-Sn-122	50122.30c	200	X	50Sn122
119	50-Sn-124	50124.30c	200	X	50Sn124
120	51-Sb-121	51121.30c	200	X	51Sb121
121	51-Sb-123	51123.30c	200	X	51Sb123
122	53-I-127	53127.30c	200	X	53I_127
123	55-Cs-133	55133.30c	200	X	55Cs133
124	56-Ba-130	56130.30c	200	X	56Ba130
125	56-Ba-132	56132.30c	200	X	56Ba132
126	56-Ba-134	56134.30c	200	X	56Ba134
127	56-Ba-135	56135.30c	200	X	56Ba135
128	56-Ba-136	56136.30c	200	X	56Ba136
129	56-Ba-137	56137.30c	200	X	56Ba137
130	56-Ba-138	56138.30c	200		56Ba138
131	57-La-138	57138.30c	200	X	57La138
132	57-La-139	57139.30c	200	X	57La139
133	58-Ce-136	58136.30c	200	X	58Ce136
134	58-Ce-138	58138.30c	200	X	58Ce138
135	58-Ce-140	58140.30c	200		58Ce140
136	58-Ce-142	58142.30c	200	X	58Ce142
137	64-Gd-152	64152.30c	200	X	64Gd152
138	64-Gd-154	64154.30c	200	X	64Gd154
139	64-Gd-155	64155.30c	200	X	64Gd155
140	64-Gd-156	64156.30c	200	X	64Gd156
141	64-Gd-157	64157.30c	200	X	64Gd157
142	64-Gd-158	64158.30c	200	X	64Gd158
143	64-Gd-160	64160.30c	200	X	64Gd160
144	68-Er-162	68162.30c	200		68Er162
145	68-Er-164	68164.30c	200		68Er164
146	68-Er-166	68166.30c	200		68Er166
147	68-Er-167	68167.30c	200	X	68Er167
148	68-Er-168	68168.30c	200		68Er168
149	68-Er-170	68170.30c	200	X	68Er170
150	71-Lu-175	71175.30c	200	X	71Lu175
151	71-Lu-176	71176.30c	200	X	71Lu176
152	72-Hf-174	72174.30c	200	X	72Hf174
153	72-Hf-176	72176.30c	200	X	72Hf176
154	72-Hf-177	72177.30c	200	X	72Hf177
155	72-Hf-178	72178.30c	200	X	72Hf178
156	72-Hf-179	72179.30c	200	X	72Hf179
157	72-Hf-180	72180.30c	200	X	72Hf180
158	73-Ta-181	73181.30c	150	X	73Ta181
159	74-W-180	74180.30c	150		74W_180
160	74-W-182	74182.30c	150	X	74W_182
161	74-W-183	74183.30c	150	X	74W_183
162	74-W-184	74184.30c	150	X	74W_184
163	74-W-186	74186.30c	150	X	74W_186
164	75-Re-185	75185.30c	200	X	75Re185
165	75-Re-187	75187.30c	200	X	75Re187

No.	MATERIAL	ZAID	E_{max} [MeV]	PT	Filenames [*.ace],[*.xdr]
166	78-Pt-190	78190.30c	200		78Pt190
167	78-Pt-192	78192.30c	200		78Pt192
168	78-Pt-194	78194.30c	200		78Pt194
169	78-Pt-195	78195.30c	200		78Pt195
170	78-Pt-196	78196.30c	200		78Pt196
171	78-Pt-198	78198.30c	200		78Pt198
172	79-Au-197	79197.30c	150		79Au197
173	82-Pb-204	82204.30c	200		82Pb204
174	82-Pb-206	82206.30c	200		82Pb206
175	82-Pb-207	82207.30c	200		82Pb207
176	82-Pb-208	82208.30c	200		82Pb208
177	83-Bi-209	83209.30c	200		83Bi209
178	90-Th-232	90232.30c	60	X	90Th232
179	92-U-235	92235.30c	150	X	92U_235
180	92-U-238	92238.30c	150	X	92U_238

4. Multi-group cross section data library FENDL/MG-3.0

FENDL/MG-3.0 contains neutron-photon coupled multi-group cross section data in MATXS (ASCII) format. These data can be easily processed by the code TRANXS [12] for further use in deterministic transport codes like DORT and TORT. For neutrons 211-energy groups were applied between 0.00001 eV and 55 MeV. Below 19.64 MeV the energy structure matches with the Vitamin-J 175-group energy structure, additionally one group is included between 19.64 and 20 MeV and 35 more groups are added between 20 and 55 MeV, having an energy-width equal to 1 MeV (see Appendix 2) . For photons the Vitamin-J 42-group energy structure was used between 1 KeV and 20 MeV. Cross section data are given at 300 K for the Bondarenko σ_0 values given in Table 3.

Three data files are supplied for each material: one with extension "`.m`" containing the MATXS-formatted cross section data, and two additional files with extensions "`.g`" and "`.gam`" containing respectively GROUPR and GAMINR output in GENDF format, which could be useful for sensitivity analysis or for re-formatting the multi-group cross section files using NJOY-99. Table 5 summarizes the FENDL/MG-3.0 multi-group data library.

Table 5: FENDL/MG-3.0 library-summary.

No.	MATERIAL	MAT (n)	MAT (γ)	MATXS ID	Filenames [*.m] n-γ- MATXS [*.g] n-GENDF [*.gam] γ-GENDF
1	1-H-1	125	100	h1	01H_001
2	1-H-2	128		d	01H_002
3	1-H-3	131		h3	01H_003
4	2-He-3	225	200	he3	02He003
5	2-He-4	228		he4	02He004
6	3-Li-6	325	300	li6	03Li006
7	3-Li-7	328		li7	03Li007
8	4-Be-9	425	400	be9	04Be009
9	5-B-10	525	500	b10	05B_010
10	5-B-11	528		b11	05B_011

No.	MATERIAL	MAT (n)	MAT (γ)	MATXS ID	Filenames [*.m] n-γ- MATXS [*.g] n-GENDF [*.gam] γ-GENDF
11	6-C-12	625	600	c12	06C_012
12	6-C-13	628		c13	06C_013
13	7-N-14	725	700	n14	07N_014
14	7-N-15	728		n15	07N_015
15	8-O-16	825	800	o16	08O_016
16	8-O-17	828		o17	08O_017
17	8-O-18	831		o18	08O_018
18	9-F-19	925	900	f19	09F_019
19	11-Na-23	1125	1100	na23	11Na023
20	12-Mg-24	1225	1200	mg24	12Mg024
21	12-Mg-25	1228		mg25	12Mg025
22	12-Mg-26	1231		mg26	12Mg026
23	13-Al-27	1325	1300	al27	13Al027
24	14-Si-28	1425	1400	si28	14Si028
25	14-Si-29	1428		si29	14Si029
26	14-Si-30	1431		si30	14Si030
27	15-P-31	1525	1500	p31	15P_031
28	16-S-32	1625	1600	s32	16S_032
29	16-S-33	1628		s33	16S_033
30	16-S-34	1631		s34	16S_034
31	16-S-36	1637		s36	16S_036
32	17-Cl-35	1725	1700	cl35	17Cl035
33	17-Cl-37	1731		cl37	17Cl037
34	18-Ar-36	1825	1800	ar36	18Ar036
35	18-Ar-38	1831		ar38	18Ar038
36	18-Ar-40	1837		ar40	18Ar040
37	19-K-39	1925	1900	k39	19K_039
38	19-K-40	1928		k40	19K_040
39	19-K-41	1931		k41	19K_041
40	20-Ca-40	2025	2000	ca40	20Ca040
41	20-Ca-42	2031		ca42	20Ca042
42	20-Ca-43	2034		ca43	20Ca043
43	20-Ca-44	2037		ca44	20Ca044
44	20-Ca-46	2043		ca46	20Ca046
45	20-Ca-48	2049		ca48	20Ca048
46	21-Sc-45	2125	2100	sc45	21Sc045
47	22-Ti-46	2225	2200	ti46	22Ti046
48	22-Ti-47	2228		ti47	22Ti047
49	22-Ti-48	2231		ti48	22Ti048
50	22-Ti-49	2234		ti49	22Ti049
51	22-Ti-50	2237		ti50	22Ti050
52	23-V-50	2325	2300	v50	23V_050
53	23-V-51	2328		v51	23V_051
54	24-Cr-50	2425	2400	cr50	24Cr050
55	24-Cr-52	2431		cr52	24Cr052
56	24-Cr-53	2434		cr53	24Cr053
57	24-Cr-54	2437		cr54	24Cr054
58	25-Mn-55	2525	2500	mn55	25Mn055
59	26-Fe-54	2625	2600	fe54	26Fe054

No.	MATERIAL	MAT (n)	MAT (γ)	MATXS ID	Filenames [*.m] n-γ- MATXS [*.g] n-GENDF [*.gam] γ-GENDF
60	26-Fe-56	2631		fe56	26Fe056
61	26-Fe-57	2634		fe57	26Fe057
62	26-Fe-58	2637		fe58	26Fe058
63	27-Co-59	2725	2700	co59	27Co059
64	28-Ni-58	2825	2800	ni58	28Ni058
65	28-Ni-60	2831		ni60	28Ni060
66	28-Ni-61	2834		ni61	28Ni061
67	28-Ni-62	2837		ni62	28Ni062
68	28-Ni-64	2843		ni64	28Ni064
69	29-Cu-63	2925	2900	cu63	29Cu063
70	29-Cu-65	2931		cu65	29Cu065
71	30-Zn-64	3025	3000	zn64	30Zn064
72	30-Zn-66	3031		zn66	30Zn066
73	30-Zn-67	3034		zn67	30Zn067
74	30-Zn-68	3037		zn68	30Zn068
75	30-Zn-70	3043		zn70	30Zn070
76	31-Ga-69	3125	3100	ga69	31Ga069
77	31-Ga-71	3131		ga71	31Ga071
78	32-Ge-70	3225	3200	ge70	32Ge070
79	32-Ge-72	3231		ge72	32Ge072
80	32-Ge-73	3234		ge73	32Ge073
81	32-Ge-74	3237		ge74	32Ge074
82	32-Ge-76	3243		ge76	32Ge076
83	35-Br-79	3525	3500	br79	35Br079
84	35-Br-81	3531		br81	35Br081
85	39-Y-89	3925	3900	y89	39Y_089
86	40-Zr-90	4025	4000	zr90	40Zr090
87	40-Zr-91	4028		zr91	40Zr091
88	40-Zr-92	4031		zr92	40Zr092
89	40-Zr-94	4037		zr94	40Zr094
90	40-Zr-96	4043		zr96	40Zr096
91	41-Nb-93	4125	4100	nb93	41Nb093
92	42-Mo-92	4225	4200	mo92	42Mo092
93	42-Mo-94	4231		mo94	42Mo094
94	42-Mo-95	4234		mo95	42Mo095
95	42-Mo-96	4237		mo96	42Mo096
96	42-Mo-97	4240		mo97	42Mo097
97	42-Mo-98	4243		mo98	42Mo098
98	42-Mo-100	4249		mo100	42Mo100
99	45-Rh-103	4525	4500	rh103	45Rh103
100	47-Ag-107	4725	4700	ag107	47Ag107
101	47-Ag-109	4731		ag109	47Ag109
102	48-Cd-106	4825	4800	cd106	48Cd106
103	48-Cd-108	4831		cd108	48Cd108
104	48-Cd-110	4837		cd110	48Cd110
105	48-Cd-111	4840		cd111	48Cd111
106	48-Cd-112	4843		cd112	48Cd112
107	48-Cd-113	4846		cd113	48Cd113
108	48-Cd-114	4849		cd114	48Cd114

No.	MATERIAL	MAT (n)	MAT (γ)	MATXS ID	Filenames [*.m] n-γ- MATXS [*.g] n-GENDF [*.gam] γ-GENDF
109	48-Cd-116	4855		cd116	48Cd116
110	50-Sn-112	5025	5000	sn112	50Sn112
111	50-Sn-114	5031		sn114	50Sn114
112	50-Sn-115	5034		sn115	50Sn115
113	50-Sn-116	5037		sn116	50Sn116
114	50-Sn-117	5040		sn117	50Sn117
115	50-Sn-118	5043		sn118	50Sn118
116	50-Sn-119	5046		sn119	50Sn119
117	50-Sn-120	5049		sn120	50Sn120
118	50-Sn-122	5055		sn122	50Sn122
119	50-Sn-124	5061		sn124	50Sn124
120	51-Sb-121	5125	5100	sb121	51Sb121
121	51-Sb-123	5131		sb123	51Sb123
122	53-I-127	5325	5300	i127	53I_127
123	55-Cs-133	5525	5500	cs133	55Cs133
124	56-Ba-130	5625	5600	ba130	56Ba130
125	56-Ba-132	5631		ba132	56Ba132
126	56-Ba-134	5637		ba134	56Ba134
127	56-Ba-135	5640		ba135	56Ba135
128	56-Ba-136	5643		ba136	56Ba136
129	56-Ba-137	5646		ba137	56Ba137
130	56-Ba-138	5649		ba138	56Ba138
131	57-La-138	5725	5700	la138	57La138
132	57-La-139	5728		la139	57La139
133	58-Ce-136	5825	5800	ce136	58Ce136
134	58-Ce-138	5831		ce138	58Ce138
135	58-Ce-140	5837		ce140	58Ce140
136	58-Ce-142	5843		ce142	58Ce142
137	64-Gd-152	6425	6400	gd152	64Gd152
138	64-Gd-154	6431		gd154	64Gd154
139	64-Gd-155	6434		gd155	64Gd155
140	64-Gd-156	6437		gd156	64Gd156
141	64-Gd-157	6440		gd157	64Gd157
142	64-Gd-158	6443		gd158	64Gd158
143	64-Gd-160	6449		gd160	64Gd160
144	68-Er-162	6825	6800	er162	68Er162
145	68-Er-164	6831		er164	68Er164
146	68-Er-166	6837		er166	68Er166
147	68-Er-167	6840		er167	68Er167
148	68-Er-168	6843		er168	68Er168
149	68-Er-170	6849		er170	68Er170
150	71-Lu-175	7125	7100	lu175	71Lu175
151	71-Lu-176	7128		lu176	71Lu176
152	72-Hf-174	7225	7200	hf174	72Hf174
153	72-Hf-176	7231		hf176	72Hf176
154	72-Hf-177	7234		hf177	72Hf177
155	72-Hf-178	7237		hf178	72Hf178
156	72-Hf-179	7240		hf179	72Hf179
157	72-Hf-180	7243		hf180	72Hf180

No.	MATERIAL	MAT (n)	MAT (γ)	MATXS ID	Filenames [*.m] n-γ- MATXS [*.g] n-GENDF [*.gam] γ-GENDF
158	73-Ta-181	7328	7300	ta181	73Ta181
159	74-W-180	7425	7400	w180	74W_180
160	74-W-182	7431		w182	74W_182
161	74-W-183	7434		w183	74W_183
162	74-W-184	7437		w184	74W_184
163	74-W-186	7443		w186	74W_186
164	75-Re-185	7525	7500	re185	75Re185
165	75-Re-187	7531		re187	75Re187
166	78-Pt-190	7825	7800	pt190	78Pt190
167	78-Pt-192	7831		pt192	78Pt192
168	78-Pt-194	7837		pt194	78Pt194
169	78-Pt-195	7840		pt195	78Pt195
170	78-Pt-196	7843		pt196	78Pt196
171	78-Pt-198	7849		pt198	78Pt198
172	79-Au-197	7925	7900	au197	79Au197
173	82-Pb-204	8225	8200	pb204	82Pb204
174	82-Pb-206	8231		pb206	82Pb206
175	82-Pb-207	8234		pb207	82Pb207
176	82-Pb-208	8237		pb208	82Pb208
177	83-Bi-209	8325	8300	bi209	83Bi209
178	90-Th-232	9040	9000	th232	90Th232
179	92-U-235	9228	9200	u235	92U_235
180	92-U-238	9237		u238	92U_238

5. Verification of FENDL/MC-3.0 and FENDL/MG-3.0

The main verification technique used was to check the NJOY output file for each material. The "warning messages" generated were examined, and most of them were related to incomplete or inconsistent evaluations. Some comments about the major findings are given below:

- Evaluations for H-3 and He-4 do not have photon production data.
- For several evaluations File 6 (MF = 6) is used, although incomplete: the energy distribution is not given for the recoil nucleus. NJOY-99 applied one particle approximation in these cases.
- For Li-6, Li-7, Be-9, B-10, C-12, N-14, N-15, F-19, Na-23, Mg-24,-25,-26, Cl-35,-37, Ti- 46, -47, -48, 49, -50, Co-59, Br-79,-81, Zr-92, -94, -96, Nb-93, Mo-92, -94, -95, -96, -97,-98, -100, Ag-107, Cd-106, Cd-111, Er-162,-164,-166, -167, -168, -170, Hf-174, -176, -177, -178, -179, -180, Ta-181, Au-197, U-235, -238 discontinuities were found in the gamma files. Corrective action was done by NJOY-99.
- For 119 materials inconsistencies were found at several incident energies because E<E'. Corrective action was done by NJOY-99.
- For Br-81, Mo-92, -94, -95, -96, -97, -98 and Hf-180 problems were found with the sum of the photon production. Re-normalization was applied to correct this by NJOY-99.

All the corrective actions performed in the second run of ACER were considered appropriate. Additionally, the plots generated by ACER were visually inspected and no trivial errors were detected.

A second verification technique was used for all the ACE-formatted files. Processed data were converted back to ENDF-6 format using the code ACELST [13]. The original evaluation was processed using the PREPRO-2010 code system (LINEAR+RECENT+SIGMA1), and the two ENDF-6 formatted files were compared using COMHARD.

No significant deviations in the cross section data were found for most of the materials. The main sources of differences could be due to a different treatment of small cross sections and energy discontinuity problems by NJOY-99 and PREPRO-2010 code systems. However, some differences are worthy to note. For Rh-103, I-127 and U-238 that appears to be a double counting of one partial reaction as can be seen in Figures 2, 3 and 4. To clear the origin of the difference the sequence LINEAR+RECENT+FIXUP was run on the FENDL/E-3.0 evaluated nuclear data files, in such a way that redundant cross sections were obtained by summation of the corresponding partial cross section data according to the ENDF-6 format rules. The resulting files from RECENT were compared to the ones from FIXUP. Figures 5, 6 and 7 show the comparison for Rh-103, I-127 and U-238 respectively. As you can see after running FIXUP the cross sections have the same shapes as those processed by NJOY-99, so the differences could come from some inconsistencies present in the primary evaluated nuclear data files.

Figures 8, 9 and 10 present the Rh-103, I-127 and U-238 evaluated cross section data. From the plots it can be sees that it is likely that some partial cross section data that is contributing to the inelastic (non-elastic) cross section (MT=3) is also included into the (n,x) cross section (MT=5) in the energy range between 20 and 30 MeV.

After running these basic verification procedures, the processed data were judged to be acceptable for initial transport calculations in fusion applications. The cross section data of FENDL/MC-3.0 and FENDL/MG-3.0 libraries seem to have the same quality of the primary FENDL/E-3.0 evaluated nuclear data file in ENDFB-6 format. Based on this experience some changes were made in the sources of data for the final version of FENDL-3.

6. Point-wise data library FENDL/PD-3.0 in ENDFB-6 format

As a result of the verification process for the transport cross section libraries a point-wise evaluated nuclear data library was produce at 0K. The sequence of processing was LINEAR+RECENT+FIXUP+STANEF. The first three codes are from the PREPRO-2010 system and the last one from an updated version of the 8.02 ENDFB-6 utilities. All primary evaluated nuclear data files from FENDL/E-3.0 for neutrons were successfully processed using the following main options:

- Reconstruction tolerance: 0.1%
- Temperature: 0K
- Minimal cross section: 10^{-10} barns
- FIXUP corrective options:
    - Correct ZA and AWR in all cross sections
    - Correct cross section thresholds
    - Reconstruction of redundant cross section according to the ENDFB-6 format summing rules
    - Insure non-negative cross sections
    - Delete energies that are not in ascending order, energy repetition is allowed
    - Eliminate duplicate unnecessary points

- Check MF/MT in each section according to ENDFB-6 format.

The files were re-sequenced and the directory section was updated using STANEF.

The names of the files are the same as those for the FENDL/E-3.0 library, but the extension is *.PND, meaning a point-wise evaluated nuclear data file. The rest of the parameters are the same as the ones for the FENDL/E-3.0 library (Table 1).

The point-wise library FENDL/PD-3.0 can be useful for evaluators and gives a clear image of cross section data.

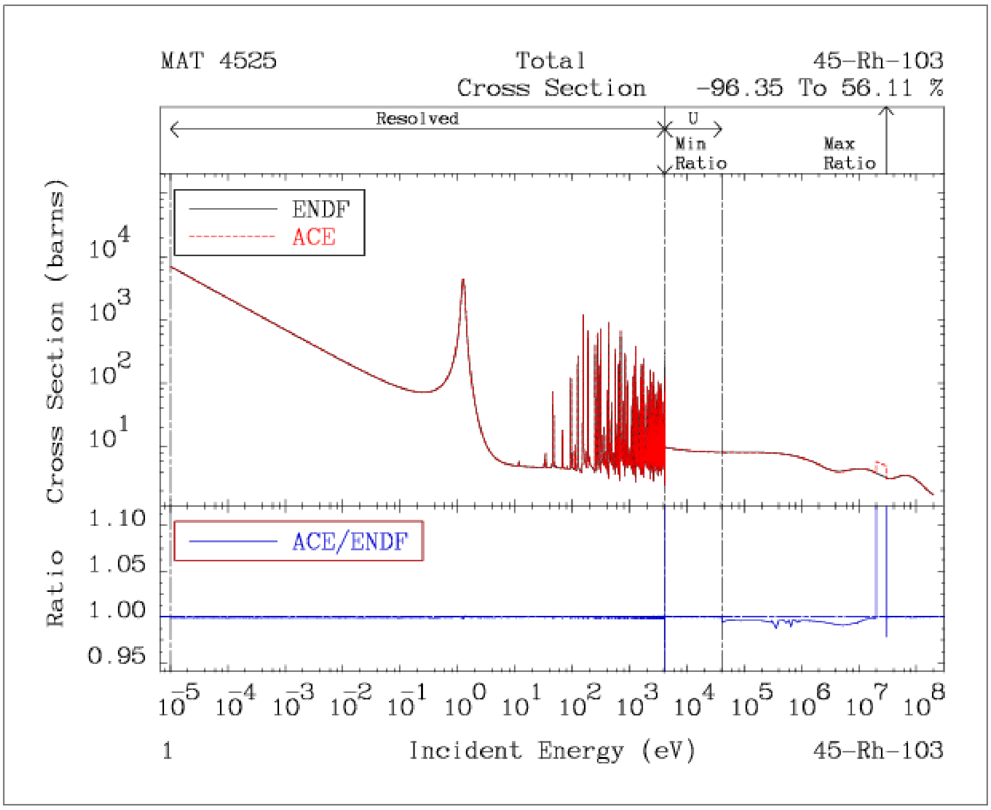

Fig. 2: FENDL/MC-3.0 vs FENDL/E-3.0 for Rh-103 total cross section

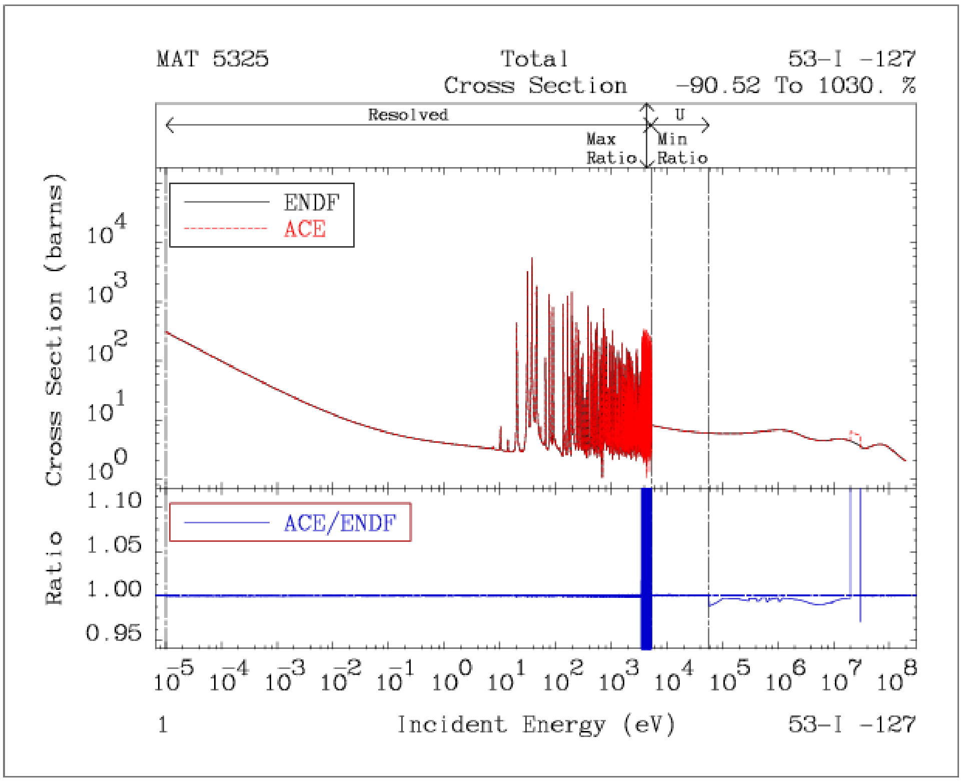

Fig. 3: FENDL/MC-3.0 vs FENDL/E-3.0 for I-127 total cross section

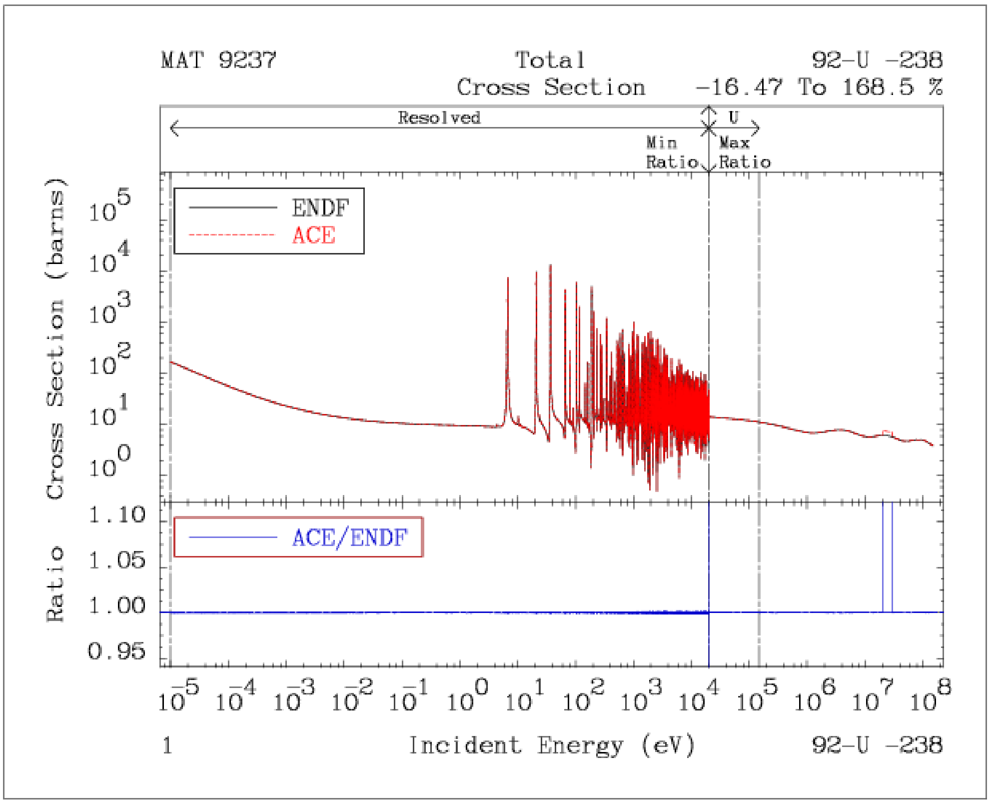

Fig. 4: FENDL/MC-3.0 vs FENDL/E-3.0 for U-238 total cross section

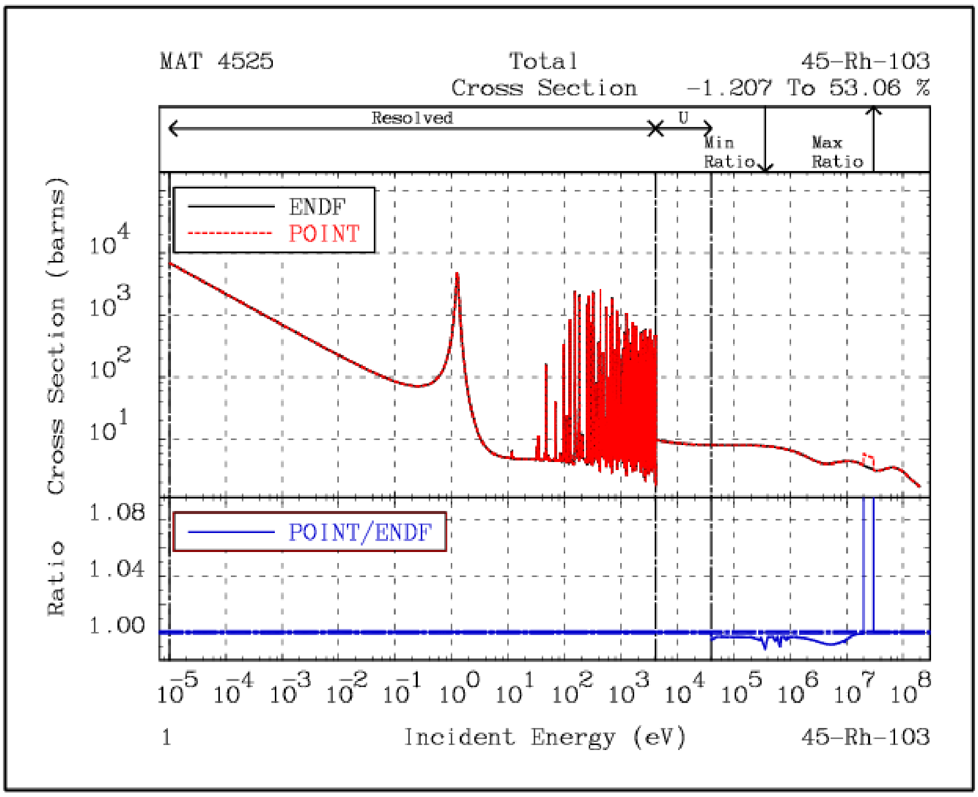

Fig. 5: FENDL/PD-3.0 vs FENDL/E-3.0 for Rh-103

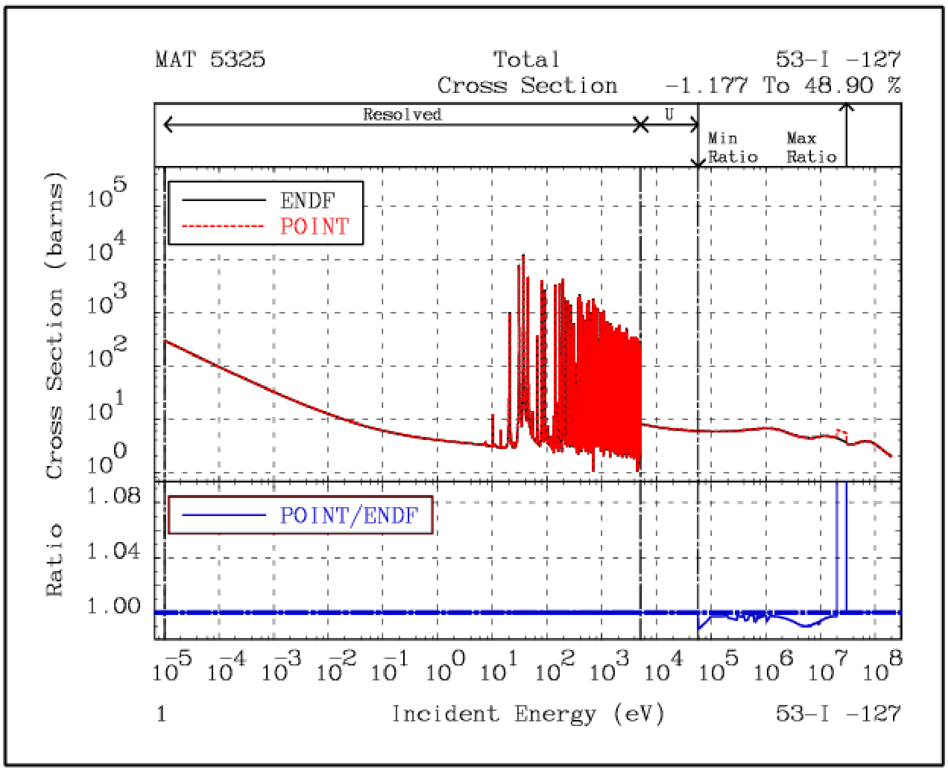

Fig. 6: FENDL/PD-3.0 vs FENDL/E-3.0 for I-127

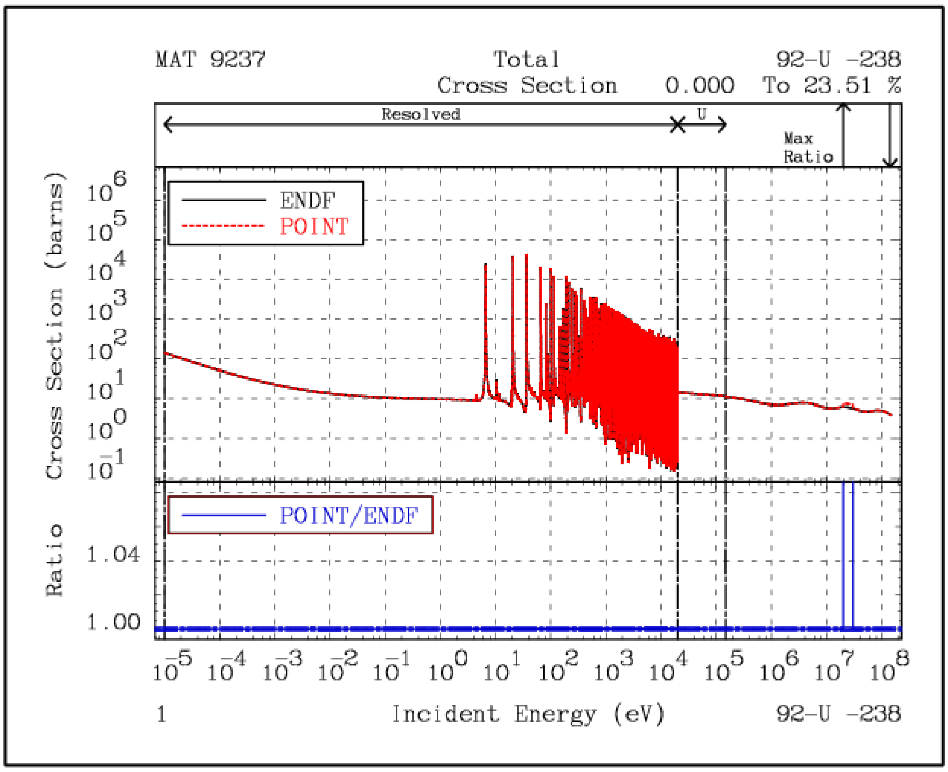

Fig. 7: FENDL/PD-3.0 vs FENDL/E-3.0 for U-238

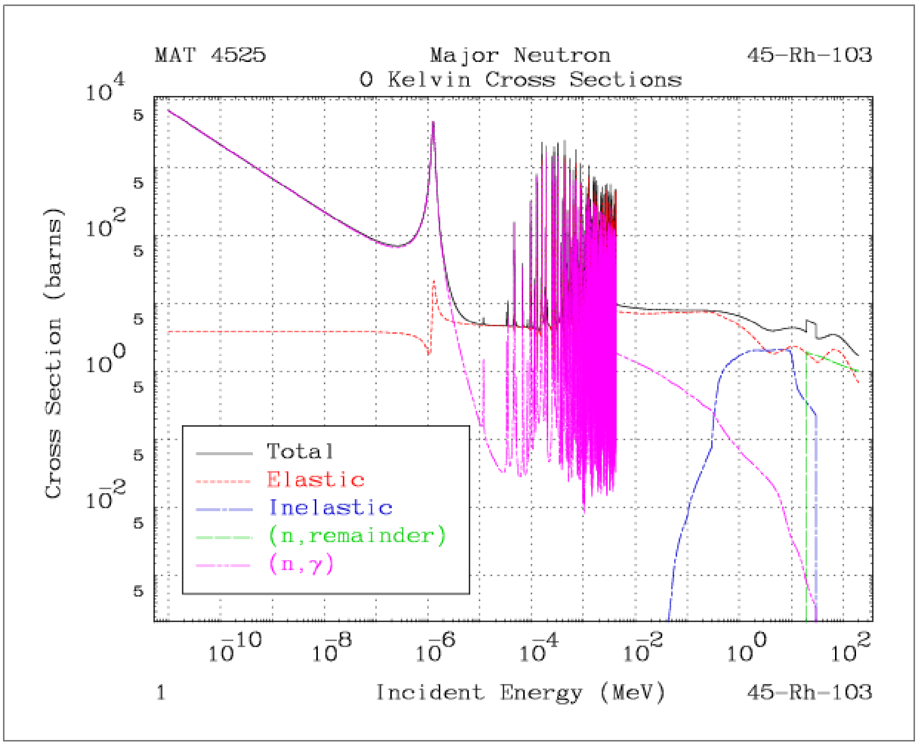

Fig. 8: FENDL/E-3.0 cross sections for Rh-103

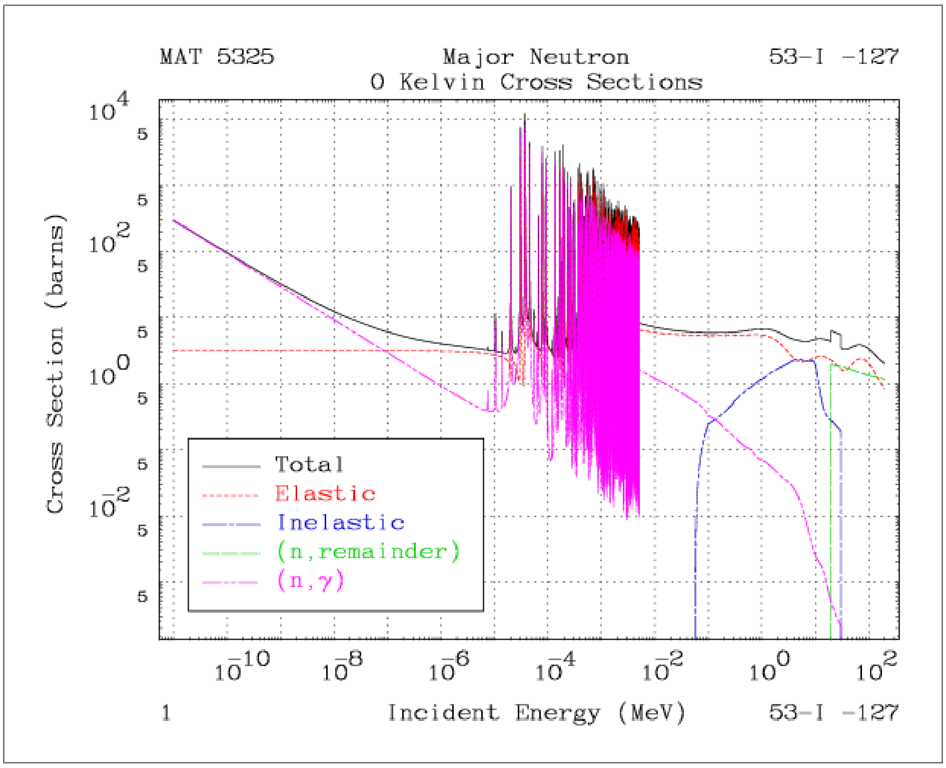

Fig. 9: FENDL/E-3.0 cross sections for I-127

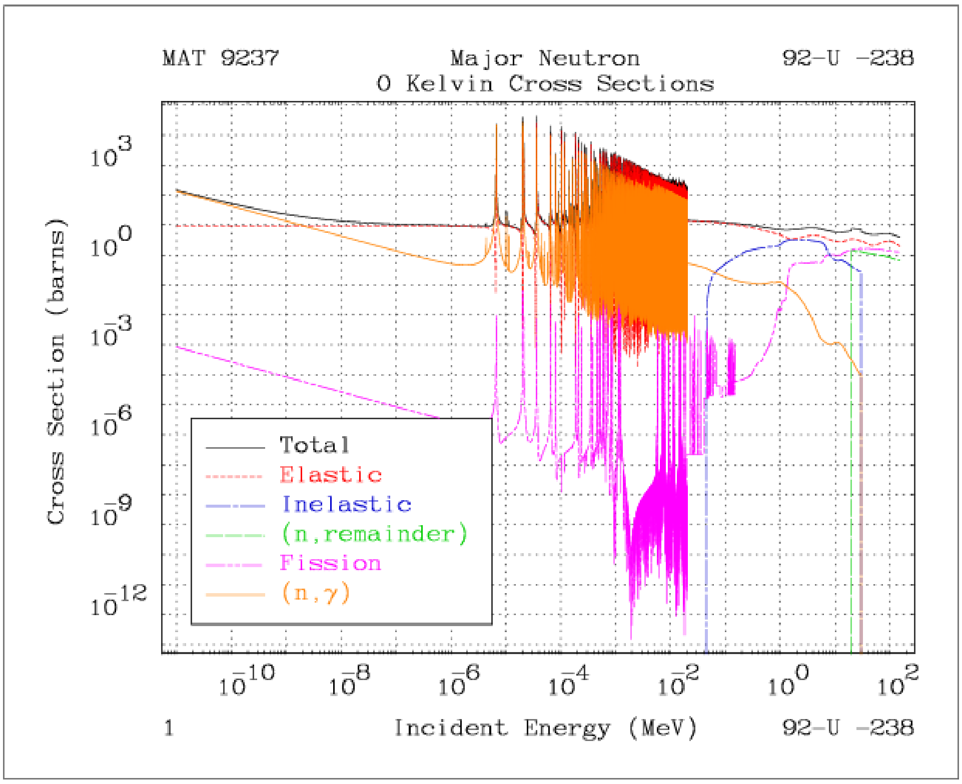

Fig. 10: FENDL/E-3.0 cross sections for U-238

7. Accessing FENDL-3.0 data

The FENDL-3.0 data library is freely available from the IAEA-NDS upon request, and is also readily accessible at the http://www-nds.iaea.org/ web site.

The FENDL-3.0 package includes the following information:

- FENDL/E-3.0 evaluated nuclear data files for neutron and photo-atomic interaction data in ENDFB-6 format.
- Deuteron-, neutron- and proton-induced activation file.
- FENDL/PW-3.0 point-wise evaluated nuclear data files in ENDFB-6 format at 0K (preprocessed by PREPRO10 code package)
- FENDL/MC-3.0: continuous energy data files for MCNP calculations (*.ace and *.xdr files).
- FENDL/MG-3.0: coupled neutron-photon multi-group data library for transport calculations (*.m,*.g,*.gam files).
- NJOY inputs for generation of FENDL-3.0.
- Auxiliary programs and MSDOS/WINDOWS batch procedures used in the generation and verification of the FENDL-3.0 transport libraries.
- Documentation: INDC(NDS)-0611 report (this document).

8. Final remarks and recommendations

A new version of FENDL (termed FENDL-3.0) has been assembled and made available for fusion applications. All evaluated nuclear data files (180 materials) from FENDL/E-3.0 were processed using the NJOY-99.364+ code system. FENDL/MC-3.0 and FENDL/MG-3.0 libraries were assembled. A point-wise evaluated nuclear data library in ENDFB-6 format was also produced at 0K.

FENDL-3.0 libraries, input files and report are freely available on the web site http://www-nds.iaea.org/ or can be requested on CD-ROM from the IAEA-NDS.

An extensive and intensive benchmarking of the transport libraries is strongly recommended, analysing an appropriate set of benchmarks as was done for the FENDL-2.1 library.

Afterwards, a revision of the FENDL/E-3.0 evaluated nuclear data library is recommended to finally set up all the files and to include the feedback coming from benchmarking.

References

1. López Aldama, D., Trkov, A., "FENDL-2.1: Update of an evaluated nuclear data library for fusion applications", INDC(NDS)-467, IAEA Nuclear Data Section, December 2004.
2. Sharma A.R. *et al*., "Integral validation and use of improved nuclear data in fusion blanket studies", 302-F4-IND-11566 (B5-IND-29641), 2002.
3. 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", Los Alamos National Laboratory, PSR-480, 2000.
4. Cullen, D.E., "PREPRO 2010: 2010 ENDF/B Pre-processing codes (ENDF/B-VII Tested)", IAEA-NDS-39, Rev. 14, October 31, 2010.
5. Dunford, C.L., "ENDF Utility Codes Release &.01/02", May 31, 2005
6. Herman, M, Trkov, A. (Eds), "ENDF-6 Formats Manuals", ENDF-102, BNL-90365-2009, June 2009.
7. Trkov, A., Private communication on chmf32 code, November 2011.
8. Briesmeister, J.F., "MCNP – A General Monte Carlo N-Particle Transport Code, Version 4C", Los Alamos National Laboratory, LA-13709-M, 2000.
9. Rhoades, W.A., *et al*., "DOORS 3.2, One-, Two-, Three-Dimensional Discrete Ordinates Neutron/Photon Transport Code System", RSICC, Oak Ridge National Laboratory, CCC-650, 1998.
10. Forrest, R., Trkov, A., "Maintain FENDL Library for Fusion Applications. FENDL-2 Library for Fusion Applications – Status and Future Developments", Summary Report of an IAEA Consultants' Meeting, 10-12 November 2003, Vienna, INDC(NDS)-451, 2003.
11. Herman, M., "Validation and Improvement of the FENDL-2.0 Transport Sublibraries", Report on an IAEA Consultants' Meeting, Vienna, Austria, 12-14 October 1998, INDC(NDS)-395, 1999
12. MacFarlane, R.E., "TRANSX 2: A Code for Interfacing MATXS Cross Section Libraries to Nuclear Transport Codes", Los Alamos National Laboratory, LA-12312-MS, 1992.
13. Trkov, A., Private communication on ACELST code, December 2002.

APPENDIX 1: NJOY local updates at IAEA-NDS.

1.1 OECD/NEA updates

```
*/
*/ OECD/NEA compilation of NJOY updates
*/ compatible with the official patch distribution up364
*/
*/ The patches include those carried-over from the set compatible
*/ with the official up296 but not adopted in up364.
*/
*ident upnea001
*/ njoy - C. Broeders, 6-Oct-2006
*/        Open scratch files in local disc area
*/        Ref.: Comments by D.E. Cullen in PrePro-2004 (Scratcha.f) on p.19
of:
*/                                                              "http://www-
nds.iaea.org/ndspub/endf/prepro/DOCUMENT/PDF/Overview.pdf"
*/        Status "scratch" does not work with Lahey compiler on Linux,
*/        therefore 'age" is set "unknown"
*d njoy.470
         age='unknown'
*d njoy.471
         write(fn,'(a,i2.2)') 'temp',nun
         open(nun,file=fn,form=for,status=age)
*/
*ident upnea004
*/ groupr - C. Broeders, 6-Oct-2006
*/          extend IWT=5 spectrum definition up to 200MeV
*/ -------------------------------------------
*d groupr.2145
      dimension w1(92),w2(92),w3(10)
*d groupr.2150
      data w1/0d0,0d0,0d0,0d0,1.d0,93.d0,93.d0,5.d0,
*i groupr.2175
      data w3/3.d7,1.0318d-10,5.d7,6.1908d-11,1.d8,3.0954d-11,
     &1.5d8,2.0636d-11,2.d8,1.5477d-11/
*d groupr.2358
      iw=194
*i groupr.2365
      do i=1,10
         a(i+183+iwght)=w3(i)
      enddo
*/
*/ *ident upnea019 is included in up265
*/
*/ *ident upnea020 is included in up235
*/
*/ *ident upnea021 is included in up261
*/
*/ *ident upnea022 is included in up260
*/
*/ *ident upnea023 is included in up272
*/
*/ *ident upnea024 is included in up273
*/
*/ *ident upnea025 is included in up315
*/
*/ *ident upnea026 is included in up316
```

```
*/
*/ *ident upnea027 is included mostly in up317, except a few statements
*/                  which are placed in upnea068
*/
*/ *ident upnea028 is included in up318
*/
*/ *ident upnea029 is included in up316
*/
*/ *ident upnea030 is included in up272
*/
*/ *ident upnea031 is included in up289
*/
*ident upnea032
*/ acer     A. Trkov, 30 May 2008
*/          Plots of discrete inelastic make sense below 10 MeV
*d acer.19586
c                        limit discrete inelastic plots to 10 MeV
                         if (x.gt.xmax) xmax=min(x,10.)
*/
*/ *ident upnea033 included in up278
*/
*/ *ident upnea034 included in up277
*/
*/ *ident upnea035 included in up279
*/
*/ *ident upnea036 included in up279
*/
*/ *ident upnea037 included in up277
*/
*ident upnea038
*/ covr    A. Trkov, 20 October 2008
*          Fix diagnostic message
*d covr.1793,1805
      zero=0
      if (abs(crit).gt.zero) write(strng,
     &      '(''i'',i3,'' j'',i3,'' xa(i,j)='',1p,e12.4,'' xa(j,i)='',
     &     1p,e12.4)') i,im1,xa(im1ind,i),xa(iind,im1)
      if (abs(crit).gt.test .and. abs(xa(im1ind,i)).gt.1e-20) then
         call error('press','matrix not symmetric',strng)
      endif
      test=1
      test=test/1000000
      if (abs(crit).lt.test) go to 250
      call mess('press','matrix not symmetric',strng)
*/
*/ *ident upnea039 included in up272
*/
*ident upnea040
*/
*/ GROUPR - R. Perry, 15 October 2008
*/          (Original update name: upwe6)
*/          Problem with thermal scattering matricies in GROUPR
*/          There were small discrepancies between the sums thermal scatter
*/          matrices and the group cross-sections. This update renormalises
*/          the interpolated spectra (produced during integration)
*/          to sum to unity.
*/          (guarding against array overflow added by A. Trkov)
*i groupr.6915
      integer nsi
      parameter (mxnsi=15000)
*i groupr.6922
      dimension sint(2,mxnsi)
```

```
*i groupr.7030
      nsi = 0
*i groupr.7146
c
c store interpolated function.
c
      nsi = nsi+1
      if(nsi.gt.mxnsi)
     &   call error('getaed','mxnsi array limit exceeded',' ')
      sint(1,nsi) = ei
      sint(2,nsi) = fi(1)
*i groupr.7155
c
c sum interpolated spectrum and adjust aed.
c
      sisum = 0.0
      do il = 1, nsi - 1
        sisum = sisum + (sint(2,il)+sint(2,il+1))*
     &                                  (sint(1,il+1)-sint(1,il))/2
      enddo
c
c don't re-normalise if scatter source above top energy group.
c
      if(i .lt. ngn .or. (k1 .eq. nlo .and. k2 .eq. nhi) ) then
        do il = 1, i
          aed(1,il) = aed(1,il)/sisum
        enddo
      endif
*/
*/ *ident upnea041 included in up282
*/
*/ *ident upnea042 is not included; it is redefined in upnea069
*/
*/ *ident upnea043 included in up282
*/
*/ *ident upnea044 included in up273
*/
*/ *ident upnea045 included in up282
*/
*/ *ident upnea046 withdrawn
*/
*/ *ident upnea047 included in up287
*/
*/ *ident upnea048 included in up329 and extended
*/
*/ *ident upnea049 is included in up290
*/
*/ *ident upnea050 is included in up289
*/
*/ *ident upnea051 is included in up363
*/
*/ *ident upnea052 is included in up361
*/
*/ *ident upnea053 is included in up307
*/
*ident upnea054
*/ errorr D.L. Aldama, July 2009
*/        Fix weighting function option
*d errorj.660
      if (iwt.eq.1.or.iwt.eq.4.or.iwt.eq.5.or.
     &     (iwt.ge.7.and.iwt.lt.11))
*d errorj.1492
```

```
      if (iwt.eq.1.or.iwt.eq.4.or.iwt.eq.5.or.
     &     (iwt.ge.7.and.iwt.lt.11))
*/
*/ *ident upnea055 is included in up314
*/
*/ *ident upnea056 is included in up312
*/
*/ *ident upnea057 is included in up305
*/
*/ *ident upnea058 is included in up318
*/
*/ *ident upnea059 is included in up205
*/
*/ *ident upnea060 is not needed due to alternative coding in up329
*/
*/ *ident upnea061 is superseeded by upnea068
*/
*/ *ident upnea062 is included in up324
*/
*/ *ident upnea063 is dealt with differently in upnea315
*/
*ident upnea064
*/ acer    A. Trkov, February 2010
*/         Particle emission spectra in the acer plots are corrupted
*/         for MF6 Law 1 LANG 1 when more than one interpolation range
*/         is specified for the distributions on incident particle
*/         energies. In some cases the MCNP calculations are also wrong.
*/         A fix is done when writing the data to a temporary file.
*/         The multiple ranges are suppressed. The first interpolation
*/         law is prescribed over the entire incident energy range
*/         and a message is printed.
*/         WARNING:
*/         This is a temporary patch before a proper solution is found.
*/         The true error probably occurs somewhere near acer.6651
*/         or later, and/or possibly in MCNP.
*/         Implications:
*/         JENDL-HE files truncated to 150 MeV (as proposed for FENDL-3)
*/         led to strongly discrepant results in a benchmark model
*/         calculation representative of the ITER device. The discrepancy
*/         is greatly reduced with the use of this patch. The assumption
*/         in the patch has no influence on the evaluated data because
*/         the interpolation law changes above 20 MeV where the yield
*/         drops to zero due to the reaction representation in MT5.
*d acer.2373,2374
                 call tab2io(nin,0,0,b,nb,nw)
                 nr=n1h
                 ne=nint(b(6))
                 if(nr.gt.1) then
                   write(string,'(a,i3)')
     &                  'multiple interp. ranges for mf6, mt',mt
                   call mess('topfil',string
     &                   ,'first law applied everywhere')
                   nr=1
                   b(5)=nr
                   b(7)=ne
                 end if
                 call tab2io(0,nout,0,b,nb,nw)
*/
*/ *ident upnea065 included in up341
*/
*/ *ident upnea066 is included in up342
*/
```

```
*/ *ident upnea067 is included in up363
*/
*ident upnea068
*/ acer    A. Trkov, January 2010
*/          (Revision of upnea061, noticed by Skip Kahler)
*d acer.119,120
c     *              7   read fast ace files to print or edit         *
c     *              8   read thermal ace files to print or edit      *
c     *              9   read dosimetry ace files to print or edit    *
*d acer.407
      else if (iopt.eq.6.or.iopt.gt.9) then
*d acer.435
      else if (iopt.ge.7.and.iopt.le.9) then
*i acer.17639
c
c     ***read type 3 ace format file
      else if (itype.eq.3) then
         if (mcnpx.eq.0) then
           read(nin) hz(1:10),aw0,tz,hd,hko,hm,(izo(i),awo(i),i=1,16),
     &       (nxs(i),i=1,16),(jxs(i),i=1,32)
         else
           read(nin) hz(1:13),aw0,tz,hd,hko,hm,(izo(i),awo(i),i=1,16),
     &       (nxs(i),i=1,16),(jxs(i),i=1,32)
         endif
         len2=nxs(1)
         n=(len2+ner-1)/ner
         l=0
         do i=1,n
            max=len2-l
            if (max.gt.ner) max=ner
            read (nin) (xss(l+j),j=1,max)
            l=l+max
         enddo
         call closz(-nin)
c        flag incident particle "undefined"
         izai=-1
         awi =-1
*/
*/ *ident upnea069 is included in up362
*/
*/ *ident upnea070 is included in up363
*/
*/ *ident upnea071 is included in up363
*/
*ident upnea073
*/ acer    A. Trkov, January 2011
*/         Error message lenth exceeds string size
*d up360.91,93
                          write(strng,'(''mtd='',i3,'' mt='',i6,
     &                      '' ie='',i4,i5,'' nd='',3i4,'' ed='',
     &                      1p,e9.3e1)')
*/
*ident upnea074
*/ acer    A. Trkov, June 2011
*/           zaid is re-defined incorrectly when editing fast ace files if
original
*/         suffix is greater than 0.50
*d acer.17652
         iza=int(zaid+0.001)
*/
*ident upnea075
*/ errorr  A. Trkov, June 2011
```

```
*/         One more case to skip input if there are no data to process
*i up324.105
         if(iwt.eq.4) read(nsysi,*) eb,tb,ec,tc
*/
*ident upnea076
*/
*/ HEATR  - K. Vignitchouk, 06/09/11
*/          Calculate mean neutron energy for law 12-energy
*/          dependent fission neutron spectrum (madland-nix)
*/          (originaly submitted as upwd20)
*/
*i heatr.2169
c
c     ***law 12--energy dependent fission neutron spectrum (madland-nix)
      else if (lf.eq.12) then
          s=((a(lnext)+a(lnext+1))/2)+(4*theta/3)
*/
*ident upnea077
*/ broadr  A. Trkov, October 2011
*/         Increase the maximum number of no-threshold cross sections
*/         (case: NNDC evaluation of Tm-168)
*d up175.13
      parameter (nttmax=48)
*d up175.21
      parameter (nttmax=48)
*d up175.25
      parameter (nttmax=48)
*d up175.30
      parameter (nttmax=48)
*d up175.34
      parameter (nttmax=48)
*/
```

1.2 Updates for processing FENDL-3.0 at IAEA-NDS

```
*ident upnds01
*/
*/ ACER  - D. L. Aldama (IAEA/NDS Consultant)
*/         Nov./2011
*/         Correction to NJOY update up360 for processing
*/         MF6(16) with different number of discrete
*/         photon energies by sections
*d up360.17
      nwordg=2000
*d up360.94
                           a(idise)=ep
*i up360.95
                        else if (abs(ep).lt.abs(a(idise+nd0-1))) then
                           a(idise+nd0)=ep
                           nd0=nd0+1
*d up360.123
     &                     nwordg,nd0
*/
*ident upnds02
*/
*/ HEATR  - D. L. Aldama (IAEA/NDS Consultant)
*/          Nov./2011
*/          Correction for large MF4/MT=2 sections
*i heatr.3832
         if (nb.ne.0) then
           l=iraw
           do while (nb.ne.0)
             l=l+nwc
             call moreio(nin,0,0,c(l),nb,nwc)
           enddo
         endif
*i heatr.3837
         if (nb.ne.0) then
           l=iraw
           do while (nb.ne.0)
             l=l+nwc
             call moreio(nin,0,0,c(l),nb,nwc)
           enddo
         endif
*i heatr.3877
      if (nb.ne.0) then
        l=iraw
        do while (nb.ne.0)
          l=l+nwc
          call moreio(nin,0,0,c(l),nb,nwc)
        enddo
      endif
*/
```

APPENDIX 2: Energy boundaries for the 211-group structure for fusion applications
(175 groups of VITAMIN-J + 36 groups up to 55 MeV)

N	N+1	N+2	N+3	N+4
0	1.0000100E-05	1.0000100E-01	4.1399401E-01	5.3157902E-01
4	6.8256003E-01	8.7642503E-01	1.1230000E+00	1.4400001E+00
8	1.8553900E+00	2.3823700E+00	3.0590200E+00	3.9278600E+00
12	5.0434799E+00	6.4759498E+00	8.3152905E+00	1.0677000E+01
16	1.3709600E+01	1.7603500E+01	2.2603300E+01	2.9023199E+01
20	3.7266499E+01	4.7851200E+01	6.1442101E+01	7.8893204E+01
24	1.0130100E+02	1.3007300E+02	1.6701700E+02	2.1445399E+02
28	2.7536401E+02	3.5357501E+02	4.5399899E+02	5.8294702E+02
32	7.4851801E+02	9.6111700E+02	1.2341000E+03	1.5846100E+03
36	2.0346801E+03	2.2486699E+03	2.4851699E+03	2.6125901E+03
40	2.7465400E+03	3.0353899E+03	3.3546299E+03	3.7074399E+03
44	4.3074199E+03	5.5308398E+03	7.1017402E+03	9.1188203E+03
48	1.0594600E+04	1.1708800E+04	1.5034400E+04	1.9304500E+04
52	2.1874900E+04	2.3578600E+04	2.4175500E+04	2.4787500E+04
56	2.6058400E+04	2.7000100E+04	2.8501100E+04	3.1827801E+04
60	3.4306699E+04	4.0867699E+04	4.6309199E+04	5.2475199E+04
64	5.6562199E+04	6.7379500E+04	7.2024500E+04	7.9498703E+04
68	8.2503398E+04	8.6517000E+04	9.8036500E+04	1.1109000E+05
72	1.1678600E+05	1.2277300E+05	1.2906800E+05	1.3568600E+05
76	1.4264200E+05	1.4995600E+05	1.5764400E+05	1.6572700E+05
80	1.7422400E+05	1.8315600E+05	1.9254700E+05	2.0241900E+05
84	2.1279700E+05	2.2370800E+05	2.3517700E+05	2.4723500E+05
88	2.7323700E+05	2.8724600E+05	2.9451800E+05	2.9721100E+05
92	2.9849100E+05	3.0197400E+05	3.3373300E+05	3.6883200E+05
96	3.8774200E+05	4.0762200E+05	4.5049200E+05	4.9787100E+05
100	5.2339700E+05	5.5023200E+05	5.7844300E+05	6.0810100E+05
104	6.3927900E+05	6.7205500E+05	7.0651200E+05	7.4273600E+05
108	7.8081700E+05	8.2085000E+05	8.6293600E+05	9.0718000E+05
112	9.6167200E+05	1.0025900E+06	1.1080300E+06	1.1648400E+06
116	1.2245600E+06	1.2873500E+06	1.3533500E+06	1.4227400E+06
120	1.4956900E+06	1.5723700E+06	1.6529900E+06	1.7377400E+06
124	1.8268400E+06	1.9205000E+06	2.0189700E+06	2.1224800E+06
128	2.2313000E+06	2.3069300E+06	2.3457000E+06	2.3653300E+06
132	2.3851300E+06	2.4659700E+06	2.5924000E+06	2.7253200E+06
136	2.8650500E+06	3.0119400E+06	3.1663700E+06	3.3287100E+06
140	3.6787900E+06	4.0657000E+06	4.4932900E+06	4.7236700E+06
144	4.9658500E+06	5.2204600E+06	5.4881200E+06	5.7695000E+06
148	6.0653100E+06	6.3762800E+06	6.5924100E+06	6.7032000E+06
152	7.0468800E+06	7.4081800E+06	7.7880100E+06	8.1873100E+06
156	8.6070800E+06	9.0483700E+06	9.5122900E+06	1.0000000E+07
160	1.0512700E+07	1.1051700E+07	1.1618300E+07	1.2214000E+07
164	1.2523200E+07	1.2840300E+07	1.3498600E+07	1.3840300E+07
178	1.4190700E+07	1.4549900E+07	1.4918200E+07	1.5683100E+07
172	1.6487200E+07	1.6904600E+07	1.7332500E+07	1.9640300E+07
176	2.0000000E+07	2.1000000E+07	2.2000000E+07	2.3000000E+07
180	2.4000000E+07	2.5000000E+07	2.6000000E+07	2.7000000E+07
184	2.8000000E+07	2.9000000E+07	3.0000000E+07	3.1000000E+07
198	3.2000000E+07	3.3000000E+07	3.4000000E+07	3.5000000E+07
192	3.6000000E+07	3.7000000E+07	3.8000000E+07	3.9000000E+07
196	4.0000000E+07	4.1000000E+07	4.2000000E+07	4.3000000E+07
200	4.4000000E+07	4.5000000E+07	4.6000000E+07	4.7000000E+07

204	4.8000000E+07	4.9000000E+07	5.0000000E+07	5.1000000E+07
208	5.2000000E+07	5.3000000E+07	5.4000000E+07	5.5000000E+07

APPENDIX 3: Examples of NJOY-99.364+ inputs for FENDL-3.0

3.1 NJOY input option for Fe-56

```
moder / Extract/convert neutron evaluated data
1 -21
'26-Fe-56 for FENDL-3.0'/
20 2631
0/
moder / Extract/convert photo-atomic data
1 -41
'26-Fe-56 from FENDLE photo-atomic'/
40 2600
0/
reconr / Reconstruct XS for neutrons
-21 -22
'PENDF for 26-Fe-56'/
2631 2/
0.001 0. 0.002/
'26-Fe-56 from JEFF-3.1.1'/
'Processed by NJOY99.364+  on 20111125'/
0/
broadr / Doppler broaden XS
-21 -22 -23
2631 1 0 0 0./
0.001 2.0e7 0.002/
300.
0/
heatr / Add heating kerma and damage energy
-21 -23 -24 34/
2631 5 0 0 0 2/
302 304 404 443 444/
viewr / Plot energy balance from HEATR
 34 32
gaspr / Add gas production
-21 -24 -25
purr / Process Unresolved Resonance Range if any
-21 -25 -26
2631 1 10 20 100/
300.
1.E+10 1.E+05 1.E+04 1.E+03 1.E+02 1.E+01 3.E+00 1.E+00 3.E-01 1.E-01
0/
acer / Prepare ACE files
-21 -26 0 27 28
1 0 1 .30/
'26-Fe-56 for FENDL-3.0 from JEFF-3.1.1 with NJOY99.364+  on 20111125'/
2631 300.
1 1/
/
acer / Check ACE files
0 27 34 29 30
7 1 1 -1/
/
viewr / Plot ACE cross sections
34 35
groupr / Prepare multigroup data for neutrons
-21 -26 0 31
2631 1 10 11 6 1 10 1/
'26-Fe-56 for FENDL-3.0 from JEFF-3.1.1 with NJOY99.364+  on 20111125'/
300.
1.E+10 1.E+05 1.E+04 1.E+03 1.E+02 1.E+01 3.E+00 1.E+00 3.E-01 1.E-01
```

```
  211
    1.0000100E-05   1.0000100E-01   4.1399401E-01   5.3157902E-01
    6.8256003E-01   8.7642503E-01   1.1230000E+00   1.4400001E+00
    1.8553900E+00   2.3823700E+00   3.0590200E+00   3.9278600E+00
    5.0434799E+00   6.4759498E+00   8.3152905E+00   1.0677000E+01
    1.3709600E+01   1.7603500E+01   2.2603300E+01   2.9023199E+01
    3.7266499E+01   4.7851200E+01   6.1442101E+01   7.8893204E+01
    1.0130100E+02   1.3007300E+02   1.6701700E+02   2.1445399E+02
    2.7536401E+02   3.5357501E+02   4.5399899E+02   5.8294702E+02
    7.4851801E+02   9.6111700E+02   1.2341000E+03   1.5846100E+03
    2.0346801E+03   2.2486699E+03   2.4851699E+03   2.6125901E+03
    2.7465400E+03   3.0353899E+03   3.3546299E+03   3.7074399E+03
    4.3074199E+03   5.5308398E+03   7.1017402E+03   9.1188203E+03
    1.0594600E+04   1.1708800E+04   1.5034400E+04   1.9304500E+04
    2.1874900E+04   2.3578600E+04   2.4175500E+04   2.4787500E+04
    2.6058400E+04   2.7000100E+04   2.8501100E+04   3.1827801E+04
    3.4306699E+04   4.0867699E+04   4.6309199E+04   5.2475199E+04
    5.6562199E+04   6.7379500E+04   7.2024500E+04   7.9498703E+04
    8.2503398E+04   8.6517000E+04   9.8036500E+04   1.1109000E+05
    1.1678600E+05   1.2277300E+05   1.2906800E+05   1.3568600E+05
    1.4264200E+05   1.4995600E+05   1.5764400E+05   1.6572700E+05
    1.7422400E+05   1.8315600E+05   1.9254700E+05   2.0241900E+05
    2.1279700E+05   2.2370800E+05   2.3517700E+05   2.4723500E+05
    2.7323700E+05   2.8724600E+05   2.9451800E+05   2.9721100E+05
    2.9849100E+05   3.0197400E+05   3.3373300E+05   3.6883200E+05
    3.8774200E+05   4.0762200E+05   4.5049200E+05   4.9787100E+05
    5.2339700E+05   5.5023200E+05   5.7844300E+05   6.0810100E+05
    6.3927900E+05   6.7205500E+05   7.0651200E+05   7.4273600E+05
    7.8081700E+05   8.2085000E+05   8.6293600E+05   9.0718000E+05
    9.6167200E+05   1.0025900E+06   1.1080300E+06   1.1648400E+06
    1.2245600E+06   1.2873500E+06   1.3533500E+06   1.4227400E+06
    1.4956900E+06   1.5723700E+06   1.6529900E+06   1.7377400E+06
    1.8268400E+06   1.9205000E+06   2.0189700E+06   2.1224800E+06
    2.2313000E+06   2.3069300E+06   2.3457000E+06   2.3653300E+06
    2.3851300E+06   2.4659700E+06   2.5924000E+06   2.7253200E+06
    2.8650500E+06   3.0119400E+06   3.1663700E+06   3.3287100E+06
    3.6787900E+06   4.0657000E+06   4.4932900E+06   4.7236700E+06
    4.9658500E+06   5.2204600E+06   5.4881200E+06   5.7695000E+06
    6.0653100E+06   6.3762800E+06   6.5924100E+06   6.7032000E+06
    7.0468800E+06   7.4081800E+06   7.7880100E+06   8.1873100E+06
    8.6070800E+06   9.0483700E+06   9.5122900E+06   1.0000000E+07
    1.0512700E+07   1.1051700E+07   1.1618300E+07   1.2214000E+07
    1.2523200E+07   1.2840300E+07   1.3498600E+07   1.3840300E+07
    1.4190700E+07   1.4549900E+07   1.4918200E+07   1.5683100E+07
    1.6487200E+07   1.6904600E+07   1.7332500E+07   1.9640300E+07
    2.0000000E+07   2.1000000E+07   2.2000000E+07   2.3000000E+07
    2.4000000E+07   2.5000000E+07   2.6000000E+07   2.7000000E+07
    2.8000000E+07   2.9000000E+07   3.0000000E+07   3.1000000E+07
    3.2000000E+07   3.3000000E+07   3.4000000E+07   3.5000000E+07
    3.6000000E+07   3.7000000E+07   3.8000000E+07   3.9000000E+07
    4.0000000E+07   4.1000000E+07   4.2000000E+07   4.3000000E+07
    4.4000000E+07   4.5000000E+07   4.6000000E+07   4.7000000E+07
    4.8000000E+07   4.9000000E+07   5.0000000E+07   5.1000000E+07
    5.2000000E+07   5.3000000E+07   5.4000000E+07   5.5000000E+07
3/
3  251 'mubar'/
3  252 'xi'/
3  253 'gamma'/
3  259 '1/v'/
6/
16/
0/
```

```
0/
reconr / Reconstruct photo-atomic data
-41 -42
'PENDF photo-atomic data for 26-Fe-56'/
2600 2/
0.001 0. 0.003/
'26-Fe-56 from ENDF/B-VI'/
'Processed by NJOY99.364+  on 20111125'/
0/
gaminr / Prepare multigroup data for photons
-41 -42 0 43/
2600 10 3 6 1/
'26-Fe-56 for FENDL-3.0 from JEFF-3.1.1 with NJOY99.364+  on 20111125'/
-1/
0/
matxsr / Produce MATXS file
31 43 44/
1 'FENDL-3.0fe56'/
2 3 3 1
'26-Fe-56 FENDL-3.0 from JEFF-3.1.1'/
'Photo-atomic data from ENDF/B-VI'/
'Processed by NJOY99.364+  on 20111125'/
'n' 'g'/
 211  42
'nscat' 'ng' 'gscat'/
1 1 2/
1 2 2/
'fe56' 2631 2600/
stop
```

3.2 NYOY input options for W-184

```
moder / Extract/convert neutron evaluated data
1 -21
'74-W-184 for FENDL-3.0'/
20 7437
0/
moder / Extract/convert photo-atomic data
1 -41
'74-W-184 from FENDLE photo-atomic'/
40 7400
0/
reconr / Reconstruct XS for neutrons
-21 -22
'PENDF for 74-W-184'/
7437 2/
0.001 0. 0.002/
'74-W-184 from INDL/V-3'/
'Processed by NJOY99.364+  on 20111125'/
0/
broadr / Doppler broaden XS
-21 -22 -23
7437 1 0 0 0./
0.001 2.0e7 0.002/
300.
0/
heatr / Add heating kerma and damage energy
-21 -23 -24 34/
7437 5 0 0 0 2/
302 304 404 443 444/
```

```
viewr / Plot energy balance from HEATR
 34 32
gaspr / Add gas production
-21 -24 -25
purr / Process Unresolved Resonance Range if any
-21 -25 -26
7437 1 10 20 100/
300.
1.E+10 1.E+04 1.E+03 3.E+02 1.E+02 3.E+01 1.E+01 1.E+00 1.E-01 1.E-03
0/
acer / Prepare ACE files
-21 -26 0 27 28
1 0 1 .30/
'74-W-184 for FENDL-3.0 from INDL/V-3 with NJOY99.364+  on 20111125'/
7437 300.
1 1/
/
acer / Check ACE files
0 27 34 29 30
7 1 1 -1/
/
viewr / Plot ACE cross sections
34 35
groupr / Prepare multigroup data for neutrons
-21 -26 0 31
7437 1 10 11 6 1 10 1/
'74-W-184 for FENDL-3.0 from INDL/V-3 with NJOY99.364+  on 20111125'/
300.
1.E+10 1.E+04 1.E+03 3.E+02 1.E+02 3.E+01 1.E+01 1.E+00 1.E-01 1.E-03
 211
   1.0000100E-05   1.0000100E-01   4.1399401E-01   5.3157902E-01
   6.8256003E-01   8.7642503E-01   1.1230000E+00   1.4400001E+00
   1.8553900E+00   2.3823700E+00   3.0590200E+00   3.9278600E+00
   5.0434799E+00   6.4759498E+00   8.3152905E+00   1.0677000E+01
   1.3709600E+01   1.7603500E+01   2.2603300E+01   2.9023199E+01
   3.7266499E+01   4.7851200E+01   6.1442101E+01   7.8893204E+01
   1.0130100E+02   1.3007300E+02   1.6701700E+02   2.1445399E+02
   2.7536401E+02   3.5357501E+02   4.5399899E+02   5.8294702E+02
   7.4851801E+02   9.6111700E+02   1.2341000E+03   1.5846100E+03
   2.0346801E+03   2.2486699E+03   2.4851699E+03   2.6125901E+03
   2.7465400E+03   3.0353899E+03   3.3546299E+03   3.7074399E+03
   4.3074199E+03   5.5308398E+03   7.1017402E+03   9.1188203E+03
   1.0594600E+04   1.1708800E+04   1.5034400E+04   1.9304500E+04
   2.1874900E+04   2.3578600E+04   2.4175500E+04   2.4787500E+04
   2.6058400E+04   2.7000100E+04   2.8501100E+04   3.1827801E+04
   3.4306699E+04   4.0867699E+04   4.6309199E+04   5.2475199E+04
   5.6562199E+04   6.7379500E+04   7.2024500E+04   7.9498703E+04
   8.2503398E+04   8.6517000E+04   9.8036500E+04   1.1109000E+05
   1.1678600E+05   1.2277300E+05   1.2906800E+05   1.3568600E+05
   1.4264200E+05   1.4995600E+05   1.5764400E+05   1.6572700E+05
   1.7422400E+05   1.8315600E+05   1.9254700E+05   2.0241900E+05
   2.1279700E+05   2.2370800E+05   2.3517700E+05   2.4723500E+05
   2.7323700E+05   2.8724600E+05   2.9451800E+05   2.9721100E+05
   2.9849100E+05   3.0197400E+05   3.3373300E+05   3.6883200E+05
   3.8774200E+05   4.0762200E+05   4.5049200E+05   4.9787100E+05
   5.2339700E+05   5.5023200E+05   5.7844300E+05   6.0810100E+05
   6.3927900E+05   6.7205500E+05   7.0651200E+05   7.4273600E+05
   7.8081700E+05   8.2085000E+05   8.6293600E+05   9.0718000E+05
   9.6167200E+05   1.0025900E+06   1.1080300E+06   1.1648400E+06
   1.2245600E+06   1.2873500E+06   1.3533500E+06   1.4227400E+06
   1.4956900E+06   1.5723700E+06   1.6529900E+06   1.7377400E+06
   1.8268400E+06   1.9205000E+06   2.0189700E+06   2.1224800E+06
```

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   2.2313000E+06   2.3069300E+06   2.3457000E+06   2.3653300E+06
   2.3851300E+06   2.4659700E+06   2.5924000E+06   2.7253200E+06
   2.8650500E+06   3.0119400E+06   3.1663700E+06   3.3287100E+06
   3.6787900E+06   4.0657000E+06   4.4932900E+06   4.7236700E+06
   4.9658500E+06   5.2204600E+06   5.4881200E+06   5.7695000E+06
   6.0653100E+06   6.3762800E+06   6.5924100E+06   6.7032000E+06
   7.0468800E+06   7.4081800E+06   7.7880100E+06   8.1873100E+06
   8.6070800E+06   9.0483700E+06   9.5122900E+06   1.0000000E+07
   1.0512700E+07   1.1051700E+07   1.1618300E+07   1.2214000E+07
   1.2523200E+07   1.2840300E+07   1.3498600E+07   1.3840300E+07
   1.4190700E+07   1.4549900E+07   1.4918200E+07   1.5683100E+07
   1.6487200E+07   1.6904600E+07   1.7332500E+07   1.9640300E+07
   2.0000000E+07   2.1000000E+07   2.2000000E+07   2.3000000E+07
   2.4000000E+07   2.5000000E+07   2.6000000E+07   2.7000000E+07
   2.8000000E+07   2.9000000E+07   3.0000000E+07   3.1000000E+07
   3.2000000E+07   3.3000000E+07   3.4000000E+07   3.5000000E+07
   3.6000000E+07   3.7000000E+07   3.8000000E+07   3.9000000E+07
   4.0000000E+07   4.1000000E+07   4.2000000E+07   4.3000000E+07
   4.4000000E+07   4.5000000E+07   4.6000000E+07   4.7000000E+07
   4.8000000E+07   4.9000000E+07   5.0000000E+07   5.1000000E+07
   5.2000000E+07   5.3000000E+07   5.4000000E+07   5.5000000E+07
3/
3  251 'mubar'/
3  252 'xi'/
3  253 'gamma'/
3  259 '1/v'/
6/
16/
0/
0/
reconr / Reconstruct photo-atomic data
-41 -42
'PENDF photo-atomic data for 74-W-184'/
7400 2/
0.001 0. 0.003/
'74-W-184 from ENDF/B-VI'/
'Processed by NJOY99.364+  on 20111125'/
0/
gaminr / Prepare multigroup data for photons
-41 -42 0 43/
7400 10 3 6 1/
'74-W-184 for FENDL-3.0 from INDL/V-3 with NJOY99.364+  on 20111125'/
-1/
0/
matxsr / Produce MATXS file
31 43 44/
1 'FENDL-3.0w184'/
2 3 3 1
'74-W-184 FENDL-3.0 from INDL/V-3'/
'Photo-atomic data from ENDF/B-VI'/
'Processed by NJOY99.364+  on 20111125'/
'n' 'g'/
 211  42
'nscat' 'ng' 'gscat'/
1 1 2/
1 2 2/
'w184' 7437 7400/
stop
```

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