

## APPENDIX 3

Below follows a list of definitions to the ENDF-6 file format for JEFF-3.1. The different file numbers (MFs) listed in Table A3.1 followed by the reaction types (MTs) in Table A3.2. For a complete description of the ENDF-6 format, see reference V. McLane, *ENDF-102, Data Formats and Procedures for the Evaluated Nuclear Data File ENDF-6*, BNL-NCS-44945-01/04-Rev., April 2001.

**Table A3.1. Definitions of file types (MF)**

MF	Description
1	General information
2	Resonance parameter data
3	Reaction cross-sections
4	Angular distributions for emitted particles
5	Energy distributions for emitted particles
6	Energy-angle distributions for emitted particles
7	Thermal neutron scattering law data
8	Radioactivity and fission product yield data
9	Multiplicities for radioactive nuclide production
10	Cross-sections for radioactive nuclide production
12	Multiplicities for photon production
13	Cross-sections for photon production
14	Angular distributions for photon production
15	Energy distributions for photon production
23	Photo-atomic interaction cross-sections
27	Atomic form factors or scattering functions for photo-atomic interactions
30	Data covariances obtained from parameter covariances and sensitivities
31	Data covariances for nubar
32	Data covariances for resonance parameters
33	Data covariances for reaction cross-sections
34	Data covariances for angular distributions
35	Data covariances for energy distributions
39	Data covariances for radionuclide production yields
40	Data covariances for radionuclide production cross-sections

**Table A3.2. Definitions of reaction types (MT)**

MT	reaction	Description	Comments
1	(n,total)	Neutron total cross-sections. Sum of MT=2, 4, 5, 11, 16-18, 22-26, 28-37, 41-42, 44-45, 102-117.	Redundant. Undefined for incident charged particles.
2	(z,z <sub>0</sub> )	Elastic scattering cross-section for incident particles.	
3	(z,nonelastic)	Nonelastic neutron cross-section. Sum of MT=4, 5, 11, 16-18, 22-26, 28-37, 41-42, 44-45, 102-117.	Redundant. For photon production only.
4	(z,n)	Production of one neutron in the exit channel. Sum of the MT=50-91.	Redundant. For incident neutrons, this is inelastic scattering (MT=50 is undefined).
5	(z,anything)	Sum of all reactions not given explicitly in another MT number. This is a partial reaction to be added to obtain MT=1.	Each particle can be identified and its multiplicity given in File 6. Not allowed in Files 4, 5.
6-9		Not allowed in version 6.	<sup>9</sup> Be(n,2n) in version 5.
10	(z,continuum)	Total continuum reaction; includes all continuum reactions and excludes all discrete reactions.	Redundant; to be used for derived files only.
11	(z,2nd)	Production of two neutrons and a deuteron, plus a residual.	
12-15		Unassigned.	
16	(z,2n)	Production of two neutrons and a residual <sup>1</sup> . Sum of MT=875-891, if they are present.	
17	(z,3n)		
18	(z,fission)		
19	(n,f)		
20	(n,nf)	Second-chance fission <sup>2</sup> .	
21	(n,2nf)	Third-chance fission <sup>2</sup> .	
22	(z,nα)	Production of a neutron and an alpha particle, plus a residual.	
23	(n,n3α)	Production of a neutron and three alpha particles, plus a residual.	

<sup>1</sup> The “residual” is the remainder after the reaction specified by MT has taken place (for example, A-1 after an n,2n reaction on target A). This “residual” may break up further if LR > 0.

<sup>2</sup> Note that the partial fission cross-sections are not defined for incident charged particles.

**Table A3.2. Definitions of reaction types (MT) (cont.)**

MT	reaction	Description	Comments
24	(z,2n $\alpha$ )	Production of two neutrons and an alpha particle, plus a residual.	
25	(z,3n $\alpha$ )	Production of three neutrons and an alpha particle, plus a residual.	
26		Not allowed in version 6.	Version 5: (n,2n) isomeric state; used in File 8 and 6, 9, or 10.
27	(n,abs)	Absorption; sum of MT=18 and MT=102 through MT=117.	Rarely used.
28	(z,np)	Production of a neutron and a proton, plus a residual.	
29	(z,n2 $\alpha$ )	Production of a neutron and two alpha particles, plus a residual.	
30	(z,2n2 $\alpha$ )	Production of two neutrons and two alpha particles, plus a residual.	
31		Not allowed for version 6.	Used only as an LR flag.
32	(z,nd)	Production of a neutron and a deuteron, plus a residual.	
33	(z,nt)	Production of a neutron and a triton, plus a residual.	
34	(z,n <sup>3</sup> He)	Production of a neutron and a <sup>3</sup> He particle, plus a residual.	
35	(z,nd2 $\alpha$ )	Production of a neutron, a deuteron and 2 alpha particles, plus a residual.	
36	(z,nt2 $\alpha$ )	Production of a neutron, a triton and 2 alpha particles, plus a residual.	
37	(z,4n)	Production of 4 neutrons, plus a residual.	
38	(n,3nf)	Fourth-chance fission cross-section <sup>2</sup> .	
39		Not allowed for version 6.	Used only as an LR flag.
40		Not allowed for version 6.	Used only as an LR flag.
41	(z,2np)	Production of 2 neutrons and a proton, plus a residual.	
42	(z,3np)	Production of 3 neutrons and a proton, plus a residual.	
43		(Unassigned)	
44	(z,n2p)	Production of a neutron and 2 protons, plus a residual.	
45	(z,np $\alpha$ )	Production of a neutron, a proton and an alpha particle, plus a residual.	
46-49		Not allowed in Version 6.	Version 5: description of 2 <sup>nd</sup> neutron from <sup>9</sup> Be(n,2n) reactions to excited states.
50	(y,n <sub>0</sub> )	Production of a neutron, leaving the residual nucleus in the ground state.	Not allowed for incident neutrons; use MT=2.
51	(z,n <sub>1</sub> )	Production of a neutron, with residual in the 1 <sup>st</sup> excited state	

**Table A3.2. Definitions of reaction types (MT) (cont.)**

MT	reaction	Description	Comments
52	(z,n <sub>2</sub> )	Production of a neutron, with residual in the 2 <sup>nd</sup> excited state.	
	...		
	...		
90	(z,n <sub>40</sub> )	Production of a neutron, with residual in the 40 <sup>th</sup> excited state.	
91	(z,n <sub>c</sub> )	Production of a neutron in the continuum not included in the above discrete representation.	
92-100		(Unassigned)	
101	(n,disap)	Neutron disappearance; equal to sum of MT=102-117.	Rarely used.
102	(z,γ)	Radiative capture.	
103	(z,p)	Production of a proton, plus a residual. Sum of MT=600-649, if they are present.	For incident protons, this is inelastic scattering (MT=600 is undefined).
104	(z,d)	Production of a deuteron, plus a residual. Sum of MT=650-699, if they are present.	For incident deuterons, this is inelastic scattering (MT=650 is undefined).
105	(z,t)	Production of a triton, plus a residual. Sum of MT=700-749, if they are present.	For incident tritons, this is inelastic scattering (MT=700 is undefined).
106	(z, <sup>3</sup> He)	Production of a <sup>3</sup> He particle plus a residual. Sum of MT=750-799, if they are present.	For incident <sup>3</sup> He particles, this is inelastic scattering (MT=750 is undefined).
107	(z,α)	Production of an alpha particle, plus a residual. Sum of MT=800-849, if they are present.	For incident alpha particles, this is inelastic scattering (MT=800 is undefined).
108	(z,2α)	Production of 2 alpha particles, plus a residual.	
109	(z,3α)	Production of 3 alpha particles, plus a residual.	
110		(Unassigned)	
111	(z,2p)	Production of 2 protons, plus a residual.	
112	(z,pα)	Production of a proton and an alpha particle, plus a residual.	
113	(z,t2α)	Production of a triton and 2 alpha particles, plus a residual.	
114	(z,d2α)	Production of a deuteron and 2 alpha particles, plus a residual.	
115	(z,pd)	Production of proton and a deuteron, plus a residual.	
116	(z,pt)	Production of proton and a triton, plus a residual.	

**Table A3.2. Definitions of reaction types (MT) (cont.)**

MT	reaction	Description	Comments
117	(z,d $\alpha$ )	Production of deuteron and an alpha particle, plus a residual.	
118-119		(Unassigned)	
120		Not allowed for version 6.	Version 5: target destruction – non-elastic minus total (n,n' $\gamma$ )
121-150		(Unassigned)	
151	(n,RES)	Resonance parameters that can be used to calculate cross-sections at different temperatures in the resolved and unresolved energy regions.	Incident neutrons only.
152-200		(Unassigned)	
201	(z,Xn)	Total neutron production.	Redundant; use in derived files only.
202	(z,X $\gamma$ )	Total gamma production.	Redundant; use in derived files only.
203	(z,Xp)	Total proton production.	Redundant; use in derived files only.
204	(z,Xd)	Total deuteron production.	Redundant; use in derived files only.
205	(z,Xt)	Total triton production.	Redundant; use in derived files only.
206	(z,X <sup>3</sup> He)	Total <sup>3</sup> He production.	Redundant; use in derived files only.
207	(z,X $\alpha$ )	Total alpha particle production.	Redundant; use in derived files only.
208	(z,X $\pi^+$ )	Total $\pi^+$ production.	For use in high-energy evaluations.
209	(z,X $\pi^0$ )	Total $\pi^0$ production.	For use in high-energy evaluations.
210	(z,X $\pi^-$ )	Total $\pi^-$ production.	For use in high-energy evaluations.
211	(z,X $\mu^+$ )	Total $\mu^+$ production.	For use in high-energy evaluations.
212	(z,X $\mu^-$ )	Total $\mu^-$ production.	For use in high-energy evaluations.
213	(z,X $\kappa^+$ )	Total $\kappa^+$ production.	For use in high-energy evaluations.
214	(z,X $\kappa^0_{(long)}$ )	Total $\kappa^0_{(long)}$ production.	For use in high-energy evaluations.
215	(z,X $\kappa^0_{(short)}$ )	Total $\kappa^0_{(short)}$ production.	For use in high-energy evaluations.
216	(z,X $\kappa^-$ )	Total $\kappa^-$ production.	For use in high-energy evaluations.
217	(z,X $\bar{p}$ )	Total anti-proton production.	For use in high-energy evaluations.
218	(z,X $\bar{n}$ )	Total anti-neutron production.	For use in high-energy evaluations.
219-250		(Unassigned)	
251	(n,...)	$\bar{\mu}_L$ , average cosine of the scattering angle (laboratory system) for elastic scattering of neutrons.	Derived files only.
252	(n,...)	$\xi$ , average logarithmic energy decrement for elastic scattering of neutrons.	Derived files only.
253	(n,...)	$\gamma$ , average of the square of the logarithmic energy decrement divided by twice the average logarithmic energy decrement, for elastic scattering of neutrons.	Derived files only.
254-300		(Unassigned)	

**Table A3.2. Definitions of reaction types (MT) (cont.)**

MT	reaction	Description	Comments
301-450	(z,...)	Energy release parameters, $\bar{E}$ , $\bar{\sigma}$ , for total and partial cross-sections; MT= 300 plus the reaction MT number, <i>e.g.</i> MT=302 is the elastic scattering kerma.	Derived files only.
451	(z,...)	Heading or title information; given in File 1 only.	
452	(z,...)	$\bar{\nu}_T$ , average total (prompt plus delayed) number of neutrons released per fission event.	
453		(Unassigned)	
454	(z,...)	Independent fission product yield data.	
455	(z,...)	$\bar{\nu}_d$ , average number of delayed neutrons released per fission event.	
456	(z,...)	$\bar{\nu}_p$ , average number of prompt neutrons released per fission event.	
457	(z,...)	Radioactive decay data.	
458	(n,...)	Energy release in fission for incident neutrons.	
459	(z,...)	Cumulative fission product yield data.	
460-464		(Unassigned)	
465-466		Not allowed in version 6.	Version 5: delayed and prompt neutrons from spontaneous fission.
467-499		(Unassigned)	
500		Total charged-particle stopping power.	
501		Total photon interaction.	
502		Photon coherent scattering.	
503		(Unassigned)	
504		Photon incoherent scattering.	
505		Imaginary scattering factor.	
506		Real scattering factor.	
507-514		(Unassigned)	
515		Pair production, electron field.	
516		Pair production; sum of MT=515, 517.	Redundant.
517		Pair production, nuclear field.	
518		Not allowed in version 6.	
519-521		(Unassigned)	
522		Photoelectric absorption.	Version 5: MT=602.
523		Photo-excitation cross-section.	
524-525		(Unassigned)	
526		Electro-atomic scattering.	

**Table A3.2. Definitions of reaction types (MT) (cont.)**

MT	reaction	Description	Comments
527		Electro-atomic bremsstrahlung.	
528		Electro-atomic excitation cross-section.	
529-531		(Unassigned)	
532		Not allowed in version 6.	Version 5: ( $\gamma$ ,n).
533		Atomic relaxation data.	Version 5: total photonuclear.
534	K	(1s <sup>1/2</sup> ) subshell photoelectric or electro-atomic cross-section.	
535	L1	(2s <sup>1/2</sup> ) subshell photoelectric or electro-atomic cross-section.	
536	L2	(2p <sup>1/2</sup> ) subshell photoelectric or electro-atomic cross-section.	
537	L3	(2p <sup>3/2</sup> ) subshell photoelectric or electro-atomic cross-section.	
538	M1	(3s <sup>1/2</sup> ) subshell photoelectric or electro-atomic cross-section.	
539	M2	(3p <sup>1/2</sup> ) subshell photoelectric or electro-atomic cross-section.	
540	M3	(3p <sup>3/2</sup> ) subshell photoelectric or electro-atomic cross-section.	
541	M4	(3d <sup>3/2</sup> ) subshell photoelectric or electro-atomic cross-section.	
542	M5	(3d <sup>5/2</sup> ) subshell photoelectric or electro-atomic cross-section.	
543	N1	(4s <sup>1/2</sup> ) subshell photoelectric or electro-atomic cross-section.	
544	N2	(4p <sup>1/2</sup> ) subshell photoelectric or electro-atomic cross-section.	
545	N3	(4p <sup>3/2</sup> ) subshell photoelectric or electro-atomic cross-section.	
546	N4	(4d <sup>3/2</sup> ) subshell photoelectric or electro-atomic cross-section.	
547	N5	(4d <sup>5/2</sup> ) subshell photoelectric or electro-atomic cross-section.	
548	N6	(4f <sup>5/2</sup> ) subshell photoelectric or electro-atomic cross-section.	
549	N7	(4f <sup>7/2</sup> ) subshell photoelectric or electro-atomic cross-section.	
550	O1	(5s <sup>1/2</sup> ) subshell photoelectric or electro-atomic cross-section.	
551	O2	(5p <sup>1/2</sup> ) subshell photoelectric or electro-atomic cross-section.	
552	O3	(5p <sup>3/2</sup> ) subshell photoelectric or electro-atomic cross-section.	

**Table A3.2. Definitions of reaction types (MT) (cont.)**

MT	reaction	Description	Comments
553	O4	(5d <sup>3/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
554	O5	(5d <sup>5/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
555	O6	(5f <sup>5/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
556	O7	(5f <sup>7/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
557	O8	(5g <sup>7/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
558	O9	(5g <sup>9/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
559	P1	(6s <sup>1/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
560	P2	(6p <sup>1/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
561	P3	(6p <sup>3/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
562	P4	(6d <sup>3/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
563	P5	(6d <sup>5/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
564	P6	(6f <sup>5/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
565	P7	(6f <sup>7/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
566	P8	(6g <sup>7/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
567	P9	(6g <sup>9/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
568	P10	(6h <sup>9/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
569	P11	(6h <sup>11/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
570	Q1	(7s <sup>1/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
571	Q2	(7p <sup>1/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
572	Q3	(7p <sup>3/2</sup> ) subshell photoelectric or elctro-atomic cross-section.	
573-599		(Unassigned)	
600	(z,p <sub>0</sub> )	Production of a proton leaving the residual nucleus in the ground state.	Not allowed for incident protons; use MT=2.
601	(z,p <sub>1</sub> )	Production of a proton, with residual in the 1 <sup>st</sup> excited state.	



**Table A3.2. Definitions of reaction types (MT) (cont.)**

MT	reaction	Description	Comments
602	(z,p <sub>2</sub> )	Production of a proton, with residual in the 2 <sup>nd</sup> excited state.	Version 5: photoelectric absorption; see MT=522.
603	(z,p <sub>3</sub> )	Production of a proton, with residual in the 3 <sup>rd</sup> excited state.	
604	(z,p <sub>4</sub> )	Production of a proton, with residual in the 4 <sup>th</sup> excited state.	
	...		
	...		
649	(z,p <sub>c</sub> )	Production of a proton in the continuum not included in the above discrete representation.	
650	(z,d <sub>0</sub> )	Production of a deuteron leaving the residual nucleus in the ground state.	
651	(z,d <sub>1</sub> )	Production of a deuteron, with the residual in the 1 <sup>st</sup> excited state.	
652	(z,d <sub>2</sub> )	Production of a deuteron, with the residual in the 2 <sup>nd</sup> excited state.	
	...		
	...		
699	(z,d <sub>c</sub> )	Production of a deuteron in the continuum not included in the above discrete representation.	
700	(z,t <sub>0</sub> )	Production of a triton leaving the residual nucleus in the ground state.	
701	(z,t <sub>1</sub> )	Production of a triton, with residual in the 1 <sup>st</sup> excited state.	
702	(z,t <sub>2</sub> )	Production of a triton, with residual in the 2 <sup>nd</sup> excited state.	
	...		
	...		
749	(z,t <sub>c</sub> )	Production of a triton in the continuum not included in the above discrete representation.	
750	(n, <sup>3</sup> He <sub>0</sub> )	Production of a <sup>3</sup> He particle leaving the residual nucleus in the ground state.	
751	(n, <sup>3</sup> He <sub>1</sub> )	Production of a <sup>3</sup> He, with residual in the 1 <sup>st</sup> excited state.	
	...		
	...		
799	(n, <sup>3</sup> He <sub>c</sub> )	Production of a <sup>3</sup> He in the continuum not included in the above discrete representation.	
800	(z,α <sub>0</sub> )	Production of an alpha particle leaving the residual nucleus in the ground state.	

**Table A3.2. Definitions of reaction types (MT) (cont.)**

MT	reaction	Description	Comments
801	$(z, \alpha_1)$	Production of an alpha particle, with residual in the 1 <sup>st</sup> excited state.	
	...		
	...		
849	$(z, \alpha_c)$	Production of an alpha particle in the continuum not included in the above discrete representation.	
850		(Unassigned)	
851-870		Lumped reaction covariances.	
871-874		(Unassigned)	
875	$(z, 2n_0)$	Production of 2 neutrons with residual in the ground state.	
876	$(z, 2n_1)$	Production of 2 neutrons with residual in the 1 <sup>st</sup> excited state.	
	...		
891	$(z, 2n_c)$	Production of 2 neutrons in the continuum not included in the above discrete representation.	
892-999		(Unassigned)	