

# Los Alamos

NATIONAL LABORATORY

## memorandum

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### **SUBJECT: Neutron and Photon Multigroup Data Tables for MCNP3B**

Version 3B will be our first production version of MCNP to provide the capability of using multigroup cross-section sets. The format of multigroup cross-section tables for MCNP is documented in Ref. 1. This memo describes the neutron and photon multigroup libraries that we plan to provide with MCNP3B.

We will use the transport cross sections contained on the public libraries MENDF5 and MENDF5G as the starting point for the MCNP libraries. MENDF5 and MENDF5G are used by several deterministic production codes at Los Alamos. The latest versions of the libraries are described in Ref. 2. The multigroup data on MENDF5 and MENDF5G were originally generated from pointwise cross sections using the NJOY<sup>3</sup> and CLYDE<sup>4</sup> processing codes.

Multigroup neutron cross sections will be available for 95 isotopes or elements as listed in Table I. ZAID identifiers, evaluated data sources, and references are given for each of the 95 materials. Finally, Table I indicates whether photon-production data are included for each cross-section set.

Neutron cross sections are given in 30 groups. The boundaries are listed in Table II. The spectrum used for collapse is the standard TD-Division weight function described in Ref. 5. Neutron cross sections have generally been processed at room temperature (300°K) with the exception of the ENDL85 and PERMFILE sets which have been processed at 0°K. No self-shielding has been incorporated; all cross sections are infinitely dilute. No upscatter groups are provided for.

For fissionable isotopes, the data tables will contain either prompt nubar, total nubar, or both prompt and total nubar. The type of nubar available for a particular isotope will be the same as what is available for its continuous-energy counterpart. This information is documented in Appendix G of the MCNP manual.<sup>6</sup> Presently, the fission chi is independent of incident neutron energy and is generally the prompt chi. As is the case with all of our continuous-energy neutron tables, secondary photon-production data include prompt photons only.

Multigroup photon cross sections will be available for 55 elements as listed in Table III. All photon transport cross sections have been obtained from R. E. MacFarlane's file /LIB12/DTF12<sup>7</sup> and are based on the DLC-7E<sup>8</sup> library.

Photon cross sections are given in 12 groups. The boundaries are listed in Table IV. The weight function used for collapse of photon cross sections is described in Ref. 9.

Angular distributions of scattered particles are accounted for on MENDF5 and MENDF5G by PO through P4 Legendre scattering tables (no transport correction). MCNP requires angular distributions for each group-to-group scattering in terms of either discrete cosines or equally-probable cosine bins. We have chosen to process the data contained in the PO-P4 tables into equally-probable cosine bins. We are able to

calculate three equally-probable cosine bins for each combination of incident and exiting group using methods described in Ref. 10.

To use multigroup cross sections in MCNP3B, it is necessary that the cross-section directory contain information about the multigroup libraries. When MCNP3B becomes the production version, the public file XSDIR will be expanded to include the necessary information. Until that time, the user must fetch /X6MGXS/CTSS/DIR2NP from CFS. Then, switch DIR2NP to XSDIR, or set XSDIR=DIR2NP on the MCNP execute line. The MGOPT card<sup>11</sup> in your input deck will signal MCNP that you want a multigroup calculation. When using the cross-section tables described in this memo, the second entry on the MGOPT card (IGM) should be 30 for MODE N, 12 for MODE P, and 42 for MODE N P. Users will have the same flexibility in specifying ZAIDs on the MCNP material cards that exists now for continuous-energy calculations. For example, the following three Mn cards are all equivalent:

```
Mn 92235 1
Mn 92235.50 1
Mn 92235.50M 1
```

In a MODE N P problem, any of the above material cards would force the code to access both the 92235.50M and the 92000.01G tables.

Very complete edit cross sections for use with the FM feature of MCNP are available on these libraries. The edits have been obtained from TRANSX<sup>12</sup> and CLYDE<sup>4</sup> calculations. In general, any cross section available to MCNP as a response function from a continuous-energy table (including any of the special negative FM reaction numbers) will be available to MCNP from the corresponding multigroup table. The edit reactions available for each multigroup table are listed in Table V. Most of the edit numbers identify reactions as defined in the ENDF/B system for evaluated data.<sup>13</sup> Table VI is a list of many of these reactions. Users should be aware of exceptions for several light isotopes (D, <sup>6</sup>Li, <sup>7</sup>Li, <sup>10</sup>B, C, <sup>12</sup>C, <sup>14</sup>N, <sup>16</sup>O, and <sup>27</sup>Al). For these isotopes, reactions identified in Table VI as (n,n') inelastic scattering may actually be (n,n'X) inelastic scattering, where X indicates some combination of particles. The exceptions are described in Refs. 14 and 15. We have also defined several additional reaction numbers. These special reaction numbers are listed in Table VII.

We will conclude this memo by acknowledging our understanding that one multigroup library cannot be adequate for all problems. There will, therefore, be available a code that will read from several standard multigroup formats (e.g., DTF, FIDO), process the data, and produce multigroup tables in a format ready for use in MCNP. This code will be described in a subsequent memo.

**Table 1: Neutron Multigroup Cross-Section Tables for MCNP3B**

Isotope	ZAID	Source	Reference	Photon Production
H	1001.50m	ENDF/B-V	16	Yes
D	1002.55m	Group T-2	17	Yes
T	1003.50m	ENDF/B-V	16	No
He-3	2003.50m	ENDF/B-V	16	No
He-4	2004.50m	ENDF/B-V	16	No
Li-6	3006.50m	ENDF/B-V	16	Yes
Li-7	3007.55m	Group T-2	18	Yes
Be-7	4007.35m	ENDL85	19	No
Be-9	4009.50m	ENDF/B-V	16	Yes
B-10	5010.50m	ENDF/B-V	16	Yes
B-11	5011.56m	Group T-2	20	Yes
C	6000.50m	ENDF/B-V	16	Yes
C-12*	6012.50m	ENDF/B-V	16	Yes
N-14	7014.50m	ENDF/B-V	16	Yes
N-15	7015.55m	Group T-2	21	Yes
O-16	8016.50m	ENDF/B-V	16	Yes
F-19	9019.50m	ENDF/B-V	16	Yes
Na-23	11023.50m	ENDF/B-V	16	Yes
Mg	12000.50m	ENDF/B-V	16	Yes
Al-27	13027.50m	ENDF/B-V	16	Yes
Si	14000.50m	ENDF/B-V	16	Yes
P-31	15031.50m	ENDF/B-V	16	Yes
S-32	16032.50m	ENDF/B-V	16	Yes
Cl	17000.50m	ENDF/B-V	16	Yes
Ar	18000.35m	ENDL85	19	Yes
K	19000.50m	ENDF/B-V	16	Yes
Ca	20000.50m	ENDF/B-V	16	Yes
Ti	22000.50m	ENDF/B-V	16	Yes
V	23000.50m	ENDF/B-V	16	Yes
Cr	24000.50m	ENDF/B-V	16	Yes
Mn-55	25055.50m	ENDF/B-V	16	Yes
Fe	26000.55m	Group T-2	22	Yes
Co-59	27059.50m	ENDF/B-V	16	Yes
Ni	28000.50m	ENDF/B-V	16	Yes
Cu	29000.50m	ENDF/B-V	16	Yes

Table 1 cont.

Isotope	ZAID	Source	Reference	Photon Production
Ga	31000.50m	ENDF/B-V	16	Yes
As-75	33075.35m	ENDL85	19	Yes
Kr-78	36078.50m	ENDF/B-V	16	No
Kr-80	36080.50m	ENDF/B-V	16	No
Kr-82	36082.50m	ENDF/B-V	16	No
Kr-83	36083.50m	ENDF/B-V	16	No
Kr-84	36084.50m	ENDF/B-V	16	No
Kr-86	36086.50m	ENDF/B-V	16	No
Zr	40000.50m	ENDF/B-V	16	No
Nb-93	41093.50m	ENDF/B-V	16	Yes
Mo	42000.50m	ENDF/B-V	16	Yes
Rh-103	45103.50m	ENDF/B-V	16	No
U235 FP**	45117.90m	Group T-2	23	Yes
Pu239 FP**	46119.90m	Group T-2	23	Yes
Ag	47000.55m	Group T-2	24	Yes
Ag-107	47107.50m	ENDF/B-V	16	No
Ag-109	47109.50m	ENDF/B-V	16	No
Cd	48000.50m	ENDF/B-V	16	No
Ave FP**	50120.35m	ENDL85	19	Yes
FPP**	50998.99m	PERMFILE	25	No
FPA**	50999.99m	PERMFILE	25	No
Xe	54000.35m	ENDL85	19	Yes
Ba-138	56138.50m	ENDF/B-V	16	Yes
Eu	63000.35m	ENDL85	19	Yes
Eu-151	63151.55m	Group T-2	26	Yes
Eu-153	63153.55m	Group T-2	26	Yes
Gd	64000.35m	ENDL85	19	Yes
Ho-165	67165.55m	Group T-2	26	Yes
Ta-181	73181.50m	ENDF/B-V	16	Yes
W	74000.55m	Group T-2	27	Yes
W-182	74182.55m	Group T-2	28	Yes
W-183	74183.55m	Group T-2	28	Yes
w-184	74184.55m	Group T-2	28	Yes
W-186	74186.55m	Group T-2	28	Yes
Re-185	75185.50m	ENDF/B-V	16	No

**Table 1 cont.**

Isotope	ZAID	Source	Reference	Photon Production
Re-187	75187.50m	ENDF/B-V	16	No
Pt	78000.35m	ENDL85	19	Yes
Au-197	79197.56m	Group T-2	29	Yes
Pb	82000.50m	ENDF/B-V	16	Yes
Bi-209	83209.50m	ENDF/B-V	16	Yes
Th-232	90232.50m	ENDF/B-V	16	Yes
Pa-233	91233.50m	ENDF/B-V	16	No
U-233	92233.50m	ENDF/B-V	16	No
U-234	92234.50m	ENDF/B-V	16	No
U-235	92235.50m	ENDF/B-V	16	Yes
U-236	92236.50m	ENDF/B-V	16	No
U-237	92237.50m	ENDF/B-V	16	Yes
U-238	92238.50m	ENDF/B-V	16	Yes
U-239	92239.35m	ENDL85	19	Yes
Np-237	93237.55m	Group T-2	30	No
Pu-238	94238.50m	ENDF/B-V	16	No
Pu-239	94239.55m	Group T-2	31	Yes
Pu-240	94240.50m	ENDF/B-V	16	Yes
Pu-241	94241.50m	ENDF/B-V	16	Yes
Pu-242	94242.50m	ENDF/B-V	16	Yes
Am-241	95241.50m	ENDF/B-V	16	No
Am-242m	95242.50m	ENDF/B-V	16	No
Am-243	95243.50m	ENDF/B-V	16	No
Cm-242	96242.50m	ENDF/B-V	16	No
Cm-244	96244.50m	ENDF/B-V	16	No

\* - Data for C-12 are identical to those for natural carbon.

\*\* - Several sets of fission-product cross sections are included. ZAID=50120.35M is the cross section for an average fission product from ENDL85. ZAID=45117.90M and ZAID=46119.90M are cross sections from Group T-2 for prompt fission products from <sup>235</sup>U fission and <sup>239</sup>Pu fission, respectively. ZAID=50998.99M and ZAID=50999.99M are older cross section sets intended for fission-product pairs. The data have been used often over the years at Los Alamos and are included here for completeness.

**Table II: Boundaries of Neutron Energy Groups**

Group	Upper Energy (MeV)	Group	Upper Energy (MeV)
1	17.000	16	0.184
2	15.000	17	0.0676
3	13.500	18	0.0248
4	12.000	19	0.00912
5	10.000	20	0.00335
6	7.790	21	0.001235
7	6.070	22	4.54E-04
8	3.680	23	1.67E-04
9	2.865	24	6.14E-05
10	2.232	25	2.26E-05
11	1.738	26	8.32E-06
12	1.353	27	3.06E-06
13	0.823	28	1.13E-06
14	0.500	29	4.14E-07
15	0.303	30	1.52E-07
lower energy of Group 30 is equal to 1.39E-10 MeV			

**Table III: Photon Multigroup Cross-Section Tables for MCNP3B**

<u>Element</u>	<u>ZAID</u>	<u>Element</u>	<u>ZAID</u>
H	1000.01g	Zr	40000.01g
He	2000.01g	Nb	41000.01g
Li	3000.01g	Mo	42000.01g
Be	4000.01g	Rh	45000.01g
B	5000.01g	Pd	46000.01g
C	6000.01g	Ag	47000.01g
N	7000.01g	Cd	48000.01g
O	8000.01g	Sn	50000.01g
F	9000.01g	Xe	54000.01g
Na	11000.01g	Ba	56000.01g
Mg	12000.01g	Eu	63000.01g
Al	13000.01g	Gd	64000.01g
Si	14000.01g	Ho	67000.01g
P	15000.01g	Ta	73000.01g
S	16000.01g	w	74000.01g
Cl	17000.01g	Re	75000.01g
Ar	18000.01g	Pt	78000.01g
K	19000.01g	Au	79000.01g
Ca	20000.01g	Pb	82000.01g
Ti	22000.01g	Bi	83000.01g
V	23000.01g	Th	90000.01g
Cr	24000.01g	Pa*	91000.01g
Mn	25000.01g	U	92000.01g
Fe	26000.01g	Np*	93000.01g
Co	27000.01g	Pu	94000.01g
Ni	28000.01g		
Cu	29000.01g		
Ga	31000.01g		
As	33000.01g		
Kr	36000.01g		

\* - Data for Z=91 and Z=93 are not available on DLC-7E. The values here have been arrived at for Z=91 by averaging data for Z=90 and Z=92, and for Z=93 by averaging data for Z=92 and Z=94.

**Table IV: Boundaries of Photon Energy Groups**

<u>Group</u>	<u>Upper Energy (MeV)</u>
1	20.0
2	9.0
3	8.0
4	7.0
5	6.0
6	5.0
7	4.0
8	3.0
9	2.0
10	1.0
11	0.5
12	0.1

lower energy of Group 12 is equal to 0.01 MeV



**Table V: Edit Reactions for Each Multigroup Table**

For ZAID= 1001.50m there are 8 edits available

1 2 101 102 204 301 302 401

For ZAID= 1000.01g there are 8 edits available

1 101 301 401 502 504 516 602

For ZAID= 1002.55m there are 39 edits available

1 2 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68  
69 70 71 72 73 74 75 76 77 78 79 80 101 102 203 205 301 302 401

For ZAID= 1003.50m there are 6 edits available

1 2 16 204 301 401

For ZAID= 2003.50m there are 10 edits available

1 2 101 103 104 203 204 205 301 401

For ZAID= 2000.01g there are 8 edits available

1 101 301 401 502 504 516 602

For ZAID= 2004.50m there are 4 edits available

1 2 301 401

For ZAID= 3006.50m there are 43 edits available

1 2 24 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67  
68 69 70 71 72 73 74 75 76 77 78 79 101 102 103 105 203 204 205 207  
301 302 401

For ZAID= 3000.01g there are 8 edits available

1 101 301 401 502 504 516 602

For ZAID= 3007.55m there are 42 edits available

1 2 16 24 25 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65  
66 67 68 69 70 71 72 73 74 75 76 77 101 102 104 203 204 205 207 301  
302 401

For ZAID= 4007.35m there are 7 edits available

1 2 101 103 107 203 207

For ZAID= 4000.01g there are 6 edits available

1 101 502 504 516 602

For ZAID= 4009.50m there are 23 edits available

1 2 6 7 8 9 46 47 48 49 101 102 103 104 105 107 203 204 205 207  
301 302 401

For ZAID= 5010.50m there are 44 edits available

1 2 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68  
69 70 71 72 73 74 75 76 77 78 79 101 102 103 104 107 113 203 204 205  
207 301 302 401

For ZAID= 5000.01g there are 8 edits available

1 101 301 401 502 504 516 602

For ZAID= 5011.56m there are 26 edits available

1 2 16 22 28 51 52 53 54 55 56 57 58 59 60 101 102 103 105 107  
203 205 207 301 302 401

**Table V cont.**

For ZAID= 6000.50m there are 28 edits available  
 1 2 51 52 53 54 55 56 57 58 59 60 61 62 63 64 91 101 102 103  
 104 107 203 204 207 301 302 401

For ZAID= 6000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 6012.50m there are 28 edits available  
 1 2 51 52 53 54 55 56 57 58 59 60 61 62 63 64 91 101 102 103  
 104 107 203 204 207 301 302 401

For ZAID= 7014.50m there are 44 edits available  
 1 2 16 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67  
 68 69 70 71 72 73 74 75 76 77 101 102 103 104 105 107 108 203 204 205  
 207 301 302 401

For ZAID= 7000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 7015.55m there are 26 edits available  
 1 2 16 22 28 51 52 53 54 55 56 57 91 101 102 103 104 105 107 203  
 204 205 207 301 302 401

For ZAID= 8016.50m there are 43 edits available  
 1 2 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68  
 69 70 71 72 73 74 75 76 77 78 79 80 101 102 103 104 107 203 204 207  
 301 302 401

For ZAID= 8000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 9019.50m there are 40 edits available  
 1 2 16 22 28 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65  
 66 67 68 69 70 71 91 101 102 103 104 105 107 203 204 205 207 301 302 401

For ZAID= 9000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 11023.50m there are 31 edits available  
 1 2 16 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67  
 68 91 101 102 103 107 203 207 301 302 401

For ZAID= 11000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 12000.50m there are 55 edits available  
 1 2 16 22 28 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65  
 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85  
 86 87 88 89 90 91 101 102 103 107 203 207 301 302 401

For ZAID= 12000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 13027.50m there are 52 edits available  
 1 2 16 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67  
 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 101  
 102 103 104 105 107 203 204 205 207 301 302 401

For ZAID= 13000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

**Table V cont.**

For ZAID= 14000.50m there are 39 edits available

1 2 16 22 28 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65  
66 67 68 69 70 71 72 91 101 102 103 104 107 203 204 207 301 302 401

For ZAID= 14000.01g there are 8 edits available

1 101 301 401 502 504 516 602

For ZAID= 15031.50m there are 14 edits available

1 2 16 28 91 101 102 103 107 203 207 301 302 401

For ZAID= 15000.01g there are 8 edits available

1 101 301 401 502 504 516 602

For ZAID= 16032.50m there are 16 edits available

1 2 16 28 91 101 102 103 105 107 203 205 207 301 302 401

For ZAID= 16000.01g there are 8 edits available

1 101 301 401 502 504 516 602

For ZAID= 17000.50m there are 28 edits available

1 2 16 22 28 51 52 53 54 55 56 57 58 59 60 61 62 63 91 101  
102 103 107 203 207 301 302 401

For ZAID= 17000.01g there are 8 edits available

1 101 301 401 502 504 516 602

For ZAID= 18000.35m there are 11 edits available

1 2 16 91 101 102 103 107 203 207 302

For ZAID= 18000.01g there are 6 edits available

1 101 502 504 516 602

For ZAID= 19000.50m there are 32 edits available

1 2 16 22 28 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65  
66 67 91 101 102 103 107 203 207 301 302 401

For ZAID= 19000.01g there are 8 edits available

1 101 301 401 502 504 516 602

For ZAID= 20000.50m there are 47 edits available

1 2 16 22 28 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65  
66 67 68 69 70 71 72 73 91 101 102 103 104 105 106 107 108 111 112 203  
204 205 206 207 301 302 401

For ZAID= 20000.01g there are 8 edits available

1 101 301 401 502 504 516 602

For ZAID= 22000.50m there are 34 edits available

1 2 16 22 28 51 52 53 54 55 56 57 58 59 60 61 62 91 101 102  
103 104 105 106 107 111 203 204 205 206 207 301 302 401

For ZAID= 22000.01g there are 8 edits available

1 101 301 401 502 504 516 602

For ZAID= 23000.50m there are 26 edits available

1 2 16 22 28 51 52 53 54 55 56 57 91 101 102 103 104 105 107 203  
204 205 207 301 302 401

For ZAID= 23000.01g there are 8 edits available

1 101 301 401 502 504 516 602

**Table V cont.**

For ZAID= 24000.50m there are 61 edits available  
 1 2 16 22 28 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65  
 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85  
 86 87 88 89 90 91 101 102 103 104 105 106 107 203 204 205 206 207 301 302  
 401

For ZAID= 24000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 25055.50m there are 31 edits available  
 1 2 16 22 28 51 52 53 54 55 56 57 58 59 60 61 62 91 101 102  
 103 104 106 107 203 204 206 207 301 302 401

For ZAID= 25000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 26000.55m there are 61 edits available  
 1 2 16 22 28 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65  
 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85  
 86 87 88 89 90 91 101 102 103 104 105 106 107 203 204 205 206 207 301 302  
 401

For ZAID= 26000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 27059.50m there are 32 edits available  
 1 2 16 22 28 51 52 53 54 55 56 57 58 59 60 61 91 101 102 103  
 104 105 106 107 203 204 205 206 207 301 302 401

For ZAID= 27000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 28000.50m there are 44 edits available  
 1 2 16 22 28 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65  
 66 67 68 69 70 71 72 73 74 75 76 91 101 102 103 104 107 111 203 204  
 207 301 302 401

For ZAID= 28000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 29000.50m there are 30 edits available  
 1 2 16 22 28 51 52 53 54 55 56 57 58 59 60 61 91 101 102 103  
 104 106 107 203 204 206 207 301 302 401

For ZAID= 29000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 31000.50m there are 13 edits available  
 1 2 16 91 101 102 103 107 203 207 301 302 401

For ZAID= 31000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 33075.35m there are 11 edits available  
 1 2 16 91 101 102 103 107 203 207 302

For ZAID= 33000.01g there are 6 edits available  
 1 101 502 504 516 602

**Table V cont.**

For ZAID= 36078.50m there are 21 edits available  
 1 2 16 51 52 53 91 101 102 103 104 105 106 107 203 204 205 206 207 301  
 401

For ZAID= 36000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 36080.50m there are 24 edits available  
 1 2 16 51 52 53 54 55 56 91 101 102 103 104 105 106 107 203 204 205  
 206 207 301 401

For ZAID= 36082.50m there are 25 edits available  
 1 2 16 51 52 53 54 55 56 57 58 59 91 101 102 103 104 105 107 203  
 204 205 207 301 401

For ZAID= 36083.50m there are 24 edits available  
 1 2 16 51 52 53 54 55 56 91 101 102 103 104 105 106 107 203 204 205  
 206 207 301 401

For ZAID= 36084.50m there are 29 edits available  
 1 2 16 51 52 53 54 55 56 57 58 59 60 61 62 63 91 101 102 103  
 104 105 107 203 204 205 207 301 401

For ZAID= 36086.50m there are 28 edits available  
 1 2 16 51 52 53 54 55 56 57 58 59 60 61 62 63 64 91 101 102  
 103 104 105 203 204 205 301 401

For ZAID= 40000.50m there are 31 edits available  
 1 2 16 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67  
 68 69 91 101 102 103 107 203 207 301 401

For ZAID= 40000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 41093.50m there are 27 edits available  
 1 2 16 17 22 51 52 53 54 55 56 57 58 59 60 61 62 91 101 102  
 103 107 203 207 301 302 401

For ZAID= 41000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 42000.50m there are 10 edits available  
 1 2 16 17 91 101 102 301 302 401

For ZAID= 42000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 45103.50m there are 22 edits available  
 1 2 16 51 52 53 54 55 56 57 58 59 60 61 62 63 64 91 101 102  
 301 401

For ZAID= 45000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 45117.90m there are 8 edits available  
 1 2 16 17 91 101 102 302

For ZAID= 46119.90m there are 8 edits available  
 1 2 16 17 91 101 102 302

**Table V cont.**

For ZAID= 46000.01g there are 6 edits available

1 101 502 504 516 602

For ZAID= 47000.55m there are 28 edits available

1 2 16 51 52 53 54 55 56 57 58 59 60 61 91 101 102 103 104 105  
107 203 204 205 207 301 302 401

For ZAID= 47000.01g there are 8 edits available

1 101 301 401 502 504 516 602

For ZAID= 47107.50m there are 22 edits available

1 2 16 51 52 53 54 55 56 91 101 102 103 104 105 107 203 204 205 207  
301 401

For ZAID= 47109.50m there are 17 edits available

1 2 16 51 52 53 54 55 91 101 102 103 107 203 207 301 401

For ZAID= 48000.50m there are 16 edits available

1 2 16 51 52 53 54 91 101 102 103 107 203 207 301 401

For ZAID= 48000.01g there are 8 edits available

1 101 301 401 502 504 516 602

For ZAID= 50120.35m there are 8 edits available

1 2 16 17 91 101 102 302

For ZAID= 50000.01g there are 6 edits available

1 101 502 504 516 602

For ZAID= 50998.99m there are 3 edits available

1 2 91

For ZAID= 50999.99m there are 4 edits available

1 2 16 91

For ZAID= 54000.35m there are 8 edits available

1 2 16 17 91 101 102 302

For ZAID= 54000.01g there are 6 edits available

1 101 502 504 516 602

For ZAID= 56138.50m there are 14 edits available

1 2 16 17 91 101 102 103 107 203 207 301 302 401

For ZAID= 56000.01g there are 8 edits available

1 101 301 401 502 504 516 602

For ZAID= 63000.35m there are 8 edits available

1 2 16 17 91 101 102 302

For ZAID= 63000.01g there are 6 edits available

1 101 502 504 516 602

For ZAID= 63151.55m there are 37 edits available

1 2 16 17 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66  
67 91 101 102 103 104 105 106 107 203 204 205 206 207 301 302 401

For ZAID= 63153.55m there are 30 edits available

1 2 16 17 51 52 53 54 55 56 57 58 59 60 91 101 102 103 104 105  
106 107 203 204 205 206 207 301 302 401

**Table V cont.**

For ZAID= 64000.35m there are 8 edits available

1 2 16 17 91 101 102 302

For ZAID= 64000.01g there are 6 edits available

1 101 502 504 516 602

For ZAID= 67165.55m there are 23 edits available

1 2 16 17 51 52 53 54 55 56 57 58 59 60 61 62 63 91 101 102  
301 302 401

For ZAID= 67000.01g there are 8 edits available

1 101 301 401 502 504 516 602

For ZAID= 73181.50m there are 22 edits available

1 2 16 17 51 52 53 54 55 56 57 58 59 60 91 101 102 103 203 301  
302 401

For ZAID= 73000.01g there are 8 edits available

1 101 301 401 502 504 516 602

For ZAID= 74000.55m there are 53 edits available

1 2 16 17 28 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65  
66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85  
86 87 88 89 90 91 101 102 103 107 203 207 302

For ZAID= 74000.01g there are 8 edits available

1 101 301 401 502 504 516 602

For ZAID= 74182.55m there are 34 edits available

1 2 16 17 28 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65  
66 67 68 69 91 101 102 103 107 203 207 301 302 401

For ZAID= 74183.55m there are 29 edits available

1 2 16 17 28 51 52 53 54 55 56 57 58 59 60 61 62 63 64 91  
101 102 103 107 203 207 301 302 401

For ZAID= 74184.55m there are 33 edits available

1 2 16 17 28 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65  
66 67 68 91 101 102 103 107 203 207 301 302 401

For ZAID= 74186.55m there are 33 edits available

1 2 16 17 28 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65  
66 67 68 91 101 102 103 107 203 207 301 302 401

For ZAID= 75185.50m there are 17 edits available

1 2 16 17 51 52 53 54 55 56 57 58 91 101 102 301 401

For ZAID= 75000.01g there are 8 edits available

1 101 301 401 502 504 516 602

For ZAID= 75187.50m there are 20 edits available

1 2 16 17 51 52 53 54 55 56 57 58 59 60 61 91 101 102 301 401

For ZAID= 78000.35m there are 8 edits available

1 2 16 17 91 101 102 302

For ZAID= 78000.01g there are 6 edits available

1 101 502 504 516 602

**Table V cont.**

For ZAID= 79197.56m there are 27 edits available  
 1 2 16 17 51 52 53 54 55 56 57 58 59 60 61 62 63 91 101 102  
 103 107 203 207 301 302 401

For ZAID= 79000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 82000.50m there are 45 edits available  
 1 2 16 17 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66  
 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 91  
 101 102 301 302 401

For ZAID= 82000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 83209.50m there are 21 edits available  
 1 2 16 17 22 51 52 53 54 55 56 91 101 102 103 107 203 207 301 302  
 401

For ZAID= 83000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 90232.50m there are 29 edits available  
 1 2 16 17 18 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65  
 91 101 102 301 302 318 401 452 456

For ZAID= 90000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 91233.50m there are 17 edits available  
 1 2 16 17 18 51 52 53 54 55 91 101 102 301 318 401 452

For ZAID= 91000.01g there are 0 edits available

For ZAID= 92233.50m there are 17 edits available  
 1 2 16 17 18 51 52 53 54 91 101 102 301 318 401 452 456

For ZAID= 92000.01g there are 8 edits available  
 1 101 301 401 502 504 516 602

For ZAID= 92234.50m there are 21 edits available  
 1 2 16 17 18 19 20 21 51 52 53 54 55 56 91 101 102 301 318 401  
 452

For ZAID= 92235.50m there are 33 edits available  
 1 2 16 17 18 19 20 21 51 52 53 54 55 56 57 58 59 60 61 62  
 63 64 65 66 91 101 102 301 302 318 401 452 456

For ZAID= 92236.50m there are 21 edits available  
 1 2 16 17 18 19 20 21 51 52 53 54 55 56 91 101 102 301 318 401  
 452

For ZAID= 92237.50m there are 13 edits available  
 1 2 16 17 18 91 101 102 301 302 318 401 452

For ZAID= 92238.50m there are 44 edits available  
 1 2 16 17 18 19 20 21 51 52 53 54 55 56 57 58 59 60 61 62  
 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 91 101 102 301 302  
 318 401 452 456



**Table V cont.**

For ZAID= 92239.35m there are 12 edits available

1 2 16 17 18 37 91 101 102 302 318 456

For ZAID= 93237.55m there are 41 edits available

1 2 16 17 18 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65  
66 67 68 69 70 71 72 73 74 75 76 77 78 91 101 102 301 318 401 452  
456

For ZAID= 93000.01g there are 0 edits available

For ZAID= 94238.50m there are 29 edits available

1 2 16 17 18 19 20 51 52 53 54 55 56 57 58 59 60 61 62 63  
64 65 91 101 102 301 318 401 452

For ZAID= 94000.01g there are 8 edits available

1 101 301 401 502 504 516 602

For ZAID= 94239.55m there are 35 edits available

1 2 16 17 18 19 20 21 51 52 53 54 55 56 57 58 59 60 61 62  
63 64 65 66 67 68 91 101 102 301 302 318 401 452 456

For ZAID= 94240.50m there are 29 edits available

1 2 16 17 18 19 20 21 51 52 53 54 55 56 57 58 59 60 61 62  
91 101 102 301 302 318 401 452 456

For ZAID= 94241.50m there are 29 edits available

1 2 16 17 18 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65  
91 101 102 301 302 318 401 452 456

For ZAID= 94242.50m there are 33 edits available

1 2 16 17 18 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65  
66 67 68 69 91 101 102 301 302 318 401 452 456

For ZAID= 95241.50m there are 32 edits available

1 2 16 17 18 19 20 51 52 53 54 55 56 57 58 59 60 61 62 63  
64 65 66 67 68 91 101 102 301 318 401 452

For ZAID= 95242.50m there are 27 edits available

1 2 16 17 18 19 20 51 52 53 54 55 56 57 58 59 60 61 62 63  
91 101 102 301 318 401 452

For ZAID= 95243.50m there are 31 edits available

1 2 16 17 18 19 20 51 52 53 54 55 56 57 58 59 60 61 62 63  
64 65 66 67 91 101 102 301 318 401 452

For ZAID= 96242.50m there are 17 edits available

1 2 16 17 18 19 20 51 52 53 91 101 102 301 318 401 452

For ZAID= 96244.50m there are 17 edits available

1 2 16 17 18 19 20 51 52 53 91 101 102 301 318 401 452

**Table VI: Definition of ENDF/B-V Reaction Types**

1	Total cross section
2	Elastic scattering cross section
6	(n, 2n) cross section for first excited state (describes first neutron)
7	(n,2n) cross section for second excited state (describes first neutron)
8	(n,2n) cross section for third excited state (describes first neutron)
9	(n,2n) cross section for fourth excited state (describes first neutron)
16	direct (n,2n) cross section
17	(n,3n) cross section
18	Total fission cross section
19	(n,f) cross section (first chance fission)
20	(n,n' f) cross section (second chance fission)
21	(n,2nf) cross section (third chance fission)
22	(n,n' $\alpha$ ) cross section
24	(n,2n $\alpha$ ) cross section
25	(n,3n $\alpha$ ) cross section
28	(n,n' p) cross section
37	(n,4n) cross section
46	cross section for describing the second neutron from (n,2n) reaction for first excited state
47	cross section for describing the second neutron from (n,2n) reaction for second excited state
48	cross section for describing the second neutron from (n,2n) reaction for third excited state
49	cross section for describing the second neutron from (n,2n) reaction for fourth excited state

**Table VI cont.**

51	(n,n' ) to the first excited state
52	(n,n' ) to the second excited state
.	
.	
.	
90	(n,n' ) to the 40th excited state
91	(n,n' ) to the continuum
101	neutron disappearance (Sum of all cross sections in which a neutron is not in the exit channel, MT=102-117); also called total capture or absorption.
102	(n, $\gamma$ ) radiative capture cross section
103	(n,p) cross section
104	(n,d) cross section
105	(n,t) cross section
106	(n, $^3\text{He}$ ) cross section
107	(n, $\alpha$ ) cross section
108	(n,2 $\alpha$ ) cross section
111	(n,2p) cross section
112	(n,p $\alpha$ ) cross section
113	(n,t2 $\alpha$ ) cross section
203	Total hydrogen production
204	Total deuterium production
205	Total tritium production
206	Total $^3\text{He}$ production
207	Total $\alpha$ production

**Table VI cont.**

452	Total nubar
456	Prompt nubar
502	Photon coherent scattering
504	Photon incoherent scattering
516	Pair production, nuclear and electron field (i.e., pair plus triplet production)
602	Photoelectric (MT=522 in ENDF/B-VI)

**Table VII: Special Reaction Numbers**

302	$\sigma_{pp}$ - total photon-production cross section (MT=202 in ENDF/B-VI)
301	H - average heating number (MeV/collision)
318	$Q_f$ - fission Q (MeV)
401	$H\sigma_t$ - heating number times the total cross section (MeV • barns)

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