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MACKLIB-IV

A Library of Nuclear Response Functions Generated
with the MACK-IV Computer Program from ENDF/B-IV

by

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MACKLIB

A Library of Nuclear Response Functions Generated
with the MACK-IV Computer Program from ENDF/B-IV

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ABSTRACT

A new library, MACKLIB-IV, of processed nuclear data for neutronics analysis of nuclear systems has been generated. The library was prepared using the new version of the MACK code, MACK-IV, and nuclear data from ENDF/B-IV. The library includes all nuclear response functions for all materials presently of interest in fusion and fusion-fission hybrid applications for 49 materials. The new library is a significant upgrade from the earlier version, MACKLIB.

MACKLIB-IV employs the CTR energy group structure of 171 neutron groups and 36 gamma groups. A retrieval computer program is included with the library to permit collapsing into any other energy group structure. The library is in the new format of the "MACK-Activity Table" which uses a fixed position for each specific response function. This permits the user when employing the library with present transport codes to obtain directly the nuclear responses (e.g. the total nuclear heating) summed for all isotopes and integrated over any geometrical volume. The response functions included in the library are neutron kerma factor, gamma kerma factor, gas production and tritium-breeding functions, and all important reaction cross sections. Pertinent information about the library and a graphical display of six response functions for all materials in the library are given.

INTRODUCTION

This report describes a new version of the MACKLIB⁽¹⁾ library, MACKLIB-IV. The library includes the nuclear response functions, e.g. kerma-factors, gas production, and tritium breeding cross sections, for a large number of materials of interest in fusion and fission applications. MACKLIB-IV was generated with the new version of the MACK computer program, MACK-IV,⁽²⁾ employing basic nuclear data from ENDF/B-IV.⁽³⁾ Although the basic structure of MACKLIB-IV is similar to the earlier version, the new library is given in the new⁽²⁾ versatile format of the "MACK-Activity-Table". This format allows considerable flexibility in calculating the nuclear responses internally with presently available transport codes.

A list of the 49 materials for which nuclear response functions are given in MACKLIB-IV is shown in Table I. The response functions included in the library are given in the format of the "MACK-Activity-Table" shown in Table II. The library is in the CTR energy group structure⁽⁴⁾ of 171 neutron groups and 36 gamma groups shown in Tables III and IV, respectively.

Pertinent information about the library is given in the rest of the report. A general-purpose retrieval program is described. Graphical displays of six response functions for all materials in the library are given in Appendix A.

MACKLIB FORMAT

The library is distributed in the "MACK-Activity-Table" format. For each material there is one data set. Within each data set there is an activity table for each energy group. This table consists of IHM positions. The type of information given in each position is shown in Table II. For example, the neutron kerma factor always appears in position 2 while the tritium-production cross section always appears in position 7.

The distributed library is a coupled neutron-gamma structure with 171 neutron groups and 36 gamma groups. The retrieval program described later in this report permits collapsing into a smaller number of groups. If we denote the number of neutron groups by IGN and the number of gamma groups as IGG , then the data set for one material consists of IGM activity tables where $IGM = IGN + IGG$. Tables for groups 1 through IGN contain the response functions for neutron interaction while the tables for groups $IGN+1$ through IGM contain the response functions for gamma interaction. Thus, in reference to Table II, it follows that position 3 which is reserved for gamma kerma factor is always zero in the tables for groups 1 through IGN . One can also note that for groups $IGN+1$ through IGM only positions 1, 3, 32, and 34 have nonzero entries. For position 1, the neutron kerma factors appear in groups 1 through IGN and the gamma kerma factors appear in groups $IGN+1$ through IGM . Similar observations can be made about position 32.

The library is distributed in card image format (80 characters per record). All numbers are in FIDØ format (see, for example, ANISN manual⁽⁵⁾).

MACKLIB UTILIZATION

MACKLIB can be used with any neutron and gamma-ray flux spectra to calculate the spatial distribution of neutron, gamma, and total heating, rates of atomic displacements, tritium breeding ratio, gas production, and other reactions of interest. Since the response functions in MACKLIB are flux- and density-independent, the library can be utilized for calculating the nuclear responses in one-, two-, and three-dimensional geometries for any spatial distribution of mixtures of materials.

One way to calculate the nuclear responses is to employ a simple computer program to carry out the summation over energy groups of the product of the flux and the appropriate response function from MACKLIB. Another convenient way is to mix the "MACK-Activity-Tables" explicitly with the "regular transport" multigroup cross sections via the mixing tables in the transport code employed to predict the flux solution (e.g., via the 10\$, 11\$, and 12* arrays in ANISN⁽⁵⁾ or the equivalent in DØT⁽⁶⁾). The number density for each activity table should be the appropriate number for the material multiplied by a small (e.g.

10^{-15}) fixed number, f . This multiplication factor ensures that the transport cross sections are not significantly altered. The reaction rates and other integrated responses calculated directly by the transport codes will be the true values multiplied by f .

For this procedure to be successful the group structure of the multigroup transport cross sections must be identical to that of the MACK-Activity-tables. Furthermore, the length of the cross-section table, IHM (number of positions per group), must be the same in the transport cross sections and the activity tables. Notice that in MACKLIB-IV each response function has a fixed position for all materials; and, therefore, response functions for a mixture of materials is readily obtainable by mixing the MACK-Activity-tables for the materials in exact analogy to mixing the "regular transport" multigroup cross sections.

RESPONSE FUNCTIONS

The response functions included in MACKLIB-IV are listed in Table II. All the neutron response functions except the atomic displacement cross sections were generated with the MACK-IV⁽²⁾ computer program using basic nuclear data from ENDF/B-IV. A weighting function similar to that described in Ref. 4 was employed for generating the 171 neutron group data from one thousand energy points. The gamma kerma factors were generated with the SMUG⁽⁷⁾ computer program. The atomic displacement cross sections in position 4 were taken from the work of Doran.⁽⁸⁾ The displacement cross sections were available only for the materials listed in Table V. The displacement energies assumed in generating the displacement cross sections for the various materials are given in Table V. Position 5 in the activity table, labelled "Displacement Cross Section B," currently has no information and the position is reserved for the convenience of the user in entering new data, since there is considerable uncertainty in displacement cross sections at present.

The integrated responses for positions 1, 2, and 3 yield the neutron, gamma, and total heating, respectively. The entry in position 7 (total tritium production cross section) integrated over space and energy variables yield directly the tritium breeding ratio if the neutron source strength is normalized to unity.

Positions 23 through 31 include the contribution to the neutron kerma factor from individual reaction types.⁽²⁾ Such individual contributions are not available for materials whose neutron kerma factors were generated using the direct gamma-production path⁽²⁾ of MACK-IV.

The average energy (taken as the mid-point energy) of each neutron group is included in positions 32 and 33 for groups 1 through IGN. The average energy of each gamma group is given in positions 32 and 34 for groups IGN+1 through IGM. Positions 32, 33, and 34 can be utilized efficiently to obtain the integrated energy flux and energy leakage.

Positions 35 through IHM (IHM = IGM+3) are filled with zeroes. Notice that a zero value is entered for each position at each group where a response function is not applicable or not available. For example, positions 3 and 34 will always have zero entries for all groups 1 through IGN and actual values for groups IGN+1 through IGM. As another example, positions 13 and 14 [(n,3n) and (n,f) cross sections] are filled with zeroes for all groups for materials such as hydrogen, helium, and lithium.

DECAY AND FISSION ENERGIES

The contribution to nuclear heating from the radioactive decay of the reaction products has been discussed in Refs. 2 and 9. The neutron kerma factors in MACKLIB-IV include the contribution to neutron heating from radioactive decay (primarily β^- and β^+) of the reaction products. This is an approximation which is shown^(2,9) to be reasonable for the applications in which MACKLIB-IV is expected to be employed. It should be noted that this approximation is not valid for other applications such as certain types of health physics calculations.

The average beta decay energies were prepared using the tables in Ref. 2. Decay modes, half-lives, branching ratios, and maximum beta energies were determined from data in Refs. 10 and 11. The decay energy for each reaction included in MACKLIB-IV calculations is shown for the various materials in Appendix B.

The local energy deposition per fission reaction is given by the sum of the final kinetic energies of the fission fragments. Detailed studies show that the kinetic energy of the fission fragments is not sensitive to the incident

neutron energy at low energies. However, it is expected that the kinetic energy of the fission fragments has an important energy dependence for incident neutron energies in the 5 to 20 MeV. Since reliable data on such energy dependence is lacking we have adopted values⁽¹²⁾ for the kinetic energy of the fission fragments that are independent of the incident neutron energy. These values are shown in Table VI.

ALTERNATE FORMAT AND ADDITIONAL DATA

The data in MACKLIB-IV is also available in a structured format different from that of the MACK-Activity-Table. In this alternate format, each material has a set of arrays; each array contains the data for one response function. Each array is preceded by two title cards; the first is for the material identification and the second is for the response function title. Each response function array contains only a number of entries equal to the number of neutron groups (171 groups for MACKLIB-IV). This alternate format is useful for users who do not wish to work with the fixed format of the MACK-Activity-Table.

Gamma-production matrices generated concurrently with MACKLIB-IV are also available. The use of these gamma-production cross sections is not a requirement for the adequate use of the MACKLIB-IV, but it would ensure preserving the energy in all phases of heating calculations for those materials whose ENDF/B evaluations do not consistently preserve the energy.

RETRIEVAL PROGRAM

A retrieval program has been written to perform several functions. The program reads the library in FIDØ card image format (the distribution format for the library), performs the user's requests, and writes a new library in FIDØ card image format or ANISN binary tape.

INPUT INSTRUCTIONS

CARD No. 1 FORMAT (2A4,3I6)

I1,I2 Define the program function with eight characters in columns

(1) ADD
Add new material(s) to the existing library.

(2) REPLACE
Replace specific material(s) in the existing library.

(3) DELETE
Delete certain material(s) from the existing library.

(4) COLLAPSE -
Collapse the library from 171 neutron, 36 gamma groups to a broader group structure.

(5) MIX
Mix certain material(s) from the existing library to generate a mixture(s).

(6) ANISN_{UF}
Generate an output library in unformatted ANISN tape library.

IN Unit number for the input library.

IØU Unit number for the output library in ANISN card image format except for function number six.

INM Unit number for the input material(s) to be added or replaced in the input library on unit IN.

CARD NO. 2 FORMAT (15I5)

This card is input for replace, delete, or collapse function only.

N Number of materials to be replaced, deleted, or collapsed from the library.

IMAT(N) ID number of the material(s) to be replaced or deleted from the library. A list of ID numbers for the library are given in Table I. The MAT number has been used as ID number for the materials in the library.

CARD NO. 3 (ANISN Free Format)

These data are needed for the collapse function only. ANISN integer array of 207 values gives the broad-group number by fine group. As an example, if the 207 group will be collapsed to four-neutron group and two-gamma group structures, this array will be as follows:

1\$\$	35R1	40R2	35R3	61R4	18R5	18R6	T
-------	------	------	------	------	------	------	---

This means the first 35 fine groups will be group No. 1 and the next 40 fine groups will be the second group as illustrated in the data card.

CARD NO. 4 FØRMAT (3I5)

IW Weighting option.

- (1) Flat weighting function for neutron and gamma groups.
- (2) 1/E weighting function for neutron groups and flat weighting function for fine gamma groups.
- (3) Input weighting function for neutron groups and flat weighting for gamma groups.
- (4) Input weighting functions for neutron and gamma groups.

ITA Table length for each group ($ITA \geq \text{number of groups} + 3$).

NNN Number of broad groups (neutron plus gamma).

CARD NO. 5 FØRMAT (6E12.6)

This card is input for IW = 3/4 only.

PHI(I) Weighting function for neutron groups if IW = 3 or neutron and gamma groups for IW = 4.

CARDS NOS. 6 and 7 are input for MIX function only.

CARD NO. 6 FØRMAT (I5)

N Number of mixture(s).

CARD(s) NO. 7 FØRMAT (2I5/(I12,E12.5))

MM Mixture ID number.

M Number of material(s) in the mixture.

IMAT(1) ID number for the first material in the mixture.

DIMAT(1) Number density for the first material in the mixture.

IMAT(2)	ID number for the second material in the mixture.
DIMAT(2)	Number density for the second material in the mixture.
:	
:	
IMAT(M)	ID number for the m-th material in the mixture.
DSMAT(M)	Number density for the m-th material in the mixture.

Detailed Notes

(1) This program can be used for different functions in the same run. As an example add some materials and replace others and then collapse to lower number of groups. The only restriction is that the input library must be in ANISN card image format, so the output from function to another must be in ANISN card image format.

(2) The input to the collapse program is restricted to 171 neutron groups and 36 gamma groups. In others words, it is not allowed to start collapsing from other group structures.

(3) The program can be used to generate a small library with limited number of materials. The delete option can be used to keep the required material only.

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TABLE I
List of Materials in MACKLIB-IV

	ENDF/B MAT No.		ENDF/B MAT No.
Hydrogen	1269	Copper	1295
Helium	1270	Niobium	1189
Lithium-6	1271	Molybdenum	1287
Lithium-7	1272	Tantalum	1285
Beryllium	1289	Tungsten-182	1128
Boron-10	1273	Tungsten-183	1129
Boron-11	1160	Tungsten-184	1130
Carbon	1274	Tungsten-186	1131
Nitrogen	1275	Lead	1288
Oxygen	1276	Thorium-232	1296
Flourine	1277	Protactinium	1297
Sodium	1156	Uranium-233	1260
Magnesium	1280	Uranium-234	1043
Aluminum	1193	Uranium-235	1261
Silicon	1194	Uranium-236	1163
Chlorine	1149	Uranium-238	1262
Potassium	1150	Neptunium	1263
Calcium	1195	Plutonium-238	1050
Titanium	1286	Plutonium-239	1264
Vanadium	1196	Plutonium-240	1265
Chromium	1191	Plutonium-241	1266
Manganese	1197	Plutonium-242	1161
Iron	1192	Americium-241	1056
Cobalt	1199	Americium-243	1057
Nickel	1190		

TABLE II

MACK-Activity Table

(For each energy group, there are IHM entries arranged according to this table.)

Position	Content
1	Neutron and gamma kerma factors
2	Neutron kerma factor
3	Gamma kerma factor
4	Displacement cross section - A
5	Displacement cross section - B
6	Total hydrogen production cross section
7	Total tritium production cross section
8	Total helium production cross section
9	Total cross section
10	Elastic cross section
11	Total inelastic cross section
12	(n,2n) cross section
13	(n,3n) cross section
14	Total fission cross section
15	(n,n't) cross section
16	(n,n') continuum cross section
17	(n, γ) cross section
18	(n,p) cross section
19	(n,D) cross section
20	(n,t) cross section
21	(n, ^3He) cross section
22	(n, α) cross section
23	Elastic scattering kerma factor
24	(n,n') charged particles kerma factor
25	Inelastic-level scattering kerma factor
26	(n, charged particles) kerma factor
27	(n,2n) kerma factor
28	(n,3n) kerma factor
29	Fission kerma factor
30	Inelastic continuum kerma factor
31	Radiative capture kerma factor
32	Group mid-energy for neutron and gamma
33	Group mid-energy for neutron only
34	Group mid-energy for gamma only
35	{ Positions 35-IHM are filled with cross sections for the MT reactions not given in the fixed positions 1-34.
.	
IHM	

TABLE III
Neutron 171 Energy Group Structure (eV)

Group	E(TOP)	Lethargy
1	0.17333E + 08	-0.55000E + 00
2	0.16487E + 08	-0.50000E + 00
3	0.15683E + 08	-0.45000E + 00
4	0.14918E + 08	-0.40000E + 00
5	0.14550E + 08	-0.37500E + 00
6	0.14191E + 08	-0.35000E + 00
7	0.13840E + 08	-0.32500E + 00
8	0.13499E + 08	-0.30000E + 00
9	0.12840E + 08	-0.25000E + 00
10	0.12214E + 08	-0.20000E + 00
11	0.11618E + 08	-0.15000E + 00
12	0.11052E + 08	-0.10000E + 00
13	0.10513E + 08	-0.50000E + 01
14	0.10000E + 08	0.0
15	0.95123E + 07	0.50000E - 01
16	0.90484E + 07	0.10000E + 00
17	0.86071E + 07	0.15000E + 00
18	0.81873E + 07	0.20000E + 00
19	0.77880E + 07	0.25000E + 00
20	0.74082E + 07	0.30000E + 00
21	0.70469E + 07	0.35000E + 00
22	0.67032E + 07	0.40000E + 00
23	0.65924E + 07	0.41667E + 00
24	0.63763E + 07	0.45000E + 00
25	0.60653E + 07	0.50000E + 00
26	0.57695E + 07	0.55000E + 00
27	0.54881E + 07	0.60000E + 00
28	0.52205E + 07	0.65000E + 00
29	0.49659E + 07	0.70000E + 00
30	0.47237E + 07	0.75000E + 00
31	0.44933E + 07	0.80000E + 00
32	0.40657E + 07	0.90000E + 00
33	0.36788E + 07	0.10000E + 01
34	0.33287E + 07	0.11000E + 01
35	0.31664E + 07	0.11500E + 01
36	0.30119E + 07	0.12000E + 01
37	0.28650E + 07	0.12500E + 01
38	0.27253E + 07	0.13000E + 01
39	0.25924E + 07	0.13500E + 01
40	0.24660E + 07	0.14000E + 01
41	0.23852E + 07	0.14333E + 01
42	0.23653E + 07	0.14417E + 01
43	0.23457E + 07	0.14500E + 01
44	0.23069E + 07	0.14667E + 01
45	0.22313E + 07	0.15000E + 01
46	0.21225E + 07	0.15500E + 01

TABLE III (Contd.)

Neutron 171 Energy Group Structure (eV)

Group	E(TOP)	Lethargy
47	0.20190E + 07	0.16000E + 01
48	0.19205E + 07	0.16500E + 01
49	0.18268E + 07	0.17000E + 01
50	0.17377E + 07	0.17500E + 01
51	0.16530E + 07	0.18000E + 01
52	0.15724E + 07	0.18500E + 01
53	0.14957E + 07	0.19000E + 01
54	0.14227E + 07	0.19500E + 01
55	0.13534E + 07	0.20000E + 01
56	0.12873E + 07	0.20500E + 01
57	0.12246E + 07	0.21000E + 01
58	0.11648E + 07	0.21500E + 01
59	0.11080E + 07	0.22000E + 01
60	0.10026E + 07	0.23000E + 01
61	0.96164E + 06	0.23417E + 01
62	0.90718E + 06	0.24000E + 01
63	0.86294E + 06	0.24500E + 01
64	0.82085E + 06	0.25000E + 01
65	0.78082E + 06	0.25500E + 01
66	0.74274E + 06	0.26000E + 01
67	0.70651E + 06	0.26500E + 01
68	0.67206E + 06	0.27000E + 01
69	0.63928E + 06	0.27500E + 01
70	0.60810E + 06	0.28000E + 01
71	0.57844E + 06	0.28500E + 01
72	0.55023E + 06	0.29000E + 01
73	0.52340E + 06	0.29500E + 01
74	0.49787E + 06	0.30000E + 01
75	0.45049E + 06	0.31000E + 01
76	0.40762E + 06	0.32000E + 01
77	0.38774E + 06	0.32500E + 01
78	0.36883E + 06	0.33000E + 01
79	0.33373E + 06	0.34000E + 01
80	0.30197E + 06	0.35000E + 01
81	0.29850E + 06	0.35116E + 01
82	0.29720E + 06	0.35159E + 01
83	0.29452E + 06	0.35250E + 01
84	0.28725E + 06	0.35500E + 01
85	0.27324E + 06	0.36000E + 01
86	0.24724E + 06	0.37000E + 01
87	0.23518E + 06	0.37500E + 01
88	0.22371E + 06	0.38000E + 01
89	0.21280E + 06	0.38500E + 01
90	0.20242E + 06	0.39000E + 01
91	0.19255E + 06	0.39500E + 01
92	0.18316E + 06	0.40000E + 01

TABLE III (Contd.)

Neutron 171 Energy Group Structure (eV)

Group	E(TOP)	Lethargy
93	0.17422E + 06	0.40500E + 01
94	0.16573E + 06	0.41000E + 01
95	0.15764E + 06	0.41500E + 01
96	0.14996E + 06	0.42000E + 01
97	0.14264E + 06	0.42500E + 01
98	0.13569E + 06	0.43000E + 01
99	0.12907E + 06	0.43500E + 01
100	0.12277E + 06	0.44000E + 01
101	0.11679E + 06	0.44500E + 01
102	0.11109E + 06	0.45000E + 01
103	0.98037E + 05	0.46250E + 01
104	0.86517E + 05	0.47500E + 01
105	0.82500E + 05	0.47975E + 01
106	0.79500E + 05	0.48346E + 01
107	0.72000E + 05	0.49337E + 01
108	0.67379E + 05	0.50000E + 01
109	0.56562E + 05	0.51750E + 01
110	0.52475E + 05	0.52500E + 01
111	0.46309E + 05	0.53750E + 01
112	0.40868E + 05	0.55000E + 01
113	0.34307E + 05	0.56750E + 01
114	0.31828E + 05	0.57500E + 01
115	0.28500E + 05	0.58604E + 01
116	0.27000E + 05	0.59145E + 01
117	0.26058E + 05	0.59500E + 01
118	0.24788E + 05	0.60000E + 01
119	0.24176E + 05	0.60250E + 01
120	0.23579E + 05	0.60500E + 01
121	0.21875E + 05	0.61250E + 01
122	0.19305E + 05	0.62500E + 01
123	0.15034E + 05	0.65000E + 01
124	0.11709E + 05	0.67500E + 01
125	0.91188E + 04	0.70000E + 01
126	0.71017E + 04	0.72500E + 01
127	0.55308E + 04	0.75000E + 01
128	0.43074E + 04	0.77500E + 01
129	0.37074E + 04	0.79000E + 01
130	0.33546E + 04	0.80000E + 01
131	0.30354E + 04	0.81000E + 01
132	0.27465E + 04	0.82000E + 01
133	0.26126E + 04	0.82500E + 01
134	0.24852E + 04	0.83000E + 01
135	0.22487E + 04	0.84000E + 01
136	0.20347E + 04	0.85000E + 01
137	0.15846E + 04	0.87500E + 01
138	0.12341E + 04	0.90000E + 01

TABLE III (Contd.)

Neutron 171 Energy Group Structure (eV)

Group	E(TOP)	Lethargy
139	0.96112E + 03	0.92500E + 01
140	0.74852E + 03	0.95000E + 01
141	0.58295E + 03	0.97500E + 01
142	0.45400E + 03	0.10000E + 02
143	0.35358E + 03	0.10250E + 02
144	0.27536E + 03	0.10500E + 02
145	0.21445E + 03	0.10750E + 02
146	0.16702E + 03	0.11000E + 02
147	0.13007E + 03	0.11250E + 02
148	0.10130E + 03	0.11500E + 02
149	0.78893E + 02	0.11750E + 02
150	0.61442E + 02	0.12000E + 02
151	0.47851E + 02	0.12250E + 02
152	0.37267E + 02	0.12500E + 02
153	0.29203E + 02	0.12750E + 02
154	0.22603E + 02	0.13000E + 02
155	0.17603E + 02	0.13250E + 02
156	0.13710E + 02	0.13500E + 02
157	0.10677E + 02	0.13750E + 02
158	0.83153E + 01	0.14000E + 02
159	0.64760E + 01	0.14250E + 02
160	0.50435E + 01	0.14500E + 02
161	0.39279E + 01	0.14750E + 02
162	0.30590E + 01	0.15000E + 02
163	0.23824E + 01	0.15250E + 02
164	0.18554E + 01	0.15500E + 02
165	0.14450E + 01	0.15750E + 02
166	0.11254E + 01	0.16000E + 02
167	0.87642E + 00	0.16250E + 02
168	0.68256E + 00	0.16500E + 02
169	0.53158E + 00	0.16750E + 02
170	0.41399E + 00	0.17000E + 02
171	0.10000E - 00	
172	0.10000E - 04	

TABLE IV
Gamma 36 Energy Group Structure (MeV)

Group	E(TØP)	Group	E(TØP)
1	14.0	19	1.33
2	12.0	20	1.0
3	10.0	21	0.80
4	8.0	22	0.70
5	7.5	23	0.60
6	7.0	24	0.512
7	6.5	25	0.510
8	6.0	26	0.45
9	5.5	27	0.40
10	5.0	28	0.30
11	4.5	29	0.20
12	4.0	30	0.15
13	3.5	31	0.10
14	3.0	32	0.075
15	2.5	33	0.060
16	2.0	34	0.045
17	1.66	35	0.030
18	1.50	36	0.020
			0.010

TABLE V
Displacement Energy (E_d) Assumed in
Generating the Displacement Cross
Sections Given in Position 4
of MACKLIB-IV

Material	E_d (eV)
Aluminum	25
Vanadium	40
Chromium	40
Iron	40
Nickel	40
Copper	30
Niobium	60
Molybdenum	60
Tantalum	90
Tungsten	90
Lead	25

TABLE VI
Fission Energy Used for
Neutron Kerma Factor Calculation

	Fission Fragments Energy	Delayed Beta Energy	Delayed Gamma Energy
^{232}Th	162.10	8.23	8.01
^{233}U	168.68	5.13	4.99
^{235}U	169.58	6.43	6.26
^{238}U	170.03	8.25	8.04
^{239}Pu	175.90	5.30	5.16
^{238}Pu	176.30	5.20	5.00
^{240}Pu	175.80	6.10	6.00
^{242}Pu	175.20	7.40	7.20
^{241}Am	179.50	5.30	5.20
^{243}Am	179.00	6.30	6.10
^{241}Pu	175.53	6.51	6.33
^{233}Pa	165.70	6.90	6.70
^{234}U	169.40	5.80	5.60
^{235}U	168.90	7.00	6.80
^{237}Np	172.60	5.80	8.00

APPENDIX A

Graphical Displays of Six Response Functions for All Materials in the Library

TOTAL H PRODUCTION X-S. LITHIUM-6 MAT NO 1271

TOTAL HE PRODUCTION X-S. LITHIUM-6 MAT NO 1271

RADIATIVE CAPTURE X-S. LITHIUM-6 MAT NO 1271

TOTAL INELASTIC X-S. LITHIUM-6 MAT NO 1271

RADIATIVE CAPTURE X-S. LITHIUM-7 MAT NO 1272

TOTAL INELASTIC X-S. LITHIUM-7 MAT NO 1272

TOTAL H PRODUCTION X-S. LITHIUM-7 MAT NO 1272

TOTAL HE PRODUCTION X-S. LITHIUM-7 MAT NO 1272

RADIATIVE CAPTURE X-S. BERYLLIUM MAT NO 1289

TOTAL X-S. BORON-10 MAT NO 1273

NEUTRON KERMA FACTOR BORON-10 MAT NO 1273

TOTAL H PRODUCTION X-S. BORON-10

MAT NO 1273

TOTAL HE PRODUCTION X-S. BORON-10

MAT NO 1273

TOTAL HE PRODUCTION X-S.CARBON

MAT NO 1274

TOTAL H PRODUCTION X-S. OXYGEN

MAT NO 1276

TOTAL HE PRODUCTION X-S.OXYGEN

MAT NO 1276

RADIATIVE CAPTURE X-S. OXYGEN MAT NO 1276

TOTAL INELASTIC X-S. OXYGEN MAT NO 1276

TOTAL H PRODUCTION X-S. NITROGEN

MAT NO 1275

TOTAL HE PRODUCTION X-S. NITROGEN

MAT NO 1275

RADIATIVE CAPTURE X-S. NITROGEN

MAT NO 1275

TOTAL INELASTIC X-S. NITROGEN

MAT NO 1275

RADIATIVE CAPTURE X-S. FLUORINE

MAT NO 1277

TOTAL INELASTIC X-S. FLUORINE

MAT NO 1277

TOTAL H PRODUCTION X-S. SODIUM

MAT NO 1156

TOTAL HE PRODUCTION X-S. SODIUM

MAT NO 1156

RADIATIVE CAPTURE X-S. SODIUM MAT NO 1156

TOTAL INELASTIC X-S. SODIUM MAT NO 1156

TOTAL H PRODUCTION X-S. MAGNESIUM MAT NO 1280

TOTAL HE PRODUCTION X-S. MAGNESIUM MAT NO 1280

RADIATIVE CAPTURE X-S. MAGNESIUM MAT NO 1280

TOTAL INELASTIC X-S. MAGNESIUM MAT NO 1280

TOTAL X-S. ALUMINUM MAT NO 1193

NEUTRON KERMA FACTOR ALUMINUM MAT NO 1193

TOTAL H PRODUCTION X-S. ALUMINUM

MAT NO 1193

TOTAL HE PRODUCTION X-S. ALUMINUM

MAT NO 1193

RADIATIVE CAPTURE X-S. ALUMINUM MAT NO 1193

TOTAL INELASTIC X-S. ALUMINUM MAT NO 1193

TOTAL H PRODUCTION X-S. SILICON

MAT NO 1194

TOTAL HE PRODUCTION X-S.SILICON

MAT NO 1194

RADIATIVE CAPTURE X-S. SILICON MAT NO 1194

TOTAL INELASTIC X-S. SILICON MAT NO 1194

TOTAL H PRODUCTION X-S. CHLORINE MAT NO 1149

TOTAL HE PRODUCTION X-S. CHLORINE MAT NO 1149

RADIATIVE CAPTURE X-S. CHLORINE MAT NO 1149

TOTAL INELASTIC X-S. CHLORINE MAT NO 1149

TOTAL H PRODUCTION X-S. POTASSIUM MAT NO 1150

TOTAL HE PRODUCTION X-S. POTASSIUM MAT NO 1150

RADIATIVE CAPTURE X-S. POTASSIUM MAT NO 1150

TOTAL INELASTIC X-S. POTASSIUM MAT NO 1150

TOTAL H PRODUCTION X-S. CALCIUM

MAT NO 1195

TOTAL HE PRODUCTION X-S. CALCIUM

MAT NO 1195

RADIATIVE CAPTURE X-S. CALCIUM

MAT NO 1195

TOTAL INELASTIC X-S. CALCIUM

MAT NO 1195

TOTAL X-S. TITANIUM MAT NO 1286

NEUTRON KERMA FACTOR TITANIUM MAT NO 1286

TOTAL H PRODUCTION X-S. TITANIUM

MAT NO 1286

TOTAL HE PRODUCTION X-S. TITANIUM

MAT NO 1286

RADIATIVE CAPTURE X-S. TITANIUM MAT NO 1286

TOTAL INELASTIC X-S. TITANIUM MAT NO 1286

TOTAL X-S. VANADIUM MAT NO 1196

NEUTRON KERMA FACTOR VANADIUM MAT NO 1196

TOTAL H PRODUCTION X-S. VANEDIUM

MAT NO 1196

TOTAL HE PRODUCTION X-S. VANEDIUM

MAT NO 1196

RADIATIVE CAPTURE X-S. VANEDIUM MAT NO 1196

TOTAL INELASTIC X-S. VANEDIUM MAT NO 1196

TOTAL H PRODUCTION X-S. CHROMIUM

MAT NO 1191

TOTAL HE PRODUCTION X-S. CHROMIUM

MAT NO 1191

RADIATIVE CAPTURE X-S. CHROMIUM MAT NO 1191

TOTAL INELASTIC X-S. CHROMIUM MAT NO 1191

TOTAL X-S. MANGANESE MAT NO 1197

NEUTRON KERN FACTOR MANGANESE MAT NO 1197

TOTAL H PRODUCTION X-S. MANGANESE MAT NO 1197

TOTAL HE PRODUCTION X-S. MANGANESE MAT NO 1197

RADIATIVE CAPTURE X-S. MANGANESE. MAT NO 1197

TOTAL INELASTIC X-S. MANGANESE MAT NO 1197

TOTAL H PRODUCTION X-S. IRON

MAT NO 1192

TOTAL HE PRODUCTION X-S. IRON

MAT NO 1192

RADIATIVE CAPTURE X-S. IRON

MAT NO 1192

TOTAL INELASTIC X-S. IRON

MAT NO 1192

TOTAL H PRODUCTION X-S. COBALT

MAT NO 1199

TOTAL HE PRODUCTION X-S. COBALT

MAT NO 1199

RADIATIVE CAPTURE X-S. COBALT MAT NO 1199

TOTAL INELASTIC X-S. COBALT MAT NO 1199

TOTAL X-S.

NICKEL

MAT NO 1190

NEUTRON KERMA FACTOR

NICKEL

MAT NO 1190

RADIATIVE CAPTURE X-S. NICKEL MAT NO 1190

TOTAL INELASTIC X-S. NICKEL MAT NO 1190

TOTAL X-S. COPPER MAT NO 1295

NEUTRON KERMA FACTOR COPPER MAT NO 1295

RADIATIVE CAPTURE X-S. NIOBIUM MAT NO 1189

TOTAL INELASTIC X-S. NIOBIUM MAT NO 1189

TOTAL X-S.

MOLYBDENUM MAT NO 1287

NEUTRON KERMA FACTOR

MOLYBDENUM MAT NO 1287

TOTAL X-S. TANTALUM MAT NO 1285

NEUTRON KERMA FACTOR TANTALUM MAT NO 1285

TOTAL X-S.

TUNGSTEN-182MAT NO 1128

NEUTRON KERMA FACTOR

TUNGSTEN-182MAT NO 1128

TOTAL H PRODUCTION X-S. TUNGSTEN-182MAT NO 1128

TOTAL HE PRODUCTION X-S. TUNGSTEN-182MAT NO 1128

RADIATIVE CAPTURE X-S. TUNGSTEN-182MAT NO 1128

TOTAL INELASTIC X-S. TUNGSTEN-182MAT NO 1128

TOTAL X-S.

TUNGSTEN-183MAT NO 1129

NEUTRON KERMA FACTOR

TUNGSTEN-183MAT NO 1129

TOTAL H PRODUCTION X-S. TUNGSTEN-184MAT NO 1130

TOTAL HE PRODUCTION X-S. TUNGSTEN-184MAT NO 1130

TOTAL X-S.

TUNGSTEN-186MAT NO 1131

NEUTRON KERMA FACTOR

TUNGSTEN-186MAT NO 1131

TOTAL H PRODUCTION X-S. TUNGSTEN-186MAT NO 1131

TOTAL HE PRODUCTION X-S. TUNGSTEN-186MAT NO 1131

RADIATIVE CAPTURE X-S. TUNGSTEN-186MAT NO 1131

TOTAL INELASTIC X-S. TUNGSTEN-186MAT NO 1131

TOTAL X-S.

LEAD

MAT NO 1288

NEUTRON KERMA FACTOR

LEAD

MAT NO 1288

TOTAL X-S.

THORIUM

MAT NO 1296

NEUTRON KERMA FACTOR

THORIUM

MAT NO 1296

TOTAL X-S. PROTACTINIUM MAT 1297

NEUTRON KERMA FACTOR PROTACTINIUM MAT 1297

TOTAL X-S.

URANIUM-233 MAT NO 1260

NEUTRON KERMA FACTOR URANIUM-233 MAT NO 1260

TOTAL X-S. URANIUM-234 MAT NO 1043

NEUTRON KERMA FACTOR URANIUM-234 MAT NO 1043

RADIATIVE CAPTURE X-S. URANIUM-234 MAT NO 1043

TOTAL INELASTIC X-S. URANIUM-234 MAT NO 1043

TOTAL X-S.

URANIUM-235 MAT NO 1261

NEUTRON KERMA FACTOR

URANIUM-235 MAT NO 1261

RADIATIVE CAPTURE X-S. URANIUM-235 MAT NO 1261

TOTAL INELASTIC X-S. URANIUM-235 MAT NO 1261

TOTAL X-S.

URANIUM-236 MAT NO 1163

NEUTRON KERMA FACTOR

URANIUM-236 MAT NO 1163

RADIATIVE CAPTURE X-S. URANIUM-236 MAT NO 1163

TOTAL INELASTIC X-S. URANIUM-236 MAT NO 1163

TOTAL X-S.

URANIUM-238 MAT NO 1262

NEUTRON KERMA FACTOR

URANIUM-238 MAT NO 1262

RADIATIVE CAPTURE X-S. URANIUM-238 MAT NO 1262

TOTAL INELASTIC X-S. URANIUM-238 MAT NO 1262

TOTAL X-S.

NEPTUNIUM-237 MAT 1263

NEUTRON KERMA FACTOR

NEPTUNIUM-237 MAT 1263

RADIATIVE CAPTURE X-S. NEPTUNIUM-237 MAT 1263

TOTAL INELASTIC X-S. NEPTUNIUM-237 MAT 1263

TOTAL X-S.

PLUTONIUM-238 MAT 1050

NEUTRON KERMA FACTOR

PLUTONIUM-238 MAT 1050

RADIATIVE CAPTURE X-S. PLUTONIUM-238 MAT. 1050

TOTAL INELASTIC X-S. PLUTONIUM-238 MAT 1050

TOTAL X-S.

PLUTONIUM-239 MAT 1264

NEUTRON KERMA FACTOR

PLUTONIUM-239 MAT 1264

RADIATIVE CAPTURE X-S. PLUTONIUM-239 MAT 1264

TOTAL INELASTIC X-S. PLUTONIUM-239 MAT 1264

TOTAL X-S.

PLUTONIUM-240 MAT 1265

NEUTRON KERMA FACTOR

PLUTONIUM-240 MAT 1265

TOTAL X-S.

PLUTONIUM-241 MAT 1266

NEUTRON KERMA FACTOR

PLUTONIUM-241 MAT 1266

TOTAL X-S.

PLUTONIUM-242 MAT 1161

NEUTRON KERMA FACTOR

PLUTONIUM-242 MAT 1161

RADIATIVE CAPTURE X-S. PLUTONIUM-242 MAT 1161

TOTAL INELASTIC X-S. PLUTONIUM-242 MAT 1161

TOTAL X-S. AMERICIUM-241 MAT 1056

NEUTRON KERMA FACTOR AMERICIUM-241 MAT 1056

RADIATIVE CAPTURE X-S. AMERICIUM-241 MAT 1056

TOTAL INELASTIC X-S. AMERICIUM-241 MAT 1056

TOTAL X-S. AMERICIUM-243 MAT 1057

NEUTRON KERMA FACTOR AMERICIUM-243 MAT 1057

RADIATIVE CAPTURE X-S. AMERICIUM-243 MAT 1057

TOTAL INELASTIC X-S. AMERICIUM-243 MAT 1057

APPENDIX B

Decay Type and Average Decay Energy in MeV Included in MACKLIB Calculations

HYDROGEN H

MAT 1269

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
102		2.225 + 06			

HELIUM He

MAT 1270

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					

LITHIUM ${}^6\text{Li}$

MAT 1271

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-1.471 + 06			
24		-5.660 + 06			
52		-3.562 + 06			
91	32	-1.471 + 06	-1.471 + 06		
102		7.252 + 06			
103		-2.733 + 06		β^-	1.560
107		4.786 + 06			

LITHIUM ${}^7\text{Li}$

MAT 1272

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-4.780 + 05			
16		-7.252 + 06			
24		-8.723 + 06			
51		-4.776 + 05			
91	33	-2.466 + 06	-2.466 + 06		
102		2.033 + 06		B^{-}, α	2.31
104		-7.760 + 06		B^{-}	1.56

BERYLLIUM Be

MAT 1289

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
6		-1.680 + 06		α	0.0921
7		-2.430 + 06		α	0.0921
8		-6.760 + 06		α	0.0921
9		-1.128 + 07		α	0.0921
46		-1.680 + 06			
47		-2.430 + 06			
48		-6.760 + 06			
49		-1.128 + 07			
102		6.820 + 06			
103		-1.283 + 07		B^-	6.24
104		-1.466 + 07		B^-, α	9.31
105		-1.044 + 07			
107		-6.000 + 05		B^-	1.56

BORON-10 ¹⁰B

MAT 1273

<u>MT</u>	<u>LR</u>	<u>Q (MR)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-7.170 + 05			
51	31	-7.170 + 05	0.0		
52	31	-1.740 + 06	0.0		
53	31	-2.154 + 06	0.0		
54	31	-3.585 + 06	0.0		
55	22	-4.774 + 06	-4.460 + 06		
56	22	-5.114 + 06	-4.460 + 06		
57	31	-5.166 + 06	0.0		
58	22	-5.183 + 06	-4.460 + 06		
59	22	-5.923 + 06	-4.460 + 06		
60	22	-6.029 + 06	-4.460 + 06		
61	22	-6.133 + 06	-4.460 + 06		
62	35	-6.500 + 06	-5.934 + 06		
63	22	-7.000 + 06	-4.460 + 06		
64	35	-7.500 + 06	-5.934 + 06		
65	28	-8.000 + 06	-6.585 + 06		
66	22	-8.500 + 06	-4.460 + 06		
67	22	-9.000 + 06	-4.460 + 06		
68	35	-9.500 + 06	-5.934 + 06		
69	22	-1.000 + 07	-4.460 + 06		
70	35	-1.050 + 07	-5.934 + 06		
71	35	-1.100 + 07	-5.934 + 06		
72	22	-1.150 + 07	-4.460 + 06		
73	35	-1.200 + 07	-5.934 + 06		
74	35	-1.250 + 07	-5.934 + 06		
75	22	-1.300 + 07	-4.460 + 06		
76	35	-1.350 + 07	-5.934 + 06		
77	35	-1.400 + 07	-5.934 + 06		
78	28	-1.450 + 07	-6.585 + 06		
79	35	-1.500 + 07	-5.934 + 06		
80	35	-1.550 + 07	-5.934 + 06		
81	35	-1.600 + 07	-5.934 + 06		
82	22	-1.650 + 07	-4.460 + 06		
83	35	-1.700 + 07	-5.934 + 06		
84	35	-1.750 + 07	-5.934 + 06		
85	22	-1.800 + 07	-4.460 + 06		
103		2.267 + 05			
104		-4.361 + 06			
107		2.790 + 06			
113		2.318 + 05		α	0.0921

BORON ¹¹B

MAT 1160

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-2.140 + 06			
16		-1.145 + 07			
51		-2.140 + 06			
52		-4.458 + 06			
53		-5.030 + 06			
91		-5.873 + 06			
102		3.369 + 06		B ⁻	6.42
103		-1.073 + 07		B ⁻	4.86
105		-9.561 + 06			
107		-6.632 + 06		B ⁻ ,α	9.31

CARBON C

MAT 1274

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
3		4.947 + 06			
4		-4.433 + 06			
51		-4.433 + 06			
91	23	-7.274 + 06	-7.274 + 06		
102		4.947 + 06			
107		-5.695 + 06			

NITROGEN N

MAT 1275

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-2.313 + 06			
16		-1.055 + 07			
51		-2.313 + 06			
52		-3.945 + 06			
53		-4.913 + 06			
54		-5.106 + 06			
55		-5.691 + 06			
56		-5.834 + 06			
57		-6.198 + 06			
58		-6.444 + 06			
59		-7.028 + 06			
60	28	-7.966 + 06	-7.550 + 06		
61	28	-8.061 + 06	-7.550 + 06		
62		-8.489 + 06			
63	28	-8.750 + 06	-7.550 + 06		
64	28	-9.250 + 06	-7.550 + 06		
65	28	-9.750 + 06	-7.550 + 06		
66	28	-1.025 + 07	-7.550 + 06		
67	28	-1.075 + 07	-7.550 + 06		
68	28	-1.125 + 07	-7.550 + 06		
69	28	-1.175 + 07	-7.550 + 06		
70	28	-1.225 + 07	-7.550 + 06		
71	28	-1.275 + 07	-7.550 + 06		
72	28	-1.325 + 07	-7.550 + 06		
73	28	-1.375 + 07	-7.550 + 06		
74	28	-1.425 + 07	-7.550 + 06		
75	22	-1.475 + 07	-1.161 + 07		
76	28	-1.525 + 07	-7.550 + 06		
77	28	-1.575 + 07	-7.550 + 06		
78	28	-1.625 + 07	-7.550 + 06		
79	28	-1.675 + 07	-7.550 + 06		
80	22	-1.725 + 07	-1.161 + 07		
81	28	-1.775 + 07	-7.550 + 06		
82	28	-1.825 + 07	-7.550 + 06		
102		1.084 + 07			
103		6.264 + 05			
104		-5.325 + 06			
105		-4.015 + 06			
107		-1.573 + 05			
108					

OXYGEN 0
MAT 1276

MT	LR	Q (MT)	Q (LR)	Decay Type	Average Decay Energy
1					
2					
4		-6.052 + 06			
51	40	-6.042 + 06	-6.052 + 06		
52		-6.131 + 06			
53		-6.917 + 06			
54		-7.119 + 06			
55		-8.872 + 06			
56	22	-9.597 + 06	-7.161 + 06		
57	22	-9.847 + 06	-7.161 + 06		
58	22	-1.035 + 07	-7.161 + 06		
59		-1.095 + 07			
60		-1.108 + 07			
61	22	-1.110 + 07	-7.161 + 06		
62	22	-1.126 + 07	-7.161 + 06		
63	22	-1.144 + 07	-7.161 + 06		
64	22	-1.152 + 07	-7.161 + 06		
65	22	-1.163 + 07	-7.161 + 06		
66	22	-1.205 + 07	-7.161 + 06		
67	28	-1.244 + 07	1.213 + 07		
68	22	-1.253 + 07	-7.161 + 06		
69	22	-1.280 + 07	-7.161 + 06		
70	22	-1.297 + 07	-7.161 + 06		
71	28	-1.315 + 07	-1.213 + 07		
72	22	-1.345 + 07	-7.161 + 06		
73	22	-1.375 + 07	-7.161 + 06		
74	28	-1.405 + 07	-1.213 + 07		
75	22	-1.435 + 07	-7.161 + 06		
76	28	-1.465 + 07	-1.213 + 07		
77	22	-1.495 + 07	-7.161 + 06		
78	22	-1.525 + 07	-7.161 + 06		
79	28	-1.555 + 07	-1.213 + 07		
80	22	-1.585 + 07	-7.161 + 06		
81	28	-1.615 + 07	-1.213 + 07		
82	22	-1.645 + 07	-7.161 + 06		
83	22	-1.675 + 07	-7.161 + 06		
84	28	-1.705 + 07	-1.213 + 07		
85	22	-1.735 + 07	-7.161 + 06		
86	28	-1.765 + 07	-1.213 + 07		
87	22	-1.795 + 07	-7.161 + 06		
88	28	-1.825 + 07	-1.213 + 07		
89	22	-1.855 + 07	-7.161 + 06		
102		4.143 + 06			
103		-9.639 + 06			
104		-9.901 + 06			
107		-2.214 + 06			

B⁻

FLUORINE F

MAT 1277

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
3					
4		-1.100 + 05			
16		-1.043 + 07		B ⁺	0.2534
22		-4.878 + 06			
28		-7.993 + 06			
51		-1.100 + 05			
52		-1.970 + 05			
53		-1.417 + 06			
54		-1.458 + 06			
55		-1.554 + 06			
56		-2.780 + 06			
57		-3.907 + 06			
58		-3.998 + 06			
59		-4.032 + 06			
60		-4.378 + 06			
61		-4.555 + 06			
62		-4.557 + 06			
63		-4.648 + 06			
64		-4.683 + 06			
65		-5.106 + 06			
66		-5.340 + 06			
67		-5.428 + 06			
68		-5.464 + 06			
69		-5.499 + 06			
70		-5.540 + 06			
71		-5.630 + 06			
91		-5.943 + 06			
102		6.601 + 06		B ⁻	2.4886
103		-4.036 + 06		B ⁻	1.701
104		-5.768 + 06			
105		-7.557 + 06			
107		-1.523 + 06		B ⁻	2.6924

SODIUM Na
MAT 1156

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
3					
4		-4.390 + 05			
16		-1.241 + 07		B ⁺	0.216
51		-4.390 + 05			
52		-2.078 + 06			
53		-2.393 + 06			
54		-2.640 + 06			
55		-2.705 + 06			
56		-2.983 + 06			
57		-3.680 + 06			
58		-3.880 + 06			
59		-4.430 + 06			
60		-4.770 + 06			
61		-5.380 + 06			
62		-5.530 + 06			
63		-5.760 + 06			
64		-5.955 + 06			
65		-6.079 + 06			
66		-6.270 + 06			
67		-7.110 + 06			
68		-7.790 + 06			
91	4	-8.630 + 06			
102		6.962 + 06		B ⁻	0.557
103		-3.597 + 06		B ⁻	1.909
107		-3.866 + 06		B ⁻	2.4886

MAGNESIUM Mg

MAT 1280

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
3					
4		-5.840 + 05			
16		-7.316 + 06		B ⁺	1.0504
22		-9.313 + 06			
28		-1.170 + 07		B ⁻	0.2195
51		-5.840 + 05			
52		-9.760 + 05			
53		-1.370 + 06			
54		-1.611 + 06			
55		-1.808 + 06			
56		-1.962 + 06			
57		-2.565 + 06			
58		-2.736 + 06			
59		-2.803 + 06			
60		-2.940 + 06			
61		-3.399 + 06			
62		-3.408 + 06			
63		-3.586 + 06			
64		-3.903 + 06			
65		-3.942 + 06			
66		-3.969 + 06			
67		-4.055 + 06			
68		-4.120 + 06			
69		-4.230 + 06			
70		-4.270 + 06			
71		-4.320 + 06			
72		-4.333 + 06			
73		-4.351 + 06			
74		-4.351 + 06			
75		-4.704 + 06			
76		-4.712 + 06			
77		-4.835 + 06			
78		-5.230 + 06			
79		-6.000 + 06			
80		-6.440 + 06			
81		-7.350 + 06			
82		-7.560 + 06			
83		-7.620 + 06			
84		-7.750 + 06			
85		-8.120 + 06			
86		-8.350 + 06			
87		-8.440 + 06			
88		-8.441 + 06			
89		-8.650 + 06			
90		-8.880 + 06			
91		-4.300 + 06			
102		8.167 + 06		B ⁻	0.0763
103		-3.040 + 06		B ⁻	0.9486
107		4.600 + 05		B ⁻	0.2102

ALUMINUM A1

MAT 1193

MT	LR	Q (MT)	Q (LR)	Decay Type	Average Decay Energy
1					
2					
4		-8.430 + 05			
16		-1.306 + 07			
51	31	-8.430 + 05			
52	31	-1.013 + 06			
53	31	-2.210 + 06			
54	31	-2.732 + 06			
55	31	-2.980 + 06			
56	31	-3.001 + 06			
57	31	-3.678 + 06			
58	31	-3.956 + 06			
59	31	-4.055 + 06			
60	31	-4.409 + 06			
61	31	-4.508 + 06			
62	31	-4.580 + 06			
63	31	-4.811 + 06			
64	31	-5.250 + 06			
65	31	-5.750 + 06			
66	31	-6.250 + 06			
66	31	-6.250 + 06			
67	31	-6.750 + 06			
68	31	-7.250 + 06			
69	31	-7.750 + 06			
70	31	-8.250 + 06			
71	31	-8.750 + 06			
72	31	-9.250 + 06			
73	31	-9.750 + 06			
74	31	-1.025 + 07			
75	28	-1.075 + 07	-8.271 + 06		
76	31	-1.125 + 07			
77	31	-1.175 + 07			
78	28	-1.225 + 07	-8.271 + 06		
79	31	-1.275 + 07			
80	28	-1.325 + 07	-8.271 + 06		
81	28	-1.375 + 07	-8.271 + 06		
82	22	-1.425 + 07	-1.010 + 07		
83	28	-1.475 + 07	-8.271 + 06		
84	28	-1.525 + 07	-8.271 + 06		
85	28	-1.575 + 07	-8.271 + 06		
86	22	-1.625 + 07	-1.010 + 07		
87	28	-1.675 + 07	-8.271 + 06		
88	28	-1.737 + 07	-8.271 + 06		
89	22	-1.813 + 07	-1.010 + 07		
90	28	-1.887 + 07	-8.271 + 06		
102		7.724 + 07		B ⁻	1.2448
103		-1.828 + 06		B ⁻	0.7055
104		-6.046 + 06			
105		-1.088 + 07			
107		-3.132 + 06		B ⁻	0.5570

SILICON Si

MAT 1194

<u>MT</u>	<u>LR</u>	<u>Q (LR)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
3					
4		-1.273 + 06			
16		-8.474 + 06		B ⁺	1.612
22		-9.985 + 06		B ⁻	0.02145
28		-1.159 + 07		B ⁻	0.02847
51		-1.273 + 06			
52		-1.779 + 06			
53		-2.028 + 06			
54		-2.235 + 06			
55		-2.425 + 06			
56		-3.068 + 06			
57		-3.498 + 06			
58		-3.624 + 06			
59		-3.770 + 06			
60		-3.788 + 06			
61		-4.617 + 06			
62		-4.809 + 06			
63		-4.830 + 06			
64		-4.975 + 06			
65		-6.272 + 06			
66		-6.690 + 06			
67		-6.878 + 06			
68		-6.887 + 06			
69		-7.380 + 06			
70		-7.415 + 06			
71		-7.798 + 06			
72		-7.935 + 06			
91		-4.000 + 06			
102		8.768 + 06		B ⁻	0.0208
103		-3.860 + 06		B ⁻	0.3881
104		-9.358 + 06		B ⁻	0.28698
107		-2.650 + 06		B ⁻	0.02187

CHLORINE C1

MAT 1149

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4			-1.220 + 06		
16			-1.208 + 07	B ⁺	1.094
22			-6.990 + 06	B ⁺	0.4992
28			-6.370 + 06		
51			-1.220 + 06		
52			-1.762 + 08		
53			-2.645 + 06		
54			-2.695 + 06		
55			-3.006 + 06		
56			-3.163 + 06		
57			-4.058 + 06		
58			-4.113 + 06		
59			-4.174 + 06		
60			-5.130 + 06		
61			-5.220 + 06		
62			-6.040 + 06		
63			-6.100 + 06		
91					
102			7.976 + 06	B ⁻	0.3528
103			6.151 + 05	B ⁻	0.2128
107			8.925 + 0.05	B ⁻	1.0177

POTASSIUM K
MAT 1150

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-1.003 + 06			
16		-1.307 + 07		B ⁺	3.2724
22		-7.365 + 06			
28		-6.424 + 06			
51		-2.526 + 06			
52		-2.817 + 06			
53		-3.021 + 06			
54		-3.603 + 06			
55		-3.879 + 06			
56		-3.935 + 06			
57		-4.122 + 06			
58		-4.678 + 06			
59		-5.280 + 06			
60		-5.370 + 06			
61		-5.620 + 06			
62		-5.740 + 06			
63		-5.960 + 06			
64		-6.120 + 06			
65		-6.210 + 06			
66		-6.350 + 06			
67		-6.500 + 06			
91		-1.003 + 06			
102		7.800 + 06		B ⁻	0.104
103		2.170 + 05		B ⁻	0.0269
107		1.363 + 06		B ⁻	0.0966

CALCIUM Ca
MAT 1195

MT	LR	Q (MT)	Q (LR)	Decay Type	Average Decay Energy
1					
2					
3					
4		-1.158 + 06			
16		-1.114 + 07		B ⁺	2.471
22		-7.040 + 06			
28		-8.330 + 06		B ⁻	0.010767
51		-1.158 + 06			
52		-3.354 + 06			
53		-3.737 + 06			
54		-3.904 + 06			
55		-4.492 + 06			
56		-5.212 + 06			
57		-5.249 + 06			
58		-5.279 + 06			
59		-5.615 + 06			
60		-5.627 + 06			
61		-5.900 + 06			
62		-6.025 + 06			
63		-6.029 + 06			
64		-6.285 + 06			
65		-6.510 + 06			
66		-6.752 + 06			
67		-7.114 + 06			
68		-7.280 + 06			
69		-7.536 + 06			
70		-7.760 + 06			
71		-8.020 + 06			
72		-8.271 + 06			
73		-8.540 + 06			
91		-8.670 + 06			
102		-8.363 + 06		B ⁻	0.00318
103		-5.250 + 05		B ⁻	0.0603
104		-6.019 + 06			
105		-1.293 + 07			
106		-6.991 + 06			
107		1.749 + 06		B ⁻	0.008337
108		-5.037 + 06		B ⁻	0.00963
111		-8.112 + 06		B ⁻	0.0026
112		-6.966 + 06		B ⁻	0.0811

TITANIUM Ti

MAT 1286

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
3					
4		-2.440 + 05			
16		-1.163 + 07		B ⁺	0.0353
51		-9.870 + 05			
91		-2.440 + 05			
102		8.140 + 06		B ⁻	0.0474
103		-3.210 + 06		B ⁻	0.3196
107		-2.030 + 06		B ⁻	0.07461

VANADIUM V

MAT 1196

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
3					
4		-3.190 + 05			
16		-1.106 + 07			
22		-1.030 + 07			
28		-8.057 + 06			
51		-3.190 + 05			
52		-9.290 + 05			
53		-1.608 + 06			
54		-1.812 + 06			
91		-2.409 + 06			
102		7.304 + 06		B ⁻	1.07
103		-1.679 + 06		B ⁻	0.934
104		-5.833 + 06			
105		-1.052 + 07			
107		-2.047 + 06		B ⁻	0.210

CHROMIUM Cr

MAT 1191

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
3					
4		-5.640 + 05			
16		-7.940 + 06		B ⁺	0.02621
22		-7.927 + 06			
28		-9.588 + 06		B ⁻	0.1275
51		-5.640 + 05			
52		-7.831 + 05			
53		-8.348 + 05			
54		-1.006 + 06			
55		-1.287 + 06			
56		-1.434 + 06			
57		-1.539 + 06			
58		-1.973 + 06			
59		-2.173 + 06			
60		-2.233 + 06			
61		-2.321 + 06			
62		-2.370 + 06			
63		-2.647 + 06			
64		-2.661 + 06			
65		-2.768 + 06			
66		-2.827 + 06			
67		-2.965 + 06			
68		-3.084 + 06			
69		-3.114 + 06			
70		-3.162 + 06			
71		-3.352 + 06			
72		-3.414 + 06			
73		-3.593 + 06			
74		-3.617 + 06			
75		-3.713 + 06			
76		-3.771 + 06			
77		-3.982 + 06			
78		-4.039 + 06			
79		-4.563 + 06			
80		-4.630 + 06			
81		-4.837 + 06			
82		-5.097 + 06			
83		-5.292 + 06			
84		-5.585 + 06			
85		-5.737 + 06			

CHROMIUM Cr (Contd.)

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
86		-6.070 + 06			
87		-6.154 + 06			
88		-6.490 + 06			
89		-6.820 + 06			
90		-7.070 + 06			
91		-1.825 + 06			
102		9.237 + 06		B ⁻	0.02528
103		-2.569 + 05		B ⁻	1.02899
104		-7.364 + 06		B ⁻	0.12754
105		-9.965 + 06		B ⁻ , B ⁺	0.03351
106		-8.628 + 06			
107		1.794 + 06		B ⁻	0.02223

MANGANESE Mn

MAT 1197

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
3					
4		-1.258 + 05			
16		-1.023 + 07			
17		-1.917 + 07			
22		-7.931 + 06			
28		-8.063 + 06			
51		-1.258 + 05			
52		-9.840 + 04			
53		-1.292 + 06			
54		-1.528 + 06			
55		-1.883 + 06			
91		-1.883 + 06			
102		7.270 + 06		B ⁻	0.777
103		-1.810 + 06		B ⁻	1.06228
104		-5.839 + 06			
106		-1.238 + 07			
107		-6.216 + 05			

IRON Fe
MAT 1192

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
3					
4		-8.460 + 05			
16		-1.120 + 07		B ⁺	0.06421
22		-7.619 + 06			
28		-1.019 + 07		B ⁻	0.01968
51		-8.460 + 05			
52		-1.408 + 06			
53		-2.084 + 06			
54		-2.654 + 06			
55		-2.939 + 06			
56		-2.957 + 06			
57		-3.119 + 06			
58		-3.122 + 06			
59		-3.368 + 06			
60		-3.388 + 06			
61		-3.445 + 06			
62		-3.450 + 06			
63		-3.600 + 06			
64		-3.605 + 06			
65		-3.747 + 06			
66		-3.829 + 06			
67		-3.856 + 06			
68		-4.046 + 06			
69		-4.099 + 06			
70		-4.116 + 06			
71		-4.298 + 06			
72		-4.300 + 06			
73		-4.389 + 06			
74		-4.395 + 06			
75		-4.453 + 06			
76		-4.505 + 06			
91		-4.531 + 06			
102		7.803 + 06		B ⁻	0.000485
103		8.900 + 04		B ⁻	0.738
104		-7.965 + 06		B ⁺	0.019778
105		-1.193 + 07		B ⁺	0.0087
106		-1.054 + 07		B ⁻	0.02489
107		8.484 + 05		B ⁻	0.9768

COBALT Co

MAT 1199

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-1.099 + 06		B ⁺	0.0736
16		-1.046 + 07			
51		-1.099 + 06			
52		-1.190 + 06			
53		-1.291 + 06			
54		-1.460 + 06			
55		-1.744 + 06			
56		-2.070 + 06			
57		-2.160 + 06			
58		-2.350 + 06			
59		-2.500 + 06			
91					
102		7.490 + 06		B ⁻	0.1564
103		-7.830 + 05			
104		-5.145 + 00			
105		-8.930 + 06		B ⁻	0.777
107		3.178 + 05			

NICKEL Ni

MAT 1190

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-1.172 + 06			
16		-7.820 + 06		B ⁺	0.2601
28		-8.177 + 06		B ⁻	0.0328
51		-1.172 + 06			
52		-1.332 + 06			
53		-1.454 + 06			
54		-2.158 + 06			
55		-2.286 + 06			
56		-2.459 + 06			
57		-2.506 + 06			
58		-2.625 + 06			
59		-2.775 + 06			
60		-2.902 + 06			
61		-2.942 + 06			
62		-3.038 + 06			
63		-3.123 + 06			
64		-3.264 + 06			
65		-3.420 + 06			
91		-3.441 + 06			
102		8.600 + 06		B ⁻	0.007377
103		3.947 + 05		B ⁻	0.0838
107		2.890 + 06		B ⁻	0.01967

COPPER Cu

MAT 1295

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
3					
4		-6.700 + 05			
16		-9.900 + 06		B ⁺	0.9441
17					
22		-5.777 + 06			
28		-6.120 + 06			
51		-6.700 + 05			
52		-7.700 + 05			
53		-9.620 + 05			
54		-1.115 + 06			
55		-1.326 + 06			
56		-1.412 + 06			
57		-1.482 + 06			
58		-1.547 + 06			
59		-1.623 + 06			
60		-1.725 + 06			
61		-1.865 + 06			
91		-1.900 + 06			
102		7.750 + 06		B ⁻ , B ⁺	0.4694
103		7.086 + 05		B ⁻	0.196524
104		-3.897 + 06			
106		-9.517 + 06			
107		1.693 + 06		B ⁻	0.311781

NIOBIUM Nb

MAT 1189

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-2.900 + 04			
16		-8.826 + 06			
17		-1.672 + 07			
22		-1.946 + 06			
51		-2.900 + 04			
52		-7.400 + 05			
53		-8.100 + 05			
54		-9.590 + 05			
55		-1.070 + 06			
56		-1.315 + 06			
57		-1.488 + 06			
58		-1.674 + 06			
59		-1.947 + 06			
60		-2.159 + 06			
61		-2.335 + 06			
62		-2.519 + 06			
91		-2.550 + 06			
102		7.214 + 06			
103		7.190 + 05			
107		4.914 + 06		B ⁻	0.931

MOLYBDENUM Mo

MAT 1287

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-2.470 + 05			
16		-7.800 + 06		B ⁺	0.284
17		-1.480 + 07		B ⁺	0.07129
91					
102		7.250 + 06		B ⁻	0.1967

TANTALUM Ta

MAT 1285

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-6.200 + 03			
16		-7.630 + 06			
17		-1.422 + 07			
51		-6.200 + 03			
52		-1.361 + 05			
53		-1.586 + 05			
54		-3.015 + 05			
55		-3.375 + 05			
56		-4.822 + 05			
57		-4.950 + 05			
58		-6.200 + 05			
59		-7.200 + 05			
60		-9.250 + 05			
91					
102		6.070 + 06			
103		-2.390 + 05		B ⁻	0.1233

TUNGSTEN-182 ¹⁸²W

MAT 1128

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-1.010 + 05			
16		-8.050 + 06			
17		-1.470 + 07			
28		-7.080 + 06			
51		-1.010 + 05			
52		-3.290 + 05			
53		-6.800 + 05			
54		-1.220 + 06			
55		-1.258 + 06			
56		-1.289 + 06			
57		-1.331 + 06			
58		-1.374 + 06			
91		-9.940 + 05			
102		6.191 + 06			
103		-1.022 + 06			
107		7.750 + 06			

TUNGSTEN-183 ^{183}W

MAT 11129

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-4.650 + 04			
16		-6.190 + 06			
17		-1.420 + 07			
28		-7.210 + 06			
51		-4.650 + 04			
52		-9.900 + 04			
53		-2.070 + 05			
54		-2.090 + 05			
55		-2.920 + 05			
56		-3.090 + 05			
57		-4.120 + 05			
58		-4.530 + 05			
59		-5.950 + 05			
91		-5.970 + 05			
102		7.412 + 06			
103		-2.860 + 05		β^-	0.2085
107		8.140 + 06			

TUNGSTEN-184 ^{184}W

MAT 1130

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-1.120 + 05			
16		-7.410 + 06			
17		-1.360 + 07			
28		-7.700 + 06		B^-	0.2085
51		-1.120 + 05			
52		-3.650 + 05			
53		-7.480 + 05			
54		-9.040 + 05			
55		-1.007 + 06			
56		-1.135 + 06			
57		-1.223 + 06			
58		-1.270 + 06			
59		-1.287 + 06			
91		-9.950 + 05			
102		5.750 + 06		B^-	0.1309
103		-2.250 + 06		B^-	0.428
107		8.370 + 06		B^-	0.12329

TUNGSTEN-186 186W

MAT 1131

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-1.220 + 05			
16		-7.200 + 06			
17		-1.295 + 07			
28		-8.380 + 06		B ⁻	0.5023
51		-1.220 + 05			
52		-4.010 + 05			
53		-7.300 + 05			
54		-8.400 + 05			
55		-8.500 + 05			
56		-9.600 + 05			
57		-1.040 + 06			
58		-1.110 + 06			
59		-1.250 + 06			
91		-9.950 + 05			
102		5.467 + 06		B ⁻	0.34138
103		-3.120 + 06		B ⁻	0.885
107		8.410 + 06		B ⁻	0.8135

LEAD Pb

MAT 1288

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
3					
4		-5.700 + 05			
16		-6.733 + 06			
17		-1.411 + 07			
51		-5.700 + 05			
52		-8.030 + 05			
53		-8.980 + 05			
54		-1.175 + 06			
55		-1.341 + 06			
56		-1.462 + 06			
57		-1.633 + 06			
58		-1.682 + 06			
59		-1.762 + 06			
60		-1.998 + 06			
61		-2.160 + 06			
62		-2.340 + 06			
63		-2.385 + 06			
64		-2.615 + 06			
65		-2.624 + 06			
66		-2.634 + 06			
67		-2.783 + 06			
68		-3.017 + 06			
69		-3.057 + 06			
70		-3.198 + 06			
71		-3.250 + 06			
72		-3.382 + 06			
73		-3.453 + 06			
74		-3.475 + 06			
75		-3.560 + 06			
76		-3.708 + 06			
77		-3.750 + 06			
78		-3.854 + 06			
79		-3.920 + 06			
80		-3.989 + 06			
81		-4.078 + 06			
82		-4.125 + 06			
83		-4.200 + 06			
84		-4.288 + 06			
85		-4.339 + 06			
91		-4.400 + 06			
102		5.415 + 06		B ⁻	0.107312

THORIUM Th

MAT 1296

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-5.000 + 04			
16		-6.340 + 06		B ⁻	0.06715
17		-1.137 + 07			
18					
51		-5.000 + 04			
52		-1.700 + 05			
53		-3.300 + 05			
54		-7.200 + 05			
55		-7.900 + 05			
56		-8.200 + 05			
57		-1.050 + 06			
58		-1.150 + 06			
91					
102		4.780 + 06		B ⁻	0.537

PROTACTINIUM Pa

MAT 1297

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
3					
4		-1.870 + 04		β ⁻	0.0668
16		-6.656 + 06			
17		-1.218 + 07			
18					
51		-1.870 + 04			
52		-5.690 + 04			
53		-7.120 + 04			
54		-8.680 + 04			
55		-1.040 + 05			
91		-1.870 + 04			
102		5.197 + 06			

URANIUM-233 ^{233}U

MAT 1260

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-4.040 + 04			
16		-5.904 + 06			
17		-1.319 + 07			
18					
51		-4.040 + 04			
52		-9.200 + 04			
53		-3.120 + 05			
54		-3.400 + 05			
55		-3.990 + 05			
56		-4.160 + 05			
57		-4.610 + 05			
91					
102		6.800 + 06			

URANIUM-234 ^{234}U

MAT 1043

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-4.400 + 04			
16		-6.771 + 06			
17		-1.267 + 07			
18					
51		-4.400 + 07			
52		-1.440 + 05			
53		-2.970 + 05			
54		-8.000 + 05			
55		-9.450 + 05			
56		-1.035 + 06			
91		-8.950 + 05			
102		5.297 + 06			

URANIUM-235 ^{235}U

MAT 1261

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
3					
4		-1.300 + 04			
16		-5.306 + 06			
17		-1.215 + 07			
18					
19					
20					
21					
51		-1.300 + 04			
52		-4.960 + 04			
53		-8.360 + 04			
54		-1.025 + 05			
55		-1.492 + 05			
56		-1.720 + 05			
57		-2.340 + 05			
58		-2.680 + 05			
59		-3.980 + 05			
60		-5.970 + 05			
61		-9.958 + 05			
62		-1.992 + 06			
63		-2.987 + 06			
64		-3.983 + 06			
65		-4.979 + 06			
66		-5.975 + 06			
91		-9.459 + 05			
102		6.545 + 06			

URANIUM-236 ^{236}U

MAT 1163

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-4.528 + 04			
16		-6.910 + 06			
17		-1.164 + 07			
18					
51		-4.528 + 04			
52		-1.460 + 05			
53		-2.980 + 05			
54		-6.950 + 05			
55		-9.800 + 05			
56		-1.060 + 06			
91		-8.950 + 05			
102		5.124 + 06			

URANIUM-238 ²³⁸U

MAT 1262

MT	LR	Q (MT)	Q (LR)	Decay Type	Average Decay Energy
1					
2					
3					
4		-4.500 + 04		B ⁻	0.071
16		-6.040 + 06			
17		-1.146 + 07			
18					
19					
20					
21					
38					
51		-4.500 + 04			
52		-1.460 + 05			
53		-3.080 + 05			
54		-6.800 + 05			
55		-7.320 + 05			
56		-8.270 + 05			
57		-9.300 + 05			
58		-9.670 + 05			
59		-1.000 + 06			
60		-1.041 + 06			
61		-1.060 + 06			
62		-1.120 + 06			
63		-1.160 + 06			
64		-1.220 + 06			
65		-1.270 + 06			
66		-1.300 + 06			
67		-1.361 + 06			
68		-1.409 + 06			
69		-1.437 + 06			
70		-1.470 + 06			
71		-1.625 + 06			
72		-1.875 + 06			
73		-1.950 + 06			
74		-2.950 + 06			
75		-3.950 + 06			
76		-4.950 + 06			
91		-4.470 + 04			
102		4.804 + 06			

NEPTUNIUM-237

²³⁷Np

MAT

1263

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-3.320 + 04			
16		-6.760 + 04			
17		-1.229 + 07			
18					
51		-3.320 + 04			
52		-5.960 + 04			
53		-7.600 + 04			
54		-1.030 + 05			
55		-1.590 + 05			
56		-2.240 + 05			
57		-2.680 + 05			
58		-3.050 + 05			
59		-3.320 + 05			
60		-3.690 + 05			
61		-3.710 + 05			
91		-3.320 + 05			
102		5.490 + 06			

PLUTONIUM-238 ^{238}Pu

MAT 1050

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-4.410 + 04			
16		-6.930 + 06			
17		-1.291 + 07			
18					
51		-4.410 + 04			
52		-1.458 + 05			
53		-6.050 + 05			
54		-6.720 + 05			
55		-7.550 + 05			
56		-9.370 + 05			
57		-9.850 + 05			
58		-1.030 + 06			
59		-1.070 + 06			
91		-1.195 + 06			
102		5.630 + 06			

PLUTONIUM-239 ^{239}Pu

MAT 1264

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-7.850 + 03			
16		-5.656 + 06			
17		-1.265 + 07			
18					
19					
20					
21					
37					
38					
51		-7.850 + 03			
52		-5.700 + 04			
53		-7.600 + 04			
54		-1.640 + 05			
55		-1.930 + 05			
56		-2.860 + 05			
57		-3.300 + 05			
58		-3.880 + 05			
59		-3.920 + 05			
60		-4.340 + 05			
61		-4.700 + 05			
62		-4.860 + 05			
63		-4.920 + 05			
64		-5.050 + 05			
65		-5.120 + 05			
66		-5.560 + 05			
67		-7.300 + 05			
68		-7.600 + 05			
69		-8.000 + 05			
70		-8.490 + 05			
71		-9.958 + 05			
72		-1.992 + 06			
73		-2.987 + 06			
74		-3.983 + 06			
75		-4.979 + 06			
76		-5.975 + 06			
91		-5.560 + 05			
102		6.533 + 06			

PLUTONIUM-240 ^{240}Pu

MAT

1265

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-4.300 + 04			
16		-6.534 + 06			
17		-1.219 + 07			
18					
19					
20					
21					
51		-4.300 + 04			
52		-1.420 + 05			
53		-2.960 + 05			
54		-5.990 + 05			
55		-8.630 + 05			
56		-9.030 + 05			
57		-9.450 + 05			
58		-1.420 + 06			
59		-2.000 + 06			
60		-3.000 + 06			
61		-4.000 + 06			
62		-5.000 + 06			
91		-9.450 + 05			
102		5.241 + 06			

PLUTONIUM-241 ^{241}Pu

MAT 1266

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-4.000 + 04			
16		-5.220 + 06			
17		-1.168 + 07			
18					
51		-4.000 + 04			
52		-9.500 + 04			
53		-1.630 + 05			
54		-1.690 + 05			
55		-1.740 + 05			
56		-2.310 + 05			
57		-2.450 + 05			
58		-3.000 + 05			
59		-3.350 + 05			
60		-4.480 + 05			
61		-7.530 + 05			
62		-8.280 + 05			
63		-8.940 + 05			
64		-9.180 + 05			
65		-9.410 + 05			
91		-1.195 + 06			
102		6.301 + 06			

PLUTONIUM-242 ^{242}Pu

MAT 1161

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-4.490 + 04			
16		-6.240 + 06			
17		-1.178 + 07			
18					
51		-4.490 + 04			
52		-1.490 + 05			
53		-3.120 + 05			
54		-6.470 + 05			
55		-6.970 + 05			
56		-7.960 + 05			
57		-9.650 + 05			
58		-1.010 + 06			
59		-1.060 + 06			
60		-1.110 + 06			
91		-1.195 + 06			
102		5.037 + 06			

AMERICIUM-241 ^{241}Am

MAT 1056

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-4.150 + 04			
18					
91		-4.195 + 04			
102		5.528 + 06			

AMERICIUM-243 ²⁴³Am

MAT 1057

<u>MT</u>	<u>LR</u>	<u>Q (MT)</u>	<u>Q (LR)</u>	<u>Decay Type</u>	<u>Average Decay Energy</u>
1					
2					
4		-8.340 + 04			
18					
91		-8.390 + 04			
102		5.364 + 06			

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