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JSD1000 : MULTI-GROUP CROSS SECTION SETS
FOR SHIELDING MATERIALS

March 1984

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JSD1000: Multi-Group Cross Section Sets
for Shielding Materials

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A multi-group cross section library for shielding safety analysis has been produced by using ENDF/B-IV. The library consists of ultra-fine group cross sections, fine-group cross sections, secondary gamma-ray production cross sections and effective macroscopic cross sections for typical shielding materials. Temperature dependent data at 300, 560 and 900 K have been also provided. Angular distributions of the group to group transfer cross section are defined by a new method of "Direct Angular Representation" (DAR) instead of the method of finite Legendre expansion. The library designated JSD1000 are stored in a direct access data base named DATA-POOL and data manipulations are available by using the DATA-POOL access package. The 3824 neutron group data of the ultra-fine group cross sections and the 100 neutron, 20 photon group cross sections are applicable to shielding safety analyses of nuclear facilities. This report provides detailed specifications and the access method for the JSD1000 library.

Keywords: JSD1000 Code, RADHEAT-V4 Code, Cross Section, Neutron, Gamma-Ray, Secondary Gamma-Ray, Multi-Group, Transport Code, Calculation, Radiation Shieldings, Data Library, Atomic Displacement, User's Manual, Energy Deposition

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遮蔽安全解析のための多群定数ライブラリを評価済核データENDF/B-Nより作成した。このライブラリは代表的な遮蔽材料における超微細群定数、微細群定数、二次ガンマ線生成断面積及び典型的な遮蔽材の実効巨視的断面積より成っている。温度依存性については300, 560及び900Kを考慮した。散乱断面積の角度依存性は従来の有限項Legendre展開法に替り、新たな直接角度表示(DAR)法を採用した。本ライブラリJSD1000は直接アクセスデータベースDATA-POOLに格納されており、DATA-POOLアクセスパッケージによって取扱われる。本ライブラリの3824群中性子超微細群定数及び中性子100群、ガンマ線20群群定数は原子力施設の遮蔽安全解析に適用可能である。

本報告はJSD 1000 ライブラリの詳細な仕様及び取扱方法について述べられている。

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1. Introduction

A multi-group cross section library for shielding safety analyses has been produced by using the RADHEAT-V4¹⁾ code system. RADHEAT-V4 which is the latest version of the RADHEAT²⁾ code system has been developed for performing precisely neutron and photon transport analyses, and shielding safety evaluations.

In 1977, the Japan Atomic Energy Research Institute provided two libraries JSD100/120/DLC-51³⁾ as a part of the shielding calculations scheme RADHEAT-V3/CCC-300⁴⁾. Many experiences with the code system have shown that more rigorous group cross sections and transport calculations are essentially needed to improve the accuracy of shielding design and safety calculations.

Particularly, the angular flux distribution is a basic quantity for evaluating the radiation current in shielding materials. Various attempts have been made for describing more precisely the anisotropic scattering of radiations in order to calculate the angular flux distributions. One of the recent outstanding results is the use of the discrete ordinates S_N -transport calculation by expressing the anisotropic scattering cross section with the Legendre expansion of the cosine of the scattering angle.

However, it is known^{5~7)} that the S_N -transport calculation gives the negative angular fluxes remarkably when a strong anisotropic source is present in the shielding materials. One of the causes for the fact that negative angular fluxes appear in the S_N -transport calculation is a truncation error of the angular cross section by using the finite Legendre expansion. The other is the fitting error of the scattering source obtained by S_N -transport calculation. To remove the former cause, a difficulty exists in generating group to group transfer cross sections as far as the finite Legendre expansion is used. That is, the data of angular dependency are given generally in the form of the Legendre coefficients in the evaluated nuclear data file such as ENDF/B-IV⁸⁾. The maximum order of these coefficients increases according as the energy of incident neutron goes up. Therefore, in order to get an accurate angular dependency of the scattering cross section, it is necessary to consider up to the maximum order of the coefficients given in the library. However, a high order of expansion is needed when the

nucleus has the scattering cross section like a delta-function of the scattering angles. It is practically difficult from the actual restrictions of computation times and computer memories.

To eliminate the latter cause, the first collision method is generally effective. But it is not effective as a remedy for the former cause. Therefore, an improvement for obtaining accurately the angular flux has to be done by using the method without adopting the Legendre expansion for generating the group to group transfer cross sections and for performing the S_N -transport calculations.

RADHEAT-V4 adopts a new method⁹⁾ named "Direct Angular Representation" (DAR) for expressing the angular distributions of the group to group transfer cross section in order to eliminate the difficulty mentioned above. The group to group transfer cross sections are stored in the JSD1000 library with the appropriate form of the DAR method. The DAR method and the form of the group to group transfer cross section are briefly described in Chapt. 4.

The JSD1000 library contains ultra-fine group cross sections, fine-group cross sections that include self-shielding tables, secondary gamma-ray production cross sections and effective macroscopic cross sections used as source, shielding and detector materials.

The ultra-fine data consist of 3824-neutron, and the fine-group ones consist of 100-neutron and 20-photon groups. The energy group structures of the ultra-fine and the fine-group cross sections are described in Chapt. 2. The ultra-fine group and the fine group cross sections for 42 nuclides used as source, shielding and detector materials are produced at the temperature of 300, 560 and 900 K from ENDF/B-IV. The Bondarenko-type self-shielding factor¹⁰⁾ is given by the appropriate σ_0 values of 0, 1, 10, 10^2 , 10^3 , 10^4 and 10^8 . The secondary gamma-ray production cross sections for 32 nuclides at 300, 560 and 900 K are generated with ENDF/B-IV. The effective macroscopic cross sections for 33 materials at 300 K are produced by using the fine-group cross sections and the secondary gamma-ray production ones. The identification of the data and the method of generation are described in Chapters 3 and 4, respectively.

JSD1000 is stored in the direct access data base named "DATA-POOL"¹¹⁾. DATA-POOL consists of a control, a directory and a data section. The directory section has informations for node names defined by 4-characters

and record addresses in the data section. The node name is used for searching the records of the data. The data in the JSD1000 library are classified according to several tree structures of the node names and stored in the data section. The record format of the data and the access method of DATA-POOL are described in Chapt. 5.

JSD1000 which is revised data library of JSD100/120 will be utilized as a standard library of shielding safety analyses for nuclear fuel facilities after the detailed evaluation is established.

2. Energy Group Structure

The energy group structure for multi-group transport calculation directly affects the accuracy of shielding calculations. Detailed energy group structure is needed as much as possible when an accurate shielding evaluation is required. Particularly, the energy width and boundary of group cross section must be carefully chosen when shielding materials have cross sections of large resonance windows. However, the adequate energy group structure depends on each shielding problem, so that it is not easy to determine a unique group structure.

JSD1000 contains an "ultra-fine group" cross section which consists of 3824 energy groups as shown in Table 2.1. The ultra-fine group cross section has a character as a basic library which is not affected by the effect of resonance self-shielding. The "fine-group" cross section which generally consists of 100 to 200 groups, the scattering matrix and the secondary gamma-ray cross section are generated from the ultra-fine group cross section by using an adequate weighting spectrum.

Adopted neutron and gamma-ray fine energy group structure are shown in Tables 2.2 and 2.3, respectively. The neutron energy group consists of 100 groups. The energy group structure up to the 92th group is the same as the standard 137 energy group structure¹²⁾ of JAERI described in Table 2.4. The JAERI 137 energy group structure has fine energy meshes below the epithermal energy region in order to perform detailed evaluations of thermal reactor and criticality safety analyseses. The energy groups from 93 to 100 of the fine energy group structure in the JSD1000 library are given by bunching the standard 137 energy group structure of JAERI because the region below epithermal energy is not so important in shielding calculations compared with the criticality safety analyses.

The gamma-ray energy group consists of 20 groups. The energy group structure is the same as the EURLIB-2¹³⁾ group structure that was adopted in the JSD120 library produced by the RADHEAT-V3 code system.

TABLE 2.1 ENERGY GROUP STRUCTURE

NEUTRON ENERGY GROUP (EV) (1 - 100 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
1	2.2104E-04	2.8289E-04	51	1.2649E-02	1.3092E-02
2	2.8289E-04	3.5236E-04	52	1.3092E-02	1.3543E-02
3	3.5236E-04	4.2946E-04	53	1.3543E-02	1.4001E-02
4	4.2946E-04	5.1418E-04	54	1.4001E-02	1.4467E-02
5	5.1418E-04	6.0651E-04	55	1.4467E-02	1.4940E-02
6	6.0651E-04	7.0647E-04	56	1.4940E-02	1.5421E-02
7	7.0647E-04	8.1405E-04	57	1.5421E-02	1.5910E-02
8	8.1405E-04	9.2925E-04	58	1.5910E-02	1.6406E-02
9	9.2925E-04	1.0521E-03	59	1.6406E-02	1.6910E-02
10	1.0521E-03	1.1825E-03	60	1.6910E-02	1.7421E-02
11	1.1825E-03	1.3206E-03	61	1.7421E-02	1.7940E-02
12	1.3206E-03	1.4663E-03	62	1.7940E-02	1.8467E-02
13	1.4663E-03	1.6196E-03	63	1.8467E-02	1.9001E-02
14	1.6196E-03	1.7805E-03	64	1.9001E-02	1.9543E-02
15	1.7805E-03	1.9490E-03	65	1.9543E-02	2.0093E-02
16	1.9490E-03	2.1252E-03	66	2.0093E-02	2.0650E-02
17	2.1252E-03	2.3090E-03	67	2.0650E-02	2.1215E-02
18	2.3090E-03	2.5004E-03	68	2.1215E-02	2.1787E-02
19	2.5004E-03	2.6994E-03	69	2.1787E-02	2.2368E-02
20	2.6994E-03	2.9061E-03	70	2.2368E-02	2.2955E-02
21	2.9061E-03	3.1203E-03	71	2.2955E-02	2.3551E-02
22	3.1203E-03	3.3422E-03	72	2.3551E-02	2.4153E-02
23	3.3422E-03	3.5717E-03	73	2.4153E-02	2.4764E-02
24	3.5717E-03	3.8089E-03	74	2.4764E-02	2.5382E-02
25	3.8089E-03	4.0536E-03	75	2.5382E-02	2.6008E-02
26	4.0536E-03	4.3060E-03	76	2.6008E-02	2.6641E-02
27	4.3060E-03	4.5660E-03	77	2.6641E-02	2.7282E-02
28	4.5660E-03	4.8336E-03	78	2.7282E-02	2.7931E-02
29	4.8336E-03	5.1089E-03	79	2.7931E-02	2.8587E-02
30	5.1089E-03	5.3917E-03	80	2.8587E-02	2.9251E-02
31	5.3917E-03	5.6822E-03	81	2.9251E-02	2.9923E-02
32	5.6822E-03	5.9803E-03	82	2.9923E-02	3.0602E-02
33	5.9803E-03	6.2860E-03	83	3.0602E-02	3.1289E-02
34	6.2860E-03	6.5994E-03	84	3.1289E-02	3.1983E-02
35	6.5994E-03	6.9203E-03	85	3.1983E-02	3.2685E-02
36	6.9203E-03	7.2489E-03	86	3.2685E-02	3.3395E-02
37	7.2489E-03	7.5851E-03	87	3.3395E-02	3.4112E-02
38	7.5851E-03	7.9289E-03	88	3.4112E-02	3.4837E-02
39	7.9289E-03	8.2804E-03	89	3.4837E-02	3.5569E-02
40	8.2804E-03	8.6395E-03	90	3.5569E-02	3.6309E-02
41	8.6395E-03	9.0062E-03	91	3.6309E-02	3.7057E-02
42	9.0062E-03	9.3805E-03	92	3.7057E-02	3.7813E-02
43	9.3805E-03	9.7624E-03	93	3.7813E-02	3.8576E-02
44	9.7624E-03	1.0152E-02	94	3.8576E-02	3.9346E-02
45	1.0152E-02	1.0549E-02	95	3.9346E-02	4.0124E-02
46	1.0549E-02	1.0954E-02	96	4.0124E-02	4.0910E-02
47	1.0954E-02	1.1366E-02	97	4.0910E-02	4.1704E-02
48	1.1366E-02	1.1786E-02	98	4.1704E-02	4.2505E-02
49	1.1786E-02	1.2214E-02	99	4.2505E-02	4.3313E-02
50	1.2214E-02	1.2649E-02	100	4.3313E-02	4.4130E-02

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (101 - 200 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
101	4.4130E-02	4.4954E-02	151	9.4662E-02	9.5867E-02
102	4.4954E-02	4.5785E-02	152	9.5867E-02	9.7080E-02
103	4.5785E-02	4.6624E-02	153	9.7080E-02	9.8300E-02
104	4.6624E-02	4.7471E-02	154	9.8300E-02	9.9528E-02
105	4.7471E-02	4.8326E-02	155	9.9528E-02	1.0076E-01
106	4.8326E-02	4.9188E-02	156	1.0076E-01	1.0201E-01
107	4.9188E-02	5.0057E-02	157	1.0201E-01	1.0326E-01
108	5.0057E-02	5.0935E-02	158	1.0326E-01	1.0452E-01
109	5.0935E-02	5.1820E-02	159	1.0452E-01	1.0578E-01
110	5.1820E-02	5.2712E-02	160	1.0578E-01	1.0706E-01
111	5.2712E-02	5.3612E-02	161	1.0706E-01	1.0834E-01
112	5.3612E-02	5.4520E-02	162	1.0834E-01	1.0963E-01
113	5.4520E-02	5.5435E-02	163	1.0963E-01	1.1092E-01
114	5.5435E-02	5.6358E-02	164	1.1092E-01	1.1223E-01
115	5.6358E-02	5.7289E-02	165	1.1223E-01	1.1354E-01
116	5.7289E-02	5.8227E-02	166	1.1354E-01	1.1486E-01
117	5.8227E-02	5.9173E-02	167	1.1486E-01	1.1618E-01
118	5.9173E-02	6.0127E-02	168	1.1618E-01	1.1752E-01
119	6.0127E-02	6.1088E-02	169	1.1752E-01	1.1886E-01
120	6.1088E-02	6.2057E-02	170	1.1886E-01	1.2021E-01
121	6.2057E-02	6.3033E-02	171	1.2021E-01	1.2157E-01
122	6.3033E-02	6.4017E-02	172	1.2157E-01	1.2293E-01
123	6.4017E-02	6.5009E-02	173	1.2293E-01	1.2431E-01
124	6.5009E-02	6.6008E-02	174	1.2431E-01	1.2569E-01
125	6.6008E-02	6.7015E-02	175	1.2569E-01	1.2707E-01
126	6.7015E-02	6.8029E-02	176	1.2707E-01	1.2847E-01
127	6.8029E-02	6.9051E-02	177	1.2847E-01	1.2987E-01
128	6.9051E-02	7.0081E-02	178	1.2987E-01	1.3128E-01
129	7.0081E-02	7.1118E-02	179	1.3128E-01	1.3270E-01
130	7.1118E-02	7.2163E-02	180	1.3270E-01	1.3413E-01
131	7.2163E-02	7.3216E-02	181	1.3413E-01	1.3556E-01
132	7.3216E-02	7.4276E-02	182	1.3556E-01	1.3700E-01
133	7.4276E-02	7.5344E-02	183	1.3700E-01	1.3845E-01
134	7.5344E-02	7.6419E-02	184	1.3845E-01	1.3991E-01
135	7.6419E-02	7.7502E-02	185	1.3991E-01	1.4137E-01
136	7.7502E-02	7.8593E-02	186	1.4137E-01	1.4284E-01
137	7.8593E-02	7.9691E-02	187	1.4284E-01	1.4432E-01
138	7.9691E-02	8.0797E-02	188	1.4432E-01	1.4581E-01
139	8.0797E-02	8.1911E-02	189	1.4581E-01	1.4730E-01
140	8.1911E-02	8.3032E-02	190	1.4730E-01	1.4881E-01
141	8.3032E-02	8.4161E-02	191	1.4881E-01	1.5032E-01
142	8.4161E-02	8.5297E-02	192	1.5032E-01	1.5183E-01
143	8.5297E-02	8.6441E-02	193	1.5183E-01	1.5336E-01
144	8.6441E-02	8.7593E-02	194	1.5336E-01	1.5489E-01
145	8.7593E-02	8.8752E-02	195	1.5489E-01	1.5643E-01
146	8.8752E-02	8.9919E-02	196	1.5643E-01	1.5798E-01
147	8.9919E-02	9.1093E-02	197	1.5798E-01	1.5954E-01
148	9.1093E-02	9.2275E-02	198	1.5954E-01	1.6110E-01
149	9.2275E-02	9.3465E-02	199	1.6110E-01	1.6267E-01
150	9.3465E-02	9.4662E-02	200	1.6267E-01	1.6425E-01

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (201 - 300 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
201	1.6425E-01	1.6583E-01	251	2.5288E-01	2.5485E-01
202	1.6583E-01	1.6743E-01	252	2.5485E-01	2.5683E-01
203	1.6743E-01	1.6903E-01	253	2.5683E-01	2.5881E-01
204	1.6903E-01	1.7064E-01	254	2.5881E-01	2.6080E-01
205	1.7064E-01	1.7225E-01	255	2.6080E-01	2.6280E-01
206	1.7225E-01	1.7388E-01	256	2.6280E-01	2.6480E-01
207	1.7388E-01	1.7551E-01	257	2.6480E-01	2.6681E-01
208	1.7551E-01	1.7715E-01	258	2.6681E-01	2.6883E-01
209	1.7715E-01	1.7880E-01	259	2.6883E-01	2.7086E-01
210	1.7880E-01	1.8045E-01	260	2.7086E-01	2.7290E-01
211	1.8045E-01	1.8211E-01	261	2.7290E-01	2.7494E-01
212	1.8211E-01	1.8378E-01	262	2.7494E-01	2.7699E-01
213	1.8378E-01	1.8546E-01	263	2.7699E-01	2.7905E-01
214	1.8546E-01	1.8715E-01	264	2.7905E-01	2.8112E-01
215	1.8715E-01	1.8884E-01	265	2.8112E-01	2.8319E-01
216	1.8884E-01	1.9054E-01	266	2.8319E-01	2.8527E-01
217	1.9054E-01	1.9225E-01	267	2.8527E-01	2.8736E-01
218	1.9225E-01	1.9396E-01	268	2.8736E-01	2.8946E-01
219	1.9396E-01	1.9569E-01	269	2.8946E-01	2.9156E-01
220	1.9569E-01	1.9742E-01	270	2.9156E-01	2.9367E-01
221	1.9742E-01	1.9915E-01	271	2.9367E-01	2.9579E-01
222	1.9915E-01	2.0090E-01	272	2.9579E-01	2.9792E-01
223	2.0090E-01	2.0265E-01	273	2.9792E-01	3.0006E-01
224	2.0265E-01	2.0442E-01	274	3.0006E-01	3.0220E-01
225	2.0442E-01	2.0618E-01	275	3.0220E-01	3.0435E-01
226	2.0618E-01	2.0796E-01	276	3.0435E-01	3.0651E-01
227	2.0796E-01	2.0975E-01	277	3.0651E-01	3.0867E-01
228	2.0975E-01	2.1154E-01	278	3.0867E-01	3.1084E-01
229	2.1154E-01	2.1334E-01	279	3.1084E-01	3.1302E-01
230	2.1334E-01	2.1514E-01	280	3.1302E-01	3.1521E-01
231	2.1514E-01	2.1696E-01	281	3.1521E-01	3.1741E-01
232	2.1696E-01	2.1878E-01	282	3.1741E-01	3.1961E-01
233	2.1878E-01	2.2061E-01	283	3.1961E-01	3.2182E-01
234	2.2061E-01	2.2245E-01	284	3.2182E-01	3.2404E-01
235	2.2245E-01	2.2429E-01	285	3.2404E-01	3.2627E-01
236	2.2429E-01	2.2615E-01	286	3.2627E-01	3.2850E-01
237	2.2615E-01	2.2801E-01	287	3.2850E-01	3.3074E-01
238	2.2801E-01	2.2987E-01	288	3.3074E-01	3.3299E-01
239	2.2987E-01	2.3175E-01	289	3.3299E-01	3.3525E-01
240	2.3175E-01	2.3363E-01	290	3.3525E-01	3.3751E-01
241	2.3363E-01	2.3552E-01	291	3.3751E-01	3.3978E-01
242	2.3552E-01	2.3742E-01	292	3.3978E-01	3.4206E-01
243	2.3742E-01	2.3933E-01	293	3.4206E-01	3.4435E-01
244	2.3933E-01	2.4124E-01	294	3.4435E-01	3.4665E-01
245	2.4124E-01	2.4316E-01	295	3.4665E-01	3.4895E-01
246	2.4316E-01	2.4509E-01	296	3.4895E-01	3.5126E-01
247	2.4509E-01	2.4703E-01	297	3.5126E-01	3.5358E-01
248	2.4703E-01	2.4897E-01	298	3.5358E-01	3.5590E-01
249	2.4897E-01	2.5093E-01	299	3.5590E-01	3.5823E-01
250	2.5093E-01	2.5288E-01	300	3.5823E-01	3.6057E-01

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (301 - 400 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
301	3.6057E-01	3.6292E-01	351	4.7860E-01	4.8100E-01
302	3.6292E-01	3.6528E-01	352	4.8100E-01	4.8341E-01
303	3.6528E-01	3.6764E-01	353	4.8341E-01	4.8583E-01
304	3.6764E-01	3.7001E-01	354	4.8583E-01	4.8827E-01
305	3.7001E-01	3.7239E-01	355	4.8827E-01	4.9072E-01
306	3.7239E-01	3.7478E-01	356	4.9072E-01	4.9317E-01
307	3.7478E-01	3.7717E-01	357	4.9317E-01	4.9564E-01
308	3.7717E-01	3.7957E-01	358	4.9564E-01	4.9813E-01
309	3.7957E-01	3.8198E-01	359	4.9813E-01	5.0062E-01
310	3.8198E-01	3.8440E-01	360	5.0062E-01	5.0313E-01
311	3.8440E-01	3.8682E-01	361	5.0313E-01	5.0566E-01
312	3.8682E-01	3.8925E-01	362	5.0566E-01	5.0819E-01
313	3.8925E-01	3.9169E-01	363	5.0819E-01	5.1074E-01
314	3.9169E-01	3.9414E-01	364	5.1074E-01	5.1330E-01
315	3.9414E-01	3.9660E-01	365	5.1330E-01	5.1587E-01
316	3.9660E-01	3.9906E-01	366	5.1587E-01	5.1846E-01
317	3.9906E-01	4.0153E-01	367	5.1846E-01	5.2106E-01
318	4.0153E-01	4.0401E-01	368	5.2106E-01	5.2366E-01
319	4.0401E-01	4.0649E-01	369	5.2366E-01	5.2629E-01
320	4.0649E-01	4.0898E-01	370	5.2629E-01	5.2893E-01
321	4.0898E-01	4.1399E-01	371	5.2893E-01	5.3158E-01
322	4.1399E-01	4.1607E-01	372	5.3158E-01	5.3425E-01
323	4.1607E-01	4.1816E-01	373	5.3425E-01	5.3693E-01
324	4.1816E-01	4.2025E-01	374	5.3693E-01	5.3961E-01
325	4.2025E-01	4.2236E-01	375	5.3961E-01	5.4232E-01
326	4.2236E-01	4.2448E-01	376	5.4232E-01	5.4504E-01
327	4.2448E-01	4.2661E-01	377	5.4504E-01	5.4778E-01
328	4.2661E-01	4.2874E-01	378	5.4778E-01	5.5052E-01
329	4.2874E-01	4.3089E-01	379	5.5052E-01	5.5328E-01
330	4.3089E-01	4.3305E-01	380	5.5328E-01	5.5605E-01
331	4.3305E-01	4.3522E-01	381	5.5605E-01	5.5883E-01
332	4.3522E-01	4.3740E-01	382	5.5883E-01	5.6164E-01
333	4.3740E-01	4.3960E-01	383	5.6164E-01	5.6446E-01
334	4.3960E-01	4.4180E-01	384	5.6446E-01	5.6728E-01
335	4.4180E-01	4.4401E-01	385	5.6728E-01	5.7013E-01
336	4.4401E-01	4.4624E-01	386	5.7013E-01	5.7299E-01
337	4.4624E-01	4.4847E-01	387	5.7299E-01	5.7585E-01
338	4.4847E-01	4.5073E-01	388	5.7585E-01	5.7874E-01
339	4.5073E-01	4.5299E-01	389	5.7874E-01	5.8165E-01
340	4.5299E-01	4.5525E-01	390	5.8165E-01	5.8456E-01
341	4.5525E-01	4.5754E-01	391	5.8456E-01	5.8749E-01
342	4.5754E-01	4.5983E-01	392	5.8749E-01	5.9044E-01
343	4.5983E-01	4.6213E-01	393	5.9044E-01	5.9339E-01
344	4.6213E-01	4.6445E-01	394	5.9339E-01	5.9637E-01
345	4.6445E-01	4.6678E-01	395	5.9637E-01	5.9936E-01
346	4.6678E-01	4.6912E-01	396	5.9936E-01	6.0236E-01
347	4.6912E-01	4.7147E-01	397	6.0236E-01	6.0538E-01
348	4.7147E-01	4.7384E-01	398	6.0538E-01	6.0842E-01
349	4.7384E-01	4.7621E-01	399	6.0842E-01	6.1146E-01
350	4.7621E-01	4.7860E-01	400	6.1146E-01	6.1453E-01

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (401 - 500 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
401	6.1453E-01	6.1761E-01	451	7.8907E-01	7.9303E-01
402	6.1761E-01	6.2071E-01	452	7.9303E-01	7.9701E-01
403	6.2071E-01	6.2382E-01	453	7.9701E-01	8.0099E-01
404	6.2382E-01	6.2695E-01	454	8.0099E-01	8.0501E-01
405	6.2695E-01	6.3009E-01	455	8.0501E-01	8.0905E-01
406	6.3009E-01	6.3324E-01	456	8.0905E-01	8.1310E-01
407	6.3324E-01	6.3642E-01	457	8.1310E-01	8.1718E-01
408	6.3642E-01	6.3961E-01	458	8.1718E-01	8.2128E-01
409	6.3961E-01	6.4281E-01	459	8.2128E-01	8.2539E-01
410	6.4281E-01	6.4604E-01	460	8.2539E-01	8.2953E-01
411	6.4604E-01	6.4928E-01	461	8.2953E-01	8.3369E-01
412	6.4928E-01	6.5253E-01	462	8.3369E-01	8.3786E-01
413	6.5253E-01	6.5580E-01	463	8.3786E-01	8.4207E-01
414	6.5580E-01	6.5909E-01	464	8.4207E-01	8.4629E-01
415	6.5909E-01	6.6239E-01	465	8.4629E-01	8.5052E-01
416	6.6239E-01	6.6571E-01	466	8.5052E-01	8.5479E-01
417	6.6571E-01	6.6905E-01	467	8.5479E-01	8.5908E-01
418	6.6905E-01	6.7240E-01	468	8.5908E-01	8.6338E-01
419	6.7240E-01	6.7577E-01	469	8.6338E-01	8.6771E-01
420	6.7577E-01	6.7916E-01	470	8.6771E-01	8.7206E-01
421	6.7916E-01	6.8256E-01	471	8.7206E-01	8.7642E-01
422	6.8256E-01	6.8599E-01	472	8.7642E-01	8.8082E-01
423	6.8599E-01	6.8943E-01	473	8.8082E-01	8.8524E-01
424	6.8943E-01	6.9288E-01	474	8.8524E-01	8.8967E-01
425	6.9288E-01	6.9635E-01	475	8.8967E-01	8.9413E-01
426	6.9635E-01	6.9985E-01	476	8.9413E-01	8.9862E-01
427	6.9985E-01	7.0336E-01	477	8.9862E-01	9.0313E-01
428	7.0336E-01	7.0688E-01	478	9.0313E-01	9.0765E-01
429	7.0688E-01	7.1042E-01	479	9.0765E-01	9.1220E-01
430	7.1042E-01	7.1399E-01	480	9.1220E-01	9.1678E-01
431	7.1399E-01	7.1756E-01	481	9.1678E-01	9.2136E-01
432	7.1756E-01	7.2116E-01	482	9.2136E-01	9.2599E-01
433	7.2116E-01	7.2478E-01	483	9.2599E-01	9.3063E-01
434	7.2478E-01	7.2840E-01	484	9.3063E-01	9.3529E-01
435	7.2840E-01	7.3206E-01	485	9.3529E-01	9.3998E-01
436	7.3206E-01	7.3573E-01	486	9.3998E-01	9.4470E-01
437	7.3573E-01	7.3941E-01	487	9.4470E-01	9.4942E-01
438	7.3941E-01	7.4312E-01	488	9.4942E-01	9.5418E-01
439	7.4312E-01	7.4685E-01	489	9.5418E-01	9.5897E-01
440	7.4685E-01	7.5058E-01	490	9.5897E-01	9.6377E-01
441	7.5058E-01	7.5435E-01	491	9.6377E-01	9.6860E-01
442	7.5435E-01	7.5814E-01	492	9.6860E-01	9.7347E-01
443	7.5814E-01	7.6193E-01	493	9.7347E-01	9.7833E-01
444	7.6193E-01	7.6575E-01	494	9.7833E-01	9.8324E-01
445	7.6575E-01	7.6959E-01	495	9.8324E-01	9.8818E-01
446	7.6959E-01	7.7344E-01	496	9.8818E-01	9.9312E-01
447	7.7344E-01	7.7732E-01	497	9.9312E-01	9.9810E-01
448	7.7732E-01	7.8122E-01	498	9.9810E-01	1.0031E+00
449	7.8122E-01	7.8513E-01	499	1.0031E+00	1.0081E+00
450	7.8513E-01	7.8907E-01	500	1.0081E+00	1.0132E+00

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (< 501 - 600 GROUPS >)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
501	1.0132E+00	1.0183E+00	551	1.3010E+00	1.3075E+00
502	1.0183E+00	1.0234E+00	552	1.3075E+00	1.3140E+00
503	1.0234E+00	1.0285E+00	553	1.3140E+00	1.3206E+00
504	1.0285E+00	1.0337E+00	554	1.3206E+00	1.3272E+00
505	1.0337E+00	1.0388E+00	555	1.3272E+00	1.3339E+00
506	1.0388E+00	1.0440E+00	556	1.3339E+00	1.3406E+00
507	1.0440E+00	1.0493E+00	557	1.3406E+00	1.3473E+00
508	1.0493E+00	1.0545E+00	558	1.3473E+00	1.3540E+00
509	1.0545E+00	1.0598E+00	559	1.3540E+00	1.3608E+00
510	1.0598E+00	1.0651E+00	560	1.3608E+00	1.3677E+00
511	1.0651E+00	1.0705E+00	561	1.3677E+00	1.3745E+00
512	1.0705E+00	1.0758E+00	562	1.3745E+00	1.3814E+00
513	1.0758E+00	1.0812E+00	563	1.3814E+00	1.3883E+00
514	1.0812E+00	1.0867E+00	564	1.3883E+00	1.3953E+00
515	1.0867E+00	1.0921E+00	565	1.3953E+00	1.4023E+00
516	1.0921E+00	1.0976E+00	566	1.4023E+00	1.4093E+00
517	1.0976E+00	1.1031E+00	567	1.4093E+00	1.4164E+00
518	1.1031E+00	1.1086E+00	568	1.4164E+00	1.4235E+00
519	1.1086E+00	1.1142E+00	569	1.4235E+00	1.4306E+00
520	1.1142E+00	1.1198E+00	570	1.4306E+00	1.4378E+00
521	1.1198E+00	1.1254E+00	571	1.4378E+00	1.4450E+00
522	1.1254E+00	1.1310E+00	572	1.4450E+00	1.4522E+00
523	1.1310E+00	1.1367E+00	573	1.4522E+00	1.4595E+00
524	1.1367E+00	1.1424E+00	574	1.4595E+00	1.4668E+00
525	1.1424E+00	1.1481E+00	575	1.4668E+00	1.4742E+00
526	1.1481E+00	1.1538E+00	576	1.4742E+00	1.4816E+00
527	1.1538E+00	1.1596E+00	577	1.4816E+00	1.4890E+00
528	1.1596E+00	1.1654E+00	578	1.4890E+00	1.4964E+00
529	1.1654E+00	1.1713E+00	579	1.4964E+00	1.5039E+00
530	1.1713E+00	1.1771E+00	580	1.5039E+00	1.5115E+00
531	1.1771E+00	1.1830E+00	581	1.5115E+00	1.5191E+00
532	1.1830E+00	1.1890E+00	582	1.5191E+00	1.5267E+00
533	1.1890E+00	1.1949E+00	583	1.5267E+00	1.5343E+00
534	1.1949E+00	1.2009E+00	584	1.5343E+00	1.5420E+00
535	1.2009E+00	1.2069E+00	585	1.5420E+00	1.5498E+00
536	1.2069E+00	1.2130E+00	586	1.5498E+00	1.5575E+00
537	1.2130E+00	1.2191E+00	587	1.5575E+00	1.5653E+00
538	1.2191E+00	1.2252E+00	588	1.5653E+00	1.5732E+00
539	1.2252E+00	1.2313E+00	589	1.5732E+00	1.5811E+00
540	1.2313E+00	1.2375E+00	590	1.5811E+00	1.5890E+00
541	1.2375E+00	1.2437E+00	591	1.5890E+00	1.5969E+00
542	1.2437E+00	1.2499E+00	592	1.5969E+00	1.6050E+00
543	1.2499E+00	1.2562E+00	593	1.6050E+00	1.6130E+00
544	1.2562E+00	1.2625E+00	594	1.6130E+00	1.6211E+00
545	1.2625E+00	1.2688E+00	595	1.6211E+00	1.6292E+00
546	1.2688E+00	1.2752E+00	596	1.6292E+00	1.6374E+00
547	1.2752E+00	1.2816E+00	597	1.6374E+00	1.6456E+00
548	1.2816E+00	1.2880E+00	598	1.6456E+00	1.6538E+00
549	1.2880E+00	1.2945E+00	599	1.6538E+00	1.6621E+00
550	1.2945E+00	1.3010E+00	600	1.6621E+00	1.6705E+00

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (601 - 700 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
601	1.6705E+00	1.6788E+00	651	2.1449E+00	2.1557E+00
602	1.6788E+00	1.6872E+00	652	2.1557E+00	2.1665E+00
603	1.6872E+00	1.6957E+00	653	2.1665E+00	2.1773E+00
604	1.6957E+00	1.7042E+00	654	2.1773E+00	2.1882E+00
605	1.7042E+00	1.7127E+00	655	2.1882E+00	2.1992E+00
606	1.7127E+00	1.7213E+00	656	2.1992E+00	2.2102E+00
607	1.7213E+00	1.7300E+00	657	2.2102E+00	2.2213E+00
608	1.7300E+00	1.7386E+00	658	2.2213E+00	2.2324E+00
609	1.7386E+00	1.7473E+00	659	2.2324E+00	2.2436E+00
610	1.7473E+00	1.7561E+00	660	2.2436E+00	2.2549E+00
611	1.7561E+00	1.7649E+00	661	2.2549E+00	2.2662E+00
612	1.7649E+00	1.7737E+00	662	2.2662E+00	2.2775E+00
613	1.7737E+00	1.7826E+00	663	2.2775E+00	2.2890E+00
614	1.7826E+00	1.7916E+00	664	2.2890E+00	2.3004E+00
615	1.7916E+00	1.8006E+00	665	2.3004E+00	2.3120E+00
616	1.8006E+00	1.8096E+00	666	2.3120E+00	2.3235E+00
617	1.8096E+00	1.8187E+00	667	2.3235E+00	2.3352E+00
618	1.8187E+00	1.8278E+00	668	2.3352E+00	2.3469E+00
619	1.8278E+00	1.8369E+00	669	2.3469E+00	2.3587E+00
620	1.8369E+00	1.8461E+00	670	2.3587E+00	2.3705E+00
621	1.8461E+00	1.8554E+00	671	2.3705E+00	2.3824E+00
622	1.8554E+00	1.8647E+00	672	2.3824E+00	2.3943E+00
623	1.8647E+00	1.8740E+00	673	2.3943E+00	2.4063E+00
624	1.8740E+00	1.8834E+00	674	2.4063E+00	2.4184E+00
625	1.8834E+00	1.8929E+00	675	2.4184E+00	2.4305E+00
626	1.8929E+00	1.9024E+00	676	2.4305E+00	2.4427E+00
627	1.9024E+00	1.9119E+00	677	2.4427E+00	2.4549E+00
628	1.9119E+00	1.9215E+00	678	2.4549E+00	2.4672E+00
629	1.9215E+00	1.9311E+00	679	2.4672E+00	2.4796E+00
630	1.9311E+00	1.9408E+00	680	2.4796E+00	2.4920E+00
631	1.9408E+00	1.9505E+00	681	2.4920E+00	2.5045E+00
632	1.9505E+00	1.9603E+00	682	2.5045E+00	2.5171E+00
633	1.9603E+00	1.9701E+00	683	2.5171E+00	2.5297E+00
634	1.9701E+00	1.9800E+00	684	2.5297E+00	2.5424E+00
635	1.9800E+00	1.9899E+00	685	2.5424E+00	2.5551E+00
636	1.9899E+00	1.9999E+00	686	2.5551E+00	2.5679E+00
637	1.9999E+00	2.0099E+00	687	2.5679E+00	2.5808E+00
638	2.0099E+00	2.0200E+00	688	2.5808E+00	2.5937E+00
639	2.0200E+00	2.0301E+00	689	2.5937E+00	2.6067E+00
640	2.0301E+00	2.0403E+00	690	2.6067E+00	2.6198E+00
641	2.0403E+00	2.0505E+00	691	2.6198E+00	2.6329E+00
642	2.0505E+00	2.0608E+00	692	2.6329E+00	2.6461E+00
643	2.0608E+00	2.0711E+00	693	2.6461E+00	2.6594E+00
644	2.0711E+00	2.0815E+00	694	2.6594E+00	2.6727E+00
645	2.0815E+00	2.0919E+00	695	2.6727E+00	2.6861E+00
646	2.0919E+00	2.1024E+00	696	2.6861E+00	2.6996E+00
647	2.1024E+00	2.1130E+00	697	2.6996E+00	2.7131E+00
648	2.1130E+00	2.1236E+00	698	2.7131E+00	2.7267E+00
649	2.1236E+00	2.1342E+00	699	2.7267E+00	2.7404E+00
650	2.1342E+00	2.1449E+00	700	2.7404E+00	2.7541E+00

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (701 - 800 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
701	2.7541E+00	2.7679E+00	751	3.5363E+00	3.5541E+00
702	2.7679E+00	2.7818E+00	752	3.5541E+00	3.5719E+00
703	2.7818E+00	2.7957E+00	753	3.5719E+00	3.5898E+00
704	2.7957E+00	2.8097E+00	754	3.5898E+00	3.6078E+00
705	2.8097E+00	2.8238E+00	755	3.6078E+00	3.6259E+00
706	2.8238E+00	2.8380E+00	756	3.6259E+00	3.6440E+00
707	2.8380E+00	2.8522E+00	757	3.6440E+00	3.6623E+00
708	2.8522E+00	2.8665E+00	758	3.6623E+00	3.6807E+00
709	2.8665E+00	2.8809E+00	759	3.6807E+00	3.6991E+00
710	2.8809E+00	2.8953E+00	760	3.6991E+00	3.7177E+00
711	2.8953E+00	2.9098E+00	761	3.7177E+00	3.7363E+00
712	2.9098E+00	2.9244E+00	762	3.7363E+00	3.7550E+00
713	2.9244E+00	2.9391E+00	763	3.7550E+00	3.7738E+00
714	2.9391E+00	2.9538E+00	764	3.7738E+00	3.7928E+00
715	2.9538E+00	2.9686E+00	765	3.7928E+00	3.8118E+00
716	2.9686E+00	2.9835E+00	766	3.8118E+00	3.8309E+00
717	2.9835E+00	2.9984E+00	767	3.8309E+00	3.8501E+00
718	2.9984E+00	3.0135E+00	768	3.8501E+00	3.8694E+00
719	3.0135E+00	3.0286E+00	769	3.8694E+00	3.8888E+00
720	3.0286E+00	3.0438E+00	770	3.8888E+00	3.9083E+00
721	3.0438E+00	3.0590E+00	771	3.9083E+00	3.9279E+00
722	3.0590E+00	3.0744E+00	772	3.9279E+00	3.9475E+00
723	3.0744E+00	3.0898E+00	773	3.9475E+00	3.9673E+00
724	3.0898E+00	3.1053E+00	774	3.9673E+00	3.9872E+00
725	3.1053E+00	3.1208E+00	775	3.9872E+00	4.0072E+00
726	3.1208E+00	3.1365E+00	776	4.0072E+00	4.0273E+00
727	3.1365E+00	3.1522E+00	777	4.0273E+00	4.0475E+00
728	3.1522E+00	3.1680E+00	778	4.0475E+00	4.0678E+00
729	3.1680E+00	3.1839E+00	779	4.0678E+00	4.0882E+00
730	3.1839E+00	3.1998E+00	780	4.0882E+00	4.1087E+00
731	3.1998E+00	3.2159E+00	781	4.1087E+00	4.1292E+00
732	3.2159E+00	3.2320E+00	782	4.1292E+00	4.1499E+00
733	3.2320E+00	3.2482E+00	783	4.1499E+00	4.1707E+00
734	3.2482E+00	3.2645E+00	784	4.1707E+00	4.1916E+00
735	3.2645E+00	3.2808E+00	785	4.1916E+00	4.2127E+00
736	3.2808E+00	3.2973E+00	786	4.2127E+00	4.2338E+00
737	3.2973E+00	3.3138E+00	787	4.2338E+00	4.2550E+00
738	3.3138E+00	3.3304E+00	788	4.2550E+00	4.2763E+00
739	3.3304E+00	3.3471E+00	789	4.2763E+00	4.2978E+00
740	3.3471E+00	3.3639E+00	790	4.2978E+00	4.3193E+00
741	3.3639E+00	3.3807E+00	791	4.3193E+00	4.3410E+00
742	3.3807E+00	3.3977E+00	792	4.3410E+00	4.3627E+00
743	3.3977E+00	3.4147E+00	793	4.3627E+00	4.3846E+00
744	3.4147E+00	3.4318E+00	794	4.3846E+00	4.4066E+00
745	3.4318E+00	3.4490E+00	795	4.4066E+00	4.4286E+00
746	3.4490E+00	3.4663E+00	796	4.4286E+00	4.4508E+00
747	3.4663E+00	3.4837E+00	797	4.4508E+00	4.4732E+00
748	3.4837E+00	3.5012E+00	798	4.4732E+00	4.4956E+00
749	3.5012E+00	3.5187E+00	799	4.4956E+00	4.5181E+00
750	3.5187E+00	3.5363E+00	800	4.5181E+00	4.5408E+00

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (801 - 900 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
801	4.5408E+00	4.5635E+00	851	5.8304E+00	5.8597E+00
802	4.5635E+00	4.5864E+00	852	5.8597E+00	5.8890E+00
803	4.5864E+00	4.6094E+00	853	5.8890E+00	5.9186E+00
804	4.6094E+00	4.6325E+00	854	5.9186E+00	5.9482E+00
805	4.6325E+00	4.6557E+00	855	5.9482E+00	5.9781E+00
806	4.6557E+00	4.6790E+00	856	5.9781E+00	6.0080E+00
807	4.6790E+00	4.7025E+00	857	6.0080E+00	6.0381E+00
808	4.7025E+00	4.7261E+00	858	6.0381E+00	6.0684E+00
809	4.7261E+00	4.7498E+00	859	6.0684E+00	6.0988E+00
810	4.7498E+00	4.7736E+00	860	6.0988E+00	6.1294E+00
811	4.7736E+00	4.7975E+00	861	6.1294E+00	6.1601E+00
812	4.7975E+00	4.8215E+00	862	6.1601E+00	6.1910E+00
813	4.8215E+00	4.8457E+00	863	6.1910E+00	6.2220E+00
814	4.8457E+00	4.8700E+00	864	6.2220E+00	6.2532E+00
815	4.8700E+00	4.8944E+00	865	6.2532E+00	6.2846E+00
816	4.8944E+00	4.9189E+00	866	6.2846E+00	6.3161E+00
817	4.9189E+00	4.9436E+00	867	6.3161E+00	6.3477E+00
818	4.9436E+00	4.9684E+00	868	6.3477E+00	6.3795E+00
819	4.9684E+00	4.9933E+00	869	6.3795E+00	6.4115E+00
820	4.9933E+00	5.0183E+00	870	6.4115E+00	6.4436E+00
821	5.0183E+00	5.0435E+00	871	6.4436E+00	6.4759E+00
822	5.0435E+00	5.0688E+00	872	6.4759E+00	6.5084E+00
823	5.0688E+00	5.0942E+00	873	6.5084E+00	6.5410E+00
824	5.0942E+00	5.1197E+00	874	6.5410E+00	6.5738E+00
825	5.1197E+00	5.1454E+00	875	6.5738E+00	6.6068E+00
826	5.1454E+00	5.1711E+00	876	6.6068E+00	6.6399E+00
827	5.1711E+00	5.1971E+00	877	6.6399E+00	6.6732E+00
828	5.1971E+00	5.2231E+00	878	6.6732E+00	6.7066E+00
829	5.2231E+00	5.2493E+00	879	6.7066E+00	6.7402E+00
830	5.2493E+00	5.2756E+00	880	6.7402E+00	6.7740E+00
831	5.2756E+00	5.3021E+00	881	6.7740E+00	6.8080E+00
832	5.3021E+00	5.3286E+00	882	6.8080E+00	6.8421E+00
833	5.3286E+00	5.3553E+00	883	6.8421E+00	6.8764E+00
834	5.3553E+00	5.3822E+00	884	6.8764E+00	6.9109E+00
835	5.3822E+00	5.4092E+00	885	6.9109E+00	6.9455E+00
836	5.4092E+00	5.4363E+00	886	6.9455E+00	6.9803E+00
837	5.4363E+00	5.4635E+00	887	6.9803E+00	7.0153E+00
838	5.4635E+00	5.4909E+00	888	7.0153E+00	7.0505E+00
839	5.4909E+00	5.5184E+00	889	7.0505E+00	7.0858E+00
840	5.5184E+00	5.5461E+00	890	7.0858E+00	7.1213E+00
841	5.5461E+00	5.5739E+00	891	7.1213E+00	7.1570E+00
842	5.5739E+00	5.6018E+00	892	7.1570E+00	7.1929E+00
843	5.6018E+00	5.6299E+00	893	7.1929E+00	7.2290E+00
844	5.6299E+00	5.6581E+00	894	7.2290E+00	7.2652E+00
845	5.6581E+00	5.6865E+00	895	7.2652E+00	7.3016E+00
846	5.6865E+00	5.7150E+00	896	7.3016E+00	7.3382E+00
847	5.7150E+00	5.7436E+00	897	7.3382E+00	7.3750E+00
848	5.7436E+00	5.7724E+00	898	7.3750E+00	7.4120E+00
849	5.7724E+00	5.8014E+00	899	7.4120E+00	7.4491E+00
850	5.8014E+00	5.8304E+00	900	7.4491E+00	7.4864E+00

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (901 - 1000 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
901	7.4864E+00	7.5240E+00	951	9.6128E+00	9.6610E+00
902	7.5240E+00	7.5617E+00	952	9.6610E+00	9.7094E+00
903	7.5617E+00	7.5996E+00	953	9.7094E+00	9.7581E+00
904	7.5996E+00	7.6377E+00	954	9.7581E+00	9.8070E+00
905	7.6377E+00	7.6760E+00	955	9.8070E+00	9.8561E+00
906	7.6760E+00	7.7144E+00	956	9.8561E+00	9.9055E+00
907	7.7144E+00	7.7531E+00	957	9.9055E+00	9.9552E+00
908	7.7531E+00	7.7920E+00	958	9.9552E+00	1.0005E+01
909	7.7920E+00	7.8310E+00	959	1.0005E+01	1.0055E+01
910	7.8310E+00	7.8703E+00	960	1.0055E+01	1.0106E+01
911	7.8703E+00	7.9097E+00	961	1.0106E+01	1.0156E+01
912	7.9097E+00	7.9494E+00	962	1.0156E+01	1.0207E+01
913	7.9494E+00	7.9892E+00	963	1.0207E+01	1.0258E+01
914	7.9892E+00	8.0293E+00	964	1.0258E+01	1.0310E+01
915	8.0293E+00	8.0695E+00	965	1.0310E+01	1.0361E+01
916	8.0695E+00	8.1100E+00	966	1.0361E+01	1.0413E+01
917	8.1100E+00	8.1506E+00	967	1.0413E+01	1.0466E+01
918	8.1506E+00	8.1915E+00	968	1.0466E+01	1.0518E+01
919	8.1915E+00	8.2325E+00	969	1.0518E+01	1.0571E+01
920	8.2325E+00	8.2738E+00	970	1.0571E+01	1.0624E+01
921	8.2738E+00	8.3153E+00	971	1.0624E+01	1.0677E+01
922	8.3153E+00	8.3570E+00	972	1.0677E+01	1.0731E+01
923	8.3570E+00	8.3989E+00	973	1.0731E+01	1.0784E+01
924	8.3989E+00	8.4409E+00	974	1.0784E+01	1.0838E+01
925	8.4409E+00	8.4833E+00	975	1.0838E+01	1.0893E+01
926	8.4833E+00	8.5258E+00	976	1.0893E+01	1.0947E+01
927	8.5258E+00	8.5685E+00	977	1.0947E+01	1.1002E+01
928	8.5685E+00	8.6115E+00	978	1.1002E+01	1.1057E+01
929	8.6115E+00	8.6546E+00	979	1.1057E+01	1.1113E+01
930	8.6546E+00	8.6980E+00	980	1.1113E+01	1.1168E+01
931	8.6980E+00	8.7416E+00	981	1.1168E+01	1.1224E+01
932	8.7416E+00	8.7854E+00	982	1.1224E+01	1.1281E+01
933	8.7854E+00	8.8295E+00	983	1.1281E+01	1.1337E+01
934	8.8295E+00	8.8737E+00	984	1.1337E+01	1.1394E+01
935	8.8737E+00	8.9182E+00	985	1.1394E+01	1.1451E+01
936	8.9182E+00	8.9629E+00	986	1.1451E+01	1.1509E+01
937	8.9629E+00	9.0078E+00	987	1.1509E+01	1.1566E+01
938	9.0078E+00	9.0530E+00	988	1.1566E+01	1.1624E+01
939	9.0530E+00	9.0984E+00	989	1.1624E+01	1.1683E+01
940	9.0984E+00	9.1440E+00	990	1.1683E+01	1.1741E+01
941	9.1440E+00	9.1898E+00	991	1.1741E+01	1.1800E+01
942	9.1898E+00	9.2359E+00	992	1.1800E+01	1.1859E+01
943	9.2359E+00	9.2822E+00	993	1.1859E+01	1.1919E+01
944	9.2822E+00	9.3287E+00	994	1.1919E+01	1.1978E+01
945	9.3287E+00	9.3755E+00	995	1.1978E+01	1.2038E+01
946	9.3755E+00	9.4224E+00	996	1.2038E+01	1.2099E+01
947	9.4224E+00	9.4697E+00	997	1.2099E+01	1.2159E+01
948	9.4697E+00	9.5171E+00	998	1.2159E+01	1.2220E+01
949	9.5171E+00	9.5648E+00	999	1.2220E+01	1.2281E+01
950	9.5648E+00	9.6128E+00	1000	1.2281E+01	1.2343E+01

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (1001 - 1100 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
1001	1.2343E+01	1.2405E+01	1051	1.5849E+01	1.5928E+01
1002	1.2405E+01	1.2467E+01	1052	1.5928E+01	1.6008E+01
1003	1.2467E+01	1.2530E+01	1053	1.6008E+01	1.6088E+01
1004	1.2530E+01	1.2592E+01	1054	1.6088E+01	1.6169E+01
1005	1.2592E+01	1.2656E+01	1055	1.6169E+01	1.6250E+01
1006	1.2656E+01	1.2719E+01	1056	1.6250E+01	1.6331E+01
1007	1.2719E+01	1.2783E+01	1057	1.6331E+01	1.6413E+01
1008	1.2783E+01	1.2847E+01	1058	1.6413E+01	1.6496E+01
1009	1.2847E+01	1.2911E+01	1059	1.6496E+01	1.6578E+01
1010	1.2911E+01	1.2976E+01	1060	1.6578E+01	1.6661E+01
1011	1.2976E+01	1.3041E+01	1061	1.6661E+01	1.6745E+01
1012	1.3041E+01	1.3106E+01	1062	1.6745E+01	1.6829E+01
1013	1.3106E+01	1.3172E+01	1063	1.6829E+01	1.6913E+01
1014	1.3172E+01	1.3238E+01	1064	1.6913E+01	1.6998E+01
1015	1.3238E+01	1.3304E+01	1065	1.6998E+01	1.7083E+01
1016	1.3304E+01	1.3371E+01	1066	1.7083E+01	1.7169E+01
1017	1.3371E+01	1.3438E+01	1067	1.7169E+01	1.7255E+01
1018	1.3438E+01	1.3505E+01	1068	1.7255E+01	1.7341E+01
1019	1.3505E+01	1.3573E+01	1069	1.7341E+01	1.7428E+01
1020	1.3573E+01	1.3641E+01	1070	1.7428E+01	1.7516E+01
1021	1.3641E+01	1.3710E+01	1071	1.7516E+01	1.7603E+01
1022	1.3710E+01	1.3778E+01	1072	1.7603E+01	1.7692E+01
1023	1.3778E+01	1.3847E+01	1073	1.7692E+01	1.7780E+01
1024	1.3847E+01	1.3917E+01	1074	1.7780E+01	1.7869E+01
1025	1.3917E+01	1.3987E+01	1075	1.7869E+01	1.7959E+01
1026	1.3987E+01	1.4057E+01	1076	1.7959E+01	1.8049E+01
1027	1.4057E+01	1.4127E+01	1077	1.8049E+01	1.8140E+01
1028	1.4127E+01	1.4198E+01	1078	1.8140E+01	1.8230E+01
1029	1.4198E+01	1.4269E+01	1079	1.8230E+01	1.8322E+01
1030	1.4269E+01	1.4341E+01	1080	1.8322E+01	1.8414E+01
1031	1.4341E+01	1.4412E+01	1081	1.8414E+01	1.8506E+01
1032	1.4412E+01	1.4485E+01	1082	1.8506E+01	1.8599E+01
1033	1.4485E+01	1.4557E+01	1083	1.8599E+01	1.8692E+01
1034	1.4557E+01	1.4630E+01	1084	1.8692E+01	1.8786E+01
1035	1.4630E+01	1.4704E+01	1085	1.8786E+01	1.8880E+01
1036	1.4704E+01	1.4777E+01	1086	1.8880E+01	1.8974E+01
1037	1.4777E+01	1.4851E+01	1087	1.8974E+01	1.9070E+01
1038	1.4851E+01	1.4926E+01	1088	1.9070E+01	1.9165E+01
1039	1.4926E+01	1.5001E+01	1089	1.9165E+01	1.9261E+01
1040	1.5001E+01	1.5076E+01	1090	1.9261E+01	1.9358E+01
1041	1.5076E+01	1.5151E+01	1091	1.9358E+01	1.9455E+01
1042	1.5151E+01	1.5227E+01	1092	1.9455E+01	1.9552E+01
1043	1.5227E+01	1.5304E+01	1093	1.9552E+01	1.9650E+01
1044	1.5304E+01	1.5380E+01	1094	1.9650E+01	1.9749E+01
1045	1.5380E+01	1.5458E+01	1095	1.9749E+01	1.9848E+01
1046	1.5458E+01	1.5535E+01	1096	1.9848E+01	1.9947E+01
1047	1.5535E+01	1.5613E+01	1097	1.9947E+01	2.0047E+01
1048	1.5613E+01	1.5691E+01	1098	2.0047E+01	2.0148E+01
1049	1.5691E+01	1.5770E+01	1099	2.0148E+01	2.0249E+01
1050	1.5770E+01	1.5849E+01	1100	2.0249E+01	2.0350E+01

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (1101 - 1200 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
1101	2.0350E+01	2.0452E+01	1151	2.6130E+01	2.6261E+01
1102	2.0452E+01	2.0555E+01	1152	2.6261E+01	2.6393E+01
1103	2.0555E+01	2.0658E+01	1153	2.6393E+01	2.6525E+01
1104	2.0658E+01	2.0761E+01	1154	2.6525E+01	2.6658E+01
1105	2.0761E+01	2.0865E+01	1155	2.6658E+01	2.6792E+01
1106	2.0865E+01	2.0970E+01	1156	2.6792E+01	2.6926E+01
1107	2.0970E+01	2.1075E+01	1157	2.6926E+01	2.7061E+01
1108	2.1075E+01	2.1181E+01	1158	2.7061E+01	2.7197E+01
1109	2.1181E+01	2.1287E+01	1159	2.7197E+01	2.7333E+01
1110	2.1287E+01	2.1394E+01	1160	2.7333E+01	2.7470E+01
1111	2.1394E+01	2.1501E+01	1161	2.7470E+01	2.7608E+01
1112	2.1501E+01	2.1609E+01	1162	2.7608E+01	2.7746E+01
1113	2.1609E+01	2.1717E+01	1163	2.7746E+01	2.7885E+01
1114	2.1717E+01	2.1826E+01	1164	2.7885E+01	2.8025E+01
1115	2.1826E+01	2.1935E+01	1165	2.8025E+01	2.8165E+01
1116	2.1935E+01	2.2045E+01	1166	2.8165E+01	2.8307E+01
1117	2.2045E+01	2.2156E+01	1167	2.8307E+01	2.8448E+01
1118	2.2156E+01	2.2267E+01	1168	2.8448E+01	2.8591E+01
1119	2.2267E+01	2.2378E+01	1169	2.8591E+01	2.8734E+01
1120	2.2378E+01	2.2491E+01	1170	2.8734E+01	2.8878E+01
1121	2.2491E+01	2.2603E+01	1171	2.8878E+01	2.9023E+01
1122	2.2603E+01	2.2717E+01	1172	2.9023E+01	2.9169E+01
1123	2.2717E+01	2.2830E+01	1173	2.9169E+01	2.9315E+01
1124	2.2830E+01	2.2945E+01	1174	2.9315E+01	2.9462E+01
1125	2.2945E+01	2.3060E+01	1175	2.9462E+01	2.9609E+01
1126	2.3060E+01	2.3175E+01	1176	2.9609E+01	2.9758E+01
1127	2.3175E+01	2.3292E+01	1177	2.9758E+01	2.9907E+01
1128	2.3292E+01	2.3408E+01	1178	2.9907E+01	3.0057E+01
1129	2.3408E+01	2.3526E+01	1179	3.0057E+01	3.0208E+01
1130	2.3526E+01	2.3644E+01	1180	3.0208E+01	3.0359E+01
1131	2.3644E+01	2.3762E+01	1181	3.0359E+01	3.0511E+01
1132	2.3762E+01	2.3881E+01	1182	3.0511E+01	3.0664E+01
1133	2.3881E+01	2.4001E+01	1183	3.0664E+01	3.0818E+01
1134	2.4001E+01	2.4121E+01	1184	3.0818E+01	3.0972E+01
1135	2.4121E+01	2.4242E+01	1185	3.0972E+01	3.1128E+01
1136	2.4242E+01	2.4364E+01	1186	3.1128E+01	3.1284E+01
1137	2.4364E+01	2.4486E+01	1187	3.1284E+01	3.1440E+01
1138	2.4486E+01	2.4609E+01	1188	3.1440E+01	3.1598E+01
1139	2.4609E+01	2.4732E+01	1189	3.1598E+01	3.1756E+01
1140	2.4732E+01	2.4856E+01	1190	3.1756E+01	3.1916E+01
1141	2.4856E+01	2.4980E+01	1191	3.1916E+01	3.2076E+01
1142	2.4980E+01	2.5106E+01	1192	3.2076E+01	3.2236E+01
1143	2.5106E+01	2.5232E+01	1193	3.2236E+01	3.2398E+01
1144	2.5232E+01	2.5358E+01	1194	3.2398E+01	3.2560E+01
1145	2.5358E+01	2.5485E+01	1195	3.2560E+01	3.2724E+01
1146	2.5485E+01	2.5613E+01	1196	3.2724E+01	3.2888E+01
1147	2.5613E+01	2.5741E+01	1197	3.2888E+01	3.3052E+01
1148	2.5741E+01	2.5870E+01	1198	3.3052E+01	3.3218E+01
1149	2.5870E+01	2.6000E+01	1199	3.3218E+01	3.3385E+01
1150	2.6000E+01	2.6130E+01	1200	3.3385E+01	3.3552E+01

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (1201 - 1300 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
1201	3.3552E+01	3.3720E+01	1251	4.3082E+01	4.3297E+01
1202	3.3720E+01	3.3889E+01	1252	4.3297E+01	4.3514E+01
1203	3.3889E+01	3.4059E+01	1253	4.3514E+01	4.3733E+01
1204	3.4059E+01	3.4230E+01	1254	4.3733E+01	4.3952E+01
1205	3.4230E+01	3.4401E+01	1255	4.3952E+01	4.4172E+01
1206	3.4401E+01	3.4574E+01	1256	4.4172E+01	4.4394E+01
1207	3.4574E+01	3.4747E+01	1257	4.4394E+01	4.4616E+01
1208	3.4747E+01	3.4921E+01	1258	4.4616E+01	4.4840E+01
1209	3.4921E+01	3.5096E+01	1259	4.4840E+01	4.5064E+01
1210	3.5096E+01	3.5272E+01	1260	4.5064E+01	4.5290E+01
1211	3.5272E+01	3.5449E+01	1261	4.5290E+01	4.5517E+01
1212	3.5449E+01	3.5627E+01	1262	4.5517E+01	4.5746E+01
1213	3.5627E+01	3.5805E+01	1263	4.5746E+01	4.5975E+01
1214	3.5805E+01	3.5985E+01	1264	4.5975E+01	4.6205E+01
1215	3.5985E+01	3.6165E+01	1265	4.6205E+01	4.6437E+01
1216	3.6165E+01	3.6346E+01	1266	4.6437E+01	4.6670E+01
1217	3.6346E+01	3.6529E+01	1267	4.6670E+01	4.6904E+01
1218	3.6529E+01	3.6712E+01	1268	4.6904E+01	4.7139E+01
1219	3.6712E+01	3.6896E+01	1269	4.7139E+01	4.7375E+01
1220	3.6896E+01	3.7081E+01	1270	4.7375E+01	4.7612E+01
1221	3.7081E+01	3.7266E+01	1271	4.7612E+01	4.7851E+01
1222	3.7266E+01	3.7453E+01	1272	4.7851E+01	4.8091E+01
1223	3.7453E+01	3.7641E+01	1273	4.8091E+01	4.8332E+01
1224	3.7641E+01	3.7830E+01	1274	4.8332E+01	4.8574E+01
1225	3.7830E+01	3.8019E+01	1275	4.8574E+01	4.8818E+01
1226	3.8019E+01	3.8210E+01	1276	4.8818E+01	4.9062E+01
1227	3.8210E+01	3.8401E+01	1277	4.9062E+01	4.9308E+01
1228	3.8401E+01	3.8594E+01	1278	4.9308E+01	4.9556E+01
1229	3.8594E+01	3.8787E+01	1279	4.9556E+01	4.9804E+01
1230	3.8787E+01	3.8982E+01	1280	4.9804E+01	5.0054E+01
1231	3.8982E+01	3.9177E+01	1281	5.0054E+01	5.0304E+01
1232	3.9177E+01	3.9374E+01	1282	5.0304E+01	5.0557E+01
1233	3.9374E+01	3.9571E+01	1283	5.0557E+01	5.0810E+01
1234	3.9571E+01	3.9769E+01	1284	5.0810E+01	5.1065E+01
1235	3.9769E+01	3.9969E+01	1285	5.1065E+01	5.1321E+01
1236	3.9969E+01	4.0169E+01	1286	5.1321E+01	5.1578E+01
1237	4.0169E+01	4.0370E+01	1287	5.1578E+01	5.1837E+01
1238	4.0370E+01	4.0573E+01	1288	5.1837E+01	5.2096E+01
1239	4.0573E+01	4.0776E+01	1289	5.2096E+01	5.2357E+01
1240	4.0776E+01	4.0980E+01	1290	5.2357E+01	5.2620E+01
1241	4.0980E+01	4.1186E+01	1291	5.2620E+01	5.2884E+01
1242	4.1186E+01	4.1392E+01	1292	5.2884E+01	5.3149E+01
1243	4.1392E+01	4.1600E+01	1293	5.3149E+01	5.3415E+01
1244	4.1600E+01	4.1808E+01	1294	5.3415E+01	5.3683E+01
1245	4.1808E+01	4.2018E+01	1295	5.3683E+01	5.3952E+01
1246	4.2018E+01	4.2228E+01	1296	5.3952E+01	5.4222E+01
1247	4.2228E+01	4.2440E+01	1297	5.4222E+01	5.4494E+01
1248	4.2440E+01	4.2653E+01	1298	5.4494E+01	5.4767E+01
1249	4.2653E+01	4.2867E+01	1299	5.4767E+01	5.5042E+01
1250	4.2867E+01	4.3082E+01	1300	5.5042E+01	5.5318E+01

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (1301 - 1400 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
1301	5.5318E+01	5.5595E+01	1351	7.1029E+01	7.1385E+01
1302	5.5595E+01	5.5874E+01	1352	7.1385E+01	7.1743E+01
1303	5.5874E+01	5.6154E+01	1353	7.1743E+01	7.2103E+01
1304	5.6154E+01	5.6435E+01	1354	7.2103E+01	7.2464E+01
1305	5.6435E+01	5.6718E+01	1355	7.2464E+01	7.2828E+01
1306	5.6718E+01	5.7002E+01	1356	7.2828E+01	7.3193E+01
1307	5.7002E+01	5.7288E+01	1357	7.3193E+01	7.3559E+01
1308	5.7288E+01	5.7575E+01	1358	7.3559E+01	7.3928E+01
1309	5.7575E+01	5.7864E+01	1359	7.3928E+01	7.4299E+01
1310	5.7864E+01	5.8154E+01	1360	7.4299E+01	7.4671E+01
1311	5.8154E+01	5.8445E+01	1361	7.4671E+01	7.5045E+01
1312	5.8445E+01	5.8738E+01	1362	7.5045E+01	7.5422E+01
1313	5.8738E+01	5.9033E+01	1363	7.5422E+01	7.5800E+01
1314	5.9033E+01	5.9329E+01	1364	7.5800E+01	7.6180E+01
1315	5.9329E+01	5.9626E+01	1365	7.6180E+01	7.6561E+01
1316	5.9626E+01	5.9925E+01	1366	7.6561E+01	7.6945E+01
1317	5.9925E+01	6.0225E+01	1367	7.6945E+01	7.7331E+01
1318	6.0225E+01	6.0527E+01	1368	7.7331E+01	7.7719E+01
1319	6.0527E+01	6.0831E+01	1369	7.7719E+01	7.8108E+01
1320	6.0831E+01	6.1136E+01	1370	7.8108E+01	7.8500E+01
1321	6.1136E+01	6.1442E+01	1371	7.8500E+01	7.8893E+01
1322	6.1442E+01	6.1750E+01	1372	7.8893E+01	7.9289E+01
1323	6.1750E+01	6.2060E+01	1373	7.9289E+01	7.9686E+01
1324	6.2060E+01	6.2371E+01	1374	7.9686E+01	8.0085E+01
1325	6.2371E+01	6.2683E+01	1375	8.0085E+01	8.0487E+01
1326	6.2683E+01	6.2997E+01	1376	8.0487E+01	8.0890E+01
1327	6.2997E+01	6.3313E+01	1377	8.0890E+01	8.1296E+01
1328	6.3313E+01	6.3631E+01	1378	8.1296E+01	8.1703E+01
1329	6.3631E+01	6.3949E+01	1379	8.1703E+01	8.2113E+01
1330	6.3949E+01	6.4270E+01	1380	8.2113E+01	8.2524E+01
1331	6.4270E+01	6.4592E+01	1381	8.2524E+01	8.2938E+01
1332	6.4592E+01	6.4916E+01	1382	8.2938E+01	8.3354E+01
1333	6.4916E+01	6.5241E+01	1383	8.3354E+01	8.3772E+01
1334	6.5241E+01	6.5568E+01	1384	8.3772E+01	8.4192E+01
1335	6.5568E+01	6.5897E+01	1385	8.4192E+01	8.4614E+01
1336	6.5897E+01	6.6227E+01	1386	8.4614E+01	8.5038E+01
1337	6.6227E+01	6.6559E+01	1387	8.5038E+01	8.5464E+01
1338	6.6559E+01	6.6893E+01	1388	8.5464E+01	8.5892E+01
1339	6.6893E+01	6.7228E+01	1389	8.5892E+01	8.6323E+01
1340	6.7228E+01	6.7565E+01	1390	8.6323E+01	8.6756E+01
1341	6.7565E+01	6.7904E+01	1391	8.6756E+01	8.7190E+01
1342	6.7904E+01	6.8244E+01	1392	8.7190E+01	8.7627E+01
1343	6.8244E+01	6.8586E+01	1393	8.7627E+01	8.8067E+01
1344	6.8586E+01	6.8930E+01	1394	8.8067E+01	8.8508E+01
1345	6.8930E+01	6.9276E+01	1395	8.8508E+01	8.8952E+01
1346	6.9276E+01	6.9623E+01	1396	8.8952E+01	8.9398E+01
1347	6.9623E+01	6.9972E+01	1397	8.9398E+01	8.9846E+01
1348	6.9972E+01	7.0323E+01	1398	8.9846E+01	9.0296E+01
1349	7.0323E+01	7.0675E+01	1399	9.0296E+01	9.0749E+01
1350	7.0675E+01	7.1029E+01	1400	9.0749E+01	9.1204E+01

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (1401 - 1500 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
1401	9.1204E+01	9.1661E+01	1451	1.1711E+02	1.1769E+02
1402	9.1661E+01	9.2120E+01	1452	1.1769E+02	1.1828E+02
1403	9.2120E+01	9.2582E+01	1453	1.1828E+02	1.1888E+02
1404	9.2582E+01	9.3046E+01	1454	1.1888E+02	1.1947E+02
1405	9.3046E+01	9.3512E+01	1455	1.1947E+02	1.2007E+02
1406	9.3512E+01	9.3981E+01	1456	1.2007E+02	1.2067E+02
1407	9.3981E+01	9.4452E+01	1457	1.2067E+02	1.2128E+02
1408	9.4452E+01	9.4926E+01	1458	1.2128E+02	1.2189E+02
1409	9.4926E+01	9.5401E+01	1459	1.2189E+02	1.2250E+02
1410	9.5401E+01	9.5880E+01	1460	1.2250E+02	1.2311E+02
1411	9.5880E+01	9.6360E+01	1461	1.2311E+02	1.2373E+02
1412	9.6360E+01	9.6843E+01	1462	1.2373E+02	1.2435E+02
1413	9.6843E+01	9.7329E+01	1463	1.2435E+02	1.2497E+02
1414	9.7329E+01	9.7817E+01	1464	1.2497E+02	1.2560E+02
1415	9.7817E+01	9.8307E+01	1465	1.2560E+02	1.2623E+02
1416	9.8307E+01	9.8800E+01	1466	1.2623E+02	1.2686E+02
1417	9.8800E+01	9.9295E+01	1467	1.2686E+02	1.2750E+02
1418	9.9295E+01	9.9793E+01	1468	1.2750E+02	1.2814E+02
1419	9.9793E+01	1.0029E+02	1469	1.2814E+02	1.2878E+02
1420	1.0029E+02	1.0080E+02	1470	1.2878E+02	1.2942E+02
1421	1.0080E+02	1.0130E+02	1471	1.2942E+02	1.3007E+02
1422	1.0130E+02	1.0181E+02	1472	1.3007E+02	1.3072E+02
1423	1.0181E+02	1.0232E+02	1473	1.3072E+02	1.3138E+02
1424	1.0232E+02	1.0283E+02	1474	1.3138E+02	1.3204E+02
1425	1.0283E+02	1.0335E+02	1475	1.3204E+02	1.3270E+02
1426	1.0335E+02	1.0387E+02	1476	1.3270E+02	1.3337E+02
1427	1.0387E+02	1.0439E+02	1477	1.3337E+02	1.3403E+02
1428	1.0439E+02	1.0491E+02	1478	1.3403E+02	1.3471E+02
1429	1.0491E+02	1.0543E+02	1479	1.3471E+02	1.3538E+02
1430	1.0543E+02	1.0596E+02	1480	1.3538E+02	1.3606E+02
1431	1.0596E+02	1.0649E+02	1481	1.3606E+02	1.3674E+02
1432	1.0649E+02	1.0703E+02	1482	1.3674E+02	1.3743E+02
1433	1.0703E+02	1.0756E+02	1483	1.3743E+02	1.3812E+02
1434	1.0756E+02	1.0810E+02	1484	1.3812E+02	1.3881E+02
1435	1.0810E+02	1.0865E+02	1485	1.3881E+02	1.3950E+02
1436	1.0865E+02	1.0919E+02	1486	1.3950E+02	1.4020E+02
1437	1.0919E+02	1.0974E+02	1487	1.4020E+02	1.4091E+02
1438	1.0974E+02	1.1029E+02	1488	1.4091E+02	1.4161E+02
1439	1.1029E+02	1.1084E+02	1489	1.4161E+02	1.4232E+02
1440	1.1084E+02	1.1140E+02	1490	1.4232E+02	1.4304E+02
1441	1.1140E+02	1.1195E+02	1491	1.4304E+02	1.4375E+02
1442	1.1195E+02	1.1252E+02	1492	1.4375E+02	1.4447E+02
1443	1.1252E+02	1.1308E+02	1493	1.4447E+02	1.4520E+02
1444	1.1308E+02	1.1365E+02	1494	1.4520E+02	1.4593E+02
1445	1.1365E+02	1.1422E+02	1495	1.4593E+02	1.4666E+02
1446	1.1422E+02	1.1479E+02	1496	1.4666E+02	1.4739E+02
1447	1.1479E+02	1.1536E+02	1497	1.4739E+02	1.4813E+02
1448	1.1536E+02	1.1594E+02	1498	1.4813E+02	1.4887E+02
1449	1.1594E+02	1.1652E+02	1499	1.4887E+02	1.4962E+02
1450	1.1652E+02	1.1711E+02	1500	1.4962E+02	1.5037E+02

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (1501 - 1600 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
1501	1.5037E+02	1.5112E+02	1551	1.9308E+02	1.9405E+02
1502	1.5112E+02	1.5188E+02	1552	1.9405E+02	1.9502E+02
1503	1.5188E+02	1.5264E+02	1553	1.9502E+02	1.9600E+02
1504	1.5264E+02	1.5341E+02	1554	1.9600E+02	1.9698E+02
1505	1.5341E+02	1.5418E+02	1555	1.9698E+02	1.9797E+02
1506	1.5418E+02	1.5495E+02	1556	1.9797E+02	1.9896E+02
1507	1.5495E+02	1.5573E+02	1557	1.9896E+02	1.9996E+02
1508	1.5573E+02	1.5651E+02	1558	1.9996E+02	2.0096E+02
1509	1.5651E+02	1.5729E+02	1559	2.0096E+02	2.0197E+02
1510	1.5729E+02	1.5808E+02	1560	2.0197E+02	2.0298E+02
1511	1.5808E+02	1.5887E+02	1561	2.0298E+02	2.0399E+02
1512	1.5887E+02	1.5967E+02	1562	2.0399E+02	2.0502E+02
1513	1.5967E+02	1.6047E+02	1563	2.0502E+02	2.0604E+02
1514	1.6047E+02	1.6127E+02	1564	2.0604E+02	2.0708E+02
1515	1.6127E+02	1.6208E+02	1565	2.0708E+02	2.0812E+02
1516	1.6208E+02	1.6289E+02	1566	2.0812E+02	2.0916E+02
1517	1.6289E+02	1.6371E+02	1567	2.0916E+02	2.1021E+02
1518	1.6371E+02	1.6453E+02	1568	2.1021E+02	2.1126E+02
1519	1.6453E+02	1.6535E+02	1569	2.1126E+02	2.1232E+02
1520	1.6535E+02	1.6618E+02	1570	2.1232E+02	2.1338E+02
1521	1.6618E+02	1.6702E+02	1571	2.1338E+02	2.1445E+02
1522	1.6702E+02	1.6785E+02	1572	2.1445E+02	2.1553E+02
1523	1.6785E+02	1.6870E+02	1573	2.1553E+02	2.1661E+02
1524	1.6870E+02	1.6954E+02	1574	2.1661E+02	2.1769E+02
1525	1.6954E+02	1.7039E+02	1575	2.1769E+02	2.1879E+02
1526	1.7039E+02	1.7124E+02	1576	2.1879E+02	2.1988E+02
1527	1.7124E+02	1.7210E+02	1577	2.1988E+02	2.2098E+02
1528	1.7210E+02	1.7297E+02	1578	2.2098E+02	2.2209E+02
1529	1.7297E+02	1.7383E+02	1579	2.2209E+02	2.2321E+02
1530	1.7383E+02	1.7470E+02	1580	2.2321E+02	2.2432E+02
1531	1.7470E+02	1.7558E+02	1581	2.2432E+02	2.2545E+02
1532	1.7558E+02	1.7646E+02	1582	2.2545E+02	2.2658E+02
1533	1.7646E+02	1.7734E+02	1583	2.2658E+02	2.2771E+02
1534	1.7734E+02	1.7823E+02	1584	2.2771E+02	2.2886E+02
1535	1.7823E+02	1.7913E+02	1585	2.2886E+02	2.3000E+02
1536	1.7913E+02	1.8002E+02	1586	2.3000E+02	2.3116E+02
1537	1.8002E+02	1.8093E+02	1587	2.3116E+02	2.3231E+02
1538	1.8093E+02	1.8183E+02	1588	2.3231E+02	2.3348E+02
1539	1.8183E+02	1.8275E+02	1589	2.3348E+02	2.3465E+02
1540	1.8275E+02	1.8366E+02	1590	2.3465E+02	2.3583E+02
1541	1.8366E+02	1.8458E+02	1591	2.3583E+02	2.3701E+02
1542	1.8458E+02	1.8551E+02	1592	2.3701E+02	2.3820E+02
1543	1.8551E+02	1.8644E+02	1593	2.3820E+02	2.3939E+02
1544	1.8644E+02	1.8737E+02	1594	2.3939E+02	2.4059E+02
1545	1.8737E+02	1.8831E+02	1595	2.4059E+02	2.4180E+02
1546	1.8831E+02	1.8925E+02	1596	2.4180E+02	2.4301E+02
1547	1.8925E+02	1.9020E+02	1597	2.4301E+02	2.4423E+02
1548	1.9020E+02	1.9116E+02	1598	2.4423E+02	2.4545E+02
1549	1.9116E+02	1.9211E+02	1599	2.4545E+02	2.4668E+02
1550	1.9211E+02	1.9308E+02	1600	2.4668E+02	2.4792E+02

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (1601 - 1700 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
1601	2.4792E+02	2.4916E+02	1651	3.1833E+02	3.1993E+02
1602	2.4916E+02	2.5041E+02	1652	3.1993E+02	3.2153E+02
1603	2.5041E+02	2.5166E+02	1653	3.2153E+02	3.2314E+02
1604	2.5166E+02	2.5293E+02	1654	3.2314E+02	3.2476E+02
1605	2.5293E+02	2.5419E+02	1655	3.2476E+02	3.2639E+02
1606	2.5419E+02	2.5547E+02	1656	3.2639E+02	3.2803E+02
1607	2.5547E+02	2.5675E+02	1657	3.2803E+02	3.2967E+02
1608	2.5675E+02	2.5803E+02	1658	3.2967E+02	3.3132E+02
1609	2.5803E+02	2.5933E+02	1659	3.3132E+02	3.3298E+02
1610	2.5933E+02	2.6063E+02	1660	3.3298E+02	3.3465E+02
1611	2.6063E+02	2.6193E+02	1661	3.3465E+02	3.3633E+02
1612	2.6193E+02	2.6325E+02	1662	3.3633E+02	3.3802E+02
1613	2.6325E+02	2.6457E+02	1663	3.3802E+02	3.3971E+02
1614	2.6457E+02	2.6589E+02	1664	3.3971E+02	3.4141E+02
1615	2.6589E+02	2.6723E+02	1665	3.4141E+02	3.4312E+02
1616	2.6723E+02	2.6857E+02	1666	3.4312E+02	3.4484E+02
1617	2.6857E+02	2.6991E+02	1667	3.4484E+02	3.4657E+02
1618	2.6991E+02	2.7126E+02	1668	3.4657E+02	3.4831E+02
1619	2.7126E+02	2.7262E+02	1669	3.4831E+02	3.5006E+02
1620	2.7262E+02	2.7399E+02	1670	3.5006E+02	3.5181E+02
1621	2.7399E+02	2.7536E+02	1671	3.5181E+02	3.5357E+02
1622	2.7536E+02	2.7674E+02	1672	3.5357E+02	3.5535E+02
1623	2.7674E+02	2.7813E+02	1673	3.5535E+02	3.5713E+02
1624	2.7813E+02	2.7953E+02	1674	3.5713E+02	3.5892E+02
1625	2.7953E+02	2.8093E+02	1675	3.5892E+02	3.6072E+02
1626	2.8093E+02	2.8233E+02	1676	3.6072E+02	3.6252E+02
1627	2.8233E+02	2.8375E+02	1677	3.6252E+02	3.6434E+02
1628	2.8375E+02	2.8517E+02	1678	3.6434E+02	3.6617E+02
1629	2.8517E+02	2.8660E+02	1679	3.6617E+02	3.6800E+02
1630	2.8660E+02	2.8804E+02	1680	3.6800E+02	3.6985E+02
1631	2.8804E+02	2.8948E+02	1681	3.6985E+02	3.7170E+02
1632	2.8948E+02	2.9093E+02	1682	3.7170E+02	3.7357E+02
1633	2.9093E+02	2.9239E+02	1683	3.7357E+02	3.7544E+02
1634	2.9239E+02	2.9386E+02	1684	3.7544E+02	3.7732E+02
1635	2.9386E+02	2.9533E+02	1685	3.7732E+02	3.7921E+02
1636	2.9533E+02	2.9681E+02	1686	3.7921E+02	3.8111E+02
1637	2.9681E+02	2.9830E+02	1687	3.8111E+02	3.8302E+02
1638	2.9830E+02	2.9979E+02	1688	3.8302E+02	3.8494E+02
1639	2.9979E+02	3.0130E+02	1689	3.8494E+02	3.8687E+02
1640	3.0130E+02	3.0281E+02	1690	3.8687E+02	3.8881E+02
1641	3.0281E+02	3.0432E+02	1691	3.8881E+02	3.9076E+02
1642	3.0432E+02	3.0585E+02	1692	3.9076E+02	3.9272E+02
1643	3.0585E+02	3.0738E+02	1693	3.9272E+02	3.9469E+02
1644	3.0738E+02	3.0892E+02	1694	3.9469E+02	3.9667E+02
1645	3.0892E+02	3.1047E+02	1695	3.9667E+02	3.9865E+02
1646	3.1047E+02	3.1203E+02	1696	3.9865E+02	4.0065E+02
1647	3.1203E+02	3.1359E+02	1697	4.0065E+02	4.0266E+02
1648	3.1359E+02	3.1516E+02	1698	4.0266E+02	4.0468E+02
1649	3.1516E+02	3.1674E+02	1699	4.0468E+02	4.0671E+02
1650	3.1674E+02	3.1833E+02	1700	4.0671E+02	4.0875E+02

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (1701 - 1800 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
1701	4.0875E+02	4.1079E+02	1751	5.2484E+02	5.2747E+02
1702	4.1079E+02	4.1285E+02	1752	5.2747E+02	5.3011E+02
1703	4.1285E+02	4.1492E+02	1753	5.3011E+02	5.3277E+02
1704	4.1492E+02	4.1700E+02	1754	5.3277E+02	5.3544E+02
1705	4.1700E+02	4.1909E+02	1755	5.3544E+02	5.3813E+02
1706	4.1909E+02	4.2119E+02	1756	5.3813E+02	5.4082E+02
1707	4.2119E+02	4.2331E+02	1757	5.4082E+02	5.4353E+02
1708	4.2331E+02	4.2543E+02	1758	5.4353E+02	5.4626E+02
1709	4.2543E+02	4.2756E+02	1759	5.4626E+02	5.4900E+02
1710	4.2756E+02	4.2970E+02	1760	5.4900E+02	5.5175E+02
1711	4.2970E+02	4.3186E+02	1761	5.5175E+02	5.5451E+02
1712	4.3186E+02	4.3402E+02	1762	5.5451E+02	5.5729E+02
1713	4.3402E+02	4.3620E+02	1763	5.5729E+02	5.6009E+02
1714	4.3620E+02	4.3838E+02	1764	5.6009E+02	5.6290E+02
1715	4.3838E+02	4.4058E+02	1765	5.6290E+02	5.6572E+02
1716	4.4058E+02	4.4279E+02	1766	5.6572E+02	5.6855E+02
1717	4.4279E+02	4.4501E+02	1767	5.6855E+02	5.7140E+02
1718	4.4501E+02	4.4724E+02	1768	5.7140E+02	5.7427E+02
1719	4.4724E+02	4.4948E+02	1769	5.7427E+02	5.7714E+02
1720	4.4948E+02	4.5173E+02	1770	5.7714E+02	5.8004E+02
1721	4.5173E+02	4.5400E+02	1771	5.8004E+02	5.8295E+02
1722	4.5400E+02	4.5627E+02	1772	5.8295E+02	5.8587E+02
1723	4.5627E+02	4.5856E+02	1773	5.8587E+02	5.8880E+02
1724	4.5856E+02	4.6086E+02	1774	5.8880E+02	5.9176E+02
1725	4.6086E+02	4.6317E+02	1775	5.9176E+02	5.9472E+02
1726	4.6317E+02	4.6549E+02	1776	5.9472E+02	5.9770E+02
1727	4.6549E+02	4.6782E+02	1777	5.9770E+02	6.0070E+02
1728	4.6782E+02	4.7017E+02	1778	6.0070E+02	6.0371E+02
1729	4.7017E+02	4.7253E+02	1779	6.0371E+02	6.0674E+02
1730	4.7253E+02	4.7490E+02	1780	6.0674E+02	6.0978E+02
1731	4.7490E+02	4.7728E+02	1781	6.0978E+02	6.1283E+02
1732	4.7728E+02	4.7967E+02	1782	6.1283E+02	6.1591E+02
1733	4.7967E+02	4.8207E+02	1783	6.1591E+02	6.1899E+02
1734	4.8207E+02	4.8449E+02	1784	6.1899E+02	6.2210E+02
1735	4.8449E+02	4.8692E+02	1785	6.2210E+02	6.2521E+02
1736	4.8692E+02	4.8936E+02	1786	6.2521E+02	6.2835E+02
1737	4.8936E+02	4.9181E+02	1787	6.2835E+02	6.3150E+02
1738	4.9181E+02	4.9428E+02	1788	6.3150E+02	6.3466E+02
1739	4.9428E+02	4.9675E+02	1789	6.3466E+02	6.3784E+02
1740	4.9675E+02	4.9924E+02	1790	6.3784E+02	6.4104E+02
1741	4.9924E+02	5.0175E+02	1791	6.4104E+02	6.4425E+02
1742	5.0175E+02	5.0426E+02	1792	6.4425E+02	6.4748E+02
1743	5.0426E+02	5.0679E+02	1793	6.4748E+02	6.5073E+02
1744	5.0679E+02	5.0933E+02	1794	6.5073E+02	6.5399E+02
1745	5.0933E+02	5.1188E+02	1795	6.5399E+02	6.5727E+02
1746	5.1188E+02	5.1445E+02	1796	6.5727E+02	6.6056E+02
1747	5.1445E+02	5.1703E+02	1797	6.6056E+02	6.6387E+02
1748	5.1703E+02	5.1962E+02	1798	6.6387E+02	6.6720E+02
1749	5.1962E+02	5.2222E+02	1799	6.6720E+02	6.7055E+02
1750	5.2222E+02	5.2484E+02	1800	6.7055E+02	6.7391E+02

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (1801 - 1900 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
1801	6.7391E+02	6.7729E+02	1851	8.6531E+02	8.6965E+02
1802	6.7729E+02	6.8068E+02	1852	8.6965E+02	8.7401E+02
1803	6.8068E+02	6.8409E+02	1853	8.7401E+02	8.7839E+02
1804	6.8409E+02	6.8752E+02	1854	8.7839E+02	8.8280E+02
1805	6.8752E+02	6.9097E+02	1855	8.8280E+02	8.8722E+02
1806	6.9097E+02	6.9443E+02	1856	8.8722E+02	8.9167E+02
1807	6.9443E+02	6.9791E+02	1857	8.9167E+02	8.9614E+02
1808	6.9791E+02	7.0141E+02	1858	8.9614E+02	9.0063E+02
1809	7.0141E+02	7.0493E+02	1859	9.0063E+02	9.0514E+02
1810	7.0493E+02	7.0846E+02	1860	9.0514E+02	9.0968E+02
1811	7.0846E+02	7.1201E+02	1861	9.0968E+02	9.1424E+02
1812	7.1201E+02	7.1558E+02	1862	9.1424E+02	9.1882E+02
1813	7.1558E+02	7.1917E+02	1863	9.1882E+02	9.2343E+02
1814	7.1917E+02	7.2277E+02	1864	9.2343E+02	9.2806E+02
1815	7.2277E+02	7.2640E+02	1865	9.2806E+02	9.3271E+02
1816	7.2640E+02	7.3004E+02	1866	9.3271E+02	9.3738E+02
1817	7.3004E+02	7.3369E+02	1867	9.3738E+02	9.4208E+02
1818	7.3369E+02	7.3737E+02	1868	9.4208E+02	9.4681E+02
1819	7.3737E+02	7.4107E+02	1869	9.4681E+02	9.5155E+02
1820	7.4107E+02	7.4478E+02	1870	9.5155E+02	9.5632E+02
1821	7.4478E+02	7.4852E+02	1871	9.5632E+02	9.6111E+02
1822	7.4852E+02	7.5227E+02	1872	9.6111E+02	9.6593E+02
1823	7.5227E+02	7.5604E+02	1873	9.6593E+02	9.7077E+02
1824	7.5604E+02	7.5983E+02	1874	9.7077E+02	9.7564E+02
1825	7.5983E+02	7.6364E+02	1875	9.7564E+02	9.8053E+02
1826	7.6364E+02	7.6747E+02	1876	9.8053E+02	9.8545E+02
1827	7.6747E+02	7.7131E+02	1877	9.8545E+02	9.9038E+02
1828	7.7131E+02	7.7518E+02	1878	9.9038E+02	9.9535E+02
1829	7.7518E+02	7.7906E+02	1879	9.9535E+02	1.0003E+03
1830	7.7906E+02	7.8297E+02	1880	1.0003E+03	1.0054E+03
1831	7.8297E+02	7.8689E+02	1881	1.0054E+03	1.0104E+03
1832	7.8689E+02	7.9084E+02	1882	1.0104E+03	1.0155E+03
1833	7.9084E+02	7.9480E+02	1883	1.0155E+03	1.0205E+03
1834	7.9480E+02	7.9879E+02	1884	1.0205E+03	1.0257E+03
1835	7.9879E+02	8.0279E+02	1885	1.0257E+03	1.0308E+03
1836	8.0279E+02	8.0681E+02	1886	1.0308E+03	1.0360E+03
1837	8.0681E+02	8.1086E+02	1887	1.0360E+03	1.0412E+03
1838	8.1086E+02	8.1492E+02	1888	1.0412E+03	1.0464E+03
1839	8.1492E+02	8.1901E+02	1889	1.0464E+03	1.0516E+03
1840	8.1901E+02	8.2311E+02	1890	1.0516E+03	1.0569E+03
1841	8.2311E+02	8.2724E+02	1891	1.0569E+03	1.0622E+03
1842	8.2724E+02	8.3139E+02	1892	1.0622E+03	1.0675E+03
1843	8.3139E+02	8.3555E+02	1893	1.0675E+03	1.0729E+03
1844	8.3555E+02	8.3974E+02	1894	1.0729E+03	1.0782E+03
1845	8.3974E+02	8.4395E+02	1895	1.0782E+03	1.0837E+03
1846	8.4395E+02	8.4818E+02	1896	1.0837E+03	1.0891E+03
1847	8.4818E+02	8.5243E+02	1897	1.0891E+03	1.0945E+03
1848	8.5243E+02	8.5671E+02	1898	1.0945E+03	1.1000E+03
1849	8.5671E+02	8.6100E+02	1899	1.1000E+03	1.1055E+03
1850	8.6100E+02	8.6531E+02	1900	1.1055E+03	1.1111E+03

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (1901 - 2000 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
1901	1.1111E+03	1.1167E+03	1951	1.4267E+03	1.4338E+03
1902	1.1167E+03	1.1223E+03	1952	1.4338E+03	1.4410E+03
1903	1.1223E+03	1.1279E+03	1953	1.4410E+03	1.4482E+03
1904	1.1279E+03	1.1335E+03	1954	1.4482E+03	1.4555E+03
1905	1.1335E+03	1.1392E+03	1955	1.4555E+03	1.4628E+03
1906	1.1392E+03	1.1449E+03	1956	1.4628E+03	1.4701E+03
1907	1.1449E+03	1.1507E+03	1957	1.4701E+03	1.4775E+03
1908	1.1507E+03	1.1564E+03	1958	1.4775E+03	1.4849E+03
1909	1.1564E+03	1.1622E+03	1959	1.4849E+03	1.4923E+03
1910	1.1622E+03	1.1681E+03	1960	1.4923E+03	1.4998E+03
1911	1.1681E+03	1.1739E+03	1961	1.4998E+03	1.5073E+03
1912	1.1739E+03	1.1798E+03	1962	1.5073E+03	1.5149E+03
1913	1.1798E+03	1.1857E+03	1963	1.5149E+03	1.5225E+03
1914	1.1857E+03	1.1916E+03	1964	1.5225E+03	1.5301E+03
1915	1.1916E+03	1.1976E+03	1965	1.5301E+03	1.5378E+03
1916	1.1976E+03	1.2036E+03	1966	1.5378E+03	1.5455E+03
1917	1.2036E+03	1.2097E+03	1967	1.5455E+03	1.5532E+03
1918	1.2097E+03	1.2157E+03	1968	1.5532E+03	1.5610E+03
1919	1.2157E+03	1.2218E+03	1969	1.5610E+03	1.5688E+03
1920	1.2218E+03	1.2279E+03	1970	1.5688E+03	1.5767E+03
1921	1.2279E+03	1.2341E+03	1971	1.5767E+03	1.5846E+03
1922	1.2341E+03	1.2403E+03	1972	1.5846E+03	1.5926E+03
1923	1.2403E+03	1.2465E+03	1973	1.5926E+03	1.6005E+03
1924	1.2465E+03	1.2527E+03	1974	1.6005E+03	1.6086E+03
1925	1.2527E+03	1.2590E+03	1975	1.6086E+03	1.6166E+03
1926	1.2590E+03	1.2653E+03	1976	1.6166E+03	1.6247E+03
1927	1.2653E+03	1.2717E+03	1977	1.6247E+03	1.6329E+03
1928	1.2717E+03	1.2781E+03	1978	1.6329E+03	1.6411E+03
1929	1.2781E+03	1.2845E+03	1979	1.6411E+03	1.6493E+03
1930	1.2845E+03	1.2909E+03	1980	1.6493E+03	1.6575E+03
1931	1.2909E+03	1.2974E+03	1981	1.6575E+03	1.6659E+03
1932	1.2974E+03	1.3039E+03	1982	1.6659E+03	1.6742E+03
1933	1.3039E+03	1.3104E+03	1983	1.6742E+03	1.6826E+03
1934	1.3104E+03	1.3170E+03	1984	1.6826E+03	1.6910E+03
1935	1.3170E+03	1.3236E+03	1985	1.6910E+03	1.6995E+03
1936	1.3236E+03	1.3302E+03	1986	1.6995E+03	1.7080E+03
1937	1.3302E+03	1.3369E+03	1987	1.7080E+03	1.7166E+03
1938	1.3369E+03	1.3436E+03	1988	1.7166E+03	1.7252E+03
1939	1.3436E+03	1.3503E+03	1989	1.7252E+03	1.7338E+03
1940	1.3503E+03	1.3571E+03	1990	1.7338E+03	1.7425E+03
1941	1.3571E+03	1.3639E+03	1991	1.7425E+03	1.7513E+03
1942	1.3639E+03	1.3707E+03	1992	1.7513E+03	1.7600E+03
1943	1.3707E+03	1.3776E+03	1993	1.7600E+03	1.7689E+03
1944	1.3776E+03	1.3845E+03	1994	1.7689E+03	1.7777E+03
1945	1.3845E+03	1.3914E+03	1995	1.7777E+03	1.7866E+03
1946	1.3914E+03	1.3984E+03	1996	1.7866E+03	1.7956E+03
1947	1.3984E+03	1.4054E+03	1997	1.7956E+03	1.8046E+03
1948	1.4054E+03	1.4125E+03	1998	1.8046E+03	1.8136E+03
1949	1.4125E+03	1.4195E+03	1999	1.8136E+03	1.8227E+03
1950	1.4195E+03	1.4267E+03	2000	1.8227E+03	1.8319E+03

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (2001 - 2100 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
2001	1.8319E+03	1.8411E+03	2051	2.3522E+03	2.3640E+03
2002	1.8411E+03	1.8503E+03	2052	2.3640E+03	2.3758E+03
2003	1.8503E+03	1.8596E+03	2053	2.3758E+03	2.3877E+03
2004	1.8596E+03	1.8689E+03	2054	2.3877E+03	2.3997E+03
2005	1.8689E+03	1.8782E+03	2055	2.3997E+03	2.4117E+03
2006	1.8782E+03	1.8877E+03	2056	2.4117E+03	2.4238E+03
2007	1.8877E+03	1.8971E+03	2057	2.4238E+03	2.4360E+03
2008	1.8971E+03	1.9066E+03	2058	2.4360E+03	2.4482E+03
2009	1.9066E+03	1.9162E+03	2059	2.4482E+03	2.4604E+03
2010	1.9162E+03	1.9258E+03	2060	2.4604E+03	2.4728E+03
2011	1.9258E+03	1.9354E+03	2061	2.4728E+03	2.4852E+03
2012	1.9354E+03	1.9451E+03	2062	2.4852E+03	2.4976E+03
2013	1.9451E+03	1.9549E+03	2063	2.4976E+03	2.5101E+03
2014	1.9549E+03	1.9647E+03	2064	2.5101E+03	2.5227E+03
2015	1.9647E+03	1.9745E+03	2065	2.5227E+03	2.5354E+03
2016	1.9745E+03	1.9844E+03	2066	2.5354E+03	2.5481E+03
2017	1.9844E+03	1.9944E+03	2067	2.5481E+03	2.5608E+03
2018	1.9944E+03	2.0044E+03	2068	2.5608E+03	2.5737E+03
2019	2.0044E+03	2.0144E+03	2069	2.5737E+03	2.5866E+03
2020	2.0144E+03	2.0245E+03	2070	2.5866E+03	2.5995E+03
2021	2.0245E+03	2.0347E+03	2071	2.5995E+03	2.6126E+03
2022	2.0347E+03	2.0449E+03	2072	2.6126E+03	2.6257E+03
2023	2.0449E+03	2.0551E+03	2073	2.6257E+03	2.6388E+03
2024	2.0551E+03	2.0654E+03	2074	2.6388E+03	2.6521E+03
2025	2.0654E+03	2.0758E+03	2075	2.6521E+03	2.6654E+03
2026	2.0758E+03	2.0862E+03	2076	2.6654E+03	2.6787E+03
2027	2.0862E+03	2.0966E+03	2077	2.6787E+03	2.6921E+03
2028	2.0966E+03	2.1072E+03	2078	2.6921E+03	2.7056E+03
2029	2.1072E+03	2.1177E+03	2079	2.7056E+03	2.7192E+03
2030	2.1177E+03	2.1283E+03	2080	2.7192E+03	2.7328E+03
2031	2.1283E+03	2.1390E+03	2081	2.7328E+03	2.7465E+03
2032	2.1390E+03	2.1497E+03	2082	2.7465E+03	2.7603E+03
2033	2.1497E+03	2.1605E+03	2083	2.7603E+03	2.7741E+03
2034	2.1605E+03	2.1713E+03	2084	2.7741E+03	2.7880E+03
2035	2.1713E+03	2.1822E+03	2085	2.7880E+03	2.8020E+03
2036	2.1822E+03	2.1931E+03	2086	2.8020E+03	2.8161E+03
2037	2.1931E+03	2.2041E+03	2087	2.8161E+03	2.8302E+03
2038	2.2041E+03	2.2152E+03	2088	2.8302E+03	2.8444E+03
2039	2.2152E+03	2.2263E+03	2089	2.8444E+03	2.8586E+03
2040	2.2263E+03	2.2375E+03	2090	2.8586E+03	2.8729E+03
2041	2.2375E+03	2.2487E+03	2091	2.8729E+03	2.8873E+03
2042	2.2487E+03	2.2599E+03	2092	2.8873E+03	2.9018E+03
2043	2.2599E+03	2.2713E+03	2093	2.9018E+03	2.9164E+03
2044	2.2713E+03	2.2827E+03	2094	2.9164E+03	2.9310E+03
2045	2.2827E+03	2.2941E+03	2095	2.9310E+03	2.9457E+03
2046	2.2941E+03	2.3056E+03	2096	2.9457E+03	2.9604E+03
2047	2.3056E+03	2.3171E+03	2097	2.9604E+03	2.9753E+03
2048	2.3171E+03	2.3288E+03	2098	2.9753E+03	2.9902E+03
2049	2.3288E+03	2.3404E+03	2099	2.9902E+03	3.0052E+03
2050	2.3404E+03	2.3522E+03	2100	3.0052E+03	3.0202E+03

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (2101 - 2200 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
2101	3.0202E+03	3.0354E+03	2151	3.8781E+03	3.8975E+03
2102	3.0354E+03	3.0506E+03	2152	3.8975E+03	3.9170E+03
2103	3.0506E+03	3.0659E+03	2153	3.9170E+03	3.9367E+03
2104	3.0659E+03	3.0813E+03	2154	3.9367E+03	3.9564E+03
2105	3.0813E+03	3.0967E+03	2155	3.9564E+03	3.9762E+03
2106	3.0967E+03	3.1122E+03	2156	3.9762E+03	3.9962E+03
2107	3.1122E+03	3.1278E+03	2157	3.9962E+03	4.0162E+03
2108	3.1278E+03	3.1435E+03	2158	4.0162E+03	4.0363E+03
2109	3.1435E+03	3.1593E+03	2159	4.0363E+03	4.0566E+03
2110	3.1593E+03	3.1751E+03	2160	4.0566E+03	4.0769E+03
2111	3.1751E+03	3.1910E+03	2161	4.0769E+03	4.0973E+03
2112	3.1910E+03	3.2070E+03	2162	4.0973E+03	4.1179E+03
2113	3.2070E+03	3.2231E+03	2163	4.1179E+03	4.1385E+03
2114	3.2231E+03	3.2392E+03	2164	4.1385E+03	4.1593E+03
2115	3.2392E+03	3.2555E+03	2165	4.1593E+03	4.1801E+03
2116	3.2555E+03	3.2718E+03	2166	4.1801E+03	4.2011E+03
2117	3.2718E+03	3.2882E+03	2167	4.2011E+03	4.2221E+03
2118	3.2882E+03	3.3047E+03	2168	4.2221E+03	4.2433E+03
2119	3.3047E+03	3.3212E+03	2169	4.2433E+03	4.2646E+03
2120	3.3212E+03	3.3379E+03	2170	4.2646E+03	4.2859E+03
2121	3.3379E+03	3.3546E+03	2171	4.2859E+03	4.3074E+03
2122	3.3546E+03	3.3714E+03	2172	4.3074E+03	4.3290E+03
2123	3.3714E+03	3.3883E+03	2173	4.3290E+03	4.3507E+03
2124	3.3883E+03	3.4053E+03	2174	4.3507E+03	4.3725E+03
2125	3.4053E+03	3.4224E+03	2175	4.3725E+03	4.3944E+03
2126	3.4224E+03	3.4395E+03	2176	4.3944E+03	4.4165E+03
2127	3.4395E+03	3.4568E+03	2177	4.4165E+03	4.4386E+03
2128	3.4568E+03	3.4741E+03	2178	4.4386E+03	4.4608E+03
2129	3.4741E+03	3.4915E+03	2179	4.4608E+03	4.4832E+03
2130	3.4915E+03	3.5090E+03	2180	4.4832E+03	4.5057E+03
2131	3.5090E+03	3.5266E+03	2181	4.5057E+03	4.5283E+03
2132	3.5266E+03	3.5443E+03	2182	4.5283E+03	4.5510E+03
2133	3.5443E+03	3.5621E+03	2183	4.5510E+03	4.5738E+03
2134	3.5621E+03	3.5799E+03	2184	4.5738E+03	4.5967E+03
2135	3.5799E+03	3.5979E+03	2185	4.5967E+03	4.6197E+03
2136	3.5979E+03	3.6159E+03	2186	4.6197E+03	4.6429E+03
2137	3.6159E+03	3.6340E+03	2187	4.6429E+03	4.6662E+03
2138	3.6340E+03	3.6522E+03	2188	4.6662E+03	4.6896E+03
2139	3.6522E+03	3.6705E+03	2189	4.6896E+03	4.7131E+03
2140	3.6705E+03	3.6889E+03	2190	4.7131E+03	4.7367E+03
2141	3.6889E+03	3.7074E+03	2191	4.7367E+03	4.7604E+03
2142	3.7074E+03	3.7260E+03	2192	4.7604E+03	4.7843E+03
2143	3.7260E+03	3.7447E+03	2193	4.7843E+03	4.8083E+03
2144	3.7447E+03	3.7635E+03	2194	4.8083E+03	4.8324E+03
2145	3.7635E+03	3.7823E+03	2195	4.8324E+03	4.8566E+03
2146	3.7823E+03	3.8013E+03	2196	4.8566E+03	4.8809E+03
2147	3.8013E+03	3.8203E+03	2197	4.8809E+03	4.9054E+03
2148	3.8203E+03	3.8395E+03	2198	4.9054E+03	4.9300E+03
2149	3.8395E+03	3.8587E+03	2199	4.9300E+03	4.9547E+03
2150	3.8587E+03	3.8781E+03	2200	4.9547E+03	4.9795E+03

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (2201 - 2300 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
2201	4.9795E+03	5.0045E+03	2251	6.3939E+03	6.4259E+03
2202	5.0045E+03	5.0296E+03	2252	6.4259E+03	6.4581E+03
2203	5.0296E+03	5.0548E+03	2253	6.4581E+03	6.4905E+03
2204	5.0548E+03	5.0801E+03	2254	6.4905E+03	6.5230E+03
2205	5.0801E+03	5.1056E+03	2255	6.5230E+03	6.5557E+03
2206	5.1056E+03	5.1312E+03	2256	6.5557E+03	6.5886E+03
2207	5.1312E+03	5.1569E+03	2257	6.5886E+03	6.6216E+03
2208	5.1569E+03	5.1828E+03	2258	6.6216E+03	6.6548E+03
2209	5.1828E+03	5.2087E+03	2259	6.6548E+03	6.6882E+03
2210	5.2087E+03	5.2348E+03	2260	6.6882E+03	6.7217E+03
2211	5.2348E+03	5.2611E+03	2261	6.7217E+03	6.7554E+03
2212	5.2611E+03	5.2875E+03	2262	6.7554E+03	6.7892E+03
2213	5.2875E+03	5.3140E+03	2263	6.7892E+03	6.8233E+03
2214	5.3140E+03	5.3406E+03	2264	6.8233E+03	6.8575E+03
2215	5.3406E+03	5.3674E+03	2265	6.8575E+03	6.8918E+03
2216	5.3674E+03	5.3943E+03	2266	6.8918E+03	6.9264E+03
2217	5.3943E+03	5.4213E+03	2267	6.9264E+03	6.9611E+03
2218	5.4213E+03	5.4485E+03	2268	6.9611E+03	6.9960E+03
2219	5.4485E+03	5.4758E+03	2269	6.9960E+03	7.0311E+03
2220	5.4758E+03	5.5032E+03	2270	7.0311E+03	7.0663E+03
2221	5.5032E+03	5.5308E+03	2271	7.0663E+03	7.1017E+03
2222	5.5308E+03	5.5586E+03	2272	7.1017E+03	7.1373E+03
2223	5.5586E+03	5.5864E+03	2273	7.1373E+03	7.1731E+03
2224	5.5864E+03	5.6144E+03	2274	7.1731E+03	7.2091E+03
2225	5.6144E+03	5.6426E+03	2275	7.2091E+03	7.2452E+03
2226	5.6426E+03	5.6708E+03	2276	7.2452E+03	7.2815E+03
2227	5.6708E+03	5.6993E+03	2277	7.2815E+03	7.3180E+03
2228	5.6993E+03	5.7278E+03	2278	7.3180E+03	7.3547E+03
2229	5.7278E+03	5.7565E+03	2279	7.3547E+03	7.3916E+03
2230	5.7565E+03	5.7854E+03	2280	7.3916E+03	7.4286E+03
2231	5.7854E+03	5.8144E+03	2281	7.4286E+03	7.4658E+03
2232	5.8144E+03	5.8435E+03	2282	7.4658E+03	7.5033E+03
2233	5.8435E+03	5.8728E+03	2283	7.5033E+03	7.5409E+03
2234	5.8728E+03	5.9023E+03	2284	7.5409E+03	7.5787E+03
2235	5.9023E+03	5.9319E+03	2285	7.5787E+03	7.6167E+03
2236	5.9319E+03	5.9616E+03	2286	7.6167E+03	7.6548E+03
2237	5.9616E+03	5.9915E+03	2287	7.6548E+03	7.6932E+03
2238	5.9915E+03	6.0215E+03	2288	7.6932E+03	7.7318E+03
2239	6.0215E+03	6.0517E+03	2289	7.7318E+03	7.7705E+03
2240	6.0517E+03	6.0820E+03	2290	7.7705E+03	7.8095E+03
2241	6.0820E+03	6.1125E+03	2291	7.8095E+03	7.8486E+03
2242	6.1125E+03	6.1432E+03	2292	7.8486E+03	7.8880E+03
2243	6.1432E+03	6.1739E+03	2293	7.8880E+03	7.9275E+03
2244	6.1739E+03	6.2049E+03	2294	7.9275E+03	7.9672E+03
2245	6.2049E+03	6.2360E+03	2295	7.9672E+03	8.0072E+03
2246	6.2360E+03	6.2672E+03	2296	8.0072E+03	8.0473E+03
2247	6.2672E+03	6.2987E+03	2297	8.0473E+03	8.0876E+03
2248	6.2987E+03	6.3302E+03	2298	8.0876E+03	8.1282E+03
2249	6.3302E+03	6.3620E+03	2299	8.1282E+03	8.1689E+03
2250	6.3620E+03	6.3939E+03	2300	8.1689E+03	8.2099E+03

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (2301 - 2400 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
2301	8.2099E+03	8.2510E+03	2351	1.0542E+04	1.0595E+04
2302	8.2510E+03	8.2924E+03	2352	1.0595E+04	1.0648E+04
2303	8.2924E+03	8.3339E+03	2353	1.0648E+04	1.0701E+04
2304	8.3339E+03	8.3757E+03	2354	1.0701E+04	1.0755E+04
2305	8.3757E+03	8.4177E+03	2355	1.0755E+04	1.0809E+04
2306	8.4177E+03	8.4599E+03	2356	1.0809E+04	1.0863E+04
2307	8.4599E+03	8.5023E+03	2357	1.0863E+04	1.0917E+04
2308	8.5023E+03	8.5449E+03	2358	1.0917E+04	1.0972E+04
2309	8.5449E+03	8.5878E+03	2359	1.0972E+04	1.1027E+04
2310	8.5878E+03	8.6308E+03	2360	1.1027E+04	1.1082E+04
2311	8.6308E+03	8.6741E+03	2361	1.1082E+04	1.1138E+04
2312	8.6741E+03	8.7175E+03	2362	1.1138E+04	1.1194E+04
2313	8.7175E+03	8.7612E+03	2363	1.1194E+04	1.1250E+04
2314	8.7612E+03	8.8052E+03	2364	1.1250E+04	1.1306E+04
2315	8.8052E+03	8.8493E+03	2365	1.1306E+04	1.1363E+04
2316	8.8493E+03	8.8937E+03	2366	1.1363E+04	1.1420E+04
2317	8.8937E+03	8.9382E+03	2367	1.1420E+04	1.1477E+04
2318	8.9382E+03	8.9830E+03	2368	1.1477E+04	1.1534E+04
2319	8.9830E+03	9.0281E+03	2369	1.1534E+04	1.1592E+04
2320	9.0281E+03	9.0733E+03	2370	1.1592E+04	1.1650E+04
2321	9.0733E+03	9.1188E+03	2371	1.1650E+04	1.1709E+04
2322	9.1188E+03	9.1645E+03	2372	1.1709E+04	1.1767E+04
2323	9.1645E+03	9.2104E+03	2373	1.1767E+04	1.1826E+04
2324	9.2104E+03	9.2566E+03	2374	1.1826E+04	1.1886E+04
2325	9.2566E+03	9.3030E+03	2375	1.1886E+04	1.1945E+04
2326	9.3030E+03	9.3496E+03	2376	1.1945E+04	1.2005E+04
2327	9.3496E+03	9.3965E+03	2377	1.2005E+04	1.2065E+04
2328	9.3965E+03	9.4436E+03	2378	1.2065E+04	1.2126E+04
2329	9.4436E+03	9.4909E+03	2379	1.2126E+04	1.2187E+04
2330	9.4909E+03	9.5385E+03	2380	1.2187E+04	1.2248E+04
2331	9.5385E+03	9.5863E+03	2381	1.2248E+04	1.2309E+04
2332	9.5863E+03	9.6344E+03	2382	1.2309E+04	1.2371E+04
2333	9.6344E+03	9.6827E+03	2383	1.2371E+04	1.2433E+04
2334	9.6827E+03	9.7312E+03	2384	1.2433E+04	1.2495E+04
2335	9.7312E+03	9.7800E+03	2385	1.2495E+04	1.2558E+04
2336	9.7800E+03	9.8290E+03	2386	1.2558E+04	1.2621E+04
2337	9.8290E+03	9.8783E+03	2387	1.2621E+04	1.2684E+04
2338	9.8783E+03	9.9278E+03	2388	1.2684E+04	1.2748E+04
2339	9.9278E+03	9.9776E+03	2389	1.2748E+04	1.2811E+04
2340	9.9776E+03	1.0028E+04	2390	1.2811E+04	1.2876E+04
2341	1.0028E+04	1.0078E+04	2391	1.2876E+04	1.2940E+04
2342	1.0078E+04	1.0128E+04	2392	1.2940E+04	1.3005E+04
2343	1.0128E+04	1.0179E+04	2393	1.3005E+04	1.3070E+04
2344	1.0179E+04	1.0230E+04	2394	1.3070E+04	1.3136E+04
2345	1.0230E+04	1.0281E+04	2395	1.3136E+04	1.3202E+04
2346	1.0281E+04	1.0333E+04	2396	1.3202E+04	1.3268E+04
2347	1.0333E+04	1.0385E+04	2397	1.3268E+04	1.3334E+04
2348	1.0385E+04	1.0437E+04	2398	1.3334E+04	1.3401E+04
2349	1.0437E+04	1.0489E+04	2399	1.3401E+04	1.3468E+04
2350	1.0489E+04	1.0542E+04	2400	1.3468E+04	1.3536E+04

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (2401 - 2500 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
2401	1.3536E+04	1.3604E+04	2451	1.7380E+04	1.7467E+04
2402	1.3604E+04	1.3672E+04	2452	1.7467E+04	1.7555E+04
2403	1.3672E+04	1.3740E+04	2453	1.7555E+04	1.7643E+04
2404	1.3740E+04	1.3809E+04	2454	1.7643E+04	1.7731E+04
2405	1.3809E+04	1.3878E+04	2455	1.7731E+04	1.7820E+04
2406	1.3878E+04	1.3948E+04	2456	1.7820E+04	1.7910E+04
2407	1.3948E+04	1.4018E+04	2457	1.7910E+04	1.7999E+04
2408	1.4018E+04	1.4088E+04	2458	1.7999E+04	1.8090E+04
2409	1.4088E+04	1.4159E+04	2459	1.8090E+04	1.8180E+04
2410	1.4159E+04	1.4230E+04	2460	1.8180E+04	1.8271E+04
2411	1.4230E+04	1.4301E+04	2461	1.8271E+04	1.8363E+04
2412	1.4301E+04	1.4373E+04	2462	1.8363E+04	1.8455E+04
2413	1.4373E+04	1.4445E+04	2463	1.8455E+04	1.8548E+04
2414	1.4445E+04	1.4517E+04	2464	1.8548E+04	1.8641E+04
2415	1.4517E+04	1.4590E+04	2465	1.8641E+04	1.8734E+04
2416	1.4590E+04	1.4663E+04	2466	1.8734E+04	1.8828E+04
2417	1.4663E+04	1.4737E+04	2467	1.8828E+04	1.8922E+04
2418	1.4737E+04	1.4811E+04	2468	1.8922E+04	1.9017E+04
2419	1.4811E+04	1.4885E+04	2469	1.9017E+04	1.9112E+04
2420	1.4885E+04	1.4959E+04	2470	1.9112E+04	1.9208E+04
2421	1.4959E+04	1.5034E+04	2471	1.9208E+04	1.9304E+04
2422	1.5034E+04	1.5110E+04	2472	1.9304E+04	1.9401E+04
2423	1.5110E+04	1.5185E+04	2473	1.9401E+04	1.9499E+04
2424	1.5185E+04	1.5262E+04	2474	1.9499E+04	1.9596E+04
2425	1.5262E+04	1.5338E+04	2475	1.9596E+04	1.9694E+04
2426	1.5338E+04	1.5415E+04	2476	1.9694E+04	1.9793E+04
2427	1.5415E+04	1.5492E+04	2477	1.9793E+04	1.9892E+04
2428	1.5492E+04	1.5570E+04	2478	1.9892E+04	1.9992E+04
2429	1.5570E+04	1.5648E+04	2479	1.9992E+04	2.0092E+04
2430	1.5648E+04	1.5726E+04	2480	2.0092E+04	2.0193E+04
2431	1.5726E+04	1.5805E+04	2481	2.0193E+04	2.0294E+04
2432	1.5805E+04	1.5884E+04	2482	2.0294E+04	2.0396E+04
2433	1.5884E+04	1.5964E+04	2483	2.0396E+04	2.0498E+04
2434	1.5964E+04	1.6044E+04	2484	2.0498E+04	2.0601E+04
2435	1.6044E+04	1.6124E+04	2485	2.0601E+04	2.0704E+04
2436	1.6124E+04	1.6205E+04	2486	2.0704E+04	2.0808E+04
2437	1.6205E+04	1.6287E+04	2487	2.0808E+04	2.0912E+04
2438	1.6287E+04	1.6368E+04	2488	2.0912E+04	2.1017E+04
2439	1.6368E+04	1.6450E+04	2489	2.1017E+04	2.1122E+04
2440	1.6450E+04	1.6533E+04	2490	2.1122E+04	2.1228E+04
2441	1.6533E+04	1.6616E+04	2491	2.1228E+04	2.1335E+04
2442	1.6616E+04	1.6699E+04	2492	2.1335E+04	2.1442E+04
2443	1.6699E+04	1.6783E+04	2493	2.1442E+04	2.1549E+04
2444	1.6783E+04	1.6867E+04	2494	2.1549E+04	2.1657E+04
2445	1.6867E+04	1.6951E+04	2495	2.1657E+04	2.1766E+04
2446	1.6951E+04	1.7036E+04	2496	2.1766E+04	2.1875E+04
2447	1.7036E+04	1.7122E+04	2497	2.1875E+04	2.1984E+04
2448	1.7122E+04	1.7207E+04	2498	2.1984E+04	2.2095E+04
2449	1.7207E+04	1.7294E+04	2499	2.2095E+04	2.2205E+04
2450	1.7294E+04	1.7380E+04	2500	2.2205E+04	2.2317E+04

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (2501 - 2600 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
2501	2.2317E+04	2.2429E+04	2551	2.8655E+04	2.8799E+04
2502	2.2429E+04	2.2541E+04	2552	2.8799E+04	2.8943E+04
2503	2.2541E+04	2.2654E+04	2553	2.8943E+04	2.9088E+04
2504	2.2654E+04	2.2768E+04	2554	2.9088E+04	2.9234E+04
2505	2.2768E+04	2.2882E+04	2555	2.9234E+04	2.9381E+04
2506	2.2882E+04	2.2996E+04	2556	2.9381E+04	2.9528E+04
2507	2.2996E+04	2.3112E+04	2557	2.9528E+04	2.9676E+04
2508	2.3112E+04	2.3228E+04	2558	2.9676E+04	2.9825E+04
2509	2.3228E+04	2.3344E+04	2559	2.9825E+04	2.9974E+04
2510	2.3344E+04	2.3461E+04	2560	2.9974E+04	3.0124E+04
2511	2.3461E+04	2.3579E+04	2561	3.0124E+04	3.0275E+04
2512	2.3579E+04	2.3697E+04	2562	3.0275E+04	3.0427E+04
2513	2.3697E+04	2.3816E+04	2563	3.0427E+04	3.0580E+04
2514	2.3816E+04	2.3935E+04	2564	3.0580E+04	3.0733E+04
2515	2.3935E+04	2.4055E+04	2565	3.0733E+04	3.0887E+04
2516	2.4055E+04	2.4175E+04	2566	3.0887E+04	3.1042E+04
2517	2.4175E+04	2.4297E+04	2567	3.1042E+04	3.1198E+04
2518	2.4297E+04	2.4418E+04	2568	3.1198E+04	3.1354E+04
2519	2.4418E+04	2.4541E+04	2569	3.1354E+04	3.1511E+04
2520	2.4541E+04	2.4664E+04	2570	3.1511E+04	3.1669E+04
2521	2.4664E+04	2.4787E+04	2571	3.1669E+04	3.1828E+04
2522	2.4787E+04	2.4912E+04	2572	3.1828E+04	3.1987E+04
2523	2.4912E+04	2.5037E+04	2573	3.1987E+04	3.2148E+04
2524	2.5037E+04	2.5162E+04	2574	3.2148E+04	3.2309E+04
2525	2.5162E+04	2.5288E+04	2575	3.2309E+04	3.2471E+04
2526	2.5288E+04	2.5415E+04	2576	3.2471E+04	3.2633E+04
2527	2.5415E+04	2.5542E+04	2577	3.2633E+04	3.2797E+04
2528	2.5542E+04	2.5670E+04	2578	3.2797E+04	3.2961E+04
2529	2.5670E+04	2.5799E+04	2579	3.2961E+04	3.3127E+04
2530	2.5799E+04	2.5928E+04	2580	3.3127E+04	3.3293E+04
2531	2.5928E+04	2.6058E+04	2581	3.3293E+04	3.3460E+04
2532	2.6058E+04	2.6189E+04	2582	3.3460E+04	3.3627E+04
2533	2.6189E+04	2.6320E+04	2583	3.3627E+04	3.3796E+04
2534	2.6320E+04	2.6452E+04	2584	3.3796E+04	3.3965E+04
2535	2.6452E+04	2.6585E+04	2585	3.3965E+04	3.4135E+04
2536	2.6585E+04	2.6718E+04	2586	3.4135E+04	3.4307E+04
2537	2.6718E+04	2.6852E+04	2587	3.4307E+04	3.4479E+04
2538	2.6852E+04	2.6987E+04	2588	3.4479E+04	3.4651E+04
2539	2.6987E+04	2.7122E+04	2589	3.4651E+04	3.4825E+04
2540	2.7122E+04	2.7258E+04	2590	3.4825E+04	3.5000E+04
2541	2.7258E+04	2.7394E+04	2591	3.5000E+04	3.5175E+04
2542	2.7394E+04	2.7532E+04	2592	3.5175E+04	3.5351E+04
2543	2.7532E+04	2.7670E+04	2593	3.5351E+04	3.5529E+04
2544	2.7670E+04	2.7808E+04	2594	3.5529E+04	3.5707E+04
2545	2.7808E+04	2.7948E+04	2595	3.5707E+04	3.5886E+04
2546	2.7948E+04	2.8088E+04	2596	3.5886E+04	3.6066E+04
2547	2.8088E+04	2.8229E+04	2597	3.6066E+04	3.6246E+04
2548	2.8229E+04	2.8370E+04	2598	3.6246E+04	3.6428E+04
2549	2.8370E+04	2.8512E+04	2599	3.6428E+04	3.6611E+04
2550	2.8512E+04	2.8655E+04	2600	3.6611E+04	3.6794E+04

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (2601 - 2700 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
2601	3.6794E+04	3.6979E+04	2651	4.7245E+04	4.7481E+04
2602	3.6979E+04	3.7164E+04	2652	4.7481E+04	4.7719E+04
2603	3.7164E+04	3.7350E+04	2653	4.7719E+04	4.7959E+04
2604	3.7350E+04	3.7537E+04	2654	4.7959E+04	4.8199E+04
2605	3.7537E+04	3.7726E+04	2655	4.8199E+04	4.8441E+04
2606	3.7726E+04	3.7915E+04	2656	4.8441E+04	4.8683E+04
2607	3.7915E+04	3.8105E+04	2657	4.8683E+04	4.8927E+04
2608	3.8105E+04	3.8296E+04	2658	4.8927E+04	4.9173E+04
2609	3.8296E+04	3.8488E+04	2659	4.9173E+04	4.9419E+04
2610	3.8488E+04	3.8681E+04	2660	4.9419E+04	4.9667E+04
2611	3.8681E+04	3.8874E+04	2661	4.9667E+04	4.9916E+04
2612	3.8874E+04	3.9069E+04	2662	4.9916E+04	5.0166E+04
2613	3.9069E+04	3.9265E+04	2663	5.0166E+04	5.0417E+04
2614	3.9265E+04	3.9462E+04	2664	5.0417E+04	5.0670E+04
2615	3.9462E+04	3.9660E+04	2665	5.0670E+04	5.0924E+04
2616	3.9660E+04	3.9859E+04	2666	5.0924E+04	5.1179E+04
2617	3.9859E+04	4.0058E+04	2667	5.1179E+04	5.1436E+04
2618	4.0058E+04	4.0259E+04	2668	5.1436E+04	5.1694E+04
2619	4.0259E+04	4.0461E+04	2669	5.1694E+04	5.1953E+04
2620	4.0461E+04	4.0664E+04	2670	5.1953E+04	5.2213E+04
2621	4.0664E+04	4.0868E+04	2671	5.2213E+04	5.2475E+04
2622	4.0868E+04	4.1072E+04	2672	5.2475E+04	5.2738E+04
2623	4.1072E+04	4.1278E+04	2673	5.2738E+04	5.3002E+04
2624	4.1278E+04	4.1485E+04	2674	5.3002E+04	5.3268E+04
2625	4.1485E+04	4.1693E+04	2675	5.3268E+04	5.3535E+04
2626	4.1693E+04	4.1902E+04	2676	5.3535E+04	5.3803E+04
2627	4.1902E+04	4.2112E+04	2677	5.3803E+04	5.4073E+04
2628	4.2112E+04	4.2323E+04	2678	5.4073E+04	5.4344E+04
2629	4.2323E+04	4.2535E+04	2679	5.4344E+04	5.4617E+04
2630	4.2535E+04	4.2749E+04	2680	5.4617E+04	5.4890E+04
2631	4.2749E+04	4.2963E+04	2681	5.4890E+04	5.5166E+04
2632	4.2963E+04	4.3178E+04	2682	5.5166E+04	5.5442E+04
2633	4.3178E+04	4.3395E+04	2683	5.5442E+04	5.5720E+04
2634	4.3395E+04	4.3612E+04	2684	5.5720E+04	5.5999E+04
2635	4.3612E+04	4.3831E+04	2685	5.5999E+04	5.6280E+04
2636	4.3831E+04	4.4051E+04	2686	5.6280E+04	5.6562E+04
2637	4.4051E+04	4.4271E+04	2687	5.6562E+04	5.6846E+04
2638	4.4271E+04	4.4493E+04	2688	5.6846E+04	5.7130E+04
2639	4.4493E+04	4.4716E+04	2689	5.7130E+04	5.7417E+04
2640	4.4716E+04	4.4940E+04	2690	5.7417E+04	5.7705E+04
2641	4.4940E+04	4.5166E+04	2691	5.7705E+04	5.7994E+04
2642	4.5166E+04	4.5392E+04	2692	5.7994E+04	5.8285E+04
2643	4.5392E+04	4.5620E+04	2693	5.8285E+04	5.8577E+04
2644	4.5620E+04	4.5848E+04	2694	5.8577E+04	5.8870E+04
2645	4.5848E+04	4.6078E+04	2695	5.8870E+04	5.9165E+04
2646	4.6078E+04	4.6309E+04	2696	5.9165E+04	5.9462E+04
2647	4.6309E+04	4.6541E+04	2697	5.9462E+04	5.9760E+04
2648	4.6541E+04	4.6774E+04	2698	5.9760E+04	6.0060E+04
2649	4.6774E+04	4.7009E+04	2699	6.0060E+04	6.0361E+04
2650	4.7009E+04	4.7245E+04	2700	6.0361E+04	6.0663E+04

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (2701 - 2800 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
2701	6.0663E+04	6.0967E+04	2751	7.7893E+04	7.8284E+04
2702	6.0967E+04	6.1273E+04	2752	7.8284E+04	7.8676E+04
2703	6.1273E+04	6.1580E+04	2753	7.8676E+04	7.9070E+04
2704	6.1580E+04	6.1889E+04	2754	7.9070E+04	7.9467E+04
2705	6.1889E+04	6.2199E+04	2755	7.9467E+04	7.9865E+04
2706	6.2199E+04	6.2511E+04	2756	7.9865E+04	8.0265E+04
2707	6.2511E+04	6.2824E+04	2757	8.0265E+04	8.0668E+04
2708	6.2824E+04	6.3139E+04	2758	8.0668E+04	8.1072E+04
2709	6.3139E+04	6.3455E+04	2759	8.1072E+04	8.1478E+04
2710	6.3455E+04	6.3773E+04	2760	8.1478E+04	8.1887E+04
2711	6.3773E+04	6.4093E+04	2761	8.1887E+04	8.2297E+04
2712	6.4093E+04	6.4414E+04	2762	8.2297E+04	8.2710E+04
2713	6.4414E+04	6.4737E+04	2763	8.2710E+04	8.3124E+04
2714	6.4737E+04	6.5062E+04	2764	8.3124E+04	8.3541E+04
2715	6.5062E+04	6.5388E+04	2765	8.3541E+04	8.3960E+04
2716	6.5388E+04	6.5716E+04	2766	8.3960E+04	8.4381E+04
2717	6.5716E+04	6.6045E+04	2767	8.4381E+04	8.4804E+04
2718	6.6045E+04	6.6376E+04	2768	8.4804E+04	8.5229E+04
2719	6.6376E+04	6.6709E+04	2769	8.5229E+04	8.5656E+04
2720	6.6709E+04	6.7043E+04	2770	8.5656E+04	8.6085E+04
2721	6.7043E+04	6.7379E+04	2771	8.6085E+04	8.6517E+04
2722	6.7379E+04	6.7717E+04	2772	8.6517E+04	8.6950E+04
2723	6.7717E+04	6.8056E+04	2773	8.6950E+04	8.7386E+04
2724	6.8056E+04	6.8398E+04	2774	8.7386E+04	8.7824E+04
2725	6.8398E+04	6.8740E+04	2775	8.7824E+04	8.8264E+04
2726	6.8740E+04	6.9085E+04	2776	8.8264E+04	8.8707E+04
2727	6.9085E+04	6.9431E+04	2777	8.8707E+04	8.9151E+04
2728	6.9431E+04	6.9779E+04	2778	8.9151E+04	8.9598E+04
2729	6.9779E+04	7.0129E+04	2779	8.9598E+04	9.0048E+04
2730	7.0129E+04	7.0481E+04	2780	9.0048E+04	9.0499E+04
2731	7.0481E+04	7.0834E+04	2781	9.0499E+04	9.0953E+04
2732	7.0834E+04	7.1189E+04	2782	9.0953E+04	9.1408E+04
2733	7.1189E+04	7.1546E+04	2783	9.1408E+04	9.1867E+04
2734	7.1546E+04	7.1904E+04	2784	9.1867E+04	9.2327E+04
2735	7.1904E+04	7.2265E+04	2785	9.2327E+04	9.2790E+04
2736	7.2265E+04	7.2627E+04	2786	9.2790E+04	9.3255E+04
2737	7.2627E+04	7.2991E+04	2787	9.3255E+04	9.3722E+04
2738	7.2991E+04	7.3357E+04	2788	9.3722E+04	9.4192E+04
2739	7.3357E+04	7.3725E+04	2789	9.4192E+04	9.4664E+04
2740	7.3725E+04	7.4094E+04	2790	9.4664E+04	9.5139E+04
2741	7.4094E+04	7.4466E+04	2791	9.5139E+04	9.5616E+04
2742	7.4466E+04	7.4839E+04	2792	9.5616E+04	9.6095E+04
2743	7.4839E+04	7.5214E+04	2793	9.6095E+04	9.6577E+04
2744	7.5214E+04	7.5591E+04	2794	9.6577E+04	9.7061E+04
2745	7.5591E+04	7.5970E+04	2795	9.7061E+04	9.7547E+04
2746	7.5970E+04	7.6351E+04	2796	9.7547E+04	9.8036E+04
2747	7.6351E+04	7.6733E+04	2797	9.8036E+04	9.8528E+04
2748	7.6733E+04	7.7118E+04	2798	9.8528E+04	9.9022E+04
2749	7.7118E+04	7.7505E+04	2799	9.9022E+04	9.9518E+04
2750	7.7505E+04	7.7893E+04	2800	9.9518E+04	1.0002E+05

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (2801 - 2900 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
2801	1.0002E+05	1.0052E+05	2851	1.2842E+05	1.2907E+05
2802	1.0052E+05	1.0102E+05	2852	1.2907E+05	1.2971E+05
2803	1.0102E+05	1.0153E+05	2853	1.2971E+05	1.3036E+05
2804	1.0153E+05	1.0204E+05	2854	1.3036E+05	1.3102E+05
2805	1.0204E+05	1.0255E+05	2855	1.3102E+05	1.3168E+05
2806	1.0255E+05	1.0306E+05	2856	1.3168E+05	1.3234E+05
2807	1.0306E+05	1.0358E+05	2857	1.3234E+05	1.3300E+05
2808	1.0358E+05	1.0410E+05	2858	1.3300E+05	1.3367E+05
2809	1.0410E+05	1.0462E+05	2859	1.3367E+05	1.3434E+05
2810	1.0462E+05	1.0514E+05	2860	1.3434E+05	1.3501E+05
2811	1.0514E+05	1.0567E+05	2861	1.3501E+05	1.3569E+05
2812	1.0567E+05	1.0620E+05	2862	1.3569E+05	1.3637E+05
2813	1.0620E+05	1.0673E+05	2863	1.3637E+05	1.3705E+05
2814	1.0673E+05	1.0727E+05	2864	1.3705E+05	1.3774E+05
2815	1.0727E+05	1.0781E+05	2865	1.3774E+05	1.3843E+05
2816	1.0781E+05	1.0835E+05	2866	1.3843E+05	1.3912E+05
2817	1.0835E+05	1.0889E+05	2867	1.3912E+05	1.3982E+05
2818	1.0889E+05	1.0944E+05	2868	1.3982E+05	1.4052E+05
2819	1.0944E+05	1.0998E+05	2869	1.4052E+05	1.4122E+05
2820	1.0998E+05	1.1054E+05	2870	1.4122E+05	1.4193E+05
2821	1.1054E+05	1.1109E+05	2871	1.4193E+05	1.4264E+05
2822	1.1109E+05	1.1165E+05	2872	1.4264E+05	1.4336E+05
2823	1.1165E+05	1.1221E+05	2873	1.4336E+05	1.4408E+05
2824	1.1221E+05	1.1277E+05	2874	1.4408E+05	1.4480E+05
2825	1.1277E+05	1.1333E+05	2875	1.4480E+05	1.4552E+05
2826	1.1333E+05	1.1390E+05	2876	1.4552E+05	1.4625E+05
2827	1.1390E+05	1.1447E+05	2877	1.4625E+05	1.4699E+05
2828	1.1447E+05	1.1505E+05	2878	1.4699E+05	1.4772E+05
2829	1.1505E+05	1.1562E+05	2879	1.4772E+05	1.4846E+05
2830	1.1562E+05	1.1620E+05	2880	1.4846E+05	1.4921E+05
2831	1.1620E+05	1.1679E+05	2881	1.4921E+05	1.4996E+05
2832	1.1679E+05	1.1737E+05	2882	1.4996E+05	1.5071E+05
2833	1.1737E+05	1.1796E+05	2883	1.5071E+05	1.5146E+05
2834	1.1796E+05	1.1855E+05	2884	1.5146E+05	1.5222E+05
2835	1.1855E+05	1.1914E+05	2885	1.5222E+05	1.5298E+05
2836	1.1914E+05	1.1974E+05	2886	1.5298E+05	1.5375E+05
2837	1.1974E+05	1.2034E+05	2887	1.5375E+05	1.5452E+05
2838	1.2034E+05	1.2095E+05	2888	1.5452E+05	1.5530E+05
2839	1.2095E+05	1.2155E+05	2889	1.5530E+05	1.5608E+05
2840	1.2155E+05	1.2216E+05	2890	1.5608E+05	1.5686E+05
2841	1.2216E+05	1.2277E+05	2891	1.5686E+05	1.5764E+05
2842	1.2277E+05	1.2339E+05	2892	1.5764E+05	1.5843E+05
2843	1.2339E+05	1.2401E+05	2893	1.5843E+05	1.5923E+05
2844	1.2401E+05	1.2463E+05	2894	1.5923E+05	1.6003E+05
2845	1.2463E+05	1.2525E+05	2895	1.6003E+05	1.6083E+05
2846	1.2525E+05	1.2588E+05	2896	1.6083E+05	1.6163E+05
2847	1.2588E+05	1.2651E+05	2897	1.6163E+05	1.6244E+05
2848	1.2651E+05	1.2715E+05	2898	1.6244E+05	1.6326E+05
2849	1.2715E+05	1.2778E+05	2899	1.6326E+05	1.6408E+05
2850	1.2778E+05	1.2842E+05	2900	1.6408E+05	1.6490E+05

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (2901 - 3000 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
2901	1.6490E+05	1.6573E+05	2951	2.1174E+05	2.1280E+05
2902	1.6573E+05	1.6656E+05	2952	2.1280E+05	2.1386E+05
2903	1.6656E+05	1.6739E+05	2953	2.1386E+05	2.1494E+05
2904	1.6739E+05	1.6823E+05	2954	2.1494E+05	2.1601E+05
2905	1.6823E+05	1.6907E+05	2955	2.1601E+05	2.1710E+05
2906	1.6907E+05	1.6992E+05	2956	2.1710E+05	2.1818E+05
2907	1.6992E+05	1.7077E+05	2957	2.1818E+05	2.1928E+05
2908	1.7077E+05	1.7163E+05	2958	2.1928E+05	2.2038E+05
2909	1.7163E+05	1.7249E+05	2959	2.2038E+05	2.2148E+05
2910	1.7249E+05	1.7335E+05	2960	2.2148E+05	2.2259E+05
2911	1.7335E+05	1.7422E+05	2961	2.2259E+05	2.2371E+05
2912	1.7422E+05	1.7510E+05	2962	2.2371E+05	2.2483E+05
2913	1.7510E+05	1.7597E+05	2963	2.2483E+05	2.2596E+05
2914	1.7597E+05	1.7686E+05	2964	2.2596E+05	2.2709E+05
2915	1.7686E+05	1.7774E+05	2965	2.2709E+05	2.2823E+05
2916	1.7774E+05	1.7863E+05	2966	2.2823E+05	2.2937E+05
2917	1.7863E+05	1.7953E+05	2967	2.2937E+05	2.3052E+05
2918	1.7953E+05	1.8043E+05	2968	2.3052E+05	2.3168E+05
2919	1.8043E+05	1.8133E+05	2969	2.3168E+05	2.3284E+05
2920	1.8133E+05	1.8224E+05	2970	2.3284E+05	2.3400E+05
2921	1.8224E+05	1.8316E+05	2971	2.3400E+05	2.3518E+05
2922	1.8316E+05	1.8407E+05	2972	2.3518E+05	2.3636E+05
2923	1.8407E+05	1.8500E+05	2973	2.3636E+05	2.3754E+05
2924	1.8500E+05	1.8592E+05	2974	2.3754E+05	2.3873E+05
2925	1.8592E+05	1.8686E+05	2975	2.3873E+05	2.3993E+05
2926	1.8686E+05	1.8779E+05	2976	2.3993E+05	2.4113E+05
2927	1.8779E+05	1.8873E+05	2977	2.4113E+05	2.4234E+05
2928	1.8873E+05	1.8968E+05	2978	2.4234E+05	2.4355E+05
2929	1.8968E+05	1.9063E+05	2979	2.4355E+05	2.4477E+05
2930	1.9063E+05	1.9159E+05	2980	2.4477E+05	2.4600E+05
2931	1.9159E+05	1.9255E+05	2981	2.4600E+05	2.4723E+05
2932	1.9255E+05	1.9351E+05	2982	2.4723E+05	2.4847E+05
2933	1.9351E+05	1.9448E+05	2983	2.4847E+05	2.4972E+05
2934	1.9448E+05	1.9546E+05	2984	2.4972E+05	2.5097E+05
2935	1.9546E+05	1.9644E+05	2985	2.5097E+05	2.5223E+05
2936	1.9644E+05	1.9742E+05	2986	2.5223E+05	2.5349E+05
2937	1.9742E+05	1.9841E+05	2987	2.5349E+05	2.5476E+05
2938	1.9841E+05	1.9940E+05	2988	2.5476E+05	2.5604E+05
2939	1.9940E+05	2.0040E+05	2989	2.5604E+05	2.5732E+05
2940	2.0040E+05	2.0141E+05	2990	2.5732E+05	2.5861E+05
2941	2.0141E+05	2.0242E+05	2991	2.5861E+05	2.5991E+05
2942	2.0242E+05	2.0343E+05	2992	2.5991E+05	2.6121E+05
2943	2.0343E+05	2.0445E+05	2993	2.6121E+05	2.6252E+05
2944	2.0445E+05	2.0548E+05	2994	2.6252E+05	2.6384E+05
2945	2.0548E+05	2.0651E+05	2995	2.6384E+05	2.6516E+05
2946	2.0651E+05	2.0754E+05	2996	2.6516E+05	2.6649E+05
2947	2.0754E+05	2.0858E+05	2997	2.6649E+05	2.6783E+05
2948	2.0858E+05	2.0963E+05	2998	2.6783E+05	2.6917E+05
2949	2.0963E+05	2.1068E+05	2999	2.6917E+05	2.7052E+05
2950	2.1068E+05	2.1174E+05	3000	2.7052E+05	2.7187E+05

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (3001 - 3100 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
3001	2.7187E+05	2.7324E+05	3051	3.4909E+05	3.5084E+05
3002	2.7324E+05	2.7461E+05	3052	3.5084E+05	3.5260E+05
3003	2.7461E+05	2.7598E+05	3053	3.5260E+05	3.5437E+05
3004	2.7598E+05	2.7737E+05	3054	3.5437E+05	3.5614E+05
3005	2.7737E+05	2.7876E+05	3055	3.5614E+05	3.5793E+05
3006	2.7876E+05	2.8015E+05	3056	3.5793E+05	3.5972E+05
3007	2.8015E+05	2.8156E+05	3057	3.5972E+05	3.6153E+05
3008	2.8156E+05	2.8297E+05	3058	3.6153E+05	3.6334E+05
3009	2.8297E+05	2.8439E+05	3059	3.6334E+05	3.6516E+05
3010	2.8439E+05	2.8581E+05	3060	3.6516E+05	3.6699E+05
3011	2.8581E+05	2.8725E+05	3061	3.6699E+05	3.6883E+05
3012	2.8725E+05	2.8869E+05	3062	3.6883E+05	3.7068E+05
3013	2.8869E+05	2.9013E+05	3063	3.7068E+05	3.7254E+05
3014	2.9013E+05	2.9159E+05	3064	3.7254E+05	3.7440E+05
3015	2.9159E+05	2.9305E+05	3065	3.7440E+05	3.7628E+05
3016	2.9305E+05	2.9452E+05	3066	3.7628E+05	3.7817E+05
3017	2.9452E+05	2.9599E+05	3067	3.7817E+05	3.8006E+05
3018	2.9599E+05	2.9748E+05	3068	3.8006E+05	3.8197E+05
3019	2.9748E+05	2.9897E+05	3069	3.8197E+05	3.8388E+05
3020	2.9897E+05	3.0047E+05	3070	3.8388E+05	3.8581E+05
3021	3.0047E+05	3.0197E+05	3071	3.8581E+05	3.8774E+05
3022	3.0197E+05	3.0349E+05	3072	3.8774E+05	3.8968E+05
3023	3.0349E+05	3.0501E+05	3073	3.8968E+05	3.9164E+05
3024	3.0501E+05	3.0654E+05	3074	3.9164E+05	3.9360E+05
3025	3.0654E+05	3.0807E+05	3075	3.9360E+05	3.9557E+05
3026	3.0807E+05	3.0962E+05	3076	3.9557E+05	3.9756E+05
3027	3.0962E+05	3.1117E+05	3077	3.9756E+05	3.9955E+05
3028	3.1117E+05	3.1273E+05	3078	3.9955E+05	4.0155E+05
3029	3.1273E+05	3.1430E+05	3079	4.0155E+05	4.0356E+05
3030	3.1430E+05	3.1587E+05	3080	4.0356E+05	4.0559E+05
3031	3.1587E+05	3.1746E+05	3081	4.0559E+05	4.0762E+05
3032	3.1746E+05	3.1905E+05	3082	4.0762E+05	4.0966E+05
3033	3.1905E+05	3.2065E+05	3083	4.0966E+05	4.1172E+05
3034	3.2065E+05	3.2225E+05	3084	4.1172E+05	4.1378E+05
3035	3.2225E+05	3.2387E+05	3085	4.1378E+05	4.1586E+05
3036	3.2387E+05	3.2549E+05	3086	4.1586E+05	4.1794E+05
3037	3.2549E+05	3.2712E+05	3087	4.1794E+05	4.2003E+05
3038	3.2712E+05	3.2876E+05	3088	4.2003E+05	4.2214E+05
3039	3.2876E+05	3.3041E+05	3089	4.2214E+05	4.2426E+05
3040	3.3041E+05	3.3207E+05	3090	4.2426E+05	4.2638E+05
3041	3.3207E+05	3.3373E+05	3091	4.2638E+05	4.2852E+05
3042	3.3373E+05	3.3540E+05	3092	4.2852E+05	4.3067E+05
3043	3.3540E+05	3.3709E+05	3093	4.3067E+05	4.3283E+05
3044	3.3709E+05	3.3878E+05	3094	4.3283E+05	4.3500E+05
3045	3.3878E+05	3.4047E+05	3095	4.3500E+05	4.3718E+05
3046	3.4047E+05	3.4218E+05	3096	4.3718E+05	4.3937E+05
3047	3.4218E+05	3.4390E+05	3097	4.3937E+05	4.4157E+05
3048	3.4390E+05	3.4562E+05	3098	4.4157E+05	4.4378E+05
3049	3.4562E+05	3.4735E+05	3099	4.4378E+05	4.4601E+05
3050	3.4735E+05	3.4909E+05	3100	4.4601E+05	4.4824E+05

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (3101 - 3200 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
3101	4.4824E+05	4.5049E+05	3151	5.7556E+05	5.7844E+05
3102	4.5049E+05	4.5275E+05	3152	5.7844E+05	5.8134E+05
3103	4.5275E+05	4.5502E+05	3153	5.8134E+05	5.8425E+05
3104	4.5502E+05	4.5730E+05	3154	5.8425E+05	5.8718E+05
3105	4.5730E+05	4.5959E+05	3155	5.8718E+05	5.9013E+05
3106	4.5959E+05	4.6189E+05	3156	5.9013E+05	5.9308E+05
3107	4.6189E+05	4.6421E+05	3157	5.9308E+05	5.9606E+05
3108	4.6421E+05	4.6654E+05	3158	5.9606E+05	5.9905E+05
3109	4.6654E+05	4.6888E+05	3159	5.9905E+05	6.0205E+05
3110	4.6888E+05	4.7123E+05	3160	6.0205E+05	6.0507E+05
3111	4.7123E+05	4.7359E+05	3161	6.0507E+05	6.0810E+05
3112	4.7359E+05	4.7596E+05	3162	6.0810E+05	6.1115E+05
3113	4.7596E+05	4.7835E+05	3163	6.1115E+05	6.1421E+05
3114	4.7835E+05	4.8074E+05	3164	6.1421E+05	6.1729E+05
3115	4.8074E+05	4.8315E+05	3165	6.1729E+05	6.2038E+05
3116	4.8315E+05	4.8558E+05	3166	6.2038E+05	6.2349E+05
3117	4.8558E+05	4.8801E+05	3167	6.2349E+05	6.2662E+05
3118	4.8801E+05	4.9046E+05	3168	6.2662E+05	6.2976E+05
3119	4.9046E+05	4.9292E+05	3169	6.2976E+05	6.3292E+05
3120	4.9292E+05	4.9539E+05	3170	6.3292E+05	6.3609E+05
3121	4.9539E+05	4.9787E+05	3171	6.3609E+05	6.3928E+05
3122	4.9787E+05	5.0036E+05	3172	6.3928E+05	6.4248E+05
3123	5.0036E+05	5.0287E+05	3173	6.4248E+05	6.4570E+05
3124	5.0287E+05	5.0539E+05	3174	6.4570E+05	6.4894E+05
3125	5.0539E+05	5.0793E+05	3175	6.4894E+05	6.5219E+05
3126	5.0793E+05	5.1047E+05	3176	6.5219E+05	6.5546E+05
3127	5.1047E+05	5.1303E+05	3177	6.5546E+05	6.5875E+05
3128	5.1303E+05	5.1560E+05	3178	6.5875E+05	6.6205E+05
3129	5.1560E+05	5.1819E+05	3179	6.6205E+05	6.6537E+05
3130	5.1819E+05	5.2078E+05	3180	6.6537E+05	6.6870E+05
3131	5.2078E+05	5.2340E+05	3181	6.6870E+05	6.7205E+05
3132	5.2340E+05	5.2602E+05	3182	6.7205E+05	6.7542E+05
3133	5.2602E+05	5.2866E+05	3183	6.7542E+05	6.7881E+05
3134	5.2866E+05	5.3131E+05	3184	6.7881E+05	6.8221E+05
3135	5.3131E+05	5.3397E+05	3185	6.8221E+05	6.8563E+05
3136	5.3397E+05	5.3665E+05	3186	6.8563E+05	6.8907E+05
3137	5.3665E+05	5.3934E+05	3187	6.8907E+05	6.9252E+05
3138	5.3934E+05	5.4204E+05	3188	6.9252E+05	6.9599E+05
3139	5.4204E+05	5.4476E+05	3189	6.9599E+05	6.9948E+05
3140	5.4476E+05	5.4749E+05	3190	6.9948E+05	7.0299E+05
3141	5.4749E+05	5.5023E+05	3191	7.0299E+05	7.0651E+05
3142	5.5023E+05	5.5299E+05	3192	7.0651E+05	7.1005E+05
3143	5.5299E+05	5.5576E+05	3193	7.1005E+05	7.1361E+05
3144	5.5576E+05	5.5855E+05	3194	7.1361E+05	7.1719E+05
3145	5.5855E+05	5.6135E+05	3195	7.1719E+05	7.2078E+05
3146	5.6135E+05	5.6416E+05	3196	7.2078E+05	7.2439E+05
3147	5.6416E+05	5.6699E+05	3197	7.2439E+05	7.2803E+05
3148	5.6699E+05	5.6983E+05	3198	7.2803E+05	7.3168E+05
3149	5.6983E+05	5.7269E+05	3199	7.3168E+05	7.3534E+05
3150	5.7269E+05	5.7556E+05	3200	7.3534E+05	7.3903E+05

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (3201 - 3300 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
3201	7.3903E+05	7.4273E+05	3251	9.4893E+05	9.5369E+05
3202	7.4273E+05	7.4646E+05	3252	9.5369E+05	9.5847E+05
3203	7.4646E+05	7.5020E+05	3253	9.5847E+05	9.6327E+05
3204	7.5020E+05	7.5396E+05	3254	9.6327E+05	9.6810E+05
3205	7.5396E+05	7.5774E+05	3255	9.6810E+05	9.7295E+05
3206	7.5774E+05	7.6154E+05	3256	9.7295E+05	9.7783E+05
3207	7.6154E+05	7.6535E+05	3257	9.7783E+05	9.8273E+05
3208	7.6535E+05	7.6919E+05	3258	9.8273E+05	9.8766E+05
3209	7.6919E+05	7.7304E+05	3259	9.8766E+05	9.9261E+05
3210	7.7304E+05	7.7692E+05	3260	9.9261E+05	9.9759E+05
3211	7.7692E+05	7.8081E+05	3261	9.9759E+05	1.0026E+06
3212	7.8081E+05	7.8473E+05	3262	1.0026E+06	1.0076E+06
3213	7.8473E+05	7.8866E+05	3263	1.0076E+06	1.0127E+06
3214	7.8866E+05	7.9261E+05	3264	1.0127E+06	1.0177E+06
3215	7.9261E+05	7.9659E+05	3265	1.0177E+06	1.0228E+06
3216	7.9659E+05	8.0058E+05	3266	1.0228E+06	1.0280E+06
3217	8.0058E+05	8.0459E+05	3267	1.0280E+06	1.0331E+06
3218	8.0459E+05	8.0863E+05	3268	1.0331E+06	1.0383E+06
3219	8.0863E+05	8.1268E+05	3269	1.0383E+06	1.0435E+06
3220	8.1268E+05	8.1675E+05	3270	1.0435E+06	1.0487E+06
3221	8.1675E+05	8.2085E+05	3271	1.0487E+06	1.0540E+06
3222	8.2085E+05	8.2496E+05	3272	1.0540E+06	1.0593E+06
3223	8.2496E+05	8.2910E+05	3273	1.0593E+06	1.0646E+06
3224	8.2910E+05	8.3325E+05	3274	1.0646E+06	1.0699E+06
3225	8.3325E+05	8.3743E+05	3275	1.0699E+06	1.0753E+06
3226	8.3743E+05	8.4163E+05	3276	1.0753E+06	1.0807E+06
3227	8.4163E+05	8.4585E+05	3277	1.0807E+06	1.0861E+06
3228	8.4585E+05	8.5009E+05	3278	1.0861E+06	1.0915E+06
3229	8.5009E+05	8.5435E+05	3279	1.0915E+06	1.0970E+06
3230	8.5435E+05	8.5863E+05	3280	1.0970E+06	1.1025E+06
3231	8.5863E+05	8.6293E+05	3281	1.1025E+06	1.1080E+06
3232	8.6293E+05	8.6726E+05	3282	1.1080E+06	1.1136E+06
3233	8.6726E+05	8.7161E+05	3283	1.1136E+06	1.1192E+06
3234	8.7161E+05	8.7597E+05	3284	1.1192E+06	1.1248E+06
3235	8.7597E+05	8.8037E+05	3285	1.1248E+06	1.1304E+06
3236	8.8037E+05	8.8478E+05	3286	1.1304E+06	1.1361E+06
3237	8.8478E+05	8.8921E+05	3287	1.1361E+06	1.1418E+06
3238	8.8921E+05	8.9367E+05	3288	1.1418E+06	1.1475E+06
3239	8.9367E+05	8.9815E+05	3289	1.1475E+06	1.1532E+06
3240	8.9815E+05	9.0265E+05	3290	1.1532E+06	1.1590E+06
3241	9.0265E+05	9.0718E+05	3291	1.1590E+06	1.1648E+06
3242	9.0718E+05	9.1172E+05	3292	1.1648E+06	1.1707E+06
3243	9.1172E+05	9.1629E+05	3293	1.1707E+06	1.1765E+06
3244	9.1629E+05	9.2089E+05	3294	1.1765E+06	1.1824E+06
3245	9.2089E+05	9.2550E+05	3295	1.1824E+06	1.1884E+06
3246	9.2550E+05	9.3014E+05	3296	1.1884E+06	1.1943E+06
3247	9.3014E+05	9.3480E+05	3297	1.1943E+06	1.2003E+06
3248	9.3480E+05	9.3949E+05	3298	1.2003E+06	1.2063E+06
3249	9.3949E+05	9.4420E+05	3299	1.2063E+06	1.2124E+06
3250	9.4420E+05	9.4893E+05	3300	1.2124E+06	1.2185E+06

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (3301 - 3400 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
3301	1.2185E+06	1.2246E+06	3351	1.5645E+06	1.5724E+06
3302	1.2246E+06	1.2307E+06	3352	1.5724E+06	1.5802E+06
3303	1.2307E+06	1.2369E+06	3353	1.5802E+06	1.5882E+06
3304	1.2369E+06	1.2431E+06	3354	1.5882E+06	1.5961E+06
3305	1.2431E+06	1.2493E+06	3355	1.5961E+06	1.6041E+06
3306	1.2493E+06	1.2556E+06	3356	1.6041E+06	1.6122E+06
3307	1.2556E+06	1.2619E+06	3357	1.6122E+06	1.6203E+06
3308	1.2619E+06	1.2682E+06	3358	1.6203E+06	1.6284E+06
3309	1.2682E+06	1.2745E+06	3359	1.6284E+06	1.6365E+06
3310	1.2745E+06	1.2809E+06	3360	1.6365E+06	1.6447E+06
3311	1.2809E+06	1.2873E+06	3361	1.6447E+06	1.6530E+06
3312	1.2873E+06	1.2938E+06	3362	1.6530E+06	1.6613E+06
3313	1.2938E+06	1.3003E+06	3363	1.6613E+06	1.6696E+06
3314	1.3003E+06	1.3068E+06	3364	1.6696E+06	1.6780E+06
3315	1.3068E+06	1.3134E+06	3365	1.6780E+06	1.6864E+06
3316	1.3134E+06	1.3199E+06	3366	1.6864E+06	1.6948E+06
3317	1.3199E+06	1.3266E+06	3367	1.6948E+06	1.7033E+06
3318	1.3266E+06	1.3332E+06	3368	1.7033E+06	1.7119E+06
3319	1.3332E+06	1.3399E+06	3369	1.7119E+06	1.7204E+06
3320	1.3399E+06	1.3466E+06	3370	1.7204E+06	1.7291E+06
3321	1.3466E+06	1.3533E+06	3371	1.7291E+06	1.7377E+06
3322	1.3533E+06	1.3601E+06	3372	1.7377E+06	1.7464E+06
3323	1.3601E+06	1.3669E+06	3373	1.7464E+06	1.7552E+06
3324	1.3669E+06	1.3738E+06	3374	1.7552E+06	1.7640E+06
3325	1.3738E+06	1.3807E+06	3375	1.7640E+06	1.7728E+06
3326	1.3807E+06	1.3876E+06	3376	1.7728E+06	1.7817E+06
3327	1.3876E+06	1.3946E+06	3377	1.7817E+06	1.7907E+06
3328	1.3946E+06	1.4016E+06	3378	1.7907E+06	1.7996E+06
3329	1.4016E+06	1.4086E+06	3379	1.7996E+06	1.8087E+06
3330	1.4086E+06	1.4156E+06	3380	1.8087E+06	1.8177E+06
3331	1.4156E+06	1.4227E+06	3381	1.8177E+06	1.8268E+06
3332	1.4227E+06	1.4299E+06	3382	1.8268E+06	1.8360E+06
3333	1.4299E+06	1.4370E+06	3383	1.8360E+06	1.8452E+06
3334	1.4370E+06	1.4442E+06	3384	1.8452E+06	1.8544E+06
3335	1.4442E+06	1.4515E+06	3385	1.8544E+06	1.8637E+06
3336	1.4515E+06	1.4588E+06	3386	1.8637E+06	1.8731E+06
3337	1.4588E+06	1.4661E+06	3387	1.8731E+06	1.8825E+06
3338	1.4661E+06	1.4734E+06	3388	1.8825E+06	1.8919E+06
3339	1.4734E+06	1.4808E+06	3389	1.8919E+06	1.9014E+06
3340	1.4808E+06	1.4882E+06	3390	1.9014E+06	1.9109E+06
3341	1.4882E+06	1.4957E+06	3391	1.9109E+06	1.9205E+06
3342	1.4957E+06	1.5032E+06	3392	1.9205E+06	1.9301E+06
3343	1.5032E+06	1.5107E+06	3393	1.9301E+06	1.9398E+06
3344	1.5107E+06	1.5183E+06	3394	1.9398E+06	1.9495E+06
3345	1.5183E+06	1.5259E+06	3395	1.9495E+06	1.9593E+06
3346	1.5259E+06	1.5335E+06	3396	1.9593E+06	1.9691E+06
3347	1.5335E+06	1.5412E+06	3397	1.9691E+06	1.9790E+06
3348	1.5412E+06	1.5490E+06	3398	1.9790E+06	1.9889E+06
3349	1.5490E+06	1.5567E+06	3399	1.9889E+06	1.9989E+06
3350	1.5567E+06	1.5645E+06	3400	1.9989E+06	2.0089E+06

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (3401 - 3500 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
3401	2.0089E+06	2.0190E+06	3451	2.5795E+06	2.5924E+06
3402	2.0190E+06	2.0291E+06	3452	2.5924E+06	2.6054E+06
3403	2.0291E+06	2.0392E+06	3453	2.6054E+06	2.6184E+06
3404	2.0392E+06	2.0495E+06	3454	2.6184E+06	2.6316E+06
3405	2.0495E+06	2.0597E+06	3455	2.6316E+06	2.6448E+06
3406	2.0597E+06	2.0701E+06	3456	2.6448E+06	2.6580E+06
3407	2.0701E+06	2.0804E+06	3457	2.6580E+06	2.6713E+06
3408	2.0804E+06	2.0909E+06	3458	2.6713E+06	2.6847E+06
3409	2.0909E+06	2.1014E+06	3459	2.6847E+06	2.6982E+06
3410	2.1014E+06	2.1119E+06	3460	2.6982E+06	2.7117E+06
3411	2.1119E+06	2.1225E+06	3461	2.7117E+06	2.7253E+06
3412	2.1225E+06	2.1331E+06	3462	2.7253E+06	2.7390E+06
3413	2.1331E+06	2.1438E+06	3463	2.7390E+06	2.7527E+06
3414	2.1438E+06	2.1545E+06	3464	2.7527E+06	2.7665E+06
3415	2.1545E+06	2.1653E+06	3465	2.7665E+06	2.7804E+06
3416	2.1653E+06	2.1762E+06	3466	2.7804E+06	2.7943E+06
3417	2.1762E+06	2.1871E+06	3467	2.7943E+06	2.8083E+06
3418	2.1871E+06	2.1981E+06	3468	2.8083E+06	2.8224E+06
3419	2.1981E+06	2.2091E+06	3469	2.8224E+06	2.8365E+06
3420	2.2091E+06	2.2202E+06	3470	2.8365E+06	2.8507E+06
3421	2.2202E+06	2.2313E+06	3471	2.8507E+06	2.8650E+06
3422	2.2313E+06	2.2425E+06	3472	2.8650E+06	2.8794E+06
3423	2.2425E+06	2.2537E+06	3473	2.8794E+06	2.8938E+06
3424	2.2537E+06	2.2650E+06	3474	2.8938E+06	2.9083E+06
3425	2.2650E+06	2.2764E+06	3475	2.9083E+06	2.9229E+06
3426	2.2764E+06	2.2878E+06	3476	2.9229E+06	2.9376E+06
3427	2.2878E+06	2.2992E+06	3477	2.9376E+06	2.9523E+06
3428	2.2992E+06	2.3108E+06	3478	2.9523E+06	2.9671E+06
3429	2.3108E+06	2.3224E+06	3479	2.9671E+06	2.9820E+06
3430	2.3224E+06	2.3340E+06	3480	2.9820E+06	2.9969E+06
3431	2.3340E+06	2.3457E+06	3481	2.9969E+06	3.0119E+06
3432	2.3457E+06	2.3575E+06	3482	3.0119E+06	3.0270E+06
3433	2.3575E+06	2.3693E+06	3483	3.0270E+06	3.0422E+06
3434	2.3693E+06	2.3811E+06	3484	3.0422E+06	3.0574E+06
3435	2.3811E+06	2.3931E+06	3485	3.0574E+06	3.0728E+06
3436	2.3931E+06	2.4051E+06	3486	3.0728E+06	3.0882E+06
3437	2.4051E+06	2.4171E+06	3487	3.0882E+06	3.1037E+06
3438	2.4171E+06	2.4292E+06	3488	3.1037E+06	3.1192E+06
3439	2.4292E+06	2.4414E+06	3489	3.1192E+06	3.1349E+06
3440	2.4414E+06	2.4537E+06	3490	3.1349E+06	3.1506E+06
3441	2.4537E+06	2.4660E+06	3491	3.1506E+06	3.1664E+06
3442	2.4660E+06	2.4783E+06	3492	3.1664E+06	3.1822E+06
3443	2.4783E+06	2.4907E+06	3493	3.1822E+06	3.1982E+06
3444	2.4907E+06	2.5032E+06	3494	3.1982E+06	3.2142E+06
3445	2.5032E+06	2.5158E+06	3495	3.2142E+06	3.2303E+06
3446	2.5158E+06	2.5284E+06	3496	3.2303E+06	3.2465E+06
3447	2.5284E+06	2.5411E+06	3497	3.2465E+06	3.2628E+06
3448	2.5411E+06	2.5538E+06	3498	3.2628E+06	3.2791E+06
3449	2.5538E+06	2.5666E+06	3499	3.2791E+06	3.2956E+06
3450	2.5666E+06	2.5795E+06	3500	3.2956E+06	3.3121E+06

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (3501 - 3600 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
3501	3.3121E+06	3.3287E+06	3551	4.2528E+06	4.2741E+06
3502	3.3287E+06	3.3454E+06	3552	4.2741E+06	4.2955E+06
3503	3.3454E+06	3.3622E+06	3553	4.2955E+06	4.3171E+06
3504	3.3622E+06	3.3790E+06	3554	4.3171E+06	4.3387E+06
3505	3.3790E+06	3.3959E+06	3555	4.3387E+06	4.3604E+06
3506	3.3959E+06	3.4130E+06	3556	4.3604E+06	4.3823E+06
3507	3.4130E+06	3.4301E+06	3557	4.3823E+06	4.4043E+06
3508	3.4301E+06	3.4473E+06	3558	4.4043E+06	4.4263E+06
3509	3.4473E+06	3.4645E+06	3559	4.4263E+06	4.4485E+06
3510	3.4645E+06	3.4819E+06	3560	4.4485E+06	4.4708E+06
3511	3.4819E+06	3.4994E+06	3561	4.4708E+06	4.4932E+06
3512	3.4994E+06	3.5169E+06	3562	4.4932E+06	4.5158E+06
3513	3.5169E+06	3.5345E+06	3563	4.5158E+06	4.5384E+06
3514	3.5345E+06	3.5523E+06	3564	4.5384E+06	4.5612E+06
3515	3.5523E+06	3.5701E+06	3565	4.5612E+06	4.5840E+06
3516	3.5701E+06	3.5880E+06	3566	4.5840E+06	4.6070E+06
3517	3.5880E+06	3.6059E+06	3567	4.6070E+06	4.6301E+06
3518	3.6059E+06	3.6240E+06	3568	4.6301E+06	4.6533E+06
3519	3.6240E+06	3.6422E+06	3569	4.6533E+06	4.6766E+06
3520	3.6422E+06	3.6604E+06	3570	4.6766E+06	4.7001E+06
3521	3.6604E+06	3.6788E+06	3571	4.7001E+06	4.7236E+06
3522	3.6788E+06	3.6972E+06	3572	4.7236E+06	4.7473E+06
3523	3.6972E+06	3.7157E+06	3573	4.7473E+06	4.7711E+06
3524	3.7157E+06	3.7343E+06	3574	4.7711E+06	4.7950E+06
3525	3.7343E+06	3.7531E+06	3575	4.7950E+06	4.8190E+06
3526	3.7531E+06	3.7719E+06	3576	4.8190E+06	4.8432E+06
3527	3.7719E+06	3.7908E+06	3577	4.8432E+06	4.8674E+06
3528	3.7908E+06	3.8098E+06	3578	4.8674E+06	4.8919E+06
3529	3.8098E+06	3.8289E+06	3579	4.8919E+06	4.9164E+06
3530	3.8289E+06	3.8481E+06	3580	4.9164E+06	4.9410E+06
3531	3.8481E+06	3.8674E+06	3581	4.9410E+06	4.9658E+06
3532	3.8674E+06	3.8868E+06	3582	4.9658E+06	4.9907E+06
3533	3.8868E+06	3.9062E+06	3583	4.9907E+06	5.0157E+06
3534	3.9062E+06	3.9258E+06	3584	5.0157E+06	5.0408E+06
3535	3.9258E+06	3.9455E+06	3585	5.0408E+06	5.0661E+06
3536	3.9455E+06	3.9652E+06	3586	5.0661E+06	5.0915E+06
3537	3.9652E+06	3.9851E+06	3587	5.0915E+06	5.1170E+06
3538	3.9851E+06	4.0051E+06	3588	5.1170E+06	5.1427E+06
3539	4.0051E+06	4.0252E+06	3589	5.1427E+06	5.1685E+06
3540	4.0252E+06	4.0454E+06	3590	5.1685E+06	5.1943E+06
3541	4.0454E+06	4.0657E+06	3591	5.1943E+06	5.2204E+06
3542	4.0657E+06	4.0861E+06	3592	5.2204E+06	5.2466E+06
3543	4.0861E+06	4.1065E+06	3593	5.2466E+06	5.2728E+06
3544	4.1065E+06	4.1271E+06	3594	5.2728E+06	5.2993E+06
3545	4.1271E+06	4.1478E+06	3595	5.2993E+06	5.3259E+06
3546	4.1478E+06	4.1686E+06	3596	5.3259E+06	5.3525E+06
3547	4.1686E+06	4.1895E+06	3597	5.3525E+06	5.3794E+06
3548	4.1895E+06	4.2105E+06	3598	5.3794E+06	5.4064E+06
3549	4.2105E+06	4.2316E+06	3599	5.4064E+06	5.4334E+06
3550	4.2316E+06	4.2528E+06	3600	5.4334E+06	5.4607E+06

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (3601 - 3700 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
3601	5.4607E+06	5.4881E+06	3651	7.0117E+06	7.0468E+06
3602	5.4881E+06	5.5155E+06	3652	7.0468E+06	7.0821E+06
3603	5.5155E+06	5.5432E+06	3653	7.0821E+06	7.1176E+06
3604	5.5432E+06	5.5710E+06	3654	7.1176E+06	7.1533E+06
3605	5.5710E+06	5.5989E+06	3655	7.1533E+06	7.1891E+06
3606	5.5989E+06	5.6270E+06	3656	7.1891E+06	7.2252E+06
3607	5.6270E+06	5.6552E+06	3657	7.2252E+06	7.2614E+06
3608	5.6552E+06	5.6835E+06	3658	7.2614E+06	7.2978E+06
3609	5.6835E+06	5.7120E+06	3659	7.2978E+06	7.3344E+06
3610	5.7120E+06	5.7407E+06	3660	7.3344E+06	7.3712E+06
3611	5.7407E+06	5.7694E+06	3661	7.3712E+06	7.4080E+06
3612	5.7694E+06	5.7983E+06	3662	7.4080E+06	7.4452E+06
3613	5.7983E+06	5.8274E+06	3663	7.4452E+06	7.4826E+06
3614	5.8274E+06	5.8567E+06	3664	7.4826E+06	7.5201E+06
3615	5.8567E+06	5.8860E+06	3665	7.5201E+06	7.5577E+06
3616	5.8860E+06	5.9155E+06	3666	7.5577E+06	7.5957E+06
3617	5.9155E+06	5.9452E+06	3667	7.5957E+06	7.6338E+06
3618	5.9452E+06	5.9749E+06	3668	7.6338E+06	7.6719E+06
3619	5.9749E+06	6.0049E+06	3669	7.6719E+06	7.7104E+06
3620	6.0049E+06	6.0350E+06	3670	7.7104E+06	7.7491E+06
3621	6.0350E+06	6.0652E+06	3671	7.7491E+06	7.7879E+06
3622	6.0652E+06	6.0956E+06	3672	7.7879E+06	7.8270E+06
3623	6.0956E+06	6.1262E+06	3673	7.8270E+06	7.8662E+06
3624	6.1262E+06	6.1569E+06	3674	7.8662E+06	7.9056E+06
3625	6.1569E+06	6.1878E+06	3675	7.9056E+06	7.9452E+06
3626	6.1878E+06	6.2188E+06	3676	7.9452E+06	7.9851E+06
3627	6.2188E+06	6.2499E+06	3677	7.9851E+06	8.0251E+06
3628	6.2499E+06	6.2813E+06	3678	8.0251E+06	8.0653E+06
3629	6.2813E+06	6.3128E+06	3679	8.0653E+06	8.1058E+06
3630	6.3128E+06	6.3444E+06	3680	8.1058E+06	8.1463E+06
3631	6.3444E+06	6.3762E+06	3681	8.1463E+06	8.1872E+06
3632	6.3762E+06	6.4082E+06	3682	8.1872E+06	8.2283E+06
3633	6.4082E+06	6.4403E+06	3683	8.2283E+06	8.2694E+06
3634	6.4403E+06	6.4726E+06	3684	8.2694E+06	8.3109E+06
3635	6.4726E+06	6.5050E+06	3685	8.3109E+06	8.3526E+06
3636	6.5050E+06	6.5376E+06	3686	8.3526E+06	8.3944E+06
3637	6.5376E+06	6.5704E+06	3687	8.3944E+06	8.4365E+06
3638	6.5704E+06	6.6033E+06	3688	8.4365E+06	8.4789E+06
3639	6.6033E+06	6.6365E+06	3689	8.4789E+06	8.5214E+06
3640	6.6365E+06	6.6697E+06	3690	8.5214E+06	8.5640E+06
3641	6.6697E+06	6.7031E+06	3691	8.5640E+06	8.6070E+06
3642	6.7031E+06	6.7368E+06	3692	8.6070E+06	8.6502E+06
3643	6.7368E+06	6.7705E+06	3693	8.6502E+06	8.6935E+06
3644	6.7705E+06	6.8044E+06	3694	8.6935E+06	8.7371E+06
3645	6.8044E+06	6.8386E+06	3695	8.7371E+06	8.7809E+06
3646	6.8386E+06	6.8728E+06	3696	8.7809E+06	8.8248E+06
3647	6.8728E+06	6.9073E+06	3697	8.8248E+06	8.8691E+06
3648	6.9073E+06	6.9419E+06	3698	8.8691E+06	8.9136E+06
3649	6.9419E+06	6.9767E+06	3699	8.9136E+06	8.9582E+06
3650	6.9767E+06	7.0117E+06	3700	8.9582E+06	9.0031E+06

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (3701 - 3800 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
3701	9.0031E+06	9.0483E+06	3751	1.1560E+07	1.1618E+07
3702	9.0483E+06	9.0936E+06	3752	1.1618E+07	1.1676E+07
3703	9.0936E+06	9.1392E+06	3753	1.1676E+07	1.1735E+07
3704	9.1392E+06	9.1851E+06	3754	1.1735E+07	1.1794E+07
3705	9.1851E+06	9.2310E+06	3755	1.1794E+07	1.1853E+07
3706	9.2310E+06	9.2773E+06	3756	1.1853E+07	1.1912E+07
3707	9.2773E+06	9.3239E+06	3757	1.1912E+07	1.1972E+07
3708	9.3239E+06	9.3705E+06	3758	1.1972E+07	1.2032E+07
3709	9.3705E+06	9.4175E+06	3759	1.2032E+07	1.2092E+07
3710	9.4175E+06	9.4648E+06	3760	1.2092E+07	1.2153E+07
3711	9.4648E+06	9.5121E+06	3761	1.2153E+07	1.2214E+07
3712	9.5121E+06	9.5598E+06	3762	1.2214E+07	1.2275E+07
3713	9.5598E+06	9.6078E+06	3763	1.2275E+07	1.2337E+07
3714	9.6078E+06	9.6560E+06	3764	1.2337E+07	1.2399E+07
3715	9.6560E+06	9.7043E+06	3765	1.2399E+07	1.2461E+07
3716	9.7043E+06	9.7530E+06	3766	1.2461E+07	1.2523E+07
3717	9.7530E+06	9.8019E+06	3767	1.2523E+07	1.2586E+07
3718	9.8019E+06	9.8510E+06	3768	1.2586E+07	1.2649E+07
3719	9.8510E+06	9.9004E+06	3769	1.2649E+07	1.2712E+07
3720	9.9004E+06	9.9501E+06	3770	1.2712E+07	1.2776E+07
3721	9.9501E+06	9.9998E+06	3771	1.2776E+07	1.2840E+07
3722	9.9998E+06	1.0050E+07	3772	1.2840E+07	1.2904E+07
3723	1.0050E+07	1.0100E+07	3773	1.2904E+07	1.2969E+07
3724	1.0100E+07	1.0151E+07	3774	1.2969E+07	1.3034E+07
3725	1.0151E+07	1.0202E+07	3775	1.3034E+07	1.3099E+07
3726	1.0202E+07	1.0253E+07	3776	1.3099E+07	1.3165E+07
3727	1.0253E+07	1.0304E+07	3777	1.3165E+07	1.3231E+07
3728	1.0304E+07	1.0356E+07	3778	1.3231E+07	1.3297E+07
3729	1.0356E+07	1.0408E+07	3779	1.3297E+07	1.3364E+07
3730	1.0408E+07	1.0460E+07	3780	1.3364E+07	1.3431E+07
3731	1.0460E+07	1.0513E+07	3781	1.3431E+07	1.3498E+07
3732	1.0513E+07	1.0565E+07	3782	1.3498E+07	1.3566E+07
3733	1.0565E+07	1.0618E+07	3783	1.3566E+07	1.3634E+07
3734	1.0618E+07	1.0671E+07	3784	1.3634E+07	1.3702E+07
3735	1.0671E+07	1.0725E+07	3785	1.3702E+07	1.3771E+07
3736	1.0725E+07	1.0779E+07	3786	1.3771E+07	1.3840E+07
3737	1.0779E+07	1.0833E+07	3787	1.3840E+07	1.3909E+07
3738	1.0833E+07	1.0887E+07	3788	1.3909E+07	1.3979E+07
3739	1.0887E+07	1.0942E+07	3789	1.3979E+07	1.4049E+07
3740	1.0942E+07	1.0996E+07	3790	1.4049E+07	1.4120E+07
3741	1.0996E+07	1.1052E+07	3791	1.4120E+07	1.4191E+07
3742	1.1052E+07	1.1107E+07	3792	1.4191E+07	1.4262E+07
3743	1.1107E+07	1.1163E+07	3793	1.4262E+07	1.4333E+07
3744	1.1163E+07	1.1219E+07	3794	1.4333E+07	1.4405E+07
3745	1.1219E+07	1.1275E+07	3795	1.4405E+07	1.4477E+07
3746	1.1275E+07	1.1331E+07	3796	1.4477E+07	1.4550E+07
3747	1.1331E+07	1.1388E+07	3797	1.4550E+07	1.4623E+07
3748	1.1388E+07	1.1445E+07	3798	1.4623E+07	1.4696E+07
3749	1.1445E+07	1.1503E+07	3799	1.4696E+07	1.4770E+07
3750	1.1503E+07	1.1560E+07	3800	1.4770E+07	1.4844E+07

TABLE 2.1 ENERGY GROUP STRUCTURE (CONTINUED)
 NEUTRON ENERGY GROUP (EV) (3801 - 3824 GROUPS).

NO.	LOWER	UPPER
3801	1.4844E+07	1.4918E+07
3802	1.4918E+07	1.4993E+07
3803	1.4993E+07	1.5068E+07
3804	1.5068E+07	1.5144E+07
3805	1.5144E+07	1.5219E+07
3806	1.5219E+07	1.5296E+07
3807	1.5296E+07	1.5372E+07
3808	1.5372E+07	1.5449E+07
3809	1.5449E+07	1.5527E+07
3810	1.5527E+07	1.5605E+07
3811	1.5605E+07	1.5683E+07
3812	1.5683E+07	1.5762E+07
3813	1.5762E+07	1.5841E+07
3814	1.5841E+07	1.5920E+07
3815	1.5920E+07	1.6000E+07
3816	1.6000E+07	1.6080E+07
3817	1.6080E+07	1.6161E+07
3818	1.6161E+07	1.6242E+07
3819	1.6242E+07	1.6323E+07
3820	1.6323E+07	1.6405E+07
3821	1.6405E+07	1.6487E+07
3822	1.6487E+07	1.6570E+07
3823	1.6570E+07	1.6653E+07
3824	1.6653E+07	1.6736E+07

TABLE 2.2 ENERGY GROUP STRUCTURE

NEUTRON ENERGY GROUP (EV) (1 - 100 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
1	1.4550E+07	1.6487E+07	51	2.8088E+04	3.1828E+04
2	1.2840E+07	1.4550E+07	52	2.4788E+04	2.8088E+04
3	1.1331E+07	1.2840E+07	53	2.1875E+04	2.4788E+04
4	1.0000E+07	1.1331E+07	54	1.9305E+04	2.1875E+04
5	8.8250E+06	1.0000E+07	55	1.7036E+04	1.9305E+04
6	7.7880E+06	8.8250E+06	56	1.5034E+04	1.7036E+04
7	6.8729E+06	7.7880E+06	57	1.1709E+04	1.5034E+04
8	6.0653E+06	6.8729E+06	58	9.1188E+03	1.1709E+04
9	5.3526E+06	6.0653E+06	59	7.1017E+03	9.1188E+03
10	4.7237E+06	5.3526E+06	60	5.5308E+03	7.1017E+03
11	4.1686E+06	4.7237E+06	61	4.3074E+03	5.5308E+03
12	3.6788E+06	4.1686E+06	62	3.3546E+03	4.3074E+03
13	3.2465E+06	3.6788E+06	63	2.6126E+03	3.3546E+03
14	2.8650E+06	3.2465E+06	64	2.0347E+03	2.6126E+03
15	2.5284E+06	2.8650E+06	65	1.5846E+03	2.0347E+03
16	2.2313E+06	2.5284E+06	66	1.2341E+03	1.5846E+03
17	1.9691E+06	2.2313E+06	67	9.6112E+02	1.2341E+03
18	1.7377E+06	1.9691E+06	68	7.4852E+02	9.6112E+02
19	1.5335E+06	1.7377E+06	69	5.8295E+02	7.4852E+02
20	1.3534E+06	1.5335E+06	70	4.5400E+02	5.8295E+02
21	1.1943E+06	1.3534E+06	71	3.5357E+02	4.5400E+02
22	1.0540E+06	1.1943E+06	72	2.7536E+02	3.5357E+02
23	9.3014E+05	1.0540E+06	73	2.1445E+02	2.7536E+02
24	8.2085E+05	9.3014E+05	74	1.6702E+02	2.1445E+02
25	7.2440E+05	8.2085E+05	75	1.3007E+02	1.6702E+02
26	6.3928E+05	7.2440E+05	76	1.0130E+02	1.3007E+02
27	5.6416E+05	6.3928E+05	77	7.8893E+01	1.0130E+02
28	4.9787E+05	5.6416E+05	78	6.1442E+01	7.8893E+01
29	4.3937E+05	4.9787E+05	79	4.7851E+01	6.1442E+01
30	3.8774E+05	4.3937E+05	80	3.7267E+01	4.7851E+01
31	3.4218E+05	3.8774E+05	81	2.9023E+01	3.7267E+01
32	3.0197E+05	3.4218E+05	82	2.2603E+01	2.9023E+01
33	2.6649E+05	3.0197E+05	83	1.7603E+01	2.2603E+01
34	2.3518E+05	2.6649E+05	84	1.3710E+01	1.7603E+01
35	2.0754E+05	2.3518E+05	85	1.0677E+01	1.3710E+01
36	1.8316E+05	2.0754E+05	86	8.3153E+00	1.0677E+01
37	1.6163E+05	1.8316E+05	87	6.4760E+00	8.3153E+00
38	1.4264E+05	1.6163E+05	88	5.0435E+00	6.4760E+00
39	1.2588E+05	1.4264E+05	89	3.9279E+00	5.0435E+00
40	1.1109E+05	1.2588E+05	90	3.0590E+00	3.9279E+00
41	9.8037E+04	1.1109E+05	91	2.3824E+00	3.0590E+00
42	8.6517E+04	9.8037E+04	92	1.8554E+00	2.3824E+00
43	7.6351E+04	8.6517E+04	93	1.4450E+00	1.8554E+00
44	6.7379E+04	7.6351E+04	94	1.1254E+00	1.4450E+00
45	5.9462E+04	6.7379E+04	95	8.7642E-01	1.1254E+00
46	5.2475E+04	5.9462E+04	96	6.8256E-01	8.7642E-01
47	4.6309E+04	5.2475E+04	97	5.3158E-01	6.8256E-01
48	4.0868E+04	4.6309E+04	98	4.1399E-01	5.3158E-01
49	3.6066E+04	4.0868E+04	99	1.5183E-01	4.1399E-01
50	3.1828E+04	3.6066E+04	100	3.5238E-04	1.5183E-01

TABLE 2.3 ENERGY GROUP STRUCTURE
PHOTON ENERGY GROUP (EV)

NO.	LOWER	UPPER
1	1.2000E+07	1.4000E+07
2	1.0000E+07	1.2000E+07
3	8.0000E+06	1.0000E+07
4	6.5000E+06	8.0000E+06
5	5.0000E+06	6.5000E+06
6	4.0000E+06	5.0000E+06
7	3.0000E+06	4.0000E+06
8	2.5000E+06	3.0000E+06
9	2.0000E+06	2.5000E+06
10	1.6600E+06	2.0000E+06
11	1.3300E+06	1.6600E+06
12	1.0000E+06	1.3300E+06
13	8.0000E+05	1.0000E+06
14	6.0000E+05	8.0000E+05
15	4.0000E+05	6.0000E+05
16	3.0000E+05	4.0000E+05
17	2.0000E+05	3.0000E+05
18	1.0000E+05	2.0000E+05
19	5.0000E+04	1.0000E+05
20	2.0000E+04	5.0000E+04

TABLE 2.4 ENERGY GROUP STRUCTURE

NEUTRON ENERGY GROUP (EV) (1 - 100 GROUPS)

NO.	LOWER	UPPER	NO.	LOWER	UPPER
1	1.4550E+07	1.6487E+07	51	2.8088E+04	3.1828E+04
2	1.2840E+07	1.4550E+07	52	2.4788E+04	2.8088E+04
3	1.1331E+07	1.2840E+07	53	2.1875E+04	2.4788E+04
4	1.0000E+07	1.1331E+07	54	1.9305E+04	2.1875E+04
5	8.8250E+06	1.0000E+07	55	1.7036E+04	1.9305E+04
6	7.7880E+06	8.8250E+06	56	1.5034E+04	1.7036E+04
7	6.8729E+06	7.7880E+06	57	1.1709E+04	1.5034E+04
8	6.0653E+06	6.8729E+06	58	9.1188E+03	1.1709E+04
9	5.3526E+06	6.0653E+06	59	7.1017E+03	9.1188E+03
10	4.7237E+06	5.3526E+06	60	5.5308E+03	7.1017E+03
11	4.1686E+06	4.7237E+06	61	4.3074E+03	5.5308E+03
12	3.6788E+06	4.1686E+06	62	3.3546E+03	4.3074E+03
13	3.2465E+06	3.6788E+06	63	2.6126E+03	3.3546E+03
14	2.8650E+06	3.2465E+06	64	2.0347E+03	2.6126E+03
15	2.5284E+06	2.8650E+06	65	1.5846E+03	2.0347E+03
16	2.2313E+06	2.5284E+06	66	1.2341E+03	1.5846E+03
17	1.9691E+06	2.2313E+06	67	9.6112E+02	1.2341E+03
18	1.7377E+06	1.9691E+06	68	7.4852E+02	9.6112E+02
19	1.5335E+06	1.7377E+06	69	5.8295E+02	7.4852E+02
20	1.3534E+06	1.5335E+06	70	4.5400E+02	5.8295E+02
21	1.1943E+06	1.3534E+06	71	3.5357E+02	4.5400E+02
22	1.0540E+06	1.1943E+06	72	2.7536E+02	3.5357E+02
23	9.3014E+05	1.0540E+06	73	2.1445E+02	2.7536E+02
24	8.2085E+05	9.3014E+05	74	1.6702E+02	2.1445E+02
25	7.2440E+05	8.2085E+05	75	1.3007E+02	1.6702E+02
26	6.3928E+05	7.2440E+05	76	1.0130E+02	1.3007E+02
27	5.6416E+05	6.3928E+05	77	7.8893E+01	1.0130E+02
28	4.9787E+05	5.6416E+05	78	6.1442E+01	7.8893E+01
29	4.3937E+05	4.9787E+05	79	4.7851E+01	6.1442E+01
30	3.8774E+05	4.3937E+05	80	3.7267E+01	4.7851E+01
31	3.4218E+05	3.8774E+05	81	2.9023E+01	3.7267E+01
32	3.0197E+05	3.4218E+05	82	2.2603E+01	2.9023E+01
33	2.6649E+05	3.0197E+05	83	1.7603E+01	2.2603E+01
34	2.3518E+05	2.6649E+05	84	1.3710E+01	1.7603E+01
35	2.0754E+05	2.3518E+05	85	1.0677E+01	1.3710E+01
36	1.8316E+05	2.0754E+05	86	8.3153E+00	1.0677E+01
37	1.6163E+05	1.8316E+05	87	6.4760E+00	8.3153E+00
38	1.4264E+05	1.6163E+05	88	5.0435E+00	6.4760E+00
39	1.2588E+05	1.4264E+05	89	3.9279E+00	5.0435E+00
40	1.1109E+05	1.2588E+05	90	3.0590E+00	3.9279E+00
41	9.8037E+04	1.1109E+05	91	2.3824E+00	3.0590E+00
42	8.6517E+04	9.8037E+04	92	1.8554E+00	2.3824E+00
43	7.6351E+04	8.6517E+04	93	1.6374E+00	1.8554E+00
44	6.7379E+04	7.6351E+04	94	1.4450E+00	1.6374E+00
45	5.9462E+04	6.7379E+04	95	1.2752E+00	1.4450E+00
46	5.2475E+04	5.9462E+04	96	1.1254E+00	1.2752E+00
47	4.6309E+04	5.2475E+04	97	9.9312E-01	1.1254E+00
48	4.0868E+04	4.6309E+04	98	8.7642E-01	9.9312E-01
49	3.6066E+04	4.0868E+04	99	7.7344E-01	8.7642E-01
50	3.1828E+04	3.6066E+04	100	6.8256E-01	7.7344E-01

TABLE 2.4 ENERGY GROUP STRUCTURE (CONTINUED)

NEUTRON ENERGY GROUP (EV) (101 - 137 GROUPS)

NO.	LOWER	UPPER
101	6.0236E-01	6.8256E-01
102	5.3158E-01	6.0236E-01
103	4.6912E-01	5.3158E-01
104	4.1399E-01	4.6912E-01
105	3.8925E-01	4.1399E-01
106	3.6528E-01	3.8925E-01
107	3.4206E-01	3.6528E-01
108	3.1961E-01	3.4206E-01
109	2.9792E-01	3.1961E-01
110	2.7699E-01	2.9792E-01
111	2.5683E-01	2.7699E-01
112	2.3742E-01	2.5683E-01
113	2.1878E-01	2.3742E-01
114	2.0090E-01	2.1878E-01
115	1.8378E-01	2.0090E-01
116	1.6743E-01	1.8378E-01
117	1.5183E-01	1.6743E-01
118	1.3700E-01	1.5183E-01
119	1.2293E-01	1.3700E-01
120	1.0963E-01	1.2293E-01
121	9.7080E-02	1.0963E-01
122	8.5297E-01	9.7080E-02
123	7.4276E-02	8.5297E-01
124	6.4017E-02	7.4276E-02
125	5.4520E-02	6.4017E-02
126	4.5785E-02	5.4520E-02
127	3.7813E-02	4.5785E-02
128	3.0602E-02	3.7813E-02
129	2.4153E-02	3.0602E-02
130	1.8467E-02	2.4153E-02
131	1.3543E-02	1.8467E-02
132	9.3805E-03	1.3543E-02
133	5.9803E-03	9.3805E-03
134	3.3422E-03	5.9803E-03
135	1.4663E-03	3.3422E-03
136	3.5236E-04	1.4663E-03
137	3.3100E-05	3.5236E-04

3. Nuclide and Material Identification

The JSD1000 library contains 42 nuclides which are generally used as source, shielding, structure and detector materials as shown in Table 3.1. Temperature dependent data at 300, 560 and 900 K are also considered for all of the nuclides.

Data included in the library are i) ultra-fine group cross section, ii) infinite dilution group cross section, iii) group to group transfer matrix, iv) self-shielding factor of the Bondarenko-type, v) atomic displacement cross section and energy deposition factor, vi) secondary gamma-ray production cross section and vii) effective macroscopic cross section.

Many types of data mentioned above are identified by node names which are defined by 4-characters. Node names are related with the hierarchy of data, and classified according to tree structures. These node names recorded in the JSD1000 library are used to read and/or write the data, and controlled by a "DATA-POOL" access package¹¹⁾ which is a direct-access data base management sub-system in the RADHEAT-V4 code system. Arbitrary data included in the JSD1000 library will be easily obtained by indicating the node name. For the above reason, the DATA-POOL access package must be used to utilize the JSD1000 library.

Node name structures and definitions for each group cross section data are described in the following sections.

Descriptions of the DATA-POOL access package and structures of the JSD1000 library are given in Chapt. 5. A method of utilization for JSD1000 is also described in this Chapter.

Table 3.1 Nuclides and node names contained in JSD1000

NODE NAME	NUCLIDE NAME	CONTENTS
* 1130	W-184 FROM ENDF/B-IV	SMT FTB ELA INS N2N
1128	W-182 FROM ENDF/B-IV	SMT FTB ELA INS N2N
1129	W-183 FROM ENDF/B-IV	SMT FTB ELA INS N2N
1131	W-186 FROM ENDF/B-IV	SMT FTB ELA INS N2N
1272	LI-7 FROM ENDF/B-IV	SMT FTB ELA INS N2N
1261	U-235 FROM ENDF/B-IV	SMT FTB ELA INS N2N
1262	U-238 FROM ENDF/B-IV	SMT FTB ELA INS N2N
1264	PU-239 FROM ENDF/B-IV	SMT FTB ELA INS N2N
1274	C FROM ENDF/B-IV	SMT FTB H+D ELA INS
1266	PU-241 FROM ENDF/B-IV	SMT FTB ELA INS N2N
1050	PU-238 FROM ENDF/B-IV	SMT FTB ELA INS N2N
1150	K FROM ENDF/B-IV	SMT FTB ELA INS N2N
1194	SI FROM ENDF/B-IV	SMT FTB ELA INS N2N
1161	PU-242 FROM ENDF/B-IV	SMT FTB ELA INS N2N
1265	PU-240 FROM ENDF/B-IV	SMT FTB ELA INS N2N
1263	NP-237 FROM ENDF/B-IV	SMT FTB ELA INS N2N
1283	AU FROM ENDF/B-IV	SMT FTB ELA INS N2N
1288	PB FROM ENDF/B-IV	SMT FTB H+D ELA INS N2N
1189	NB FROM ENDF/B-IV	SMT FTB ELA INS N2N
1056	AM-241 FROM ENDF/B-IV	SMT FTB ELA INS
131	KR-80 FROM ENDF/B-IV	SMT FTB ELA INS N2N

Table 3.1 (continued)

NODE NAME	NUCLIDE NAME	CONTENTS
1192	FE FROM ENDF/B-IV	SMT FTB H+D ELA INS N2N
1193	AL FROM ENDF/B-IV	SMT FTB H+D ELA INS N2N
1191	CR FROM ENDF/B-IV	SMT FTB H+D ELA INS N2N
1197	MN FROM ENDF/B-IV	SMT FTB H+D ELA INS N2N
1295	CU FROM ENDF/B-IV	SMT FTB H+D ELA INS N2N
1287	MO FROM ENDF/B-IV	SMT FTB H+D ELA INS N2N
1280	MG FROM ENDF/B-IV	SMT FTB ELA INS N2N
1273	B-10 FROM ENDF/B-IV	SMT FTB ELA INS
1271	LI-6 FROM ENDF/B-IV	SMT FTB ELA INS
1160	B-11 FROM ENDF/B-IV	SMT FTB ELA INS N2N
1269	1-H-1 FROM ENDF/B-IV	SMT FTB ELA
1289	BE FROM ENDF/B-IV	SMT FTB ELA N2N
1195	CA FROM ENDF/B-IV	SMT FTB ELA INS N2N
1156	NA FROM ENDF/B-IV	SMT FTB ELA INS N2N
1275	N FROM ENDF/B-IV	SMT FTB ELA INS N2N
1276	O FROM ENDF/B-IV	SMT FTB ELA INS
1199	CO-59 FROM ENDF/B-IV	SMT FTB ELA INS N2N
1281	CD FROM ENDF/B-IV	SMT FTB ELA INS N2N
1284	ZR FROM ENDF/B-IV	SMT FTB ELA INS N2N
1277	F FROM ENDF/B-IV	SMT FTB ELA INS N2N
1190	NI FROM ENDF/B-IV	SMT FTB ELA INS N2N

3.1 Fine-Group Cross Section

The fine-group cross section library contains 6 kinds of data described below.

- i) Smooth cross sections of each reaction.
- ii) Self-shielding factors.
- iii) Atomic displacement cross section and energy deposition factors.
- iv) Elastic scattering group to group transfer matrix.
- v) Inelastic scattering group to group transfer matrix.
- vi) ($n,2n$) scattering group to group transfer matrix.

```

EGRP ( NEUTRON AND GAMMA-RAY ENERGY STRUCTURE
I
I-----INFX ( INFINITE DILUTION CROSS SECTION
I
I-----1192 ( 1192 FE FROM ENDF/B-IV
I
I----- SMT ( SMOOTH CROSS SECTION
I
I----- FTB ( F-TABLE LIBRARY
I
I----- H+D ( HEAT GENERATION AND DISPLACEMENT CROSS SECTION
I
I----- ELA ( ELASTIC SCATTERING MATRIX
I
I----- INS ( INELASTIC SCATTERING MATRIX
I
I----- N2N ( (N,2N) SCATTERING MATRIX
I
I-----1193 ( 1193 AL FROM ENDF/B-IV
I
I----- SMT ( SMOOTH CROSS SECTION
I
I----- FTB ( F-TABLE LIBRARY
I
I----- H+D ( HEAT GENERATION AND DISPLACEMENT CROSS SECTION
I
I----- ELA ( ELASTIC SCATTERING MATRIX
I
I----- INS ( INELASTIC SCATTERING MATRIX
I
I----- N2N ( (N,2N) SCATTERING MATRIX

```

Fig. 3.1 Typical node structure of the fine-group cross section library

A typical tree structure of the fine-group cross section is shown in Fig. 3.1. The first node name is used as an identification of energy group structure. The energy group structure adopted in JSD1000 is defined as a node name of EGRP. The second node name INFX shows the fine-group cross section data. The third node name is used as a nuclide

identification. The nuclide identification number for the JSD1000 library is the same as the material number in ENDF/B-IV. The fourth node name indicates each type of data described in Table 3.2.

Table 3.2 Node names associated with the data contained in the fine-group cross section library

NODE NAME	DATA INFORMATION
SMT	SMOOTH CROSS SECTION
FTB	F-TABLE LIBRARY
H+D	HEAT GENERATION AND DISPLACEMENT CROSS SECTION
ELA	ELASTIC SCATTERING MATRIX
INS	INELASTIC SCATTERING MATRIX
N2N	(N,2N) SCATTERING MATRIX

SMT shows the smooth cross sections of each reaction. Reactions contained in the data are identified by the MT number described in Table 3.3. The smooth cross section means infinitely diluted cross section which is calculated by a condition of $\sigma_0 = 10^8$. The record format of the data is described in Chapt. 5.

Table 3.3 Reaction types and identification numbers in the smooth cross section data

No.	Reaction Type
1	Total cross section
2	Elastic scattering cross section
4	Total inelastic cross section
16	(n,2n) cross section
18	Total fission cross section
27	Absorption cross section
102	(n, γ) radiative capture cross section
103	(n,p) cross section
107	(n, α) cross section
452	\bar{v} , average total (prompt plus delayed) number of neutrons released per fission event

FTB shows the Bondarenko-type self-shielding factor of each reaction. Reactions contained in the data are total, elastic, fission and capture. The self-shielding factors are presented for each background cross section of $\sigma_0 = 0, 1, 10, 100, 1000$ and 10000 .

H+D shows the atomic displacement cross section and energy deposition factor of each reaction. The data are utilized for the evaluation of radiation damage and heating in the shielding materials. Reactions contained in the data are described in Table 3.4.

Table 3.4 Reaction type and identification number in the H+D data

No.	Reaction Type
1002	Heat generation by elastic scattering
1004	Heat generation by inelastic reaction
1016	Heat generation by $(n,2n)$ reaction
1018	Heat generation by fission reaction
1102	Heat generation by (n,γ) reaction
1103	Heat generation by (n,p) reaction
1107	Heat generation by (n,α) reaction
2002	Atomic displacement by elastic scattering
2004	Atomic displacement by inelastic reaction
2016	Atomic displacement by $(n,2n)$ reaction
2102	Atomic displacement by (n,γ) reaction
2103	Atomic displacement by (n,p) reaction
2107	Atomic displacement by (n,α) reaction

ELA shows the group to group transfer matrix of elastic scattering. Angular distributions of each group to group transfer cross section are given by the form of Direct Angular Representation which is directly defined as a function of cosine of scattering angle. The scattering angular distribution of the DAR form is newly applied to the JSD1000 library in order to eliminate negative values of cross sections introduced from finite Legendre expansion. The data in the DAR form of the JSD1000 library are presented by the tabulated data $[\cos \beta, \sigma(\cos \beta)]$. The $\cos \beta$ is a direction cosine of a scattering angle and this table can be interpolated by linear in $\cos \beta$. The data format of the DAR form is described in Chapt. 5, and the method for producing the angular dis-

tribution of scattering cross section is shown in Chapt. 4.

INS shows the group to group transfer matrix of inelastic scattering. Angular distributions of each group to group transfer cross section are also given by the DAR form. The data format is the same as the data of node ELA described in Chapt. 5.

N2N shows the group to group transfer matrix of ($n,2n$) scattering. Angular distributions of each group to group transfer cross section are given in the same format of the data of node ELA.

The fine-group cross section library contains above six kind of data of each nuclide described in Table 3.1. The data at the temperature of 300, 560 and 900 K are prepared in the fine-group cross section library.

Adopted weighting function to produce the fine-group cross section consists of three parts of fission spectrum, $1/E$ and thermal Maxwellian. It is defined by the following equation.

$$\phi(E, \sigma_0, T) = \frac{\phi_s(E, T)}{\sigma_t(E, T) + \sigma_0} , \quad (3.1)$$

$$\phi_s(E, T) = \begin{cases} \sqrt{E} \exp(-E/T_n) & 0.8205 \text{ MeV} \leq E \\ 1/E & 0.125 \text{ eV} < E < 0.8205 \text{ MeV} \\ E \exp(-E/kT) , & E \leq 0.125 \text{ eV} \end{cases} \quad (3.2)$$

where σ_t is total cross section, σ_0 the background cross section, k the Boltzmann constant and T_n the neutron temperature of fission spectrum which is assumed to be 1.4 MeV.

3.2 Effective Macroscopic Cross Section

Neutron and gamma-ray coupled group cross section library is produced for typical shielding or structural materials described in Table 3.5. Atomic compositions and atomic number densities of these materials are also shown in this table. Typical node structure of the effective macroscopic cross section library is shown in Fig. 3.2.

```

EGRP < NEUTRON AND GAMMA-RAY ENERGY STRUCTURE
I
I-----SELF (SELF-SHIELDING FACTOR LIBRARY
I
I-----160  < STANDARD AIR (20 CENT.) DENSITY:1.2049 KG/M3
I
I-----1269 < 1269 1-H-1 FROM ENDF/B-IV
I
I-----1274 < 1274 C FROM ENDF/B-IV
I
I-----1275 < 1275 N FROM ENDF/B-IV
I
I-----1276 < 1276 O FROM ENDF/B-IV
I
I-----161  < PARTICULAR      AIR      DENSITY:1.1503 KG/M3
I
I-----1269 < 1269 1-H-1 FROM ENDF/B-IV
I
I-----1275 < 1275 N FROM ENDF/B-IV
I
I-----1276 < 1276 O FROM ENDF/B-IV
I
I-----170  < SOIL        (N.T.S.)  DENSITY:1.7 G/CM3 AT NEVADA TEST SITE
I
I-----1269 < 1269 1-H-1 FROM ENDF/B-IV
I
I-----1276 < 1276 O FROM ENDF/B-IV
I
I-----1193 < 1193 AL FROM ENDF/B-IV
I
I-----1194 < 1194 SI FROM ENDF/B-IV
I
I-----FX32 (D.A.R. CROSS SECTION SETS  32 ANGULAR POINTS
I
I-----160  < STANDARD AIR (20 CENT.) DENSITY:1.2049 KG/M3
I
I-----161  < PARTICULAR      AIR      DENSITY:1.1503 KG/M3
I
I-----170  < SOIL        (N.T.S.)  DENSITY:1.7 G/CM3 AT NEVADA TEST SITE

```

Fig. 3.2 Typical node structure of the effective macroscopic cross section library

The first node name shows the energy group structure. The second node name SELF shows a branch of self-shielding factors for the material. The another node name FX32 indicates a branch of the data for the effective macroscopic cross section. Angular distributions of scattering matrix are given by each discrete angular mesh with 32 points defined in Table 3.6

The angular distributions are produced by averaging the interpolated values of the DAR data described in the previous section. The

third node name shows the material identification number. The data of cross section belong to the third node name of the FX32 branch. The data of the self-shielding factor belong to the fourth node name of the SELF branch. The self-shielding factors are given by the determined background cross section of each nuclide which is included in the material. The data are utilized to collapse the energy groups of the effective macroscopic cross section. The method to produce the effective macroscopic cross section is described in Chapt. 4. The record format of the data is described in Chapt. 5.

Table 3.5 Materials and atomic compositions contained in
the effective macroscopic cross section library

RADHEAT-V4 DATA POOL (J3679. FNSPOOL2. DATA) : REVISED JULY 14 '82

MATERIAL NAME	STANDARD AIR (20 CENT.)	PARTICULAR AIR	SOIL (N. T. S.)	IRON (7. 87 G/CM3)	HIROSIMA AIR (EXCLUDE AR)
NODE NAME	160	161	170	200	162
NUCLIDE	ATOM DENSITY (n/barn·cm)				
1- H-	7. 1990×10 ⁻⁹	1. 1926×10 ⁻⁶	9. 7700×10 ⁻³		1. 1770×10 ⁻⁶
6- C-	7. 5846×10 ⁻⁹				3. 6760×10 ⁻⁵
7- N-	3. 9099×10 ⁻⁵	3. 7248×10 ⁻⁵			
8- O-	1. 0538×10 ⁻⁵	1. 0629×10 ⁻⁵	3. 4800×10 ⁻²		1. 0490×10 ⁻⁵
13-AL-	27		4. 8800×10 ⁻³		
14-SI		1. 1600×10 ⁻²			
26-FE			8. 4869×10 ⁻²		

Table 3.5 (continued)

RADHEAT-V4 DATA POOL (J3679. FNSPOOL2. DATA)

: REVISED JULY 14 '82

MATERIAL NAME	SODIUM	WATER	GRAPHITE	POLYETHYLEN	PARAFFIN
NODE NAME	110	100	120	140	130
NUCLIDE	ATOM DENSITY (n/barn·cm)				
11-NA- 23	2. 5442×10 ⁻²				
1- H- 1		6. 6738×10 ⁻²		7. 9793×10 ⁻²	7. 8966×10 ⁻²
8- O- 16		3. 3370×10 ⁻²			
6- C- 12			8. 5240×10 ⁻²	3. 9930×10 ⁻²	3. 7999×10 ⁻²

Table 3.5 (continued)

RADHEAT-V4 DATA POOL (J3679.FNSPOOL3.DATA) : REVISED AUGUST 26 '82

MATERIAL NAME	COPPER	ALUMINIUM	CHROMIUM	NICKEL	SB-42
NODE NAME	210	150	220	230	331
NUCLIDE	ATOM DENSITY (n/barn·cm)				
29-CU	8.4916×10^{-2}	6.0244×10^{-2}	8.2700×10^{-2}	9.1289×10^{-2}	
13-AL- 27					
24-CR					
28-NI					
6-C- 12					
14-SI					
25-MN- 55					
26-FE					

Table 3.5 (continued)

RADHEAT-V4 DATA POOL (J3679.FNSPOOL3. DATA) : REVISED AUGUST 26 '82

MATERIAL NAME	LEAD			
NODE NAME	240			
NUCL IDE	ATOM DENSITY (n / barn · cm)			
82-PB	3.2960×10^{-2}			

Table 3.5 (continued)

RADHEAT-V4 DATA POOL (J0662, FNSPOOL4, DATA) : REVISED SEP. 6 '82

MATERIAL NAME	B4C+AL	SS-41	PRESSURE VESSEL	ORDINARY CONCRETE1	ZIRCALOY-4
NODE NAME	550	310	330	400	340
NUCLIDE	ATOM DENSITY (n/barn·cm)				
5-B-10	2. 2125×10 ⁻²				
6-C-12	5. 4549×10 ⁻³	8. 2658×10 ⁻⁴	9. 8293×10 ⁻⁴		
13-AL-27	4. 5178×10 ⁻²			2. 2897×10 ⁻⁴	
14-SI		1. 1468×10 ⁻⁴	3. 8698×10 ⁻⁴	1. 9070×10 ⁻²	
25-MN-55		9. 8102×10 ⁻⁴	1. 1399×10 ⁻³		
26-FE		8. 4296×10 ⁻²	8. 2195×10 ⁻²	6. 7911×10 ⁻⁴	
28-NI			4. 4297×10 ⁻⁴		1. 4383×10 ⁻⁴
42-MO			2. 4599×10 ⁻⁴		
1-H-1				5. 7167×10 ⁻³	
8-O-16				4. 3929×10 ⁻²	
12-MG				6. 5540×10 ⁻⁵	
20-CA				2. 3741×10 ⁻³	
24-CR					7. 5891×10 ⁻⁵
40-ZIRC-2					4. 2982×10 ⁻²

Table 3.5 (continued)

RADHEAT-V4 DATA POOL (J0662, FNSPOOL4, DATA)

:REVISED SEP. 6 '82

MATERIAL NAME	IRON HIROIMA	CONCRETE HIROIMA	SERPENTINE CONCRETE	HIROSIMA AIR (INCLUDE AR)
NODE NAME	201	450	420	165
NUCLIDE	ATOM DENSITY (n/ $\sqrt{\text{barn} \cdot \text{cm}}$)			
6-C-12	4. 4200 $\times 10^{-4}$			
27-CO-59	1. 5282 $\times 10^{-5}$			
5-B-10	3. 3138 $\times 10^{-5}$			
14-SI	5. 7382 $\times 10^{-4}$	1. 7490 $\times 10^{-2}$	8. 0123 $\times 10^{-3}$	
24-CR	1. 1823 $\times 10^{-5}$			
25-MN-55	4. 6592 $\times 10^{-4}$			
29-CU	1. 2681 $\times 10^{-4}$			
28-NI	3. 2285 $\times 10^{-5}$			
26-FE	8. 3773 $\times 10^{-2}$	2. 6000 $\times 10^{-4}$	7. 0546 $\times 10^{-4}$	
8-O-16		4. 5050 $\times 10^{-2}$	4. 6005 $\times 10^{-2}$	1. 0490 $\times 10^{-5}$
1-H-1		1. 0770 $\times 10^{-2}$	2. 7920 $\times 10^{-2}$	1. 1770 $\times 10^{-6}$
20-CA		2. 8700 $\times 10^{-3}$	2. 5566 $\times 10^{-3}$	
13-AL-27		6. 4000 $\times 10^{-4}$	1. 6962 $\times 10^{-3}$	
11-NA-23		2. 5000 $\times 10^{-4}$		
12-MG		2. 2000 $\times 10^{-4}$	9. 8006 $\times 10^{-3}$	
19-K		4. 0000 $\times 10^{-5}$		
7-N-14				3. 6760 $\times 10^{-5}$
AR				2. 2710 $\times 10^{-7}$

Table 3.5 (continued)

RADHEAT-V4 DATA POOL (J0662, FNSPOOL5, DATA)

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MATERIAL NAME	HEAVY CONCRETE	ORDINARY CONCRETE	INSULATION (CHRYSTOTILE)	SUS-32 (ANSI 316)	2S-AL (AL-1110)
NODE NAME	410	401	430	321	300
NUCLIDE	ATOM DENSITY (n/barn·cm)				
1-H- 1	9. 9885×10 ⁻³	6. 9932×10 ⁻³	4. 5086×10 ⁻³		
8-O- 16	4. 3899×10 ⁻²	4. 5302×10 ⁻²	1. 0238×10 ⁻²		
12-MG	4. 3265×10 ⁻⁵	5. 6982×10 ⁻⁴	3. 2877×10 ⁻³		
13-AL- 27	1. 6502×10 ⁻⁴	3. 0424×10 ⁻³	6. 1949×10 ⁻⁵		5. 9885×10 ⁻²
14-SI	3. 7264×10 ⁻³	1. 5619×10 ⁻²	2. 1197×10 ⁻³	1. 8100×10 ⁻³	2. 0339×10 ⁻⁴
20-CA	2. 2782×10 ⁻³	3. 0101×10 ⁻³	6. 1216×10 ⁻⁶		
26-FE	2. 3602×10 ⁻²	7. 2017×10 ⁻⁴	2. 2442×10 ⁻⁴	5. 5740×10 ⁻²	8. 7673×10 ⁻⁵
6-C- 12	3. 2631×10 ⁻⁴	3. 6093×10 ⁻⁴	3. 1729×10 ⁻⁴		
11-NA- 23	7. 0229×10 ⁻⁴	1. 2185×10 ⁻⁵			
19-K	2. 9887×10 ⁻⁴	2. 4010×10 ⁻⁵			
25-MN- 55	6. 5751×10 ⁻⁵	9. 6784×10 ⁻⁷	1. 7343×10 ⁻³	1. 4854×10 ⁻⁵	
5-B- 10		3. 0823×10 ⁻⁴			
5-B- 11		1. 1355×10 ⁻³			
24-CR		2. 2586×10 ⁻⁶	1. 5575×10 ⁻²		
27-CO- 59		2. 2906×10 ⁻⁷			
28-NI		4. 1344×10 ⁻⁶	9. 7339×10 ⁻³		
40-ZIRC-2		1. 8610×10 ⁻⁷	1. 2421×10 ⁻³		
42-MO					7. 6323×10 ⁻⁵
29-CU					

Table 3.5 (continued)

RADHEAT-V4 DATA POOL (J0662, FNSPOOL5, DATA)

:REVISED SEP. 6 '82

MATERIAL NAME	FUEL PIN (BWR)	FUEL PIN (PWR)	SUS-27 (ANSI 304)	STANDARD AIR (20 CENT.)
NODE NAME	510	500	320	AIR
NUCLIDE	ATOM DENSITY (n/barn·cm)	ATOM DENSITY (n/barn·cm)	ATOM DENSITY (n/barn·cm)	ATOM DENSITY (n/barn·cm)
8-O-16	4. 6323×10 ⁻²	4. 5990×10 ⁻²		1. 0538×10 ⁻⁵
92-U-235	5. 6387×10 ⁻⁴	7. 5900×10 ⁻⁴		
92-U-238	2. 2641×10 ⁻²	2. 2350×10 ⁻²		
6-C-12			3. 1729×10 ⁻⁴	7. 5846×10 ⁻⁹
14-SI			1. 8100×10 ⁻³	
24-CR			1. 7408×10 ⁻²	
25-MN-55			1. 7343×10 ⁻³	
26-FE			5. 7872×10 ⁻²	
28-NI			8. 1116×10 ⁻³	
1-H-1				7. 1990×10 ⁻⁹
7-N-14				3. 9099×10 ⁻⁵

Table 3.6 Angular mesh boundaries of the effective macroscopic cross section library

No.	$\cos \theta$
1	-1.00000E+00
2	-9.92981E-01
3	-9.76707E-01
4	-9.51315E-01
5	-9.17041E-01
6	-8.74205E-01
7	-8.23207E-01
8	-7.64523E-01
9	-6.98701E-01
10	-6.26355E-01
11	-5.48161E-01
12	-4.64849E-01
13	-3.77197E-01
14	-2.86023E-01
15	-1.92179E-01
16	-9.65399E-02
17	0.0
18	9.65401E-02
19	1.92179E-01
20	2.86023E-01
21	3.77197E-01
22	4.64849E-01
23	5.48161E-01
24	6.26355E-01
25	6.98701E-01
26	7.64523E-01
27	8.23207E-01
28	8.74205E-01
29	9.17041E-01
30	9.51315E-01
31	9.76707E-01
32	9.92981E-01
33	1.00000E+00

3.3 Secondary Gamma-Ray Production Cross Section

The secondary gamma-ray production cross section is provided by the TWOWAY module of the RADHEAT-V4 code system. The data in ENDF/B-IV and POPOP4¹⁴⁾ library can be used to generate the secondary gamma-ray production cross section. However, JSD1000 only contains the cross section data of ENDF/B-IV.

Typical node structure of the secondary gamma-ray production cross section is shown in Fig. 3.3. The first node name shows the energy group structure and the second node name SGRX indicates a branch of the secondary gamma-ray production cross section. The third node name shows the material number and the fourth node name indicates the reaction name which enables it to emit the secondary gamma-ray.

```

EGRP C NEUTRON ENERGY STRUCTURE
I
I-----SGRX C SECONDARY GAMMA-RAY DATA
I
I-----1269 C 1269 1-H-1 FROM ENDF/B-IV
I
I----- 101 C H-1      FROM ENDF/B  MATNO=1269,MT= 102
I
I-----1272 C 1272 LI-7 FROM ENDF/B-IV
I
I----- 103 C LI-7      FROM ENDF/B  MATNO=1272,MT= 102
I
I----- 303 C LI-7      FROM ENDF/B  MATNO=1272,MT=    4
I
I-----1274 C 1274 C FROM ENDF/B-IV
I
I----- 106 C C-12      FROM ENDF/B  MATNO=1274,MT= 102
I
I----- 306 C C-12      FROM ENDF/B  MATNO=1274,MT=    4

```

Fig. 3.3 Typical node structure of the secondary gamma-ray production cross section library

The secondary gamma-ray production cross section library contains the data at temperatures of 300, 560 and 900 K. Nuclide and reaction names contained in the secondary gamma-ray production cross section library are described in Table 3.7. The record format of the data is described in Chapt. 5.

Table 3.7 Nuclides and reaction names contained in the secondary gamma-ray production cross section library

NODE NAME	NUCLIDE NAME	REACTION CHANNEL
1269	1-H-1 FROM ENDF/B-IV	101
1272	LI-7 FROM ENDF/B-IV	103 303
1274	C FROM ENDF/B-IV	106 306
1156	NA FROM ENDF/B-IV	111 311
1280	MG FROM ENDF/B-IV	112 312 412
1275	N FROM ENDF/B-IV	107 607 207 307
1194	SI FROM ENDF/B-IV	114 614 214 314
1150	K FROM ENDF/B-IV	119 619 219 319
1195	CA FROM ENDF/B-IV	120 620 220 320
1191	CR FROM ENDF/B-IV	124 924
1197	MN FROM ENDF/B-IV	925 125 325
1192	FE FROM ENDF/B-IV	926 126 326
1199	CO-59 FROM ENDF/B-IV	127 927
1190	NI FROM ENDF/B-IV	128 928
1295	CU FROM ENDF/B-IV	129 929
1189	NB FROM ENDF/B-IV	141 941
1287	MO FROM ENDF/B-IV	142 942
1128	W-182 FROM ENDF/B-IV	174 374
1129	W-183 FROM ENDF/B-IV	174 374
1130	W-184 FROM ENDF/B-IV	174 374
1131	W-186 FROM ENDF/B-IV	174 374

Table 3.7 (continued)

NODE NAME	NUCLIDE NAME	REACTION CHANNEL
1288	PB FROM ENDF/B-IV	982
1262	U-238 FROM ENDF/B-IV	892 192 992
1261	U-235 FROM ENDF/B-IV	892 192 992 392
1277	F FROM ENDF/B-IV	909 109 209 309
1264	PU-239 FROM ENDF/B-IV	894 194 994 394
1265	PU-240 FROM ENDF/B-IV	894 194 994 394
1271	LI-6 FROM ENDF/B-IV	103
1273	B-10 FROM ENDF/B-IV	605 305
1289	BE FROM ENDF/B-IV	104
1276	O FROM ENDF/B-IV	108 608 208 308
1193	AL FROM ENDF/B-IV	113 613 313

3.4 Ultra-Fine Group Cross Section

The ultra-fine group cross section is used as the basic cross section to generate the fine-group cross section and secondary gamma-ray production cross section. The ultra-fine group cross section is given by each temperature and background cross section.

Typical node structure is shown in Fig. 3.4. The first node name ULTX indicates the branch of the ultra-fine group cross section. The second node name shows the nuclide identification name of the data. The fourth node name SIGm shows the m-th branch of the background cross section. The data of the ultra-fine group cross section belong to the fourth node name.

```

ULTX CULTRA-FINE GROUP CROSS SECTION FILE
I
I-----1192 C 1192 FE FROM ENDF/B-IV
I
I-----TMP1 C TEMPERATURE = 300.0
I
I-----SIG1 C BACK-GROUND = 1.00E+08
I
I-----1193 C 1193 AL FROM ENDF/B-IV
I
I-----TMP1 C TEMPERATURE = 300.0
I
I-----SIG1 C BACK-GROUND = 1.00E+08
I
I-----1191 C 1191 CR FROM ENDF/B-IV
I
I-----TMP1 C TEMPERATURE = 300.0
I
I-----SIG1 C BACK-GROUND = 1.00E+08
I
I-----1197 C 1197 MN FROM ENDF/B-IV
I
I-----TMP1 C TEMPERATURE = 300.0
I
I-----SIG1 C BACK-GROUND = 1.00E+08

```

Fig. 3.4 Typical node structure of the ultra-fine group cross section library

The nuclide identification names in the JSD1000 library are described in Table 3.1. The reaction type of the ultra-fine group cross section is identified by the reaction I.D. number described in Chapt. 4. The record format of the ultra-fine group cross section is described in Chapt. 5.

Table 3.8 Nuclide identification name contained in the ultra-fine group cross section library

NODE NAME	NUCLIDE NAME	NODE NAME	NUCLIDE NAME
1130	W-184 FROM ENDF/B-IV	1192	FE FROM ENDF/B-IV
1128	W-182 FROM ENDF/B-IV	1193	AL FROM ENDF/B-IV
1129	W-183 FROM ENDF/B-IV	1191	CR FROM ENDF/B-IV
1131	W-186 FROM ENDF/B-IV	1197	MN FROM ENDF/B-IV
1272	LI-7 FROM ENDF/B-IV	1295	CU FROM ENDF/B-IV
1261	U-235 FROM ENDF/B-IV	1287	MO FROM ENDF/B-IV
1262	U-238 FROM ENDF/B-IV	1280	MG FROM ENDF/B-IV
1264	PU-239 FROM ENDF/B-IV	1273	B-10 FROM ENDF/B-IV
1274	C FROM ENDF/B-IV	1271	LI-6 FROM ENDF/B-IV
1266	PU-241 FROM ENDF/B-IV	1160	B-11 FROM ENDF/B-IV
1050	PU-238 FROM ENDF/B-IV	1269	1-H-1 FROM ENDF/B-IV
1150	K FROM ENDF/B-IV	1289	BE FROM ENDF/B-IV
1194	SI FROM ENDF/B-IV	1195	CA FROM ENDF/B-IV
1161	PU-242 FROM ENDF/B-IV	1156	NA FROM ENDF/B-IV
1265	PU-240 FROM ENDF/B-IV	1275	N FROM ENDF/B-IV
1263	NP-237 FROM ENDF/B-IV	1276	O FROM ENDF/B-IV
1283	AU FROM ENDF/B-IV	1199	CO-59 FROM ENDF/B-IV
1288	PB FROM ENDF/B-IV	1281	CD FROM ENDF/B-IV
1189	NB FROM ENDF/B-IV	1284	ZR FROM ENDF/B-IV
1056	AM-241 FROM ENDF/B-IV	1277	F FROM ENDF/B-IV
131	KR-80 FROM ENDF/B-IV	1190	NI FROM ENDF/B-IV

4. Production of Group Cross Section

Date contained in JSD1000 are produced by the RADHEAT-V4 code system. In this Chapter, the methods of the data generations are briefly described. The detailed informations are described in the user's manual of FAIR-CROSS and TWOWAY of the RADHEAT-V4 code system. The hierarchy of the code system is shown in Fig. 4.1.

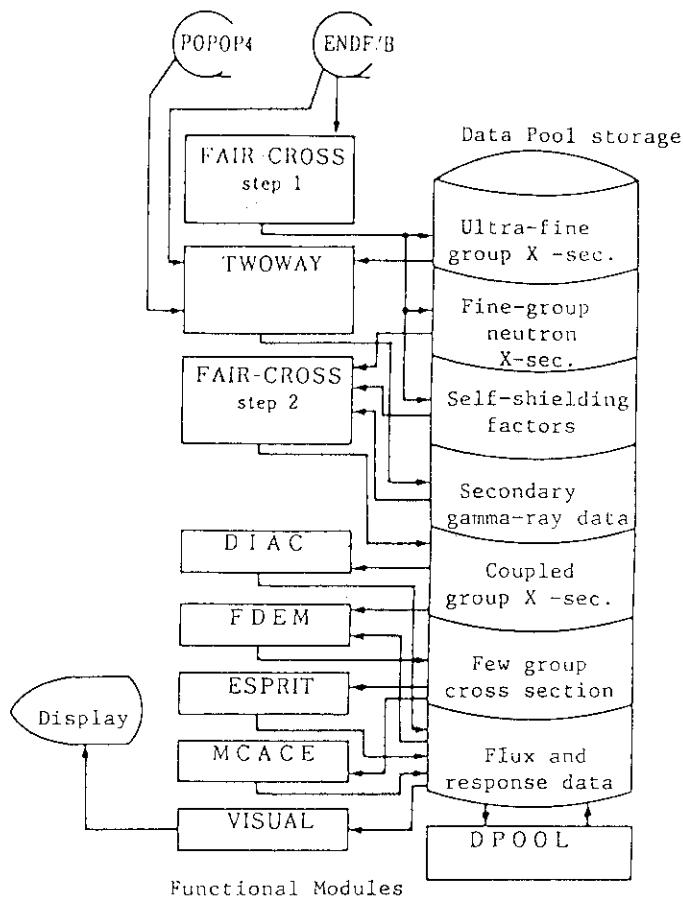


Fig. 4.1 Hierarchy of RADHEAT-V4 code system

One of the features of JSD1000 is adopting a method of the Direct Angular Representation. The DAR method means that the angular distribution of the scattering cross section is directly expressed by the function of the scattering angle instead of the finite Legendre expansion. Numerical description and utilization of the data are noted in the following sections.

4.1 Processing Method

The FAIR-CROSS and the TWOWAY modules produce the data contained in the JSD1000 library. System flow of the FAIR-CROSS and the TWOWAY modules is shown in Fig. 4.2. The ultra-fine group cross sections are produced in the forward stage of the FAIR-CROSS step 1. The fine-group cross sections are generated in the latter stage of the FAIR-CROSS step 1 by using the ultra-fine group cross sections. Secondary gamma-ray production cross sections are produced by the TWOWAY module with the ultra-fine group cross sections and nuclear data libraries, namely, ENDF/B-IV or POPOP4. Effective macroscopic cross sections are generated by the FAIR-CROSS step 2 with the fine-group cross sections and the secondary gamma-ray production cross sections. Each stage for generating the cross sections is described in the following sections.

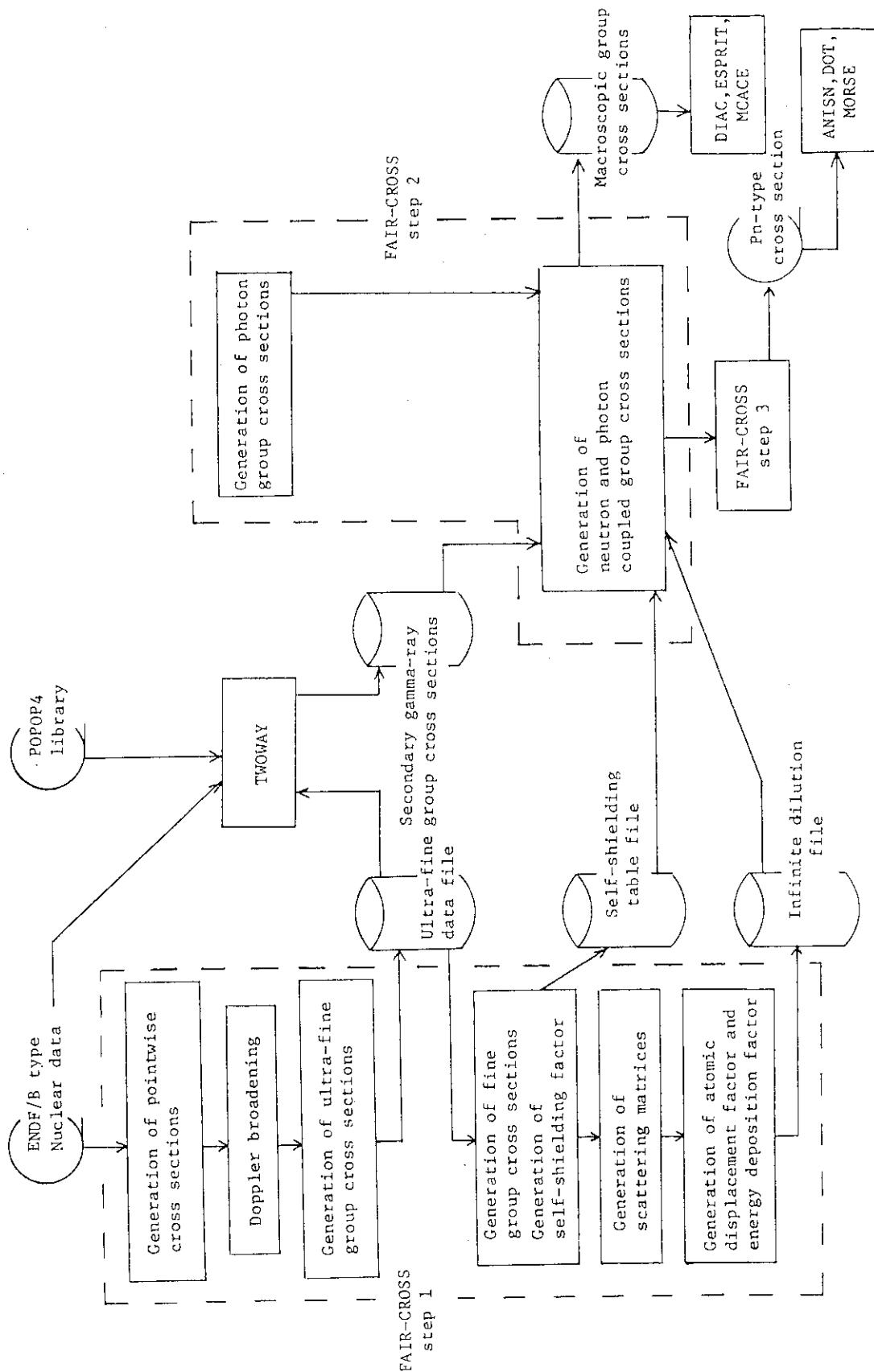


Fig. 4.2 Flow chart of generating group cross sections in RADHEAT-V4 code system

4.2 Ultra-Fine Group Cross Section

The ultra-fine group cross sections are generated by processing the nuclear data of ENDF/B format. The calculational process is divided into three parts of resonance treatment, Doppler-broadening and weighting procedures.

In the energy region of resolved resonance, point-wise cross sections are generated from resonance parameters in the nuclear data file by using the method adopted in a modified version of the RESEND¹⁵⁾ program. In the method, the following algorithm is used to reconstruct the resonances exactly within some specified tolerance.

(a) Neighbouring two peak energies of resonances are selected as shown in Fig. 4.3. (points A and B)

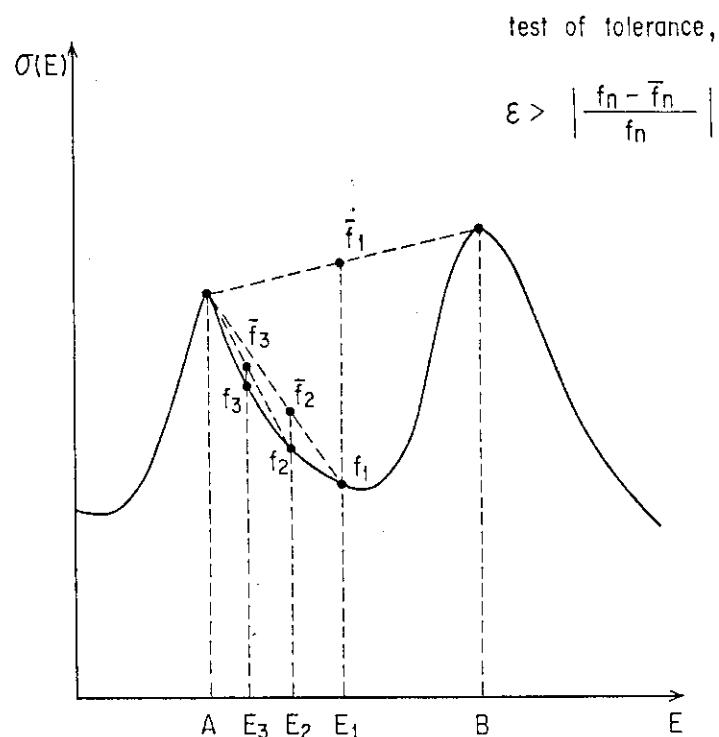


Fig. 4.3 Reconstruction procedure for resolved resonances

(b) The exact cross section f_1 at the mid-point E_1 between two peaks is calculated using a specified formula.

(c) The approximated value \bar{f}_1 at the E_1 is calculated by the linear interpolation and compared with the exact value. If the fractional difference at the mid-point is larger than the specified tolerance, a new mid-point E_2 is appointed in the left half interval and the same process

described above is repeated.

(d) When the fractional difference is attained smaller than the specified tolerance, the energy interval is fixed and the process is repeated for the right side of energy interval.

For the energy region of unresolved resonance, the averaged cross sections are computed by the method adopted in the MC² code¹⁶⁾. In this method, the infinitely diluted cross sections and self-shielded cross sections with Doppler-broadening are directly obtained.

Temperature dependency of the cross section is taken into account by the method of kernel-broadening described below.

The change of cross sections caused by the thermal vibration of a target nucleus at temperature T is given by the following equation.

$$\sigma(v, T) = \frac{1}{\rho v} \int d v' \cdot \rho \cdot |v-v'| \cdot \sigma(|v-v'|, T=0) P(v', T), \quad (4.1)$$

where ρ : density of a target nucleus,

v, v' : velocities of a incident neutron and a target nucleus,

$\sigma(|v-v'|, T=0)$: cross section for a static target nucleus ($T=0$ K)

$P(v', T)$: velocity distribution function of a target nucleus in the laboratory of mass system.

Assuming that the distribution function is a Maxwell-Boltzmann distribution, this function is given by following equation.

$$P(v', T) dv' = \left(\frac{\beta}{\pi}\right)^{3/2} \exp(-\beta v'^2) dv', \quad (4.2)$$

where

$$\beta = \frac{M}{2kT},$$

and M being mass of a target nucleus, k is Boltzmann constant. Define a relative velocity $V = |v-v'|$, Eq. (4.1) becomes,

$$\sigma(v, T) = \frac{1}{v^2} \left(\frac{\beta}{\pi}\right)^{1/2} \int_0^\infty dV \sigma(V, 0) V^2 [\exp\{-\beta(V-v)^2\} - \exp\{-\beta(V+v)^2\}]. \quad (4.3)$$

Converting velocity to energy $E = mv^2/2$, Eq. (4.3) becomes,

$$\sigma(E, T) = \frac{1}{2E} \left(\frac{\alpha}{\pi}\right)^{1/2} \int_0^\infty dE_r \sqrt{E_r} \sigma(E_r, 0) [\exp\{-\alpha(\sqrt{E_r}-\sqrt{E})^2\} - \exp\{-\alpha(\sqrt{E_r}+\sqrt{E})^2\}], \quad (4.4)$$

where, $\alpha = A/kT$ (Doppler width constant),
 $A = M/m$ (atomic mass ratio),
 $E_r = mv^2/2$ (relative energy).

Now define new variables x and y for a numerical calculation,

$$x^2 = \alpha E_r ,$$

$$y^2 = \alpha E.$$

Substituting of the variables into Eq. (4.4) yields,

$$\sigma(y, T) = \frac{1}{y^2} \left(\frac{1}{\pi}\right)^{1/2} \int_0^\infty dx \cdot x^2 \sigma(x, 0) [\exp{-(x-y)^2} - \exp{-(x+y)^2}] , \quad (4.5)$$

Equation (4.5) is divided into two terms which are called Doppler broadening and Doppler thinning, respectively.

$$\sigma(y, T) = \sigma^*(y, T) + \sigma^*(-y, T) , \quad (4.6)$$

$$\sigma^*(y, T) = \frac{1}{y^2} \left(\frac{1}{\pi}\right)^{1/2} \int_0^\infty x^2 \sigma(x, 0) \exp{-(x-y)^2} dx . \quad (4.7)$$

When $|x-y| \gg 1$, the expansion term in Eq. (4.7) becomes to near zero, so that we have the following equation.

$$\sigma^*(y, T) = \frac{1}{y^2} \left(\frac{1}{\pi}\right)^{1/2} \int_{y-\Delta}^{y+\Delta} x^2 \sigma(x, 0) \exp{-(x-y)^2} dx + R(y) , \quad (4.8)$$

$$R(y) = \frac{1}{y^2} \left(\frac{1}{\pi}\right)^{1/2} \left\{ \int_0^{y-\Delta} x^2 \sigma(x, 0) \exp{-(x-y)^2} dx + \int_{y+\Delta}^0 x^2 \sigma(x, 0) \exp{-(x-y)^2} dx \right\} . \quad (4.9)$$

If determine the value Δ to make $\epsilon > R(y)/\sigma^*(y, T)$, Eq. (4.7) can be approximated by the following expression,

$$\sigma^*(y, T) = \frac{1}{y^2} \left(\frac{1}{\pi}\right)^{1/2} \int_{y-\Delta}^{y+\Delta} x^2 \sigma(x, 0) \exp{-(x-y)^2} dx . \quad (4.10)$$

In this procedure, 4.0 is set for Δ . This condition is equivalent to set the tolerance $\epsilon = 10^{-3}$. Assuming that $\sigma(x, 0)$ is given by a linear interpolation with the point-wise data of (x_i, σ_i) , Eq. (4.10) becomes simple form described as below,

$$\sigma(x,0) = \sigma_i + S_i(x^2 - x_i^2) \text{ for } x_i \leq x \leq x_{i+1} \quad (4.11)$$

where $S_i = (\sigma_{i+1} - \sigma_i)/(x_{i+1}^2 - x_i^2)$,

$$\sigma^*(y,T) = \frac{1}{y^2} \left(\frac{1}{\pi}\right)^{1/2} \sum_i \int_{x_i}^{x_{i+1}} x^2 [\sigma_i + S_i(x^2 - x_i^2) \exp(-(x-y)^2)] dx . \quad (4.12)$$

Defining $z = x-y$, Eq. (4.12) becomes

$$\begin{aligned} \sigma^*(y,T) &= \frac{1}{y^2} \left(\frac{1}{\pi}\right)^{1/2} \sum_i \int_{x_i-y}^{x_{i+1}-y} (z+y)^2 \{\sigma_i - S_i x_i^2 + S_i (z+y)^2\} \exp(-z^2) dz . \\ &= \sum_i \{A_i (\sigma_i - S_i x_i^2) + B_i S_i\} . \end{aligned} \quad (4.13)$$

where

$$A_i = \frac{1}{y^2} \left(\frac{1}{\pi}\right)^{1/2} \int_{x_i-y}^{x_{i+1}-y} (y+z)^2 \exp(-z^2) dz , \quad (4.14)$$

$$B_i = \frac{1}{y^2} \left(\frac{1}{\pi}\right)^{1/2} \int_{x_i-y}^{x_{i+1}-y} (y+z)^4 \exp(-z^2) dz . \quad (4.15)$$

The above A_i and B_i are computed by using the error function, $\operatorname{erfc}(a)$.

For $a, b \geq 0 \quad (a < b)$

$$A_i = H_2(a,b)/y^2 + 2H_1(a,b)/y + H_0(a,b) , \quad (4.16)$$

$$B_i = H_4(a,b)/y^2 + 4H_3(a,b)/y + 6H_2(a,b) + 4yH_1(a,b) + y^2H_0(a,b) , \quad (4.17)$$

For $a, b < 0 \quad (a > b)$

$$A_i = H_2(a,b)/y^2 - 2H_1(a,b)/y + H_0(a,b) , \quad (4.18)$$

$$B_i = H_4(a,b)/y^2 - 4H_3(a,b)/y + 6H_2(a,b) - 4yH_1(a,b) + y^2H_0(a,b) , \quad (4.19)$$

where the function $H_n(a,b)$ is defined below.

$$\begin{aligned} H_n(a,b) &\equiv \left(\frac{1}{\pi}\right)^{1/2} \int_a^b z^n \exp(-z^2) dz , \\ &= F_n(a) - F_n(b) , \end{aligned} \quad (4.20)$$

and

$$F_0(a) = \operatorname{erfc}(a)/2 , \quad (4.21)$$

$$F_1(a) = \left(\frac{1}{\pi}\right)^{1/2} \exp(-a^2)/2 , \quad (4.22)$$

$$F_n(a) = \frac{1}{2} \{ (n-1)F_{n-2}(a) + a^{n-1} \left(\frac{1}{\pi}\right)^{1/2} \exp(-a^2) \}. \quad (n \geq 2) \quad (4.23)$$

The Doppler-broadening described above is calculated for the energy range from 50 meV to 3 MeV. Reactions considered the Doppler-broadening are total, elastic scattering, fission, (n,γ) , (n,p) and (n,α) .

The ultra-fine group cross sections are produced by averaging the point cross sections generated above. A weighting function using average process is given by the following equation,

$$\phi(E, \sigma_0, T) = \frac{\phi_s(E, T)}{\sigma_t(E, T) + \sigma_0} , \quad (4.24)$$

$$\phi_s(E, T) = \begin{cases} \sqrt{E} \exp(-E/T_c) & 0.8205 \text{MeV} \leq E \\ 1/E & 0.125 \text{eV} < E < 0.8205 \text{MeV} \\ E \exp(-E/kT) & E \leq 0.125 \text{eV} \end{cases} , \quad (4.25)$$

where σ_t is total cross section, k is Boltzmann constant and T_c neutron temperature of fission spectrum selected as $T_c = 1.4$ MeV.

Group cross sections with the ultra-fine group structure are calculated by two equations.

For outside of the unresolved resonance region,

$$\sigma_x^i(\sigma_0, T) = \frac{\int_{E_i}^{E_{i+1}} \sigma_x(E, T) \cdot \phi(E, \sigma_0, T) dE}{\int_{E_i}^{E_{i+1}} \phi(E, \sigma_0, T) dE} , \quad (4.26)$$

and for the unresolved resonance region,

$$\sigma_x^i(\sigma_0, T) = \sigma_{ux}^i(\sigma_0, T) , \quad (4.27)$$

where σ_x^i : group cross section for ultra-fine group i and reaction type X ,

$\sigma_x(E, T)$: Doppler broadened point-wise cross section,

$\sigma_{ux}^i(\sigma_0, T)$: averaged unresolved resonance cross section for ultra-fine group i and reaction type X ,

$\phi(E, \sigma_0, T)$: weighting function described above,

σ_0, T : background cross section and temperature.

Group average neutrons per fission \bar{v}^i is calculated by the following way.

For outside of the resonance region,

$$\bar{v}^i = \frac{\int_{E_i}^{E_{i+1}} v(E) \sigma_f(E, T_0) \phi_s(E, T_0) dE}{\int_{E_i}^{E_{i+1}} \sigma_f(E, T_0) \phi_s(E, T_0) dE}, \quad (4.28)$$

and for the resonance region,

$$\bar{v}^i = \frac{\int_{E_i}^{E_{i+1}} v(E) \phi_s(E, T_0) dE}{\int_E^{E_{i+1}} \phi_s(E, T_0) dE}, \quad (4.29)$$

where σ_f is the fission cross section and T_0 a standard temperature selected as 300 K.

The ultra-fine group cross section consists of 3824 groups whose energy group structure is shown in Table 4.1. The reaction types contained in the ultra-fine group cross section are shown in Table 4.2.

Table 4.1 Energy group structure for the ultra-fine group cross sections

Group No.	Lower energy (eV)	Lower velocity (cm/sec)	Lower lethargy
1	2.2104E-4 ⁺	2.0564E+4	24.53526
		{ an equi-velocity width of 2700.0 }	
321	4.0898E-1	8.8455E+5	17.01218
322	4.1399E-1	8.8995E+5	17.00000
		{ an equi-lethargy width of 0.005 }	
3722	1.0000E+7	4.3740E+9	0.0
		{ an equi-lethargy width of 0.005 }	
3824	1.6736E+7 [*]	5.6585E+9 [*]	-0.515 [*]

+) read as 2.2104×10^{-4} .

*) these values indicate the upper ones of the energy group.

Table 4.2 Processed reaction types and the identification numbers in the ultra-fine group cross section

Reaction type	Reaction I.D. No.
Total	1
Elastic scattering	2
Total inelastic scattering	4
Total ($n,2n$) scattering	16
Excited ($n,2n$) scattering	6-9 , 46-49
Fission	18
Neutrons per fission	452
($n,n'\alpha$) scattering	22
($n,n'3\alpha$) scattering	23
($n,2np$) scattering	24
($n,n'p$) scattering	28
Absorption	27
Inelastic discrete level	51-90
Inelastic continuum level	91
(n,γ)	102
(n,p)	103
(n,d)	104
(n,t)	105
(n,He)	106
(n,α)	107
($n,2\alpha$)	108

4.3 Infinite Dilution Cross Section

Infinitely diluted cross sections of each reaction ($\sigma_0 = \infty$) are generated by using the following equations.

$$\sigma_x^j(\sigma_0, T) = \frac{\sum_{i \in j} \sigma_x^i(\sigma_0, T) W^i(\sigma_0, T) (E_{i+1} - E_i)}{\sum_{i \in j} W^i(\sigma_0, T) (E_{i+1} - E_i)}, \quad (4.30)$$

$$\nu^j = \frac{\sum_{i \in j} \nu^i \sigma_f^i(\sigma_0, T_0) W^i(\sigma_0, T_0) (E_{i+1} - E_i)}{\sum_{i \in j} \sigma_f^i(\sigma_0, T_0) W^i(\sigma_0, T_0) (E_{i+1} - E_i)}, \quad (4.31)$$

where a suffix i shows a ultra-fine group number, j shows a fine-group number, $i \in j$ means the ultra-fine group numbers included in a fine-group number j , and W^i is given by the following equation.

$$W^i(\sigma_0, T) = \frac{\int_{E_i}^{E_{i+1}} \phi(E, \sigma_0, T) dE}{E_{i+1} - E_i}. \quad (4.32)$$

When the boundary energy of the fine-group structure is not equal to that of the ultra-fine group structure, the ultra-fine group cross section is assumed to be constant in the fine-group to calculate Eqs. (4.30) and (4.31). If the both boundary energies are equal, the fine-group cross sections calculated by Eq. (4.30) is exactly same to the fine-group cross sections calculated directly from Eq. (4.26) not way of the ultra-fine group cross sections.

The fine-group cross section for total reaction is calculated from the total cross section given by the nuclear data file, so that the elastic scattering cross section is modified to conserve the neutron balance. The modification is performed by the following manner,

$$\delta^j = \sigma_t^j(\sigma_0=\infty, T_0) - \sigma_e^j(\sigma_0=\infty, T_0) - \sigma_f^j(\sigma_0=\infty, T_0) - \sigma_{n\gamma}^j(\sigma_0=\infty, T_0) - \sigma_{\text{others}}^j, \quad (4.33)$$

$$\sigma_e'^j(\sigma_0, T) = \sigma_e^j(\sigma_0, T) + \delta^j. \quad (4.34)$$

means the sum of residual cross sections which is not processed by the FAIR-CROSS module, and errors of calculation. Reactions contained in the fine-group cross sections are shown in Table 3.3.

4.4 Self-Shielding Factor

Temperature dependent self-shielded cross section $\sigma_x^j(\sigma_0, T)$ is calculated only for total, elastic scattering, capture and fission reactions. For the other reactions, the infinitely diluted cross sections for 0 K are calculated except for (n,p) and (n, α) reactions. (n,p) and (n, α) reaction cross sections are calculated for a standard temperature, normally 300 K. Self-shielding factors are calculated from the fine-group cross sections by using the following equation.

$$f_t^j(\sigma_0, T) = \frac{\sigma_e^j(\sigma_0, T) + \sigma_f^j(\sigma_0, T) + \sigma_{n\gamma}^j(\sigma_0, T) + \sigma_{\text{others}}^j}{\sigma_t^j(\sigma_0 = \infty, T)} , \quad (4.35)$$

$$f_x^j(\sigma_0, T) = \frac{\sigma_x^j(\sigma_0, T)}{\sigma_x^j(\sigma_0 = \infty, T_0)} , \quad (4.36)$$

where reaction type X means elastic scattering, fission and capture.

JSD1000 contains these self-shielding factors at $\sigma_0 = 0, 1, 10, 100, 1000, 10000$ and $T = 300, 560, 900$ K. The data are utilized for generating the effective cross section.

4.5 Scattering Matrix

The double differential scattering cross section is given by the following form,

$$\sigma_s(E', E, \mu) = \frac{\sigma_s(E')}{2\pi} f(E', \eta) g(E', E, \eta) \left| \frac{dn}{d\mu} \right| , \quad (4.37)$$

where E' : energy of incident neutron,
 E : energy of scattered neutron,
 μ : cosine of a scattering angle in the laboratory system,
 η : cosine of a scattering angle in the center of mass system,
 $\sigma_s(E')$: scattering total cross section,
 $f(E', \eta)$: angular distribution of scattered neutron,
 $g(E', E, \eta)$: energy distribution of scattered neutron.

The angular distribution $f(E', \eta)$ is given by the nuclear data file. The form is Legendre expansion shown in Eq. (4.38) or a tabular representation.

$$f(E', \eta) = \frac{1}{2} \left\{ 1 + \sum_{\ell=1}^N (2\ell+1) f_\ell(E') P_\ell(\eta) \right\}, \quad (4.38)$$

where N : maximum order of Legendre expansion,

$f_\ell(E')$: Legendre coefficients,

$P_\ell(\eta)$: Legendre polynomials.

The energy distribution $g(E', E, \eta)$ for the elastic scattering and the discrete part of the inelastic scattering are given by the conservation law of energy and momentum,

$$g(E', E, \eta) = \delta\left(E - \frac{A^2+1}{(A+1)} E' + \frac{A}{A+1} Q_i - \frac{2}{A+1} \eta \sqrt{E'} \sqrt{\left(\frac{A}{A+1}\right)^2 E' - \frac{A}{A+1} Q_i}\right), \quad (4.39)$$

where δ : Dirac delta function,

Q_i : Q -value of the i -th excited level
(for elastic scattering, $Q_i = 0$),

A : atomic mass ratio.

The relation of the scattering angle between the center of mass system and the laboratory system is given by the conservation law,

$$\mu = \frac{\gamma + \eta}{\sqrt{\gamma^2 + 2\gamma\eta + 1}}, \quad (4.40)$$

where

$$\gamma = \frac{1}{A} \sqrt{\frac{E'}{E' - (1+1/A)Q_i}}. \quad (4.41)$$

The conversion factor $|d\eta/d\mu|$ is obtained from Eq. (4.40).

$$|\frac{d\eta}{d\mu}| = |2\gamma\mu \pm \gamma \sqrt{\frac{1}{\gamma^2} + \mu^2 - 1} \pm \frac{\gamma\mu^2}{\sqrt{\frac{1}{\gamma^2} + \mu^2 - 1}}|. \quad (4.42)$$

The group to group transfer matrix used in the multi-group transport calculation is defined as follows,

$$\sigma_{g'g}(\mu) = \frac{\int_{E_{g'+1}}^{E_g} dE' \int_{E_{g'+1}}^{E_g} n \sigma_s(E', E, \mu) \phi(E') dE}{\int_{E_g}^{E_{g'+1}} \phi(E') dE'}, \quad (4.43)$$

where g' : energy group of incident neutron ($E_{g'+1} \leq E \leq E_{g'}$),
 g : energy group of scattered neutron ($E_{g+1} \leq E \leq E_g$),
 $\sigma_{g'g}(\mu)$: group to group transfer cross section scattered from g'
 to g by a direction cosine μ of a scattering angle,
 which is named as the cross section of DAR form,
 n : number of scattered neutron ($n=1$ for elastic and in-
 elastic scattering, $n=2$ for $(n,2n)$ scattering),
 $\phi(E')$: weighting function.

Because the energy distribution $g(E',E,n)$ is given by the Dirac delta function, Eq. (4.43) becomes,

$$\sigma_{g'g}(\mu) = \frac{n \int_a^b \frac{\sigma_s(E')}{2\pi} f(E',n) \left| \frac{dn}{d\mu} \right| \phi(E') dE'}{\int_{E_{g'}}^{E_{g'+1}} \phi(E') dE'}. \quad (4.44)$$

The integral boundaries a and b indicate the limits of the incident energy E' in which it is possible to scatter into group g by a direction cosine μ of a scattering angle. These limits are obtained from Eqs. (4.39) and (4.40).

$$a = \text{Max}\{E_{g'+1}, h(E_{g+1}, \mu)\} \quad (4.45)$$

$$b = \text{Min}\{E_{g'}, h(E_g, \mu)\}$$

where

$$h(E, \mu) = \frac{(A^2-1)E + A(A-1)Q + 2E\mu^2 - 2E\mu\sqrt{\mu^2 + A^2 - 1} + A(A-1)Q/E}{(A-1)^2}. \quad (4.46)$$

A special treatment is required to calculate Eq. (4.44) in the cases of inelastic and $(n,2n)$ reactions. Detailed description of the treatment for numerical integration is noted in user's manual of the FAIR-CROSS module¹⁷⁾.

For the continuum parts of the inelastic and $(n,2n)$ reactions, the energy distribution $g(E',E,n)$ is given by the nuclear data file. The form is an evaporation model, a tabular representation or others. This energy distribution is independent of the scattering angle. Therefore, Eq. (4.43) can be approximated by the following equation.

$$\sigma_{g'g}(\mu) = \frac{\int_{E_{g'+1}}^{E_g} f(E', \mu) \sigma_s(E') \phi(E') dE'}{\int_{E_{g'+1}}^{E_g} \sigma_s(E') \phi(E') dE'} \times \frac{\int_{E_{g'+1}}^{E_g} dE' \int_{E_{g'+1}}^{E_g} dE \pi \frac{\sigma_s(E')}{2\pi} g(E', E) \phi(E')}{\int_{E_{g'+1}}^{E_g} \phi(E') dE'}. \quad (4.47)$$

From Eq. (4.44) or (4.47), we can compute the scattering matrix directly by the function of the scattering angle. However, it is difficult to determine the fixed angular mesh to fit the function $\sigma_{g'g}(\mu)$ accurately because that the shape of this function differs for the kind of nuclides and the incident energy. For this reason, the scattering matrices of each reaction are calculated in the ultra-fine group structure by using the following algorithm, and then converted a point-wise angular distribution named a "Direct Angular Representation" form in the fine-group structure:

- 1) Selection of a scattered energy group g . ($E_{g+1} \leq E \leq E_g$)
- 2) Determination of the bounds of the source energy E' in which it is possible to scatter to the energy group g .
- 3) Selection of a source energy group g' ($E_{g'+1} \leq E' \leq E_{g'}$) in the above energy range.
- 4) Determination of the bounds of the scattering angle for the scattering from the energy group g' to g .
- 5) Calculation of the cross section ($\sigma_0 - \sigma_4$) from Eq. (4.44) or (4.47) for 5 angular points ($\mu_0 - \mu_4$) which divide the range of the scattering angle into four. (see Fig. 4.4)

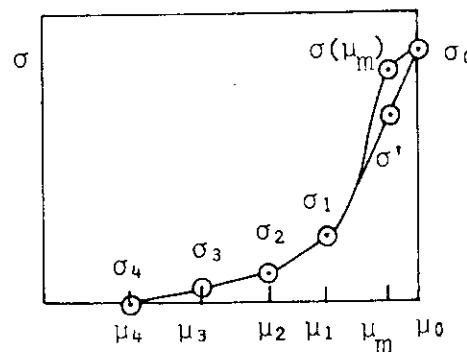


Fig. 4.4 Algorithm to determine the optimum angular mesh

- 6) Calculation of approximated integral value σ^t with the scattering angle by using a 4-th order Newton-Cote's law.
- 7) Test whether a linear interpolation can be applied between μ_0 and μ_1 ,

$$\mu_m = (\mu_0 + \mu_1)/2 , \quad (4.48a)$$

$$\sigma' = (\sigma_0 + \sigma_1)/2 , \quad (4.48b)$$

i.e.,

- (i) test of relative error, (condition 1)

$$\left| \frac{\sigma(\mu_m) - \sigma'}{\sigma(\mu_m)} \right| < \varepsilon , \quad (4.49a)$$

- (ii) test of integral error, (condition 2)

$$|\sigma(\mu_m) - \sigma'| \frac{\mu_0 - \mu_1}{2} < \frac{\varepsilon}{20} \sigma^t , \quad (4.49b)$$

where ε is a permissible error specified by the user. The condition 2 becomes severe for a peak of the cross section and loose for the part of small values. Therefore, this condition is useful to decrease the number of the angular mesh in the part of small values.

- 8) When either condition is satisfied, no additional points are required between μ_0 and μ_1 . Otherwise the angular point μ_m is added and the item (7) is repeated for the two intervals of (μ_0, μ_m) and (μ_m, μ_1) .
This iteration is executed until the either condition is satisfied.
- 9) For other intervals (μ_1, μ_2) , (μ_2, μ_3) and (μ_3, μ_4) , the same process is executed.

Adopting the new DAR method, the angular distributions of cross sections do not take any negative value for all directions.

4.6 Secondary Gamma-Ray Production Cross Section

Secondary gamma-ray production cross sections are produced in the TWOWAY module by using ENDF/B-IV and the ultra-fine group cross sections generated in the FAIR-CROSS step 1.

Data generated in the TWOWAY module are the neutron interaction cross section σ_n , the gamma-ray yields γ , and the probabilities $P_{n \rightarrow g}$ of each reaction. The relations with the three quantities are as follows:

$$\gamma_n = \sum_g \sigma_{n \rightarrow g} / \sigma_n , \quad (4.50)$$

$$P_{n \rightarrow g} = \sigma_{n \rightarrow g} / \gamma_n \sigma_n . \quad (4.51)$$

When the multiplicities (File 12 in ENDF/B) are given for a discrete photon energy, the secondary gamma-ray production cross section $\sigma_{n \rightarrow g}$ is calculated from the following equation.

$$\sigma_{n \rightarrow g} = \int_{E_n}^{E_{n+1}} \gamma(E) \sigma(E) \phi(E) dE / \int_{E_n}^{E_{n+1}} \phi(E) dE , \quad (4.52)$$

where the multiplicity γ at the mid-point energy of the ultra-fine group is calculated by interpolating the table of multiplicities. The neutron interaction cross section σ and the weighting function ϕ are retrieved from the ultra-fine group cross section library.

When the multiplicity is given by a continuous photon energy spectrum at the neutron energy E , the spectrum P is integrated between the energy interval for each gamma-ray group g :

$$P_g(E) = \int_{E_g}^{E_{g+1}} P(E \rightarrow E_\gamma) dE_\gamma . \quad (4.53)$$

Hence

$$\sigma_{n \rightarrow g} = \int_{E_n}^{E_{n+1}} \gamma(E) \sigma(E) \phi(E) P_g(E) dE / \int_{E_n}^{E_{n+1}} \phi(E) dE . \quad (4.54)$$

When the secondary gamma-ray production cross section is given by the transition probability arrays, the following procedure is adopted.

The photon energy E_γ by a transition from level j to level i is as follows:

$$E_\gamma = ES_j - ES_i , \quad (4.55)$$

where ES_i shows the energy of level i .

The secondary gamma-ray production cross section at the photon energy E_γ by a transition from level j to level i is given by the following equation,

$$\sigma(N \rightarrow E_\gamma) = TP_{j,i} \cdot GP_{j,i} \cdot \int_{E_n}^{E_{n+1}} \sigma(E) \phi(E) dE / \int_{E_n}^{E_{n+1}} \phi(E) dE , \quad (4.56)$$

where $TP_{j,i}$ is probability of a transition from level j to i , $GP_{j,i}$ is conditional probability of photon emission in a transition from level j to i . The secondary gamma-ray production cross section $\sigma(N - E_\gamma)$ is converted to the group cross section in the same manner as a discrete photon energy. The angular distribution of the secondary gamma-ray production cross section assumes isotropic in the laboratory system.

The data of each reaction are identified by the three digits. The first digit indicates the reaction channel defined by Table 4.3. In this table, the code number 3 includes inelastic scattering ($MT=4$ or $51 - 91$), $(n,n'\alpha)$ reaction ($MT=22$), $(n,n'3\alpha)$ reaction ($MT=23$), and $(n,n'p)$ reaction ($MT=28$). The code number 4 includes $(n,2n)$ reaction ($MT=16$) and $(n,2n\alpha)$ reaction ($MT=24$). The second and third digits indicate the atomic number of the nuclide.

Table 4.3 Identification number of the reaction channel in the secondary gamma-ray production cross section

Code No.	Reaction channel	ENDF/B MT number
1	(n,γ) non-fission	102
2	$(n,\alpha\gamma)$	107
3	$(n,n'\gamma)$	4,22,23,28, 51-91
4	$(n,2n'\gamma)$	16,24
5	$(n,3n'\gamma)$	17
6	$(n,p\gamma)$	104
7	not used	--
8	(n,γ) fission	18
9	non-elastic	3

4.7 Atomic Displacement Cross Section and Energy Deposition Factor

The atomic displacement cross section F and the energy deposition factor H at the neutron energy E are defined as follows:

$$F(E) = \sigma(E) \int_{-1}^{+1} P(E, \eta) \cdot v[T(E, \eta)] d\eta , \quad (4.57)$$

$$H(E) = C \cdot \sigma(E) \int_{-1}^{+1} P(E, \eta) T(E, \eta) d\eta , \quad (4.58)$$

where T is the kinetic energy in the laboratory system of the primary knock-on atom (PKA) which is scattered by a center of mass angle $\beta (\beta = \cos^{-1} \eta)$, with the probability $P(E, \eta)$. $v(T)$ means the number of secondary displacements produced by the PKA in coming to rest. The $v(T)$ is calculated by using the Lindhard model¹⁸⁾ of slowing down for energetic atom in solids. A constant C in Eq. (4.58) is the conversion factor. The units of $F(E)$ and $H(E)$ are (barn) and (barn·watt·sec), respectively.

The number of displacement $v(T)$ is defined as follows:

$$v(T) = 0.8T_D/2E_d , \quad (T > 2E_d) \quad (4.59)$$

$$T_D = T/(1+K_L \cdot g(\epsilon)) , \quad (4.60)$$

$$K_L = 0.1334 Z^{2/3}/A^{1/2} , \quad (4.61a)$$

$$g(\epsilon) = \epsilon + 0.40244 \epsilon^{3/4} + 3.4008 \epsilon^{1/6} \quad (4.61b)$$

$$= 0.01151 T/Z^{7/3} , \quad (4.61c)$$

where E_d is an effective displacement energy and A and Z are the atomic weight and atomic number, respectively.

A general relation with T , E , η and E_p which is the energy of scattered neutron in the center of mass system is found from the conservation of momentum

$$T = \alpha_1 \alpha_2 E + (\alpha_1 / \alpha_2) E_p - 2\alpha_1 \eta \sqrt{E \cdot E_p} , \quad (4.62)$$

where $\alpha_1 = 1/(1+A)$ and $\alpha_2 = A/(1+A)$. The values of $F(E)$ and $H(E)$ are calculated for each ultra-fine group and then converted to the fine-group structure with the following manner,

$$F_g = \int_{E_g}^{E_{g+1}} F(E) \phi(E) dE / \int_{E_g}^{E_{g+1}} \phi(E) dE , \quad (4.63)$$

$$H_g = \frac{\int_{E_g}^{E_{g+1}} H(E) \phi(E) dE}{\int_{E_g}^{E_{g+1}} \phi(E) dE}, \quad (4.64)$$

where ϕ is weighting function retrieved from the ultra-fine group cross section library. Adopted values of the effective displacement energies for each nuclide are shown in Table 4.4.

Table 4.4 Threshold displacement energy adopted in the atomic displacement cross section

Nuclide	ENDF/B-IV material No.	Adopted value	76Idet (adopt)	76Dran (adopt)	76Gabriel (adopt)	73Nelson (adopt)	72Doran (adopt)	65Chadderton (Exp.compile)	Sone (Exp.compile)	Brooks (Exp.review)
C	1274	47	47*					25 (300°K)	28	
Si	1194	46	46*					32,16.5±3,17		
Al	1193	27	27*	25*					29	
Ti	1286	48	48*							
V	1196	43	43*	40*						
Cr	1191	40	40*	40*						
Fe	1192	40	40*	40*						
Ni	1190	40	40*	40*						
Cu	1295	32	33*	30*				25 (78°K) ~ 19 (4.2°K)	22*,19,16-19	20-22
Zn	--	40							17.5±1.5	
Ge	--	40						31 (78°K)		
Zr	1284	60		40*						
Nb	1189	62	60*	60*					36	
Mo	1287	45	62*	60*					37	
Ag	1138	90	90*					28*(4.2°K)	28,24	
Ta	1127	90						68*	32	
Au	1283	25						40*(4.2°K)	740,33-36	
Pb	1288	40		25*						
W	--	--	60*	90*					735	
316SUS	--	--	--	40*				40*	35*	

*) Adopted value means effective value.

4.8 Effective Macroscopic Cross Section

The effective macroscopic cross section of neutron and gamma-ray coupled multi-group structure is produced in the FAIR-CROSS step 2. In this step, the following 4 processes are executed:

- Process-1) Calculate the effective neutron cross sections by using the infinitely diluted cross sections and the self-shielding factors and convert the group to group transfer matrices into the DAR form.
- Process-2) Calculate the effective secondary gamma-ray production cross sections.
- Process-3) Calculate the gamma-ray cross sections.
- Process-4) Connect the neutron cross sections with the gamma-ray ones and generate the cross section tables for coupled multi-group transport calculations.

In the process-1, the following quantities are calculated:

$$\sigma_{\text{eff},x,n}^i = f_{x,n}(T, \sigma_0) \cdot \sigma_{x,n}^i, \quad (4.65)$$

$$\sigma_0 = \frac{1}{\rho_n} \sum_{m \neq n} \rho_m \sigma_{\text{eff},\text{total},m}, \quad (4.66)$$

where

i : neutron energy group,
 x : reaction type,
 n : nuclide,
 ρ : atomic number density,
 σ_x : infinitely diluted cross section for reaction type x,
 σ_{eff} : effective cross section,
 f(T, σ₀) : self-shielding factor.

It is necessary to compute Eqs. (4.65) and (4.66) iteratively for total cross section in order to get accurate σ₀. The FAIR-CROSS module performs the computation of the effective total cross section within error of 1 percent.

In the process-2, the secondary gamma-ray production cross sections are generated by following equation,

$$\sigma_{n \rightarrow g} = \sigma_n \cdot Y_n \cdot P_{n \rightarrow g}, \quad (4.67)$$

where the notations are the same as Eqs. (4.50) and (4.51). Adopted reaction channels to produce the secondary gamma-ray production cross section are described in Table 3.7.

In the process-3, the gamma-ray cross sections by photo-electric effect, compton scattering, coherent scattering and pair-production are calculated. The angular distribution of the compton scattering is calculated with the DAR method by means of Klein-Nishina formula¹⁹⁾. The other reactions are computed by using simple emperical formulae which are given by a function of the atomic number adopted in GAMLEG-JR²⁰⁾. The energy transfer cross section is also calculated in the form of KERMA factor as follows:

$$h_g = 1.6 \times 10^{-19} (\mu_{en}/\rho) E_g, \quad (4.68)$$

where h_g is KERMA factor for energy group g , (μ_{en}/ρ) indicates mass energy transfer coefficient and E_g shows mean energy of energy group g . The unit of KERMA factor is (barr·watt·sec).

In the process-1, the angular distributions of the group to group transfer cross sections with the DAR form are also converted into the form of the discrete-type DAR which is slightly different from that adopted in the FAIR-CROSS step 1. The discrete-type Direct Angular Representation means that the data are given by each of the fixed discrete angular points which correspond to those of the symmetrical S_N -quadrature set. This form is suitable for applying the group cross sections directly to the S_N -transport calculation. The number of the angular points can be chosen from 12 to 64 by the user, however the data contained in JSD1000 are given with fixed 32 angular points as shown in Table 3.6.

5. Structure of JSD1000 Library

The JSD1000 data library is stored in the form of a direct-access data base named a "DATA-POOL". The DATA-POOL storage which is adopted in the RADHEAT-V4 code system is suitable for handling the large-size data such as the group cross section.

The data in JSD1000 are identified by the node name which consists of 4-characters defined in Chapt. 3. The data are characterized by several tree structures of node names, and can be read by pointing out the series of the node names.

The DATA-POOL access package which controls DATA-POOL, consists of various functional subroutines written in the FORTRAN-77 language. The usage of the software package will be described in the user's manual of DATA-POOL. In this Chapter, the structure of DATA-POOL is briefly noted. The node structures and record formats of JSD1000 are also described.

5.1 DATA-POOL Structure

DATA-POOL is a direct-access data set defined by the direct-access read/write statements of the FORTRAN language. The data set has a fixed and unblocked record length of 3600 bytes (900 words). The data in the record are written under the control of unformatted statement.

DATA-POOL consists of three sections named a "Control Section", a "Directory Section" and a "Data Section", respectively. The Control Section is located at the first record of DATA-POOL and has a size of 40 words. The variables in the section are used for the control of DATA-POOL. The record structure of the Control Section is shown in Fig. 5.1.

No.	Variable	Data Information
1	TITLE(1)	title of the DATA-POOL
	{ } { }	data set name, revised data, contents of the DATA-POOL et al.
20	TITLE(20)	
21	NA1	address for the directory of the first level node
22	NA2	head address of the vacant directory section
23	NA3	head address of the vacant data section
24	KEY1	write flag for the exclusive control
25	KEY2	read flag for the exclusive control (not used)
26	LREC	length of a physical record (words)
27	MAX1	maximum number of the same level node
28	MAX2	size of the directory section
29	MAX3	size of the data section
30	NREAL1	number of used records in the directory section
31	NREAL2	number of used records in the data section
32	--	for future use
	{ } { }	
40	--	for future use
		dummy (not used)
LREC	--	

Fig. 5.1 Record information of the Control Section
in a DATA-POOL

The Directory Section takes an important role which determines the relation between the node name and the record address of the data, and has the informations of the lower nodes in the tree structure. The Directory Section consists of the several sub-directories. The sub-directory has the informations of a node name, a head address of the data section associated with the node name, the date of creation and control variables defined by the user. The structure of the Directory Section is shown in Fig. 5.2. A sub-directory takes 12 words in the Directory Section, so that the number of nodes associated with the same level is limited to 74. A feature of DATA-POOL is that the informations for the nodes of the lower level can be obtained at once by referring a directory.

No.	Variable	Data Information
1	NODE	node name
2	DUMMY	for future use
3	NAUP	address of the upper node directory
4	ITEM	number of the sub-directory
5	NODES	node name of the first lower node
6	DUMMY	for future use
7	NADWN	address for the directory of the lower node (zero means not exist)
8	NADAT	address for the data set associated with this node (zero means not exist)
9	NDASET	number of the sub-data set (zero means not exist)
10	NDATE(1)	date of creation (YY-MM-DD)
11	NDATE(2)	YY:year, MM:month, DD:day
12	INFOM(1)	information defined by the user
13	INFOM(2)	information defined by the user
14	INFOM(3)	information defined by the user
15	INFOM(4)	information defined by the user
16	INFOM(5)	information defined by the user
17	NODE	node name
18	DUMMY	for future use
19	.	
.	.	
.	.	
.	.	
LREC		

Fig. 5.2 Record information of the Directory Section
in a DATA-POOL

The Data Section consists of several sub-data sets. A sub-data set is produced by executing a writing. The writing is carried out by calling a subroutine from PRITE to PRITE4. The subroutine PRITE only generates the comments of the node. The data of one-dimensional array are written in the regions from DATA1 to DATA4 by calling a subroutine from PRITE1 to PRITE4, respectively. (see Fig. 5.3) The subroutine PRITE1 generates the comments of the node and the DATA1. The subroutine PRITE4 generates the comments of the node, DATA1, DATA2, DATA3 and DATA4 as shown in Fig. 5.3. These data can be read by using the subroutines of PREAD - PREAD4 which correspond to the PRITE - PRITE4 subroutines.

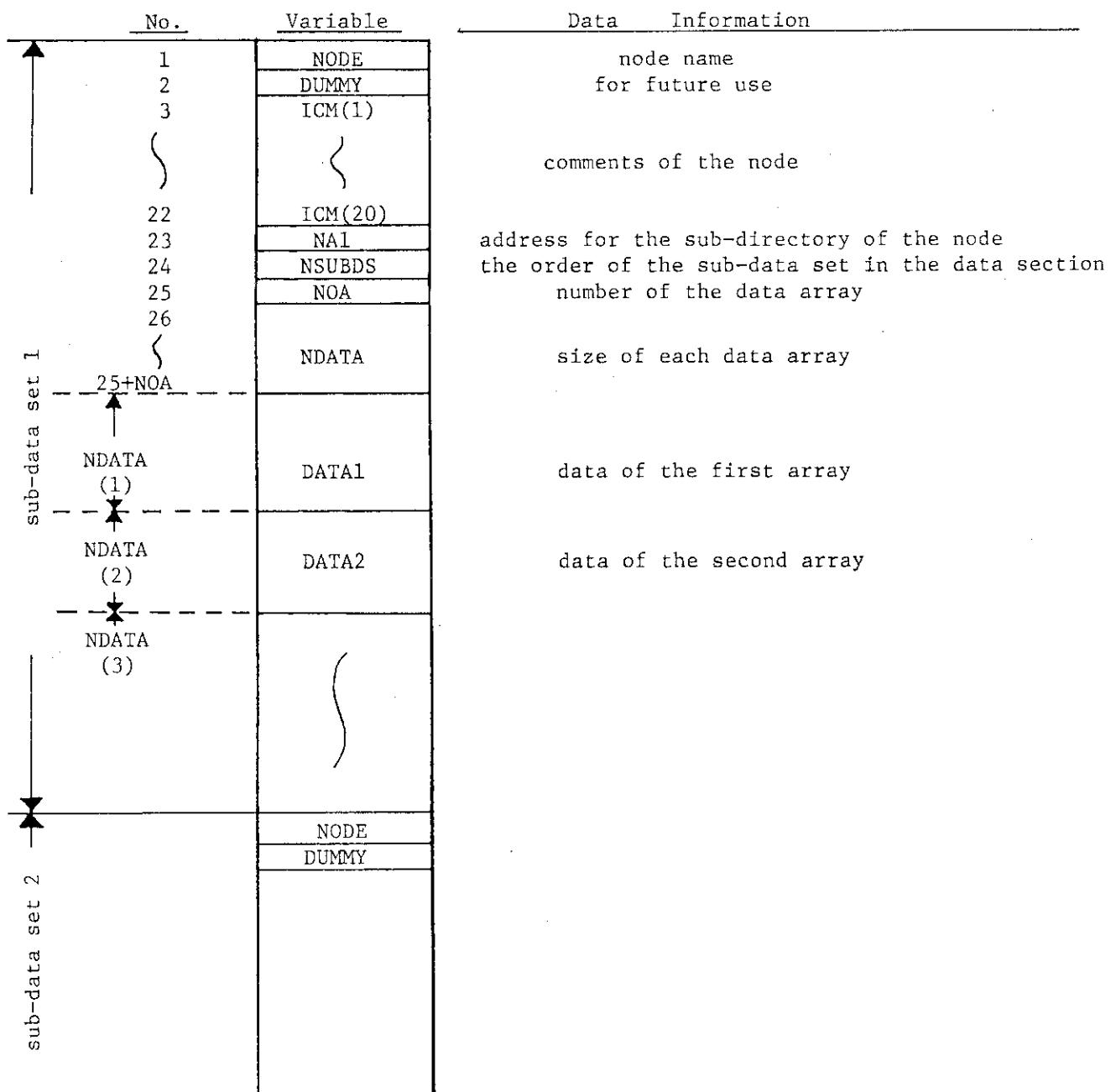


Fig. 5.3 Record information of the Data Section in a DATA-POOL

5.2 Node Structure of JSD1000

The data contained in JSD1000 are classified according to 5 subjects. The data in a subject relate to each other with the node tree structure. The node names and the tree structures are summarized in this section.

The node names adopted in JSD1000 are shown in Table 5.1. The functional modules which utilize the data in the RADHEAT-V4 code system are also described in this table. The node names in this table are generated automatically by using the functional modules in the RADHEAT-V4 code system. The tree structure of node is generated by connecting the node names with each other. The fundamental tree structures are shown in Fig. 5.4. The most of the data are stored in the node of the last level, so that the data are classified and stored in the 10 forms described below. In the following description, the node name with a capital letter in the classification shows the fixed name, and a small letter means that the name changes for each of data.

a) ULTX Data Form

ULTX - matno - TMPi - SIGj

This form contains the ultra-fine group cross section. The identifications for the node names are as follows:

level 1 : ULTX shows the ultra-fine group data. The energy group structure is stored in the node.

level 2 : matno shows the nuclide number. The numbers in JSD1000 correspond to those of ENDF/B-IV.

level 3 : TMPi shows the temperature. The index i indicates the temperature of i. In JSD1000, i = 1, 2, 3, 4, 5, means 300, 560, 900, 1200 and 2100 K, respectively.

level 4 : SIGj shows the background cross section. The index j indicates the σ_0 value. j = 1 means 10^8 in JSD1000.

b) SMT Data Form

EGRP - INFX - matno - SMT

This form contains the smooth cross sections with the fine-group structure. The identifications for the node names are as follows:

level 1 : EGRP shows the fine-group data. The energy group

Table 5.1 Fixed node names contained in JSD1000

Fixed Node Name	Functional Module		Contents
	create	read	
ULTX	FAIR-CROSS step-1	TWOWAY FAIR-CROSS step-2	ultra-fine group cross section
EGRP	----	----	fine-energy group structure
INFX	----	----	infinitely diluted data
SGRX	TWOWAY	FAIR-CROSS step-2	secondary gamma-ray production data
SMT	FAIR-CROSS step-1	FAIR-CROSS step-2	smooth cross section
FTB	FAIR-CROSS step-1	FAIR-CROSS step-2	self-shielding factor table
ELA	FAIR-CROSS step-1	FAIR-CROSS step-2	elastic scattering matrix
INS	FAIR-CROSS step-1	FAIR-CROSS step-2	inelastic scattering matrix
N2N	FAIR-CROSS step-1	FAIR-CROSS step-2	(n,2n) scattering matrix
H+D	FAIR-CROSS step-1	FAIR-CROSS step-2	energy deposition factor and atomic displacement cross section
FX32	FAIR-CROSS step-2	FAIR-CROSS step-3 DIAC, FDEM	effective macroscopic cross section
SELF	FAIR-CROSS step-2	FDEM	self-shielding factor

ULTX — MATNO — TMP_N — SIGN

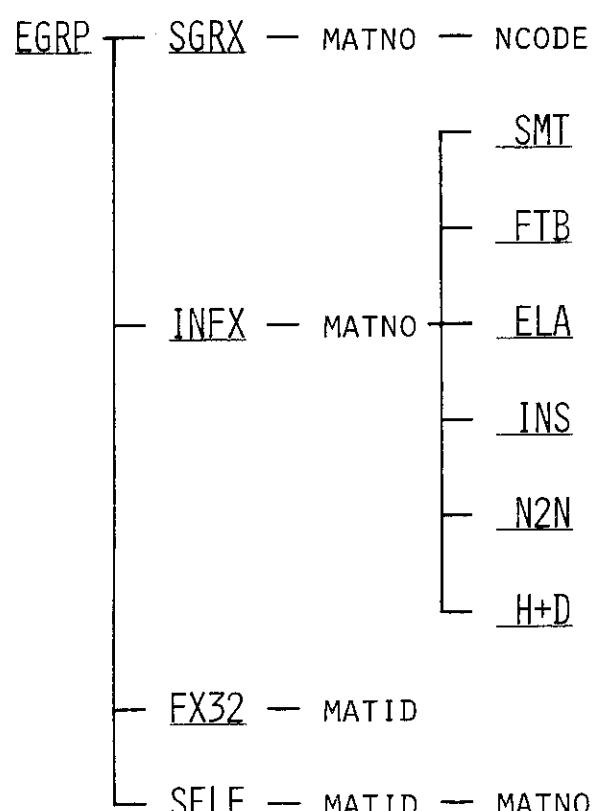


Fig. 5.4 Fundamental node tree structure in JSD1000

structure is stored in the node.

level 2 : INFX shows the infinitely diluted cross section.

level 3 : matno shows the nuclide number. The numbers in JSD1000 correspond to those of ENDF/B-IV.

level 4 : SMT shows the smooth cross section.

c) FTB Data Form

EGRP - INFX - matno - FTB

This form contains the self-shielding factors of each σ_0 value. The identifications for the node names from level 1 to 3 are the same as the SMT data form. The node name FTB indicates that the self-shielding factors are stored in the node.

d) ELA Data Form

EGRP - INFX - matno - ELA

This form contains the scattering matrix of elastic reaction. The identifications for the node names from level 1 to 3 are the same as the SMT data form. The node name ELA indicates that the scattering matrix of elastic reaction is stored in the node.

e) INS Data Form

EGRP - INFX - matno - INS

This form contains the scattering matrix of inelastic reaction. The identifications for the node names from level 1 to 3 are the same as the SMT data form. The node name INS indicates that the scattering matrix of inelastic reaction is stored in the node.

f) N2N Data Form

EGRP - INFX - matno - N2N

This form contains the scattering matrix of ($n,2n$) reaction. The identifications for the node names from level 1 to 3 are the same as the SMT data form. The node name N2N indicates that the scattering matrix of ($n,2n$) reaction is stored in the node.

g) H+D Data Form

EGRP - INFX - matno - H+D

This form contains the energy deposition factor and atomic displacement cross section. The identifications for the node names from level 1 to 3 are the same as the SMT data form. The node name H+D indicates that the energy deposition factor and the atomic displacement cross section are stored in the node.

h) SGRX Data Form

EGRP - SGRX - matno - ncode

This form contains the secondary gamma-ray production cross sections of each reaction. The identifications for the node names are as follows:

level 1 : EGRP shows the fine-group data same as the SMT data form.

level 2 : SGRX shows the secondary gamma-ray production cross section.

level 3 : matno shows the nuclide number. The numbers in JSD1000 correspond to those of ENDF/B-IV.

level 4 : ncode shows the reaction channel defined as the previous Chapter.

i) FXsn Data Form

EGRP - FXsn - matid

This form contains the effective macroscopic cross section. The identifications for the node names are as follows:

level 1 : EGRP shows the fine-group data same as the SMT data form.

level 2 : FXsn shows the effective macroscopic cross section and the number of angular points. The fixed value sn=32 is defined in JSD1000.

level 3 : matid shows the material name. This name are defined in Chapt. 3.

j) SELF Data Form

EGRP - SELF - matid - matno

This form contains the self-shielding factors of each nuclide in the material defined by the matid in the FXsn data form. The data are utilized for generating the effective macroscopic cross section. The identifications for the node names are as follows:

level 1 : EGRP shows the fine-group data same as the SMT data form.

level 2 : SELF shows that the self-shielding factors of each nuclide are defined in the FXsn data form.

level 3 : matid shows the material name defined in the FXsn data form.

level 4 : matno shows the nuclide number contained in the material.

These record formats are described in the next section.

5.3 Record Format of JSD1000

The record formats of JSD1000 are classified according to the data forms noted in Section 5.2. DATA-POOL has the user informations in the Directory Section and the data in the Data Section. Each data are utilized for the functional modules in the RADHEAT-V4 code system. The user informations of 5 words are stored by using PSET subroutine and read by using PFIND subroutine in the DATA-POOL access package, respectively. The data in the Data Section are stored by using PRITE - PRITE4 subroutines and read by using PREAD - PREAD4 subroutines noted in Section 5.1. In the following description, an "information" means the user information in the Directory Section and a "data" indicates the data in the Data Section. The node name with a capital letter shows the fixed name, and a small letter means that the name changes for each data.

a) ULTX Data Form

level 1 node : ULTX

information NGRP, 0, 0, 0, 0

data PREAD1(N, NCOM, NGRP+1, FEGRP)

level 2 node : matno

information MATNO, MTMAX, NTMP, NSIG, LFI

data PREAD3(N, NCOM, MTMAX, MTYPE, NTMP, TMP, NSIG, SIGO)

```

level 3 node : TMPi
information TMP, 0, 0, 0, 0
data      PREAD( N, NCOM )

level 4 node : SIGj
information SIG, MTMAX2, 0, 0, 0
data      PREAD2( N, NCOM, MTMAX2, MTYPE2, NGRP, W )
          DO 1 I=1, MTMAX2
          1 PREAD2( N, NCOM, 5, NDATA, M, GCS )
where NGRP : number of the ultra-fine energy groups ( 3824 ),
      N : logical unit number of DATA-POOL,
      NCOM : comment of the node ( 20 words ),
      MATNO : material identification number,
      MTMAX : number of reactions,
      NTMP : number of temperatures,
      NSIG : length of  $\sigma_0$  table,
      LFI : fission flag ( 0: non fission, 1: fission ),
      MTMAX2 : number of reactions for each  $\sigma_0$  value,
      FEGRP : energy group boundaries ( eV ),
      MTYPE : reaction identification numbers,
      TMP : temperatures,
      SIG0 :  $\sigma_0$  values,
      MTYPE2 : reaction identification numbers,
      W : weighting spectrum,
      NDATA : MTYPE(i), C1, C2, NLOW, NUP,
      M : NUP-NLOW+1,
      GCS : ultra-fine group cross section.

```

b) SMT Data Form

```

level 1 node : EGRP
information ING, IGG, 0, 0, 0
data      PREAD1( N, NCOM, ING+1, GNG )           ( IGG=0 )
          PREAD2( N, NCOM, ING+1, GNG, IGG+1, GGG ) ( IGG≠0 )

```

```

level 2 node : INFX
information 0, 0, 0, 0, 0
data      PREAD( N, NCOM )

```

level 3 node : matno
 information MATNO, 0, 0, 0, 0
 data PREAD(N, NCOM)

level 4 node : SMT
 information 0, 0, 0, 0
 data PREAD3(N, NCOM, M, MT, 1, TMP, 1, SIGO)
 PREAD1(N, NCOM, MM, SMT)
 where ING : number of neutron energy groups (100),
 IGG : number of gamma-ray energy groups (20 or 0),
 N : logical unit number of DATA-POOL,
 NCOM : comment of the node (20 words),
 MT : reaction identification numbers,
 TMP : temperature,
 SIGO : σ_0 value,
 M : number of reactions (10),
 MM : ING×M,
 SMT : smooth cross section.

c) FTB Data Form

level 1 node : EGRP
 information same as the SMT data form
 data ditto.
 level 2 node : INFX
 information same as the SMT data form
 data ditto.

level 3 node : matno
 information same as the SMT data form
 data ditto.

level 4 node : FTB
 information 0, 0, 0, 0, 0
 data PREAD3(N, NCOM, M, MT, NTMP, TMP, NSIG, SIGO)
 DO 1 I=1, NTMP
 1 PREAD4(N, NCOM, LEN, SFT, LEN, SFE, LEN, SFF, LEN, SFC)
 where M : number of reactions (4),

MT : reaction identification numbers,
 MTMP : number of temperatures,
 NSIG : number of σ_0 values,
 N : logical unit number of DATA-POOL,
 NCOM : comment of the node (20 words),
 LEN : NSIG×ING,
 TMP : temperatures,
 SIGO : σ_0 values,
 SFT : self-shielding factor for total reaction,
 SFE : self-shielding factor for elastic reaction,
 SFF : self-shielding factor for fission reaction,
 SFC : self-shielding factor for capture reaction.

d) ELA Data Form

level 1 node : EGRP
 information same as the SMT data form
 data ditto.

level 2 node : INFX
 information same as the SMT data form
 data ditto.

level 3 node : matno
 information same as the SMT data form
 data ditto.

level 4 node : ELA
 information 0, 0, 0, 0, 0
 data PREAD3(N, NCOM, 1, MT, 1, TMP, 1, SIGO)
 DO 1 I=1, ING, 10
 1 PREAD3(N, NCOM, ING, NOA, NTP, ANG, NTP, SIG)
 where N : logical unit number of DATA-POOL,
 NCOM : comment of the node (20 words),
 MT : reaction identification number (MT=2),
 TMP : temperature,
 SIGO : σ_0 value,
 NOA : number of angular points for each energy group,
 NTP : summation of NOA(M) values from M=1 to M=ING,
 ANG : cosine of scattering angles,

SIG : elastic scattering cross section in the DAR form.

e) INS Data Form

level 1 node : EGRP
information same as the SMT data form
data ditto.

level 2 node : INFX
information same as the SMT data form
data ditto.

level 3 node : matno
information same as the SMT data form
data ditto.

level 4 node : INS
information 0, 0, 0, 0, 0
data PREAD3(N, NCOM, 1, MT, 1, TMP, 1, SIGO)
DO 1 I=1, ING, 10
1 PREAD3(N, NCOM, ING, NOA, NTP, ANG, NTP, SIG)
where MT : reaction identification number (MT=4),
SIG : inelastic scattering cross section in the DAR form,
the other notations are the same as the ELA data form.

f) N2N Data Form

level 1 node : EGRP
information same as the SMT data form
data ditto.

level 2 node : INFX
information same as the SMT data form
data ditto.

level 3 node : matno
information same as the SMT data form
data ditto.

level 4 node : N2N

```

information 0, 0, 0, 0, 0
data        PREAD3( N, NCOM, 1, MT, 1, TMP, 1, SIG0 )
            DO 1 I=1, ING, 10
1 PREAD3( N, NCOM, ING, NOA, NTP, ANG, NTP, SIG )
where      MT : reaction identification number ( MT=16 ),
            SIG : (n,2n) scattering cross section in the DAR form,
            the other notations are the same as the ELA data form.

```

g) H+D Data Form

level 1 node : EGRP
 information same as the SMT data form
 data ditto.

level 2 node : INFX
 information same as the SMT data form
 data ditto.

level 3 node : matno
 information same as the SMT data form
 data ditto.

level 4 node : H+D
 information 0, 0, 0, 0, 0
 data PREAD3(N, NCOM, M, MT, 1, TMP, 1, SIG0)
 PREAD1(N, NCOM, MM, HD)
 where N : logical unit number of DATA-POOL,
 NCOM : comment of the node (20 words),
 M : number of reaction channels (M=13),
 MT : reaction identification numbers,
 TMP : temperature,
 SIG0 : σ_0 value,
 MM : ING×M,
 HD : energy deposition factors and atomic displacement cross sections.

h) SGRX Data Form

level 1 node : EGRP

information same as the SMT data form
data ditto.

level 2 node : SGRX
information 0, 0, 0, 0, 0
data PREAD(N, NCOM)

level 3 node : matno
information MATNO, 0, 0, 0, 0
data PREAD(N, NCOM)

level 4 node : ncode
information ITWO, ICON, KEY, NHI, NLLOW
data PREAD3(N, NCOM, LEN, X, LEN, Y, LEN1, P)
where MATNO : material identification number,
N : logical unit number of DATA-POOL,
NCOM : comment of the node (20 words),
ITWO : flag of the nuclear data
(1: ENDF/B-IV, 2: POPOP4),
ICON : flag of the weighting procedure
(0: constant weighting, 1: energy weighting),
KEY : flag of the reaction
(0: no effect, 1: inelastic excitation),
NHI : the highest energy group for non-zero values,
NLLOW : the lowest energy group for non-zero values,
LEN : NHI-NLOW+1,
LEN1 : LGG×LEN,
X : neutron interaction cross sections,
Y : yields,
P : probabilities ((P(i,j),i=1, IGG),j=1, LEN).

i) FXsn Data Form

level 1 node : EGRP
information same as the SMT data form
data ditto.

level 2 node : FXsn

```

information IPO, 0, 0, 0, 0
data      PREAD1( N, NCOM, IPO+1, ANG )

      level 3 node : matid
information MATID, IHS, IHT, IHM, 0
data      PREAD4( N, NCOM, NMAT, MAT1, NMAT, MAT2, NMAT, ATOM,
                  NMAT, TMP )
DO 1 I=1, ING+IGG
1  PREAD2( N, NCOM, LGT1, CRX, LGT2, CRY )
where    IPO : number of fixed angular points ( IPO=sn ),
          N : logical unit number of DATA-POOL,
          NCOM : comment of the node ( 20 words ),
          MATID : material identification name,
          IHS : position of self-scattering cross section,
          IHT : position of total cross section,
          IHM : cross section table length,
          NMAT : number of nuclides in the material,
          MAT1 : nuclide identification numbers for the SMT data,
          MAT2 : nuclide identification numbers for the FTB data,
          ATOM : atomic number densities (n/barn·cm),
          TMP : temperatures,
          LGT1 : IHM,
          LGT2 : IPO×i,
          CRX : effective macroscopic cross section  $\Sigma_g$ ,
          CRY : effective macroscopic cross section  $\Sigma_{g \rightarrow g',m}$ .

```

In the data, CRX and CRY are defined by the following sequences,

position	1 ----- NOACT+1 -- IHT IHS ----- IHM
CRX	$\Sigma_{\text{activation}} - \Sigma_a \bar{\Sigma}_f \Sigma_t \Sigma_{gg} \Sigma_{g-1 \rightarrow g} --- \Sigma_{1 \rightarrow g} -- 0.0$

where NOACT is the number of the activation cross sections consisted of the energy deposition factor and the atomic displacement cross section. The above sequence repeats ING+IGG times.

angle No.	1	2	3	IPO
1	$\Sigma_{g \rightarrow g}(\mu_1)$	$\Sigma_{g \rightarrow g}(\mu_2)$	$\Sigma_{g \rightarrow g}(\mu_3)$	$\Sigma_{g \rightarrow g}(\mu_{ipo})$
2	$\Sigma_{g-1 \rightarrow g}(\mu_1)$	$\Sigma_{g-1 \rightarrow g}(\mu_2)$	$\Sigma_{g-1 \rightarrow g}(\mu_3)$	$\Sigma_{g-1 \rightarrow g}(\mu_{ipo})$
3				
4				
g	$\Sigma_{1 \rightarrow g}(\mu_1)$	$\Sigma_{1 \rightarrow g}(\mu_2)$	$\Sigma_{1 \rightarrow g}(\mu_3)$	$\Sigma_{1 \rightarrow g}(\mu_{ipo})$

where CRY data are stored by starting at top left corner, sweeping from left to right, then from top to bottom. The sequence repeats ING+IGG times.

j) SELF Data Form

level 1 node : EGRP
 information same as the SMT data form
 data ditto.

level 2 node : SELF
 information 0, 0, 0, 0, 0
 data PREAD(N, NCOM)

level 3 node : matid
 information MATID, NMAT, MTMAX, 0, 0
 data PREAD4(N, NCOM, NMAT, MAT1, NMAT, MAT2, NMAT, ATOM,
 NMAT, TMP)

level 4 node : matno
 information MATNO, 0, 0, 0, 0
 data PREAD4(N, NCOM, ING, FTM, ING, FEM, ING, FFM, ING, FCM)
 where N : logical unit number of DATA-POOL,
 NCOM : comment of the node (20 words),

MATID : material identification number,
 NMAT : number of nuclides in the material,
 MTMAX : number of reactions (4),
 MAT1 : nuclide identification number of the SMT data,
 MAT2 : nuclide identification number of the FTB data,
 ATOM : atomic number densities (n/barn·cm),
 TMP : temperatures,
 FTM : self-shielding factor for total cross section,
 FEM : self-shielding factor for elastic cross section,
 FFM : self-shielding factor for fission cross section,
 FCM : self-shielding factor for capture cross section.

The PREAD - PREAD4 subroutines will be followed by the PFIND one which searches the series of node names and sets the first record address of the data to be read. For example, the ultra-fine group cross sections can be read by using the following FORTRAN statements.

```
DIMENSION JCONTR(40), INF(12), NODE(4), NCOM(20),
DIMENSION FEGRP(NGRP+1), MTYPE(MTMAX), TMP(NTMP),
DIMENSION SIGO(NSIG), NDATA(NOARY), MTYPE2(MTMAX2),
DIMENSION W(NGRP), NDATA(5), GCS(NGRP), CROS(NGRP,MTMAX2)
```

CC- DATA-POOL OPEN

N=91

CALL POPEN(N,JCONTR)

NODE(1)='ULTX'

NODE(2)='1192'

NODE(3)='TMP1'

NODE(4)='SIG1'

NTH=1

CC - READ DATA OF THE FIRST LEVEL NODE

CALL PFIND(N,NODE,NTH,INF,L)

IF(L.NE.0) GO TO 9000

NGRP=INF(8)

CALL PREAD1(N,NCOM,I,FEGRP)

CC - READ DATA OF THE SECOND LEVEL NODE

NTH=2

CALL PFIND(N,NODE,NTH,INF,L)

IF(L.NE.0) GO TO 9000

```

MATNO=INF(8)
MTMAX=INF(9)
NTMP=INF(10)
NSIG=INF(11)
LFI=INF(12)
CALL PREAD3(N,NCOM,MTMAX,MTYPE,NTMP,TMP,NSIG,SIG0)
CC - READ DATA OF THE THIRD LEVEL NODE
NTH=3
CALL PFIND(N,NODE,NTH,INF,L)
IF(L.NE.0) GO TO 9000
TMP=INF(8)
CALL PREAD(N,NAME1,NAME2,NCOM,NASBD,NOSBDS,NOARY,NDATA)
CC - READ DATA OF THE FOURTH LEVEL NODE
NTH=4
CALL PFIND(N,NODE,NTH,INF,L)
IF(L.NE.0) GO TO 900
SIG=INF(8)
MTMAX2=INF(9)
CALL PREAD2(N,NCOM,MTMAX2,MTYPE2,NGRP,W)
DO 1 I=1,MTMAX2
CALL PREAD2(N,NCOM,II,NDATA,M,GCS)
NLOW=NDATA(4)
NUP=NDATA(5)
DO 3 J=1,NGRP
3 CROS(J,I)=0.0
K=0
DO 2 J=NLOW,NUP
K=K+1
2 CROS(J,I)=GCS(K)
1 CONTINUE
-- -
-- -
9000 WRITE(6,9001) L
9001 FORMAT(5X,'THE SPECIFIED NODE IS NOT FOUND! CODE=',I5)
STOP

```

The data defined by the other forms can be read by the same manner.

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