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A 218 NEUTRON GROUP MASTER CROSS SECTION LIBRARY FOR CRITICALITY SAFETY STUDIES†

W. E. Ford, III
R. M. Westfall
C. C. Webster

√Computer Sciences Division
Union Carbide Corporation - Nuclear Division
Oak Ridge, Tennessee 37830

The AMPX system[1] was used to generate a P_3 218 neutron group master[a] cross-section library from ENDF/B-IV data for the fuel, structural, and neutron-absorbing materials listed in Table I. The library is the data base for the generation of broad-group cross sections for shipping cask calculations and other criticality safety analyses using codes such as KENO[2] and ANISN[3].

Selection of the fine-group energy structure for the 3-eV to 20-MeV energy range included consideration of the resonance structure of prominent nuclei, the thresholds of important reactions, and the fission spectra. For $10^{-5} \leq E_n < 3$ eV, 78 closely spaced thermal groups were chosen to examine the effects of low-energy resonances and thermal-neutron upscatter. Distribution of the 218 groups within the Hansen-Roach[4] 16-group boundries is shown in Table II.

Adequacy of the group structure and validity of selected data sets from the library were tested by P_3S_8 XSDRNPM[b] calculations of k-eff for two benchmark critical experiments. First, the 4.9%-enriched UO_2F_2-H_2O solution critical sphere experiment of Johnson and Cronin[5] was analyzed.

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This system had a critical ^{235}U mass of 4.14 kg with a $H/^{235}U$ atom ratio of 1002. The solution was contained within a 0.32-cm-thick Al shell having an outer radius of 34.82 cm. A k-eff of 0.9998 was calculated for the low-enriched thermal system.

Second, the 93.2%-enriched UO_2F_2-H_2O solution critical sphere experiment of Fox[6] was analyzed. This system had a critical mass of 3.25 kg ^{235}U with a $H/^{235}U$ atom ratio of 1393. The solution was contained within a 0.32-cm-thick Al shell having an outer radius of 34.92 cm. A k-eff of 1.0046 was calculated for the high-enriched thermal system.

The master cross-section library is available on magnetic tape from the Radiation Shielding Information Center.[c] Efforts to determine a broad-group subset of the 218 neutron groups for collapsing data sets from the library for shipping cask criticality studies are described in Ref. 7.

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[a]The AMPX system uses a fine-group master cross-section library as input to generate fine- or broad-group coupled neutron-gamma or uncoupled cross sections in formats for several codes (e.g., ANISN, VENTURE, MORSE, DOT, SWANLAKE) at a relatively low cost and in a relatively fast computer run.

[b]XSDRNPM is the AMPX module with one-dimensional S_n capability. See Ref. 1.

[c]Inquiries should be addressed to Radiation Shielding Information Center, P.O. Box X, Oak Ridge National Laboratory, Oak Ridge, TN 37830.

Table I. Fine Group[a] Master Cross Section Library for Criticality Safety Analysis

Nuclide	ENDF/B-IV MAT No.	Master Library ID Number	Nuclide	ENDF/B-IV MAT No.	Master Library ID Number
H	1269[b]	1269	Ag-107	1138[c]	113802
He-4	1270	127003	Ag-108	1139[c]	113902
Li-6	1271	127103	Cd	1281	128103
Li-7	1272	127203	Sn	7039[d]	703903
Be-9	1289	128903	Ba	7040[d]	704003
B-10	1273	127303	Gd	1030[c]	103002
B-11	1160	116003	Dy-164	1031[c]	103102
C-12	1274	127403	Lu-175	1032[c]	103202
N-14	1275	1275	Lu-176	1033[c]	103302
O-16	1276	1276	Hf	1034[c]	103402
F	1277	1277	Ta-181	1127[c]	112702
Na-23	1156[c]	115602	W-182	1128[c]	112802
Mg	1280	128003	W-183	1129[c]	112902
Al-27	1193	1193	W-184	1130[c]	113002
Si	1194	119403	W-186	1131[c]	113102
P-31	7019[d]	701903	Re-185	1083[c]	108302
S-32	7020[d]	702003	Re-187	1084[c]	108402
Cl	1149	114903	Au-192	1283	128303
K	1150	115003	Pb	1288	128803
Ca	1195	119503	Th-232	1296[c]	129602
Ti	1286	128603	U-233	1260[c]	126002
V	1196	119603	U-234	1043[c]	1043
Cr	1191[c]	119102	U-235	1261[c]	1261
Mn-55	1197[c]	119702	U-236	1163[c]	116302
Fe	1192[c]	119202	U-238	1262[c]	1262
Co-59	1199[c]	119902	Np-237	1263[c]	126302
Ni	1190[c]	119002	Pu-238	1050[c]	105002
Cu	1295[c]	129502	Pu-239	1264[c]	126402
Zn	4530[e]	453003	Pu-240	1265[c]	126502
Zr-95[c]	1202	120202	Pu-241	1266[c]	126602
ZIRC-2	1284[c]	128402	Pu-242	1161[c]	116102
Nb-93	1189[c]	118902	Am-241	1056[c]	105602
Mo	1287[c]	128702	Cm-244	1162[c]	116202

[a]The 218 neutron groups span the range $10^{-5} \leq E_n \leq 2 \times 10^7$ eV. Seventy-eight "thermal" groups are in the range $10^{-5} \leq E_n \leq 3.05$ eV.

[b]ENDF/B MAT 1002 was used for water bound thermal data.

[c]This is a resonance material. A potential scattering cross section of 5×10^4 barns/atom was used in the unresolved resonance calculation.

[d]ENDF/B formatted data was obtained from Howerton's library.[8]

[e]ENDF/B formatted data was obtained from RSIC's Defense Nuclear Agency Working Cross-Section Library.[9]

Table II. Correspondence of 218n and Hansen-Roach 16 Group Structures

Hansen-Roach		218n Group	Number of 218n Groups per Hansen-Roach Group
Group Number	Energy Range	Numbers	
1	20-3 MeV	1-4	4
2	3-1.4	5-9	5
3	1.4-0.9	10-17	8
4	900-400 KeV	18-31	14
5	400-100	32-37	6
6	100-17	38-48	11
7	17-3	49-55	7
8	3-0.55	56-66	11
9	550-100 eV	67-78	12
10	100-30	79-108	30
11	30-10	109-124	16
12	10-3	125-141	17
13	3-1	142-182	41
14	1-0.4	183-196	14
15	0.4-0.1	197-208	12
16	$0.1-10^{-5}$	209-218	10

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