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SUBJECT: Multigroup Neutron Cross Sections

TO: Distribution

FROM: C. W. Nestor

ABSTRACT

This memorandum is a revised edition of CF-60-3-35, incorporating some new data for U-235 and including some data which was inadvertently omitted from the earlier compilation.

MULTIGROUP NEUTRON CROSS SECTIONS

I. Introduction

In connection with the thorium breeder study a set of multigroup cross sections for the IBM-704 program GNU[1] has been prepared for the elements listed in Table 1. This report is a tabulation of these cross sections and a discussion of the data used in the preparation of cross sections for which there is insufficient data in the Hughes-Schwartz compilation.[2]

The elements for which all data were not taken from BNL-325 are U^{233}, Pa^{233}, Sm^{151} and "fissium" (a mixture of fission products excluding Xe and Sm). Newer data were available for U^{233}[(3)] and Sm^{151};[(4)] no data are available in BNL-325 for Pa^{233} or for gross fission product mixtures. The procedures followed in preparing the cross sections for these elements is discussed below. The group structure and cross sections are listed in Table 3.

II. U^{233}

The principal parameter of interest in nuclear calculations of a Th-U^{233} breeder is η, the number of neutrons produced per neutron absorbed. Experimental information on the energy dependence of η in the range of 0 to 10 ev as measured at the MTR was used to calculate group averaged fission cross sections, using absorption cross sections calculated from the recent total cross section data[3] and the scattering cross section as calculated by Vogt.[5] The η values used in preparation of the cross sections are normalized to a 2200 m/sec value of 2.28.[6]

In the energy range of 0 to 0.8 ev, η was assumed to be constant at 2.28. In the range of 0.8 ev to 10 ev, as mentioned, group averaged values of $\overline{\nu\sigma_f} = \overline{\eta\sigma_a}$ were calculated by numerical evaluation of the integrals in

Table 1. Elements for which Cross Sections were Prepared and/or Compiled

GNU Number	Element	Temperatures (°C)	
1	H	280	
4	Be	280, 649	
5	B	280	
6	C	280, 649, 925	
7	N	280	
8	O	280, 925	
9	F	649, 925	
11	Na	280	
12	Mg	280	
13	Al	280	
15	Li^6	649, 925	
16	S	280	
17	Li^7	649	
20	Inor-8	649	
21	MSR Fuel Salt	649	
22	MSR Blanket Salt	649	
24	Cr	280	
25	Mn	280	
26	Fe	280, 649, 925	
28	Ni	280	
29	Cu	280	
40	Zr	280	
52	"Corrosion I"	280	
53	"Corrosion II"	280	
54	Xe^{135}	280, 649, 925	
55	Sm^{151}	280, 649, 925	
62	Sm^{149}	280, 649, 925	
68	Th-MSR Core	649	Resonance σ_a only
69	Th-MSR Blanket	649	
70	Th-AHR Slurry	280	
76	Th- Pebble bed	280	
77	Th - Infinite dilution	280, 649	
78	Th - LBR core	649	

Table 1. - contd

GNU Number	Element	Temperatures (°C)
83	Bi	649
84	U^{233} capture cross section	280, 649, 925
85	U^{235} capture cross section	280, 649, 925
86	Fissium	280, 649, 925
87	Np^{237}	280, 649, 925
88	D	280, 925
91	Pa^{233}	280, 649, 925
92	Th (without resonance σ_a)	↓
93	U^{233}	↓
94	U^{234}	↓
95	U^{235}	↓
96	U^{236}	↓
98	U^{238}	280, 649

$$\bar{\eta} = \frac{\int \eta(E)\, \sigma_a(E)\, \frac{dE}{E}}{\int \sigma_a(E)\, \frac{dE}{E}} \qquad (1)$$

$$\bar{\sigma}_a = \frac{1}{\Delta u} \int \sigma_a(E)\, \frac{dE}{E} \qquad (2)$$

where Δu denotes the lethargy width of the group.

In the range of 10 ev to 30 ev η was estimated to be 2.17; the data of Gaerttner and Yeater[7] indicate an average η in this range of about 0.95 times the 2200 m/sec value.

From 30 ev to 30 kw, η was assumed to be 2.25; this is the value reported by Spivak et al.[8] at 30 kev.

From 30 kev to 900 kev, measurements of η are available;[8] fission cross sections are reported in BNL-325 for the range 30 kev to 10 Mev. The total cross section in this range was taken to be equal to that of U^{235}, as suggested by J. A. Harvey.[9] The value of ν was assumed to be linear in energy with a 2200 m/sec value of 2.50[6] and a slope of 0.127 per Mev.[10] A plot of the experimental η and the group averaged values from 0.01 ev to 1 kev is shown in Fig. 1.

III. Pa^{233}

The 2200 m/sec cross section and the resonance integral were taken to be

$$\sigma_o = 70 \text{ barns}$$

$$I_o = 1200 \text{ barns}$$

as reported by Stoughton and Halperin.[11] Multigroup absorption cross sections were prepared assuming a single Breit-Wigner resonance at 1 ev is responsible

for the entire cross section. This assumption leads to a total width Γ for the resonance of about 55 mv.

IV. Sm^{151}

The preliminary measurement of Cocking[4] can be represented by two straight line segments on a log-log plot connecting the points

E, ev	$\sigma(E)$, bn.
0.01	25,000
0.10	5,000
1.00	500

and this fit was used to calculate group averaged cross sections for this isotope in the low energy groups.

Resonance parameters listed in BNL-325 are reproduced below with calculated infinite dilution resonance integral values and calculated group averaged cross sections, assuming the entire contribution to the resonance integral of each resonance is concentrated in the group in which the resonance lies.

V. "Fissium"

Data on gross fission products as compiled by Pattenden[12] was used to prepare multigroup cross sections for the pseudo-element "fissium." The energy variation was assumed to be 1/v up to 0.6 ev with a 2200 m/sec value of 50 barns/fission. From 0.6 ev to 100 ev, the curve computed by Gordeev and Pupko[13] for U^{235} was used to calculate the group averaged cross sections. This procedure gives a resonance integral of 150 barns/fission; if the yields of fission products for U^{233} fission products are substituted into Pattenden's table for U^{235},[(12)] a resonance integral of 138 barns/fission is obtained. Thus the curve

is a fair representation in the sense of giving a reasonable value for the resonance integral. The Gordeev and Pupko curve and the group average values are shown in Fig. 2.

Table 2. Group Averaged Cross Sections for Sm^{151}

E_o, ev	g Γ_n, mv	Γ_γ, mv	I_∞, bn.	group
1.10	0.30	63	1020	31
1.70	0.13		184	30
2.04	0.24		235	30
4.10	0.25		61	29
6.30	1.65		170	27

group	$\bar{\sigma}_a$
27	550
28	0
29	130
30	720
31	2300
32	725

Acknowledgment

In the preparation of the bulk of the tables in this report the author has acted principally as a compiler and wishes to express his thanks to the many people who provided the data and did the hard part of the work.

REFERENCES

1. C. L. Davis, J. M. Bookston and B. E. Smith, GNU-II - A Multigroup One-Dimension Diffusion Program for the IBM-704, General Motors Report GMR 101 (1957).

2. D. J. Hughes and R. B. Schwartz, Neutron Cross Sections, Brookhaven National Laboratory Report BNL-325 (Second Edition, 1958).

3. New total and fission cross section data were obtained from M. S. Moore of the MTR Nuclear Physics Group; additional total cross sections and η information were communicated by J. A. Harvey, R. C. Block and N. J. Pattenden of the ORNL Physics Division.

4. Thermal (0.01 ev to 1 ev) cross sections were taken from a preliminary measurement by S. J. Cocking (TNCC(UK) 34, 1958).

5. Communicated by J. A. Harvey.

6. J. E. Evans, reported at the Argonne National Laboratory Conference on the Physics of Breeding, October 1959.

7. E. R. Gaerttner and M. L. Yeater, Reports to the AEC Nuclear Cross Section Advisory Group, WASH-194, Feb. 1958.

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9. Personal Communication.

10. G. N. Smirenkin et al., J. Nucl. Energy 9, 155 (1959).

11. R. W. Stoughton and J. Halperin, Nuclear Sci. and Eng. 6, 100 (1959).

12. N. J. Pattenden, ORNL-2778, 1959.

13. Reprinted in ORNL-2778.

gcb

FIG. 1. GROUP VALUES OF $\eta^{23}(E)$ PRESENTLY BEING USED IN THORIUM BREEDER REACTOR STUDY

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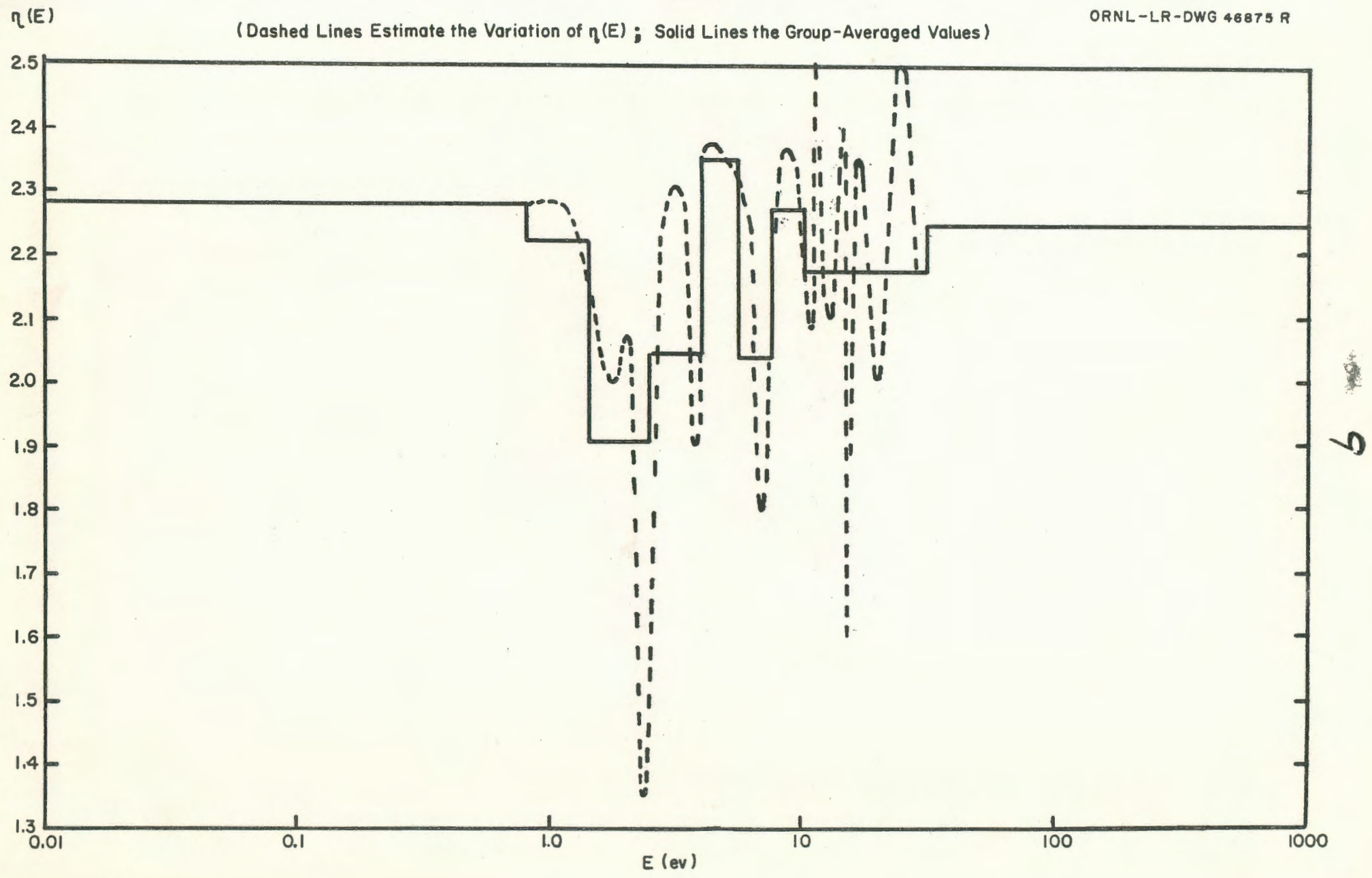

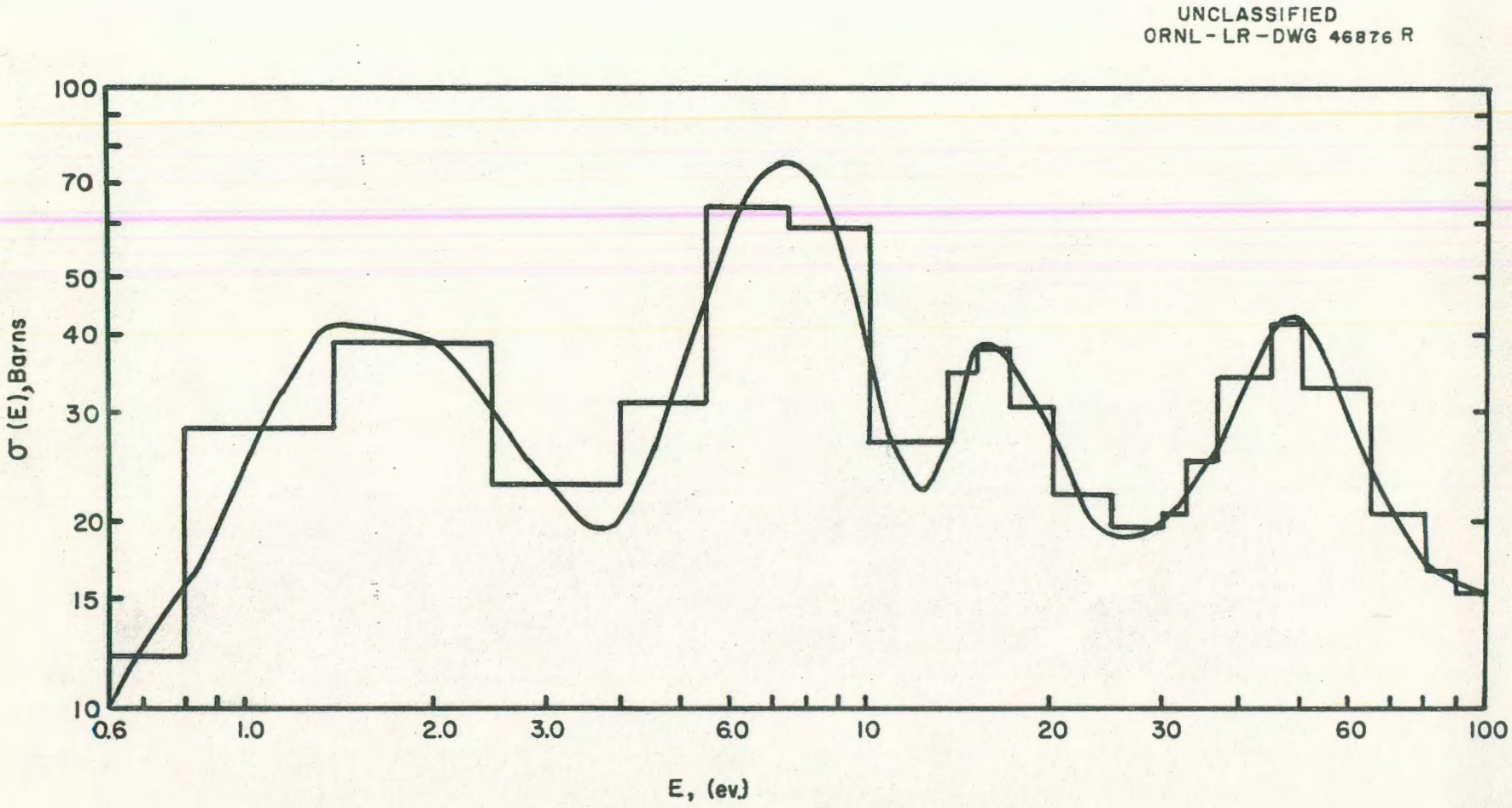

FIG. 2. "FISSIUM" CROSS SECTIONS

TABLE 3

HRP GROUP STRUCTURE FOR GNU

Group Lethargy Width Table

Group	Δu	energy (ev)
1	0.91629	$4 \times 10^6 \rightarrow 10^7$
2	0.69315	$2 \times 10^6 \rightarrow 4 \times 10^6$
3	0.69315	$1 \rightarrow 2 \times 10^6$
4	1.20400	$3 \times 10^5 \rightarrow 10^6$
5	1.09860	$1 \times 10^5 \rightarrow 3 \times 10^5$
6	1.20400	$3 \times 10^4 \rightarrow 1 \times 10^5$
7	1.09860	$1 \times 10^4 \rightarrow 3 \times 10^4$
8	1.20400	$3 \times 10^3 \rightarrow 1 \times 10^4$
9	1.09860	$1 \times 10^3 \rightarrow 3 \times 10^3$
10	0.91629	$400 \rightarrow 10^3$
11	0.98083	$150 \rightarrow 400$
12	0.40547	$100 \rightarrow 150$
13	0.10536	$90 \rightarrow 100$
14	0.11778	$80 \rightarrow 90$
15	0.20764	$65 \rightarrow 80$
16	0.26236	$50 \rightarrow 65$
17	0.10536	$45 \rightarrow 50$
18	0.19574	$37 \rightarrow 45$
19	0.11441	$33 \rightarrow 37$
20	0.09531	$30 \rightarrow 33$
21	0.18232	$25 \rightarrow 30$
22	0.22314	$20 \rightarrow 25$
23	0.16252	$17 \rightarrow 20$
24	0.23052	$13.5 \rightarrow 17$
25	0.30010	$10 \rightarrow 13.5$
26	0.28768	$7.5 \rightarrow 10$
27	0.31015	$5.5 \rightarrow 7.5$
28	0.31845	$4 \rightarrow 5.5$
29	0.47000	$2.5 \rightarrow 4$
30	0.57982	$1.4 \rightarrow 2.5$
31	0.55962	$0.8 \rightarrow 1.4$
32	0.28768	$0.6 \rightarrow 0.8$

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 1: H

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\bar{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	0	2.106×10^{-5}	0	1.374
2		3.137		2.345
3		4.436		3.521
4		7.201		5.937
5		1.277×10^{-4}		1.012×10
6		2.277		1.489
7		4.039		1.798
8		7.201		1.939
9		1.277×10^{-3}		2.005
10		2.106		2.022
11		3.388		2.034
12		4.751		2.042
13		5.390		2.045
14		5.699		2.046
15		6.184		2.048
16		6.957		2.050
17		7.623		2.053
18		8.221		2.054
19		8.882		2.057
20		9.359		2.058
21		1.003×10^{-2}		2.059
22		1.111		2.061
23		1.228		2.064
24		1.349		2.066
25		1.542		2.069
26		1.785		2.072
27		2.073		2.075
28		2.246		2.079
29		2.959		2.083
30		3.851		2.088
31		5.119		2.100
32		6.312		2.144

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 4: Be

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	0.4608	6.3425×10^{-7}	0	5.2490
2	0.3240	9.4485 ↓		6.6160
3	0.6813	1.3362×10^{-6}		6.6919
4	0.8700	2.1688		1.0649×10
5	1.1913	3.8471		1.3588
6	1.2122	6.8585 ↓		1.6068
7		1.2165×10^{-5}		1.6112
8		2.1688		
9		3.8471		
10		6.3425 ↓		
11		1.0204×10^{-4}		
12		1.4312		
13		1.6236		
14		1.7167		
15		1.8628		
16		2.0956		
17		2.2960		
18		2.4762		
19		2.6752		
20		2.8190		
21		3.0224		
22		3.3454		
23		3.6832		
24		4.0646		
25		4.6430		
26		5.3775		
27		6.2450		
28		7.3085		
29		8.9120 ↓		
30		1.1601×10^{-3}		
31		1.5142 ↓		
32		1.9013		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 5: B

Group	$\xi\sigma_T$	$\overline{\sigma_a}$	$\overline{\nu\sigma_f}$	$3\overline{\sigma_{tr}}$
1	2.76×10^{-1}	4.789×10^{-2}	0	4.024
2	3.22	7.134		4.677
3	3.174	1.009×10^{-1}		6.610
4	6.624	1.637		9.089
5	8.096	2.905		1.040×10
6	9.496	5.178		1.209
7	1.012	9.510		1.238
8	1.089	1.291		
9	1.178	1.747		
10	1.398	2.583		
11	1.785	3.998		
12	2.116	6.18		
13	2.235	7.42		
14	2.377	8.13		
15	2.648	9.24		
16	3.036	1.102×10		
17	3.203	1.255		
18	3.540	1.391		
19	3.754	1.541		
20	3.939	1.651		
21	4.324	1.804		
22	4.845	2.049		
23	5.264	2.305		
24	5.921	2.596		
25	6.900	3.037		
26	8.022	3.618		
27	9.439	4.295		
28	1.115×10	5.141		
29	1.425	6.427		
30	1.928	8.606		
31	2.556	1.174		
32	2.933	1.444		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 6: C

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	0.303676	2.1565×10^{-7}	0	3.7354
2	0.2686	3.213		5.4204
3	0.4108	4.544		6.0604
4	0.6241	7.380		9.2352
5	0.694568	1.308×10^{-6}		1.19114×10
6	0.74181	2.332		1.28686
7	0.7584	4.187		1.35370
8		7.375		1.35936
9		1.308×10^{-5}		
10		2.157		
11		3.470		
12		4.866		
13		5.520		
14		5.830		
15		6.335		
16		7.125		
17		7.805		
18		8.420		
19		9.095		
20		9.585		
21		1.028×10^{-4}		
22		1.138		
23		1.253		
24		1.382		
25		1.579		
26		1.829		
27		2.124		
28		2.485		
29		3.030		
30		3.944		
31		5.245		
32		6.465		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 7: N

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	2.448 x 10^{-1}	1.192 x 10^{-4}	0	4.070
2	2.319	1.776		4.638
3	2.191	2.512		5.861
4	4.319	4.077		6.786
5	5.814	7.233		1.009 x 10
6	6.582	1.289 x 10^{-3}		1.300
7	7.371	2.287		1.463
8	8.346	4.077		1.648
9	1.104	7.233		2.017
10	1.224	1.192 x 10^{-2}		2.450
11	1.295	1.918		2.644
12	1.319	2.691		2.737
13	1.322	3.052		2.765
14	1.325	3.227		2.770
15	1.331	3.502		2.779
16	1.337	3.940		2.790
17	1.340	4.316		2.799
18	1.345	4.655		2.806
19	1.348	5.029		2.813
20	1.350	5.300		2.817
21	1.354	5.682		2.820
22	1.360	6.289		2.832
23	1.364	6.924		2.842
24	1.370	7.641		2.849
25	1.378	8.729		2.859
26	1.384	1.011 x 10^{-1}		2.873
27	1.392	1.174		2.882
28	1.401	1.374		2.893
29	1.413	1.675		2.907
30	1.428	2.181		2.922
31	1.428	2.899		2.916
32	1.428	3.574		2.896

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 8: O

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	2.120 x 10^{-1}	0	0	4.218
2	2.204			5.074
3	9.600			9.217
4	4.260			9.982
5	4.194			1.008 x 10
6	4.182			1.003
7	4.314			1.007
8	4.555			1.075
9	4.544			1.090
10	4.535			1.087
11	4.525			1.085
12	4.521			1.083
13	4.520			1.083
14	4.519			1.082
15	4.517			1.082
16	4.514			1.081
17	4.515			1.081
18	4.511			1.080
19	4.510			
20	4.509			
21	4.508			
22	4.505			1.079
23	4.504			1.078
24	4.502			1.078
25	4.499			1.077
26	4.496			1.077
27	4.493			1.076
28	4.490			1.075
29	4.485			1.075
30	4.479			1.073
31	4.476			1.072
32	4.476			1.072

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 9: F

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\nu\sigma_f$	$3\bar{\sigma}_{tr}$
1	1.62×10^{-1}	2.00×10^{-1}	0	5.40
2	2.00	0		7.50
3	3.45	0		9.60
4	3.50	1.00×10^{-3}		1.35×10
5	7.70	1.00		2.40
6	2.55	3.00		1.50
7	4.35×10^{-1}	0		1.35
8	3.70			1.11
9				
10				
11				
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13	3.50			1.05
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TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 11: Na

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	1.859 x 10^{-2}	3.203 x 10^{-5}	0	6.409
2	2.535	4.771		7.984
3	3.309	6.748		8.416
4	3.972	1.095 x 10^{-4}		1.222 x 10
5	2.788	1.943		1.116
6	3.387	3.464		1.255
7	4.787	6.144		1.313
8	2.183 x 10^{-1}	1.095 x 10^{-3}		1.263 x 10^{2}
9	3.516 x 10^{-2}	1.943		1.503
10	2.620	3.203		1.013 x 10
11	2.620	5.153		9.016
12	2.622	7.227		9.010
13	2.624	8.199		9.022
14	2.626	8.669		9.027
15	2.631	9.407		9.036
16	2.628	1.058 x 10^{-2}		9.051
17	2.630	1.159		9.062
18	2.643	1.250		9.068
19	2.645	1.351		9.077
20	2.645	1.424		9.083
21	2.648	1.526		9.086
22	2.650	1.689		9.086
23	2.652	1.860		9.089
24	2.658	2.053		9.089
25	2.670	2.345		9.118
26	2.679	2.716		9.144
27	2.690	3.154		9.164
28	2.696	3.691		9.170
29	2.701	4.501		9.170
30	2.704	5.858		9.141
31	2.783	7.787		9.240
32	2.807	9.601		9.357

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 12: Mg

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\bar{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	1.510×10^{-1}	6.300×10^{-2}	0	5.111
2	2.222			6.337
3	2.104			7.992
4	7.887			1.606×10
5	7.493			1.913
6	2.720			2.680
7	2.640			1.205
8	2.720			9.729
9				9.741
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TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 13: Al

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	1.774×10^{-1}	3.500×10^{-4}	0	5.946
2	2.461	3.579		8.295
3	1.955	3.808		8.959
4	3.044	8.527		1.084×10
5	4.584	2.715×10^{-3}		1.519
6	5.650×10^{-2}	5.992		1.868
7	9.410	5.451		2.467
8	1.014×10^{-1}	7.000		4.303
9	1.016			4.080
10	1.018			4.089
11	1.020			4.098
12	1.021			4.104
13	1.021			4.104
14	1.022			4.107
15				4.107
16				4.110
17				4.110
18	1.023			4.113
19				
20				
21	1.024	7.058		4.116
22		7.696		4.113
23		8.473		4.116
24	1.025	9.350		4.113
25	1.025	1.068×10^{-2}		4.110
26	1.026	1.237		4.110
27	1.026	1.437		4.107
28	1.027	1.681		4.101
29	1.028	2.050		4.095
30	1.107	2.668		4.232
31	1.070	3.547		4.162
32	1.092	4.373		4.253

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 15: Li^6

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	6.16×10^{-1}	6.74×10^{-2}	0	5.04
2	4.19	1.618×10^{-1}		4.76
3	4.36	2.530		3.78
4	2.02	7.142		7.59
5	4.99×10^{-1}	1.463		1.22×10
6	4.96	7.680×10^{-1}		4.55
7	7.38	1.163		5.92
8	1.11	2.057		9.87
9	1.75	3.650		1.67×10
10	2.62	6.020		2.64
11	4.04	9.689		4.07
12	4.81	1.359×10		5.55
13	5.05	1.542		6.24
14	5.32	1.631		6.56
15	5.83	1.770		7.07
16	6.52	1.991		7.88
17	6.85	2.181		8.56
18	7.48	2.353		9.18
19	7.92	2.542		9.85
20	8.28	2.678		1.01×10^2
21	8.91	2.872		1.10
22	9.93	3.179		1.21
23	1.07×10	3.500		1.32
24	1.20	3.863		1.44
25	1.38	4.413		1.63
26	1.57	5.110		1.87
27	1.81	5.940		2.14
28	2.12	6.950		2.47
29	2.69	8.470		2.97
30	4.35	1.100×10^2		3.78
31	5.61	1.470		4.90
32	6.39	1.810		5.94

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 16: S

Group	$\bar{\sigma}_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	1.787×10^{-1}	3.298×10^{-5}	0	6.987
2	1.802	4.913		8.614
3	1.680	6.949		7.319
4	1.405	1.128×10^{-4}		7.093
5	4.408	2.000		1.811×10
6	4.301×10^{-2}	3.566		2.398
7	7.253	6.326		2.783
8	7.216	1.128×10^{-3}		3.477
9	7.185	2.000		3.454
10	7.179	3.298		3.442
11		5.306		3.436
12		7.442		3.430
13		8.442		3.427
14	7.173	8.927		3.422
15	7.161	9.687		3.416
16		1.090×10^{-2}		3.413
17		1.194		3.407
18	7.155	1.288		3.401
19	7.149	1.391		3.395
20	7.149	1.466		3.392
21	7.143	1.572		3.386
22	7.136	1.740		3.380
23	7.136	1.915		3.372
24	7.124	2.114		3.363
25	7.112	2.414		3.351
26	7.106	2.796		3.336
27	7.100	3.247		3.319
28	7.088	3.800		3.298
29		4.634		3.272
30		6.032		3.231
31	7.051	8.018		3.463
32	7.026	9.886		3.096

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 17: Li^7

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	4.45×10^{-1}	2.11×10^{-6}	0	4.915
2	4.06	3.17		3.502
3	3.28	5.76		3.451
4	3.28	7.37		4.947
5	7.86	1.34×10^{-5}		6.286
6	2.75	2.66		2.850
7		4.08		
8		7.31		
9		1.31×10^{-4}		
10		2.03		
11		3.44		
12		4.57		
13		5.75		
14		5.75		
15		5.75		
16		7.31		
17		7.73		
18		7.73		
19		8.37		
20		1.11×10^{-3}		
21				
22				
23				
24		1.30×10^{-3}		
25		1.50		
26		2.00		
27		2.00		
28		2.55		
29		3.36		
30		3.36		
31		5.12		
32		6.17		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 20: Inor-8

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	5.98×10^{-1}	1.868×10^{-1}	0	4.856×10
2	5.89	1.904		4.890
3	6.98	1.936		5.480
4	1.010	1.972		7.223
5	2.375	2.006		1.501×10^{2}
6	3.158	2.031		2.133
7	3.165	2.057		2.463
8	3.175	2.096		2.709
9	3.010	2.264		2.651
10	2.939	2.544		2.637
11	2.930	3.531		2.661
12	2.941	5.778		2.672
13	2.967	1.159		2.692
14				
15				
16				2.659
17		1.160		2.649
18		1.161		2.649
19	2.977	9.800×10^{-1}		2.637
20	3.018	2.009		2.638
21		2.016		
22		2.027		
23		2.043		
24	2.995	2.092		2.613
25	2.978	2.291		2.636
26	3.077	2.652		2.595
27	3.077	3.038		2.595
28	3.156	3.554		2.618
29	3.270	4.215		2.651
30	3.270	5.099		2.651
31	3.141	6.740		2.699
32	3.152	8.809		2.669

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 21: MSR Fuel Carrier Salt

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	1.086	4.350×10^{-1}	0	2.024×10
2	1.051	5.343×10^{-6}		2.438
3	1.514	9.075		2.812
4	1.637	2.191×10^{-3}		4.179
5	3.236	2.205		6.859
6	6.756	2.213		4.631
7	1.980	6.585		4.295
8	1.833	1.064×10^{-4}		3.752
9		1.901		
10		3.004		
11		5.008		3.753
12		6.770		3.753
13	1.789	8.246		3.618
14		8.389		
15		8.614		
16		1.053×10^{-3}		
17		1.126		
18		1.154		
19		1.248		
20		1.543		
21		1.575		
22		1.624		
23		1.676		
24		1.925		
25		2.214		
26		2.827		
27		2.961		
28		3.674		
29		4.730		
30		5.141		
31		7.479		
32		9.097		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 22: MSR Blanket Carrier Salt

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	4.302	2.174	0	8.695×10
2	4.377	2.200×10^{-5}		1.051×10^{2}
3	6.033	3.863		1.278
4	6.313	1.094×10^{-2}		1.816
5	1.331×10	1.100		3.053
6	3.040	1.103		1.951
7	7.411	3.286		1.788
8	6.705	4.444×10^{-4}		1.527
9		7.940		
10		1.252×10^{-3}		
11		2.092		
12		2.820		
13	6.487	3.453		1.462
14		3.504		
15		3.436		
16		4.406		
17		4.702		
18		4.801		
19		5.196		
20		6.492		
21		6.604		
22		6.779		
23		6.963		
24	6.488	8.021		
25		9.229		
26		1.186×10^{-2}		
27		1.234		
28		1.537		
29		1.986		
30	6.489	2.132		
31	6.490	3.125		
32	6.490	3.793		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 24: Cr

Group	$\bar{\sigma}_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	1.460 x 10^{-1}	5.90 x 10^{-2}	0	9.990
2	1.311			1.088 x 10
3	1.057			8.323
4	6.536 x 10^{-2}			8.791
5	5.084 x 10^{-1}			1.359 x 10
6	1.631			1.161
7	3.967			1.204
8	2.812			4.604
9	1.634			1.410 x 10
10				1.256
11				
12	1.635			
13	1.636			1.257
14	1.637			1.258
15	1.640			1.260
16	1.644	6.104 x 10^{-2}		1.261
17	1.645	6.653		1.262
18	1.648	7.176		
19	1.650	7.752		
20	1.651	8.169		
21	1.653	8.759		1.261
22	1.656	9.695		1.260
23	1.658	1.067 x 10^{-1}		1.260
24	1.661	1.178		1.258
25	1.665	1.346		1.256
26	1.669	1.559		1.253
27	1.678	1.810		1.249
28	1.696	2.118		1.252
29	1.718	2.583		1.254
30	1.746	3.363		1.250
31	1.775	4.470		1.240
32	1.790	5.512		1.226

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 25: Mn

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	1.329×10^{-1}	1.275×10^{-3}	0	1.025×10
2	1.291	1.970		1.082
3	1.152	3.045		1.004
4	1.566	4.988		1.015
5	1.224	1.211×10^{-2}		1.155
6	1.466	2.934		2.388
7	7.504	5.239		2.987
8	3.456	5.300		1.070
9	9.719×10^{-1}	5.550		4.630×10^{2}
10	5.430	8.370		9.020×10
11	2.927	1.347×10^{-1}		8.098×10^{2}
12	1.692	1.889		1.719×10
13	1.531	2.143		1.292
14	1.491	2.266		1.206
15	1.338	2.459		1.084
16	1.229	2.767		9.713
17	1.195	3.030		9.079
18	1.155	3.268		8.693
19	1.133	3.531		8.373
20	1.116	3.721		8.157
21	1.098	3.989		7.926
22	1.078	4.415		7.626
23	1.073	4.861		7.413
24	1.066	5.365		7.211
25	1.062	6.128		6.933
26	2.529	7.098		1.452×10
27	1.352	8.243		1.303
28	1.152	9.646		6.714
29	1.271	1.176		6.482
30	1.445	1.531		6.624
31	1.657	2.035		6.684
32	1.800	2.510		6.785

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element 26: Fe

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	1.265×10^{-1}	8.70×10^{-2}	0	1.021×10
2	1.125			9.378
3	8.096×10^{-2}			7.783
4	5.066			8.439
5	1.401×10^{-1}			9.772
6	1.894			2.051×10
7	2.443			2.494
8	2.089			2.056
9	3.186			2.087
10	3.794			2.952
11	4.070			3.293
12				3.382
13				
14				
15				
16				
17				
18				
19				
20				
21				
22	4.071	8.745×10^{-2}		
23	4.070	9.372		
24	4.071	1.034×10^{-1}		3.379
25	4.070	1.180		3.373
26	4.070	1.366		3.367
27	4.071	1.586		3.361
28	4.071	1.855		3.352
29	4.072	2.260		3.340
30	4.073	2.939		3.323
31	4.070	3.903		3.293
32	4.077	4.808		3.266

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 28: Ni

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	1.176 x 10^{-1}	1.72 x 10^{-1}	0	9.948
2	1.078			9.376
3	1.112			9.132
4	1.685			1.090 x 10
5	2.059			1.572
6	5.814			2.581
7	3.134			8.432
8	7.064			5.993
9	5.025			4.700
10	5.612			4.608
11	5.770			5.002
12	5.787			5.038
13	5.794			5.050
14	5.800			5.056
15	5.811			5.059
16	5.814			5.068
17				
18				
19				
20				
21	5.831			5.076
22	5.850			5.094
23	5.864			5.106
24	5.890	1.729 x 10^{-1}		5.124
25	5.907	1.876		5.133
26	5.908	2.142		5.133
27	5.926	2.481		5.136
28	5.948	2.880		5.142
29	5.990	3.370		5.154
30	6.039	4.108		5.171
31	6.119	5.346		5.183
32	6.185	7.104		5.207

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 29: Cu

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	1.108×10^{-1}	1.535×10^{-3}	0	1.108×10
2	9.703×10^{-2}	3.072		9.801
3	1.115×10^{-1}	4.826		9.765
4	1.524	6.388		1.261×10
5	1.555	1.133×10^{-2}		1.464
6	2.737	3.632		1.917
7	3.303	9.302		2.815
8	1.844	1.000×10^{-1}		1.953
9	1.760			2.590
10	1.912			2.084
11	2.239			2.103
12	2.262			2.119
13	2.268			2.133
14	2.275			2.139
15	2.286			2.148
16	2.301			2.161
17	2.307			2.171
18	2.318			2.179
19	2.324	1.012×10^{-1}		2.187
20	2.331	1.062		2.192
21	2.341	1.139		2.197
22	2.354	1.261		2.204
23	2.363	1.388		2.211
24	2.377	1.532		2.218
25	2.395	1.750		2.230
26	2.420	2.027		2.238
27	2.443	2.354		2.253
28	2.467	2.754		2.263
29	2.508	3.359		2.274
30	2.574	4.372		2.297
31	2.612	5.812		2.311
32	2.612	7.167		2.282

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 40: Zr

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	8.875×10^{-2}	1.142×10^{-5}	0	1.225×10
2	1.057×10^{-1}	1.701		1.305
3	1.526	2.405		1.738
4	1.815	3.904		2.494
5	1.706	6.925		2.460
6	1.744	1.235×10^{-4}		2.559
7	1.700	2.190		2.389
8	1.901	3.904		2.353
9	1.248	6.925		2.022
10	1.308	1.142×10^{-3}		1.884
11	1.352	1.837		2.089
12		2.576		1.846
13		2.922		
14		3.090		
15		3.353		
16		3.772		
17		4.133		
18		4.457		
19		4.815		
20		5.074		
21		5.440		
22		6.022		1.845
23		6.630		
24		7.316		
25		8.357		
26		9.680		1.844
27		1.124×10^{-2}		
28	1.354	1.316		
29	1.360	1.604		1.850
30	1.369	2.088		1.858
31	1.371	2.776		1.866
32	1.369	3.422		1.862

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 52: "Corrosium I"

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	0	1.400×10^{-1}	0	0
2				
3				
4				
5				
6		1.401		
7		1.401		
8		1.402		
9		1.404		
10		1.407		
11		1.411		
12		1.415		
13		1.417		
14		1.418		
15		1.419		
16		1.442		
17		1.499		
18		1.553		
19		1.613		
20		1.656		
21		1.717		
22		1.818		
23		1.978		
24		2.183		
25		2.493		
26		2.886		
27		3.352		
28		3.920		
29		4.779		
30		6.219		
31		8.262		
32		1.018		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 53: "Corrosium II"

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	0	1.722×10^{-1}	0	0
2		1.723		
3		1.724		
4		1.727		
5		1.738		
6		1.764		
7		1.798		
8		1.799		
9		1.803		
10		1.845		
11		1.922		
12		2.003		
13		2.041		
14		2.059		
15		2.089		
16		2.135		
17		2.154		
18		2.210		
19		2.249		
20		2.278		
21		2.318		
22		2.382		
23		2.449		
24		2.534		
25		2.795		
26		3.217		
27		3.717		
28		4.327		
29		5.134		
30		6.404		
31		8.399		
32		1.087		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 54: Xe^{135}

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\bar{\nu}\bar{\sigma}_f$	$3\bar{\sigma}_{tr}$
1	0	7.43×10^{-2}	0	0
2		3.908×10^{-1}		
3		7.242		
4		9.843		
5		9.546		
6		3.960		
7		1.515×10		
8		3.045		
9		5.133		
10		8.580		
11		1.047×10^{2}		
12		1.870		
13		2.198		
14				
15				
16		3.050		
17		3.282		
18				
19		4.222		
20		8.254		
21				
22				
23				
24		7.035		
25		6.781		
26		2.439×10^{3}		
27				
28		8.561		
29		1.720×10^{4}		
30				
31		2.100		
32		5.697		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 55: Sm^{151}

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
0-26	0	0	0	0
27	↓	5.50×10^2	↓	↓
28		0		
29		1.30×10^2		
30		7.20 ↓		
31		2.28×10^3		
32		7.25×10^2		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 68: MSR Core in LMFR

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma_f}$	$3\bar{\sigma}_{tr}$
1-7	0	0	0	0
8		7.958×10^{-1}		
9		1.029		
10		1.168		
11		6.172		
12		1.788×10		
13		1.481		
14		1.502		
15		4.501×10		
16		1.431 ↓		
17		1.615		
18		1.646		
19		1.678		
20		1.701		
21		1.731		
22		1.416×10^{2}		
23		1.819		
24-34		0		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 69: Blanket MSR in LMFR

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1-7	0	0	0	0
8		7.958×10^{-1}		
9		1.029		
10		1.168		
11		1.485		
12		3.897		
13		1.481		
14		1.502		
15		5.960		
16		3.303		
17		1.615		
18		1.646		
19		1.678		
20		1.701		
21		1.731		
22		2.354×10		
23		1.819		
24-34		0		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 70: Th σ_a in 1000 g/ℓ D_2O-ThO_2 Slurry

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1-7	0	0	0	0
8		7.958×10^{-1}		
9		1.029		
10		1.168		
11		2.088		
12		5.865		
13		1.481		
14		1.502		
15		9.353		
16		4.898		
17		1.615		
18		1.646		
19		1.678		
20		1.701		
21		1.731		
22		3.546×10		
23		1.819		
24-34		0		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 76: Th σ_a in 5300 g/ℓ ThO_2-D_2O Pebble Bed

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1-7	0	0	0	0
8	↓	7.958×10^{-1}	↓	↓
9	↓	1.029	↓	↓
10	↓	1.168	↓	↓
11	↓	0.823	↓	↓
12	↓	2.044	↓	↓
13	↓	1.481	↓	↓
14	↓	1.502	↓	↓
15	↓	3.803	↓	↓
16	↓	1.633	↓	↓
17	↓	1.615	↓	↓
18	↓	1.646	↓	↓
19	↓	1.678	↓	↓
20	↓	1.701	↓	↓
21	↓	1.731	↓	↓
22	↓	1.327×10	↓	↓
23	↓	1.819	↓	↓
24-34	↓	0	↓	↓

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 77: Th $[\bar{\sigma}_a$, infinite dilution$]$

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1-7	0	0	0	0
8		7.958×10^{-1}		
9		1.029		
10		1.168		
11		7.096		
12		8.435		
13		1.481		
14		1.502		
15		1.718×10		
16		4.347		
17		1.615		
18		1.646		
19		1.678		
20		1.701		
21		1.731		
22		1.98×10^{2}		
23		1.819		
24-34		0		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 78: Th (LMFR)

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1-7	0	0	0	0
8		7.958×10^{-1}		
9		1.029		
10		1.168		
11		4.858		
12		1.420×10		
13		1.481		
14		1.502		
15		2.800×10		
16		1.164		
17		1.615		
18		1.646		
19		1.678		
20		1.701		
21		1.731		
22		1.020×10^{2}		
23		1.819		
24-34		0		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 83: Bi

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	7.40×10^{-2}	0	0	1.83
2	5.80			2.16
3	4.60			1.56
4	7.10			1.83
5	9.30			2.58
6	9.60			3.00
7	8.10			4.08
8	1.04×10^{-1}			2.88
9	1.13			4.05
10	8.30×10^{-2}			4.20
11	8.70			4.20
12				2.73
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26	8.80×10^{-2}			2.74
27				
28				
29				
30				
31				
32				

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 84: $\sigma_c(U^{233})$

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1-6	0	0	0	0
7		5.86×10^{-1}		
8		1.770		
9		1.008		
10		1.412		
11		2.130		
12		3.830		
13		5.030		
14		4.090		
15		4.350		
16		4.620		
17		3.680		
18		3.920		
19		7.250		
20		6.870		
21		9.170		
22		2.050×10		
23		2.876		
24		1.536		
25		2.747		
26		4.400		
27		4.080×10		
28		1.060		
29		1.660		
30		1.250×10^2		
31		1.940×10		
32		1.182		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 85: $\sigma_c(U^{235})$

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	0	1.380	0	0
2		1.520		
3		1.530		
4		1.550		
5		1.260		
6		0.650		
7		0.916		
8		2.866		
9		6.642		
10		8.061		
11		8.859		
12		5.297		
13		8.908		
14		9.301		
15		0.739		
16		7.399		
17		1.739 x 10		
18		7.570		
19		7.785 x 10		
20		1.793		
21		1.313		
22		4.897		
23		6.420		
24		2.808		
25		7.537		
26		1.864		
27		3.973		
28		1.992		
29		1.201		
30		1.755		
31		1.501		
32		1.351		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 86: Fissum

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1-12	0	0	0	0
13		1.55×10		
14		1.65		
15		2.04		
16		3.25		
17		4.20		
18		3.37		
19		2.47		
20		2.05		
21		1.94		
22		2.20		
23		3.03		
24		3.46		
25		2.68		
26		5.94		
27		6.45		
28		3.09		
29		2.28		
30		3.87		
31		2.83		
32		1.22		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 87: Np^{237}

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	0	1.970	5.110	6.000
2		1.450	3.780	4.350
3		1.340	3.480	4.020
4		0.382	0.994	1.100
5		0.025	0.065	0.075
6-28		0	0	0
29		8.52×10		2.85×10^2
30		2.08×10^2		6.50
31		1.72		5.40
32		3.74		1.50

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 88: D

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	1.392	2.918×10^{-8}	0	2.919
2	1.863	4.346		4.458
3	2.153	6.147		5.530
4	2.371	9.977		6.282
5	2.465	1.770×10^{-7}		6.669
6	2.467	3.155		6.804
7	2.470	5.596		6.814
8	2.473	9.977		6.817
9	2.475	1.770×10^{-6}		6.828
10	2.477	2.918		6.833
11	2.479	4.694		6.839
12	2.480	6.583		6.842
13	2.480	7.468		6.843
14	2.481	7.897		6.843
15	2.481	8.569		6.845
16	2.482	9.640		6.846
17		1.056×10^{-5}		6.847
18		1.139		6.848
19	2.483	1.231		6.849
20		1.297		6.849
21		1.390		6.850
22	2.484	1.539		6.852
23	2.481	1.694		6.853
24	2.485	1.870		6.854
25	2.485	2.136		6.856
26	2.486	2.474		6.858
27	2.487	2.873		6.860
28	2.487	3.362		6.862
29	2.488	4.100		6.864
30	2.490	5.336		6.868
31	2.506	7.093		6.878
32	2.527	8.746		6.942

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 91: Pa^{233} (Single Resonance Approximation)

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	4.285×10^{-2}	4.313×10^{-3}	0	1.496×10
2	4.286	6.425		
3	8.569	9.086		
4	8.577	1.475×10^{-2}		2.991×10
5	8.589	2.616		
6	8.613	4.664		
7	8.652	8.273		
8	8.728	1.475×10^{-1}		
9	8.851	2.616		
10	9.020	4.313		
11	9.312	6.939		
12	9.480	9.732		
13	9.530	1.104		
14	9.589	1.167		
15	9.702	1.267		
16	9.862	1.425		
17	9.932	1.561		
18	1.007×10^{-1}	1.684		
19	1.016	1.819		
20	1.024	1.917		
21	1.040	2.055		
22	1.062	2.275		
23	1.079	2.505		
24	1.106	2.764		
25	1.147	3.157		
26	1.192	3.657		
27	1.248	4.247		
28	1.316	4.970		
29	1.438	6.060		
30	1.630	9.840×10^{2}		
31	1.885	1.021×10^{3}		
32	2.044	1.293×10		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 91: Pa^{233} (Constant Level Density Approximation, $I_o \simeq 10^3$ Bn.)

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1-4	0	0	0	0
5		0.90		
6		3.60		
7		3.10		
8		5.40		
9		1.09 x 10		
10		1.44		
11		2.57		
12		3.70		
13		4.00		
14		4.10		
15		4.60		
16		1.15		
17		5.15		
18		5.55		
19		7.30		
20		7.60		
21		7.90		
22		8.10		
23		9.60		
24		9.90		
25		1.20 x 10^2		
26		1.33		
27		1.55		
28		1.81		
29		2.30		
30		2.90		
31		3.86		
32		4.80		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 92: Th^{232} (Without Resonance σ_a)

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\bar{\nu}\bar{\sigma}_f$	$3\bar{\sigma}_{tr}$
1	6.100×10^{-2}	2.408×10^{-1}	5.642×10^{-1}	1.883×10
2	5.669	1.684	3.190	1.998
3	5.841	1.450	1.306	1.966
4	8.160	1.622	0	2.366
5	1.039×10^{-1}	2.708		3.132
6	1.119	4.627		3.718
7	1.130	5.680		3.739
8	1.156	0		
9	1.168			
10	1.180			
11	1.339			4.658
12	1.824			6.349
13	1.202			3.739
14	1.204			
15	2.301			8.040
16	1.728			6.014
17	1.213			3.739
18	1.217			
19	1.219			
20	1.221			
21	1.224			
22	5.117			1.781
23	1.232			3.739
24	1.236	1.864		
25	1.242	1.927		
26	1.249	2.000		
27	1.256	2.076		
28	1.263	2.160		
29	1.274	2.269		
30	1.290	2.424		
31	1.305	2.604		
32	1.314	2.745		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 93: U^{233}

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$	$\bar{\eta}$	$\bar{\nu}$
1	7.400×10^{-2}	1.940	6.570	1.230×10	3.39	3.39
2	7.110	1.810	5.190	1.442	2.87	2.87
3	6.950	1.950	5.240	1.191	2.69	2.69
4	9.320	2.160	5.430	1.461	2.51	2.51
5	1.140×10^{-1}	2.610	6.180	2.271	2.37	2.50
6	1.263	3.560	8.120	2.930	2.28	
7	1.371	5.864	1.319×10	2.991	2.25	
8	2.366	1.698×10	3.801	3.290	2.24	
9	1.838	1.008	2.268	3.739	2.25	
10	2.427	1.411	3.175			
11	3.309	2.131	4.795			
12	4.451	3.832	8.622			
13	4.324	5.031	1.132×10^2			
14	3.673	4.089	9.201×10			
15	5.273	4.352	9.799			
16	3.253	4.614	1.038×10^2			
17	2.351	3.679	8.277×10			
18	6.391	3.923	8.828			
19	6.420	7.249	1.631×10^2			
20	5.564	6.879	1.548			
21	7.434	6.837	1.480		2.16	
22	5.650	1.525×10^2	3.30		2.16	
23	7.289	2.148	4.65		2.16	
24	1.019	1.158	2.51		2.17	
25	2.284	2.059	4.46		2.17	
26	1.050	5.000×10	1.14	1.80×10^2	2.28	
27	6.010×10^{-1}	1.900×10^2	3.73	6.00	2.07	
28	6.350	8.38×10	1.83	2.80	2.18	
29	6.010	9.26	1.90	3.00	2.05	
30	8.750	5.29×10^2	1.01×10^3	1.50×10^3	1.91	
31	2.740	1.79	3.990×10^2	5.40×10^2	2.23	
32	1.430	1.405	3.217	3.739×10	2.29	

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 94: U^{234}

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	7.298 x 10^{-2}	1.556	3.875	1.754 x 10
2	6.865	1.529	3.800	2.019
3	6.718	1.353	3.350	1.990
4	8.020	0.673	1.630	2.347
5	1.007 x 10^{-1}	0.083	0.121	3.176
6	1.122	0.067	0	3.709
7	1.188	0.118		4.011
8	1.167	2.104		4.104
9	1.234	0.373		4.187
10	1.258	0.615		4.187
11	1.044	9.054		3.290
12	1.068	2.077 x 10		
13	1.075	5.957		
14	1.083	5.486		
15	1.099	1.833 x 10		
16	1.122	2.109		
17	1.132	7.901		
18	1.152	2.402		
19	1.165	2.595		
20	1.176	2.690 x 10^2		
21	1.199	2.932		
22	1.229	3.245		
23	1.254	3.573		
24	1.293	3.943		
25	1.350	4.504		
26	1.244	5.216		2.692
27	1.324	6.509 x 10^2		
28	1.420	1.158 x 10^3		
29	1.593	8.645		
30	1.871	1.125 x 10		
31	2.228	1.496		
32	2.454	1.844		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Element No. 95: U^{235}

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$	$\bar{\eta}$
1	6.62 x 10^{-2}	1.46	4.83	1.23 x 10	3.31
2	6.11	1.31	3.62	1.44	2.76
3	5.71	1.35	3.38	1.19	2.50
4	7.73	1.44	3.25	1.46	2.26
5	1.00 x 10^{-1}	1.83	3.83	2.27	2.09
6	1.14	2.75	5.27	2.92	1.92
7	1.23	4.31	7.58	2.99	1.76
8	2.03	7.44	1.14 x 10	3.74	1.54
9	2.46	1.36 x 10	1.74		1.28
10	2.38	1.97	2.92		1.48
11	3.44	2.66	4.44		1.67
12	2.86	2.78	5.63		2.02
13	3.82	2.78	4.73		1.70
14	3.24	3.76	7.08		1.88
15	3.44	2.85	6.95		2.43
16	6.79	5.12	1.09 x 10^2		2.14
17	5.94	5.40	9.14 x 10		1.69
18	4.04	4.52	9.42		2.08
19	3.82	1.58 x 10^2	2.00 x 10^2		1.27
20	2.12	5.97 x 10	1.04		1.75
21	5.40	4.91	8.99 x 10		1.83
22	3.99	1.01 x 10^2	1.29 x 10^2		1.28
23	4.42	1.47	2.07		1.41
24	4.03	6.19 x 10	8.46 x 10		1.37
25	2.80	1.28 x 10^2	1.31 x 10^2		1.03
26	1.81	1.14	2.38		2.09
27	2.39	7.02 x 10	7.60 x 10		1.08
28	2.29	2.95	2.40		0.81
29	2.97	4.21	7.53		1.79
30	3.27	3.39	4.09		1.21
31	6.45	7.20	1.42 x 10^2		1.98
32	7.89	7.17	1.45		2.03

TABLE 3- contd

HRP GROUP STRUCTURE FOR GNU

Element No. 98: U^{238}

Group	$\xi\sigma_T$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$
1	6.37×10^{-2}	7.74×10^{-1}	1.92	1.75×10
2	5.95	6.04	1.45	2.02
3	5.78	3.48	6.64×10^{-1}	1.99
4	7.88	1.34	0	2.35
5	1.01×10^{-1}	1.98		3.18
6	1.13	3.37		3.71
7	1.21	5.23		4.01
8	1.22	7.79		4.10
9	1.27	1.19		4.19
10	1.28	2.30		
11	1.03	8.51		3.29
12		2.61×10		
13		1.44		
14		1.16×10		
15		4.92		
16		1.26		
17				
18				
19		3.85×10^{2}		
20		1.26		
21		1.27		
22		2.76×10^{2}		
23		1.27		
24		1.28		
25		1.46		
26	8.62×10^{-2}	1.28		2.69
27	8.62	4.14×10^{2}		
28	8.63	1.29		
29	8.63	1.30		
30	8.64	1.31		
31	8.65	1.32		
32	8.65	1.32		

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Group 33, 280°C

Element Number	$\xi\sigma_t$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$	$\bar{\eta}$
1	0	8.40×10^{-2}	0	2.237×10	
4	1.213	2.525×10^{-3}		1.611×10	
5	4.368×10	1.900×10^{2}		1.238×10	
6	7.586×10^{-1}	4.70×10^{-4}		1.359×10	
7	1.464	4.76×10^{-2}		2.894×10	
8	4.485×10^{-2}	0		1.072×10	
11	2.746×10^{-1}	1.282×10^{-1}		9.467	
12	2.720×10^{-1}	6.30×10^{-2}		9.741	
13	1.122×10^{-1}	5.80×10^{-2}		4.300	
16	7.319×10^{-2}	1.317×10^{-1}		3.061	
24	1.923×10^{-1}	7.87×10^{-1}		1.214×10	
25	2.308×10^{-1}	3.34		6.965	
26	4.174×10^{-1}	6.40×10^{-1}		3.260×10	
28	6.413×10^{-1}	1.21		5.207×10	
29	2.726×10^{-1}	9.52×10^{-1}		2.257×10	
40	1.375×10^{-1}	4.55×10^{-2}		1.862×10	
52	0	1.409		0	
53		1.711			
54		9.40×10^{4}			
55		1.30×10^{3}			
62		1.80×10^{2}			
84		2.194×10			
85		3.15×10			
86		1.27×10			
87		3.32×10^{2}			
88	2.640	1.16×10^{-4}		7.14	
91	2.662×10^{-1}	1.72×10		2.991×10	
92	1.34×10^{-1}	2.940		3.739×10	
93	2.405	2.495×10^{2}	5.689×10^{2}	3.739×10	2.28
94	3.319×10^{-1}	2.455×10	0	2.692×10	
95	2.12	1.51×10^{2}	3.11×10^{2}	5.01×10^{2}	2.06
96	1.03×10^{-1}	1.78	0	2.69×10	
98	8.10×10^{-2}	6.88×10^{-1}	0	3.21×10	

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Group 34, 280°C

Element Number	$\xi\sigma_t$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$	$\bar{\eta}$
1	0	2.14×10^{-1}	0	6.75×10	
4	1.213	6.45×10^{-3}		1.611×10	
5	4.368×10	5.90×10^{2}		1.238×10	
6	7.586×10^{-1}	2.40×10^{-3}		1.36×10	
7	1.464	1.212		3.028×10	
8	4.485×10^{-1}	0		1.135×10	
11	2.746×10^{-1}	3.26×10^{-1}		9.904	
12	2.720×10^{-1}	6.30×10^{-2}		9.741	
13	1.122×10^{-1}	1.482×10^{-1}		4.388	
16	7.319×10^{-2}	3.33×10^{-1}		3.231	
24	1.923×10^{-1}	1.998		1.214×10	
25	2.308×10^{-1}	8.50		6.965	
26	4.174×10^{-1}	1.635		3.260×10	
28	6.413×10^{-1}	3.095		5.207×10	
29	2.726×10^{-1}	2.432		2.257×10	
40	1.375×10^{-1}	1.160×10^{-1}		1.862×10	
52	0	3.587		0	
53		4.370			
54		2.36×10^{6}			
55		7.26×10^{3}			
62		5.66×10^{4}			
84		3.366×10			
85		7.00×10			
86		3.23×10			
87		1.106×10^{2}			
88	2.640	2.97×10^{-4}		1.007×10	
91	2.662×10^{-1}	4.395×10		2.991×10	
92	1.34×10^{-1}	4.860		3.739×10	
93	2.405	3.825×10^{2}	8.721×10^{2}	3.739×10	2.28
94	3.319×10^{-1}	7.31×10	0	2.692×10	
95	2.12	3.97×10^{2}	8.26×10^{2}	1.24×10^{3}	2.08
96	1.03×10^{-1}	3.85	0	2.99×10	
98	8.10×10^{-2}	1.75	0	3.52	

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Group 33, 649°C

Element Number	$\xi\sigma_t$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$	$\bar{\eta}$
4	1.24	2.15×10^{-3}	0	1.611×10	
6	7.585×10^{-1}	1.85×10^{-3}		1.359×10	
9	3.59×10^{-1}	1.8×10^{-3}		1.05×10	
15	7.49×10	2.21×10^{2}		6.70×10^{2}	
17	2.75×10^{-1}	7.24×10^{-3}		2.85	
20	3.285	1.258		2.713×10^{2}	
21	1.797	1.506×10^{-2}		3.505×10	
22	6.480	6.653×10^{-2}		1.408×10^{2}	
26	4.106×10^{-1}	5.510×10^{-1}		3.465×10	
54	0	4.20×10^{4}		0	
55	↓	9.80×10^{2}		↓	
62		7.95×10^{2}			
83	8.80×10^{-2}	8.00×10^{-3}		2.74×10	
84	0	1.10×10		0	
85	↓	1.70×10		↓	
86		1.90×10			
87		6.35×10^{2}			
91	2.250×10^{-1}	1.503×10		7.486×10	
92	1.324×10^{-1}	2.848		4.591×10	
93	1.545	1.27×10^{2}	2.90×10^{2}	5.40×10^{2}	2.28
94	2.749×10^{-1}	2.144×10	0	9.104×10	
95	1.12	9.22×10	1.99×10^{2}	3.25×10^{2}	2.16
96	9.85×10^{-2}	1.54	0	3.45×10	
98	7.98 ↓	6.01×10^{-1}	0	2.85 ↓	

TABLE 3 - contd

HRP GROUP STRUCTURE FOR GNU

Group 34, 649°C

Element Number	$\xi\sigma_t$	$\bar{\sigma}_a$	$\overline{\nu\sigma}_f$	$3\bar{\sigma}_{tr}$	$\bar{\eta}$
4	1.24	5.048×10^{-3}	0	1.611×10	
6	7.585×10^{-1}	2.072×10^{-3}	↓	1.359×10	
9	3.59×10^{-1}	4.5×10^{-3}	↓	1.05×10	
15	7.49×10	4.720×10^{2}	↓	1.420×10^{3}	
17	2.75×10^{-1}	1.66×10^{-2}	↓	2.85	
20	3.285	2.874	↓	2.713×10^{2}	
21	1.797	3.421×10^{-2}	↓	3.506×10	
22	6.480	1.509×10^{-1}	↓	1.408×10^{2}	
26	4.106×10^{-1}	1.260	↓	3.678×10	
54	0	1.60×10^{6}	↓	0	
55	↓	4.91×10^{3}	↓	↓	
62	↓	4.20×10^{4}	↓	↓	
83	8.80×10^{-2}	1.70×10^{-2}	↓	2.74×10	
84	0	4.90×10	↓	0	
85	↓	5.70×10	↓	↓	
86	↓	4.20×10	↓	↓	
87	↓	1.07×10^{2}	↓	↓	
91	2.250×10^{-1}	3.40×10	↓	1.32×10^{2}	
92	1.324×10^{-1}	3.77	↓	4.87×10	
93	1.545	2.87×10^{2}	6.54×10^{2}	8.47×10^{2}	2.28
94	2.749×10^{-1}	5.54×10	0	2.20×10^{2}	
95	1.12	3.05×10^{2}	6.29×10^{2}	9.62×10^{2}	2.06
96	9.85×10^{-2}	2.10	0	3.05×10	
98	7.98 ↓	1.36	0	3.47 ↓	