TWO-GROUP CONSTANTS FOR REACTOR MATERIALS

By
Mary J. Stanley

May 1958

Aircraft Nuclear Propulsion Department
General Electric Company
Cincinnati, Ohio

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Date Declassified: November 4, 1959.

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

This report has been reproduced directly from the best available copy.

Printed in USA. Price \$1.50. Available from the Office of Technical Services, Department of Commerce, Washington 25, D. C.

APEX-369

TWO-GROUP CONSTANTS FOR REACTOR MATERIALS

Mary J. Stanley

**Nuclear Development
Laboratories Sub-Section**

May 1958

United States Air Force

Contract No. AF 33(038)-21102

United States Atomic Energy Commission

Contract No. AT (11-1)-171

GENERAL ELECTRIC

**AIRCRAFT NUCLEAR PROPULSION DEPARTMENT
ATOMIC PRODUCTS DIVISION**

Cincinnati 15, Ohio

ACKNOWLEDGMENTS

The author wishes to thank W. B. Henderson for tabulation of basic cross section data from which the two-group constants were computed and for his invaluable assistance in the preparation of this report. The author also wishes to thank Florence Silverstein for the U^{235} fission spectrum used in the age calculations.

ABSTRACT

In order to facilitate reactor design studies a compilation of calculated two-group constants averaged over the infinite-medium flux produced by a fission source has been made for approximately 80 materials of interest to reactor engineers. A comparison with available experimental age measurements is included.

CONTENTS

	Page
1. Glossary of Terms	5
2. Theory	7
3. Use of the Two-Group Constants	10
4. Tabulation of Two-Group Constants	11
5. Comparison With Experiment	59
6. References	61

1. GLOSSARY OF TERMS

The following is a list of terms, subscripts, and abbreviations used in this report.

NOMENCLATURE

d	extrapolation distance
D	diameter of cylinder; diffusion coefficient
H	height of cylinder
k	neutron multiplication constant
K^2	buckling
L	leakage spectrum
L^2	diffusion area
M^2	migration area
p	absorption-escape probability
q	slowing-down density
S	source spectrum; reflector savings
u	lethargy, $u = \ln \frac{E_0}{E}$ where: E = neutron energy, ev, and $E_0 = 10^7$ ev
U	lethargy interval, $U_n = u_n - u_{n-1}$
ϕ	flux
ξ	mean rise in lethargy per scattering collision
Σ_a	macroscopic absorption cross section
Σ_f	macroscopic fission cross section
Σ_l	macroscopic leakage cross section
Σ_s	macroscopic slowing-down cross section
Σ_{tr}	macroscopic transport cross section
τ	age
ν	number of neutrons per fission

SUBSCRIPTS

I_n	indium resonance of 1.4 ev
n	lethargy index
t	last-epithermal-lethargy index
$t+1$	thermal-group index
T_h	thermal energy
r, z	space coordinates
1	fast-group designation
2	thermal-group designation

ABBREVIATIONS USED IN SECTION 4

HCP: Hodgman, Charles D. Handbook of Chemistry and Physics, 37 Edition, Chemical Rubber Publishing Company, Cleveland, Ohio, 1955-1956.

MH: Lyman, Taylor, Metals Handbook, The American Society for Metals, Cleveland, Ohio, 1948.

RH: The Reactor Handbook, Volume I, Physics, U.S. Atomic Energy Commission, RH-1, June 1953.

RMH: Hampel, Clifford A., Rare Metals Handbook, New York, Reinhold Publishing Corporation, 1954.

Campbell, Ivor E., High-Temperature Technology, New York, Wiley Publishing Company, 1956, p 31.

Everhart, John L., Mechanical Properties of Metals and Alloys, Washington, D.C., Government Printing Office, Bureau of Standards circular, C447, 1943.

GE-ANPD, Internal Communications, General Electric Aircraft Nuclear Propulsion Department.

Callihan, D., and Keen, R. C., Critical Experiments on Direct Cycle Aircraft Reactor, Oak Ridge National Laboratories, ORNL-1615, November 13, 1953.

2. THEORY

In order to facilitate reactor design studies a compilation of two-energy-group parameters, commonly called two-group constants, D_1 , D_2 , Σ_{a1} , Σ_{a2} , d , d_1 , d_2 , L_1 , L_2 , Σ_s , ρ , $\nu\Sigma_{f1}$, $\nu\Sigma_{f2}$, k_1 , and k_2 was made for various reactor materials.

A program that utilizes a multi-energy diffusion theory (C_2 -Short)¹¹ for a bare cylindrical reactor was used to obtain two-group constants for an infinite medium of each material. A cylinder with a radius of 10^6 centimeters and a height of 10^6 centimeters was used to obtain an essentially infinite medium; buckling is then a very small nonzero value. The results are tabulated for Fahrenheit temperatures of 68° , 500° , 1000° , 1500° , 2000° , 2500° , and 3000° . The division of the two groups is at thermal lethargy. The two-group constants were computed for the density of the material used at GE-ANPD whenever this data was available; otherwise handbook values were used. In some cases densities other than the one used are also quoted for the information of the reader.

Modified age theory¹² was used in calculating two-group constants for all the materials. This seems to be the best slowing-down model for engineering use at the present time. (See section 5.)

The multi-energy cross sections used by Program C_2 -Short are on an ANPD nuclear-data tape and were calculated from basic cross section data.

In Program C_2 -Short the neutron conservation equation:

$$\frac{dq}{du} = S(u) - [\Sigma_a(u) + D(u)K^2(u)] \phi(u), \quad (1)$$

where:

q = slowing-down density

u = lethargy

$S(u)$ = source

Σ_a = macroscopic absorption cross section

D = diffusion coefficient

K^2 = buckling

ϕ = flux

is solved for q at each lethargy division in the following manner. The modified age treatment yields the equation:

$$\phi(u) = \frac{q(u) + S(u)}{\xi\Sigma_s(u) + \Sigma_a(u) + D(u)K^2(u)} \quad (2)$$

as the relation between flux and slowing-down density. Equation (2) is used to eliminate $\phi(u)$ in equation (1). The resultant first-order differential equation in q is integrated trapezoidally between successive lethargy divisions.

The lethargy divisions are at $u = 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 6.0, 8.0, 10.0, 12.0, 14.0, 15.5, 16.5, 17.5, 18.5, 19.795$.

From the resultant flux and slowing-down density, the two-group constants for fast and thermal groups are calculated as indicated on the following pages.

$$\phi_1 = \sum_{n=1}^t (\phi_n + \phi_{n-1}) \frac{U_n}{2} = \text{fast-group flux, where } t \text{ is the last-epithermal index.} \quad (3)$$

$$\Sigma_{a1} = \frac{1}{\phi_1} \sum_{n=1}^t (\Sigma_{a_n} \phi_n + \Sigma_{a_{n-1}} \phi_{n-1}) \frac{U_n}{2} = \text{fast-group macroscopic absorption cross section.} \quad (4)$$

$$\nu \Sigma_{f1} = \frac{1}{\phi_1} \sum_{n=1}^t (\nu \Sigma_{f_n} \phi_n + \nu \Sigma_{f_{n-1}} \phi_{n-1}) \frac{U_n}{2} = \nu \text{ times the fast-group macroscopic fission cross section.} \quad (5)$$

$$k_1 = \frac{\nu \Sigma_{f1}}{\Sigma_{a1}} = \text{fast-group multiplication constant.} \quad (6)$$

$$\Sigma_{s1} = \frac{q_t}{\phi_1} = \text{fast-group slowing-down probability per unit path length.} \quad (7)$$

$$d_1 = \frac{1}{\phi_1} \sum_{n=1}^t (d_n \phi_n + d_{n-1} \phi_{n-1}) \frac{U_n}{2} = \text{fast-group extrapolation distance.} \quad (8)$$

$$d_2 = d_{t+1} = \text{thermal-group extrapolation distance.} \quad (9)$$

$$\text{where } d_n = \frac{0.7105}{(\Sigma_a + \Sigma_{tr})_n}, \quad n = 0, \dots, 18, t, t+1.$$

$$d = \left(\frac{d_1 \phi_1 + d_2 \phi_2}{\phi_1 + \phi_2} \right) = \text{average extrapolation distance.} \quad (10)$$

$$\phi_2 = \phi_{t+1} = \text{thermal-group flux, where } t+1 \text{ is the thermal index.} \quad (11)$$

$$\Sigma_{a2} = \Sigma_{a_{t+1}} = \text{thermal-group macroscopic absorption cross section.} \quad (12)$$

$$\nu \Sigma_{f2} = \nu \Sigma_{f_{t+1}} = \nu \text{ times the thermal-group fission cross section.} \quad (13)$$

$$k_2 = \frac{\nu \Sigma_{f2}}{\Sigma_{a2}} = \text{thermal-group multiplication constant.} \quad (14)$$

$$p = \frac{\Sigma_{s1}}{\Sigma_{s1} + \Sigma_{a1}} = \text{absorption-escape probability.} \quad (15)$$

$$D_1 = \frac{\Sigma_{l1}}{K_1^2} = \text{fast-group diffusion coefficient,} \quad (16)$$

$$\text{where } \Sigma_{l1} = \frac{1}{\phi_1} \sum_{n=1}^t (\Sigma_{l_n} \phi_n + \Sigma_{l_{n-1}} \phi_{n-1}) \frac{U_n}{2}, \quad \Sigma_{l_n} = D_n K_n^2, \quad (17)$$

$$\text{and } K_1^2 = \frac{9.87}{(H+2S_z+2d_1)^2} + \frac{23.13}{(D+2S_r+2d_1)^2}. \quad (18)$$

$$D_2 = \frac{\Sigma_{l_2}}{K_2^2} = \text{thermal-group diffusion coefficient}, \quad (19)$$

$$\text{where } \Sigma_{l_2} = \Sigma_{l_{t+1}}$$

$$\text{and } K_2^2 = \frac{9.87}{(H+2 S_z + 2 d_2)^2} + \frac{23.13}{(D+2 S_r + 2 d_2)^2} \quad (20)$$

$$L_1^2 = \frac{D_1}{\Sigma_{a_1} + \Sigma_{s_1}} = \text{fast-group diffusion area.} \quad (21)$$

$$L_2^2 = \frac{D_2}{\Sigma_{a_2}} = \text{thermal-group diffusion area.} \quad (22)$$

3. USE OF THE TWO-GROUP CONSTANTS

The two-group constants presented here can be used as input data in IBM 704 diffusion programs F_2^{11} and CURE¹³. Although the two-group constants were calculated for an infinite medium, they may be used in the finite geometry of F_2 and CURE as a first approximation in nonmultiplying regions. The use of these two-group constants will save machine time and engineering time in evaluating various reactors.

The two-group equations for a space-dependent calculation of reactivity k are:

$$-\nabla \cdot D_1 \nabla \phi_1 + (\Sigma_{a_1} + \Sigma_{s_1}) \phi_1 = S_1 \left(\frac{\nu}{k} \Sigma_{f_1} \phi_1 + \frac{\nu}{k} \Sigma_{f_2} \phi_2 \right) + S_1, \text{ external} \quad (23)$$

$$-\nabla \cdot D_2 \nabla \phi_2 + \Sigma_{a_2} \phi_2 = S_2 \left(\frac{\nu}{k} \Sigma_{f_1} \phi_1 + \frac{\nu}{k} \Sigma_{f_2} \phi_2 \right) + \Sigma_{s_1} \phi_1 + S_2, \text{ external} \quad (24)$$

The criticality equation that can be derived from (23) and (24) for the case of an infinite medium or a homogeneous reactor with no reflector or external sources and group division below the fission spectrum, is:

$$k = \frac{k_1 (1 - b)}{1 + L_1^2 K^2} + \frac{k_2 b}{(1 + L_1^2 K^2) (1 + L_2^2 K^2)} \quad (25)$$

With the assumption of a value for k , e.g., $k = 1$ for a critical reactor, equation (25) can be solved for the buckling K^2 . The knowledge of K^2 enables the optimum dimensions for a bare equivalent reactor to be obtained from the equation:

$$K^2 = \left(\frac{\pi}{H + 2 S_z + 2 d} \right)^2 + \left(\frac{2.405}{R + S_r + d} \right)^2 \quad (26)$$

by finding values of H and R that minimize the core volume $\pi R^2 H$.

The two-group constants are also of use in estimating spectra and thermal-neutron production in shields.

4. TABULATION OF TWO-GROUP CONSTANTS

The two-group constants are listed alphabetically on the following pages. The dimensions of d , d_1 , d_2 , D_1 , and D_2 are centimeters (cm); of Σ_{a_1} , Σ_{a_2} , Σ_{f_1} , Σ_{f_2} , and Σ_{s_1} , reciprocal centimeters (cm^{-1}); of L_1^2 and L_2^2 square centimeters (cm^2); and of k_1 and k_2 are average neutron multiplication. p is a dimensionless fraction. For notations and definitions see sections 1 and 2 respectively.

MATERIAL: Alumina

ASSUMED DENSITY: 3.970 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.092	1.094	1.095	1.096	1.097	1.097	1.098
D_2	.9319	.9741	.9967	1.009	1.017	1.023	1.026
Σa_1	.0007826	.0006458	.0005579	.0005006	.0004609	.0004304	.0004061
Σa_2	.009584	.007108	.005760	.004975	.004439	.004044	.003744
Σs_1	.001369	.001545	.001667	.001751	.001812	.001862	.001902
d	2.284	2.286	2.288	2.288	2.289	2.289	2.289
d_1	2.327	2.332	2.335	2.336	2.338	2.339	2.340
d_2	1.986	2.076	2.124	2.151	2.168	2.180	2.188
L_1^2	507.5	499.2	492.3	486.7	482.4	478.7	475.5
L_2^2	97.24	137.0	173.0	202.9	229.1	252.9	274.2
ρ	.6362	.7053	.7492	.7777	.7973	.8122	.8241

COMPOSITION BY WEIGHT FRACTION:

Al .5292
O .4708

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

I. E. Campbell, High Temperature Technology, 1954 P. 31
3.97 gm/cm³

MATERIAL: 2S Aluminum

ASSUMED DENSITY: 2.700 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	3.858	3.859	3.859	3.859	3.860	3.860	3.860
D_2	3.366	3.459	3.528	3.573	3.605	3.630	3.650
Σa_1	.0004613	.0004348	.0004122	.0003948	.0003809	.0003691	.0003587
Σa_2	.01230	.009122	.007392	.006385	.005698	.005191	.004805
Σs_1	.00006081	.00008886	.0001130	.0001321	.0001474	.0001605	.0001721
d	8.219	8.217	8.216	8.213	8.213	8.213	8.213
d_1	8.224	8.225	8.226	8.226	8.227	8.228	8.228
d_2	7.174	7.372	7.519	7.615	7.684	7.738	7.780
L_1^2	7389.	7369.	7348.	7325.	7306.	7289.	7273.
L_2^2	273.7	379.2	477.3	559.6	632.8	699.3	759.6
ρ	.1165	.1697	.2151	.2507	.2790	.3031	.3242

COMPOSITION BY WEIGHT FRACTION:

Al 1.00

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

HCP 2.699 gm/cm³
RH 2.699 gm/cm³
ANPD: E. A. Aitken
2.70 gm/cm³

MATERIAL: Barium

ASSUMED DENSITY: 3.500 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	3.276	3.277	3.277	3.277	3.277	3.277	3.278
D_2	1.367	1.558	1.691	1.783	1.854	1.915	1.968
Σ_{a_1}	.0001363	.0001350	.0001336	.0001324	.0001312	.0001302	.0001292
Σ_{a_2}	.01593	.01181	.009578	.008267	.007378	.006725	.006222
Σ_{s_1}	1.927×10^{-6}	3.314×10^{-6}	4.659×10^{-6}	5.983×10^{-6}	7.136×10^{-6}	8.195×10^{-6}	9.184×10^{-6}
d	6.983	6.983	6.983	6.982	6.982	6.982	6.982
d_1	6.984	6.984	6.984	6.985	6.985	6.986	6.986
d_2	2.914	3.322	3.605	3.801	3.952	4.081	4.196
L_1^2	23700.	23690.	23690.	23690.	23690.	23680.	23680.
L_2^2	85.81	131.9	176.6	215.7	251.3	284.7	316.4
ρ	.01393	.02396	.03369	.04325	.05158	.05922	.06635

COMPOSITION BY WEIGHT FRACTION:

Ba 1.00

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

HCP 3.50 gm/cm³
 RH 3.50 gm/cm³

MATERIAL: Beryllium

ASSUMED DENSITY: 1.850 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.6873	.6917	.6949	.6962	.6984	.7002	.7018
D_2	.4945	.4964	.4970	.4972	.4972	.4973	.4973
Σ_{a_1}	.0001049	.00007951	.00006548	.00005507	.00004966	.00004570	.00004264
Σ_{a_2}	.001097	.0008132	.0006594	.0005691	.0005080	.0004631	.0004284
Σ_{s_1}	.006796	.007027	.007195	.007339	.007427	.007500	.007562
d	1.111	1.101	1.095	1.090	1.087	1.085	1.083
d_1	1.465	1.474	1.481	1.484	1.489	1.493	1.496
d_2	1.054	1.058	1.059	1.060	1.060	1.060	1.060
L_1^2	99.60	97.33	95.72	94.15	93.40	92.80	92.28
L_2^2	450.8	610.4	753.8	873.7	978.8	1074.	1161.
ρ	.9848	.9888	.9910	.9926	.9934	.9939	.9944

COMPOSITION BY WEIGHT FRACTION:

Be 1.00

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken
 1.85 gm/cm³
 HCP 1.84 gm/cm³
 RH 1.85 gm/cm³
 MH 1.82 gm/cm³

MATERIAL: Beryllium (n, 2n)

ASSUMED DENSITY: 1.85 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.7002	.7051	.7087	.7103	.7127	.7147	.7165
D_2	.4945	.4964	.4970	.4972	.4972	.4973	.4973
Σ_{a_1}	.001401	.001414	.001430	.001445	.001455	.001464	.001473
Σ_{a_2}	.001097	.0008132	.0006594	.0005691	.0005080	.0004631	.0004284
Σ_{s_1}	.006968	.007211	.007387	.007539	.007632	.007709	.007775
d	1.114	1.103	1.096	1.092	1.089	1.086	1.084
d_1	1.492	1.503	1.511	1.514	1.519	1.523	1.527
d_2	1.054	1.058	1.059	1.060	1.060	1.060	1.060
L_1^2	83.67	81.74	80.38	79.06	78.43	77.91	77.48
L_2^2	450.8	610.4	753.8	873.7	978.8	1074.	1161.
ρ	.8326	.8360	.8379	.8392	.8399	.8404	.8407

COMPOSITION BY WEIGHT FRACTION:

Be 1.00

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken 1.85 gm/cm³
HCP 1.84 gm/cm³
RH 1.85 gm/cm³
MH 1.82 gm/cm³

MATERIAL: Beryllium (n, 2n)

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
$\nu \Sigma_{f_1}$	.0007506	.0007736	.0007907	.0008057	.0008150	.0008227	.0008294
$\nu \Sigma_{f_2}$	0	0	0	0	0	0	0
k_1	.5358	.5469	.5531	.5577	.5600	.5618	.5631
k_2	0	0	0	0	0	0	0

MATERIAL: Beryllium Oxide

ASSUMED DENSITY: 3.010 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.6445	.6482	.6508	.6520	.6537	.6550	.6562
D_2	.4872	.4983	.5036	.5063	.5078	.5088	.5095
Σa_1	.00006398	.00004878	.00004032	.00003432	.00003098	.00002853	.00002664
Σa_2	.0006560	.0004862	.0003945	.0003402	.0003036	.0002766	.0002562
Σs_1	.005705	.005892	.006030	.006145	.006220	.006282	.006335
d	1.073	1.087	1.093	1.095	1.097	1.098	1.098
d_1	1.374	1.382	1.387	1.390	1.393	1.396	1.399
d_2	1.038	1.062	1.073	1.079	1.082	1.085	1.086
L_1^2	111.7	109.1	107.2	105.5	104.6	103.8	103.1
L_2^2	742.6	1025.	1276.	1488.	1673.	1840.	1989.
ρ	.9889	.9918	.9934	.9944	.9950	.9955	.9958

COMPOSITION BY WEIGHT FRACTION:

Be .3603
O .6397

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

ANPD: E A Aitken

3.02 gm/cm³

HCP

3.01 gm/cm³

MATERIAL: Bismuth

ASSUMED DENSITY: 9.747 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.497	1.499	1.500	1.501	1.502	1.503	1.504
D_2	1.343	1.323	1.315	1.311	1.308	1.306	1.305
Σa_1	.00005883	.00004866	.00004215	.00003765	.00003468	.00003242	.00003060
Σa_2	.0007980	.0005900	.0004805	.0004130	.0003681	.0003372	.0003119
Σs_1	.00007579	.00008818	.00009655	.0001026	.0001068	.0001101	.0001128
d	3.162	3.146	3.132	3.118	3.108	3.101	3.093
d_1	3.190	3.194	3.198	3.199	3.201	3.204	3.206
d_2	2.863	2.819	2.803	2.794	2.788	2.784	2.781
L_1^2	11120.	10950.	10820.	10700.	10620.	10550.	10490.
L_2^2	1683.	2242.	2737.	3174.	3534.	3874.	4183.
ρ	.5630	.6444	.6961	.7316	.7548	.7725	.7866

COMPOSITION BY WEIGHT FRACTION:

Bi 1.00

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

HCP 9.747 gm/cm³RH 9.8 gm/cm³

MATERIAL: Boral

ASSUMED DENSITY: 2.530 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.613	1.613	1.613	1.613	1.613	1.613	1.613
D_2	.02224	.02987	.03670	.04240	.04737	.05184	.05593
Σa_1	.007782	.007782	.007782	.007782	.007782	.007782	.007782
Σa_2	14.82	10.99	8.910	7.690	6.864	6.257	5.787
Σs_1	1.259×10^{-9}	2.549×10^{-9}	3.905×10^{-9}	5.562×10^{-9}	7.152×10^{-9}	8.674×10^{-9}	1.016×10^{-8}
d	3.438	3.438	3.438	3.438	3.438	3.438	3.438
d_1	3.438	3.438	3.438	3.438	3.438	3.438	3.438
d_2	.04740	.06366	.07823	.09037	.1010	.1105	.1192
L_1^2	207.3	207.3	207.3	207.3	207.3	207.3	207.3
L_2^2	.001501	.002718	.004119	.005513	.006902	.008286	.009664
ρ	1.618×10^{-7}	3.276×10^{-7}	5.018×10^{-7}	7.148×10^{-7}	9.190×10^{-7}	1.115×10^{-6}	1.305×10^{-6}

COMPOSITION BY WEIGHT FRACTION: B .157
 C .043
 Al .800

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken
 2.53 gm/cm³

REFERENCE: ANPD: E. A. Aitken

MATERIAL: Boron (Amorphous)

ASSUMED DENSITY: 2.340 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.6430	.6430	.6430	.6430	.6430	.6430	.6430
D_2	.003799	.005114	.006296	.007284	.008150	.008930	.009645
Σa_1	.03211	.03211	.03211	.03211	.03211	.03211	.03211
Σa_2	87.24	64.69	52.46	45.27	40.41	36.84	34.07
Σs_1	7.387×10^{-10}	1.497×10^{-9}	2.295×10^{-9}	3.271×10^{-9}	4.208×10^{-9}	5.105×10^{-9}	5.980×10^{-9}
d	1.371	1.371	1.371	1.371	1.371	1.371	1.371
d_1	1.371	1.371	1.371	1.371	1.371	1.371	1.371
d_2	.008099	.01090	.01342	.01553	.01737	.01903	.02056
L_1^2	20.03	20.03	20.03	20.03	20.03	20.03	20.03
L_2^2	.00004355	.00007905	.0001200	.0001600	.0002017	.0002424	.0002831
ρ	2.301×10^{-8}	4.664×10^{-8}	7.147×10^{-8}	1.019×10^{-7}	1.310×10^{-7}	1.590×10^{-7}	1.863×10^{-7}

COMPOSITION BY WEIGHT FRACTION:

B 1.00

DENSITY VARIATIONS AND REFERENCE:

HCP 2.34 gm/cm³
 ANPD: E. A. Aitken
 2.45 gm/cm³

REFERENCE:

MATERIAL: Boron 10

ASSUMED DENSITY: 2.168 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.9510	.9510	.9510	.9510	.9510	.9510	.9510
D_2	.0007180	.0009679	.001193	.001382	.001548	.001698	.001835
Σ_{a_1}	.08164	.08164	.08164	.08164	.08164	.08164	.08164
Σ_{a_2}	463.8	343.9	278.8	240.7	214.8	195.8	181.1
Σ_{s_1}	1.398×10^{-12}	2.838×10^{-12}	4.352×10^{-12}	6.210×10^{-12}	7.994×10^{-12}	9.703×10^{-12}	1.137×10^{-11}
d	2.027	2.027	2.027	2.027	2.027	2.027	2.027
d_1	2.027	2.027	2.027	2.027	2.027	2.027	2.027
d_2	.001530	.002063	.002544	.002946	.003300	.003619	.003912
L_1^2	11.65	11.65	11.65	11.65	11.65	11.65	11.65
L_2^2	1.548×10^{-6}	2.815×10^{-6}	4.280×10^{-6}	5.744×10^{-6}	7.208×10^{-6}	8.671×10^{-6}	.00001013
ρ	1.713×10^{-11}	3.477×10^{-11}	5.331×10^{-11}	7.607×10^{-11}	9.792×10^{-11}	1.189×10^{-10}	1.393×10^{-10}

COMPOSITION BY WEIGHT FRACTION:

B¹⁰ 1.00

DENSITY VARIATIONS AND REFERENCE:

HCP 2.168 gm/cm³ (computed)

REFERENCE:

MATERIAL: Boron Carbide

ASSUMED DENSITY: 2.519 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.6445	.6445	.6445	.6445	.6445	.6445	.6445
D_2	.004502	.006055	.007451	.008617	.009638	.01056	.01140
Σ_{a_1}	.02927	.02927	.02927	.02927	.02927	.02927	.02927
Σ_{a_2}	73.52	54.51	44.20	38.15	34.05	31.04	28.71
Σ_{s_1}	1.731×10^{-9}	3.507×10^{-9}	5.372×10^{-9}	7.655×10^{-9}	9.845×10^{-9}	1.194×10^{-8}	1.399×10^{-8}
d	1.374	1.374	1.374	1.374	1.374	1.374	1.374
d_1	1.374	1.374	1.374	1.374	1.374	1.374	1.374
d_2	.009595	.01291	.01588	.01837	.02054	.02250	.02429
L_1^2	22.02	22.02	22.02	22.02	22.02	22.02	22.02
L_2^2	.00006123	.0001111	.0001686	.0002259	.0002830	.0003401	.0003969
ρ	5.912×10^{-8}	1.198×10^{-7}	1.835×10^{-7}	2.615×10^{-7}	3.363×10^{-7}	4.080×10^{-7}	4.779×10^{-7}

COMPOSITION BY WEIGHT FRACTION:

B .7828

C .2172

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken

2.519 gm/cm³HCP 2.50 gm/cm³

MATERIAL: Cadmium

ASSUMED DENSITY: 8.648 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.123	1.123	1.123	1.123	1.123	1.123	1.123
D_2	.002386	.001966	.001859	.001989	.002234	.002553	.002927
Σa_1	.0005683	.0005678	.0005674	.0005669	.0005663	.0005658	.0005653
Σa_2	139.3	168.8	178.3	166.6	148.2	129.6	113.0
Σs_1	4.112×10^{-7}	8.348×10^{-7}	1.280×10^{-6}	1.827×10^{-6}	2.352×10^{-6}	2.855×10^{-6}	3.346×10^{-6}
d	2.395	2.395	2.395	2.395	2.395	2.395	2.395
d_1	2.395	2.395	2.395	2.395	2.395	2.395	2.395
d_2	.005085	.004190	.003962	.004239	.004763	.005442	.006239
L_1^2	1976.	1976.	1976.	1976.	1976.	1976.	1976.
L_2^2	.00001713	.00001165	.00001042	.00001194	.00001508	.00001970	.00002591
ρ	.0007231	.001468	.002251	.003213	.004136	.005021	.005884

COMPOSITION BY WEIGHT FRACTION:

Cd 1.00

DENSITY VARIATIONS AND REFERENCE:

 RH 8.648 gm/cm³
 HCP 8.648 gm/cm³

REFERENCE:

MATERIAL: Calcium

ASSUMED DENSITY: 1.550 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	4.834	4.835	4.836	4.836	4.837	4.837	4.837
D_2	4.295	4.426	4.501	4.545	4.576	4.599	4.617
Σa_1	.0002328	.0002225	.0002133	.0002062	.0002002	.0001949	.0001902
Σa_2	.008885	.006589	.005342	.004611	.004115	.003752	.003470
Σs_1	.00002062	.00003132	.00004089	.00004847	.00005492	.00006056	.00006559
d	10.30	10.30	10.30	10.30	10.30	10.30	10.30
d_1	10.30	10.30	10.31	10.31	10.31	10.31	10.31
d_2	9.155	9.434	9.593	9.689	9.754	9.803	9.842
L_1^2	19080.	19050.	19020.	18990.	18960.	18930.	18910.
L_2^2	483.4	671.8	842.4	985.9	1112.	1226.	1331.
ρ	.08137	.1234	.1608	.1903	.2153	.2371	.2564

COMPOSITION BY WEIGHT FRACTION:

Ca 1.00

DENSITY VARIATIONS AND REFERENCE:

 HCP 1.55 gm/cm³
 RH 1.55 gm/cm³

REFERENCE:

MATERIAL: Calcium Hydride (H Bound)

ASSUMED DENSITY: 1.700 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.633	1.656	1.673	1.684	1.693	1.700	1.707
D_2	.2034	.2653	.3203	.3650	.4030	.4358	.4646
Σ_{a_1}	.001403	.001072	.0008920	.0007833	.0007088	.0006539	.0006110
Σ_{a_2}	.02352	.01744	.01414	.01221	.01090	.009982	.009186
Σ_{s_1}	.03035	.03121	.03179	.03218	.03249	.03273	.03294
d	1.764	1.628	1.570	1.551	1.550	1.556	1.568
d_1	3.480	3.530	3.566	3.590	3.609	3.625	3.638
d_2	.4336	.5654	.6828	.7781	.8590	.9289	.9903
L_1^2	51.42	51.30	51.19	51.09	51.00	50.93	50.86
L_2^2	8.648	15.21	22.65	29.91	36.99	43.88	50.58
ρ	.9558	.9668	.9727	.9762	.9786	.9804	.9818

COMPOSITION BY WEIGHT FRACTION:

Ca .9521

H .0479

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

ANPD: W. E. Edwards &

M. A. Capo 1.7 gm/cm³RH 1.90 gm/cm³

MATERIAL: Calcium Hydride (H Gas)

ASSUMED DENSITY: 1.700 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.656	1.673	1.686	1.695	1.702	1.708	1.713
D_2	.3752	.4593	.5164	.5549	.5836	.6060	.6248
Σ_{a_1}	.001278	.001015	.0008565	.0007552	.0006876	.0006370	.0005971
Σ_{a_2}	.02352	.01744	.01414	.01221	.01090	.009932	.009186
Σ_{s_1}	.03077	.03147	.03198	.03235	.03263	.03285	.03305
d	1.983	1.902	1.865	1.849	1.841	1.837	1.836
d_1	3.531	3.567	3.594	3.613	3.628	3.641	3.652
d_2	.7997	.9791	1.101	1.183	1.244	1.292	1.332
L_1^2	51.69	51.51	51.34	51.20	51.10	51.00	50.92
L_2^2	15.95	26.34	36.51	45.46	53.56	61.01	68.02
ρ	.9601	.9688	.9739	.9772	.9794	.9810	.9823

COMPOSITION BY WEIGHT FRACTION:

Ca .9521

H .0479

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

ANPD: W. E. Edwards &

M. A. Capo 1.7 gm/cm³RH 1.90 gm/cm³

MATERIAL: Calcium Hydride (H Gas)

ASSUMED DENSITY: 1.700 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.656	1.673	1.686	1.695	1.702	1.708	1.713
D_2	.3752	.4593	.5164	.5549	.5836	.6060	.6248
Σ_{a_1}	.001278	.001015	.0008565	.0007552	.0006876	.0006370	.0005971
Σ_{a_2}	.02352	.01744	.01414	.01221	.01090	.009932	.009186
Σ_{s_1}	.03077	.03147	.03198	.03235	.03263	.03285	.03305
d	1.983	1.902	1.865	1.849	1.841	1.837	1.836
d_1	3.531	3.567	3.594	3.613	3.628	3.641	3.652
d_2	.7997	.9791	1.101	1.183	1.244	1.292	1.332
L_1^2	51.69	51.51	51.34	51.20	51.10	51.00	50.92
L_2^2	15.95	26.34	36.51	45.46	53.56	61.01	68.02
ρ	.9601	.9688	.9739	.9772	.9794	.9810	.9823

COMPOSITION BY WEIGHT FRACTION:

Ca .9521
H .0479

DENSITY VARIATIONS AND REFERENCE:

ANPD: W. E. Edwards &
M. A. Capo 1.7 gm/cm³
RH 1.90 gm/cm³

REFERENCE:

MATERIAL: Copper

ASSUMED DENSITY: 8.960 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.7729	.7729	.7730	.7730	.7730	.7730	.7730
D_2	.3852	.4065	.4208	.4304	.4374	.4428	.4472
Σ_{a_1}	.001546	.001541	.001535	.001529	.001524	.001519	.001514
Σ_{a_2}	.2781	.2062	.1672	.1443	.1288	.1174	.1086
Σ_{s_1}	6.568×10^{-6}	.00001220	.00001791	.00002383	.00002933	.00003448	.00003938
d	1.647	1.647	1.647	1.647	1.647	1.647	1.647
d_1	1.647	1.648	1.648	1.648	1.648	1.648	1.648
d_2	.8211	.8664	.8970	.9175	.9323	.9439	.9531
L_1^2	497.7	497.7	497.7	497.7	497.6	497.6	497.6
L_2^2	1.385	1.971	2.517	2.984	3.396	3.772	4.118
ρ	.004229	.007858	.01153	.01534	.01888	.02220	.02535

COMPOSITION BY WEIGHT FRACTION:

Cu 1.00

DENSITY VARIATIONS AND REFERENCE:

MH 8.96 gm/cm³
HCP 8.93-8.95 gm/cm³
RH 8.96 gm/cm³

REFERENCE:

MATERIAL: Dysprosium

ASSUMED DENSITY: 8.562 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.045	1.045	1.045	1.045	1.045	1.045	1.045
D_2	.01050	.01460	.01855	.02202	.02516	.02805	.03071
Σa_1	.002991	.002991	.002991	.002991	.002991	.002991	.002991
Σa_2	28.85	20.20	15.53	12.84	11.05	9.763	8.805
Σs_1	2.082×10^{-13}	4.219×10^{-13}	6.464×10^{-13}	9.207×10^{-13}	1.184×10^{-12}	1.436×10^{-12}	1.682×10^{-12}
d	2.227	2.227	2.227	2.227	2.227	2.227	2.227
d_1	2.227	2.227	2.227	2.227	2.227	2.227	2.227
d_2	.02238	.03112	.03954	.04693	.05363	.05979	.06546
L_1^2	349.2	349.2	349.2	349.2	349.2	349.2	349.2
L_2^2	.0003639	.0007227	.001194	.001715	.002278	.002873	.003488
ρ	6.962×10^{-11}	1.410×10^{-10}	2.161×10^{-10}	3.078×10^{-10}	3.958×10^{-10}	4.802×10^{-10}	5.624×10^{-10}

COMPOSITION BY WEIGHT FRACTION:

Dy 1.00

DENSITY VARIATIONS AND REFERENCE:

RMH

8.562 gm/cm³

REFERENCE:

MATERIAL: Europium

ASSUMED DENSITY: 5.166 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.634	1.634	1.634	1.634	1.634	1.634	1.634
D_2	.004264	.006764	.007980	.007582	.006919	.006473	.006253
Σa_1	.02563	.02563	.02563	.02563	.02563	.02563	.02563
Σa_2	77.95	49.08	41.53	43.63	47.77	51.03	52.79
Σs_1	7.374×10^{-20}	1.497×10^{-19}	2.295×10^{-19}	3.276×10^{-19}	4.218×10^{-19}	5.120×10^{-19}	6.000×10^{-19}
d	3.483	3.483	3.483	3.483	3.483	3.483	3.483
d_1	3.483	3.483	3.483	3.483	3.483	3.483	3.483
d_2	.009089	.01442	.01701	.01616	.01475	.01380	.01333
L_1^2	63.75	63.75	63.75	63.75	63.75	63.75	63.75
L_2^2	.00005470	.0001378	.0001922	.0001738	.0001448	.0001268	.0001185
ρ	2.877×10^{-18}	5.840×10^{-18}	8.955×10^{-18}	1.278×10^{-17}	1.645×10^{-17}	1.997×10^{-17}	2.341×10^{-17}

COMPOSITION BY WEIGHT FRACTION:

Eu 1.00

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken 5.166 gm/cm³

REFERENCE:

MATERIAL: Europium Oxide

ASSUMED DENSITY: 7.420 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.9638	.9638	.9638	.9638	.9638	.9638	.9638
D_2	.003323	.005267	.006212	.005903	.005388	.005041	.004871
Σa_1	.03603	.03603	.03603	.03603	.03603	.03603	.03603
Σa_2	99.88	62.88	53.20	55.91	61.21	65.38	67.63
Σs_1	3.344×10^{-15}	6.784×10^{-15}	1.040×10^{-14}	1.483×10^{-14}	1.909×10^{-14}	2.318×10^{-14}	2.716×10^{-14}
d	2.054	2.054	2.054	2.054	2.054	2.054	2.054
d_1	2.054	2.054	2.054	2.054	2.054	2.054	2.054
d_2	.007083	.01123	.01324	.01258	.01148	.01075	.01038
L_1^2	26.75	26.75	26.75	26.75	26.75	26.75	26.75
L_2^2	.00003327	.00008376	.0001167	.0001056	.00008803	.00007711	.00007202
ρ	9.284×10^{-14}	1.883×10^{-13}	2.887×10^{-13}	4.118×10^{-13}	5.300×10^{-13}	6.433×10^{-13}	7.539×10^{-13}

COMPOSITION BY WEIGHT FRACTION:

Eu .8636

O .1364

DENSITY VARIATIONS AND REFERENCE:

HCP 7.42 gm/cm³

REFERENCE:

MATERIAL: Gadolinium

ASSUMED DENSITY: 7.868 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.944	1.944	1.944	1.944	1.944	1.944	1.944
D_2	.0003057	.0004863	.0007319	.001019	.001346	.001714	.002122
Σa_1	.003435	.003435	.003435	.003435	.003435	.003435	.003435
Σa_2	1086.	681.3	451.9	324.2	244.9	192.1	155.0
Σs_1	1.122×10^{-15}	2.279×10^{-15}	3.494×10^{-15}	4.986×10^{-15}	6.419×10^{-15}	7.791×10^{-15}	9.131×10^{-15}
d	4.144	4.144	4.144	4.144	4.144	4.144	4.144
d_1	4.144	4.144	4.144	4.144	4.144	4.144	4.144
d_2	.0006515	.001037	.001560	.002171	.002870	.003654	.004523
L_1^2	566.1	566.1	566.1	566.1	566.1	566.1	566.1
L_2^2	2.815×10^{-7}	7.137×10^{-7}	1.620×10^{-6}	3.142×10^{-6}	5.498×10^{-6}	8.926×10^{-6}	1.369×10^{-5}
ρ	3.268×10^{-13}	6.634×10^{-13}	1.017×10^{-12}	1.452×10^{-12}	1.869×10^{-12}	2.269×10^{-12}	2.659×10^{-12}

COMPOSITION BY WEIGHT FRACTION:

Gd 1.00

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken

7.868 gm/cm³

REFERENCE:

MATERIAL: Gadolinium Oxide

ASSUMED DENSITY: 7.410 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.404	1.404	1.404	1.404	1.404	1.404	1.404
D_2	.0003741	.0005952	.0008957	.001246	.001647	.002097	.002595
Σa_1	.005348	.005348	.005348	.005348	.005348	.005348	.005348
Σa_2	887.0	556.5	369.1	264.8	200.0	156.9	126.6
Σs_1	1.779×10^{-10}	3.611×10^{-10}	5.538×10^{-10}	7.900×10^{-10}	1.017×10^{-9}	1.234×10^{-9}	1.446×10^{-9}
d	2.993	2.993	2.993	2.993	2.993	2.993	2.993
d_1	2.993	2.993	2.993	2.993	2.993	2.993	2.993
d_2	.0007975	.001269	.001909	.002657	.003511	.004470	.005531
L_1^2	262.6	262.6	262.6	262.6	262.6	262.6	262.6
L_2^2	4.218×10^{-7}	1.069×10^{-6}	2.426×10^{-6}	4.707×10^{-6}	8.234×10^{-6}	1.337×10^{-5}	2.050×10^{-5}
ρ	3.327×10^{-8}	6.753×10^{-8}	1.035×10^{-7}	1.477×10^{-7}	1.901×10^{-7}	2.308×10^{-7}	2.704×10^{-7}

COMPOSITION BY WEIGHT FRACTION:

DENSITY VARIATIONS AND REFERENCE:

Gd .8673
O .1327

ANPD: E. A. Aitken: 7.41 gm/cm³

REFERENCE:

MATERIAL: Gold

ASSUMED DENSITY: 19.30 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.9116	.9116	.9116	.9116	.9116	.9116	.9116
D_2	.06060	.07906	.09424	.1058	.1151	.1227	.1291
Σa_1	.006615	.006615	.006615	.006615	.006615	.006615	.006615
Σa_2	5.126	3.803	3.093	2.687	2.423	2.237	2.099
Σs_1	1.871×10^{-14}	3.794×10^{-14}	5.815×10^{-14}	8.287×10^{-14}	1.066×10^{-13}	1.293×10^{-13}	1.515×10^{-13}
d	1.943	1.943	1.943	1.943	1.943	1.943	1.943
d_1	1.943	1.943	1.943	1.943	1.943	1.943	1.943
d_2	.1292	.1685	.2009	.2255	.2453	.2616	.2753
L_1^2	137.8	137.8	137.8	137.8	137.8	137.8	137.8
L_2^2	.01182	.02079	.03047	.03938	.04750	.05486	.06152
ρ	2.828×10^{-12}	5.735×10^{-12}	6.789×10^{-12}	1.253×10^{-11}	1.611×10^{-11}	1.955×10^{-11}	2.290×10^{-11}

COMPOSITION BY WEIGHT FRACTION:

DENSITY VARIATIONS AND REFERENCE:

Au 1.00

HCP 19.3 gm/cm³

REFERENCE:

MATERIAL: Graphite

ASSUMED DENSITY: 1.60 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.192	1.199	1.205	1.209	1.213	1.215	1.218
D_2	.9404	.9294	.9240	.9211	.9193	.9182	.9175
Σa_1	.00002147	.00001620	.00001340	.00001173	.00001059	9.761×10^{-6}	9.120×10^{-6}
Σa_2	.0002279	.0001685	.0001372	.0001179	.0001051	.00009628	.00008906
Σs_1	.002821	.002908	.002971	.003016	.003051	.003081	.003106
d	2.044	2.012	1.996	1.986	1.980	1.976	1.973
d_1	2.541	2.557	2.569	2.578	2.585	2.591	2.596
d_2	2.004	1.981	1.970	1.963	1.960	1.957	1.956
L_1^2	419.3	410.1	403.8	399.5	396.0	393.3	390.9
L_2^2	4127.	5516.	6735.	7810.	8747.	9537.	10300.
ρ	.9924	.9945	.9955	.9961	.9965	.9968	.9971

COMPOSITION BY WEIGHT FRACTION:

C 1.00

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken
1.55-1.75 gm/cm³

REFERENCE:

MATERIAL: Hafnium

ASSUMED DENSITY: 13.09 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.065	1.065	1.065	1.065	1.065	1.065	1.065
D_2	.07362	.09391	.1086	.1154	.1086	.08713	.06328
Σa_1	.004913	.004913	.004913	.004913	.004913	.004913	.004913
Σa_2	4.176	3.198	2.717	2.531	2.698	3.424	4.818
Σs_1	4.451×10^{-14}	9.024×10^{-14}	1.383×10^{-13}	1.972×10^{-13}	2.537×10^{-13}	3.078×10^{-13}	3.606×10^{-13}
d	2.270	2.270	2.270	2.270	2.270	2.270	2.270
d_1	2.270	2.270	2.270	2.270	2.270	2.270	2.270
d_2	.1569	.2002	.2315	.2460	.2315	.1857	.1349
L_1^2	216.8	216.8	216.8	216.8	216.8	216.8	216.8
L_2^2	.01763	.02937	.03998	.04559	.04026	.02544	.01313
ρ	9.060×10^{-12}	1.837×10^{-11}	2.815×10^{-11}	4.013×10^{-11}	5.163×10^{-11}	6.265×10^{-11}	7.340×10^{-11}

COMPOSITION BY WEIGHT FRACTION:

Hf 1.00

DENSITY VARIATIONS AND REFERENCE:

RMH 13.09 gm/cm³
11.4 gm/cm³
J. L. Everhart, Bureau of
Standards Circular (C447), 1943

REFERENCE:

MATERIAL: Hydrided Yttrium (H Bound)

ASSUMED DENSITY: 4.33 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.161	1.176	1.186	1.192	1.198	1.202	1.205
D_2	.2239	.2852	.3374	.3782	.4118	.4402	.4646
Σa_1	.002445	.001886	.001577	.001389	.001259	.001163	.001088
Σa_2	.04245	.03147	.02552	.02203	.01966	.01792	.01658
Σs_1	.02384	.02482	.02544	.02585	.02617	.02642	.02662
d	1.757	1.669	1.625	1.605	1.596	1.595	1.596
d_1	2.475	2.506	2.527	2.542	2.553	2.562	2.569
d_2	.4772	.6079	.7191	.8062	.8778	.9383	.9903
L_1^2	44.17	44.02	43.88	43.77	43.67	43.58	43.50
L_2^2	5.274	9.061	13.22	17.17	20.95	24.56	28.03
ρ	.9070	.9294	.9416	.9490	.9541	.9578	.9607

COMPOSITION BY WEIGHT FRACTION:

Y .9845
 H .0155 ($N_H = 4 \times 10^{22}$)
 REFERENCE: ANPD: C. R. Simmons

DENSITY VARIATIONS AND REFERENCE:

ANPD: C. R. Simmons, 1957
 4.33 gm/cm³
 ANPD: E. A. Aitken, 1956
 4.45 gm/cm³

MATERIAL: Hydrided Yttrium (H Gas)

ASSUMED DENSITY: 4.33 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.178	1.187	1.195	1.200	1.204	1.207	1.210
D_2	.3823	.4553	.5027	.5339	.5566	.5742	.5888
Σa_1	.002238	.001789	.001516	.001340	.001222	.001134	.001064
Σa_2	.04244	.03147	.02552	.02203	.01966	.01792	.01657
Σs_1	.02427	.02506	.02561	.02600	.02629	.02652	.02671
d	1.893	1.839	1.808	1.789	1.777	1.768	1.762
d_1	2.510	2.531	2.546	2.557	2.566	2.573	2.579
d_2	.8149	.9704	1.072	1.138	1.186	1.224	1.255
L_1^2	44.43	44.22	44.03	43.88	43.76	43.65	43.56
L_2^2	9.007	14.47	19.70	24.24	28.32	32.04	35.52
ρ	.9155	.9334	.9441	.9510	.9556	.9590	.9617

COMPOSITION BY WEIGHT FRACTION:

Y .9845
 H .0155 ($N_H = 4 \times 10^{22}$)

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

ANPD: C. R. Simmons, 1957
 4.33 gm/cm³
 ANPD: E. A. Aitken, 1956
 4.45 gm/cm³

MATERIAL: Hydrided Yttrium (H Bound)

ASSUMED DENSITY: 4.30 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.081	1.095	1.104	1.111	1.116	1.121	1.124
D_2	.1845	.2366	.2816	.3171	.3466	.3717	.3934
Σa_1	.002614	.002012	.001679	.001478	.001339	.001237	.001156
Σa_2	.04504	.03339	.02708	.02337	.02086	.01902	.01759
Σs_1	.03010	.03123	.03195	.03244	.03281	.03310	.03335
d	1.538	1.449	1.405	1.385	1.377	1.375	1.376
d_1	2.304	2.333	2.354	2.368	2.379	2.388	2.396
d_2	.3932	.5044	.6002	.6759	.7389	.7923	.8385
L_1^2	33.04	32.93	32.84	32.76	32.69	32.63	32.58
L_2^2	4.096	7.086	10.40	13.57	16.62	19.55	22.37
ρ	.9201	.9395	.9501	.9564	.9608	.9640	.9665

COMPOSITION BY WEIGHT FRACTION:

Y .9805
H .0195 ($N_H = 5 \times 10^{22}$)

REFERENCE:

ANPD: C. R. Simmons

DENSITY VARIATIONS AND REFERENCE:

ANPD: C. R. Simmons
4.30 gm/cm³

MATERIAL: Hydrided Yttrium (H Gas)

ASSUMED DENSITY: 4.30 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.096	1.106	1.113	1.118	1.122	1.125	1.128
D_2	.3218	.3862	.4285	.4565	.4771	.4931	.5063
Σa_1	.002390	.001907	.001614	.001426	.001300	.001205	.001131
Σa_2	.04504	.03339	.02708	.02337	.02086	.01902	.01759
Σs_1	.03061	.03153	.03217	.03263	.03297	.03324	.03347
d	1.668	1.612	1.580	1.562	1.550	1.541	1.536
d_1	2.336	2.357	2.372	2.383	2.392	2.399	2.405
d_2	.6859	.8231	.9134	.9731	1.017	1.051	1.079
L_1^2	33.21	33.06	32.94	32.83	32.75	32.67	32.61
L_2^2	7.145	11.56	15.83	19.53	22.87	25.93	28.79
ρ	.9276	.9430	.9522	.9581	.9621	.9650	.9673

COMPOSITION BY WEIGHT FRACTION:

Y .9805
H .0195 ($N_H = 5 \times 10^{22}$)

REFERENCE:

ANPD: C. R. Simmons

DENSITY VARIATIONS AND REFERENCE:

ANPD: C. R. Simmons
4.30 gm/cm³

MATERIAL: Hydrided Yttrium (H Bound)

ASSUMED DENSITY: 4.28 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.012	1.025	1.035	1.041	1.046	1.050	1.054
D_2	.1568	.2021	.2415	.2729	.2991	.3215	.3409
Σ_{a_1}	.002783	.002138	.001784	.001569	.001421	.001312	.001227
Σ_{a_2}	.04772	.03538	.02869	.02476	.02210	.02015	.01863
Σ_{s_1}	.03636	.03764	.03847	.03902	.03945	.03979	.04007
d	1.368	1.281	1.237	1.217	1.209	1.207	1.209
d_1	2.156	2.185	2.205	2.219	2.230	2.239	2.246
d_2	.3343	.4308	.5148	.5817	.6375	.6852	.7267
L_1^2	25.84	25.77	25.70	25.65	25.60	25.55	25.51
L_2^2	3.287	5.713	8.418	11.02	13.53	15.96	18.30
ρ	.9289	.9462	.9557	.9614	.9652	.9681	.9703

COMPOSITION BY WEIGHT FRACTION:

Y .977

H .023 ($N_H = 6 \times 10^{22}$)

REFERENCE:

ANPD: C. R. Simmons

DENSITY VARIATIONS AND REFERENCE:

ANPD: C. R. Simmons

4.28 gm/cm³

MATERIAL: Hydrided Yttrium (H Gas)

ASSUMED DENSITY: 4.28 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.026	1.035	1.042	1.048	1.051	1.055	1.058
D_2	.2778	.3352	.3733	.3986	.4173	.4318	.4439
Σ_{a_1}	.002543	.002027	.001714	.001513	.001379	.001278	.001199
Σ_{a_2}	.04772	.03538	.02863	.02476	.02210	.02015	.01863
Σ_{s_1}	.03695	.03799	.03872	.03925	.03963	.03995	.04021
d	1.491	1.434	1.403	1.385	1.373	1.366	1.360
d_1	2.187	2.207	2.222	2.233	2.241	2.248	2.254
d_2	.5921	.7144	.7956	.8496	.8894	.9204	.9461
L_1^2	25.98	25.87	25.78	25.70	25.64	25.59	25.54
L_2^2	5.821	9.474	13.01	16.10	18.88	21.43	23.82
ρ	.9356	.9494	.9576	.9629	.9664	.9690	.9710

COMPOSITION BY WEIGHT FRACTION:

Y .977

H .023 ($N_H = 6 \times 10^{22}$)

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

ANPD: C. R. Simmons

4.28 gm/cm³

MATERIAL: Hydrided Zirconium (H Bound)

ASSUMED DENSITY: 5.89 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.9379	.9496	.9576	.9629	.9669	.9702	.9728
D_2	.2198	.2765	.3239	.3603	.3899	.4146	.4356
Σ_{a_1}	.001072	.0008187	.0006810	.0005978	.0005410	.0004990	.0004663
Σ_{a_2}	.01785	.01323	.01073	.009260	.008266	.007536	.006968
Σ_{s_1}	.02521	.02591	.02638	.02670	.02695	.02715	.02732
d	1.103	1.074	1.081	1.099	1.120	1.141	1.161
d_1	1.999	2.024	2.041	2.052	2.061	2.068	2.074
d_2	.4685	.5894	.6904	.7680	.8311	.8837	.9285
L_1^2	35.69	35.53	35.39	35.28	35.18	35.09	35.01
L_2^2	12.32	20.90	30.18	38.91	47.17	55.01	62.51
ρ	.9592	.9694	.9748	.9781	.9803	.9820	.9832

COMPOSITION BY WEIGHT FRACTION:

Zr .9886
H .0114 ($N_H = 4 \times 10^{22}$)

DENSITY VARIATIONS AND REFERENCE:

ANPD: C. R. Simmons, 1957 5.89 gm/cm³
ANPD: E. A. Aitken, 1956 6.05 gm/cm³

REFERENCE:

ANPD: C. R. Simmons

MATERIAL: Hydrided Zirconium (H Gas)

ASSUMED DENSITY: 5.89 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.9522	.9597	.9651	.9690	.9719	.9743	.9763
D_2	.3704	.4335	.4732	.4988	.5172	.5313	.5429
Σ_{a_1}	.0009765	.0007750	.0006539	.0005765	.0005248	.0004861	.0004556
Σ_{a_2}	.01785	.01323	.01073	.009260	.008266	.007536	.006968
Σ_{s_1}	.02555	.02612	.02653	.02683	.02706	.02725	.02740
d	1.300	1.301	1.311	1.320	1.329	1.337	1.344
d_1	2.030	2.046	2.057	2.065	2.072	2.077	2.081
d_2	.7896	.9239	1.009	1.063	1.102	1.132	1.157
L_1^2	35.90	35.68	35.50	35.35	35.23	35.13	35.04
L_2^2	20.76	32.76	44.10	53.86	62.57	70.50	77.91
ρ	.9632	.9712	.9759	.9790	.9810	.9825	.9836

COMPOSITION BY WEIGHT FRACTION:

Zr .9886
H .0114 ($N_H = 4 \times 10^{22}$)

DENSITY VARIATIONS AND REFERENCE:

ANPD: C. R. Simmons, 1957 5.89 gm/cm³
ANPD: E. A. Aitken, 1956 6.05 gm/cm³

REFERENCE:

ANPD: C. R. Simmons

MATERIAL: Hydrided Zirconium (H Bound)

ASSUMED DENSITY: 5.72 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.8969	.9086	.9167	.9221	.9262	.9296	.9323
D_2	.1822	.2315	.2733	.3060	.3328	.3554	.3747
Σ_{a_1}	.001235	.0009424	.0007837	.0006879	.0006224	.0005741	.0005363
Σ_{a_2}	.02058	.01526	.01237	.01068	.009531	.008689	.008034
Σ_{s_1}	.03146	.03231	.03288	.03327	.03357	.03382	.03403
d	.9908	.9564	.9576	.9712	.9890	1.008	1.026
d_1	1.912	1.937	1.954	1.965	1.974	1.981	1.987
d_2	.3884	.4935	.5826	.6522	.7093	.7574	.7987
L_1^2	27.43	27.32	27.23	27.15	27.09	27.03	26.97
L_2^2	8.856	15.17	22.09	28.66	34.92	40.90	46.64
ρ	.9622	.9717	.9767	.9797	.9818	.9833	.9845

COMPOSITION BY WEIGHT FRACTION:

DENSITY VARIATIONS AND REFERENCE:

Zr .9854

ANPD: C. R. Simmons

H .0146 ($N_H = 5 \times 10^{22}$)5.72 gm/cm³

REFERENCE:

ANPD: C. R. Simmons

MATERIAL: Hydrided Zirconium (H Gas)

ASSUMED DENSITY: 5.72 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.9106	.9183	.9240	.9280	.9311	.9336	.9358
D_2	.3150	.3727	.4097	.4338	.4513	.4647	.4758
Σ_{a_1}	.001124	.0008920	.0007525	.0006632	.0006037	.0005592	.0005241
Σ_{a_2}	.02058	.01526	.01237	.01068	.009531	.008689	.008034
Σ_{s_1}	.03188	.03257	.03307	.03344	.03371	.03394	.03414
d	1.169	1.165	1.172	1.180	1.187	1.194	1.201
d_1	1.941	1.957	1.970	1.978	1.985	1.990	1.995
d_2	.6714	.7944	.8734	.9247	.9619	.9905	1.014
L_1^2	27.59	27.45	27.32	27.21	27.13	27.06	27.00
L_2^2	15.31	24.43	33.11	40.63	47.35	53.48	59.22
ρ	.9659	.9733	.9778	.9806	.9824	.9838	.9849

COMPOSITION BY WEIGHT FRACTION:

DENSITY VARIATIONS AND REFERENCE:

Zr .9854

ANPD: C. R. Simmons

H .0146 ($N_H = 5 \times 10^{22}$)5.72 gm/cm³

REFERENCE:

ANPD: C. R. Simmons

MATERIAL: INCONEL "X"
Note: Mocked up Co with Mn.

ASSUMED DENSITY: 8.310 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.8593	.8593	.8594	.8595	.8595	.8596	.8597
D_2	.2239	.2340	.2408	.2451	.2483	.2508	.2528
Σa_1	.001899	.001880	.001861	.001843	.001826	.001811	.001797
Σa_2	.3424	.2539	.2059	.1777	.1586	.1446	.1337
Σs_1	.00002481	.00004429	.00006356	.00008204	.00009866	.0001140	.0001284
d	1.831	1.831	1.831	1.831	1.831	1.831	1.831
d_1	1.832	1.832	1.832	1.832	1.832	1.832	1.832
d_2	.4772	.4988	.5132	.5224	.5292	.5345	.5388
L_1^2	446.6	446.5	446.5	446.5	446.5	446.5	446.5
L_2^2	.6538	.9216	1.169	1.379	1.565	1.734	1.890
ρ	.01290	.02301	.03303	.04262	.05125	.05922	.06669

COMPOSITION BY WEIGHT FRACTION:

DENSITY VARIATIONS AND REFERENCE:

Al .007 Cu .005 Fe .074 Ni .700 Si .005
Co .01 Cr .155 Mn .01 Nb .009 Ti .025

ANPD: F. D. Kingsbury

8.31 gm/cm³

REFERENCE:

ANPD: F. D. Kingsbury

MATERIAL: Indium

ASSUMED DENSITY: 7.310 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.705	1.705	1.705	1.705	1.705	1.705	1.705
D_2	.04944	.06320	.07266	.07789	.07950	.07687	.06962
Σa_1	.004720	.004720	.004720	.004720	.004720	.004720	.004720
Σa_2	6.598	5.125	4.436	4.126	4.033	4.164	4.592
Σs_1	9.247×10^{-16}	1.876×10^{-15}	2.876×10^{-15}	4.104×10^{-15}	5.282×10^{-15}	6.412×10^{-15}	7.514×10^{-15}
d	3.634	3.634	3.634	3.634	3.634	3.634	3.634
d_1	3.634	3.634	3.634	3.634	3.634	3.634	3.634
d_2	.1054	.1347	.1549	.1660	.1695	.1638	.1484
L_1^2	361.1	361.1	361.1	361.1	361.1	361.1	361.1
L_2^2	.007493	.01233	.01638	.01888	.01971	.01846	.01516
ρ	1.959×10^{-13}	3.975×10^{-13}	6.093×10^{-13}	8.694×10^{-13}	1.119×10^{-12}	1.358×10^{-12}	1.592×10^{-12}

COMPOSITION BY WEIGHT FRACTION:

DENSITY VARIATIONS AND REFERENCE:

In 1.00

RMH

7.31 gm/cm³

REFERENCE:

MATERIAL: Iron

ASSUMED DENSITY: 7.870 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.9977	.9978	.9979	.9980	.9982	.9983	.9984
D_2	.3087	.3116	.3233	.3289	.3326	.3349	.3366
Σa_1	.001275	.001256	.001238	.001222	.001207	.001193	.001181
Σa_2	.1905	.1412	.1145	.09885	.08823	.08043	.07439
Σs_1	.00002694	.00004603	.00006440	.00008129	.00009632	.0001100	.0001227
d	2.126	2.126	2.126	2.126	2.126	2.126	2.126
d_1	2.127	2.127	2.127	2.127	2.128	2.128	2.128
d_2	.6580	.6642	.6892	.7010	.7090	.7139	.7174
L_1^2	766.2	766.2	766.1	766.1	766.0	766.0	765.9
L_2^2	1.620	2.206	2.823	3.327	3.770	4.164	4.524
ρ	.02069	.03534	.04944	.06240	.07392	.08442	.09414

COMPOSITION BY WEIGHT FRACTION:

Fe 1.00

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

MH 7.87 gm/cm³
HCP 7.85-7.88 gm/cm³
RH 7.87 gm/cm³

MATERIAL: Iron-Chrome-Aluminum

ASSUMED DENSITY: 7.200 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.127	1.127	1.127	1.128	1.128	1.128	1.128
D_2	.3939	.4038	.4206	.4293	.4353	.4393	.4423
Σa_1	.001252	.001238	.001225	.001212	.001200	.001189	.001179
Σa_2	.1773	.1314	.1066	.09198	.08210	.07484	.06923
Σs_1	.00001902	.00003322	.00004708	.00006021	.00007202	.00008288	.00009300
d	2.403	2.403	2.403	2.402	2.402	2.402	2.402
d_1	2.403	2.403	2.403	2.403	2.404	2.404	2.404
d_2	.8396	.8608	.8966	.9150	.9279	.9364	.9427
L_1^2	886.7	886.6	886.6	886.5	886.5	886.4	886.4
L_2^2	2.222	3.072	3.947	4.667	5.302	5.870	6.389
ρ	.01496	.02612	.03702	.04734	.05661	.06514	.07309

COMPOSITION BY WEIGHT FRACTION:

Fe .70

Cr .25

REFERENCE: Al .05

ANPD: E. A. Aitken

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken
7.2 gm/cm³

MATERIAL: Iron-Chrome-Aluminum (New)

ASSUMED DENSITY: 7.20 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.081	1.081	1.081	1.081	1.081	1.081	1.081
D_2	.3873	.3973	.4140	.4226	.4287	.4328	.4358
Σ_{a_1}	.001348	.001334	.001319	.001306	.001294	.001283	.001273
Σ_{a_2}	.1841	.1371	.1115	.09636	.08602	.07842	.07256
Σ_{s_1}	.00001963	.00003431	.00004866	.00006226	.00007452	.00008579	.00009630
d	2.303	2.303	2.303	2.303	2.303	2.303	2.303
d_1	2.304	2.304	2.304	2.304	2.304	2.305	2.305
d_2	.8255	.8469	.8824	.9008	.9139	.9225	.9289
L_1^2	790.1	790.1	790.0	790.0	789.9	789.9	789.8
L_2^2	2.103	2.898	3.712	4.386	4.984	5.519	6.006
ρ	.01435	.02508	.03557	.04550	.05445	.06267	.07034

COMPOSITION BY WEIGHT FRACTION:

DENSITY VARIATIONS AND REFERENCE:

C .002 Al .0525 Cd .00001 Hf .00009
 Cr .24 B .00001 Li .00009 Fe .7053

ANPD 7.2 gm/cm³

REFERENCE:

ANPD

MATERIAL: Nickel-chromium alloy (Nb Modified)

ASSUMED DENSITY: 8.440 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.8624	.8624	.8625	.8626	.8626	.8627	.8628
D_2	.2169	.2260	.2316	.2353	.2381	.2403	.2421
Σ_{a_1}	.001841	.001820	.001799	.001780	.001762	.001746	.001731
Σ_{a_2}	.3296	.2444	.1982	.1711	.1527	.1392	.1287
Σ_{s_1}	.00002767	.00004896	.00006993	.00008974	.0001075	.0001238	.0001390
d	1.838	1.838	1.838	1.838	1.838	1.838	1.838
d_1	1.838	1.838	1.838	1.839	1.839	1.839	1.839
d_2	.4624	.4816	.4937	.5016	.5075	.5121	.5159
L_1^2	461.4	461.4	461.4	461.3	461.3	461.3	461.3
L_2^2	.6580	.9245	1.169	1.376	1.559	1.726	1.880
ρ	.01480	.02619	.03741	.04800	.05747	.06618	.07433

COMPOSITION BY WEIGHT FRACTION:

DENSITY VARIATIONS AND REFERENCE:

Cr .195 Si .009 Mn .005 Ni .77
 Nb .01 Fe .01 Cu .001

ANPD: F. D. Kingsbury 8.44 gm/cm³

REFERENCE:

ANPD: F. D. Kingsbury

MATERIAL: Lead

ASSUMED DENSITY: 11.35 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.146	1.147	1.147	1.148	1.149	1.149	1.150
D_2	1.165	1.036	.9874	.9647	.9516	.9430	.9370
Σ_{a_1}	.0001708	.0001565	.0001449	.0001370	.0001305	.0001251	.0001205
Σ_{a_2}	.004976	.003689	.002993	.002581	.002303	.002102	.001944
Σ_{s_1}	.00003625	.00005135	.00006367	.00007230	.00007944	.00008543	.00009058
d	2.444	2.441	2.438	2.437	2.435	2.433	2.431
d_1	2.443	2.444	2.445	2.447	2.449	2.450	2.451
d_2	2.484	2.209	2.105	2.056	2.028	2.010	1.997
L_1^2	5536.	5517.	5499.	5485.	5472.	5460.	5449.
L_2^2	234.2	280.9	329.9	373.8	413.1	448.6	482.1
ρ	.1751	.2471	.3052	.3454	.3784	.4058	.4292

COMPOSITION BY WEIGHT FRACTION:

Pb 1.00

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

HCP 11.35 gm/cm³RH 11.34 gm/cm³

MATERIAL: Lithium

ASSUMED DENSITY: .530 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	5.285	5.285	5.285	5.285	5.285	5.285	5.285
D_2	.1133	.1519	.1865	.2152	.2402	.2627	.2832
Σ_{a_1}	.003292	.003292	.003292	.003292	.003292	.003292	.003292
Σ_{a_2}	2.897	2.148	1.742	1.503	1.342	1.223	1.131
Σ_{s_1}	1.962×10^{-8}	3.956×10^{-8}	6.047×10^{-8}	8.581×10^{-8}	1.101×10^{-7}	1.333×10^{-7}	1.559×10^{-7}
d	11.27	11.27	11.27	11.27	11.27	11.27	11.27
d_1	11.27	11.27	11.27	11.27	11.27	11.27	11.27
d_2	.2414	.3238	.3975	.4586	.5120	.5599	.6036
L_1^2	1605.	1605.	1605.	1605.	1605.	1605.	1605.
L_2^2	.03910	.07072	.1070	.1431	.1790	.2147	.2503
ρ	5.958×10^{-6}	.00001201	.00001837	.00002606	.00003343	.00004048	.00004735

COMPOSITION BY WEIGHT FRACTION:

Li 1.00

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

HCP .534 gm/cm³RH .53 gm/cm³MH .53 gm/cm³

MATERIAL: Lithium 6

ASSUMED DENSITY: .460 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	5.063	5.063	5.063	5.063	5.063	5.063	5.063
D_2	.008589	.01159	.01435	.01669	.01877	.02066	.02242
Σa_1	.01755	.01755	.01755	.01755	.01755	.01755	.01755
Σa_2	38.56	28.50	22.99	19.73	17.52	15.89	14.62
Σs_1	1.129×10^{-13}	2.285×10^{-13}	3.498×10^{-13}	4.980×10^{-13}	6.400×10^{-13}	7.760×10^{-13}	9.087×10^{-13}
d	10.79	10.79	10.79	10.79	10.79	10.79	10.79
d_1	10.79	10.79	10.79	10.79	10.79	10.79	10.79
d_2	.01831	.02471	.03058	.03557	.04000	.04404	.04779
L_1^2	288.5	288.5	288.5	288.5	288.5	288.5	288.5
L_2^2	.0002227	.0004068	.0006241	.0008458	.001071	.001301	.001533
ρ	6.433×10^{-12}	1.302×10^{-11}	1.993×10^{-11}	2.837×10^{-11}	3.646×10^{-11}	4.422×10^{-11}	5.177×10^{-11}

COMPOSITION BY WEIGHT FRACTION:

Li⁶ 1.00

DENSITY VARIATIONS AND REFERENCE:

MH .46 gm/cm³ (computed)

REFERENCE:

MATERIAL: Lithium Hydride (H Bound)

ASSUMED DENSITY: .749 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.432	1.433	1.433	1.434	1.435	1.436	1.437
D_2	.06117	.08166	.1001	.1154	.1288	.1406	.1514
Σa_1	.04456	.04294	.04148	.04031	.03930	.03841	.03762
Σa_2	3.592	2.663	2.160	1.864	1.664	1.517	1.403
Σs_1	.003045	.004694	.006184	.007393	.008432	.009349	.01017
d	3.049	3.049	3.047	3.046	3.045	3.044	3.043
d_1	3.052	3.054	3.055	3.057	3.059	3.061	3.063
d_2	.1304	.1741	.2134	.2460	.2745	.2998	.3227
L_1^2	30.07	30.07	30.07	30.07	30.07	30.07	30.06
L_2^2	.01703	.03066	.04636	.06193	.07741	.09274	.1079
ρ	.06396	.09853	.1297	.1550	.1767	.1957	.2128

COMPOSITION BY WEIGHT FRACTION:

Li .8732

H .1268

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

 ANPD: W. E. Edwards, &
 M. A. Capo .749 gm/cm³
 ANPD: E. A. Aitken
 .780 gm/cm³

MATERIAL: Lithium Hydride (H Gas)

ASSUMED DENSITY: .749 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.432	1.433	1.434	1.435	1.436	1.437	1.437
D_2	.07288	.09628	.1162	.1321	.1456	.1573	.1677
Σa_1	.04436	.04274	.04129	.04012	.03913	.03825	.03747
Σa_2	3.592	2.663	2.160	1.864	1.664	1.517	1.403
Σs_1	.003275	.004922	.006404	.007613	.008636	.009537	.01034
d	3.051	3.050	3.049	3.048	3.046	3.045	3.044
d_1	3.053	3.055	3.057	3.059	3.061	3.062	3.064
d_2	.1554	.2052	.2477	.2816	.3103	.3352	.3576
L_1^2	30.07	30.07	30.07	30.07	30.06	30.06	30.06
L_2^2	.02029	.03615	.05380	.07088	.08750	.1037	.1196
ρ	.06875	.1033	.1343	.1595	.1808	.1996	.2163

COMPOSITION BY WEIGHT FRACTION:

Li .8732
H .1268

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

ANPD: W. E. Edwards
& M. A. Capo

.749 gm/cm³
ANPD: E. A. Aitken .780 gm/cm³

MATERIAL: Lithium Oxide

ASSUMED DENSITY: 1.812 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.480	1.480	1.480	1.480	1.480	1.480	1.480
D_2	.06916	.09200	.1121	.1285	.1427	.1552	.1666
Σa_1	.006989	.006989	.006988	.006988	.006988	.006988	.006987
Σa_2	4.601	3.412	2.766	2.388	2.131	1.943	1.797
Σs_1	2.065×10^{-7}	4.143×10^{-7}	6.318×10^{-7}	8.925×10^{-7}	1.142×10^{-6}	1.380×10^{-6}	1.612×10^{-6}
d	3.154	3.154	3.154	3.154	3.154	3.154	3.154
d_1	3.154	3.154	3.154	3.154	3.154	3.154	3.154
d_2	.1474	.1961	.2389	.2739	.3041	.3308	.3550
L_1^2	211.7	211.7	211.7	211.7	211.7	211.7	211.7
L_2^2	.01503	.02697	.04051	.05382	.06694	.07989	.09269
ρ	.00002955	.00005928	.00009039	.0001277	.0001634	.0001974	.0002306

COMPOSITION BY WEIGHT FRACTION:

Li .4645
O .5355

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

ANPD: J. Y. Gerhardt

1.812 gm/cm³
HCP 2.013 gm/cm³

MATERIAL: Magnesia

ASSUMED DENSITY: 3.580 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.9493	.9511	.9524	.9533	.9540	.9546	.9550
D_2	.8781	.8891	.8950	.8984	.9007	.9022	.9032
Σa_1	.0002937	.0002305	.0001940	.0001715	.0001559	.0001445	.0001355
Σa_2	.003000	.002222	.001803	.001556	.001384	.001266	.001170
Σs_1	.001849	.001970	.002051	.002108	.002150	.002185	.002214
d	1.966	1.965	1.965	1.965	1.964	1.964	1.963
d_1	2.023	2.027	2.030	2.032	2.033	2.035	2.036
d_2	1.872	1.895	1.908	1.915	1.920	1.923	1.925
L_1^2	443.1	432.3	424.2	418.3	413.7	409.8	406.5
L_2^2	292.7	400.2	496.3	577.4	650.6	712.5	772.1
ρ	.8629	.8953	.9136	.9248	.9324	.9380	.9423

COMPOSITION BY WEIGHT FRACTION:

Mg .6032
O .3968

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

I. E. Campbell, High Temperature Technology, 1954 P. 31
3.58 gm/cm³
HCP 3.58 gm/cm³

MATERIAL: Magnesium

ASSUMED DENSITY: 1.74 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	2.384	2.383	2.383	2.385	2.385	2.385	2.386
D_2	2.488	2.408	2.376	2.362	2.354	2.350	2.347
Σa_1	.0002197	.0001761	.0001502	.0001346	.0001233	.0001148	.0001081
Σa_2	.002410	.001785	.001448	.001250	.001112	.001017	.0009397
Σs_1	.0004827	.0005424	.0005812	.0006064	.0006258	.0006412	.0006540
d	5.118	5.091	5.075	5.067	5.060	5.055	5.052
d_1	5.081	5.079	5.079	5.083	5.084	5.084	5.085
d_2	5.303	5.132	5.064	5.034	5.018	5.009	5.003
L_1^2	3394.	3316.	3258.	3218.	3184.	3155.	3131.
L_2^2	1032.	1349.	1640.	1889.	2117.	2310.	2498.
ρ	.6872	.7549	.7946	.8183	.8354	.8482	.8582

COMPOSITION BY WEIGHT FRACTION:

Mg 1.00

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

HCP 1.74 gm/cm³
RH 1.74 gm/cm³

MATERIAL: MAILORY 1000

ASSUMED DENSITY: 16.80 g/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.6804	.6804	.6804	.6804	.6804	.6804	.6804
D_2	.2564	.3013	.3342	.3578	.3761	.3912	.4039
Σa_1	.001194	.001194	.001193	.001193	.001193	.001193	.001193
Σa_2	.8977	.6693	.5438	.4697	.4194	.3825	.3539
Σs_1	1.214×10^{-7}	2.426×10^{-7}	3.693×10^{-7}	5.199×10^{-7}	6.636×10^{-7}	8.008×10^{-7}	9.341×10^{-7}
d	1.450	1.450	1.450	1.450	1.450	1.450	1.450
d_1	1.450	1.450	1.450	1.450	1.450	1.450	1.450
d_2	.5465	.6423	.7124	.7626	.8017	.8337	.8608
L_1^2	569.9	569.9	569.9	569.9	569.9	569.9	569.9
L_2^2	.2856	.4502	.6147	.7618	.8967	1.023	1.141
ρ	.0001017	.0002032	.0003093	.0004355	.0005559	.0006708	.0007824

COMPOSITION BY WEIGHT FRACTION:

W .90 Cu .04
Ni .06

DENSITY VARIATIONS AND REFERENCE:

P. R. Mallory 16.8 gm/cm³

REFERENCE:

P. R. Mallory, Vendor

MATERIAL: Mercury

ASSUMED DENSITY: 13.55 g/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.262	1.262	1.262	1.262	1.262	1.262	1.262
D_2	.02255	.02903	.03506	.04027	.04490	.04910	.05294
Σa_1	.002737	.002737	.002737	.002737	.002737	.002737	.002737
Σa_2	13.97	10.67	8.696	7.467	6.613	5.978	5.485
Σs_1	3.078×10^{-13}	6.244×10^{-13}	9.571×10^{-13}	1.365×10^{-12}	1.756×10^{-12}	2.132×10^{-12}	2.497×10^{-12}
d	2.689	2.689	2.689	2.689	2.689	2.689	2.689
d_1	2.689	2.689	2.689	2.689	2.689	2.689	2.689
d_2	.04807	.06189	.07473	.08583	.09571	.1047	.1128
L_1^2	461.0	461.0	461.0	461.0	461.0	461.0	461.0
L_2^2	.001614	.002721	.004032	.005392	.006790	.008214	.009651
ρ	1.125×10^{-10}	2.282×10^{-10}	3.497×10^{-10}	4.988×10^{-10}	6.418×10^{-10}	7.789×10^{-10}	9.126×10^{-10}

COMPOSITION BY WEIGHT FRACTION:

Hg 1.00

DENSITY VARIATIONS AND REFERENCE:

HCP 13.546 gm/cm³
RH 13.55 gm/cm³

REFERENCE:

MATERIAL: Mild Steel

ASSUMED DENSITY: 7.83 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.9544	.9545	.9546	.9548	.9549	.9550	.9552
D_2	.3084	.3112	.3227	.3281	.3318	.3340	.3356
Σa_1	.001456	.001431	.001407	.001386	.001367	.001350	.001334
Σa_2	.1876	.1391	.1128	.09737	.08691	.07923	.07328
Σs_1	.00003642	.00006153	.00008554	.0001073	.0001265	.0001440	.0001601
d	2.034	2.034	2.034	2.034	2.033	2.033	2.033
d_1	2.034	2.034	2.035	2.035	2.035	2.036	2.036
d_2	.6573	.6632	.6878	.6992	.7071	.7119	.7153
L_1^2	639.5	639.4	639.4	639.3	639.3	639.2	639.2
L_2^2	1.643	2.236	2.860	3.369	3.817	4.216	4.579
ρ	.02440	.04122	.05730	.07183	.08469	.09638	.1071

COMPOSITION BY WEIGHT FRACTION:

Fe .99
C .01

REFERENCE:

HCP

DENSITY VARIATIONS AND REFERENCE:

HCP 7.83 gm/cm³

MATERIAL: Molybdenum

ASSUMED DENSITY: 10.20 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.8639	.8639	.8639	.8639	.8639	.8639	.8639
D_2	.7018	.7304	.7478	.7595	.7684	.7755	.7818
Σa_1	.001760	.001760	.001760	.001760	.001760	.001760	.001760
Σa_2	.1420	.1053	.08538	.07369	.06578	.05996	.05546
Σs_1	3.000×10^{-9}	5.669×10^{-9}	8.398×10^{-9}	1.130×10^{-8}	1.402×10^{-8}	1.659×10^{-8}	1.904×10^{-8}
d	1.842	1.842	1.842	1.842	1.842	1.842	1.842
d_1	1.842	1.842	1.842	1.842	1.842	1.842	1.842
d_2	1.496	1.557	1.594	1.619	1.638	1.653	1.666
L_1^2	490.8	490.8	490.8	490.8	490.8	490.8	490.8
L_2^2	4.942	6.936	8.759	10.31	11.68	12.93	14.10
ρ	1.704×10^{-6}	3.221×10^{-6}	4.771×10^{-6}	6.418×10^{-6}	7.965×10^{-6}	9.422×10^{-6}	1.081×10^{-5}

COMPOSITION BY WEIGHT FRACTION:

Mo 1.00

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken
10.2 gm/cm³
HCP 10.2 gm/cm³
RH 10.2 gm/cm³

MATERIAL: Nickel

ASSUMED DENSITY: 8.902 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.7458	.7458	.7459	.7460	.7461	.7462	.7462
D_2	.1762	.1824	.1863	.1888	.1907	.1922	.1935
Σa_1	.002111	.002082	.002055	.002029	.002006	.001985	.001966
Σa_2	.3728	.2764	.2241	.1935	.1727	.1574	.1456
Σs_1	.00003810	.00006676	.00009482	.0001209	.0001440	.0001652	.0001850
d	1.590	1.589	1.589	1.589	1.589	1.589	1.589
d_1	1.590	1.590	1.590	1.590	1.590	1.590	1.591
d_2	.3755	.3888	.3970	.4024	.4065	.4098	.4125
L_1^2	347.1	347.1	347.0	347.0	347.0	347.0	347.0
L_2^2	.4726	.6598	.8310	.9760	1.104	1.221	1.329
ρ	.01773	.03107	.04411	.05623	.06698	.07685	.08602

COMPOSITION BY WEIGHT FRACTION:

Ni 1.00

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

HCP 8.60-8.90 gm/cm³
MH 8.902 gm/cm³

MATERIAL: Niobium

ASSUMED DENSITY: 8.57 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.9368	.9368	.9368	.9368	.9368	.9368	.9368
D_2	.9402	.9443	.9450	.9451	.9451	.9450	.9448
Σa_1	.0006878	.0006799	.0006721	.0006649	.0006584	.0006523	.0006467
Σa_2	.05422	.04020	.03260	.02813	.02511	.02289	.02117
Σs_1	.00001057	.00001862	.00002655	.00003399	.00004075	.00004698	.00005280
d	1.997	1.997	1.997	1.997	1.997	1.997	1.997
d_1	1.997	1.997	1.997	1.997	1.997	1.997	1.997
d_2	2.004	2.013	2.014	2.015	2.014	2.014	2.014
L_1^2	1341.	1341.	1341.	1340.	1340.	1340.	1339.
L_2^2	17.34	23.49	28.99	33.00	37.08	41.28	44.62
ρ	.01514	.02665	.03800	.04863	.05829	.06718	.07548

COMPOSITION BY WEIGHT FRACTION:

Nb 1.00

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken
8.57 or 8.4 gm/cm³
HCP 8.4 gm/cm³
RH 8.57 gm/cm³

MATERIAL: Oralloy

ASSUMED DENSITY: 18.7 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.376	1.376	1.376	1.376	1.376	1.376	1.376
D_2	.01224	.01702	.02117	.02457	.02766	.03059	.03342
Σ_{a_1}	.07221	.07221	.07221	.07221	.07221	.07221	.07221
Σ_{a_2}	26.82	19.18	15.34	13.16	11.65	10.49	9.569
Σ_{s_1}	1.837×10^{-17}	3.728×10^{-17}	5.716×10^{-17}	8.158×10^{-17}	1.050×10^{-16}	1.275×10^{-16}	1.494×10^{-16}
d	2.933	2.933	2.933	2.933	2.933	2.933	2.933
d_1	2.933	2.933	2.933	2.933	2.933	2.933	2.933
d_2	.02610	.03627	.04512	.05237	.05895	.06521	.07123
L_1^2	19.06	19.06	19.06	19.06	19.06	19.06	19.06
L_2^2	.0004565	.0008872	.001380	.001867	.002375	.002917	.003492
ρ	2.543×10^{-16}	5.163×10^{-16}	7.916×10^{-16}	1.130×10^{-15}	1.454×10^{-15}	1.765×10^{-15}	2.069×10^{-15}

COMPOSITION BY WEIGHT FRACTION:

DENSITY VARIATIONS AND REFERENCE:

U²³⁸ .068
U²³⁵ .932

ANPD: J. D. Simpson
18.7 gm/cm³
for ingot

REFERENCE:

MATERIAL: Oralloy

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
$\nu \Sigma_{f_1}$	.1452	.1452	.1452	.1452	.1452	.1452	.1452
$\nu \Sigma_{f_2}$	55.24	39.45	31.38	26.80	23.66	21.30	19.43
k_1	2.011	2.011	2.011	2.011	2.011	2.011	2.011
k_2	2.060	2.056	2.046	2.037	2.032	2.030	2.030

MATERIAL: Orallox Dioxide

ASSUMED DENSITY: 10.97 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.354	1.354	1.354	1.354	1.354	1.354	1.354
D_2	.02340	.03238	.04012	.04642	.05210	.05747	.06260
Σa_1	.03908	.03908	.03908	.03908	.03908	.03908	.03908
Σa_2	13.84	9.897	7.915	6.790	6.009	5.412	4.937
Σs_1	5.709×10^{-12}	1.155×10^{-11}	1.769×10^{-11}	2.520×10^{-11}	3.239×10^{-11}	3.929×10^{-11}	4.601×10^{-11}
d	2.886	2.886	2.886	2.886	2.886	2.886	2.886
d_1	2.886	2.886	2.886	2.886	2.886	2.886	2.886
d_2	.04988	.06902	.08552	.09894	.1110	.1225	.1334
L_1^2	34.64	34.64	34.64	34.64	34.64	34.64	34.64
L_2^2	.001691	.003272	.005069	.006836	.008670	.01062	.01268
ρ	1.461×10^{-10}	2.956×10^{-10}	4.527×10^{-10}	6.447×10^{-10}	8.288×10^{-10}	1.005×10^{-9}	1.177×10^{-9}

COMPOSITION BY WEIGHT FRACTION:

U²³⁵ .819 O .120
U²³⁸ .061

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken
10.97 gm/cm³

MATERIAL: Orallox Dioxide

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
$\nu \Sigma f_1$	.07848	.07848	.07848	.07848	.07848	.07848	.07848
$\nu \Sigma f_2$	28.50	20.35	16.19	13.83	12.21	10.99	10.02
k_1	2.008	2.008	2.008	2.008	2.008	2.008	2.008
k_2	2.060	2.056	2.046	2.037	2.032	2.030	2.030

MATERIAL: PLEXIGLAS

ASSUMED DENSITY: 1.18 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.214	1.232	1.244	1.253	1.260	1.266	1.270
D_2	.1624	.2080	.2472	.2781	.3037	.3254	.3441
Σ_{a_1}	.001041	.0007927	.0006586	.0005777	.0005224	.0004817	.0004500
Σ_{a_2}	.01693	.01255	.01018	.008784	.007841	.007147	.006610
Σ_{s_1}	.03798	.03892	.03955	.04000	.04035	.04063	.04087
d	1.037	.9754	.9618	.9669	.9790	.9933	1.008
d_1	2.587	2.625	2.652	2.671	2.686	2.698	2.708
d_2	.3462	.4433	.5268	.5927	.6473	.6935	.7334
L_1^2	31.10	31.02	30.95	30.88	30.83	30.79	30.74
L_2^2	9.596	16.58	24.29	31.66	38.73	45.52	52.06
ρ	.9733	.9800	.9836	.9858	.9872	.9883	.9891

COMPOSITION BY WEIGHT FRACTION:

C .587 O .3315
H .0815

DENSITY VARIATIONS AND REFERENCE:

HCP 1.18 gm/cm³

REFERENCE:

ORNL-1615, p.94

MATERIAL: Plutonium 239

ASSUMED DENSITY: 19.00 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.9136	.9136	.9136	.9136	.9136	.9136	.9136
D_2	.006890	.006921	.005697	.005026	.004827	.004890	.005108
Σ_{a_1}	.1269	.1269	.1269	.1269	.1269	.1269	.1269
Σ_{a_2}	47.90	47.69	58.05	65.87	68.63	67.75	64.84
Σ_{s_1}	2.047×10^{-17}	4.156×10^{-17}	6.373×10^{-17}	9.097×10^{-17}	1.171×10^{-16}	1.422×10^{-16}	1.666×10^{-16}
d	1.947	1.947	1.947	1.947	1.947	1.947	1.947
d_1	1.947	1.947	1.947	1.947	1.947	1.947	1.947
d_2	.01469	.01475	.01214	.01071	.01029	.01042	.01089
L_1^2	7.198	7.198	7.198	7.198	7.198	7.198	7.198
L_2^2	.0001438	.0001451	.00009815	.00007630	.00007033	.00007218	.00007878
ρ	1.613×10^{-16}	3.275×10^{-16}	5.022×10^{-16}	7.168×10^{-16}	9.228×10^{-16}	1.120×10^{-15}	1.313×10^{-15}

COMPOSITION BY WEIGHT FRACTION:

Pu²³⁹ 1.00

DENSITY VARIATIONS AND REFERENCE:

W. B. H. Lord, Nature 173,
534-5, (1954) 19.0 gm/cm³

REFERENCE:

MATERIAL: Plutonium 239

TEMPERATURE: 68°F 500°F 1000°F 1500°F 2000°F 2500°F 3000°F

$\nu \Sigma_{f_1}$	.2565	.2565	.2565	.2565	.2565	.2565	.2565
$\nu \Sigma_{f_2}$	99.30	92.51	105.7	116.1	118.9	116.2	110.5
k_1	2.021	2.021	2.021	2.021	2.021	2.021	2.021
k_2	2.073	1.940	1.821	1.762	1.732	1.715	1.704

MATERIAL: Potassium

ASSUMED DENSITY: .870 gm/cm³

TEMPERATURE: 68°F 500°F 1000°F 1500°F 2000°F 2500°F 3000°F

D_1	14.31	14.31	14.31	14.31	14.31	14.31	14.31
D_2	6.265	7.172	7.796	8.224	8.546	8.801	9.009
Σ_{a_1}	.0001302	.0001299	.0001296	.0001293	.0001290	.0001287	.0001285
Σ_{a_2}	.02342	.01736	.01408	.01215	.01084	.009886	.009144
Σ_{s_1}	3.306×10^{-7}	6.186×10^{-7}	9.116×10^{-7}	1.222×10^{-6}	1.512×10^{-6}	1.785×10^{-6}	2.045×10^{-6}
d	30.51	30.51	30.51	30.51	30.51	30.51	30.51
d_1	30.51	30.51	30.51	30.51	30.51	30.51	30.51
d_2	13.35	15.29	16.62	17.53	18.22	18.76	19.20
L_1^2	109700.	109700.	109700.	109700.	109700.	109700.	109700.
L_2^2	267.6	413.1	553.8	676.9	788.1	890.2	985.3
ρ	.002533	.004740	.006985	.009363	.01158	.01367	.01567

COMPOSITION BY WEIGHT FRACTION:

K 1.00

DENSITY VARIATIONS AND REFERENCE:

HCP .87 gm/cm³

REFERENCE:

MATERIAL: REFRASIL

ASSUMED DENSITY: .224 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	16.93	16.94	16.95	16.95	16.96	16.96	16.97
D_2	12.08	13.10	13.69	14.05	14.30	14.47	14.61
Σa_1	.0001455	.0001376	.0001308	.0001256	.0001213	.0001176	.0001143
Σa_2	.005028	.003728	.003023	.002609	.002329	.002123	.001964
Σs_1	.00001771	.00002593	.00003311	.00003868	.00004331	.00004733	.00005088
d	36.05	36.05	36.05	36.04	36.04	36.04	36.04
d_1	36.09	36.11	36.12	36.14	36.15	36.16	36.17
d_2	25.74	27.92	29.19	29.95	30.47	30.85	31.14
L_1^2	103700.	103600.	103400.	103200.	103000.	102900.	102700.
L_2^2	2402.	3513.	4530.	5386.	6138.	6817.	7439.
ρ	.1085	.1586	.2020	.2354	.2632	.2870	.3080

COMPOSITION BY WEIGHT FRACTION:

Si .46682 B .00057
O .53261

DENSITY VARIATIONS AND REFERENCE:

ANPD: W. Baxter .224 gm/cm³

REFERENCE:

ANPD: W. Baxter

MATERIAL: Samarium

ASSUMED DENSITY: 7.54 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.108	1.108	1.108	1.108	1.108	1.108	1.108
D_2	.001397	.001393	.001720	.002203	.002793	.003470	.004223
Σa_1	.03782	.03782	.03782	.03782	.03782	.03782	.03782
Σa_2	236.9	237.3	192.0	149.8	118.0	94.91	77.91
Σs_1	7.792×10^{-19}	1.582×10^{-18}	2.426×10^{-18}	3.462×10^{-18}	4.456×10^{-18}	5.409×10^{-18}	6.339×10^{-18}
d	2.362	2.362	2.362	2.362	2.362	2.362	2.362
d_1	2.362	2.362	2.362	2.362	2.362	2.362	2.362
d_2	.002979	.002969	.003666	.004696	.005953	.007397	.009002
L_1^2	29.30	29.30	29.30	29.30	29.30	29.30	29.30
L_2^2	5.899×10^{-6}	5.871×10^{-6}	8.959×10^{-6}	.00001471	.00002366	.00003656	.00005421
ρ	2.060×10^{-17}	4.182×10^{-17}	6.413×10^{-17}	9.153×10^{-17}	1.178×10^{-16}	1.430×10^{-16}	1.676×10^{-16}

COMPOSITION BY WEIGHT FRACTION:

Sm 1.00

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken

7.54 gm/cm³

REFERENCE:

MATERIAL: Samarium Oxide

ASSUMED DENSITY: 7.43 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.9776	.9776	.9776	.9776	.9776	.9776	.9776
D_2	.001643	.001638	.002022	.002589	.003282	.004077	.004959
Σa_1	.03535	.03535	.03535	.03535	.03535	.03535	.03535
Σa_2	201.3	201.7	163.2	127.3	100.3	80.66	66.21
Σs_1	3.570×10^{-14}	7.246×10^{-14}	1.111×10^{-13}	1.585×10^{-13}	2.039×10^{-13}	2.475×10^{-13}	2.900×10^{-13}
d	2.084	2.084	2.084	2.084	2.084	2.084	2.084
d_1	2.084	2.084	2.084	2.084	2.084	2.084	2.084
d_2	.003502	.003492	.004310	.005519	.006995	.008689	.01057
L_1^2	27.65	27.65	27.65	27.65	27.65	27.65	27.65
L_2^2	8.162×10^{-6}	8.123×10^{-6}	1.239×10^{-5}	2.034×10^{-5}	3.271×10^{-5}	5.054×10^{-5}	7.491×10^{-5}
ρ	1.010×10^{-12}	2.050×10^{-12}	3.143×10^{-12}	4.483×10^{-12}	5.769×10^{-12}	7.001×10^{-12}	8.203×10^{-12}

COMPOSITION BY WEIGHT FRACTION:

Sm .8624
O .1376

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken
7.43 gm/cm³

MATERIAL: Scandium

ASSUMED DENSITY: 3.200 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	2.583	2.583	2.583	2.583	2.583	2.583	2.583
D_2	.1656	.1906	.2076	.2191	.2277	.2345	.2401
Σa_1	.001039	.001038	.001038	.001038	.001037	.001037	.001036
Σa_2	.9125	.6778	.5501	.4746	.4230	.3848	.3550
Σs_1	4.310×10^{-7}	8.175×10^{-7}	1.213×10^{-6}	1.642×10^{-6}	2.044×10^{-6}	2.423×10^{-6}	2.787×10^{-6}
d	5.505	5.505	5.505	5.505	5.505	5.505	5.505
d_1	5.505	5.505	5.505	5.505	5.505	5.505	5.505
d_2	.3530	.4063	.4425	.4670	.4853	.4998	.5117
L_1^2	2485.	2485.	2485.	2485.	2485.	2485.	2485.
L_2^2	.1815	.2812	.3774	.4617	.5382	.6093	.6762
ρ	.0004147	.0007867	.001167	.001580	.001967	.002332	.002682

COMPOSITION BY WEIGHT FRACTION:

Sc 1.00

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

ANPD: C. R. Simmons
3.2 ± .1 gm/cm³
(experimental)

MATERIAL: Silicon (Amorphous)

ASSUMED DENSITY: 2.33 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	3.181	3.183	3.184	3.186	3.186	3.187	3.187
D_2	3.053	3.095	3.119	3.133	3.142	3.149	3.155
Σa_1	.0003301	.0002900	.0002604	.0002414	.0002264	.0002144	.0002045
Σa_2	.005761	.004272	.003464	.002990	.002669	.002433	.002250
Σs_1	.0001643	.0002090	.0002427	.0002651	.0002832	.0002979	.0003103
d	6.773	6.775	6.777	6.781	6.783	6.784	6.785
d_1	6.781	6.784	6.786	6.790	6.792	6.793	6.794
d_2	6.508	6.598	6.648	6.678	6.698	6.713	6.724
L_1^2	6435.	6379.	6328.	6289.	6253.	6221.	6192.
L_2^2	529.9	724.6	900.3	1048.	1178.	1295.	1402.
ρ	.3323	.4188	.4824	.5235	.5557	.5815	.6028

COMPOSITION BY WEIGHT FRACTION:

Si 1.0

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

HCP 2.42 gm/cm³RH 2.33 gm/cm³

MATERIAL: Silicon Carbide

ASSUMED DENSITY: 3.21 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.110	1.112	1.113	1.114	1.115	1.116	1.117
D_2	1.047	1.043	1.042	1.041	1.040	1.040	1.040
Σa_1	.0004920	.0003879	.0003275	.0002908	.0002650	.0002457	.0002307
Σa_2	.005695	.004223	.003425	.002955	.002638	.002405	.002225
Σs_1	.001778	.001934	.002035	.002102	.002153	.002193	.002226
d	2.334	2.324	2.316	2.310	2.305	2.302	2.299
d_1	2.366	2.370	2.373	2.375	2.377	2.379	2.380
d_2	2.231	2.223	2.220	2.218	2.218	2.217	2.217
L_1^2	489.1	478.8	471.1	465.7	461.3	457.6	454.5
L_2^2	183.8	247.0	304.1	352.2	394.5	432.6	467.7
ρ	.7832	.8329	.8614	.8785	.8904	.8992	.9061

COMPOSITION BY WEIGHT FRACTION:

Si .7005

C .2995

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken

3.21 gm/cm³HCP 3.217 gm/cm³

MATERIAL: Silicon Dioxide

ASSUMED DENSITY: 2.65 gm/cm³

TEMPERATURE:	60°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.417	1.421	1.423	1.425	1.426	1.427	1.427
D_2	1.235	1.287	1.313	1.327	1.336	1.342	1.346
Σ_{a_1}	.0002793	.0002223	.0001882	.0001667	.0001520	.0001410	.0001323
Σ_{a_2}	.003071	.002277	.001847	.001594	.001422	.001296	.001199
Σ_{s_1}	.001241	.001334	.001397	.001441	.001473	.001500	.001521
d	2.909	2.923	2.932	2.938	2.941	2.944	2.945
d_1	3.021	3.029	3.034	3.036	3.039	3.041	3.042
d_2	2.632	2.743	2.799	2.829	2.848	2.860	2.868
L_1^2	932.2	912.9	897.6	886.1	877.1	869.5	863.1
L_2^2	402.1	565.1	711.1	832.9	939.3	1035.	1122.
ρ	.8163	.8572	.8813	.8963	.9065	.9141	.9200

COMPOSITION BY WEIGHT FRACTION:

Si .4756
O .5244

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken
2.65 gm/cm³

MATERIAL: Sodium

ASSUMED DENSITY: .971 gm/cm³

TEMPERATURE:	60°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	4.397	4.400	4.402	4.405	4.407	4.409	4.410
D_2	3.517	3.662	3.754	3.816	3.860	3.892	3.919
Σ_{a_1}	.0004658	.0004334	.0004065	.0003871	.0003713	.0003580	.0003465
Σ_{a_2}	.01140	.008450	.006852	.005913	.005277	.004812	.004450
Σ_{s_1}	.00008438	.0001189	.0001479	.0001693	.0001869	.0002019	.0002150
d	9.358	9.356	9.355	9.354	9.353	9.353	9.352
d_1	9.372	9.378	9.384	9.389	9.393	9.397	9.400
d_2	7.498	7.805	8.002	8.133	8.228	8.297	8.354
L_1^2	7992.	7966.	7941.	7916.	7894.	7874.	7854.
L_2^2	308.6	433.3	547.9	645.3	731.5	809.0	880.7
ρ	.1534	.2153	.2668	.3043	.3348	.3606	.3829

COMPOSITION BY WEIGHT FRACTION:

Na 1.00

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

HCP .9712 gm/cm³
RH .97 gm/cm³

MATERIAL: 302 Stainless Steel

ASSUMED DENSITY: 7.93 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.035	1.035	1.035	1.035	1.035	1.035	1.035
D_2	.3167	.3237	.3360	.3424	.3468	.3497	.3519
Σa_1	.001307	.001292	.001276	.001262	.001249	.001237	.001226
Σa_2	.2103	.1559	.1264	.1091	.09741	.08880	.08213
Σs_1	.00002145	.00003733	.00005281	.00006736	.00008040	.00009237	.0001035
d	2.205	2.205	2.205	2.205	2.205	2.205	2.205
d_1	2.206	2.206	2.206	2.206	2.206	2.207	2.207
d_2	.6750	.6899	.7163	.7298	.7392	.7454	.7500
L_1^2	778.8	778.7	778.7	778.7	778.6	778.6	778.6
L_2^2	1.506	2.076	2.658	3.137	3.560	3.938	4.284
ρ	.01615	.02810	.03974	.05067	.06048	.06947	.07784

COMPOSITION BY WEIGHT FRACTION:

Fe .75 Ni .076
Cr .174

REFERENCE:

ANPD: E. A. Aitken

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken

7.87 gm/cm³
MH 7.93 gm/cm³

MATERIAL: 304 Stainless Steel

ASSUMED DENSITY: 7.94 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.030	1.030	1.030	1.031	1.031	1.031	1.031
D_2	.3149	.3224	.3346	.3409	.3454	.3483	.3505
Σa_1	.001334	.001318	.001303	.001288	.001275	.001263	.001252
Σa_2	.2138	.1585	.1285	.1109	.09903	.09027	.08350
Σs_1	.00002169	.00003778	.00005348	.00006824	.00008148	.00009363	.0001050
d	2.196	2.196	2.196	2.196	2.196	2.196	2.196
d_1	2.196	2.196	2.196	2.197	2.197	2.197	2.197
d_2	.6713	.6872	.7132	.7267	.7362	.7425	.7472
L_1^2	760.0	759.9	759.9	759.9	759.8	759.8	759.7
L_2^2	1.473	2.034	2.603	3.073	3.488	3.859	4.198
ρ	.01600	.02786	.03944	.05031	.06006	.06902	.07735

COMPOSITION BY WEIGHT FRACTION:

C .0008 Ni .095
Cr .19 Fe .7142

REFERENCE:

ANPD: E. A. Aitken

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken

7.94 gm/cm³

MATERIAL: 310 Stainless Steel

ASSUMED DENSITY: 7.98 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.033	1.033	1.033	1.033	1.033	1.033	1.033
D_2	.3050	.3143	.3257	.3319	.3364	.3395	.3418
Σa_1	.001370	.001355	.001340	.001326	.001314	.001302	.001292
Σa_2	.2312	.1715	.1390	.1200	.1071	.09764	.09031
Σs_1	.00002011	.00003532	.00005023	.00006438	.00007709	.00008878	.00009970
d	2.201	2.201	2.201	2.201	2.201	2.201	2.201
d_1	2.201	2.201	2.202	2.202	2.202	2.202	2.202
d_2	.6501	.6699	.6943	.7075	.7170	.7236	.7286
L_1^2	742.8	742.8	742.8	742.8	742.7	742.7	742.7
L_2^2	1.319	1.833	2.343	2.766	3.141	3.477	3.785
ρ	.01446	.02540	.03613	.04629	.05542	.06382	.07167

COMPOSITION BY WEIGHT FRACTION:

Fe .559 Ni .191

Cr .25

REFERENCE:

ANPD: E. A. Aitken

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken

7.98 gm/cm³MH 7.98 gm/cm³RH 7.92 gm/cm³

MATERIAL: 316 Stainless Steel

ASSUMED DENSITY: 7.98 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.013	1.013	1.013	1.013	1.013	1.013	1.013
D_2	.3065	.3136	.3253	.3313	.3355	.3383	.3404
Σa_1	.001347	.001331	.001315	.001300	.001287	.001275	.001263
Σa_2	.2177	.1614	.1309	.1129	.1008	.09190	.08501
Σs_1	.00002215	.00003858	.00005460	.00006965	.00008314	.00009552	.0001070
d	2.158	2.158	2.158	2.158	2.158	2.158	2.158
d_1	2.158	2.158	2.159	2.159	2.159	2.159	2.159
d_2	.6533	.6685	.6933	.7061	.7151	.7211	.7256
L_1^2	739.4	739.4	739.4	739.3	739.3	739.3	739.2
L_2^2	1.408	1.943	2.485	2.930	3.328	3.681	4.005
ρ	.01618	.02817	.03987	.05085	.06068	.06971	.07811

COMPOSITION BY WEIGHT FRACTION:

Fe .71 Ni .12

Cr .17

REFERENCE:

ANPD: E. A. Aitken

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken

8.03 gm/cm³MH 7.98 gm/cm³

MATERIAL: 410 Stainless Steel

ASSUMED DENSITY: 7.75 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.056	1.056	1.056	1.056	1.056	1.056	1.056
D_2	.3207	.3283	.3404	.3467	.3512	.3541	.3563
Σa_1	.001380	.001371	.001363	.001355	.001348	.001341	.001335
Σa_2	.2092	.1551	.1258	.1086	.09690	.08833	.08170
Σs_1	.00001201	.00002092	.00002961	.00003778	.00004510	.00005182	.00005807
d	2.251	2.251	2.250	2.250	2.250	2.250	2.250
d_1	2.251	2.251	2.251	2.251	2.251	2.251	2.251
d_2	.6836	.6999	.7256	.7390	.7485	.7548	.7596
L_1^2	758.4	758.4	758.3	758.3	758.3	758.3	758.3
L_2^2	1.533	2.117	2.707	3.194	3.624	4.009	4.361
ρ	.008626	.01502	.02127	.02713	.03238	.03720	.04169

COMPOSITION BY WEIGHT FRACTION:

Cr .17 Mo .025 Fe .684
Ni .12 C .001

REFERENCE:

ANPD: E. A. Aitken

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken

7.70 gm/cm³MH 7.75 gm/cm³RH 7.75 gm/cm³

MATERIAL: 430 Stainless Steel

ASSUMED DENSITY: 7.70 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.081	1.081	1.081	1.081	1.081	1.082	1.082
D_2	.3384	.3446	.3584	.3653	.3700	.3730	.3752
Σa_1	.001242	.001227	.001212	.001198	.001185	.001174	.001163
Σa_2	.1930	.1431	.1161	.1002	.08941	.08151	.07539
Σs_1	.00002144	.00003712	.00005236	.00006662	.00007940	.00009112	.0001020
d	2.304	2.304	2.304	2.304	2.304	2.304	2.304
d_1	2.304	2.304	2.305	2.305	2.305	2.305	2.306
d_2	.7213	.7346	.7640	.7785	.7887	.7952	.7998
L_1^2	855.4	855.4	855.4	855.3	855.3	855.2	855.2
L_2^2	1.753	2.408	3.088	3.646	4.138	4.577	4.977
ρ	.01696	.02937	.04142	.05269	.06279	.07205	.08065

COMPOSITION BY WEIGHT FRACTION:

C .0012 Fe .8388
Cr .16

REFERENCE:

ANPD: E. A. Aitken

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken

7.75 gm/cm³MH 7.70 gm/cm³RH 7.70 gm/cm³

MATERIAL: 446 Stainless Steel

ASSUMED DENSITY: 7.60 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.132	1.133	1.133	1.133	1.133	1.133	1.133
D_2	.3643	.3746	.3905	.3989	.4047	.4086	.4115
Σa_1	.001262	.001248	.001235	.001223	.001212	.001201	.001192
Σa_2	.1994	.1478	.1199	.1035	.09234	.08418	.07786
Σs_1	.00001790	.00003141	.00004464	.00005724	.00006861	.00007908	.00008886
d	2.414	2.414	2.414	2.414	2.413	2.413	2.413
d_1	2.414	2.414	2.414	2.414	2.415	2.415	2.415
d_2	.7765	.7984	.8324	.8502	.8627	.8710	.8772
L_1^2	885.0	885.0	884.9	884.9	884.9	884.8	884.8
L_2^2	1.827	2.534	3.258	3.855	4.383	4.854	5.285
ρ	.01399	.02454	.03488	.04472	.05359	.06177	.06939

COMPOSITION BY WEIGHT FRACTION:

C .002 Fe .6975 Nb .005 N .0025
 Cr .27 Mn .008 Ni .005 Si .010

REFERENCE:

ANPD: F. D. Kingsbury

DENSITY VARIATIONS AND REFERENCE:

ANPD: F. D. Kingsbury
 7.60 gm/cm³

MATERIAL: THERMOFLEX

ASSUMED DENSITY: .224 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	17.38	17.41	17.42	17.43	17.44	17.44	17.45
D_2	15.01	15.77	16.18	16.40	16.55	16.64	16.71
Σa_1	.00006664	.00005663	.00004979	.00004528	.00004202	.00003948	.00003741
Σa_2	.0009646	.0007152	.0005798	.0005005	.0004467	.0004072	.0003768
Σs_1	.00006480	.00007659	.00008495	.00009078	.00009510	.00009858	.0001015
d	36.74	36.77	36.80	36.82	36.84	36.85	36.86
d_1	37.06	37.11	37.14	37.15	37.17	37.18	37.19
d_2	31.99	33.61	34.48	34.96	35.27	35.48	35.63
L_1^2	132300.	130700.	129300.	128100.	127200.	126400.	125600.
L_2^2	15560.	22050.	37000.	32770.	37040.	40880.	44360.
ρ	.4930	.5749	.6306	.6672	.6936	.7141	.7306

COMPOSITION BY WEIGHT FRACTION:

Si .2337 Ti .0402 K .0033 O .4942
 Al .2223 Fe .0042 Ca .0021

REFERENCE:

ANPD: T. McClay

DENSITY VARIATIONS AND REFERENCE:

Arbitrary .224 gm/cm³

MATERIAL: Thorium

ASSUMED DENSITY: 11.85 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.532	1.532	1.532	1.532	1.532	1.532	1.532
D_2	.5843	.6390	.6724	.6892	.7090	.7211	.7310
Σa_1	.002754	.002754	.002754	.002754	.002754	.002754	.002754
Σa_2	.1902	.1412	.1147	.1021	.08845	.08061	.07451
Σs_1	1.032×10^{-13}	2.043×10^{-13}	3.096×10^{-13}	4.336×10^{-13}	5.520×10^{-13}	6.647×10^{-13}	7.740×10^{-13}
d	3.266	3.266	3.266	3.266	3.266	3.266	3.266
d_1	3.266	3.266	3.266	3.266	3.266	3.266	3.266
d_2	1.245	1.362	1.433	1.469	1.511	1.537	1.558
L_1^2	556.2	556.2	556.2	556.2	556.2	556.2	556.2
L_2^2	3.073	4.524	5.863	6.748	8.017	8.946	9.811
ρ	3.746×10^{-11}	7.417×10^{-11}	1.124×10^{-10}	1.574×10^{-10}	2.004×10^{-10}	2.413×10^{-10}	2.810×10^{-10}

COMPOSITION BY WEIGHT FRACTION:

Th 1.00

DENSITY VARIATIONS AND REFERENCE:

HCP

11.85 gm/cm³

REFERENCE:

MATERIAL: Titanium

ASSUMED DENSITY: 4.507 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.063	1.063	1.063	1.063	1.063	1.063	1.063
D_2	.5963	.7175	.8017	.8588	.9012	.9345	.9615
Σa_1	.001720	.001718	.001716	.001714	.001712	.001711	.001709
Σa_2	.2816	.2088	.1693	.1461	.1304	.1189	.1100
Σs_1	1.842×10^{-6}	3.558×10^{-6}	5.328×10^{-6}	7.312×10^{-6}	9.182×10^{-6}	.00001095	.00001266
d	2.266	2.266	2.266	2.266	2.266	2.266	2.266
d_1	2.266	2.266	2.266	2.266	2.266	2.266	2.266
d_2	1.271	1.529	1.709	1.830	1.921	1.992	2.049
L_1^2	617.7	617.7	617.7	617.7	617.7	617.7	617.7
L_2^2	2.118	3.436	4.737	5.878	6.912	7.861	8.743
ρ	.001070	.002067	.003095	.004248	.005334	.006363	.007355

COMPOSITION BY WEIGHT FRACTION:

Ti 1.00

DENSITY VARIATIONS AND REFERENCE:

RMH

4.507 gm/cm³

REFERENCE:

MATERIAL: Tuballoy

ASSUMED DENSITY: 18.9 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.6781	.6781	.6781	.6781	.6781	.6781	.6781
D_2	.4750	.5312	.5658	.5875	.6034	.6160	.6262
Σa_1	.01419	.01419	.01419	.01419	.01419	.01419	.01419
Σa_2	.3240	.2348	.1887	.1622	.1440	.1303	.1195
Σs_1	1.680×10^{-12}	3.355×10^{-12}	5.105×10^{-12}	7.185×10^{-12}	9.174×10^{-12}	1.107×10^{-11}	1.292×10^{-11}
d	1.445	1.445	1.445	1.445	1.445	1.445	1.445
d_1	1.445	1.445	1.445	1.445	1.445	1.445	1.445
d_2	1.012	1.132	1.206	1.252	1.286	1.313	1.335
L_1^2	47.80	47.80	47.80	47.80	47.80	47.80	47.80
L_2^2	1.466	2.263	2.998	3.621	4.189	4.727	5.240
p	1.184×10^{-10}	2.365×10^{-10}	3.599×10^{-10}	5.065×10^{-10}	6.467×10^{-10}	7.806×10^{-10}	9.106×10^{-10}

COMPOSITION BY WEIGHT FRACTION:

U 1.00

DENSITY VARIATIONS AND REFERENCE:

RH 18.9 gm/cm³

REFERENCE:

MATERIAL: Tuballoy

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
$\nu \Sigma f_1$	.004409	.004409	.004409	.004409	.004409	.004409	.004409
$\nu \Sigma f_2$	.4289	.3063	.2437	.2081	.1837	.1654	.1508
k_1	.3108	.3108	.3108	.3108	.3108	.3108	.3108
k_2	1.324	1.305	1.291	1.283	1.276	1.269	1.262

MATERIAL: Tungsten

ASSUMED DENSITY: 19.3 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.6534	.6534	.6534	.6534	.6534	.6534	.6534
D_2	.2558	.3117	.3551	.3876	.4137	.4357	.4546
Σa_1	.001014	.001014	.001014	.001014	.001014	.001014	.001014
Σa_2	1.065	.7947	.6457	.5577	.4981	.4542	.4204
Σs_1	2.792×10^{-8}	5.642×10^{-8}	8.634×10^{-8}	1.228×10^{-7}	1.577×10^{-7}	1.911×10^{-7}	2.237×10^{-7}
d	1.393	1.393	1.393	1.393	1.393	1.393	1.393
d_1	1.393	1.393	1.393	1.393	1.393	1.393	1.393
d_2	.5453	.6644	.7570	.8262	.8819	.9287	.9690
L_1^2	644.5	644.5	644.5	644.5	644.5	644.5	644.5
L_2^2	.2401	.3922	.5500	.6950	.8306	.9591	1.081
p	.00002754	.00005565	.00008516	.0001211	.0001555	.0001885	.0002206

COMPOSITION BY WEIGHT FRACTION:

W 1.00

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

HCP 19.3 gm/cm³
 RH 19.3 gm/cm³

MATERIAL: Tungsten Carbide

ASSUMED DENSITY: 15.63 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.5693	.5693	.5693	.5693	.5693	.5693	.5693
D_2	.2771	.3243	.3586	.3829	.4018	.4172	.4301
Σa_1	.003546	.003543	.003541	.003538	.003536	.003533	.003531
Σa_2	.8101	.6042	.4909	.4241	.3787	.3454	.3196
Σs_1	2.636×10^{-6}	5.024×10^{-6}	7.473×10^{-6}	.00001015	.00001267	.00001505	.00001733
d	1.213	1.213	1.213	1.213	1.213	1.213	1.213
d_1	1.213	1.213	1.213	1.213	1.213	1.213	1.213
d_2	.5907	.6913	.7644	.8163	.8564	.8892	.9168
L_1^2	160.4	160.4	160.4	160.4	160.4	160.4	160.4
L_2^2	.3421	.5368	.7305	.9030	1.061	1.208	1.346
p	.0007428	.001416	.002106	.002861	.003572	.004242	.004885

COMPOSITION BY WEIGHT FRACTION:

W .9387
 C .0613

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

HCP 15.63 gm/cm³

MATERIAL: Uranium 233

ASSUMED DENSITY: 18.50 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.5790	.5790	.5790	.5790	.5790	.5790	.5790
D_2	.01324	.01786	.02184	.02497	.02750	.02956	.03116
Σ_{a_1}	.09910	.09910	.09910	.09910	.09910	.09910	.09910
Σ_{a_2}	24.69	18.19	14.79	12.87	11.64	10.80	10.22
Σ_{s_1}	1.889×10^{-18}	3.835×10^{-18}	5.880×10^{-18}	8.392×10^{-18}	1.080×10^{-17}	1.311×10^{-17}	1.537×10^{-17}
d	1.234	1.234	1.234	1.234	1.234	1.234	1.234
d_1	1.234	1.234	1.234	1.234	1.234	1.234	1.234
d_2	.02823	.03807	.04655	.05321	.05862	.06300	.06642
L_1^2	5.843	5.843	5.843	5.843	5.843	5.843	5.843
L_2^2	.0005363	.0009821	.001477	.001939	.002362	.002736	.003049
ρ	1.907×10^{-17}	3.870×10^{-17}	5.934×10^{-17}	8.468×10^{-17}	1.090×10^{-16}	1.323×10^{-16}	1.551×10^{-16}

COMPOSITION BY WEIGHT FRACTION:

U²³³ 1.00

DENSITY VARIATIONS AND REFERENCE:

HCP 18.50 gm/cm³ (computed)

REFERENCE:

MATERIAL: Uranium 235

ASSUMED DENSITY: 18.66 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.473	1.473	1.473	1.473	1.473	1.473	1.473
D_2	.01145	.01592	.01981	.02300	.02590	.02865	.03131
Σ_{a_1}	.07502	.07502	.07502	.07502	.07502	.07502	.07502
Σ_{a_2}	28.71	20.53	16.42	14.09	12.47	11.23	10.24
Σ_{s_1}	5.282×10^{-18}	1.072×10^{-17}	1.644×10^{-17}	2.346×10^{-17}	3.021×10^{-17}	3.667×10^{-17}	4.297×10^{-17}
d	3.139	3.139	3.139	3.139	3.139	3.139	3.139
d_1	3.139	3.139	3.139	3.139	3.139	3.139	3.139
d_2	.02440	.03394	.04223	.04903	.05520	.06108	.06673
L_1^2	19.63	19.63	19.63	19.63	19.63	19.63	19.63
L_2^2	.0003988	.0007754	.001207	.001633	.002078	.002552	.003057
ρ	7.041×10^{-17}	1.429×10^{-16}	2.192×10^{-16}	3.128×10^{-16}	4.026×10^{-16}	4.888×10^{-16}	5.728×10^{-16}

COMPOSITION BY WEIGHT FRACTION:

U²³⁵ 1.00

DENSITY VARIATIONS AND REFERENCE:

RH 18.66 gm/cm³ (computed)

REFERENCE:

MATERIAL: Uranium 235

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
$\nu\Sigma_{f_1}$	.1522	.1522	.1522	.1522	.1522	.1522	.1522
$\nu\Sigma_{f_2}$	59.15	42.23	33.60	28.70	25.34	22.80	20.80
k_1	2.029	2.029	2.029	2.029	2.029	2.029	2.029
k_2	2.060	2.057	2.046	2.037	2.033	2.031	2.031

MATERIAL: Uranium 238

ASSUMED DENSITY: 18.9 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	.6727	.6727	.6727	.6727	.6727	.6727	.6727
D_2	.6745	.6957	.7084	.7159	.7208	.7245	.7272
Σ_{a_1}	.01364	.01364	.01364	.01364	.01364	.01364	.01364
Σ_{a_2}	.1166	.08648	.07012	.06052	.05402	.04924	.04555
Σ_{s_1}	2.590×10^{-12}	5.054×10^{-12}	7.604×10^{-12}	1.049×10^{-11}	1.322×10^{-11}	1.581×10^{-11}	1.831×10^{-11}
d	1.434	1.434	1.434	1.434	1.434	1.434	1.434
d_1	1.434	1.434	1.434	1.434	1.434	1.434	1.434
d_2	1.438	1.483	1.510	1.526	1.536	1.544	1.550
L_1^2	49.32	49.32	49.32	49.32	49.32	49.32	49.32
L_2^2	5.784	8.045	10.10	11.83	13.34	14.71	15.97
ρ	1.899×10^{-10}	3.705×10^{-10}	5.575×10^{-10}	7.689×10^{-10}	9.689×10^{-10}	1.159×10^{-9}	1.342×10^{-9}

COMPOSITION BY WEIGHT FRACTION:

U²³⁸ 1.00

DENSITY VARIATIONS AND REFERENCE:

RH 18.9 gm/cm³

REFERENCE:

MATERIAL: Uranium 238

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
$\nu\Sigma_{f_1}$	.002695	.002695	.002695	.002695	.002695	.002695	.002695
$\nu\Sigma_{f_2}$	0	0	0	0	0	0	0
k_1	.1976	.1976	.1976	.1976	.1976	.1976	.1976
k_2	0	0	0	0	0	0	0

MATERIAL: Water

ASSUMED DENSITY: .998 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.423	1.445	1.460	1.471	1.479	1.486	1.492
D_2	.1469	.1913	.2308	.2626	.2895	.3127	.3331
Σa_1	.001188	.0009054	.0007523	.0006598	.0005967	.0005503	.0005140
Σa_2	.01954	.01449	.01175	.01014	.009049	.008248	.007628
Σs_1	.04288	.04393	.04465	.04515	.04554	.04585	.04612
d	1.165	1.070	1.038	1.032	1.037	1.048	1.061
d_1	3.033	3.079	3.112	3.135	3.153	3.168	3.180
d_2	.3131	.4078	.4919	.5597	.6170	.6665	.7101
L_1^2	32.29	32.22	32.16	32.11	32.07	32.03	31.99
L_2^2	7.518	13.21	19.65	25.91	31.99	37.91	43.67
ρ	.9730	.9798	.9834	.9856	.9871	.9881	.9890

COMPOSITION BY WEIGHT FRACTION:

H .1119

O .8881

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

HCP .998 gm/cm³

MATERIAL: Heavy Water

ASSUMED DENSITY: 1.105 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.305	1.313	1.317	1.321	1.323	1.325	1.326
D_2	.9580	1.040	1.093	1.127	1.151	1.169	1.183
Σa_1	3.040×10^{-6}	2.415×10^{-6}	2.053×10^{-6}	1.834×10^{-6}	1.674×10^{-6}	1.557×10^{-6}	1.464×10^{-6}
Σa_2	.00003323	.00002459	.00001994	.00001728	.00001529	.00001396	.00001263
Σs_1	.009466	.009693	.009871	.01001	.01012	.01021	.01029
d	2.045	2.218	2.331	2.403	2.454	2.492	2.522
d_1	2.782	2.798	2.808	2.816	2.820	2.824	2.826
d_2	2.042	2.217	2.330	2.402	2.453	2.492	2.522
L_1^2	137.8	135.4	133.4	132.0	130.8	129.7	128.8
L_2^2	28830.	42300.	54840.	65220.	75290.	83760.	93700.
ρ	.9997	.9998	.9998	.9998	.9998	.9998	.9999

COMPOSITION BY WEIGHT FRACTION:

D .2007

O .7993

REFERENCE:

DENSITY VARIATIONS AND REFERENCE:

HCP 1.105 gm/cm³

MATERIAL: Yttrium

ASSUMED DENSITY: 4.472 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.755	1.755	1.756	1.756	1.756	1.756	1.756
D_2	1.524	1.585	1.620	1.641	1.655	1.666	1.675
Σa_1	.0003777	.0003739	.0003701	.0003666	.0003634	.0003604	.0003577
Σa_2	.03225	.02391	.01939	.01673	.01493	.01362	.01259
Σs_1	5.134 x 10 ⁻⁶	9.019 x 10 ⁻⁶	.00001285	.00001649	.00001979	.00002284	.00002570
d	3.742	3.742	3.742	3.742	3.742	3.742	3.742
d_1	3.742	3.742	3.742	3.742	3.742	3.742	3.742
d_2	3.249	3.378	3.452	3.497	3.528	3.552	3.570
L_1^2	4585.	4585.	4584.	4583.	4582.	4581.	4580.
L_2^2	47.27	66.27	83.53	98.04	110.8	122.4	133.0
ρ	.01341	.02355	.03354	.04304	.05166	.05960*	.06703

COMPOSITION BY WEIGHT FRACTION:

Y 1.00

DENSITY VARIATIONS AND REFERENCE:

ANPD: E. A. Aitken
4.472 gm/cm³

REFERENCE:

MATERIAL: Zirconium

ASSUMED DENSITY: 6.50 gm/cm³

TEMPERATURE:	68°F	500°F	1000°F	1500°F	2000°F	2500°F	3000°F
D_1	1.211	1.211	1.210	1.210	1.210	1.210	1.209
D_2	1.265	1.259	1.258	1.258	1.258	1.257	1.258
Σa_1	.0003251	.0002957	.0002724	.0002562	.0002433	.0002327	.0002238
Σa_2	.006852	.005083	.004121	.003555	.003173	.002893	.002675
Σs_1	.00008989	.0001217	.0001473	.0001657	.0001804	.0001926	.0002031
d	2.582	2.583	2.583	2.584	2.584	2.585	2.585
d_1	2.581	2.580	2.580	2.579	2.579	2.578	2.578
d_2	2.695	2.685	2.682	2.681	2.680	2.680	2.680
L_1^2	2917.	2900.	2883.	2868.	2855.	2844.	2833.
L_2^2	184.6	247.8	305.3	353.9	396.4	434.6	470.2
ρ	.2166	.2916	.3509	.3927	.4257	.4528	.4758

COMPOSITION BY WEIGHT FRACTION:

Zr 1.00

DENSITY VARIATIONS AND REFERENCE:

ANPD: C. R. Simmons, 1957 6.50 gm/cm³
(measured)
ANPD: E. A. Aitken, 1956 6.52 gm/cm³
HCP 6.44 gm/cm³
RH 6.4 gm/cm³

REFERENCE:

5. COMPARISON WITH EXPERIMENT

As a matter of theoretical interest the age L_1^2 calculated by Program C₂-Short has been compared to experimental age measurements for various materials for both the modified age theory and the Coveyou-Macauley slowing-down models. The comparison is given in Table 1. The equations used with Coveyou-Macauley theory are identical with those of the modified age theory, with the exception of the relation between q and ϕ in equation (2). This relationship is replaced by:

$$\phi(u) = \frac{\frac{\sum_s(u)}{\xi \sum_s(u)} q(u) + S(u)}{\sum_s(u) + \sum_a(u) + D(u) K^2(u)} .$$

On theoretical grounds one would expect that Coveyou-Macauley theory would be more accurate than modified age theory for moderators of high atomic weight and considerably less accurate for moderation by hydrogen. On the other hand modified age theory treats the hydrogen slowing down more or less exactly, but treats the slowing down that results from other moderating materials in an approximation somewhat less accurate than conventional age theory.

Most of the experimental ages are quoted to the indium resonance of 1.4 ev. In order to get a good comparison between theory and experiment the age from indium to thermal $L_2^2(1.4 \text{ ev} \rightarrow \text{Th})$ was calculated as follows from Program C₂-Short and subtracted from L_1^2 :

$$\phi_{(1.4 \text{ ev} \rightarrow \text{Th})} = \sum_{n=14}^{n=t} (\phi_n + \phi_{n+1}) \frac{U_n}{2} .$$

$$\Sigma a_{(1.4 \text{ ev} \rightarrow \text{Th})} = \frac{1}{\phi_{(1.4 \text{ ev} \rightarrow \text{Th})}} \sum_{n=14}^{n=t} \left(\Sigma a_n + \Sigma a_{n+1} \right) \frac{U_n}{2} .$$

$$\Sigma_{s\text{Th}} = \frac{q_t}{\phi_{(1.4 \text{ ev} \rightarrow \text{Th})}} .$$

$$D_{(1.4 \text{ ev} \rightarrow \text{Th})} = \frac{\sum_{n=14}^{n=t} (L_n + L_{n+1}) \frac{U_n}{2}}{\phi_{(1.4 \text{ ev} \rightarrow \text{Th})} (K^2)} .$$

$$L_1^2(1.4 \text{ ev} \rightarrow \text{Th}) = \frac{D_{(1.4 \text{ ev} \rightarrow \text{Th})}}{\Sigma a_{(1.4 \text{ ev} \rightarrow \text{Th})} + \Sigma_{s\text{Th}}} .$$

An examination of Table 1 shows that in general the modified age theory gives better correlation with experimental data than Coveyou-Macauley theory for a U²³⁵ fission source. However the reverse is true for the Po-Be and Ra-Be sources. For engineering analysis the modified age theory is recommended with the present lethargy divisions of Program C₂ and with the present fission spectrum. The spectra used for the Po-Be, Ra-Be, and U²³⁵ sources are experimental data that were normalized to a trapezoidally integrated area of unity for curves of the relative source strength as a function of lethargy $S(u)$ versus lethargy u .

TABLE 1

COMPARISON OF EXPERIMENTAL AND THEORETICAL AGES

Material Mixture by Volume	Experimental Age, cm ²	Corresponding Theoretical Age, cm ²		Theoretical Age to Thermal Energy, cm ²		Source	Reference ^a
		Modified Age Theory	Coveyou- Macauley Theory	Modified Age Theory	Coveyou- Macauley Theory		
Al/H ₂ O = 1/2	$r_{In} = 49.6$	49.53	41.23	51.76	43.46	U ²³⁵	8
Al/H ₂ O = 1	$r_{In} = 76.8$	69.10	55.53	72.85	59.29	U ²³⁵	8
Be ($\rho = 1.85$ gm/cm ³)	$r_{In} = 80.2 \pm 2.0$	85.32	68.05	99.60	82.37	Σ pile	1
Bi/H ₂ O = 1/2	$r_{In} = 66.3$	79.53	61.45	81.57	63.49	Ra-Be	7
Bi/H ₂ O = 1	$r_{In} = 79.5$	98.4	73.29	101.6	76.49	Ra-Be	7
Bi/H ₂ O = 2	$r_{In} = 86.2$	140.5	102.4	146.3	108.2	Ra-Be	7
C ($\rho = 1.6$ gm/cm ³)	$r_{In} = 311 \pm 3$	358.4	289.0	419.3	350.0	U ²³⁵	8
0.998 D ₂ O + 0.002 H ₂ O	$r_{In} = 109$	112.9	106.1	136.1	129.3	Enriched U	10
0.948 D ₂ O + 0.052 H ₂ O	$r_{In} = 93$	89.6	83.22	105.3	98.97	Enriched U	10
0.910 D ₂ O + 0.090 H ₂ O	$r_{In} = 78$	77.88	71.76	90.15	84.06	Enriched U	10
Fe/H ₂ O = 1/3	$r_{In} = 52.3$	64.39	50.02	65.67	51.31	Ra-Be	3
Fe/H ₂ O = 1/2	$r_{In} = 56.0$	66.33	50.19	67.72	51.59	Ra-Be	3
Fe/H ₂ O = 1	$r_{In} = 57.9$	75.88	55.16	77.59	56.91	Ra-Be	3
H ₂ O (distilled)	$r_{Th} = 56.6$ $r_{In} = 56.3$	{ 78.91 77.85	{ 68.61 67.55	78.91	68.61	Po-Be	4
H ₂ O	$r_{In} = 30.03$	31.23	28.15	32.29	29.21	U ²³⁵	6
H ₂ O	$M^2 = 66.3$	86.43	76.13	78.91	68.61	Po-Be	2
H ₂ O (distilled)	$r_{Th} = 59.29$	71.02	62.05	71.02	62.05	Ra-Be	5
H ₂ O (distilled)	$r_{Th} = 58.9$	71.02	62.05	71.02	62.05	Ra-Be	4
Pb/H ₂ O = 1	$r_{In} = 72.8$	87.22	63.99	90.09	66.86	Ra-Be	7
SiO ₂ ($\rho = 1.61$ gm/cm ³)	$r_{In} = 1900 \pm 90$	2623	2162	3082	2637	Ra-Be	9
0.194 Zr + 0.01 Hf + 0.796 H ₂ O	$r_{In} = 35.7$	34.30	29.00	35.36	30.11	U ²³⁵	6
Zr/H ₂ O = 1/4	$M^2 = 77.5$	91.62	75.57	81.13	65.08	Po-Be	2
Zr/H ₂ O = 1/2	$M^2 = 87.5$	101.67	81.37	88.38	67.78	Po-Be	2
Zr/H ₂ O = 1	$M^2 = 107.9$	126.7	97.99	106.8	78.09	Po-Be	2

^aA list of references is given in section 6.

6. REFERENCES

1. "Argonne National Laboratory Report for July, August, September, 1947," ANL-4076, Lemont, Illinois.
2. Baer, W., "Spatial Distribution of Thermal Neutrons from a Polonium-Beryllium Source in Water-Zirconium Mixtures," Westinghouse Electric Corporation Atomic Power Division, WAPD-99, December 1953.
3. Fieno, D., "Slowing-Down Distribution to Indium Resonance of Neutrons from a Ra- α -Be Source in Water-Iron Mixtures," National Advisory Committee for Aeronautics, NACA-RM E54HO4, November 1, 1954, p. 9.
4. Graham, R. H., Donaldson, J. R., Fitch, S. H., Flora, J. W., and Nather, R. E., "Migration Area of Polonium-Beryllium Neutrons in Water," California Research and Development Company Livermore Laboratory, MTA-45, May 13, 1953.
5. Flowers, B. H., Graham, G. A. R., Pontecorvo, B., and Seligman, H., "Migration Length of Neutrons in Water Plus Uranium Metal Systems," National Research Council of Canada Montreal Laboratory, MP-154, July 20, 1945.
6. Hoover, J. I. and Arnette, T. I., "The Resonance Integral of Zirconium ($\sim 1\%$ Hafnium) and the Slowing Down Length in a Mixture (4:1 Volume) of Light Water and Zirconium Metal," Oak Ridge National Laboratory, ORNL-641, July 27, 1950.
7. Munn, A. M. and Pontecorvo, B., "Spatial Distribution of Neutrons in Hydrogenous Media Containing Bismuth, Lead, and Iron," Canadian Journal of Research, Volume 25, No. 3, Section A, National Research Council of Canada, 1957.
8. The Reactor Handbook, Vol. 1 Physics, U.S. Atomic Energy Commission, RH-1, June 1953.
9. Tittman, Jay, "Neutron Moderation in SiO_2 ," Physical Review, 95, American Institute of Physics, Incorporated, 1954.
10. Wade, J. W., "Neutron Age in Mixtures of Light and Heavy Water," De Pont de Nemours (E. I.) and Co., DP-163, June 1956.
11. "Nuclear Codes Group Newsletter No. 4," Atomic Energy Commission Computing Facility, Institute of Mathematical Sciences, New York University, June 1, 1957.
12. Selengut, David, "Critical Mass Calculations for Bare Hydrogen Moderated Reactors By Means of Transport Theory," Aircraft Nuclear Propulsion Department, General Electric Company, APEX 121, September 1952.
13. Wachspress, E. L., "Generalized Two-Space Dimension Multigroup Coding for the IBM 704," KAPL-1724, April 30, 1957.