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EUROPEAN ATOMIC ENERGY COMMUNITY - EURATOM

FISSION PRODUCT CHAINS AND THEIR IMPORTANCE ON HIGH BURN-UP FUEL CYCLES

by

J.J. DEVOS and L. MASSIMO

1966

Joint Nuclear Research Center
Ispra Establishment - Italy

Reactor Physics Department
Reactor Theory and Analysis

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The effect of neglecting minor fission product chains and of grouping some of the fission products into aggregates is also discussed.

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SUMMARY

The inaccuracies introduced by errors in the fission yields and by simplifications of the fission product chains are assessed.

The effect of neglecting minor fission product chains and of grouping some of the fission products into aggregates is also discussed.

Introduction

In high burn-up thermal reactor fuel cycles the fission product poisoning becomes quite important.

In case of uniformly graded exposure with a fuel burn-up around 1.8 fissions per initial fissile atom the fission product absorption is more than 12 % of the total absorptions.
This means that an accurate treatment of the fission product chains becomes essential, and the inaccuracies on the fission product yields can have an important effect on the burn-up calculations.

Ordinary burn-up codes can only treat a limited number of fission products and not always allow the treatment of complicated chains.
It is therefore necessary to group many fission products into pseudo-elements or aggregates and limit the number of those treated separately.

The present work is aimed to evaluate the effect of the inaccuracies introduced by these simplifications and by the estimated errors on fission yields. It becomes in this way possible to make these simplifications in such a way as to give a minimum errors.

Manuscript received on July 7, 1966.

The BO code

This assessment was made by writing a burn-up code (B.O.) able to treat a very high number of fission products and any complicated chain.

This code can burn in a fixed flux a fuel of given composition for a specified time.

Atomic concentrations of all isotopes, neutron balances and K_∞ are printed in the output at different times in life.
The average isotopic concentrations for a uniformly graded exposure are calculated and neutron balance and K_∞ are printed for this composition.

The code uses a cross section library which has been obtained by the General Atomic G G C - II code (reference 2).

This library was produced by weighting the multi-group cross sections over a spectrum typical of uniformly graded exposure in the reactor type considered.

Fission yields, decay constants and chain coupling due to absorption and decay, are given in the input.

Fission product aggregates can be produced by a small separate code for any number of isotopes, by summation of the products of the cross sections by the fission yields of each isotope. The aggregates will then be used with a yield of 1.0.

All the fission products with appreciable yields or with zero yields but part of a chain have been treated separately. Only the isotopes with a very short half life have been neglected and their yield has been added to the one of their decay products.

Fission yields and chains

Most fission product yields have been obtained by ref. 1 where data from many different sources are quoted.

In order to assess the error due to fission yield inaccuracies, three sets of values have been used: maximum, average or most probable, and minimum.

Neglecting non binary fissions, the sum of all yields should be 200 %.
While the sum of the average yields was already very near to 200 %, the sums of the maximum and minimum yields were respectively higher and lower than this value. Because of this fact calculations have been repeated renormalizing the yields to a sum of 200 %. All fission yields used are quoted in tables 5 to 10.
The most important fission product chains have been treated. The only very important chain appears to be the one from Nd143 to Gd158, and it is shown in table 1. Other 11 chains of secondary importance have been considered and are shown in tables 2 to 4.

Results

In order to perform the present evaluations a U-Th fuel cycle for a High Temperature Graphite Reactor has been considered.
The cycle was of the uniformly graded exposure type with a burn-up of 1.82 fissions per initial fissile atom, and the power density was 7 Mw/m^3.

The burn-up calculation for this reactor has been repeated with the different sets of fission yields previously described, and with or without chains. In this latter case when no chains were considered, cumulative yields have been attributed to all the isotopes of decay chains (table 11).

The results can be seen in figures 1 and 2 where the ΔK_∞ referred to the best reference case, are plotted as function of fuel lifetime.
In the case of fig. 1 where the yields have not been normalized the effect of their uncertainties appears to be quite considerable, but in the normalized cases of fig. 2 it appears that the error is appreciably reduced.
It is still not negligible, but one must consider that while the average yields had a sum already very near to 200 %, the maximum and minimum yields needed to be renormalized. This means that they appear to come from less accurate sources.
The error due to neglecting fission product chains can also be seen from these figures, and it is much higher than the one due to fission yields uncertainties.
In fig. 2 one can see that this error can be reduced by using cumulative yields, but it still remains untollerable.

From fig. 1 it also appears that the only important chain is the one from Nd143 to Gd158. The other chains can be neglected provided one accounts for decay by using cumulative yields for the isotopes of the decay chains which are not treated.
The reduction in the chains allows the grouping of fission products in aggregates.
Different aggregates specified in table 12 have been produced.

In order to evaluate the error due to aggregating, various calculations have been made without chains, using as a reference the case with no chains and cumulative yields.
In this way it is possible to see the error introduced by aggregating, independently from the error due to neglecting the chains. The results are shown in fig. 3.
It appears that it is possible to aggregate the non saturating fission products of low cross section, but the error becomes very high if more elements enter into the aggregate.
Figs. 4 to 7 show the concentration and fractional absorption of the most important isotopes during life, for the best case, with all chains. The life averaged values of concentration and fractional absorption for this case are listed in table 12. Figs. 8 to 11 show the same data for the case with cumulative yields and no chains, out of which one can see which isotopes saturate and should not be put into the aggregate.

<u>Chain simplification</u>

As many codes cannot treat complicated fission product chains, the chain shown in table 1 has been cut in all possible ways.
The effect in ΔK_∞ relative to a reference case with the complete chain, is shown in fig. 12 as function of the fuel residence time, and the corresponding life average ΔK_∞ are quoted in table 13. All figures refer only to one cut at the time, the remaining part of the chain being not altered. In all cases where the cut involved a decay, the cumulative yield was used for the decay product.

From this study it was possible to find simplified chains involving a minimum error. They can be seen in table 14. It is of course better to use the complete chain, but these simplifications can be necessary in some code.

References

(1) Fission Product Yields and their Mass Distribution, by Yu.A.Zysin, A.A.Lbov and L.I.Sel'chenkov published by the State Committee on the Uses of Atomic Energy in the USSR by Gosatomizdat in Moscow in 1963.

(2) G G C - II, by C.V.Smith and H.A.Vieweg General Atomic Report GA-4436, December 17, 1963.

(3) Time-Dependent Fission Product Thermal and Resonance Absorption Cross Sections, by T.R.England, Bettis Atomic Power Laboratory, WAPD-TM-333, November 1962.

(4) Higher Order Fission-Product Poisoning of U233 and U235 from selected Isotopes of Neodymium, Promethium, Samarium, and Europium, by W.E.Thomas Oak Ridge National Laboratory, ORNL-TM-781, March 1964.

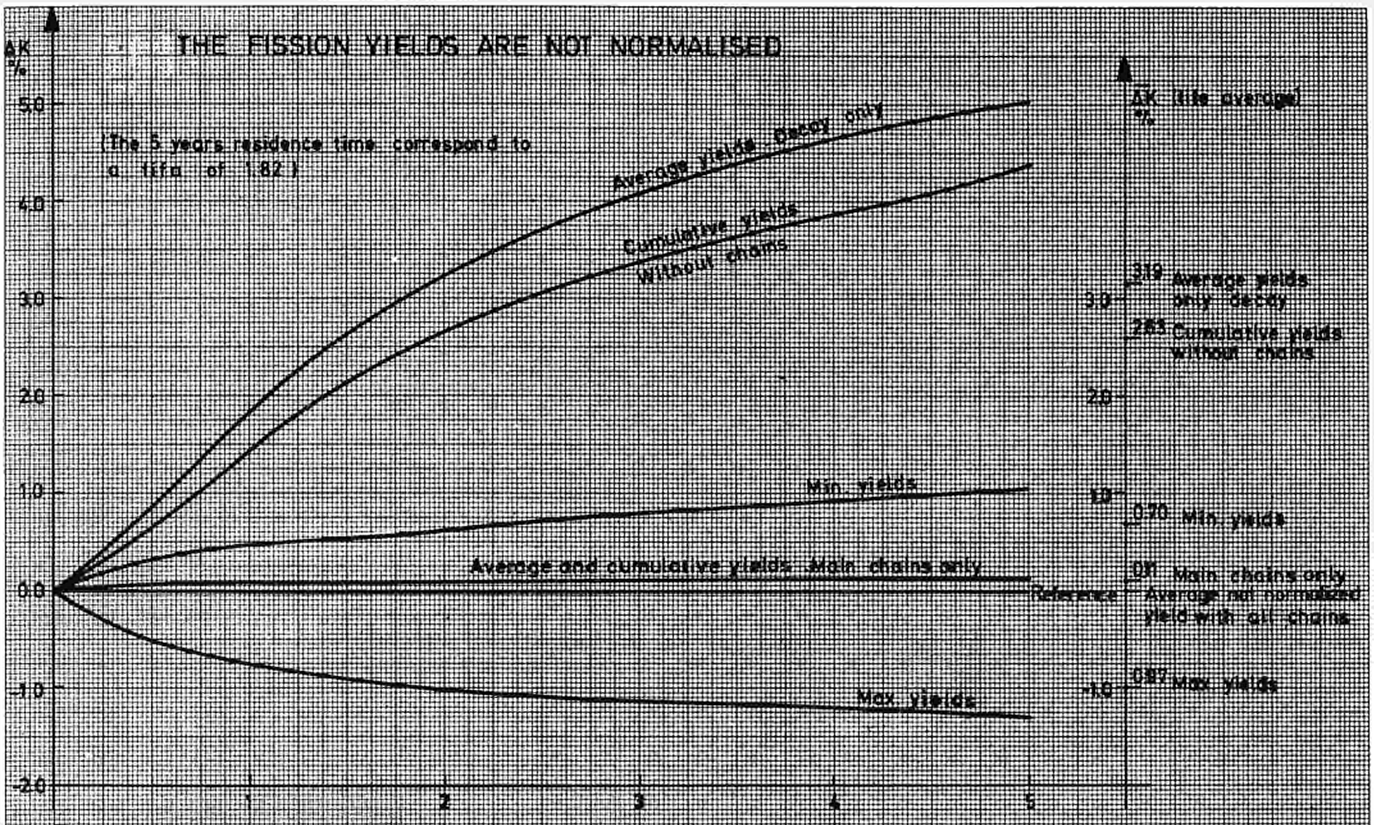


Fig.1 _ ERRORS DUE TO FISSION YIELDS INACCURACIES AND YIELD TREATMENT.

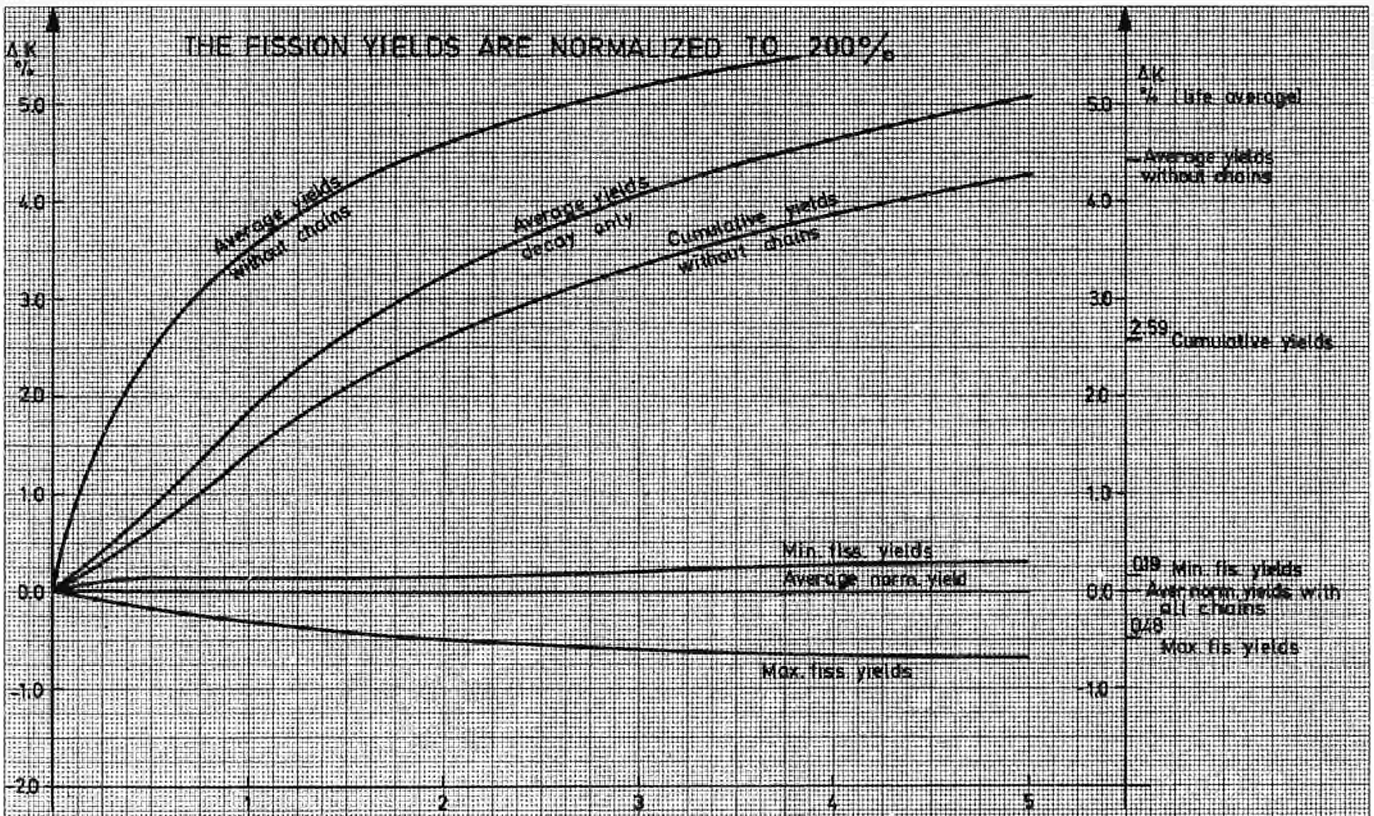


Fig.2 _ ERRORS DUE TO FISSION YIELDS INACCURACIES AND YIELD TREATMENT.

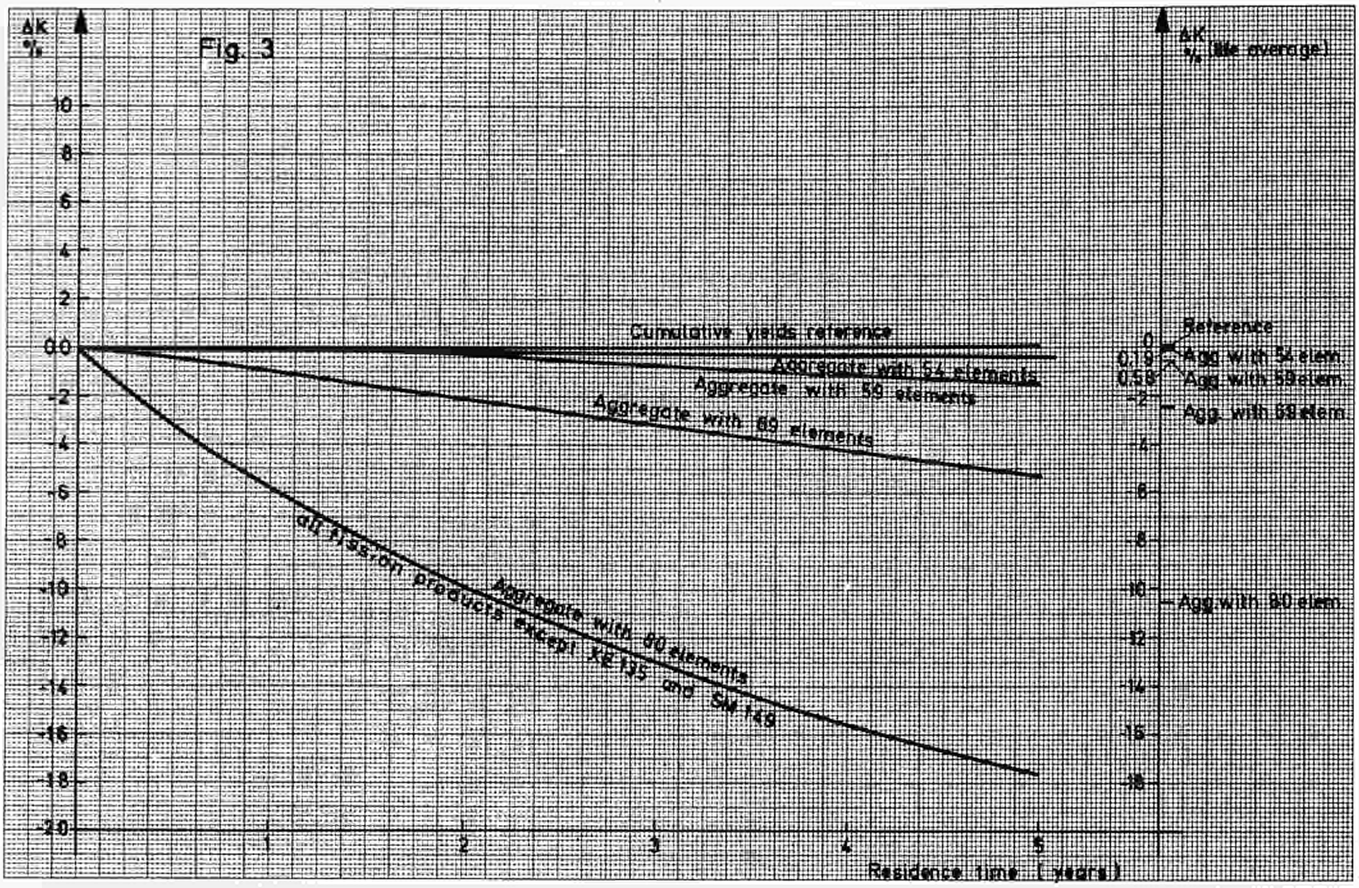


Fig. 3

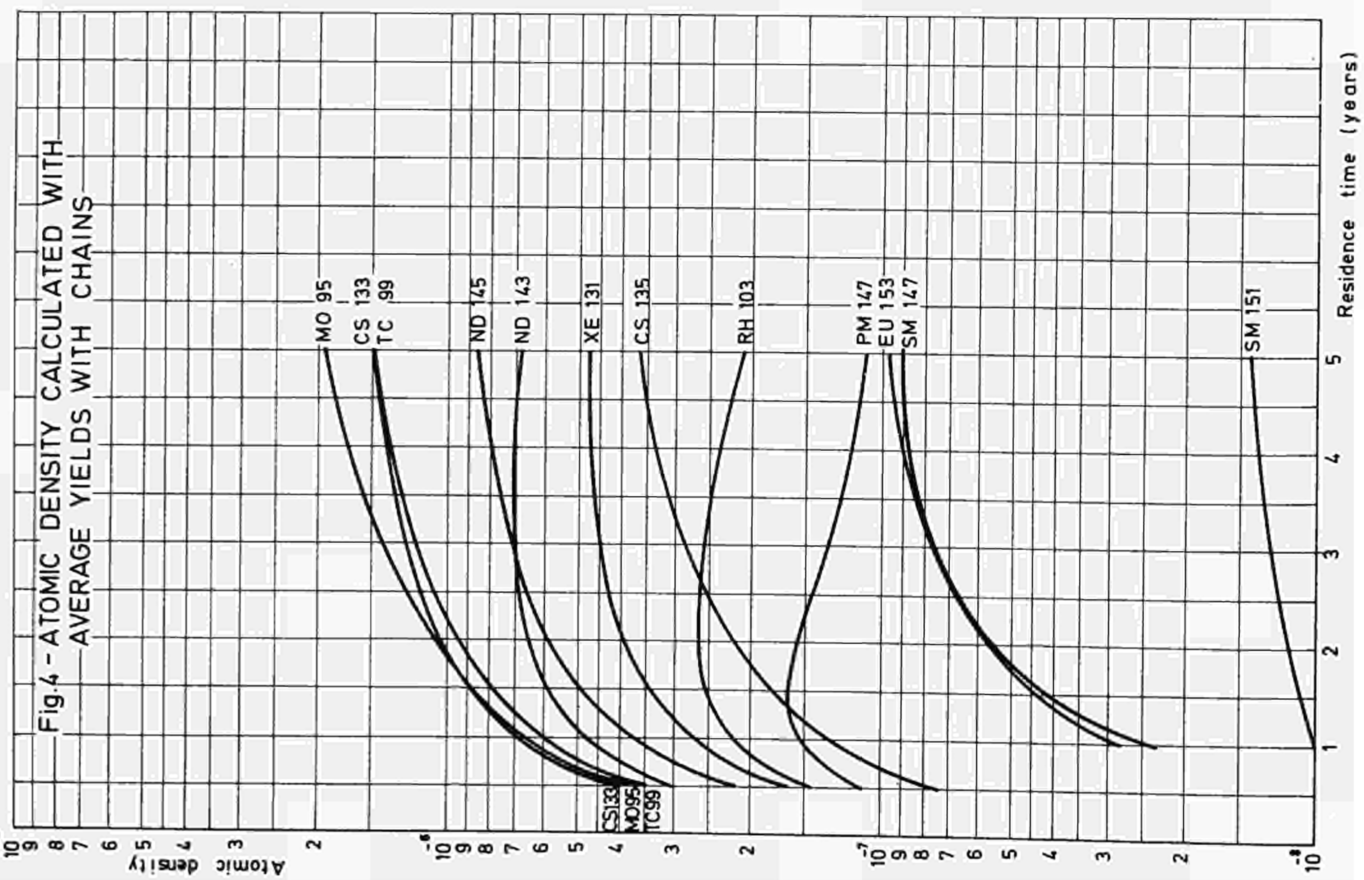


Fig.4 - ATOMIC DENSITY CALCULATED WITH AVERAGE YIELDS WITH CHAINS

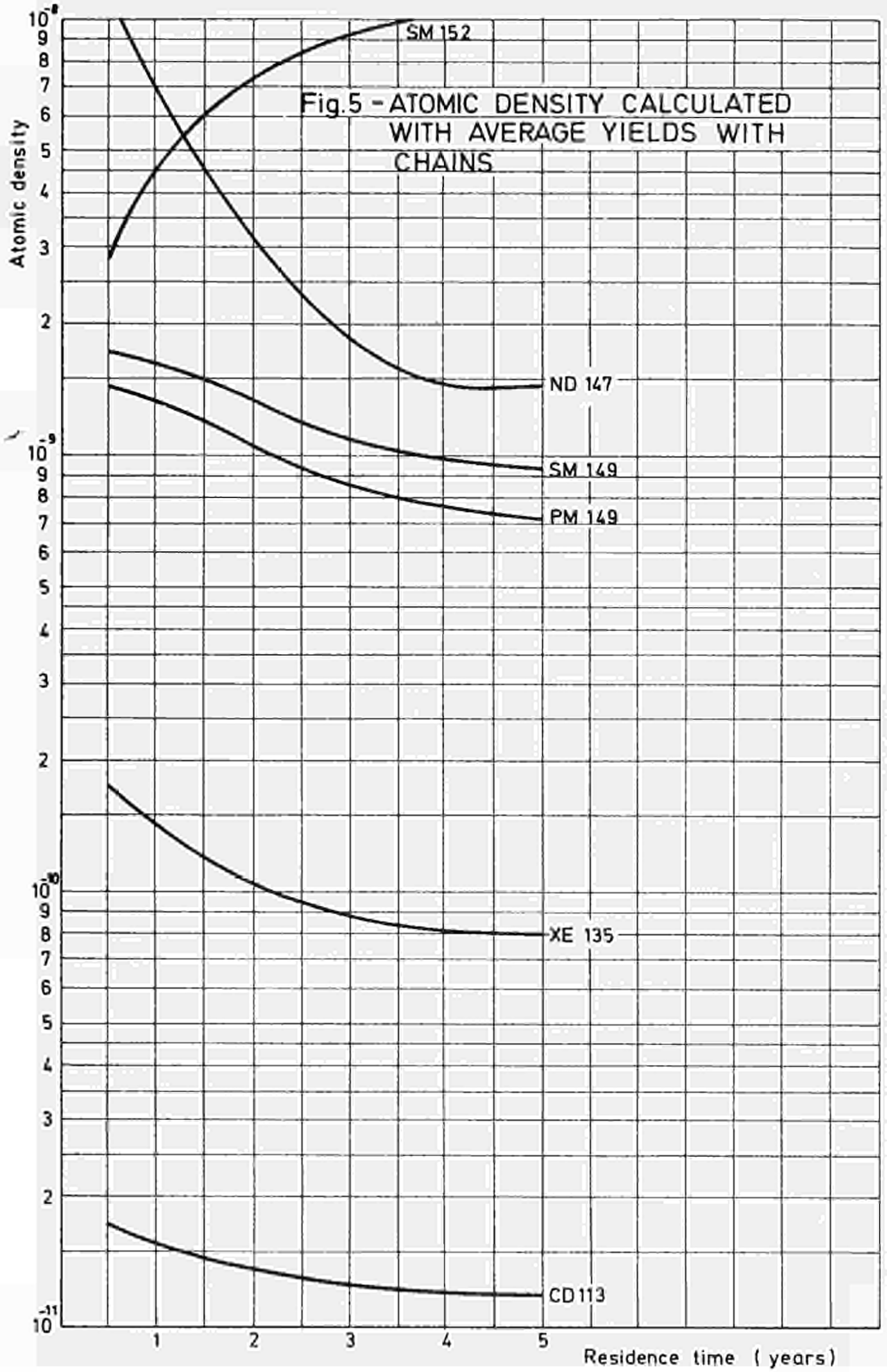


Fig.5 - ATOMIC DENSITY CALCULATED WITH AVERAGE YIELDS WITH CHAINS
Atomic density
Residence time (years)
SM 152
ND 147
SM 149
PM 149
XE 135
CD113

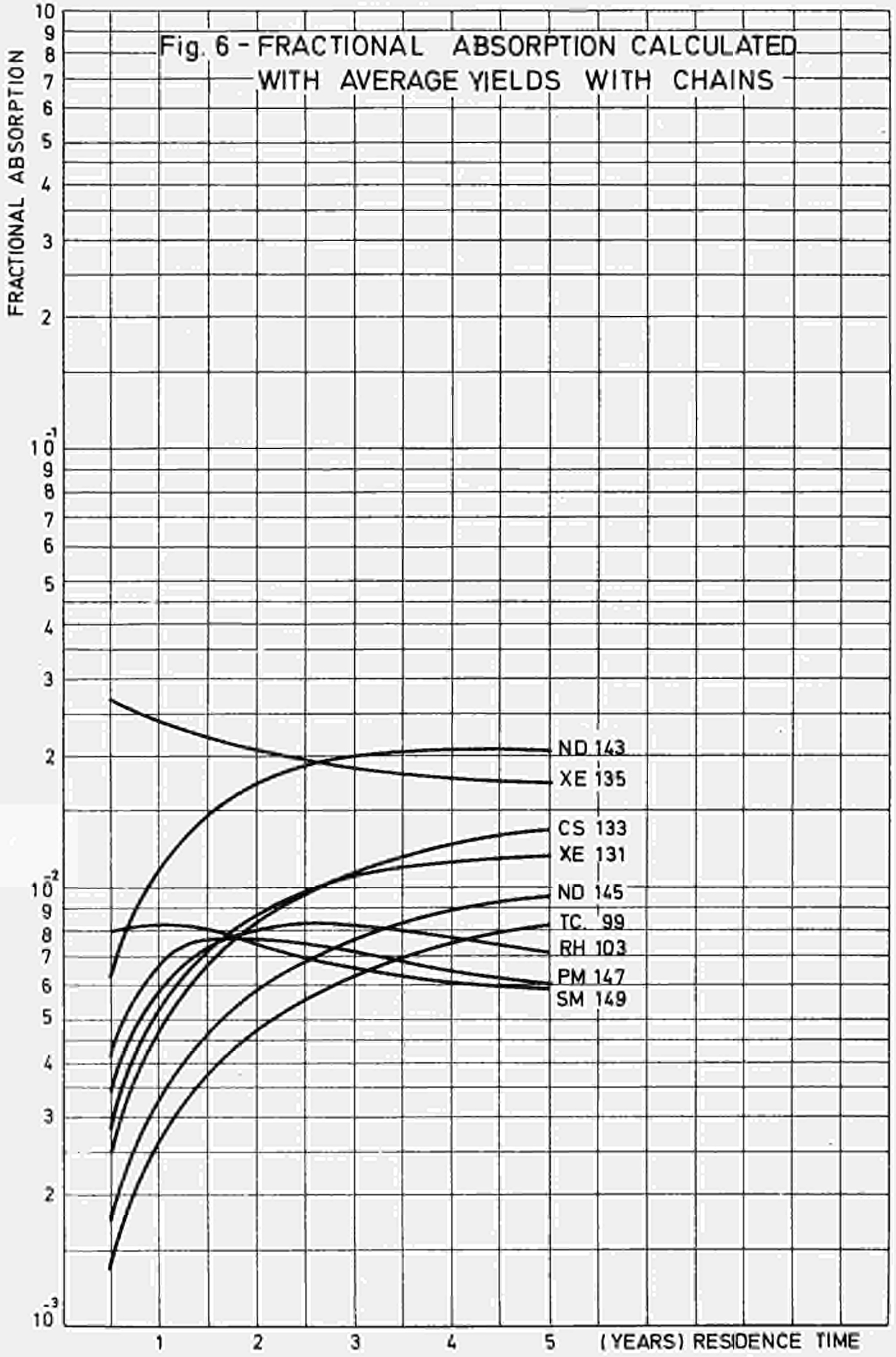


Fig. 6 - FRACTIONAL ABSORPTION CALCULATED WITH AVERAGE YIELDS WITH CHAINS
FRACTIONAL ABSORPTION
(YEARS) RESIDENCE TIME
ND 143
XE 135
CS 133
XE 131
ND 145
TC 99
RH 103
PM 147
SM 149

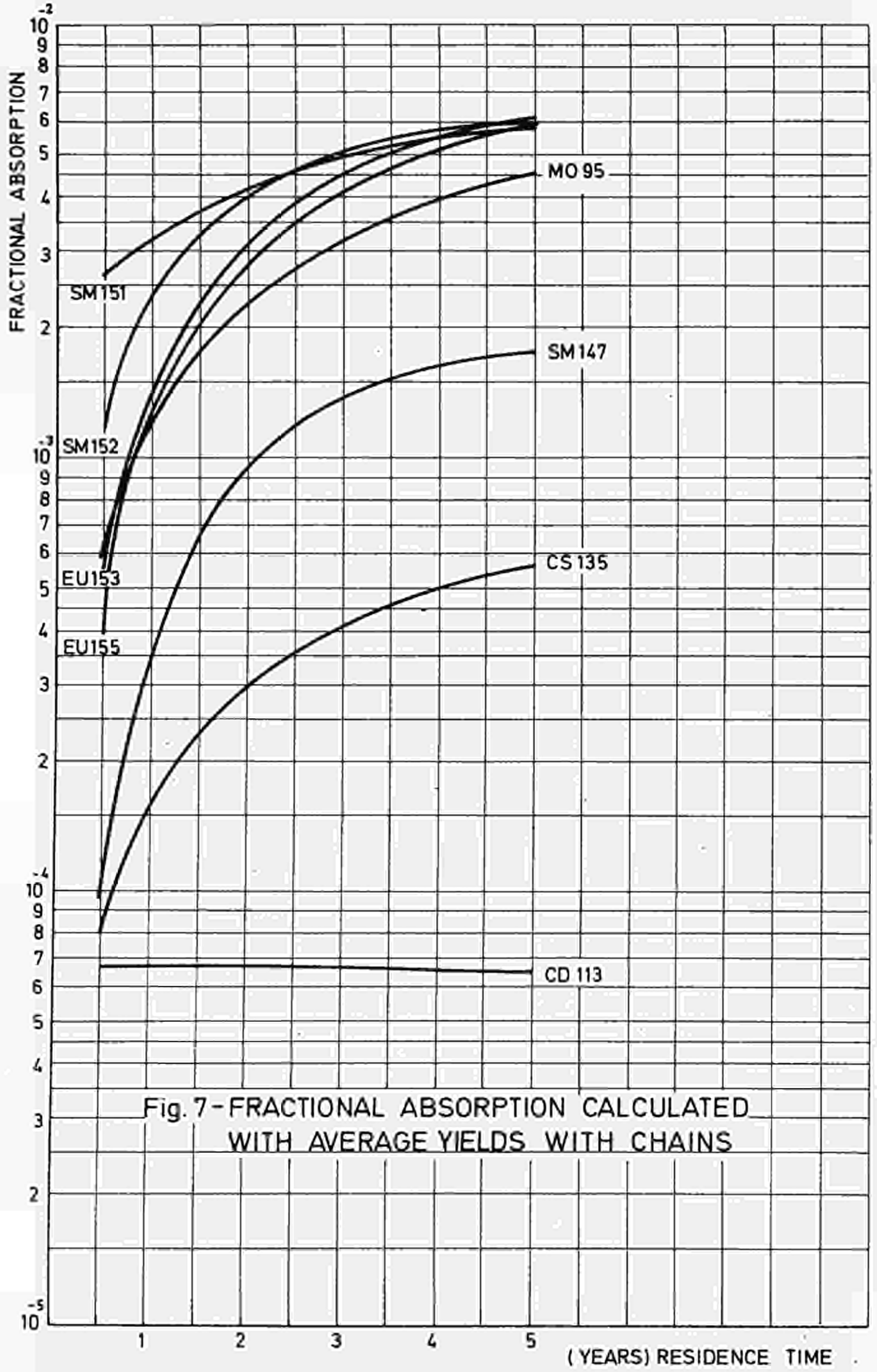


Fig. 7 - FRACTIONAL ABSORPTION CALCULATED WITH AVERAGE YIELDS WITH CHAINS

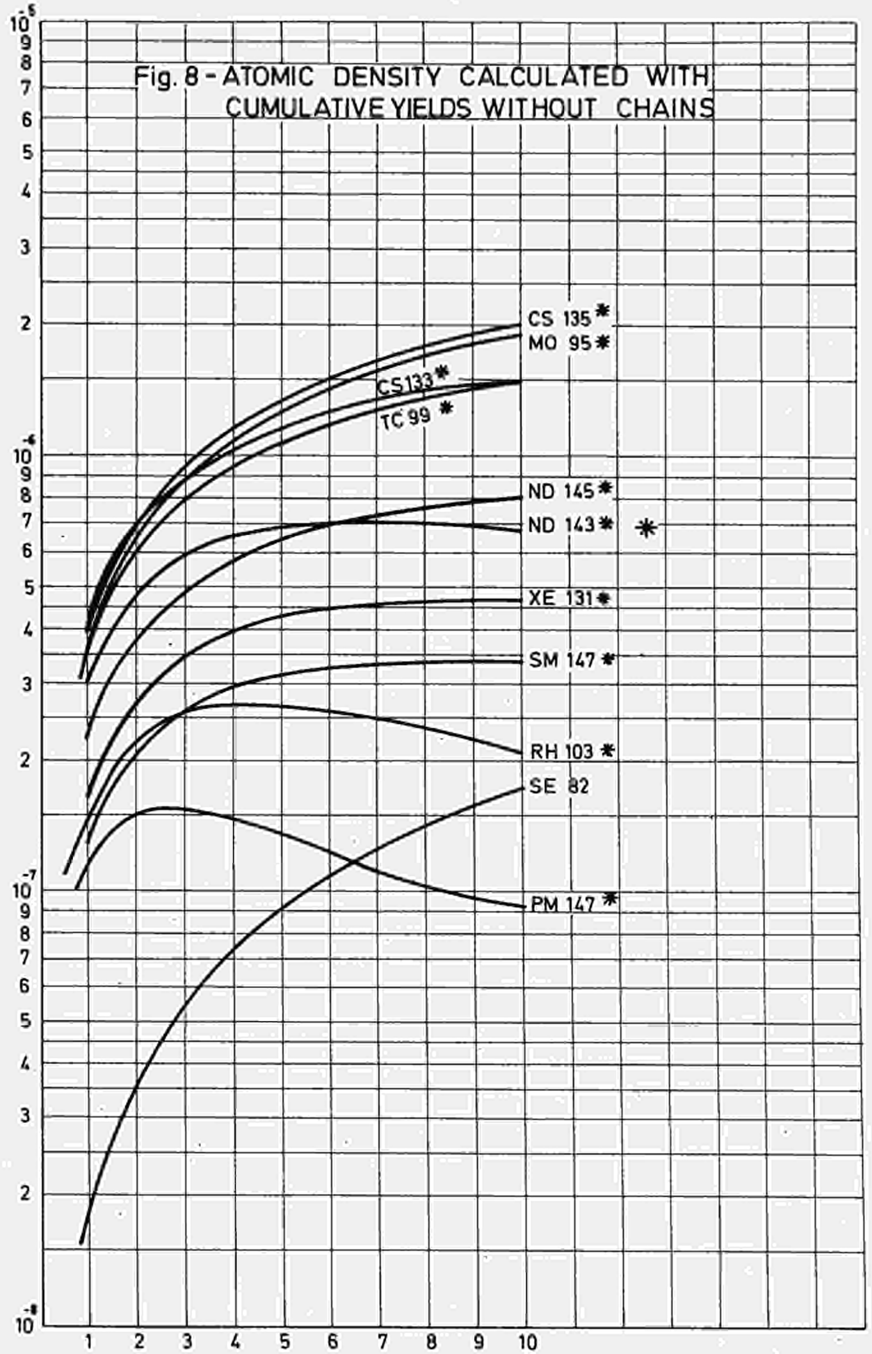


Fig. 8 - ATOMIC DENSITY CALCULATED WITH CUMULATIVE YIELDS WITHOUT CHAINS

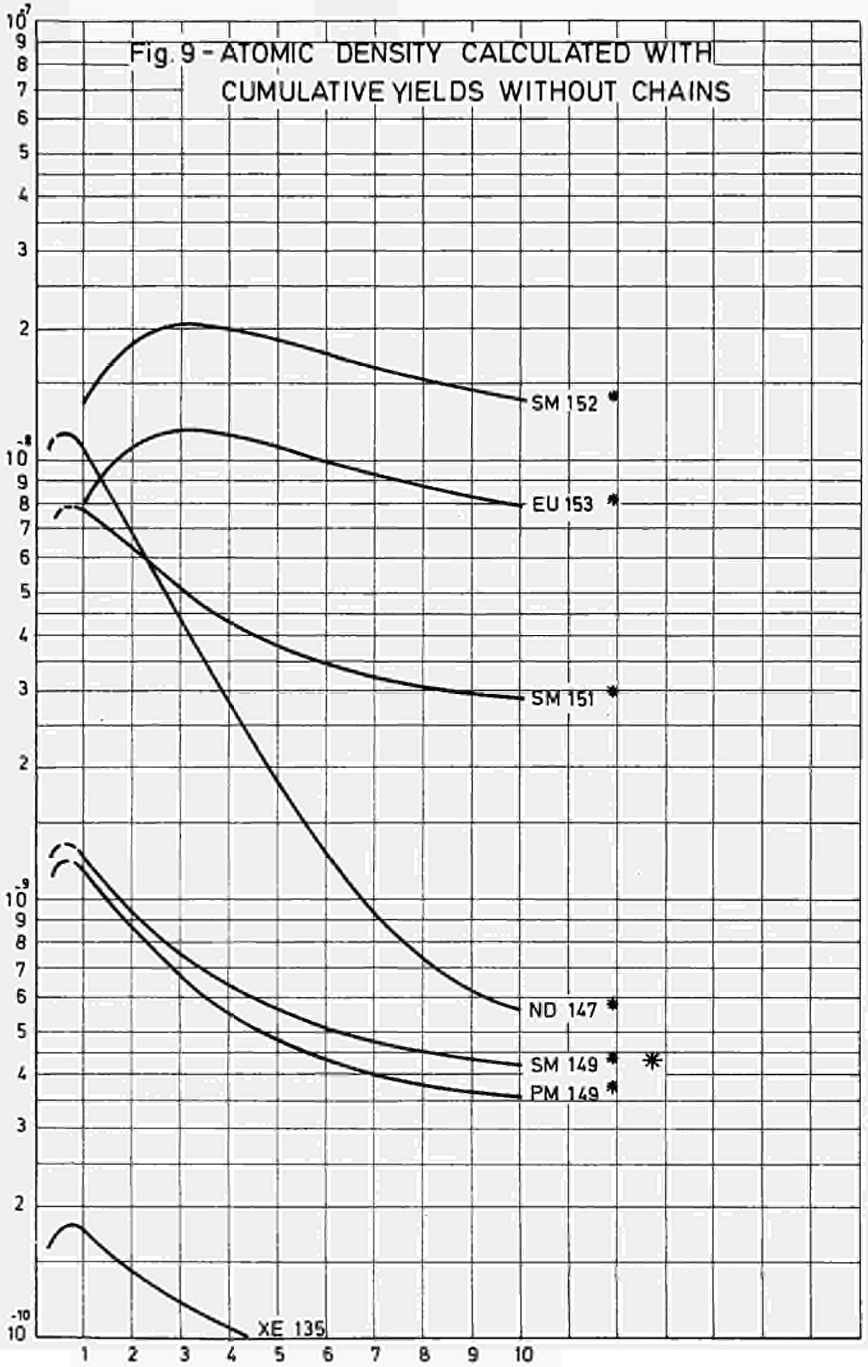


Fig. 9 - ATOMIC DENSITY CALCULATED WITH CUMULATIVE YIELDS WITHOUT CHAINS

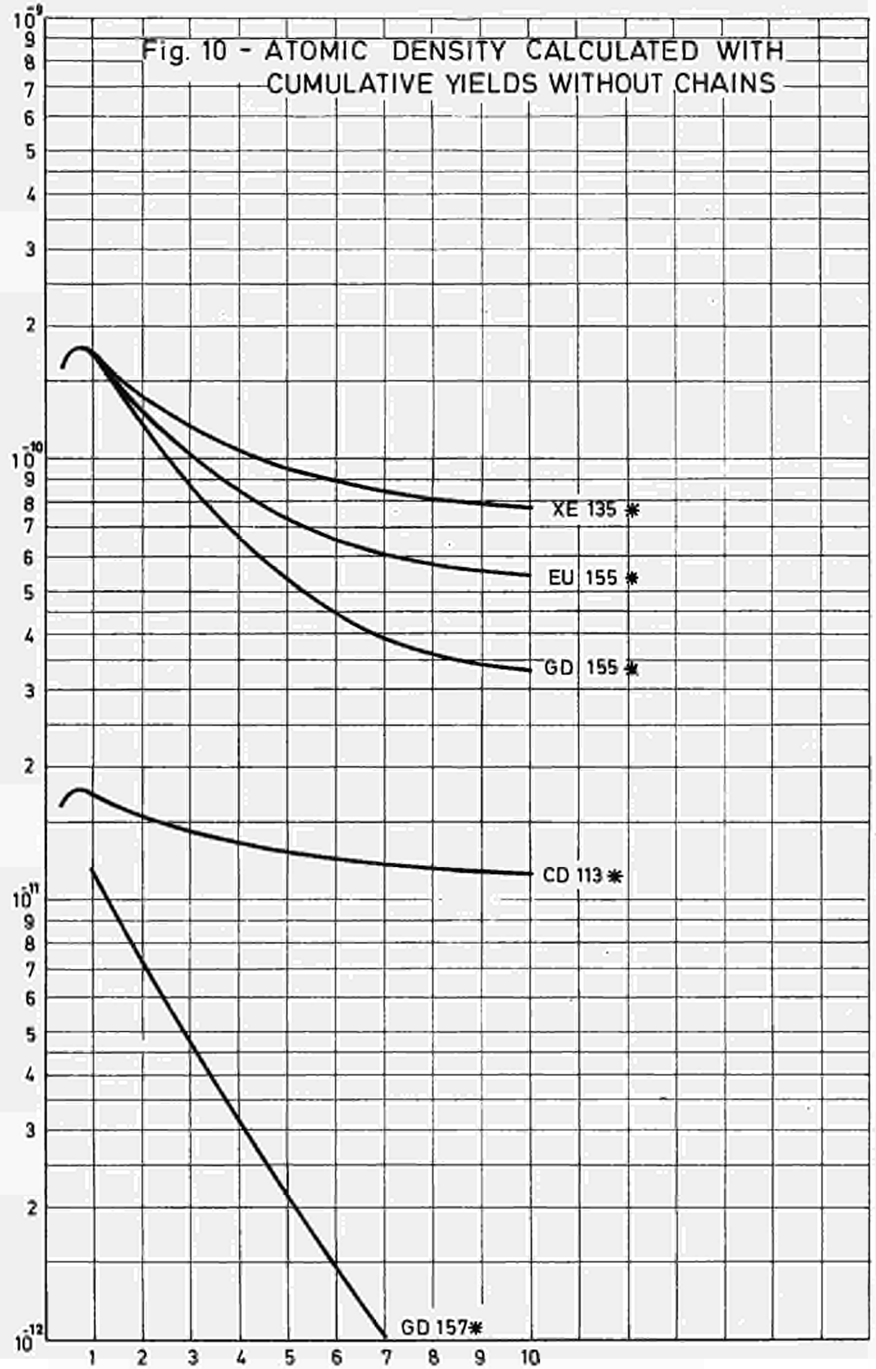


Fig. 10 - ATOMIC DENSITY CALCULATED WITH CUMULATIVE YIELDS WITHOUT CHAINS

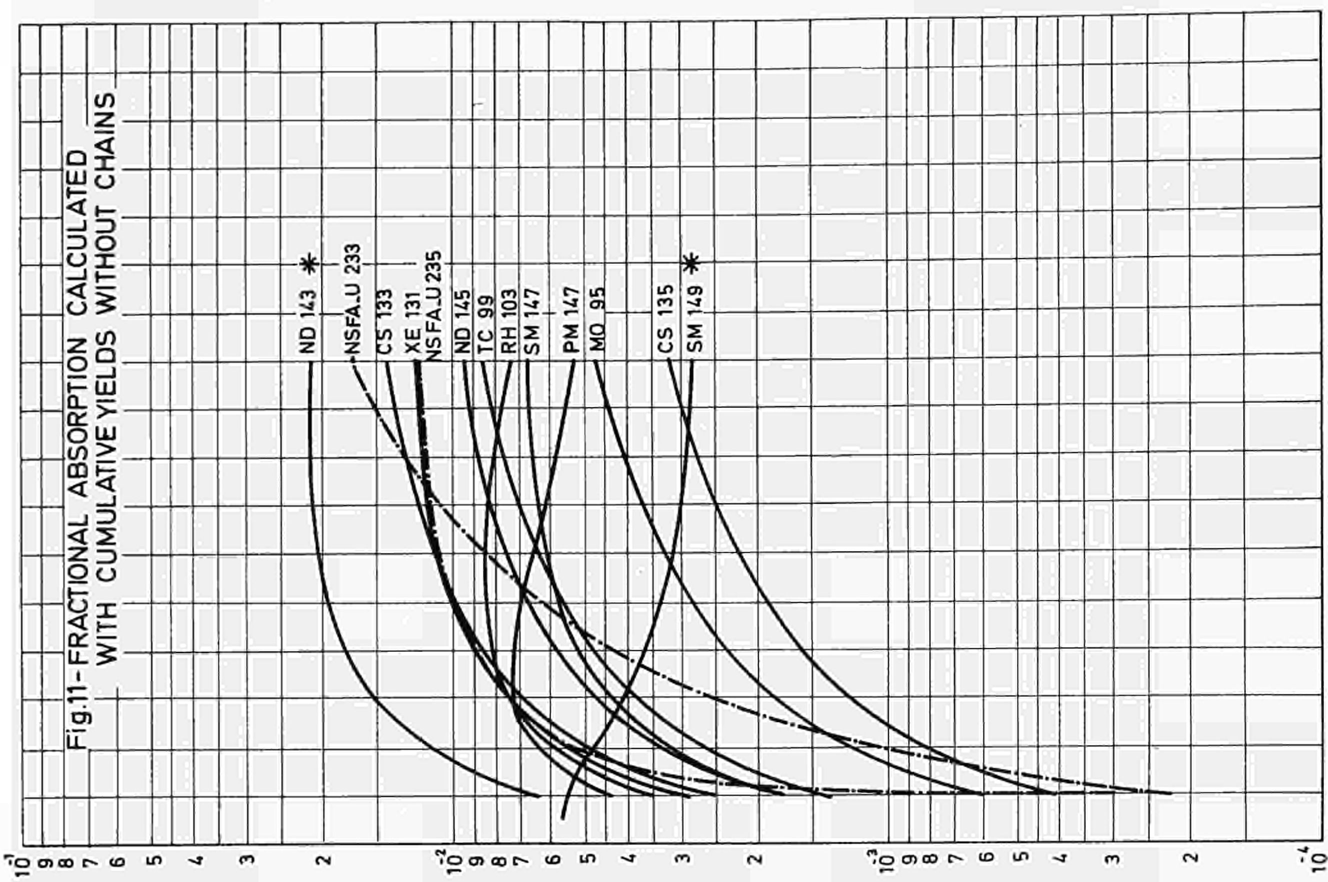


Fig.11 - FRACTIONAL ABSORPTION CALCULATED WITH CUMULATIVE YIELDS WITHOUT CHAINS

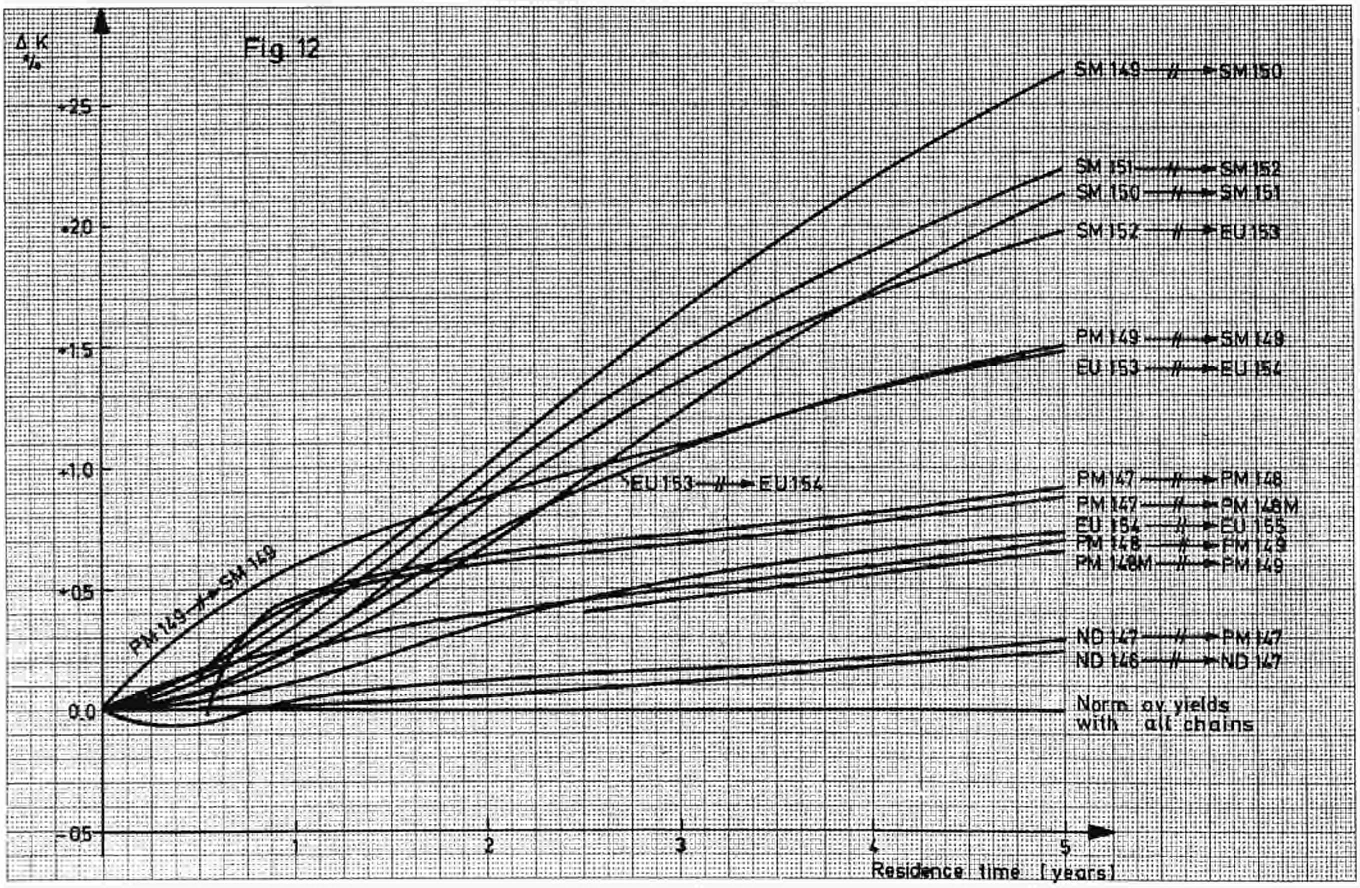
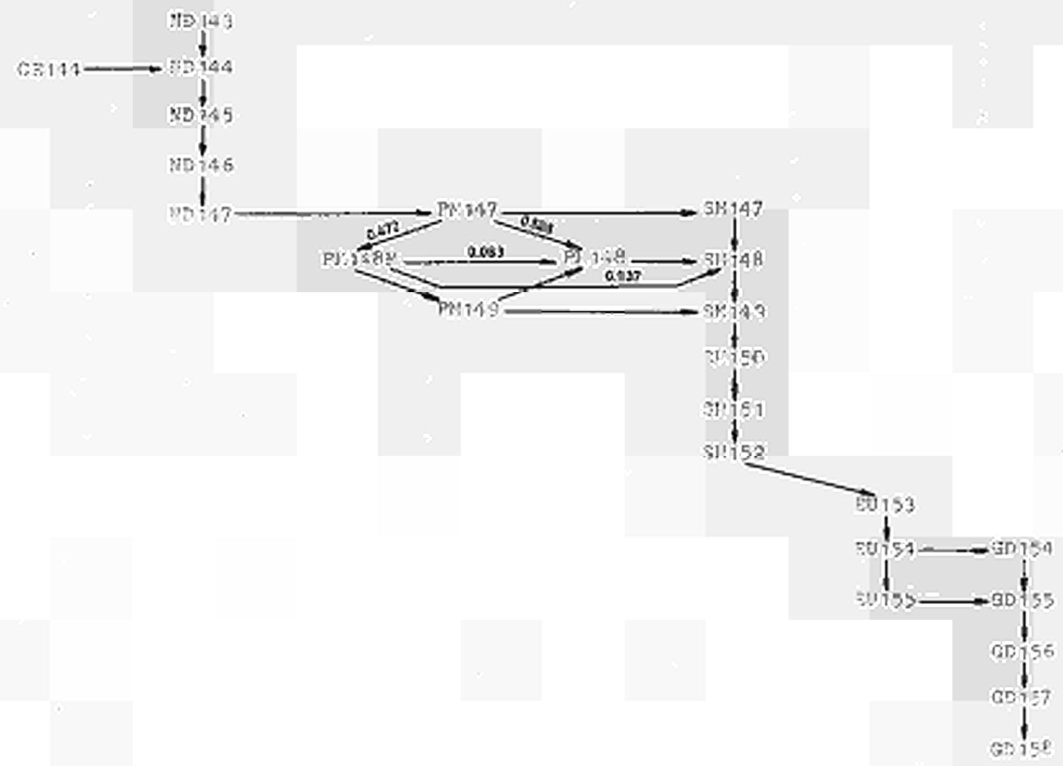


Fig 12

TABLE N° 1



BRANCHING FACTORS ARE QUOTED FOR EACH RAMIFICATION

Table N° 2

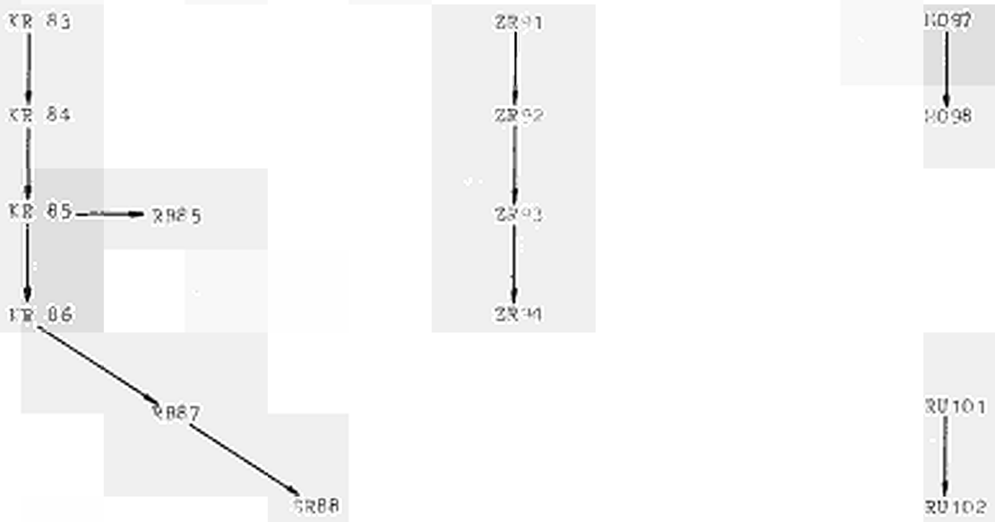


Table N° 3

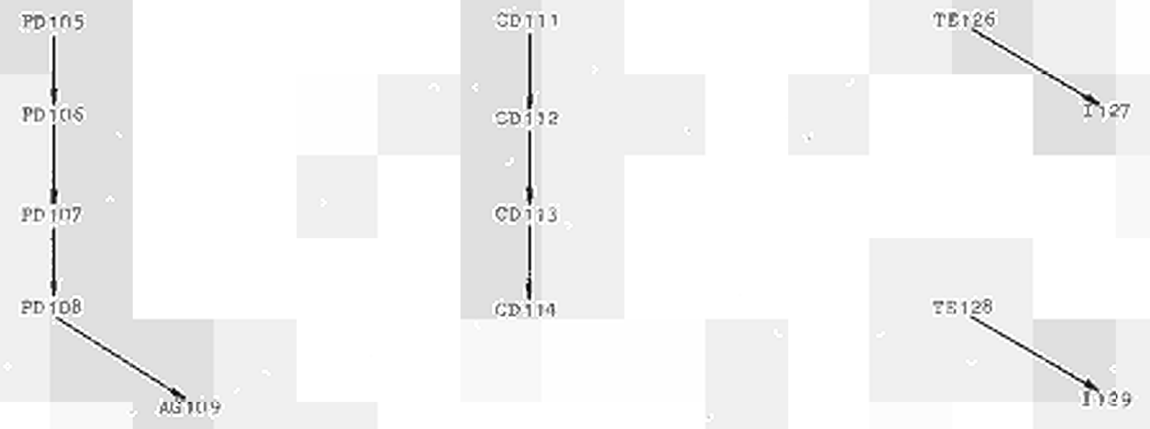


Table N° 4

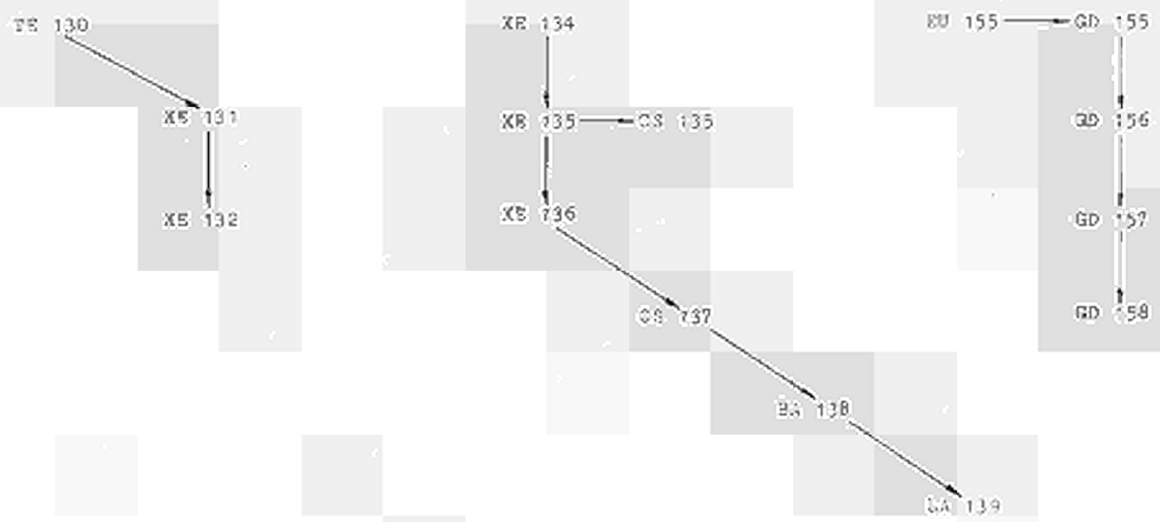


TABLE N° 5

MATERIAL	DECAY CONSTANT	AVERAGE FISSION YIELDS FROM U233	FROM U235	FROM PU239	FROM PU241
SE 82	-0.	7.0000E-03	2.8000E-03	1.8000E-03	1.8000E-03
BR 81	-0.	4.5000E-03	1.4000E-03	9.0000E-04	9.0000E-04
KR 83	-0.	1.1700E-02	5.4400E-03	2.9000E-03	2.9000E-03
KR 84	-0.	1.2500E-02	10.0000E-03	4.7000E-03	4.7000E-03
KR 85	2.0740E-09	5.3000E-03	2.9300E-03	1.2700E-03	1.2700E-03
KR 86	-0.	3.2700E-02	2.0200E-02	7.6000E-03	7.6000E-03
RB 85	-0.	1.9300E-02	10.0000E-03	4.1200E-03	4.1200E-03
RB 87	-0.	4.5600E-02	2.4900E-02	9.2000E-03	9.2000E-03
SR 88	-0.	5.3700E-02	3.5700E-02	1.4200E-02	1.4200E-02
SR 90	-0.	6.4300E-02	5.7700E-02	2.2500E-02	2.2500E-02
Y 89	-0.	5.8600E-02	4.7900E-02	1.7100E-02	1.7100E-02
ZR 91	-0.	6.4300E-02	5.8400E-02	2.6100E-02	2.6100E-02
ZR 92	-0.	6.6400E-02	6.0300E-02	3.1400E-02	3.1400E-02
ZR 93	-0.	7.0000E-02	6.4500E-02	3.9700E-02	3.9700E-02
ZR 94	-0.	6.6800E-02	6.4000E-02	4.4800E-02	4.4800E-02
ZR 96	-0.	5.5800E-02	6.3300E-02	5.1700E-02	5.1700E-02
MO 95	-0.	6.1100E-02	6.2700E-02	5.0300E-02	4.0000E-02
MO 97	-0.	5.3700E-02	6.0900E-02	5.6500E-02	5.6500E-02
MO 98	-0.	5.1500E-02	5.7800E-02	5.8900E-02	5.8900E-02
MO 100	-0.	4.4000E-02	6.3000E-02	7.1000E-02	7.1000E-02
TC 99	-0.	4.9600E-02	6.1000E-02	6.1000E-02	6.2000E-02
RU 101	-0.	2.9100E-02	5.0000E-02	5.9100E-02	5.9100E-02
RU 102	-0.	2.2200E-02	4.1000E-02	6.0000E-02	6.0000E-02
RU 104	-0.	9.4000E-03	1.8000E-02	5.9300E-02	5.9300E-02
RH 103	-0.	1.6000E-02	2.9000E-02	5.6000E-02	6.2000E-02
PD 105	-0.	5.0000E-03	9.0000E-03	3.9000E-02	3.9000E-02
PD 106	-0.	2.4000E-03	3.8000E-03	4.5700E-02	4.5700E-02
PD 107	-0.	1.5000E-03	1.9000E-03	3.0000E-02	3.0000E-02
PD 108	-0.	6.0000E-04	7.0000E-04	2.0000E-02	2.0000E-02
PD 110	-0.	3.0000E-04	2.4000E-04	7.0000E-03	7.0000E-03
AG 109	-0.	4.4000E-04	3.0000E-04	1.4000E-02	1.4000E-02
CD 111	-0.	2.5000E-04	1.9000E-04	2.7000E-03	2.7000E-03
CD 112	-0.	2.0000E-04	10.0000E-05	10.0000E-04	10.0000E-04
CD 113	-0.	1.9000E-04	1.2000E-04	7.0000E-04	4.0000E-03
CD 114	-0.	2.0000E-04	10.0000E-05	5.0000E-04	5.0000E-04
IN 115	-0.	2.0000E-04	10.0000E-05	4.0000E-04	4.0000E-04
TE 126	-0.	2.4000E-03	5.0000E-04	2.5000E-03	2.5000E-03
TE 128	-0.	10.0000E-03	3.7000E-03	8.0000E-03	8.0000E-03
TE 130	-0.	2.7000E-02	2.0000E-02	2.5000E-02	2.5000E-02
I 127	-0.	6.0000E-03	1.3000E-03	3.9000E-03	3.9000E-03
I 129	-0.	2.0000E-02	8.0000E-03	1.4000E-02	1.4000E-02
XE 131	-0.	3.5600E-02	3.0200E-02	2.7700E-02	3.4000E-02
XE 132	-0.	4.6400E-02	4.3800E-02	5.2600E-02	5.2600E-02
XE 134	-0.	5.9500E-02	8.0600E-02	7.4700E-02	7.4700E-02
XE 135	2.0928E-05	6.0000E-02	6.4100E-02	7.3500E-02	6.5000E-02
XE 136	-0.	6.6300E-02	6.4600E-02	6.6300E-02	6.6300E-02
CS 133	-0.	5.7000E-02	7.0300E-02	5.9700E-02	6.0000E-02
CS 135	-0.	-0.	2.5000E-03	-0.	-0.
CS 137	-0.	6.5800E-02	6.1500E-02	6.6300E-02	6.6300E-02
BA 138	-0.	6.8000E-02	5.7400E-02	6.3100E-02	6.3100E-02
LA 139	-0.	6.4000E-02	6.5500E-02	6.6100E-02	6.6100E-02
CE 140	-0.	6.4700E-02	6.4400E-02	5.6000E-02	5.6000E-02
CE 142	-0.	6.8300E-02	6.0100E-02	5.0100E-02	5.0100E-02
PR 141	-0.	6.4000E-02	6.4000E-02	4.5000E-02	4.5000E-02
CE 144	2.8248E-08	4.5000E-02	6.0000E-02	4.4000E-02	4.8000E-02
ND 143	-0.	5.7000E-02	5.7100E-02	4.9000E-02	5.6000E-02
ND 144	-0.	1.1000E-03	-0.	-0.	-0.
ND 145	-0.	3.4700E-02	3.9800E-02	3.6300E-02	3.6000E-02
ND 146	-0.	2.6300E-02	3.0700E-02	2.6000E-02	2.6000E-02
ND 147	7.2275E-07	0.	2.6000E-02	2.2000E-02	2.2000E-02
ND 148	-0.	1.3400E-02	1.7000E-02	1.7300E-02	1.7300E-02
ND 150	-0.	5.6000E-03	6.7000E-03	1.0100E-02	1.0100E-02
PM 147	8.4479E-09	1.7800E-02	-0.	-0.	-0.
PM 148M	1.9760E-07	0.	0.	0.	0.
PM 148	1.4857E-06	0.	0.	0.	0.
PM 149	3.6260E-06	7.7000E-03	1.3000E-02	1.4000E-02	1.2000E-02
SM 147	1.6910E-19	-0.	-0.	3.4000E-03	3.4000E-03
SM 148	-0.	-0.	-0.	1.1900E-03	1.1900E-03
SM 149	-0.	-0.	-0.	-0.	-0.
SM 150	-0.	0.	0.	0.	0.
SM 151	2.7470E-10	3.3500E-03	4.4000E-03	8.8000E-03	5.0000E-03
SM 152	-0.	1.9000E-03	2.8100E-03	7.4000E-03	3.0000E-03
SM 154	-0.	4.5000E-04	7.7000E-04	2.9000E-03	2.9000E-03
EU 153	-0.	1.3000E-03	1.6900E-03	3.4000E-03	2.0000E-03
EU 154	1.3728E-09	0.	0.	0.	0.
EU 155	5.4950E-09	2.0000E-04	3.3000E-04	1.6000E-03	10.0000E-04
GD 154	-0.	0.	0.	0.	0.
GD 155	-0.	-0.	2.0000E-04	-0.	-0.
GD 156	-0.	1.1000E-04	1.4000E-04	1.1000E-03	1.1000E-03
GD 157	-0.	0.	1.5000E-04	0.	0.
GD 158	-0.	1.0000E-05	2.0000E-05	6.1500E-04	6.1500E-04
TB 159	-0.	5.0000E-06	1.0000E-05	2.1000E-04	2.1000E-04

TABLE N° 6

MATERIAL	DECAY CONSTANT	NORMALISED AVERAGE FISSION YIELDS FROM U233	FROM U235	FROM PU239	FROM PU241
SE 82	-0.	7.0182E-03	2.7823E-03	1.8210E-03	1.8242E-03
BR 81	-0.	4.5117E-03	1.3911E-03	9.1051E-04	9.1208E-04
KR 83	-0.	1.1730E-02	5.4056E-03	2.9339E-03	2.9389E-03
KR 84	-0.	1.9551E-02	9.9367E-03	4.7549E-03	4.7631E-03
KR 85	2.0740E-09	5.8151E-03	2.9115E-03	1.2848E-03	1.2871E-03
KR 86	-0.	3.2785E-02	2.0072E-02	7.6888E-03	7.7020E-03
RB 85	-0.	1.9350E-02	9.9367E-03	4.1681E-03	4.1753E-03
RB 87	-0.	4.5719E-02	2.4742E-02	9.3075E-03	9.3235E-03
SR 88	-0.	5.3840E-02	3.5474E-02	1.4366E-02	1.4391E-02
SR 90	-0.	6.4467E-02	5.7335E-02	2.2763E-02	2.2802E-02
Y 89	-0.	5.8753E-02	4.7597E-02	1.7300E-02	1.7330E-02
ZR 91	-0.	6.4467E-02	5.8030E-02	2.6405E-02	2.6450E-02
ZR 92	-0.	6.6573E-02	5.9918E-02	3.1767E-02	3.1822E-02
ZR 93	-0.	7.0182E-02	6.4092E-02	4.0164E-02	4.0233E-02
ZR 94	-0.	6.6974E-02	6.3595E-02	4.5323E-02	4.5401E-02
ZR 96	-0.	5.5945E-02	6.2899E-02	5.2304E-02	5.2394E-02
MO 95	-0.	6.1259E-02	6.2303E-02	5.0888E-02	4.0537E-02
MO 97	-0.	5.3840E-02	6.0515E-02	5.7160E-02	5.7259E-02
MO 98	-0.	5.1634E-02	5.7434E-02	5.9588E-02	5.9691E-02
MO 100	-0.	4.4115E-02	6.2601E-02	7.1829E-02	7.1953E-02
TC 99	-0.	4.9729E-02	6.0614E-02	6.1713E-02	6.2832E-02
RU 101	-0.	2.9176E-02	4.9684E-02	5.9790E-02	5.9893E-02
RU 102	-0.	2.2258E-02	4.0740E-02	6.0701E-02	6.0806E-02
RU 104	-0.	9.4245E-03	1.7886E-02	5.9993E-02	6.0096E-02
RH 103	-0.	1.6042E-02	2.8816E-02	5.6654E-02	6.2832E-02
PD 105	-0.	5.0130E-03	8.9430E-03	3.9456E-02	3.9524E-02
PD 106	-0.	2.4063E-03	3.7759E-03	4.6234E-02	4.6314E-02
PD 107	-0.	1.5039E-03	1.8880E-03	3.0350E-02	3.0403E-02
PD 108	-0.	6.0156E-04	6.9557E-04	2.0234E-02	2.0269E-02
PD 110	-0.	3.0078E-04	2.3848E-04	7.0818E-03	7.0940E-03
AG 109	-0.	4.4115E-04	2.9810E-04	1.4164E-02	1.4188E-02
CD 111	-0.	2.5065E-04	1.8880E-04	2.7315E-03	2.7362E-03
CD 112	-0.	2.0052E-04	9.9367E-05	1.0117E-03	1.0134E-03
CD 113	-0.	1.9049E-04	1.1924E-04	7.0818E-04	4.0537E-03
CD 114	-0.	2.0052E-04	9.9367E-05	5.0584E-04	5.0671E-04
IN 115	-0.	2.0052E-04	9.9367E-05	4.0467E-04	4.0537E-04
TE 126	-0.	2.4063E-03	4.9684E-04	2.5292E-03	2.5336E-03
TE 128	-0.	1.0026E-02	3.6766E-03	8.0935E-03	8.1074E-03
TE 130	-0.	2.7070E-02	1.9873E-02	2.5292E-02	2.5336E-02
I 127	-0.	6.0156E-03	1.2918E-03	3.9456E-03	3.9524E-03
I 129	-0.	2.0052E-02	7.9494E-03	1.4164E-02	1.4188E-02
XE 131	-0.	3.5693E-02	3.0009E-02	2.8024E-02	3.4456E-02
XE 132	-0.	4.6521E-02	4.3523E-02	5.3215E-02	5.3306E-02
XE 134	-0.	5.9655E-02	8.0090E-02	7.5573E-02	7.5703E-02
XE 135	2.0928E-05	6.0156E-02	6.3694E-02	7.4359E-02	6.5873E-02
XE 136	-0.	6.6473E-02	6.4191E-02	6.7075E-02	6.7190E-02
CS 133	-0.	5.7148E-02	6.9855E-02	6.0397E-02	6.0806E-02
CS 135	-0.	-0.	2.4842E-03	-0.	-0.
CS 137	-0.	6.5971E-02	6.1111E-02	6.7075E-02	6.7190E-02
BA 138	-0.	6.8177E-02	5.7037E-02	6.3837E-02	6.3947E-02
LA 139	-0.	6.4167E-02	6.5085E-02	6.6872E-02	6.6987E-02
CE 140	-0.	6.4869E-02	6.3992E-02	5.6654E-02	5.6752E-02
CE 142	-0.	6.8478E-02	5.9720E-02	5.0685E-02	5.0773E-02
PR 141	-0.	6.4167E-02	6.3595E-02	4.5526E-02	4.5604E-02
CE 144	2.8248E-08	4.5117E-02	5.9620E-02	4.4514E-02	4.8644E-02
ND 143	-0.	5.7148E-02	5.6739E-02	4.9572E-02	5.6752E-02
ND 144	-0.	1.1029E-03	-0.	-0.	-0.
ND 145	-0.	3.4790E-02	3.9548E-02	3.6724E-02	3.6483E-02
ND 146	-0.	2.6368E-02	3.0506E-02	2.6304E-02	2.6349E-02
ND 147	7.2275E-07	0.	2.5835E-02	2.2257E-02	2.2295E-02
ND 148	-0.	1.3435E-02	1.6892E-02	1.7502E-02	1.7532E-02
ND 150	-0.	5.6146E-03	6.6576E-03	1.0218E-02	1.0236E-02
PM 147	8.4479E-09	1.7846E-02	-0.	-0.	-0.
PM 148M	1.9760E-07	0.	0.	0.	0.
PM 148	1.4857E-06	0.	0.	0.	0.
PM 149	3.6260E-06	7.7201E-03	1.2918E-02	1.4164E-02	1.2161E-02
SM 147	1.6910E-19	-0.	-0.	3.4397E-03	3.4456E-03
SM 148	-0.	-0.	-0.	1.2039E-03	1.2060E-03
SM 149	-0.	-0.	-0.	-0.	-0.
SM 150	-0.	0.	0.	0.	0.
SM 151	2.7470E-10	3.3587E-03	4.3722E-03	8.9028E-03	5.0671E-03
SM 152	-0.	1.9049E-03	2.7922E-03	7.4865E-03	3.0403E-03
SM 154	-0.	4.5117E-04	7.6513E-04	2.9339E-03	2.9389E-03
EU 153	-0.	1.3034E-03	1.6793E-03	3.4397E-03	2.0269E-03
EU 154	1.3728E-09	0.	0.	0.	0.
EU 155	5.4950E-09	2.0052E-04	3.2791E-04	1.6187E-03	1.0134E-03
GD 154	-0.	0.	0.	0.	0.
GD 155	-0.	-0.	1.9873E-04	-0.	-0.
GD 156	-0.	1.1029E-04	1.3911E-04	1.1129E-03	1.1148E-03
GD 157	-0.	0.	1.4905E-04	0.	0.
GD 158	-0.	1.0026E-05	1.9873E-05	6.2218E-04	6.2326E-04
TB 159	-0.	5.0130E-06	9.9367E-06	2.1245E-04	2.1282E-04

EURATOM - C.C.R. ISPRA - CETIS

TABLE N° 7

MATERIAL		DECAY CONSTANT	MAXIMUM FISSION YIELDS FROM U233	MAXIMUM FISSION YIELDS FROM U235	MAXIMUM FISSION YIELDS FROM PU239	MAXIMUM FISSION YIELDS FROM PU241
SE	82	-0.	7.0000E-03	2.8000E-03	1.8000E-03	1.8000E-03
BR	81	-0.	4.5000E-03	1.4000E-03	9.0000E-04	9.0000E-04
KR	83	-0.	1.1700E-02	6.7000E-03	2.9000E-03	2.9000E-03
KR	84	-0.	1.9500E-02	1.2700E-02	4.7000E-03	4.7000E-03
KR	85	2.0740E-09	5.8000E-03	3.0000E-03	5.5000E-03	5.5000E-03
KR	86	-0.	3.2700E-02	2.4500E-02	7.6000E-03	7.6000E-03
RB	85	-0.	1.9500E-02	10.0000E-03	4.1200E-03	4.1200E-03
RB	87	-0.	4.5600E-02	2.4900E-02	9.2000E-03	9.2000E-03
SR	88	-0.	5.3700E-02	3.5700E-02	1.4200E-02	1.4200E-02
SR	90	-0.	6.4300E-02	5.9000E-02	2.3100E-02	2.3100E-02
Y	89	-0.	5.8600E-02	4.7900E-02	1.7100E-02	1.7100E-02
ZR	91	-0.	6.5300E-02	5.8400E-02	2.6100E-02	2.6100E-02
ZR	92	-0.	6.7000E-02	6.0300E-02	3.1400E-02	3.1400E-02
ZR	93	-0.	7.1000E-02	6.5000E-02	3.9700E-02	3.9700E-02
ZR	94	-0.	6.8200E-02	6.4000E-02	4.4800E-02	4.4800E-02
ZR	96	-0.	5.6000E-02	6.3300E-02	5.1700E-02	5.1700E-02
MO	95	-0.	6.1100E-02	6.2700E-02	5.0300E-02	4.0000E-02
MO	97	-0.	5.3700E-02	6.0900E-02	5.6500E-02	5.6500E-02
MO	98	-0.	5.1800E-02	5.7800E-02	5.8900E-02	5.8900E-02
MO	100	-0.	4.4100E-02	6.3000E-02	7.1000E-02	7.1000E-02
TC	99	-0.	4.9600E-02	6.1000E-02	6.1000E-02	6.2000E-02
RU	101	-0.	3.0000E-02	5.0000E-02	5.9100E-02	5.9100E-02
RU	102	-0.	2.3700E-02	4.1000E-02	5.9900E-02	5.9900E-02
RU	104	-0.	9.6000E-03	1.8000E-02	5.9300E-02	5.9300E-02
RH	103	-0.	1.6000E-02	2.9000E-02	5.6000E-02	6.2000E-02
PD	105	-0.	5.0000E-03	9.0000E-03	3.9000E-02	3.9000E-02
PD	106	-0.	2.4000E-03	3.8000E-03	4.5700E-02	4.5700E-02
PD	107	-0.	1.5000E-03	1.9000E-03	3.0000E-02	3.0000E-02
PD	108	-0.	6.0000E-04	7.0000E-04	2.0000E-02	2.0000E-02
PD	110	-0.	3.0000E-04	2.4000E-04	7.0000E-03	7.0000E-03
AG	109	-0.	4.4000E-04	3.0000E-04	1.4000E-02	1.4000E-02
CD	111	-0.	2.5000E-04	1.9000E-04	2.7000E-03	2.7000E-03
CD	112	-0.	2.0000E-04	10.0000E-05	10.0000E-04	10.0000E-04
CD	113	-0.	1.9000E-04	1.2000E-04	7.0000E-04	4.0000E-03
CD	114	-0.	2.0000E-04	10.0000E-05	5.0000E-04	5.0000E-04
IN	115	-0.	2.0000E-04	1.1000E-04	4.0000E-04	4.0000E-04
TE	126	-0.	2.4000E-03	5.0000E-04	2.5000E-03	2.5000E-03
TE	128	-0.	10.0000E-03	3.7000E-03	8.0000E-03	8.0000E-03
TE	130	-0.	2.7000E-02	2.0000E-02	2.5000E-02	2.5000E-02
I	127	-0.	6.0000E-03	1.3000E-03	3.9000E-03	3.9000E-03
I	129	-0.	2.0000E-02	10.0000E-03	1.4000E-02	1.4000E-02
XE	131	-0.	3.7400E-02	3.2800E-02	3.7900E-02	3.4000E-02
XE	132	-0.	5.1000E-02	4.9200E-02	5.2900E-02	5.2900E-02
XE	134	-0.	6.5400E-02	8.6400E-02	7.4800E-02	7.4800E-02
XE	135	2.0928E-05	6.0000E-02	6.4100E-02	7.4300E-02	6.5000E-02
XE	136	-0.	6.6300E-02	7.1000E-02	7.1600E-02	7.1600E-02
CS	133	-0.	6.1800E-02	7.4300E-02	6.9200E-02	6.0000E-02
CS	135	-0.	3.0000E-04	1.3000E-02	-0.	-0.
CS	137	-0.	7.1600E-02	6.8100E-02	6.6300E-02	6.6300E-02
BA	138	-0.	6.8000E-02	5.7400E-02	6.3100E-02	6.3100E-02
LA	139	-0.	6.4000E-02	6.5500E-02	6.6100E-02	6.6100E-02
CE	140	-0.	6.4700E-02	6.4400E-02	7.3600E-02	7.3600E-02
CE	142	-0.	6.8300E-02	6.0100E-02	6.6900E-02	6.6900E-02
PR	141	-0.	6.4000E-02	6.4000E-02	6.0200E-02	6.0200E-02
CE	144	2.8248E-08	4.5000E-02	6.1000E-02	5.2900E-02	4.8000E-02
ND	143	-0.	6.4500E-02	6.0300E-02	6.3100E-02	5.6000E-02
ND	144	-0.	9.2000E-03	10.0000E-04	1.9000E-02	1.9000E-02
ND	145	-0.	3.4700E-02	4.0000E-02	4.2400E-02	3.6000E-02
ND	146	-0.	2.6300E-02	3.2000E-02	3.5300E-02	3.5300E-02
ND	147	7.2275E-07	0.	2.7000E-02	2.2000E-02	2.2000E-02
ND	148	-0.	1.3400E-02	1.7100E-02	2.3000E-02	2.3000E-02
ND	150	-0.	5.6000E-03	7.4000E-03	1.3800E-02	1.3800E-02
PM	147	8.4479E-09	2.1000E-02	2.0000E-03	3.8000E-03	3.8000E-03
PM	148M	1.9760E-07	0.	0.	0.	0.
PM	148	1.4857E-06	0.	0.	0.	0.
PM	149	3.6260E-06	7.7000E-03	1.3000E-02	1.4000E-02	1.2000E-02
SM	147	1.6910E-19	4.5000E-03	2.2000E-03	9.8000E-03	9.8000E-03
SM	148	-0.	0.	0.	1.1900E-03	1.1900E-03
SM	149	-0.	3.0000E-04	2.0000E-03	4.9000E-03	4.9000E-03
SM	150	-0.	0.	0.	0.	0.
SM	151	2.7470E-10	3.3500E-03	5.0000E-03	1.1700E-02	5.0000E-02
SM	152	-0.	2.2000E-03	2.8500E-03	8.8000E-03	3.0000E-03
SM	154	-0.	4.5000E-04	9.0800E-04	4.0000E-03	4.0000E-03
EU	153	-0.	1.3000E-03	1.7000E-03	3.4000E-03	2.0000E-03
EU	154	1.3728E-09	0.	0.	0.	0.
EU	155	1.1568E-08	2.0000E-04	3.3000E-04	3.0000E-03	3.0000E-03
GD	154	-0.	0.	0.	0.	0.
GD	155	-0.	0.	2.0000E-04	2.9000E-03	2.9000E-03
GD	156	-0.	1.1000E-04	2.6000E-04	4.7800E-03	4.7800E-03
GD	157	-0.	0.	1.5000E-04	0.	0.
GD	158	-0.	1.0000E-05	8.4000E-05	6.1500E-04	6.1500E-04
TB	159	-0.	5.0000E-06	1.0000E-05	2.1000E-04	2.1000E-04

TABLE N° 8

MATERIAL	DECAY CONSTANT	NORMALISED MAXIMUM FISSION YIELDS FROM U233	FROM U235	FROM PU239	FROM PU241
SE 82	-0.	6.8316E-03	2.6899E-03	1.6723E-03	1.6814E-03
BR 81	-0.	4.3917E-03	1.3450E-03	8.3615E-04	8.4072E-04
KR 83	-0.	1.1419E-02	6.4366E-03	2.6943E-03	2.7090E-03
KR 84	-0.	1.9031E-02	1.2201E-02	4.3666E-03	4.3904E-03
KR 85	2.0740E-09	5.6605E-03	2.8821E-03	5.1098E-03	5.1378E-03
KR 86	-0.	3.1913E-02	2.3537E-02	7.0609E-03	7.0994E-03
RB 85	-0.	1.9031E-02	9.6068E-03	3.8277E-03	3.8486E-03
RB 87	-0.	4.4503E-02	2.3921E-02	8.5473E-03	8.5941E-03
SR 88	-0.	5.2408E-02	3.4296E-02	1.3193E-02	1.3265E-02
SR 90	-0.	6.2753E-02	5.6680E-02	2.1461E-02	2.1579E-02
Y 89	-0.	5.7190E-02	4.6017E-02	1.5887E-02	1.5974E-02
ZR 91	-0.	6.3729E-02	5.6104E-02	2.4248E-02	2.4381E-02
ZR 92	-0.	6.5388E-02	5.7929E-02	2.9172E-02	2.9332E-02
ZR 93	-0.	6.9292E-02	6.2444E-02	3.6884E-02	3.7085E-02
ZR 94	-0.	6.6559E-02	6.1484E-02	4.1622E-02	4.1849E-02
ZR 96	-0.	5.4653E-02	6.0811E-02	4.8032E-02	4.8295E-02
MO 95	-0.	5.9630E-02	6.0235E-02	4.6732E-02	3.7365E-02
MO 97	-0.	5.2408E-02	5.8506E-02	5.2492E-02	5.2779E-02
MO 98	-0.	5.0554E-02	5.5527E-02	5.4722E-02	5.5021E-02
MO 100	-0.	4.3039E-02	6.0523E-02	6.5963E-02	6.6324E-02
TC 99	-0.	4.8407E-02	5.8602E-02	5.6673E-02	5.7916E-02
RU 101	-0.	2.9278E-02	4.8034E-02	5.4907E-02	5.5207E-02
RU 102	-0.	2.3130E-02	3.9388E-02	5.5651E-02	5.5955E-02
RU 104	-0.	9.3690E-03	1.7292E-02	5.5093E-02	5.5394E-02
RH 103	-0.	1.5615E-02	2.7860E-02	5.2027E-02	5.7916E-02
PD 105	-0.	4.8797E-03	8.6461E-03	3.6233E-02	3.6431E-02
PD 106	-0.	2.3423E-03	3.6506E-03	4.2458E-02	4.2690E-02
PD 107	-0.	1.4639E-03	1.8253E-03	2.7872E-02	2.8024E-02
PD 108	-0.	5.8556E-04	6.7248E-04	1.8581E-02	1.8683E-02
PD 110	-0.	2.9278E-04	2.3056E-04	6.5034E-03	6.5390E-03
AG 109	-0.	4.2941E-04	2.8821E-04	1.3007E-02	1.3078E-02
CD 111	-0.	2.4399E-04	1.8253E-04	2.5085E-03	2.5222E-03
CD 112	-0.	1.9519E-04	9.6068E-05	9.2906E-04	9.3414E-04
CD 113	-0.	1.8543E-04	1.1528E-04	6.5034E-04	3.7365E-03
CD 114	-0.	1.9519E-04	9.6068E-05	4.6453E-04	4.6707E-04
IN 115	-0.	1.9519E-04	1.0568E-04	3.7162E-04	3.7365E-04
TE 126	-0.	2.3423E-03	4.8034E-04	2.3226E-03	2.3353E-03
TE 128	-0.	9.7594E-03	3.5545E-03	7.4325E-03	7.4731E-03
TE 130	-0.	2.6350E-02	1.9214E-02	2.3226E-02	2.3353E-02
I 127	-0.	5.8556E-03	1.2489E-03	3.6233E-03	3.6431E-03
I 129	-0.	1.9519E-02	9.6068E-03	1.3007E-02	1.3078E-02
XE 131	-0.	3.6500E-02	3.1510E-02	3.5211E-02	3.1761E-02
XE 132	-0.	4.9773E-02	4.7266E-02	4.9147E-02	4.9416E-02
XE 134	-0.	6.3827E-02	8.3003E-02	6.9494E-02	6.9873E-02
XE 135	2.0928E-05	5.8556E-02	6.1580E-02	6.9029E-02	6.0719E-02
XE 136	-0.	6.4705E-02	6.8209E-02	6.6521E-02	6.6884E-02
CS 133	-0.	6.0313E-02	7.1379E-02	6.4291E-02	5.6048E-02
CS 135	-0.	2.9278E-04	1.2489E-02	-0.	-0.
CS 137	-0.	6.9877E-02	6.5423E-02	6.1597E-02	6.1933E-02
BA 138	-0.	6.6364E-02	5.5143E-02	5.8624E-02	5.8944E-02
LA 139	-0.	6.2460E-02	6.2925E-02	6.1411E-02	6.1746E-02
CE 140	-0.	6.3143E-02	6.1868E-02	6.8379E-02	6.8752E-02
CE 142	-0.	6.6657E-02	5.7737E-02	6.2154E-02	6.2494E-02
PR 141	-0.	6.2460E-02	6.1484E-02	5.5929E-02	5.6235E-02
CE 144	2.8248E-08	4.3917E-02	5.8602E-02	4.9147E-02	4.4839E-02
ND 143	-0.	6.2948E-02	5.7929E-02	5.8624E-02	5.2312E-02
ND 144	-0.	8.9787E-03	9.6068E-04	1.7652E-02	1.7749E-02
ND 145	-0.	3.3865E-02	3.8427E-02	3.9392E-02	3.3629E-02
ND 146	-0.	2.5667E-02	3.0742E-02	3.2796E-02	3.2975E-02
ND 147	7.2275E-07	0.	2.5938E-02	2.0439E-02	2.0551E-02
ND 148	-0.	1.3078E-02	1.6428E-02	2.1368E-02	2.1485E-02
ND 150	-0.	5.4653E-03	7.1091E-03	1.2821E-02	1.2891E-02
PM 147	8.4479E-09	2.0495E-02	1.9214E-03	3.5304E-03	3.5497E-03
PM 148M	1.9760E-07	0.	0.	0.	0.
PM 148	1.4857E-06	0.	0.	0.	0.
PM 149	3.6260E-06	7.5147E-03	1.2489E-02	1.3007E-02	1.1210E-02
SM 147	1.6910E-19	4.3917E-03	2.1135E-03	9.1048E-03	9.1545E-03
SM 148	-0.	0.	0.	1.1056E-03	1.1116E-03
SM 149	-0.	2.9278E-04	1.9214E-03	4.5524E-03	4.5773E-03
SM 150	-0.	0.	0.	0.	0.
SM 151	2.7470E-10	3.2694E-03	4.8034E-03	1.0870E-02	4.6707E-02
SM 152	-0.	2.1471E-03	2.7379E-03	8.1757E-03	2.8024E-03
SM 154	-0.	4.3917E-04	8.7230E-04	3.7162E-03	3.7365E-03
EU 153	-0.	1.2687E-03	1.6332E-03	3.1588E-03	1.8683E-03
EU 154	1.3728E-09	0.	0.	0.	0.
EU 155	1.1568E-08	1.9519E-04	3.1703E-04	2.7872E-03	2.8024E-03
GD 154	-0.	0.	0.	0.	0.
GD 155	-0.	0.	1.9214E-04	2.6943E-03	2.7090E-03
GD 156	-0.	1.0735E-04	2.4978E-04	4.4409E-03	4.4652E-03
GD 157	-0.	0.	1.4410E-04	0.	0.
GD 158	-0.	9.7594E-06	8.0697E-05	5.7137E-04	5.7449E-04
TB 159	-0.	4.8797E-06	9.6068E-06	1.9510E-04	1.9617E-04

TABLE N° 9

MATERIAL		DECAY CONSTANT	MINIMUM FISSION YIELDS FROM U233	FROM U235	FROM PU239	FROM PU241
SE	82	-0.	7.0000E-03	2.8000E-03	1.8000E-03	1.8000E-03
BR	81	-0.	4.5000E-03	1.4000E-03	9.0000E-04	9.0000E-04
KR	83	-0.	1.1400E-02	5.4400E-03	2.9000E-03	2.9000E-03
KR	84	-0.	1.9000E-02	10.0000E-03	4.7000E-03	4.7000E-03
KR	85	2.0740E-09	5.6000E-03	2.9300E-03	1.2700E-03	1.2700E-03
KR	86	-0.	3.1800E-02	2.0200E-02	7.5000E-03	7.5000E-03
RB	85	-0.	1.9300E-02	10.0000E-03	-0.	-0.
RB	87	-0.	4.5600E-02	2.4900E-02	9.2000E-03	9.2000E-03
SR	88	-0.	5.3000E-02	3.5700E-02	1.3900E-02	1.3900E-02
SR	90	-0.	4.5600E-02	5.7700E-02	2.2500E-02	2.2500E-02
Y	89	-0.	5.8600E-02	4.7900E-02	1.7100E-02	1.7100E-02
ZR	91	-0.	6.4300E-02	5.8400E-02	2.6100E-02	2.6100E-02
ZR	92	-0.	6.6400E-02	6.0300E-02	3.1400E-02	3.1400E-02
ZR	93	-0.	6.9800E-02	6.4500E-02	3.9700E-02	3.9700E-02
ZR	94	-0.	6.6800E-02	6.4000E-02	4.4800E-02	4.4800E-02
ZR	96	-0.	5.5800E-02	6.3300E-02	5.1700E-02	5.1700E-02
MO	95	-0.	6.1000E-02	6.2700E-02	5.0300E-02	4.0000E-02
MO	97	-0.	5.3500E-02	6.0900E-02	5.6500E-02	5.6500E-02
MO	98	-0.	5.1500E-02	5.7800E-02	5.8900E-02	5.8900E-02
MO	100	-0.	4.4000E-02	6.3000E-02	7.1000E-02	7.1000E-02
TC	99	-0.	4.9600E-02	6.1000E-02	6.1000E-02	6.2000E-02
RU	101	-0.	2.9100E-02	5.0000E-02	5.9100E-02	5.9100E-02
RU	102	-0.	2.2200E-02	4.1000E-02	5.9900E-02	5.9900E-02
RU	104	-0.	9.4000E-03	1.8000E-02	5.9300E-02	5.9300E-02
RH	103	-0.	1.6000E-02	2.9000E-02	5.6000E-02	6.2000E-02
PD	105	-0.	5.0000E-03	9.0000E-03	3.9000E-02	3.9000E-02
PD	106	-0.	2.4000E-03	3.8000E-03	4.5700E-02	4.5700E-02
PD	107	-0.	1.5000E-03	1.9000E-03	3.0000E-02	3.0000E-02
PD	108	-0.	6.0000E-04	7.0000E-04	2.0000E-02	2.0000E-02
PD	110	-0.	3.0000E-04	2.4000E-04	7.0000E-03	7.0000E-03
AG	109	-0.	4.4000E-04	3.0000E-04	1.4000E-02	1.4000E-02
CD	111	-0.	2.5000E-04	1.9000E-04	2.7000E-03	2.7000E-03
CD	112	-0.	2.0000E-04	10.0000E-05	10.0000E-04	10.0000E-04
CD	113	-0.	1.9000E-04	1.2000E-04	7.0000E-04	4.0000E-03
CD	114	-0.	2.0000E-04	10.0000E-05	5.0000E-04	5.0000E-04
IN	115	-0.	2.0000E-04	9.9990E-05	4.0000E-04	4.0000E-04
TE	126	-0.	2.4000E-03	5.0000E-04	2.5000E-03	2.5000E-03
TE	128	-0.	10.0000E-03	3.7000E-03	8.0000E-03	8.0000E-03
TE	130	-0.	2.7000E-02	2.0000E-02	2.5000E-02	2.5000E-02
I	127	-0.	6.0000E-03	1.3000E-03	3.9000E-03	3.9000E-03
I	129	-0.	2.0000E-02	8.0000E-03	1.4000E-02	1.4000E-02
XE	131	-0.	3.3900E-02	2.9300E-02	2.7100E-02	3.4000E-02
XE	132	-0.	4.6400E-02	4.3800E-02	3.7900E-02	3.7900E-02
XE	134	-0.	5.9500E-02	8.0600E-02	5.3700E-02	5.3700E-02
XE	135	2.0928E-05	6.0000E-02	6.0500E-02	7.2700E-02	6.5000E-02
XE	136	-0.	6.6300E-02	6.4600E-02	6.5700E-02	6.5700E-02
CS	133	-0.	5.2000E-02	6.5900E-02	4.9700E-02	6.0000E-02
CS	135	-0.	-0.	-0.	-0.	-0.
CS	137	-0.	5.3900E-02	5.9000E-02	4.9400E-02	4.9400E-02
BA	138	-0.	6.8000E-02	5.7400E-02	5.3800E-02	5.3800E-02
LA	139	-0.	5.9100E-02	6.5500E-02	6.6100E-02	6.6100E-02
CE	140	-0.	5.4500E-02	6.3000E-02	5.5200E-02	5.5200E-02
CE	142	-0.	5.5000E-02	5.8000E-02	4.9700E-02	4.9700E-02
PR	141	-0.	5.5700E-02	5.6000E-02	4.5000E-02	4.5000E-02
CE	144	2.8248E-08	3.6900E-02	6.0000E-02	3.6000E-02	4.8000E-02
ND	143	-0.	5.0000E-02	5.4000E-02	4.4900E-02	5.6000E-02
ND	144	-0.	1.1000E-03	-0.	-0.	-0.
ND	145	-0.	2.8200E-02	3.6200E-02	3.1200E-02	3.6000E-02
ND	146	-0.	2.2000E-02	2.8100E-02	2.5700E-02	2.5700E-02
ND	147	7.2275E-07	0.	2.6000E-02	2.2000E-02	2.2000E-02
ND	148	-0.	1.0300E-02	1.6400E-02	1.7100E-02	1.7100E-02
ND	150	-0.	4.8000E-03	6.5800E-03	1.0100E-02	1.0100E-02
PM	147	8.4479E-09	1.5300E-02	-0.	-0.	-0.
PM	148M	1.9760E-07	0.	0.	0.	0.
PM	148	1.4857E-06	0.	0.	0.	0.
PM	149	3.6260E-06	7.7000E-03	1.3000E-02	1.4000E-02	1.2000E-02
SM	147	1.6910E-19	-0.	-0.	3.4000E-03	3.4000E-03
SM	148	-0.	-0.	-0.	-0.	-0.
SM	149	-0.	-0.	-0.	-0.	-0.
SM	150	-0.	0.	0.	0.	0.
SM	151	2.7470E-10	2.6000E-03	4.4000E-03	7.9000E-03	5.0000E-02
SM	152	-0.	1.7000E-03	2.7900E-03	6.1600E-03	3.0000E-03
SM	154	-0.	3.7000E-04	7.7000E-04	2.9000E-03	2.9000E-03
EU	153	-0.	1.3000E-03	1.6900E-03	3.4000E-03	2.0000E-03
EU	154	1.3728E-09	0.	0.	0.	0.
EU	155	1.1568E-08	-0.	3.0000E-04	2.5400E-05	2.5400E-05
GD	154	-0.	0.	0.	0.	0.
GD	155	-0.	-0.	-0.	-0.	-0.
GD	156	-0.	1.1000E-04	1.4000E-04	8.0000E-04	8.0000E-04
GD	157	-0.	0.	1.5000E-04	0.	0.
GD	158	-0.	1.0000E-05	2.0000E-06	6.1500E-04	6.1500E-04
TB	159	-0.	5.0000E-06	1.0000E-05	2.1000E-04	2.1000E-04

TABLE N° 10

MATERIAL	DECAY CONSTANT	NORMALISED MINIMUM FISSION YIELDS FROM U233	FROM U235	FROM PU239	FROM PU241
SE 82	-0.	7.4303E-03	2.8325E-03	1.9207E-03	1.8488E-03
BR 81	-0.	4.7766E-03	1.4163E-03	9.6037E-04	9.2439E-04
KR 83	-0.	1.2101E-02	5.5031E-03	3.0945E-03	2.9786E-03
KR 84	-0.	2.0168E-02	1.0116E-02	5.0153E-03	4.8274E-03
KR 85	2.0740E-09	5.9442E-03	2.9640E-03	1.3552E-03	1.3044E-03
KR 86	-0.	3.3755E-02	2.0434E-02	8.0031E-03	7.7033E-03
RB 85	-0.	2.0486E-02	1.0116E-02	-0.	-0.
RB 87	-0.	4.8403E-02	2.5189E-02	9.8171E-03	9.4494E-03
SR 88	-0.	5.6258E-02	3.6114E-02	1.4832E-02	1.4277E-02
SR 90	-0.	4.8403E-02	5.8370E-02	2.4009E-02	2.3110E-02
Y 89	-0.	6.2202E-02	4.8456E-02	1.8247E-02	1.7563E-02
ZR 91	-0.	6.8253E-02	5.9078E-02	2.7851E-02	2.6807E-02
ZR 92	-0.	7.0482E-02	6.1000E-02	3.3506E-02	3.2251E-02
ZR 93	-0.	7.4091E-02	6.5249E-02	4.2363E-02	4.0776E-02
ZR 94	-0.	7.0906E-02	6.4743E-02	4.7805E-02	4.6014E-02
ZR 96	-0.	5.9230E-02	6.4035E-02	5.5168E-02	5.3101E-02
MO 95	-0.	6.4750E-02	6.3428E-02	5.3674E-02	4.1084E-02
MO 97	-0.	5.6789E-02	6.1607E-02	6.0290E-02	5.8031E-02
MO 98	-0.	5.4666E-02	5.8471E-02	6.2851E-02	6.0496E-02
MO 100	-0.	4.6705E-02	6.3731E-02	7.5762E-02	7.2924E-02
TC 99	-0.	5.2649E-02	6.1708E-02	6.5092E-02	6.3681E-02
RU 101	-0.	3.0889E-02	5.0580E-02	6.3064E-02	6.0702E-02
RU 102	-0.	2.3565E-02	4.1476E-02	6.3918E-02	6.1524E-02
RU 104	-0.	9.9778E-03	1.8209E-02	6.3278E-02	6.0907E-02
RH 103	-0.	1.6984E-02	2.9337E-02	5.9756E-02	6.3681E-02
PD 105	-0.	5.3074E-03	9.1045E-03	4.1616E-02	4.0057E-02
PD 106	-0.	2.5475E-03	3.8441E-03	4.8765E-02	4.6939E-02
PD 107	-0.	1.5922E-03	1.9221E-03	3.2012E-02	3.0813E-02
PD 108	-0.	6.3688E-04	7.0813E-04	2.1342E-02	2.0542E-02
PD 110	-0.	3.1844E-04	2.4279E-04	7.4695E-03	7.1897E-03
AG 109	-0.	4.6705E-04	3.0348E-04	1.4939E-02	1.4379E-02
CD 111	-0.	2.6537E-04	1.9221E-04	2.8811E-03	2.7732E-03
CD 112	-0.	2.1229E-04	1.0116E-04	1.0671E-03	1.0271E-03
CD 113	-0.	2.0168E-04	1.2139E-04	7.4695E-04	4.1084E-03
CD 114	-0.	2.1229E-04	1.0116E-04	5.3354E-04	5.1355E-04
IN 115	-0.	2.1229E-04	1.0115E-04	4.2683E-04	4.1084E-04
TE 126	-0.	2.5475E-03	5.0580E-04	2.6677E-03	2.5678E-03
TE 128	-0.	1.0615E-02	3.7429E-03	8.5366E-03	8.2168E-03
TE 130	-0.	2.8660E-02	2.0232E-02	2.6677E-02	2.5678E-02
I 127	-0.	6.3688E-03	1.3151E-03	4.1616E-03	4.0057E-03
I 129	-0.	2.1229E-02	8.0929E-03	1.4939E-02	1.4379E-02
XE 131	-0.	3.5984E-02	2.9640E-02	2.8918E-02	3.4922E-02
XE 132	-0.	4.9252E-02	4.4308E-02	4.0442E-02	3.8927E-02
XE 134	-0.	6.3158E-02	8.1536E-02	5.7302E-02	5.5156E-02
XE 135	2.0928E-05	6.3688E-02	6.1202E-02	7.7576E-02	6.6762E-02
XE 136	-0.	7.0376E-02	6.5350E-02	7.0107E-02	6.7481E-02
CS 133	-0.	5.5197E-02	6.6665E-02	5.3034E-02	6.1626E-02
CS 135	-0.	-0.	-0.	-0.	-0.
CS 137	-0.	5.7213E-02	5.9685E-02	5.2714E-02	5.0739E-02
BA 138	-0.	7.2180E-02	5.8066E-02	5.7409E-02	5.5258E-02
LA 139	-0.	6.2733E-02	6.6260E-02	7.0534E-02	6.7892E-02
CE 140	-0.	5.7850E-02	6.3731E-02	5.8903E-02	5.6696E-02
CE 142	-0.	5.8381E-02	5.8673E-02	5.3034E-02	5.1047E-02
PR 141	-0.	5.9124E-02	5.6650E-02	4.8018E-02	4.6220E-02
CE 144	2.8248E-08	3.9168E-02	6.0696E-02	3.8415E-02	4.9301E-02
ND 143	-0.	5.3074E-02	5.4627E-02	4.7912E-02	5.7518E-02
ND 144	-0.	1.1676E-03	-0.	-0.	-0.
ND 145	-0.	2.9934E-02	3.6620E-02	3.3293E-02	3.6976E-02
ND 146	-0.	2.3352E-02	2.8426E-02	2.7424E-02	2.6397E-02
ND 147	7.2275E-07	0.	2.6302E-02	2.3476E-02	2.2596E-02
ND 148	-0.	1.0933E-02	1.6590E-02	1.8247E-02	1.7563E-02
ND 150	-0.	5.0951E-03	6.6564E-03	1.0777E-02	1.0374E-02
PM 147	8.4479E-09	1.6241E-02	-0.	-0.	-0.
PM 148M	1.9760E-07	0.	0.	0.	0.
PM 148	1.4857E-06	0.	0.	0.	0.
PM 149	3.6260E-06	8.1733E-03	1.3151E-02	1.4939E-02	1.2325E-02
SM 147	1.6910E-19	-0.	-0.	3.6281E-03	3.4922E-03
SM 148	-0.	-0.	-0.	-0.	-0.
SM 149	-0.	-0.	-0.	-0.	-0.
SM 150	-0.	0.	0.	0.	0.
SM 151	2.7470E-10	2.7598E-03	4.4511E-03	8.4299E-03	5.1355E-02
SM 152	-0.	1.8045E-03	2.8224E-03	6.5732E-03	3.0813E-03
SM 154	-0.	3.9274E-04	7.7894E-04	3.0945E-03	2.9786E-03
EU 153	-0.	1.3799E-03	1.7096E-03	3.6281E-03	2.0542E-03
EU 154	1.3728E-09	0.	0.	0.	0.
EU 155	1.1568E-08	-0.	3.0348E-04	2.7104E-05	2.6088E-05
GD 154	-0.	0.	0.	0.	0.
GD 155	-0.	-0.	-0.	-0.	-0.
GD 156	-0.	1.1676E-04	1.4163E-04	8.5366E-04	8.2168E-04
GD 157	-0.	0.	1.5174E-04	0.	0.
GD 158	-0.	1.0615E-05	2.0232E-06	6.5625E-04	6.3167E-04
TB 159	-0.	5.3074E-06	1.0116E-05	2.2409E-04	2.1569E-04

TABLE N° 11

MATERIAL	DECAY CONSTANT	CUMULATIVE FISSION YIELDS FROM U233	FROM U235	FROM PU239	FROM PU241
SE 82	-0.	7.0000E-03	2.8000E-03	1.8000E-03	1.8000E-03
BR 81	-0.	4.5000E-03	1.4000E-03	9.0000E-04	9.0000E-04
KR 83	-0.	1.1700E-02	5.4400E-03	2.9000E-03	2.9000E-03
KR 84	-0.	1.9500E-02	10.0000E-03	4.7000E-03	4.7000E-03
KR 85	2.0740E-09	5.8000E-03	2.9300E-03	1.2700E-03	1.2700E-03
KR 86	-0.	3.2700E-02	2.0200E-02	7.6000E-03	7.6000E-03
RB 85	-0.	2.5100E-02	1.3000E-02	5.3900E-03	5.3900E-03
RB 87	-0.	4.5600E-02	2.4900E-02	9.2000E-03	9.2000E-03
SR 88	-0.	5.3700E-02	3.5700E-02	1.4200E-02	1.4200E-02
SR 90	-0.	6.4300E-02	5.7700E-02	2.2500E-02	2.2500E-02
Y 89	-0.	5.8600E-02	4.7900E-02	1.7100E-02	1.7100E-02
ZR 91	-0.	6.4300E-02	5.8400E-02	2.6100E-02	2.6100E-02
ZR 92	-0.	6.6400E-02	6.0300E-02	3.1400E-02	3.1400E-02
ZR 93	-0.	7.0000E-02	6.4500E-02	3.9700E-02	3.9700E-02
ZR 94	-0.	6.6800E-02	6.4000E-02	4.4800E-02	4.4800E-02
ZR 96	-0.	5.5800E-02	6.3300E-02	5.1700E-02	5.1700E-02
MO 95	-0.	6.1100E-02	6.2700E-02	5.0300E-02	4.0000E-02
MO 97	-0.	5.3700E-02	6.0900E-02	5.6500E-02	5.6500E-02
MO 98	-0.	5.1500E-02	5.7800E-02	5.8900E-02	5.8900E-02
MO 100	-0.	4.4000E-02	6.3000E-02	7.1000E-02	7.1000E-02
TC 99	-0.	4.9600E-02	6.1000E-02	6.1000E-02	6.2000E-02
RU 101	-0.	2.9100E-02	5.0000E-02	5.9100E-02	5.9100E-02
RU 102	-0.	2.2200E-02	4.1000E-02	6.0000E-02	6.0000E-02
RU 104	-0.	9.4000E-03	1.8000E-02	5.9300E-02	5.9300E-02
RH 103	-0.	1.6000E-02	2.9000E-02	5.6000E-02	6.2000E-02
PD 105	-0.	5.0000E-03	9.0000E-03	3.9000E-02	3.9000E-02
PD 106	-0.	2.4000E-03	3.8000E-03	4.5700E-02	4.5700E-02
PD 107	-0.	1.5000E-03	1.9000E-03	3.0000E-02	3.0000E-02
PD 108	-0.	6.0000E-04	7.0000E-04	2.0000E-02	2.0000E-02
PD 110	-0.	3.0000E-04	2.4000E-04	7.0000E-03	7.0000E-03
AG 109	-0.	4.4000E-04	3.0000E-04	1.4000E-02	1.4000E-02
CD 111	-0.	2.5000E-04	1.9000E-04	2.7000E-03	2.7000E-03
CD 112	-0.	2.0000E-04	10.0000E-05	10.0000E-04	10.0000E-04
CD 113	-0.	1.9000E-04	1.2000E-04	7.0000E-04	4.0000E-03
CD 114	-0.	2.0000E-04	10.0000E-05	5.0000E-04	5.0000E-04
IN 115	-0.	2.0000E-04	10.0000E-05	4.0000E-04	4.0000E-04
TE 126	-0.	2.4000E-03	5.0000E-04	2.5000E-03	2.5000E-03
TE 128	-0.	10.0000E-03	3.7000E-03	8.0000E-03	8.0000E-03
TE 130	-0.	2.7000E-02	2.0000E-02	2.5000E-02	2.5000E-02
I 127	-0.	6.0000E-03	1.3000E-03	3.9000E-03	3.9000E-03
I 129	-0.	2.0000E-02	8.0000E-03	1.4000E-02	1.4000E-02
XE 131	-0.	3.5600E-02	3.0200E-02	2.7700E-02	3.4000E-02
XE 132	-0.	4.6400E-02	4.3800E-02	5.2600E-02	5.2600E-02
XE 134	-0.	5.9500E-02	8.0600E-02	7.4700E-02	7.4700E-02
XE 135	2.0928E-05	6.0000E-02	6.4100E-02	7.3500E-02	6.5000E-02
XE 136	-0.	6.6300E-02	6.4600E-02	6.6300E-02	6.6300E-02
CS 133	-0.	5.7000E-02	7.0300E-02	5.9700E-02	6.0000E-02
CS 135	-0.	6.0300E-02	6.7000E-02	6.2600E-02	6.2600E-02
CS 137	-0.	6.5800E-02	6.1500E-02	6.6300E-02	6.6300E-02
BA 138	-0.	6.8000E-02	5.7400E-02	6.3100E-02	6.3100E-02
LA 139	-0.	6.4000E-02	6.5500E-02	6.6100E-02	6.6100E-02
CE 140	-0.	6.4700E-02	6.4400E-02	5.6000E-02	5.6000E-02
CE 142	-0.	6.8300E-02	6.0100E-02	5.0100E-02	5.0100E-02
PR 141	-0.	6.4000E-02	6.4000E-02	4.5000E-02	4.5000E-02
CE 144	2.8248E-08	4.5000E-02	6.0000E-02	4.4000E-02	4.8000E-02
ND 143	-0.	5.7000E-02	5.7100E-02	4.9000E-02	5.6000E-02
ND 144	-0.	4.6100E-02	5.6200E-02	3.9300E-02	3.9300E-02
ND 145	-0.	3.4700E-02	3.9800E-02	3.6300E-02	3.6000E-02
ND 146	-0.	2.6300E-02	3.0700E-02	2.6000E-02	2.6000E-02
ND 147	7.2275E-07	0.	2.6000E-02	2.2000E-02	2.2000E-02
ND 148	-0.	1.3400E-02	1.7000E-02	1.7300E-02	1.7300E-02
ND 150	-0.	5.6000E-03	6.7000E-03	1.0100E-02	1.0100E-02
PM 147	8.4479E-09	1.7800E-02	2.5200E-02	2.2600E-02	2.2000E-02
PM 148M	1.9760E-07	0.	0.	0.	0.
PM 148	1.4857E-06	0.	0.	0.	0.
PM 149	3.6260E-06	7.7000E-03	1.3000E-02	1.4000E-02	1.2000E-02
SM 147	1.6910E-19	1.8400E-02	2.3800E-02	2.4500E-02	2.4000E-02
SM 148	-0.	0.	0.	1.5200E-02	1.5200E-02
SM 149	-0.	7.6000E-03	1.1300E-02	1.6200E-02	1.2000E-02
SM 150	-0.	0.	0.	0.	0.
SM 151	2.7470E-10	3.3500E-03	4.4000E-03	8.8000E-03	5.0000E-03
SM 152	-0.	1.9000E-03	2.8100E-03	7.4000E-03	3.0000E-03
SM 154	-0.	4.5000E-04	7.7000E-04	2.9000E-03	2.9000E-03
EU 153	-0.	1.3000E-03	1.6900E-03	3.4000E-03	2.0000E-03
EU 154	1.3728E-09	0.	0.	0.	0.
EU 155	5.4950E-09	2.0000E-04	3.3000E-04	1.6000E-03	10.0000E-04
GD 154	-0.	0.	0.	0.	0.
GD 155	-0.	1.5000E-04	5.0000E-04	3.0000E-03	3.0000E-03
GD 156	-0.	1.1000E-04	1.4000E-04	1.1000E-03	1.1000E-03
GD 157	-0.	0.	1.5000E-04	0.	0.
GD 158	-0.	1.0000E-05	2.0000E-05	6.1500E-04	6.1500E-04
TB 159	-0.	5.0000E-06	1.0000E-05	2.1000E-04	2.1000E-04

EURATOM - C. C. R. ISPRA - CETIS

TABLE 12

TABLE OF ISOTOPES IN THE AGGREGATES

1 - AGGREGATE WITH 80 ELEMENTS

Se82, Br35, Kr83, Kr84, Kr85, Kr86, Rb85, Rb87, Sr88, Sr90, Y89, Zr91, Zr92, Zr93, Zr94, Zr96, Mo95, Mo97, Mo98, Mo100, Tc99, Ru101, Ru102, Ru104, Rh103, Pd105, Pd106, Pd107, Pd108, Pd110, Ag109, Cd111, Cd112, Cd113, Cd114, In115, Te126, Te128, Te129, I127, I129, Xe131, Xe132, Xe134, Xe136, Cs133, Cs135, Cs137, Ba138, La139, Ce140, Ce142, Pr141, Ce144, Nd143, Nd144, Nd145, Nd146, Nd147, Nd148, Nd150, Pm147; Pm148M, Pm148, Pm149, Sm147, Sm148, Sm150, Sm151, Sm152, Sm154, Eu153, Eu154, Eu155, Gd154, Gd155, Gd156, Gd157, Gd158, Tb159.

2 - AGGREGATE WITH 67 ELEMENTS

Se82, Br35, Kr83, Kr84, Kr85, Kr86, Rb85, Rb87, Sr88, Sr90, Y89, Zr91, Zr93, Zr94, Zr96, Mo95, Mo97, Mo98, Mo100, Tc99, Ru101, Ru102, Ru104, Pd105, Pd106, Pd107, Pd108, Pd110, Ag109, Cd111, Cd112, Cd113, Cd114, In115, Te126, Te128, Te130, I127, I132, Xe132, Xe134, Xe136, Cs133, Cs135, Cs137, Ba138, La139, Ce140, Ce142, Pr141, Ce144, Nd144, Nd145, Nd146, Nd147, Nd148, Nd150, Pm149, Sm147, Sm148, Sm150, Sm154, Gd154, Gd156, Gd158, Tb159.

3 - AGGREGATE WITH 59 ELEMENTS

Se82, Br81, Kr83, Kr84, Kr85, Kr86, Ru85, Ru87, Sr88, Sr90, Y89, Zr91, Zr92, Zr93, Zr94, Zr96, Mo95, Mo97, Mo98, Mo100, Tc99, Ru101, Ru102, Ru104, Pd105, Pd106, Pd107, Pd108, Pd110, Ag109, Cd111, Cd112, Cd114, In115, Te126, Te128, Te130, I127, I129, Xe132, Xe134, Xe136, Cs133, Cs135, Cs137, Ba138, La139, Ce140, Ce142, Pr141, Nd144, Nd145, Nd146, Nd148, Nd150, Sm154, Gd156, Gd158, Tb159.

TABLE 12 (Second Part)

4 - AGGREGATE WITH 54 ELEMENTS

Se82, Br81, Kr83, Kr84, Kr85, Kr86, Rb85, Rb87, Sr88, Sr90, Y89, Zr91, Zr92, Zr93, Zr94, Zr96, Mo97, Mo98, Mo100, Ru101, Ru102, Ru104, Pd105, Pd106, Pd107, Pd108, Pd110, Ag109, Cd111, Cd112, Cd114, In115, Te126, Te128, Te130, I127, I129, Xe132, Xe134, Xe136, Cs137, Ba138, La139, Ce140, Ce142, Pr141, Nd144, Nd146, Nd148, Nd150, Sm154, Gd156, Gd158, Tb159.

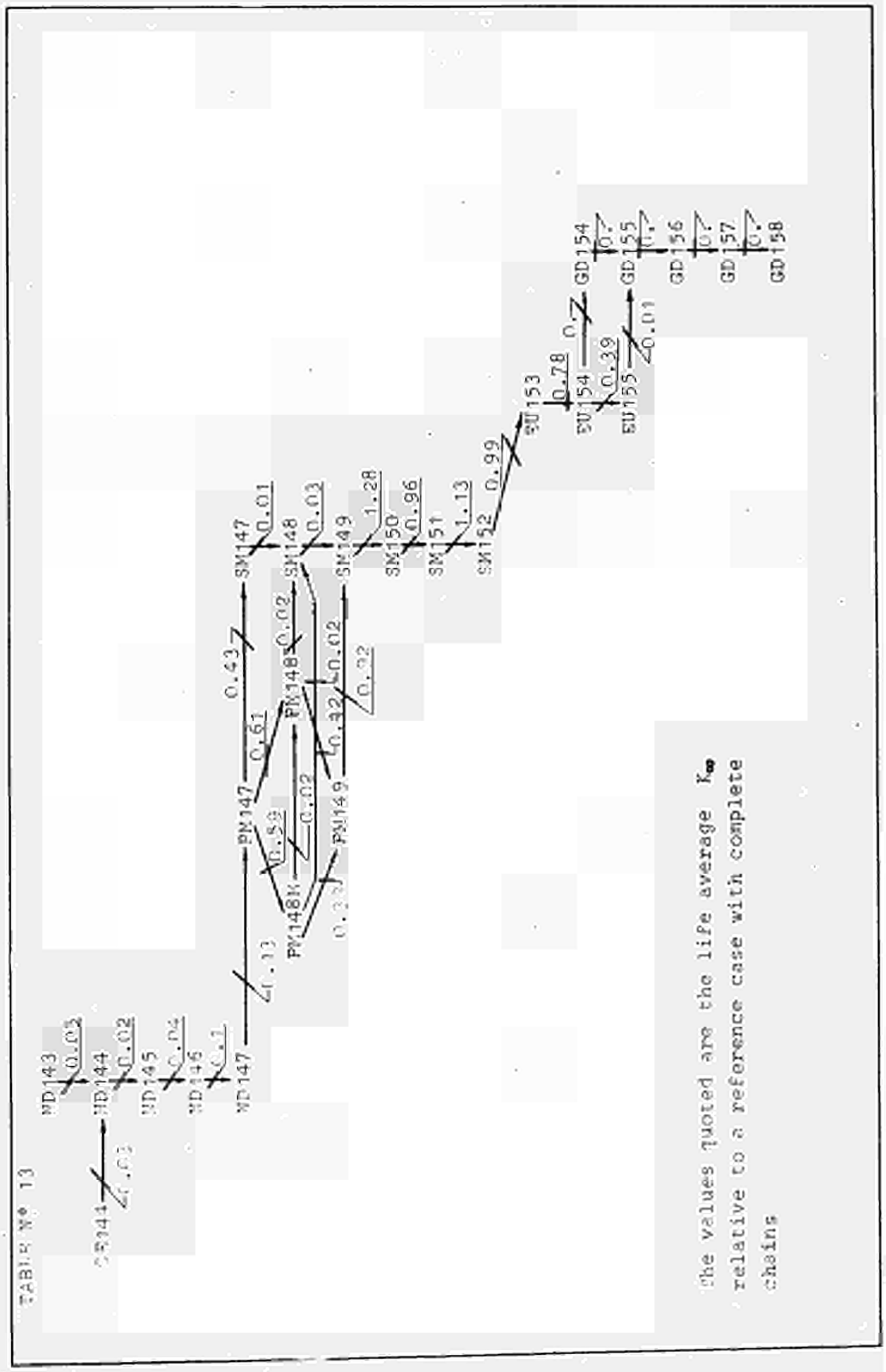
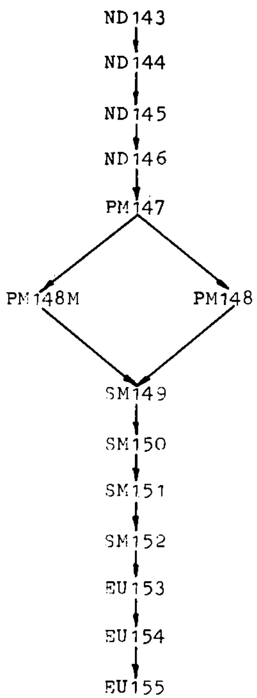


TABLE N° 13

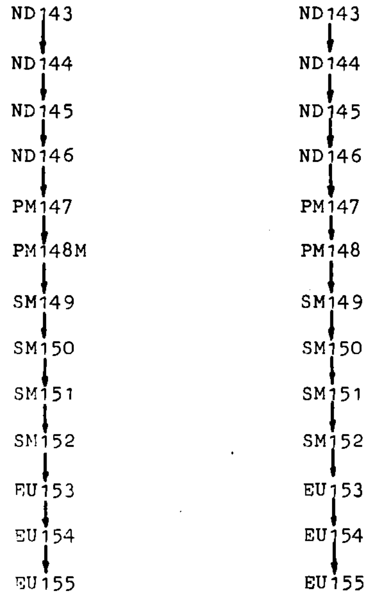
The values quoted are the life average K_∞ relative to a reference case with complete chains

Table N° 14.a



ΔK = 0.26 %

Table N° 14 b



$\overline{\Delta K}$ = 0.29 %

$\overline{\Delta K}$ = 0.24 %

TABLE N° 15

LIFE AVERAGE VALUES CALCULATED WITH AVERAGE YIELDS AND WITH CHAINS

MATERIAL	ATOM DENSITY	FRACTIONAL ABSORPTION
SE 82	0.88585E-07	0.15855E-04
BR 81	0.50439E-07	0.70322E-04
KR 83	0.10046E-06	0.18157E-02
KR 84	0.33122E-06	0.36894E-04
KR 85	0.72154E-07	0.57847E-04
KR 86	0.50304E-06	0.28160E-05
RB 85	0.28081E-06	0.22383E-04
RB 87	0.66076E-06	0.85628E-05
SR 88	0.85656E-06	0.14136E-05
SR 90	0.12012E-05	0.14028E-03
Y 89	0.10383E-05	0.11517E-03
ZR 91	0.12042E-05	0.32310E-03
ZR 92	0.12618E-05	0.29896E-04
ZR 93	0.13061E-05	0.90722E-03
ZR 94	0.13295E-05	0.11494E-04
ZR 96	0.12049E-05	0.12721E-04
MO 95	0.11668E-05	0.23932E-02
MO 97	0.11445E-05	0.53092E-03
MO 98	0.11168E-05	0.18256E-03
MO 100	0.11036E-05	0.20498E-03
TC 99	0.97788E-06	0.47243E-02
RU 101	0.79032E-06	0.13936E-02
RU 102	0.70753E-06	0.28881E-03
RU 104	0.28951E-06	0.83381E-04
RH 103	0.22283E-06	0.65375E-02
PD 105	0.13860E-06	0.30423E-03
PD 106	0.73307E-07	0.49308E-04
PD 107	0.34605E-07	0.56045E-04
PD 108	0.13353E-07	0.51897E-04
PD 110	0.52381E-08	0.10787E-05
AG 109	0.44886E-08	0.12842E-03
CD 111	0.41320E-08	0.46295E-05
CD 112	0.28976E-08	0.95772E-06
CD 113	0.13976E-10	0.65957E-04
CD 114	0.56734E-08	0.21211E-05
IN 115	0.82271E-09	0.52844E-04
TE 126	0.24762E-07	0.69496E-05
TE 128	0.12329E-06	0.92739E-05
TE 130	0.45385E-06	0.35717E-04
I 127	0.57906E-07	0.19361E-03
I 129	0.23611E-06	0.64922E-03
XE 131	0.37006E-06	0.80258E-02
XE 132	0.11710E-05	0.78870E-04
XE 134	0.14432E-05	0.73197E-04
XE 135	0.11106E-09	0.21178E-01
XE 136	0.23143E-05	0.60537E-03
CS 133	0.10311E-05	0.81874E-02
CS 135	0.23373E-06	0.30704E-03
CS 137	0.12807E-05	0.27906E-04
BA 138	0.12296E-05	0.71395E-04
LA 139	0.12660E-05	0.11044E-02
CE 140	0.12877E-05	0.74135E-04
CE 142	0.12613E-05	0.15464E-03
PR 141	0.12303E-05	0.16009E-02
CE 144	0.33784E-06	0.
ND 143	0.58829E-06	0.15341E-01
ND 144	0.12837E-05	0.81973E-03
ND 145	0.58989E-06	0.57041E-02
ND 146	0.74633E-06	0.67199E-03
ND 147	0.40883E-08	0.
ND 148	0.30710E-06	0.14277E-03
ND 150	0.12399E-06	0.42041E-04
PM 147	0.12891E-06	0.61800E-02
PM 148M	0.40772E-08	0.13515E-02
PM 148	0.67716E-09	0.14441E-02
PM 149	0.10163E-08	0.
SM 147	0.57141E-07	0.95611E-03
SM 148	0.16121E-06	0.11922E-03
SM 149	0.12719E-08	0.70521E-02
SM 150	0.24236E-06	0.27408E-02
SM 151	0.11602E-07	0.41479E-02
SM 152	0.77660E-07	0.37974E-02
SM 154	0.12694E-07	0.57371E-05
EU 153	0.59003E-07	0.32566E-02
EU 154	0.13712E-07	0.29334E-02
EU 155	0.25750E-08	0.29566E-02
GD 154	0.98371E-09	0.13137E-05
GD 155	0.38766E-10	0.64191E-04
GD 156	0.55476E-08	0.53493E-05
GD 157	0.48240E-11	0.33711E-04
GD 158	0.22245E-08	0.20437E-05
TB 159	0.11755E-09	0.12324E-05

```
      DIMENSION DEN(250,2),NHOT(250,1),FISIG(4,250),TOSIG(4,250),ABSIG(4
     1,250),OUSIG(4,250),XNU(4,250),RPHIAV(4,1),          VOL(1),CR(1),
     2VFREG(1),YIELD1(250),YIELD2(250),YIELD3(250),YIELD4(250),NX(250,1)
     3,NO(1),NY(3,1),ODEN(250),DENIOD(1),YT(250),X(15),Y(15),ANAME(250,1
     40)
      DIMENSION DIRAC(250,4),XLAM(250),AVDEN(250),DENN(250),RPHI(4)
C
      COMMON DEN,NHOT,FISIG,TOSIG,ABSIG,OUSIG,XNU,RPHIAV,DIRAC,VOL,CR,VF
     1REG,YIELD1,YIELD2,YIELD3,YIELD4,NX,NO,NY,ODEN,DENIOD,YT,X,Y,DELSEC
     2,DELDAY,N26,RPXE,NMAT,ANAME,XLAM
      COMMON JN,JNUM,JNSTOP,IPAGE,AVDEN,COUNT,DENN,FIN,RPHI,NLT,NORM
   50 FORMAT (3I12)
    7 FORMAT                                                    (72H1SPEC
     1IAL DATA       DECAY       ----------------FISSION YIELDS------------
     2- 4X43HCAPTURE FACTORS FROM 4 PRECEEDING MATERIALS/73H SET IDENT.N
     XO    CONSTANT      FROM U233    FROM U235   FROM PU239   FROM PU241 11X2
     X7H( IF NEGATIVE MEANS DECAY )//)
   90 FORMAT(I8,1PE16.4,1P4E12.4,4X,1P4E11.3)
    6 FORMAT (1P5E12.5)                                                  340
C
C
      NS=5
      NT=6
      CALL INPUTA
   15 FIN=DEN(3,1)+DEN(5,1)+DEN(9,1)+DEN(11,1)
      JN=-1
      COUNT=0.0
      DO 3 L=1,NMAT
    3 AVDEN(L)=0.0
      CALL DCALC
    1 CALL BURNUP
      CALL DCALC
      IF(JN-JNSTOP)1,2,2
    2 JN=JN+1
      DO 4 L=1,NMAT
    4 DEN(L,1)=AVDEN(L)/COUNT
      CALL DCALC
      FICMS=0.0
      J9=NHOT(9,1)
      J11=NHOT(11,1)
      J5=NHOT(5,1)
      J3=NHOT(3,1)
      DO 10 I=1,4
   10 FICMS=FICMS+(DEN(3,1)*FISIG(I,J3)/XNU(I,J3)+ DEN(5,1)*FISIG(I,J5)/
     1XNU(I,J5)+ DEN(9,1)*FISIG(I,J9)/XNU(I,J9)+ DEN(11,1)*FISIG(I,J11)/
     2XNU(I,J11))*RPHIAV(I,1)
      ANSTOP=JNSTOP
      FICM=FICMS*ANSTOP*DELDAY*8.64E+4
      FIFA=FICM/FIN
      FIWATT=3.12E+10
      POWER=(FICMS*1.0E+24)/FIWATT
      WRITE OUTPUT TAPE 6,11,FIFA,POWER
   11 FORMAT (6H0FIFA=E12.5,18H POWER (WATT/CM3)=E12.5)
      A=FICMS
      FICMS=0.0
```

```
      DO 12 I=1,4
   12 FICMS=FICMS+(DEN(3,1)*FISIG(I,J3)/XNU(I,J3)+ DEN(5,1)*FISIG(I,J3)/
     1XNU(I,J3)+ DEN(9,1)*FISIG(I,J9)/XNU(I,J9)+ DEN(11,1)*FISIG(I,J11)/
     2XNU(I,J11))*RPHI(I)
      DO 13 I=1,4
   13 RPHI(I)=RPHI(I)*A/FICMS
      WRITE OUTPUT TAPE 6,14,(RPHI(I),I=1,4)
   14 FORMAT (42HOFOR THIS POWER THE FLUXES SHOUD HAVE BEEN//6E12.5)
      READ INPUT TAPE 5,50,KK1,KK2,NORM
      IF(KK1)102,102,103
  103 WRITE OUTPUT TAPE 6,7
      DO 100 K=KK1,KK2
      READ INPUT TAPE NS,6,( XLAM(K),YIELD1(K),YIELD2(K),YIELD3(K),
     1YIELD4(K))
      READ INPUT TAPE NS,6,(DIRAC(K,L),L=1,4)
  100 CONTINUE
      DO 101 L=1,NMAT
  101 DEN(L,1)=DEN(L,2)
      DO 105 K=1,NLT
      WRITE OUTPUT TAPE NT,90,(K, XLAM(K),YIELD1(K),YIELD2(K),YIELD3(K),
     1YIELD4(K),(DIRAC(K,L),L=1,4))
  105 CONTINUE
      IF(NORM)500,500,501
  501 Y1=0.0
      Y2=0.0
      Y3=0.0
      Y4=0.0
      WRITE OUTPUT TAPE 6,7
      DO 502 K=1,NLT
      Y1=Y1+YIELD1(K)
      Y2=Y2+YIELD2(K)
      Y3=Y3+YIELD3(K)
  502 Y4=Y4+YIELD4(K)
      DO 503 K=1,NLT
      YIELD1(K)=YIELD1(K)*2./Y1
      YIELD2(K)=YIELD2(K)*2./Y2
      YIELD3(K)=YIELD3(K)*2./Y3
      YIELD4(K)=YIELD4(K)*2./Y4
      WRITE OUTPUT TAPE NT,90,(K, XLAM(K),YIELD1(K),YIELD2(K),YIELD3(K),
     1YIELD4(K),(DIRAC(K,L),L=1,4))
      WRITE OUTPUT TAPE 10,6,(XLAM(K),YIELD1(K),YIELD2(K),YIELD3(K),
     1YIELD4(K))
  503 CONTINUE
  500 GO TO 15
  102 CALL EXIT
      END(1,0,0,0,0,0,1,0,0,0,0,0,0,0,0)
```

```
      SUBROUTINE BURNUP
C
C     DEPLETION AND BUILDUP CALCULATION
C
      DIMENSION DEN(250,2),NHOT(250,1),FISIG(4,250),TOSIG(4,250),ABSIG(4
     1,250),OUSIG(4,250),XNU(4,250),RPHIAV(4,1),           VOL(1),CR(1),
     2VFREG(1),YIELD1(250),YIELD2(250),YIELD3(250),YIELD4(250),NX(250,1)
     3,NO(1),NY(3,1),ODEN(250),DENIOD(1),YT(250),X(15),Y(15),ANAME(250,1
     40)
      DIMENSION DIRAC(250,4),XLAM(250),AVDEN(250),DENN(250),RPHI(4)
C
      COMMON DEN,NHOT,FISIG,TOSIG,ABSIG,OUSIG,XNU,RPHIAV,DIRAC,VOL,CR,VF
     1REG,YIELD1,YIELD2,YIELD3,YIELD4,NX,NO,NY,ODEN,DENIOD,YT,X,Y,DELSEC
     2,DELDAY,N26,RPXE,NMAT,ANAME,XLAM
      COMMON JN,JNUM,JNSTOP,IPAGE,AVDEN,COUNT,DENN,FIN,RPHI,NLT,NORM
    1 FORMAT (13H1   TIME STEP I3//72H      REGION      ------------FRACT
     XION OF FISSIONS FROM----------------- /19X,6H U-233,9X,6H U-235,
     X8X,7H PU-239,8X,7H PU-241 //)
    2 FORMAT (I10,1PE17.5,1P3E15.5)
    3 FORMAT (42H0      REGION  CONVERSION RATIO  REG VOLUME //)
    4 FORMAT (I10,1PE17.5,1PE15.5)
C
      NT=6
      N20=1
      JN=JN+1
      WRITE OUTPUT TAPE NT,1,JN
      ZJNUM=JNUM
      IF(JN) 15,15,20
   15 DELSEC=0.0
      GO TO 25
   20 DELSEC=DELDAY*8.64E+4/ZJNUM
   24 JNN=0
   25 JNN=JNN+1
      XXP=0.0
      YYP=0.0
      IR=1
      DO 2003 L=1,NMAT
 2003 DENN(L)=DEN(L,1)
   30 CONTINUE
      XXX=0.0
      YYY=0.0
      DO 50 I=1,15
      IF(I-13)103,50,103
  103 X(I)=0.0
      Y(I)=0.0
      J=NHOT(I,IR)
      DO 102 IE=1,N26
      Y(I)=Y(I)+RPHIAV(IE,IR)*ABSIG(IE,J)
      IF(I-13)101,102,102
  101 X(I)=X(I)+RPHIAV(IE,IR)*(ABSIG(IE,J)-FISIG(IE,J)/XNU(IE,J))
  102 CONTINUE
   50 CONTINUE
      Y131=Y(1)-X(1)
      Y132=Y(3)-X(3)
      Y133=Y(5)-X(5)
      Y134=Y(7)-X(7)
```

```
      Y135=Y(9)-X(9)
  113 Y136=Y(11)-X(11)
      ODEN1=DEN(1,IR)
      DEN(1,IR)=DEN(1,IR)*(2.0-DELSEC*Y(1))/(2.0+DELSEC*Y(1))
      ODEN2=DEN(2,IR)
      DEN(2,IR)=.5*(DEN(1,IR)+ODEN1)*X(1)/( .292794E-6 +Y(2)) +(ODEN2-
     1          .5*(DEN(1,IR)+ODEN1)*X(1)/( .292794E-6 +Y(2)))*EXPF(
     2          -(.292794E-6+Y(2))*DELSEC)
      ODEN3=DEN(3,IR)
      DEN(3,IR)=(DEN(3,IR)*(2.0-DELSEC*Y(3))+(DEN(2,IR)+ODEN2)* .292794E
     1-6        *DELSEC)/(2.0+DELSEC*Y(3))
      ODEN4=DEN(4,IR)
      DEN(4,IR)=(DEN(4,IR)*(2.0-DELSEC*Y(4))+(DEN(3,IR)+ODEN3)*X(3)*
     1DELSEC     +(DEN(2,IR)+ODEN2)*X(2)*DELSEC)/(2.0+DELSEC*Y(4))
      ODEN5=DEN(5,IR)
      DEN(5,IR)=(DEN(5,IR)*(2.0-DELSEC*Y(5))+(DEN(4,IR)+ODEN4)*X(4)*
     1 DELSEC)   /(2.0+DELSEC*Y(5))
      ODEN6=DEN(6,IR)
      DEN(6,IR)=(DEN(6,IR)*(2.0-DELSEC*Y(6))+(DEN(5,IR)+ODEN5)*X(5)*
     1 DELSEC)   /(2.0+DELSEC*Y(6))
      ODEN7=DEN(7,IR)
      DEN(7,IR)=DEN(7,IR)*(2.0-DELSEC*Y(7))/(2.0+DELSEC*Y(7))
      ODEN8=DEN(8,IR)
      DEN(8,IR)=.5*(DEN(7,IR)+ODEN7)*X(7)/( .344316E-5 +Y(8)) +(ODEN8-
     1          .5*(DEN(7,IR)+ODEN7)*X(7)/( .344316E-5 +Y(8)))*EXPF(
     2          -(.344316E-5 +Y(8))*DELSEC)
      ODEN9=DEN(9,IR)
      DEN(9,IR)=(DEN(9,IR)*(2.0-DELSEC*Y(9))+(DEN(8,IR)+ODEN8)* .344316E
     1-5        *DELSEC)/(2.0+DELSEC*Y(9))
      ODEN10=DEN(10,IR)
      DEN(10,IR)=(DEN(10,IR)*(2.0-DELSEC*Y(10))+(DEN(9,IR)+ODEN9)*
     1 DELSEC*   X(9)+(DEN(8,IR)+ODEN8)*DELSEC*X(8))/(2.0+Y(10)*DELSEC)
      ODEN11=DEN(11,IR)
      DEN(11,IR)=(DEN(11,IR)*(2.0-DELSEC*(1.66362E-9+Y(11)))+
     1           (DEN(10,IR)+ODEN10)*X(10)*DELSEC)/(2.0+DELSEC*(1.66362E
     2-9           +Y(11)))
      ODEN12=DEN(12,IR)
      DEN(12,IR)=(DEN(12,IR)*(2.0-DELSEC*Y(12))+(DEN(11,IR)+ODEN11)*
     1          X(11)*DELSEC)/(2.0+DELSEC*Y(12))
      ODEN13=DEN(13,IR)
      XYZ=(DEN(1,IR)+ODEN1)*Y131/2.0+(DEN(3,IR)+ODEN3)*Y132/2.0+
     1     (DEN(5,IR)+ODEN5)*Y133/2.0+(DEN(7,IR)+ODEN7)*Y134/2.0+
     2     (DEN(9,IR)+ODEN9)*Y135/2.0+(DEN(11,IR)+ODEN11)*Y136/2.0+
     3     (DEN(2,IR)+ODEN2)*(Y(2)-X(2))/2.0+(DEN(4,IR)+ODEN4)*(Y(4)-X(4)
     4)/2.0+(DEN(6,IR)+ODEN6)*(Y(6)-X(6))/2.0+(DEN(8,IR)+ODEN8)*(Y(8)-X(
     58))/2.+(DEN(10,IR)+ODEN10)*(Y(10)-X(10))/2.0+(DEN(12,IR)+ODEN12)*(
     6Y(12)- X(12))/2.0
      XYZT=(DEN(3,IR)+ODEN3)*Y132/2.0+(DEN(5,IR)+ODEN5)*Y133/2.0+
     1     (DEN(9,IR)+ODEN9)*Y135/2.0+(DEN(11,IR)+ODEN11)*Y136/2.0
      ZF1=(DEN(3,IR)+ODEN3)*Y132*.5/XYZT
      ZF2=(DEN(5,IR)+ODEN5)*Y133*.5/XYZT
      ZF3=(DEN(9,IR)+ODEN9)*Y135*.5/XYZT
      ZF4=(DEN(11,IR)+ODEN11)*Y136*.5/XYZT
      IF (JNN-JNUM) 124,120,120
  120 WRITE OUTPUT TAPE NT,2,IR,ZF1,ZF2,ZF3,ZF4
  124 CONTINUE
```

```
      DO 125 K=1,3
  123 KX=NY(K,IR)
  125 YT(K)=YIELD1(KX)*ZF1+YIELD2(KX)*ZF2+YIELD3(KX)*ZF3+YIELD4(KX)*ZF4
      DEN(13,IR)=ODEN13+YT(1)*DELSEC*XYZ
      DEN(14,IR)=YT(2)*XYZ/(RPXE+2.1E-5+Y(14))
      DEN(15,IR)=YT(3)*XYZ/Y(15)
      DENIOD(IR)=YT(2)*XYZ/2.87E-5
      IF(NO(IR))210,210,200
  200 NK=16
      NL=15+NO(IR)
      DO 205 L=NK,NL
      IL=NHOT(L,IR)
      Y16=0.0
      Y16A=0.0
      Z16=0.0
      DO 116 IE=1,N26
  116 Y16=Y16+RPHIAV(IE,IR)*ABSIG(IE,IL)
      K=L-15
      KFU=NX(K,IR)
      YT(K)=YIELD1(KFU)*ZF1+YIELD2(KFU)*ZF2+YIELD3(KFU)*ZF3+YIELD4(KFU)
     X                    *ZF4
      ODEN(K)=DEN(L,IR)
      SPLAT=YT(K)*XYZ
      DO 10 I=1,4
      J=L-I
      IF(J)10,10,13
   13 IF(DIRAC(KFU,I))11,10,12
   12 Y16A=0.0
      ILA=NHOT(J,IR)
      DO 14 IE=1,N26
   14 Y16A=Y16A+RPHIAV(IE,IR)*ABSIG(IE,ILA)
      SPLAT=SPLAT+0.5*(DEN(J,IR)+ODEN(J-15))*Y16A*DIRAC(KFU,I)
      GO TO 10
   11 KK=NX(J-15,IR)
      SPLAT=SPLAT-0.5*(DEN(J,IR)+ODEN(J-15))*DIRAC(KFU,I)*XLAM(KK)
   10 CONTINUE
      SPLAT=SPLAT/(Y16+XLAM(KFU))
  205 DEN(L,IR)=SPLAT+(DEN(L,IR)-SPLAT)*EXPF(-(Y16+XLAM(KFU))*DELSEC)
  210 CONTINUE
  230 CONTINUE
      XXX=(.292794E-6*DEN(2,IR)+X(4)*DEN(4,IR)+.344316E-5*DEN(8,IR)+X(10
     1)*  DEN(10,IR))*VOL(IR)
      YYY=(DEN(3,IR)*Y(3)+DEN(5,IR)*Y(5)+DEN(9,IR)*Y(9)+DEN(11,IR)*Y(11)
     1)*VOL(IR)
      XXP=XXP+XXX
      YYP=YYP+YYY
      IF(XXX-1.0E+10) 250,240,240
  240 XXX=0.0
      GO TO 270
  250 IF(YYY-1.0E-25) 260,260,270
  260 YYY=0.0
      XXX=0.0
  270 CONTINUE
      CR(IR)=XXX/YYY
  900 CONTINUE
      IF(JN)1000,1000,2000
```

```
2000 DO 2004 L=1,NMAT
2004 AVDEN(L)=AVDEN(L)+(DENN(L)+DEN(L,1))/2.0
     COUNT=COUNT+1.0
1000 IF (JNN-JNUM) 25,1001,1001
1001 CONTINUE
1200 CRT=XXP/YYP
     WRITE OUTPUT TAPE NT,3
     WRITE OUTPUT TAPE NT,4,(IR,CR(IR),VOL(IR),IR=1,N20)
     JNN=0
     RETURN
     END(1,0,0,0,0,0,1,0,0,0,0,0,0,0,0)
```

```
      SUBROUTINE INPUTA
C
C     READS AND PRINTS LIBRARY DATA
C
      DIMENSION DEN(250,2),NHOT(250,1),FISIG(4,250),TOSIG(4,250),ABSIG(4
     1,250),OUSIG(4,250),XNU(4,250),RPHIAV(4,1),          VOL(1),CR(1),
     2VFREG(1),YIELD1(250),YIELD2(250),YIELD3(250),YIELD4(250),NX(250,1)
     3,NO(1),NY(3,1),ODEN(250),DENIOD(1),YT(250),X(15),Y(15),ANAME(250,1
     40)
      DIMENSION DIRAC(250,4),XLAM(250),AVDEN(250),DENN(250),RPHI(4)
C
      COMMON DEN,NHOT,FISIG,TOSIG,ABSIG,OUSIG,XNU,RPHIAV,DIRAC,VOL,CR,VF
     1REG,YIELD1,YIELD2,YIELD3,YIELD4,NX,NO,NY,ODEN,DENIOD,YT,X,Y,DELSEC
     2,DELDAY,N26,RPXE,NMAT,ANAME,XLAM
      COMMON JN,JNUM,JNSTOP,IPAGE,AVDEN,COUNT,DENN,FIN,RPHI,NLT,NORM
    1 FORMAT(48H1               LIBRARY CONTAINS THE FOLLOWING DATA   //
     X 72H  NU*FISSION  TRANSPORT   ABSORPTION SCATTER OUT NEUTS/FISSION
     X  DILUTION )
    2 FORMAT (10H0BLOCK NO.  I4)
    3 FORMAT (10A6,36X,1PE12.4/(1P5E12.4))
    4 FORMAT (18I4)
    5 FORMAT (1P6E12.5)
    6 FORMAT (1P5E12.5)
    7 FORMAT                                                    (72H1SPEC
     1IAL DATA      DECAY     ---------------FISSION YIELDS-------------
     2- 4X43HCAPTURE FACTORS FROM 4 PRECEEDING MATERIALS/73H SET IDENT.N
     XO   CONSTANT    FROM U233    FROM U235   FROM PU239   FROM PU241 11X2
     X7H( IF NEGATIVE MEANS DECAY )//)
   90 FORMAT(I8,1PE16.4,1P4E12.4,4X,1P4E11.3)
   70 FORMAT(46H1    MAFIA LIBRARY CONTAINS THE FOLLOWING DATA /72H0SPEC
     1IAL DATA    CAPTURE     ---------------FISSION YIELDS-------------
     2- /73H SET IDENT.NO      FACTOR     FROM U233    FROM U235  FROM PU23
     39   FROM PU241 /(I8,1PE16.4,1P4E12.4))
    8 FORMAT(1H0///7X 41H CRITERION FOR-      CONVERGENCE CRITERION //7X
     X20H EIGENVALUE--------- 1PE16.4/7X 20H POINT-------------- 1PE16.4
     X/7X 20H CONTROL SEARCH----- 1PE16.4//)
    9  FORMAT(I4,8X,E12.5)
  201 FORMAT(19H1TIME STEP (DAYS)= E12.5,10X,21HXE REMOVAL FRACTION= E12
     1.5/17H0MAX TIME STEPS= I4,10X,19HSMALL/LARGE STEPS= I4///4(12H FLU
     2X GROUP I5,3H  =,E12.5/))
      NS=5
      NT=6
      IPAGE=0
      WRITE OUTPUT TAPE NT,1
      READ INPUT TAPE NS,4,N26,NLB,NLT,M1,M2,M3,N,NORM
      IR=1
      NY(1,IR)=M1
      NY(2,IR)=M2
   40 NY(3,IR)=M3
      DO 100  IL=1,NLB
      READ INPUT TAPE NS,3,(ANAME(IL,K),K=1,10),XBUG,(FISIG(IE,IL),TOSIG
     X(IE,IL),ABSIG(IE,IL),  OUSIG(IE,IL),XNU(IE,IL),IE=1,N26)
   50 CONTINUE
      IPAGE=IPAGE+3+N26
      IF (IPAGE-48) 58,55,55
   55 IPAGE=0
```

```
      WRITE OUTPUT TAPE NT,1
   58 WRITE OUTPUT TAPE NT,2,IL
      WRITE OUTPUT TAPE NT,3,(ANAME(IL,K),K=1,10),XBUG,(FISIG(IE,IL),
     X  TOSIG(IE,IL),           ABSIG(IE,IL),
     X                          OUSIG(IE,IL),XNU(IE,IL),IE=1,N26)
  100 CONTINUE
      IF(N)21,21,22
   21 READ INPUT TAPE NS,6,(DIRAC(K,1),YIELD1(K),YIELD2(K),YIELD3(K),
     X                          YIELD4(K),K=1,NLT)
      WRITE OUTPUTTAPENT,70,(K,DIRAC(K,1),YIELD1(K),YIELD2(K),YIELD3(K),
     X                          YIELD4(K),K=1,NLT)
      DO 12 K=1,NLT
      DO 13 L=2,4
   13 DIRAC(K,L)=0.0
   12 XLAM(K)=0.0
      GO TO 11
   22 WRITE OUTPUT TAPE NT,7
      DO 10 K=1,NLT
      READ INPUT TAPE NS,6,( XLAM(K),YIELD1(K),YIELD2(K),YIELD3(K),
     1YIELD4(K))
      READ INPUT TAPE NS,6,(DIRAC(K,L),L=1,4)
      WRITE OUTPUT TAPE NT,90,(K, XLAM(K),YIELD1(K),YIELD2(K),YIELD3(K),
     1YIELD4(K),(DIRAC(K,L),L=1,4))
   10 CONTINUE
   11 IF(NORM)500,500,501
  501 Y1=0.0
      Y2=0.0
      Y3=0.0
      Y4=0.0
      WRITE OUTPUT TAPE 6,7
      DO 502 K=1,NLT
      Y1=Y1+YIELD1(K)
      Y2=Y2+YIELD2(K)
      Y3=Y3+YIELD3(K)
  502 Y4=Y4+YIELD4(K)
      DO 503 K=1,NLT
      YIELD1(K)=YIELD1(K)*2./Y1
      YIELD2(K)=YIELD2(K)*2./Y2
      YIELD3(K)=YIELD3(K)*2./Y3
      YIELD4(K)=YIELD4(K)*2./Y4
      WRITE OUTPUT TAPE NT,90,(K, XLAM(K),YIELD1(K),YIELD2(K),YIELD3(K),
     1YIELD4(K),(DIRAC(K,L),L=1,4))
      WRITE OUTPUT TAPE 10,6,(XLAM(K),YIELD1(K),YIELD2(K),YIELD3(K),
     1YIELD4(K))
  503 CONTINUE
  500 READ INPUT TAPE 5,4,NMAT,NO
      DO 200  IL=1, NMAT
      READ INPUT TAPE 5,9,NHOT(IL,1),DEN(IL,1)
  200 DEN(IL,2)=DEN(IL,1)
      NOTH = NO
      READ INPUT TAPE 5,4,(NX(K,1),K=1,NOTH)
      READ INPUT TAPE 5,5,DELDAY,VOL,RPXE
      READ INPUT TAPE  5,4,JNSTOP,JNUM
      READ INPUT TAPE 5,5,(RPHIAV(IE,1),IE=1,4)
      WRITE OUTPUT TAPE 6,201,DELDAY,RPXE,JNSTOP,JNUM,(IE,RPHIAV(IE,1),
     1IE=1,4)
```

```
RETURN
END(1,0,0,0,0,0,1,0,0,0,0,0,0,0,0)
```

```
      SUBROUTINE DCALC
      DIMENSION DEN(250,2),NHOT(250,1),FISIG(4,250),TOSIG(4,250),ABSIG(4
     1,250),OUSIG(4,250),XNU(4,250),RPHIAV(4,1),         VOL(1),CR(1),
     2VFREG(1),YIELD1(250),YIELD2(250),YIELD3(250),YIELD4(250),NX(250,1)
     3,NO(1),NY(3,1),ODEN(250),DENIOD(1),YT(250),X(15),Y(15),ANAME(250,1
     40)
      DIMENSION DIRAC(250,4),XLAM(250),AVDEN(250),DENN(250),RPHI(4)
C
      COMMON DEN,NHOT,FISIG,TOSIG,ABSIG,OUSIG,XNU,RPHIAV,DIRAC,VOL,CR,VF
     1REG,YIELD1,YIELD2,YIELD3,YIELD4,NX,NO,NY,ODEN,DENIOD,YT,X,Y,DELSEC
     2,DELDAY,N26,RPXE,NMAT,ANAME,XLAM
      COMMON JN,JNUM,JNSTOP,IPAGE,AVDEN,COUNT,DENN,FIN,RPHI,NLT,NORM
      DIMENSION DIFL(4,1),TOTL(4,1),SIGA(4,1),TRIC(4,1),SIGS(4,1),REACT
     1(2),TRANS(4,1)
C
C
      DIMENSION AM(250)
      IR =1
   60 DO 200 IE=1,N26
      DIFL(IE,IR)=0.0
      TOTL(IE,IR)=0.0
      SIGA(IE,IR)=0.0
      TRIC(IE,IR)=0.0
      SIGS(IE,IR)=0.0
      DO 100  L=1, NMAT
   85 IL=NHOT(L,IR)
   90 IEE=IE
      Q=DEN(L,IR)
      TOTL(IE,IR)=TOTL(IE,IR)+  Q       *TOSIG(IE,IL)
      SIGA(IE,IR)=SIGA(IE,IR)+  Q       *ABSIG(IE,IL)
      TRIC(IE,IR)=TRIC(IE,IR)+  Q       *FISIG(IE,IL)
      SIGS(IE,IR)=SIGS(IE,IR)+  Q       *OUSIG(IE,IL)
      DIFL(IE,IR)=1.0/(3.0*TOTL(IE,IR))
  100 CONTINUE
  200 CONTINUE
  300 CONTINUE
      RPHI(1)=1.0
      DO 10 IE=2,N26
   10 RPHI(IE)=RPHI(IE-1)*SIGS(IE-1,IR)/(DIFL(IE,IR)*TRANS(IE,1)+SIGA(IE
     1,IR)+SIGS(IE,IR))
  410 FORMAT (4E12.5)
  411 FORMAT (6I12)
      REACT(2)=(TRIC(1,IR)*RPHI(1)+TRIC(2,IR)*RPHI(2)+TRIC(3,IR)*RPHI(3)
     1+TRIC(4,IR)*RPHI(4))/((DIFL(1,IR)*TRANS(1,1)+SIGA(1,IR)+SIGS(1,IR)
     2)*RPHI(1))
      IF(JN-JNSTOP)405,405,406
  406 WRITE OUTPUT TAPE 6,407,REACT(2)
  407 FORMAT (28H1  LIFE AVERAGE        KEFF =,E12.5)
      GO TO 412
  405 WRITE OUTPUT TAPE 6,6,JN,REACT(2)
    6 FORMAT(12H0 TIME STEP ,I4,12H        KEFF ,E12.5)
  412 SUMA=0.0
      DO 13 L=1,NMAT
      AM(L)=0.0
      IL=NHOT(L,1)
      DO 11 IE=1,N26
```

```
   11 AM(L)=AM(L)+DEN(L,1)*RPHIAV(IE,1)*ABSIG(IE,IL)
   13 SUMA=SUMA+AM(L)
      DO 12 L=1,NMAT
   12 AM(L)=AM(L)/SUMA
C                                                                         103
      IF(JN-JNSTOP)400,400,401
  401 WRITE OUTPUT TAPE 6,402
  402 FORMAT (14H1 LIFE AVERAGE)
      GO TO 403
  400 WRITE OUTPUT TAPE 6,404
  404 FORMAT (1H1)
  403 WRITE OUTPUT TAPE 6,5
      DO 2   L=1, NMAT
      IL=NHOT(L,1)
    2 WRITE OUTPUT TAPE 6,3,L,(ANAME(IL,K),K=1,10),DEN(L,1),AM(L)
    3 FORMAT (I10,10A6,E20.5,E22.5)
    5 FORMAT (11H0  MATERIAL,31X,12HATOM DENSITY,6X,21HFRACTIONAL ABSORP
     1TION//)
      RETURN                                                              159
      END(1,0,0,0,0,0,1,0,0,0,0,0,0,0,0)
```

BO input description

Word							
Column							
Format	I4	I4	I4	I4	I4	I4	
Card 1	N° of groups	N° of materials in library	N° of yield cards in library	Yield card N° for material 13	Yield card N° for material 14	Yield card N° for material 15	
Symbol	N26	NLB	NLT	M1	M2	M3	

Word							
Column							
Format	I4	I4					
Card 1	How to read yield cards N > 0 chains with ramifications N ⩽ 0 chains without ramifications	If 1 normalizes fission yields to 2.0					
Symbol	N	NORM					

Word							
Column	1 - 60						
Format	10 A6						
Card 2	Isotope name						One per isotope
Symbol	ANAME(IL,K)						

Word							
Column							
Format	E 12.5	E 12.5	E 12.5	E 12.5	E 12.5		
Card 3	$\nu\sigma_{fission}$	$\sigma_{transport}$	$\sigma_{absorption}$	out scatter.	ν		One per group (N26) for each isotope (NLB) Cards 2 and 3 repeated NLB times
Symbol	FISIG(IE,IL)	TOSIG(TE,IL)	ABSIG(IE,IL)	OUSIG(IE,IL)	XNU(IE,IL)		

Word						
Column						
Format	E 12.5	E 12.5	E 12.5	E 12.5	E 12.5	
Card 4	Decay con- stant	U233 yield	U235 yield	Pu241 yield		
Symbol	XLAM(K)	YIELD1(K)	YIELD2(K)	YIELD3(K)	YIELD4(K)	

If $N > 0$ cards 4 and 5 needed

If $N \leq 0$ use cards 6

Word						
Column						
Format	E 12.5	E 12.5	E 12.5	E 12.5		
Card 5	Fracture of capture (or decay) from the material K - 1	Fraction of capture (or decay) from the material K - 2	Fraction of capture (or decay) from the material K - 3	Fraction of capture (or decay) from the material K - 4		
Symbol	DIRAC(K,1)	DIRAC(K,2)	DIRAC(K,3)	DIRAC(K,4)		

Cards 4 and 5 repeated NLT times

A negative DIRAC means decay

Word							
Column	1 - 4	13 - 24					
Format							
Card 8	Cross section block number for this material	Initial atom density					As many cards as materials (NMAT)
Symbol	NHOT(IL,I)	DEN(IL,I)					

Word							
Column							
Format							
Card 9	Yield card number for first special material	Yield card number for second special material	Yield card number for third special material	as many numbers as NO			
Symbol	NX(1)	NX(2)	NX(3)	------------	------------		

Word							
Column							
Format	E 12.5	E 12.5	E 12.5	E 12.5	E 12.5		
Card 6	If = 1.0 this element is a capture product of the preceding element	U233 yield	U235 yield	Pu239 yield	Pu240 yield		Only if N $\leqslant$ C (chains without ramifications) otherwise use cards 4 and 5
Symbol	DIRAC(K,I)	YIELD1(K)	YIELD2(K)	YIELD3(K)	YIELD4(K)		

Word							
Column							
Format	I4	I4					
Card 7	N° of materials in this case	N° of special materials					
Symbol	NMAT	NO					

Word							
Column							
Format	E 12.5	E 12.5	E 12.5				
Card 10	Time step length	Core volume	Xe removal constant (usually = 0.0)				
Symbol	DELDAY	VOL	RPXE				

Word							
Column							
Format	I4	I4					
Card 11	N° of time steps	N° of small time step per big time step					
Symbol	JNSTOP	JNUM					

Word							
Column							
Format	E 12.5	E 12.5	E 12.5	E 12.5			Group fluxes $x\ 10^{-24}$
Card 12	Flux group 1	Flux group 2	Flux group 3	Flux group 4			
Symbol	RPHIAV(1)	RPHIAV(2)	RPHIAV(3)	RPHIAV(4)			

Word							
Column							
Format	I 12	I 12	I 12				If blank CALL EXIT otherwise continue with cards 4 and 5 as many times as (KK2 - KK1)
Card 13	First yield card to be changed for next case	Last yield card to be changed for next case	IF 1 normalizes yields to 2.0				
Symbol	KK1	KK2	NORM				

To disseminate knowledge is to disseminate prosperity — I mean general prosperity and not individual riches — and with prosperity disappears the greater part of the evil which is our heritage from darker times.

Alfred Nobel

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