Table 3. Data and Results of Activation Calculations

A. Thermal Neutron Activation Reactions

mother (n, x) daughter	**T (years)**	**σ (barns)**	**ALI, MPC (Ci/yr, Ci/m^3)**	**q (Ci/cm^3)**	**bhp (m^3/cm^3)**	**c_p (g/l)**	**c_e (g/l)**
Be9 (n,g) Be10	1.6E+6 [1]	9.2E-3	3 E-5 !	2 E-6 [2] 5 E-12	7 E-1[2] 2 E-6	5 E-3	9 E-7
C13 (n, g) C14	5.7 E+3	9.0 E-4	8 E-3[o]	3 E-7[3] 6 E-10	4 E-4[3] 8 E-7	5 E+0	----[4]
Cl35 (n,g) Cl36	3.0 E+5	4.3 E+1	2 E-3	2 E-8	8 E-5	8 E-5	----
Ca40 (n,g) Ca41	1.3 E+5	4.0 E-1	2 E-3	6 E-10	2 E-6	3 E-3	----
Ni58(n,g) Ni59	7.5 E+4	4.6 E+0	3 E-1	8 E-4	2 E-2	5 E-2	5 E-4
Ni62 (n,g) Ni63	1.0 E+2	1.4 E+1	1 E-2	9 E-2	7 E+1	1 E-5	5 E-4
Se78 (n,g) Se79	6.5 E+4	5.3 E-1	2 E-3	2 E-10	8 E-7	1 E-2	----
(Zr92 (n,g) Zr93	1.5 E+6	2.6 E-1	2 E-3	3 E-12	1 E-8	8 E-1	----)[7]
Nb93(n,g) Nb94	2.0 E+4	1.2 E+0	8 E-4	3 E-6	3 E-2	1 E-4	----
Mo92(n,g) Mo93	3.5 E+3	5.0 E-2	3 E-3	4 E-6	1 E-2	2 E-2	2 E-3
Mo98(n,g) Tc99	2.1 E+5	1.3 E-1	3 E-3	2 E-7	5 E-4	2 E-5 [6]	----
(Ru96(n,g)Tc97	2.6 E+6	2.5 E-1	3 E-2	4 E-13	1 E-10	3 E-3 [6]	----)
(Pd106(n,g) Pd107	6.5 E+6	2.9 E-1	3 E-2	9 E-13	2 E-10	3 E+1	----)
Ag107(n,g) Ag108*	1.3 E+2	3.0 E+0	8 E-4	9 E-7	9 E-3	9 E-7	4 E-5
Cd112 (n,g) Cd113*	1.5 E+1	6.0 E-2	2 E-5	7 E-8	3 E-2	3 E-7	1 E-4
Sn120 (n,g) Sn121*	5.0 E+1	1.0 E-3	2 E-3	4 E-10	2 E-6	5 E-3	4 E-5
Te128 (n,g) I129	1.6 E+7	2.0 E-1	5 E-6	3 E-13	5 E-7	2 E-2	----
(Xe134 (n,g) Cs135	2.0 E+6	2.5 E-1	8 E-4	8 E-13	8 E-9	2 E+0	----)
Ba132 (n,g) Ba133	1.1 E+1	8.5 E+0	2 E-3	4 E-8	2 E-4	5 E-5	3 E-4
Sm144 (n,g) Pm145	1.8 E+1	7.0 E-1	3 E-5 !	7 E-8	2 E-2	2 E-11 [6]	----
Sm150 (n,g) Sm151	9.3 E+1	1.0 E+2	1 E-2	8 E-8	6 E-5	1 E-4	----
Eu151 (n,g) Eu152	1.2 E+1	5.9 E+3	1 E-3	4 E-4	3 E+0	2 E-9	----
Er162 (n,g) Ho163	3.3 E+1	1.9 E+1	3 E-5 !	4 E-8	1 E-2	6 E-7	----
Ho165 (n,g) Ho166*	1.2 E+3	3.5 E+0	3 E-5 !	1 E-7	3 E-2	2 E-7	----
(Hf177 (n,g) Hf178	3.1 E+1	1.0 E-7	3 E-5 !	2 E-14	7 E-9	1 E+0	----)
Re185 (n,g) Re186*	2.0 E+5	1.1 E+2	2 E-3	9 E-9	4 E-5	2 E-4	----
Ir191 (n,g) Ir192*	2.4 E+2	9.2 E+2	1 E-3	3 E-6	2 E-2	3 E-7	----
Pt192 (n,g) Pt193	5.0 E+1	1.4 E+1	9 E-3 !	9 E-8	1 E-4	8 E-5	----
Pb204 (n,g) Pb205	1.4 E+7	6.6 E-1	3 E-3	4 E-8 [2]	1 E-4 [2]	1 E+2	1 E-4
Bi209 (n,g) Bi210*	3.5 E+6	1.4 E-2	8 E-4	2 E-7 [2] 2 E-13	2 E-3 [2] 2 E-9	5 E+0	----

B. Fast Neutron Activation Reactions

mother (n, x) daughter	T (years)	σ (barns)	ALI, MPC (Ci/yr, Ci/m^3)	q (Ci/cm^3)	bhp (m^3/cm^3)	c_p (g/l)	c_e (g/l)
C13 (n,a) Be10	1.6 E+6	1.3 E-1	3 E-5 !	5)	5)	5)	9 E-7
N14 (n,p) C14	5.7 E+3	3.6 E-2	8 E-3 !	5)	5)	5)	----
O16 (n, a) C14	5.7 E+3	5.3 E-2	8 E-3 !	5)	5)	5)	----
Al27 (n,2n) Al26	7.2 E+6	5.9 E-3	3 E-5 !	1 E-10	3 E-5	1 E-1	3 E-3
(K39 (n,a) Cl36	3.0 E+5	1.5 E-1	2 E-3	9 E-11	4 E-7	2 E-2	----)
(Ca42 (n,2n) Ca41	1.3 E+5	9.3 E-2	2 E-3	8 E-13	3 E-9	2 E+0	----)
Fe54 (n,2n) Mn53	3.7 E+6	3.6 E-1	5 E-2	5 E-7	8 E-5	2 E+0	3 E-3
Ni60 (n,2n) Ni59	7.5 E+4	3.8 E-1	3 E-1	2 E-5	5 E-4	2 E+0	5 E-4
Ni64 (n,2n) Ni63	1.0 E+2	1.1 E+0	1 E-2	2 E-3	2 E+0	6 E-4	5 E-4
(Zr94 (n,2n) Zr93	1.5 E+6	1.5 E+0	2 E-3	1 E-11	4 E-8	1 E-1	----)
Nb93 (n,p) Zr93	1.5 E+6	4.5 E-2	2 E-3	1 E-9	4 E-6	2 E-3	----
Mo92 (n,2n) Nb91	1.0 E+4	1.5 E-2	3 E-5 !	4 E-7	1 E-1	3 E-5	----
Nb93 (n,2n) Nb92	1.0 E+8	4.1 E-1	3 E-5 !	2 E-10	7 E-5	7 E-2	----
Mo92 (n,p) Nb92	1.0 E+8	6.0 E-2	3 E-5 !	2 E-10	7 E-5	8 E-2	----
Nb93 (n,n*) Nb93	1.4 E+1	3.3 E-1	8 E-3	1 E-3	1 E+0	3 E-6	----
Mo94 (n,2n) Mo93	3.5 E+3	5.6 E-1	3 E-3	2 E-5	5 E-2	2 E-3	2 E-3
Mo100 (n,2n) Tc99	21.E+5	4.4 E+0	3 E-3	3 E-6	8 E-3	2 E-5 6)	----
(Ru98 (n,2n) Tc97	2.6 E+6	9.4 E-1	3 E-2	5 E-13	1 E-10	3 E-3 6)	----)
(Ru99 (n,p) Tc99	2.1 E+5	1.5 E-2	3 E-3	7 E-13	2 E-9	2 E-5	----)
Cd114 (n,2n) Cd113*	1.5 E+1	8.6 E-1	2 E-5	1 E-6	4 E-1	2 E-8	1 E-4
Sn122 (n,2n) Sn121*	5.0 E+1	9.0 E-1	2 E-3	5 E-8	2 E-4	3 E-5	4 E-5
Te124 (n,a) Sn121*	5.0 E+1	3.2 E-3	2 E-3	2 E-10	8 E-7	1 E-2	4 E-5
Te130 (n,2n) I129	1.6 E+7	1.2 E+0	5 E-6	2 E-12	3 E-6	3 E-3	----
Ba137 (n,p) Cs137	3.0 E+1	6.0 E-2	1 E-4	1 E-8	8 E-4	7 E-6	----
Ba134 (n,2n) Ba133	1.1 E+1	8.5 E-1	2 E-3	1 E-7	4 E-4	2 E-5	3 E-4
La138 (n,2n) La 137	6.0 E+4	1.9 E+0	3 E-5 !	2 E-12	7 E-7	1 E-2	----
Sm152 (n,2n) Sm151	9.3 E+1	2.1 E+0	1 E-2	4 E-9	3 E-6	2 E-3	----
Eu151 (n,2n) Eu150	3.5 E+1	6.1 E-1	3 E-5!	2 E-8	7 E-3	1 E-6	----
Eu153 (n,2n) Eu152	1.2 E+1	7.6 E-1	1 E-3	1 E-6	8 E-3	9 E-7	----
Tb159 (n,2n) Tb158	1.5 E+2	2.6 E-1	3 E-5 !	9 E-8	3 E-2	3 E-7	----
Er164 (n,2n) Ho163	3.3 E+1	2.1 E+0	3 E-5 !	5 E-8	2 E-2	5 E-7	----
Ir193 (n,2n) Ir192*	2.4 E+2	5.9 E-1	1 E-3	2 E-8	2 E-4	6 E-5	----
Pt194 (n,2n) Pt193	5.0 E+1	1.2 E+0	9 E-3 !	3 E-7	3 E-4	2 E-5	----
Pb206 (n,2n) Pb205	1.4 E+7	2.4 E+0	3 E-3	2 E-6 2)	5 E-3 2)	2 E+0	1 E-4
Bi209 (n,2n) Bi208	3.7 E+5	2.5 E+0	3 E-5 !	3 E-4 2) 3 E-10	1 E+2 2) 1 E-4	9 E-5	----

Legend and Note:

o) value is MPC (Maximim Permissible Concentration for occupational exposure), because ALI value is not yet available from ICRP.
!: 3 E-5 Ci/m^3 is MPC for "unidentified radionuclide".

1) 1.6 E+6 represents 1.6 10^6,

2) value valid only for neutron multiplier,

3) value valid only for neutron moderator,

4) no maximum concentration c_e available (see text),

5) data will be provided later

6) c_p is tolerable concentration of radionuclide Tc99 or Pm145 in water for public, g/l. It is
$c_p = 10^{-1}$ MPC / S,
where

S (specific activity, Ci/g) = activity (Ci/mole) of 1 mole of Tc (Pm) / weight (g/mole) of 1 mole of Tc (Pm), $S = N_A \lambda F/M'$

M' = weight (g/mole) of 1 mole,

10^{-1} factor converting occupational exposure into population exposure ($MPC_{pop} = 10^{-1}$ MPC).

c_p in Figs. 5 for Am, Pu and Np in fission reactor fuel elements were calculated from activation calculations with program ORIGEN (see text).

[7]) reactions in brackets generate radwaste with a potential population dose $d_{max} < 0.5$ rem.

(n,g) (n,γ) reaction,

(n,a) (n, α) reaction.