LWR First Recycle of TRU with Thorium Oxide for Transmutation and Cross Sections

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INL
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ACRONYMS

Th	Thorium
U	Uranium
Am	Americium
Bk	Berkelium
Cf	Californium
Cm	Curium
FP	Fission Product
GWd	Gigawatt-days
INL	Idaho National Laboratory
ItHM	Initial tons of Heavy Metals
LEU	Low Enriched Uranium
LWR	Light Water Reactor
MOX	Mixed Oxide
Np	Neptunium
Pa	Protactinium
Pu	Plutonium
TRU	Transuranic
UOX	Uranium Oxide
w/o	weight percent

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1. INTRODUCTION

Thorium has been considered as an option to uranium-based fuel, based on considerations of resource utilization (thorium is approximately three times more plentiful than uranium) and as a result of concerns about proliferation and waste management (e.g. reduced production of plutonium, etc.). Since the average composition of natural Thorium is dominated (100%) by the fertile isotope Th-232, Thorium is only useful as a resource for breeding new fissile materials, in this case U-233. Consequently a certain amount of fissile material must be present at the start-up of the reactor in order to guarantee its operation. The thorium fuel can be used in both once-through and recycle options, and in both fast and thermal spectrum systems.

The present study has been aimed by the necessity of investigating the option of using reprocessed plutonium/TRU, from a once-through reference LEU scenario (50 GWd/ tIHM), mixed with natural thorium and the need of collect data (mass fractions, cross-sections etc.) for this particular fuel cycle scenario. As previously pointed out, the fissile plutonium is needed to guarantee the operation of the reactor.

Four different scenarios have been considered:

- Thorium – recycled Plutonium;
- Thorium – recycled Plutonium/Neptunium;
- Thorium – recycled Plutonium/Neptunium/Americium;
- Thorium – recycled Transuranic.

The calculations have been performed with SCALE6.1-TRITON.

The amount of transuranic present in the reference 50.0 GWd/tIHM UOX SNF (4.2% U-235) after 5 years of cooling time is given in Table 1.1 below.

Isotope	kg/tIHM
Np237	6.497413E-01
Np238	1.550531E-10
Np239	1.691246E-07
Np240m	4.848635E-18
Pu236	2.000000E-97
Pu238	3.160877E-01
Pu239	6.175266E+00
Pu240	2.945851E+00
Pu241	1.406346E+00
Pu242	8.728926E-01

Pu243	3.494420E-16
Pu244	2.893894E-05
Pu246	1.799982E-21
Am241	4.443372E-01
Am242	9.896332E-09
Am242M	8.269964E-04
Am243	1.968006E-01
Am245	6.709985E-19
Am246	9.216389E-25
Cm242	1.308463E-05
Cm243	6.755201E-04
Cm244	6.995664E-02
Cm245	5.596512E-03
Cm246	7.152499E-04
Cm247	9.800633E-06
Cm248	7.574186E-07
Cm250	4.286988E-15
Bk249	1.728293E-10
Bk250	1.267657E-23
Cf249	1.039076E-08
Cf250	1.554787E-09
Cf251	9.700168E-10
Cf252	1.750708E-10
Total Pu	1.171647E+01
Total Np	6.497414E-01
Total Am	6.419649E-01
Total Cm	7.696756E-02
Total Bk	1.728293E-10
Total Cf	1.309063E-08
Total TRU	1.308515E+01

Table 1.1 - TRU composition in the reference 50 GWd/tIHM UOX SNF (5-year cooling time).

2. CALCULATION METHODOLOGY

As previously said, the calculations needed by this study have been performed through the code SCALE 6.1/TRITON.
A small overview on the main capabilities and models used is reported in the following paragraphs.


2.1 SCALE 6.1 CODE SYSTEMS.

The reactor physics calculations have been performed by the lattice physics capabilities of the SCALE 6.1 code systems. The calculation flow consists of the use of several modules mutually coupled. The discrete-ordinates code NEWT (**N**ew **E**SC-based **W**eighting **T**ransport code) coupled to the depletion code ORIGEN [8] via the TRITON control module [4]. Using the discrete-ordinates approximation to the transport equation on an arbitrary grid, together with a 238-group neutron cross-section library based on ENDF/B-VII, NEWT provides a robust and rigorous deterministic solution for non-orthogonal configurations. The differencing scheme employed by NEWT, the Extended Step Characteristic Approximation, allows a computational two-dimensional mesh based on arbitrary polygons. Such a mesh can be used to closely approximate curved or irregular surfaces to provide the capability to model problems that were formerly difficult or impractical to model directly with discrete-ordinates methods.

The TRITON control module performs the task of coordination of data transfer between various physics codes available within SCALE 6.1 and of invoking those codes in the proper sequence for a desired type of calculation. The high-fidelity nature of the NEWT solution in estimating angular flux distributions combined with the rigor of the ORIGEN depletion solver gives TRITON the capability to perform precise burnup-dependent physics calculations with few implicit approximations, and limited primarily by the accuracy of nuclide cross-sectional data. Such rigor may be necessary to capture the unique attributes of MOX/Th-TRU fuel behavior as well as that of advanced, highly heterogeneous fuel assembly designs being deployed in current-generation reactors. Cross-sectional self-shielding is carried out by BONAMI for unresolved-range resonance data; the resolved resonance processor module CENTRM performs a 1-D discrete-ordinates code that uses point-wise cross-section data to produce a set of continuous-energy fluxes at discrete spatial intervals for each unit cell. Following a CENTRM calculation, the code PMC uses the resulting flux to collapse the point-wise continuous-energy cross sections into multi-group cross sections for each nuclide in each material in a unit (e.g., pin cell). The result is a multi-group library in which point cross-sectional data are weighted using the explicit point-wise spectrum representative of the nuclides present in a pin cell. Effects from overlapping resonances, fissile material in the fuel and surrounding moderator, anisotropic scattering, and inelastic level scattering are explicitly handled by this approach.

For the physics calculations carried out during this study, a TRITON model of one fourth standard (17x17) fuel assembly has been used (Fig 2.1). All the Th-TRU rods have the same Th-232 enrichment and the same Plutonium content. The 0.5 mm water gap at the periphery is explicitly represented. The model uses three different burn-up zones to take into account the

different local moderating ratios: 1 for the corner rods (blue), 1 for the other rods located at the periphery (green) and 1 for the internal rods (red).
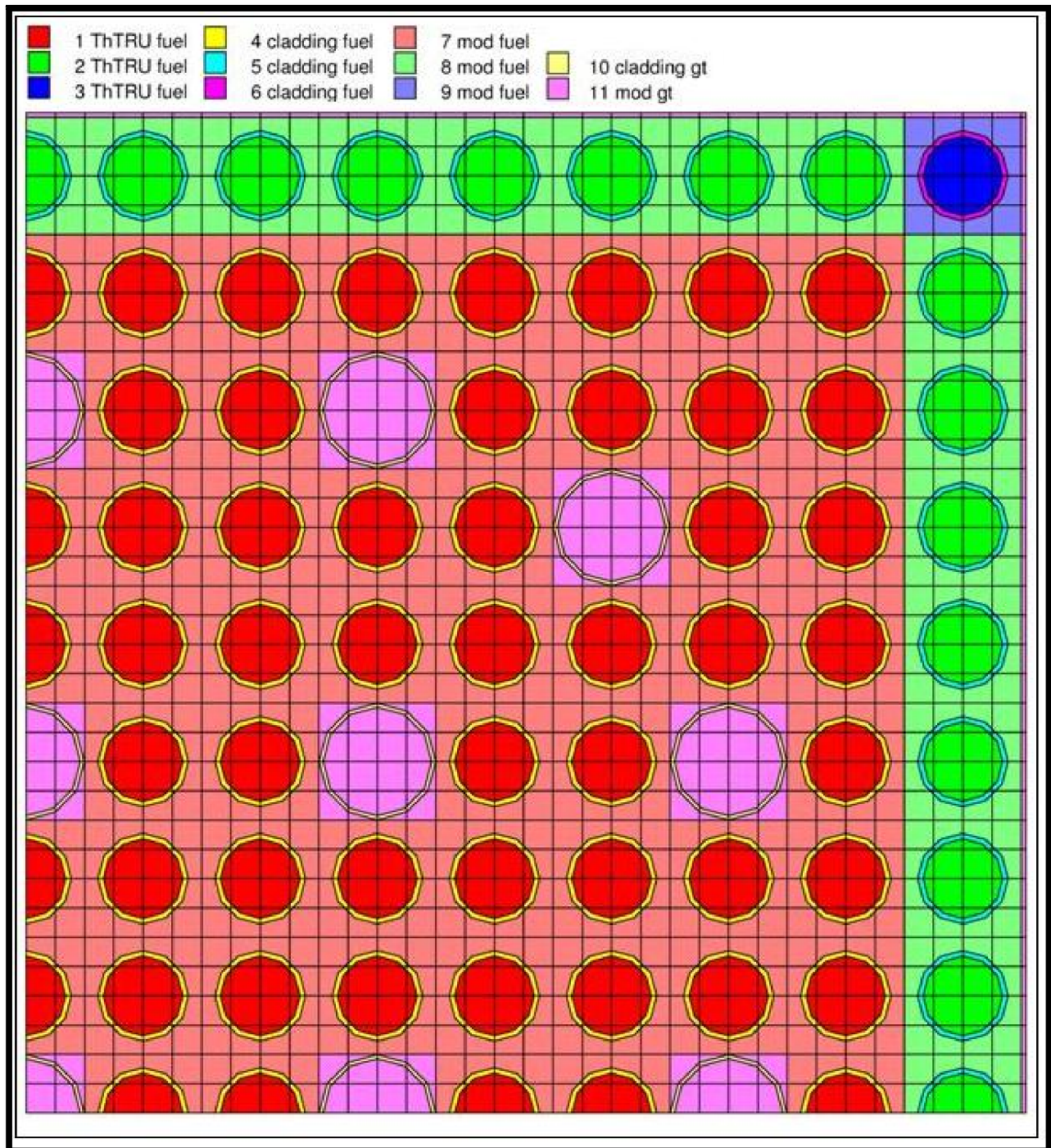
Figure 2.1 - TRITON model (one fourth of a standard 17x17 fuel assembly)

The TRU content in the Th-TRU fuel assemblies has been tuned to maintain the same average discharge burn-up and a **constant cycle length**. The calculations have been run considering a 3-batch core with an average discharge burn-up of **50.0 GWd/tIHM** and a fuel power density of ~ **39.2 MW/tIHM**. The model takes in account 2 year fuel aging (time needed by the fabrication and transport operations) and 5 years of cooling time (time needed in order to reduce the decay heat generation to levels compatible with the separation operations). The burn-up level above specified is reached after ~ 1275 days of irradiation. **One cycle then corresponds to 2 years + 50 GWd/tIHM (1275 days) + 5 years cooling time $\cong$ 10.5 years.**

The necessary TRU[1] enrichments are determined with a methodology that is standard for this kind of application: the k-infinity of the assembly at the average end of cycle burn-up (33.33 GWd/tIHM), without soluble boron, is equal to that of the reference 4.2% UOX assembly calculated using the same code (SCALE 6.1), methods (SN), nuclear data (238 group library based on ENDF/B - VII), etc., i.e. **k-inf = 1.03255** in our case.

The previous explained strategy ensures the different fuels will release the same amount of energy and thus allows relevant comparisons among them.

2.2   DENSITY CALCULATION.

The mixture densities have been calculated through the individual values of the single mixture (ρ_i) and relative volume(w_i):

$$\rho_{mixture} = \sum_{i=1}^{\# \, mixtures} \rho_i \times w_i$$

The computed value has been corrected considering the fabrication packing factor (f)[10]:

$$\rho_{mixture\_final} = \rho_{mixture} \times f$$

The following individual densities have been considered:
-   ThOx: 10.0 g/cc;
-   TRUOx: 11.5 g/cc.

Considering as an example the Th-PuOx case, the previous relations become:

$$\rho_{ThPuOx} = (\rho_{ThOx} \times w_{ThOx} + \rho_{PuOx} \times w_{PuOx}) \times f$$
$$= (10.0 \times 0.8488 + 11.5 \times 0.1512) \times 0.95 = \boldsymbol{9.715 \, g/cc}$$

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[1] *Pu, PuNp, PuNpAm or TRU*

3. RESULTS

3.1 SCALE6.1

The table and figure below show the calculated *Pu/PuNp/PuNpAm/TRU* enrichment and Pu, Np, Am, other-TRU contents in the fuel assemblies necessary to maintain the same average burn-up at discharge of 50 GWd/tIHM.

Case	*TRU* enrichment (w/o%)	Pu content (w/o%)	Np content (w/o%)	Am content (w/o%)	Other-TRU content (w/o%)
Th-Pu	15.120%	15.120%	0.000%	0.000%	0.000%
Th-PuNp	18.282%	17.322%	0.961%	0.000%	0.000%
Th-PuNpAm	22.569%	20.328%	1.127%	1.114%	0.000%
Th-TRU	22.591%	20.228%	1.122%	1.108%	0.133%
Th-Pu(51GWd/tIHM)[2]	15.969%	15.969%	0.000%	0.000%	0.000%

Table 3.1 - *TRU* enrichment and main actinide contents..
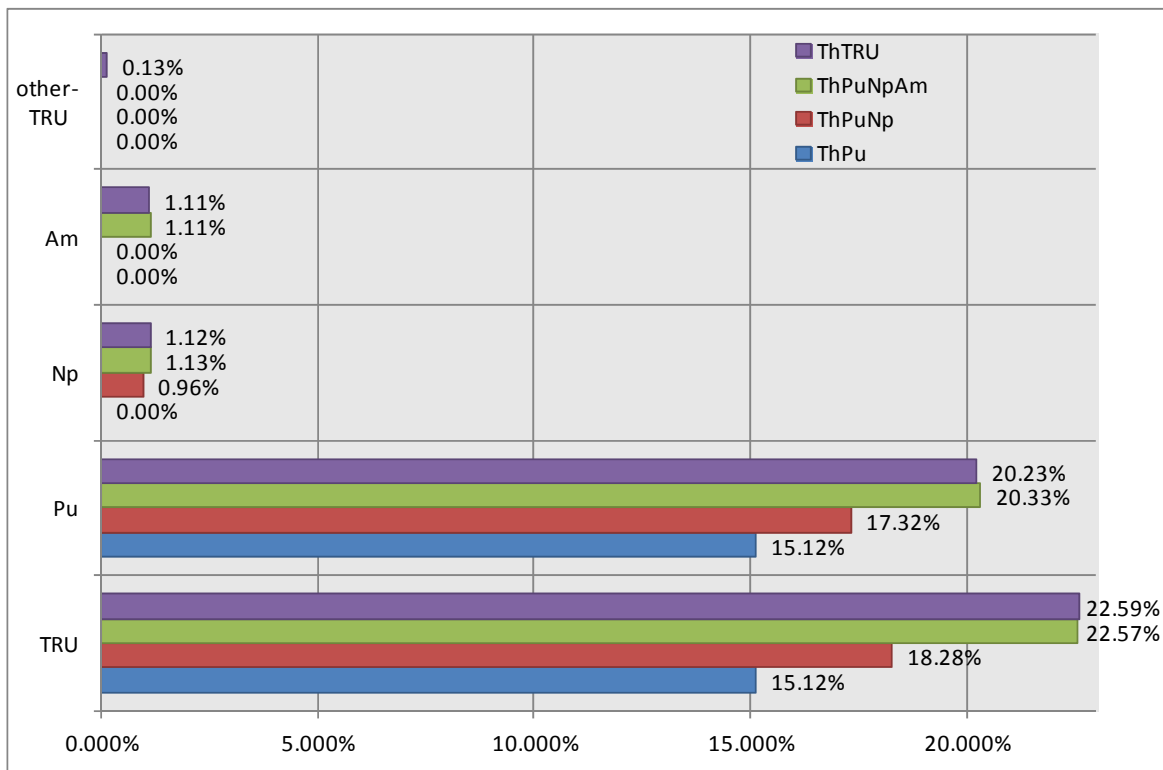
Figure 3.1 - *TRU* content in PWR Th-TRUOx fuel assemblies calculated with SCALE6.1.

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[2] Feed Material (Pu) from discharged UOX(51 GWd/tIHM) + 10 years cooling[9].

The figure below shows the k-inf trend for each case and each cycle step (initial fuel aging, burning) against the 50 GWd/tIHM UOX (4.2%) SNF reference case.
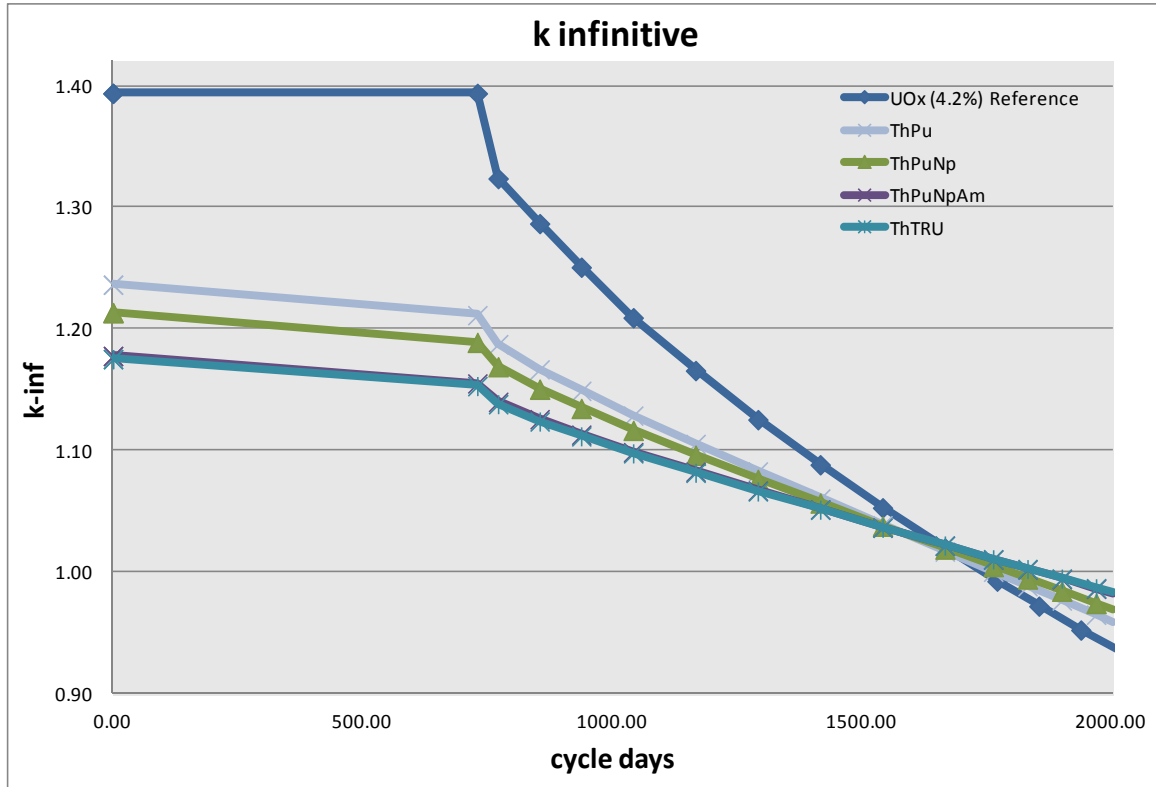
Figure 3.2 – *k-infinitive* trends.

The following table summarizes the isotopic input, after 2 years aging, and output compositions, at the average discharged burn-up of 50 GWd/tIHM, for the four cases taken in exam.

Isotopic input (2 yrs aging) and output mass vectors								
Isotope	**ThPu**		**ThPuNp**		**ThPuNpAm**		**ThTRU**	
	kg/tIHM		***kg/tIHM***		***kg/tIHM***		***kg/tIHM***	
IDs	*Input*	*Output*	*Input*	*Output*	*Input*	*Output*	*Input*	*Output*
Th228	7.265E-09	3.740E-04	6.997E-09	3.348E-04	6.626E-09	2.929E-04	6.628E-09	2.953E-04
Th229	0.000E+00	0.000E+00	2.520E-11	1.379E-04	2.961E-11	1.240E-04	2.945E-11	1.244E-04
Th230	1.750E-07	1.504E-03	2.005E-07	1.506E-03	2.353E-07	1.516E-03	2.342E-07	1.526E-03
Th232	8.488E+02	8.289E+02	8.172E+02	7.983E+02	7.744E+02	7.566E+02	7.741E+02	7.564E+02
Pa231	8.550E-12	1.555E-01	9.114E-12	1.584E-01	9.900E-12	1.599E-01	9.849E-12	1.604E-01
U232	4.466E-17	4.838E-02	1.347E-15	4.285E-02	1.635E-15	3.687E-02	1.617E-15	3.710E-02
U233	9.434E-10	1.286E+01	6.108E-06	1.259E+01	7.172E-06	1.223E+01	7.138E-06	1.224E+01
U234	6.288E-02	1.021E+00	7.204E-02	9.832E-01	8.452E-02	9.208E-01	8.415E-02	9.206E-01

U235	4.506E-03	8.896E-02	5.162E-03	8.503E-02	6.054E-03	7.852E-02	6.029E-03	7.833E-02
U236	7.898E-03	2.223E-02	9.048E-03	2.495E-02	1.062E-02	2.869E-02	1.058E-02	2.859E-02
U238	4.095E-05	1.178E-04	4.691E-05	1.308E-04	5.504E-05	1.515E-04	5.479E-05	1.508E-04
Np237	2.723E-03	1.367E-02	9.607E+00	5.897E+00	1.130E+01	7.394E+00	1.124E+01	7.353E+00
Pu238	4.015E+00	4.001E+00	4.599E+00	7.667E+00	5.399E+00	1.052E+01	5.374E+00	1.047E+01
Pu239	7.969E+01	3.532E+01	9.127E+01	4.674E+01	1.071E+02	6.267E+01	1.066E+02	6.231E+01
Pu240	3.800E+01	3.344E+01	4.354E+01	3.952E+01	5.108E+01	4.806E+01	5.092E+01	4.796E+01
Pu241	1.647E+01	1.705E+01	1.887E+01	1.901E+01	2.214E+01	2.126E+01	2.204E+01	2.120E+01
Pu242	1.126E+01	1.188E+01	1.290E+01	1.330E+01	1.514E+01	1.582E+01	1.507E+01	1.574E+01
Am241	1.675E+00	2.498E+00	1.919E+00	3.039E+00	9.935E+00	7.808E+00	9.889E+00	7.767E+00
Am242m	1.123E-09	6.651E-02	1.123E-09	8.287E-02	1.420E-02	2.517E-01	1.414E-02	2.504E-01
Am243	1.201E-09	2.327E+00	1.202E-09	2.432E+00	3.413E+00	4.356E+00	3.397E+00	4.339E+00
Cm242	5.337E-11	3.138E-01	5.338E-11	3.208E-01	3.536E-05	7.133E-01	4.529E-05	7.100E-01
Cm243	1.082E-09	1.351E-02	1.082E-09	1.371E-02	1.081E-09	3.687E-02	1.112E-02	4.038E-02
Cm244	1.050E-09	1.031E+00	1.050E-09	9.625E-01	1.092E-09	2.138E+00	1.119E+00	2.861E+00
Cm245	1.134E-09	1.225E-01	1.134E-09	1.083E-01	1.134E-09	2.658E-01	9.660E-02	4.739E-01
Cm246	1.134E-09	4.772E-03	1.134E-09	3.566E-03	1.134E-09	9.388E-03	1.234E-02	3.661E-02
Cm247	1.134E-09	8.302E-05	1.134E-09	6.021E-05	1.134E-09	1.812E-04	1.692E-04	1.472E-03
Cm248	1.134E-09	4.142E-06	1.134E-09	2.710E-06	1.134E-09	8.231E-06	1.308E-05	1.615E-04
Bk249	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.434E-10	4.738E-06
Cf249	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.335E-09	3.330E-06
Element input and output summary								
IDs	*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
Th	84.88%	82.89%	81.72%	79.83%	77.44%	75.66%	77.41%	75.64%
Pa	0.00%	0.07%	0.00%	0.07%	0.00%	0.07%	0.00%	0.07%
U	0.01%	1.40%	0.01%	1.37%	0.01%	1.33%	0.01%	1.33%
Np	0.00%	0.00%	0.96%	0.59%	1.13%	0.74%	1.12%	0.74%
Pu	14.94%	10.17%	17.12%	12.62%	20.09%	15.83%	20.00%	15.77%
Am	0.17%	0.49%	0.19%	0.56%	1.34%	1.24%	1.33%	1.24%
Cm	0.00%	0.15%	0.00%	0.14%	0.00%	0.32%	0.12%	0.41%
Bk	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Cf	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
FP	0.00%	4.82%	0.00%	4.82%	0.00%	4.81%	0.00%	4.81%

Table 3.2 – *Mass Fraction input and output* (summary).

4. CONCLUSIONS.

This report presents the results of a neutronics analysis in which the option of a thorium-based fuel cycle has been shown.

The main objective of these calculations is quantify the TRU enrichment needed to operate a Thorium based reactor (PWR) in order to maintain the same average burnup at discharge (50 GWd/tIHM) and, consequently, collect the data needed for further analysis.

It is important to recognize that these results are based on infinite lattice assembly calculations, assuming standard UOX fuel assembly parameters with homogeneously loaded fuel. While this approach increases the ability to retrofit thorium-based fuels into existing commercial PWRs with minimal or no changes required to reactor hardware, it **does not** represent the optimum performance achievable. Additionally more detailed studies (i.e. optimization of assembly and reactor parameters, calculation of void coefficients, etc.) would be required.

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Appendix 1: Detailed isotopic mass fraction input (after 2-yrs fuel aging).

Isotopic input mass vector				
Isotope	**ThPu**	**ThPuNp**	**ThPuNpAm**	**ThTRU**
IDs	*kg/tIHM*	*kg/tIHM*	*kg/tIHM*	*kg/tIHM*
He4	1.332E-03	1.527E-03	2.212E-03	3.675E-03
Ra228	7.313E-08	7.041E-08	6.670E-08	6.672E-08
Th228	7.265E-09	6.997E-09	6.626E-09	6.628E-09
Th229	0.000E+00	2.520E-11	2.961E-11	2.945E-11
Th230	1.750E-07	2.005E-07	2.353E-07	2.342E-07
Th231	1.831E-14	2.098E-14	2.462E-14	2.450E-14
Th232	8.488E+02	8.172E+02	7.744E+02	7.741E+02
Pa231	8.550E-12	9.114E-12	9.900E-12	9.849E-12
Pa233	9.223E-11	3.254E-07	3.826E-07	3.809E-07
Pa234	6.886E-18	7.890E-18	9.257E-18	9.216E-18
U232	4.466E-17	1.347E-15	1.635E-15	1.617E-15
U233	9.434E-10	6.108E-06	7.172E-06	7.138E-06
U234	6.288E-02	7.204E-02	8.452E-02	8.415E-02
U235	4.506E-03	5.162E-03	6.054E-03	6.029E-03
U236	7.898E-03	9.048E-03	1.062E-02	1.058E-02
U237	5.139E-07	5.888E-07	6.908E-07	6.874E-07
U238	4.095E-05	4.691E-05	5.504E-05	5.479E-05
Np236	0.000E+00	1.966E-15	2.387E-15	2.362E-15
Np237	2.723E-03	9.607E+00	1.130E+01	1.124E+01
Np238	2.043E-16	2.044E-16	2.584E-09	2.572E-09
Np239	1.034E-15	1.035E-15	2.938E-06	2.924E-06
Pu236	7.353E-17	2.223E-15	2.700E-15	2.670E-15
Pu237	7.709E-20	9.017E-20	1.095E-19	1.082E-19
Pu238	4.015E+00	4.599E+00	5.399E+00	5.374E+00
Pu239	7.969E+01	9.127E+01	1.071E+02	1.066E+02
Pu240	3.800E+01	4.354E+01	5.108E+01	5.092E+01
Pu241	1.647E+01	1.887E+01	2.214E+01	2.204E+01
Pu242	1.126E+01	1.290E+01	1.514E+01	1.507E+01
Pu243	4.044E-20	4.044E-20	4.043E-20	6.034E-15
Pu244	4.072E-15	4.073E-15	1.922E-14	4.696E-11
Am241	1.675E+00	1.919E+00	9.935E+00	9.889E+00
Am242	1.449E-14	1.449E-14	1.833E-07	1.824E-07
Am242M	1.123E-09	1.123E-09	1.420E-02	1.414E-02
Am243	1.201E-09	1.202E-09	3.413E+00	3.397E+00
Cm242	5.337E-11	5.338E-11	3.536E-05	4.529E-05

Cm243	1.082E-09	1.082E-09	1.081E-09	1.112E-02
Cm244	1.050E-09	1.050E-09	1.092E-09	1.119E+00
Cm245	1.134E-09	1.134E-09	1.134E-09	9.660E-02
Cm246	1.134E-09	1.134E-09	1.134E-09	1.234E-02
Cm247	1.134E-09	1.134E-09	1.134E-09	1.692E-04
Cm248	1.134E-09	1.134E-09	1.134E-09	1.308E-05
Bk249	0.000E+00	0.000E+00	0.000E+00	6.434E-10
Cf249	0.000E+00	0.000E+00	0.000E+00	2.335E-09
Zn70	7.969E-17	8.300E-17	8.567E-17	8.573E-17
Ga71	1.760E-16	1.826E-16	1.891E-16	1.892E-16
Ge72	4.075E-16	4.185E-16	4.315E-16	4.317E-16
Ge73	8.158E-16	8.287E-16	8.443E-16	8.450E-16
Ge74	1.952E-15	1.978E-15	2.013E-15	2.014E-15
Ge76	8.893E-15	8.995E-15	9.108E-15	9.110E-15
As75	4.021E-15	4.046E-15	4.081E-15	4.082E-15
Se77	2.118E-14	2.134E-14	2.155E-14	2.156E-14
Se78	5.720E-14	5.730E-14	5.733E-14	5.730E-14
Se79	1.241E-13	1.242E-13	1.241E-13	1.240E-13
Se80	2.629E-13	2.617E-13	2.595E-13	2.592E-13
Se82	7.252E-13	7.235E-13	7.181E-13	7.174E-13
Br79	6.627E-17	6.632E-17	6.626E-17	6.619E-17
Br81	5.153E-13	5.118E-13	5.051E-13	5.048E-13
Kr82	3.343E-15	3.308E-15	3.270E-15	3.269E-15
Kr83	1.026E-12	1.024E-12	1.019E-12	1.018E-12
Kr84	1.735E-12	1.733E-12	1.723E-12	1.722E-12
Kr85	4.585E-13	4.577E-13	4.549E-13	4.546E-13
Kr86	2.811E-12	2.807E-12	2.793E-12	2.792E-12
Rb85	1.584E-12	1.582E-12	1.573E-12	1.572E-12
Rb87	3.651E-12	3.648E-12	3.631E-12	3.629E-12
Sr86	5.848E-16	5.941E-16	6.107E-16	6.113E-16
Sr87	7.564E-17	7.411E-17	7.207E-17	7.200E-17
Sr88	4.761E-12	4.753E-12	4.730E-12	4.727E-12
Sr89	2.717E-16	2.713E-16	2.698E-16	2.696E-16
Sr90	7.181E-12	7.173E-12	7.137E-12	7.130E-12
Y89	6.108E-12	6.099E-12	6.067E-12	6.064E-12
Y90	1.821E-15	1.819E-15	1.810E-15	1.809E-15
Y91	1.554E-15	1.553E-15	1.547E-15	1.546E-15
Zr90	3.529E-13	3.525E-13	3.507E-13	3.504E-13
Zr91	8.844E-12	8.841E-12	8.809E-12	8.802E-12
Zr92	1.098E-11	1.098E-11	1.095E-11	1.094E-11

Zr93	1.370E-11	1.369E-11	1.364E-11	1.363E-11
Zr94	1.558E-11	1.555E-11	1.550E-11	1.548E-11
Zr95	6.495E-15	6.487E-15	6.459E-15	6.456E-15
Zr96	1.902E-11	1.901E-11	1.898E-11	1.896E-11
Nb94	4.382E-17	4.301E-17	4.248E-17	4.248E-17
Nb95	7.868E-15	7.855E-15	7.823E-15	7.816E-15
Nb95M	4.191E-18	4.185E-18	4.168E-18	4.165E-18
Mo95	1.764E-11	1.762E-11	1.755E-11	1.753E-11
Mo96	2.130E-14	2.135E-14	2.149E-14	2.147E-14
Mo97	2.123E-11	2.122E-11	2.116E-11	2.115E-11
Mo98	2.271E-11	2.268E-11	2.262E-11	2.261E-11
Mo100	2.816E-11	2.812E-11	2.806E-11	2.805E-11
Tc98	1.171E-18	1.150E-18	1.162E-18	1.168E-18
Tc99	2.720E-11	2.717E-11	2.712E-11	2.710E-11
Ru99	1.062E-15	1.061E-15	1.059E-15	1.058E-15
Ru100	8.880E-16	8.727E-16	8.659E-16	8.687E-16
Ru101	2.454E-11	2.457E-11	2.460E-11	2.460E-11
Ru102	2.659E-11	2.662E-11	2.666E-11	2.666E-11
Ru103	7.445E-17	7.433E-17	7.423E-17	7.420E-17
Ru104	2.663E-11	2.664E-11	2.669E-11	2.669E-11
Ru106	5.210E-12	5.215E-12	5.231E-12	5.233E-12
Rh103	2.972E-11	2.968E-11	2.964E-11	2.963E-11
Rh103M	7.304E-20	7.292E-20	7.282E-20	7.279E-20
Rh106	4.809E-18	4.814E-18	4.831E-18	4.832E-18
Pd104	2.176E-17	2.152E-17	2.181E-17	2.215E-17
Pd105	2.397E-11	2.393E-11	2.392E-11	2.392E-11
Pd106	1.500E-11	1.501E-11	1.506E-11	1.506E-11
Pd107	1.580E-11	1.581E-11	1.589E-11	1.590E-11
Pd108	1.111E-11	1.113E-11	1.122E-11	1.124E-11
Pd110	3.633E-12	3.649E-12	3.712E-12	3.739E-12
Ag109	7.683E-12	7.684E-12	7.726E-12	7.746E-12
Ag110M	2.086E-19	2.146E-19	6.345E-19	1.344E-18
In115	2.193E-13	2.216E-13	2.272E-13	2.307E-13
Sn115	1.084E-14	1.095E-14	1.123E-14	1.140E-14
Sn116	1.636E-18	1.781E-18	1.973E-18	1.965E-18
Sn117	2.137E-13	2.150E-13	2.180E-13	2.188E-13
Sn118	1.830E-13	1.854E-13	1.897E-13	1.902E-13
Sn119	1.819E-13	1.842E-13	1.883E-13	1.885E-13
Sn120	1.699E-13	1.725E-13	1.769E-13	1.769E-13
Sn121	5.175E-19	5.232E-19	5.359E-19	5.360E-19

Sn121M	1.189E-14	1.203E-14	1.232E-14	1.232E-14
Sn122	2.300E-13	2.322E-13	2.364E-13	2.364E-13
Sn123	1.968E-15	1.992E-15	2.037E-15	2.039E-15
Sn124	3.583E-13	3.600E-13	3.639E-13	3.640E-13
Sn126	9.087E-13	9.096E-13	9.139E-13	9.141E-13
Sb121	1.827E-13	1.847E-13	1.884E-13	1.884E-13
Sb123	2.252E-13	2.284E-13	2.336E-13	2.338E-13
Sb124	2.777E-19	2.779E-19	2.856E-19	2.852E-19
Sb125	3.073E-13	3.085E-13	3.113E-13	3.114E-13
Sb126	1.870E-20	1.872E-20	1.881E-20	1.881E-20
Te122	1.598E-16	1.617E-16	1.752E-16	1.781E-16
Te124	1.499E-15	1.500E-15	1.543E-15	1.540E-15
Te125	1.930E-13	1.938E-13	1.955E-13	1.956E-13
Te125M	4.301E-15	4.319E-15	4.358E-15	4.359E-15
Te126	1.422E-14	1.414E-14	1.432E-14	1.433E-14
Te127	3.866E-18	3.846E-18	3.820E-18	3.822E-18
Te127M	1.104E-15	1.099E-15	1.091E-15	1.091E-15
Te128	3.366E-12	3.378E-12	3.375E-12	3.375E-12
Te129M	6.640E-22	6.922E-22	7.449E-22	7.776E-22
Te130	1.157E-11	1.156E-11	1.152E-11	1.152E-11
I127	2.232E-12	2.221E-12	2.206E-12	2.206E-12
I129	6.376E-12	6.368E-12	6.345E-12	6.346E-12
Xe128	2.998E-16	2.914E-16	2.799E-16	2.794E-16
Xe130	1.786E-14	1.753E-14	1.723E-14	1.721E-14
Xe131	1.922E-11	1.918E-11	1.915E-11	1.914E-11
Xe132	2.745E-11	2.739E-11	2.731E-11	2.729E-11
Xe134	4.159E-11	4.154E-11	4.149E-11	4.147E-11
Xe136	3.852E-11	3.848E-11	3.845E-11	3.843E-11
Cs133	3.699E-11	3.695E-11	3.687E-11	3.685E-11
Cs134	1.516E-15	1.503E-15	1.523E-15	1.528E-15
Cs135	4.071E-11	4.066E-11	4.058E-11	4.057E-11
Cs136	3.473E-30	3.449E-30	3.485E-30	3.496E-30
Cs137	3.483E-11	3.481E-11	3.477E-11	3.476E-11
Ba134	1.451E-15	1.439E-15	1.458E-15	1.462E-15
Ba135	7.344E-17	7.279E-17	7.304E-17	7.341E-17
Ba136	4.193E-13	4.163E-13	4.205E-13	4.220E-13
Ba137	1.669E-12	1.667E-12	1.665E-12	1.665E-12
Ba137M	5.307E-18	5.303E-18	5.297E-18	5.294E-18
Ba138	3.478E-11	3.478E-11	3.479E-11	3.479E-11
Ba140	1.508E-28	1.508E-28	1.507E-28	1.507E-28

La138	2.505E-16	2.471E-16	2.503E-16	2.526E-16
La139	3.254E-11	3.254E-11	3.257E-11	3.258E-11
La140	2.701E-29	2.701E-29	2.699E-29	2.699E-29
Ce140	3.107E-11	3.106E-11	3.105E-11	3.104E-11
Ce141	5.188E-18	5.180E-18	5.174E-18	5.171E-18
Ce142	2.941E-11	2.938E-11	2.936E-11	2.936E-11
Ce144	3.870E-12	3.872E-12	3.871E-12	3.872E-12
Pr141	3.001E-11	2.998E-11	2.993E-11	2.993E-11
Pr143	1.844E-27	1.843E-27	1.842E-27	1.842E-27
Pr144	1.630E-16	1.631E-16	1.631E-16	1.631E-16
Nd142	4.695E-18	4.665E-18	4.928E-18	5.013E-18
Nd143	2.656E-11	2.655E-11	2.653E-11	2.653E-11
Nd144	1.902E-11	1.902E-11	1.903E-11	1.903E-11
Nd145	1.809E-11	1.810E-11	1.811E-11	1.811E-11
Nd146	1.511E-11	1.513E-11	1.514E-11	1.515E-11
Nd147	9.962E-32	9.970E-32	9.980E-32	9.986E-32
Nd148	1.042E-11	1.044E-11	1.046E-11	1.047E-11
Nd150	6.187E-12	6.196E-12	6.217E-12	6.227E-12
Pm147	7.410E-12	7.415E-12	7.423E-12	7.424E-12
Pm148	6.772E-25	6.887E-25	7.581E-25	7.763E-25
Pm148M	1.079E-22	1.098E-22	1.208E-22	1.237E-22
Sm147	5.016E-12	5.017E-12	5.025E-12	5.026E-12
Sm148	3.170E-16	3.176E-16	3.208E-16	3.217E-16
Sm149	7.740E-12	7.754E-12	7.779E-12	7.785E-12
Sm150	5.852E-15	5.875E-15	6.045E-15	6.113E-15
Sm151	4.726E-12	4.735E-12	4.756E-12	4.762E-12
Sm152	3.739E-12	3.745E-12	3.763E-12	3.770E-12
Sm154	1.779E-12	1.783E-12	1.795E-12	1.801E-12
Eu151	7.348E-14	7.362E-14	7.392E-14	7.402E-14
Eu152	2.051E-19	2.076E-19	2.423E-19	2.505E-19
Eu153	2.506E-12	2.518E-12	2.542E-12	2.551E-12
Eu154	3.702E-16	3.702E-16	3.758E-16	3.796E-16
Eu155	8.695E-13	8.744E-13	8.861E-13	8.903E-13
Eu156	2.948E-27	2.962E-27	2.999E-27	3.010E-27
Gd152	2.956E-16	2.956E-16	2.956E-16	2.957E-16
Gd154	3.639E-16	3.640E-16	3.649E-16	3.657E-16
Gd155	2.948E-13	2.964E-13	3.004E-13	3.018E-13
Gd156	8.616E-13	8.656E-13	8.765E-13	8.797E-13
Gd157	5.800E-13	5.840E-13	5.927E-13	5.963E-13
Gd158	3.525E-13	3.555E-13	3.622E-13	3.651E-13

Gd160	8.382E-14	8.476E-14	8.773E-14	8.943E-14
Tb159	1.838E-13	1.858E-13	1.906E-13	1.926E-13
Tb160	3.116E-20	3.151E-20	5.469E-20	5.937E-20
Dy160	3.430E-17	3.468E-17	6.019E-17	6.535E-17
Dy161	3.975E-14	4.028E-14	4.206E-14	4.323E-14
Dy162	1.344E-14	1.374E-14	1.448E-14	1.529E-14
Dy163	5.659E-15	5.809E-15	6.129E-15	6.685E-15
Dy164	2.362E-15	2.469E-15	2.664E-15	2.931E-15
Ho165	1.037E-15	1.095E-15	1.200E-15	1.322E-15
Er166	5.624E-16	6.007E-16	6.631E-16	7.156E-16
Er167	1.886E-16	2.089E-16	2.405E-16	2.680E-16
Er168	7.626E-17	8.485E-17	9.737E-17	1.133E-16

Appendix 2: Detailed isotopic mass fraction output (discharged burn-up 50 GWd/ tIHM).

Isotopic output mass vector				
Isotope	**ThPu**	**ThPuNp**	**ThPuNpAm**	**ThTRU**
IDs	***kg/tIHM***	***kg/tIHM***	***kg/tIHM***	***kg/tIHM***
He4	2.716E-02	2.883E-02	6.827E-02	7.151E-02
Ra228	2.688E-07	2.610E-07	2.540E-07	2.548E-07
Th228	3.740E-04	3.348E-04	2.929E-04	2.953E-04
Th229	0.000E+00	1.379E-04	1.240E-04	1.244E-04
Th230	1.504E-03	1.506E-03	1.516E-03	1.526E-03
Th231	2.404E-04	2.346E-04	2.265E-04	2.264E-04
Th232	8.289E+02	7.983E+02	7.566E+02	7.564E+02
Th233	1.115E-05	1.048E-05	9.712E-06	9.709E-06
Pa231	1.555E-01	1.584E-01	1.599E-01	1.604E-01
Pa233	5.902E-01	5.558E-01	5.168E-01	5.166E-01
Pa234	4.243E-05	3.677E-05	3.031E-05	3.029E-05
U232	4.838E-02	4.285E-02	3.687E-02	3.710E-02
U233	1.286E+01	1.259E+01	1.223E+01	1.224E+01
U234	1.021E+00	9.832E-01	9.208E-01	9.206E-01
U235	8.896E-02	8.503E-02	7.852E-02	7.833E-02
U236	2.223E-02	2.495E-02	2.869E-02	2.859E-02
U237	3.760E-05	3.953E-05	4.188E-05	4.171E-05
U238	1.178E-04	1.308E-04	1.515E-04	1.508E-04
Np236	0.000E+00	2.454E-05	3.757E-05	3.744E-05
Np236M	0.000E+00	2.262E-07	2.890E-07	2.875E-07
Np237	1.367E-02	5.897E+00	7.394E+00	7.353E+00
Np238	1.801E-05	6.762E-03	7.340E-03	7.299E-03
Np239	2.071E-06	3.939E-06	5.397E-06	5.374E-06
Pu236	3.298E-06	7.891E-05	1.011E-04	1.009E-04
Pu237	1.242E-05	2.518E-05	3.580E-05	3.565E-05
Pu238	4.001E+00	7.667E+00	1.052E+01	1.047E+01
Pu239	3.532E+01	4.674E+01	6.267E+01	6.231E+01
Pu240	3.344E+01	3.952E+01	4.806E+01	4.796E+01
Pu241	1.705E+01	1.901E+01	2.126E+01	2.120E+01
Pu242	1.188E+01	1.330E+01	1.582E+01	1.574E+01
Pu243	6.561E-04	6.512E-04	6.505E-04	6.482E-04
Pu244	4.090E-04	3.778E-04	8.574E-04	8.541E-04
Am240	0.000E+00	0.000E+00	3.193E-07	3.178E-07
Am241	2.498E+00	3.039E+00	7.808E+00	7.767E+00
Am242	1.538E-03	1.571E-03	3.194E-03	3.178E-03

Am242M	6.651E-02	8.287E-02	2.517E-01	2.504E-01
Am243	2.327E+00	2.432E+00	4.356E+00	4.339E+00
Am244	0.000E+00	0.000E+00	7.627E-05	7.596E-05
Am244M	2.339E-06	0.000E+00	3.196E-06	3.182E-06
Cm242	3.138E-01	3.208E-01	7.133E-01	7.100E-01
Cm243	1.351E-02	1.371E-02	3.687E-02	4.038E-02
Cm244	1.031E+00	9.625E-01	2.138E+00	2.861E+00
Cm245	1.225E-01	1.083E-01	2.658E-01	4.739E-01
Cm246	4.772E-03	3.566E-03	9.388E-03	3.661E-02
Cm247	8.302E-05	6.021E-05	1.812E-04	1.472E-03
Cm248	4.142E-06	2.710E-06	8.231E-06	1.615E-04
Bk249	0.000E+00	0.000E+00	0.000E+00	4.738E-06
Cf249	0.000E+00	0.000E+00	0.000E+00	3.330E-06
Zn70	4.609E-06	4.665E-06	4.749E-06	4.761E-06
Zn72	6.063E-08	5.933E-08	5.886E-08	5.889E-08
Ga71	1.095E-05	1.092E-05	1.098E-05	1.100E-05
Ge72	2.502E-05	2.504E-05	2.536E-05	2.539E-05
Ge73	5.256E-05	5.167E-05	5.132E-05	5.135E-05
Ge74	1.279E-04	1.257E-04	1.246E-04	1.247E-04
Ge76	6.075E-04	5.950E-04	5.836E-04	5.839E-04
Ge77	6.953E-07	6.753E-07	6.559E-07	6.553E-07
Ge78	1.071E-07	1.039E-07	1.005E-07	1.004E-07
Ge80	7.821E-12	7.551E-12	7.233E-12	7.226E-12
As75	2.897E-04	2.802E-04	2.717E-04	2.718E-04
As77	2.818E-06	2.737E-06	2.659E-06	2.658E-06
As78	2.090E-07	2.029E-07	1.964E-07	1.962E-07
As79	1.200E-10	1.158E-10	1.113E-10	1.111E-10
As80	5.421E-12	5.270E-12	5.098E-12	5.087E-12
As81	2.003E-11	1.957E-11	1.897E-11	1.894E-11
As82	8.485E-12	8.225E-12	7.925E-12	7.918E-12
As82M	3.585E-12	3.466E-12	3.330E-12	0.000E+00
As83	1.063E-11	1.019E-11	9.711E-12	9.708E-12
Se77	1.291E-03	1.275E-03	1.262E-03	1.261E-03
Se78	3.407E-03	3.351E-03	3.290E-03	3.287E-03
Se79	7.554E-03	7.411E-03	7.245E-03	7.238E-03
Se79M	5.425E-11	5.236E-11	5.032E-11	5.024E-11
Se80	1.522E-02	1.497E-02	1.463E-02	1.462E-02
Se81	2.232E-08	2.214E-08	2.177E-08	2.172E-08
Se81M	3.154E-08	3.151E-08	3.120E-08	3.111E-08
Se82	4.199E-02	4.126E-02	4.027E-02	4.022E-02

Se83	3.953E-08	3.792E-08	3.616E-08	3.613E-08
Se83M	1.052E-11	1.016E-11	9.747E-12	9.731E-12
Se84	4.410E-10	4.229E-10	4.028E-10	4.023E-10
Se85	7.051E-11	6.800E-11	6.517E-11	6.509E-11
Se86	2.775E-11	2.692E-11	2.593E-11	2.591E-11
Se87	5.362E-12	5.233E-12	5.073E-12	5.073E-12
Br79	3.831E-06	3.763E-06	3.684E-06	3.680E-06
Br81	2.772E-02	2.736E-02	2.680E-02	2.675E-02
Br82	2.815E-06	2.723E-06	2.595E-06	2.592E-06
Br83	5.490E-06	5.273E-06	5.032E-06	5.027E-06
Br84	2.955E-07	2.835E-07	2.701E-07	2.698E-07
Br84M	7.323E-11	7.029E-11	6.698E-11	6.690E-11
Br85	5.640E-10	5.389E-10	5.116E-10	5.113E-10
Br86	2.114E-10	2.034E-10	1.944E-10	1.942E-10
Br87	2.189E-10	2.115E-10	2.032E-10	2.030E-10
Br88	4.786E-11	4.650E-11	4.493E-11	4.489E-11
Br89	8.528E-12	8.356E-12	8.158E-12	8.156E-12
Kr82	9.205E-04	8.979E-04	8.658E-04	8.647E-04
Kr83	5.709E-02	5.611E-02	5.493E-02	5.487E-02
Kr84	1.117E-01	1.086E-01	1.048E-01	1.047E-01
Kr85	3.061E-02	2.967E-02	2.859E-02	2.856E-02
Kr85M	2.273E-05	2.174E-05	2.064E-05	2.062E-05
Kr86	1.759E-01	1.714E-01	1.659E-01	1.658E-01
Kr87	6.101E-06	5.825E-06	5.517E-06	5.512E-06
Kr88	2.981E-05	2.841E-05	2.686E-05	2.683E-05
Kr89	1.603E-09	1.533E-09	1.457E-09	1.455E-09
Kr90	2.423E-10	2.332E-10	2.229E-10	2.227E-10
Kr91	3.862E-11	3.749E-11	3.620E-11	3.616E-11
Kr92	4.192E-12	4.084E-12	3.967E-12	3.966E-12
Rb85	9.873E-02	9.612E-02	9.300E-02	9.289E-02
Rb87	2.340E-01	2.275E-01	2.197E-01	2.195E-01
Rb88	3.465E-06	3.303E-06	3.123E-06	3.120E-06
Rb89	5.508E-08	5.267E-08	5.005E-08	5.000E-08
Rb90	1.302E-09	1.252E-09	1.197E-09	1.196E-09
Rb90M	7.399E-10	7.098E-10	6.757E-10	6.743E-10
Rb91	6.335E-10	6.146E-10	5.933E-10	5.923E-10
Rb92	4.268E-11	4.177E-11	4.074E-11	4.071E-11
Rb93	4.052E-11	4.004E-11	3.944E-11	3.939E-11
Rb94	1.001E-11	9.934E-12	9.825E-12	9.818E-12
Sr86	4.113E-04	4.020E-04	3.910E-04	3.909E-04

Sr87	5.225E-06	5.162E-06	5.084E-06	5.074E-06
Sr88	3.085E-01	2.994E-01	2.886E-01	2.883E-01
Sr89	2.583E-02	2.474E-02	2.353E-02	2.350E-02
Sr90	4.377E-01	4.275E-01	4.150E-01	4.145E-01
Sr91	2.233E-04	2.165E-04	2.087E-04	2.084E-04
Sr92	4.939E-05	4.824E-05	4.685E-05	4.679E-05
Sr93	7.458E-09	7.319E-09	7.149E-09	7.139E-09
Sr94	1.201E-09	1.184E-09	1.163E-09	1.161E-09
Sr95	3.206E-10	3.175E-10	3.138E-10	3.131E-10
Sr96	9.634E-12	9.558E-12	9.462E-12	9.451E-12
Y89	3.585E-01	3.493E-01	3.384E-01	3.380E-01
Y90	1.121E-04	1.093E-04	1.060E-04	1.059E-04
Y91	3.783E-02	3.674E-02	3.547E-02	3.541E-02
Y91M	1.176E-05	1.141E-05	1.100E-05	1.098E-05
Y92	9.942E-05	9.703E-05	9.425E-05	9.410E-05
Y93	3.286E-04	3.225E-04	3.151E-04	3.145E-04
Y94	2.570E-07	2.535E-07	2.490E-07	2.484E-07
Y95	1.722E-08	1.706E-08	1.684E-08	1.681E-08
Y96	5.311E-11	5.272E-11	5.220E-11	5.212E-11
Y96M	8.204E-11	8.171E-11	8.126E-11	8.110E-11
Y97	3.872E-11	3.856E-11	3.833E-11	3.826E-11
Y97M	6.958E-12	6.958E-12	6.945E-12	6.931E-12
Y98	4.182E-12	4.177E-12	4.168E-12	4.165E-12
Y98M	9.862E-12	9.874E-12	9.881E-12	9.869E-12
Y99	1.042E-11	1.038E-11	1.033E-11	1.031E-11
Zr90	1.766E-02	1.735E-02	1.696E-02	1.694E-02
Zr91	4.750E-01	4.670E-01	4.573E-01	4.568E-01
Zr92	6.044E-01	5.963E-01	5.858E-01	5.848E-01
Zr93	7.338E-01	7.266E-01	7.161E-01	7.151E-01
Zr94	8.324E-01	8.260E-01	8.160E-01	8.149E-01
Zr95	6.772E-02	6.709E-02	6.621E-02	6.611E-02
Zr96	9.380E-01	9.347E-01	9.300E-01	9.289E-01
Zr97	7.330E-04	7.307E-04	7.270E-04	7.260E-04
Zr98	6.947E-10	6.937E-10	6.919E-10	6.909E-10
Zr99	4.661E-11	4.652E-11	4.642E-11	4.639E-11
Zr100	1.493E-10	1.496E-10	1.495E-10	1.493E-10
Zr101	2.783E-11	2.773E-11	2.765E-11	2.764E-11
Zr102	1.982E-11	1.966E-11	1.951E-11	1.949E-11
Zr103	2.704E-12	2.642E-12	0.000E+00	0.000E+00
Nb94	3.028E-06	3.062E-06	3.135E-06	3.133E-06

Nb95	3.690E-02	3.657E-02	3.611E-02	3.605E-02
Nb95M	4.138E-05	4.099E-05	4.047E-05	4.039E-05
Nb96	2.995E-06	2.869E-06	2.727E-06	2.722E-06
Nb97	5.535E-05	5.517E-05	5.488E-05	5.478E-05
Nb98	6.599E-11	6.590E-11	6.575E-11	6.564E-11
Nb98M	6.172E-08	6.188E-08	6.214E-08	6.204E-08
Nb99	3.381E-10	3.376E-10	3.369E-10	3.366E-10
Nb99M	4.257E-10	4.295E-10	4.330E-10	4.320E-10
Nb100	3.543E-11	3.552E-11	3.561E-11	3.557E-11
Nb100M	7.756E-12	7.871E-12	8.025E-12	8.018E-12
Nb101	1.678E-10	1.689E-10	1.702E-10	1.701E-10
Nb102	1.701E-11	1.703E-11	1.709E-11	1.708E-11
Nb103	2.124E-11	2.127E-11	2.138E-11	2.138E-11
Nb104	1.987E-11	1.966E-11	1.953E-11	1.953E-11
Nb105	9.054E-12	8.956E-12	8.883E-12	8.877E-12
Mo95	7.713E-01	7.689E-01	7.641E-01	7.631E-01
Mo96	3.622E-02	3.444E-02	3.237E-02	3.236E-02
Mo97	1.031E+00	1.029E+00	1.025E+00	1.023E+00
Mo98	1.094E+00	1.093E+00	1.091E+00	1.090E+00
Mo99	3.552E-03	3.552E-03	3.551E-03	3.546E-03
Mo100	1.278E+00	1.280E+00	1.281E+00	1.280E+00
Mo101	9.688E-08	9.758E-08	9.851E-08	9.849E-08
Mo102	2.968E-08	2.996E-08	3.034E-08	3.033E-08
Mo103	1.728E-09	1.751E-09	1.780E-09	1.779E-09
Mo104	1.381E-09	1.395E-09	1.415E-09	1.415E-09
Mo105	6.117E-10	6.166E-10	6.244E-10	6.242E-10
Mo106	9.528E-11	9.517E-11	9.529E-11	9.522E-11
Mo107	1.588E-11	1.559E-11	1.537E-11	1.537E-11
Tc98	1.104E-05	1.134E-05	1.177E-05	1.178E-05
Tc99	1.065E+00	1.074E+00	1.083E+00	1.082E+00
Tc99M	2.918E-04	2.918E-04	2.917E-04	2.913E-04
Tc101	4.448E-07	4.480E-07	4.526E-07	4.520E-07
Tc102	2.325E-10	2.346E-10	2.377E-10	2.376E-10
Tc102M	1.999E-11	2.088E-11	2.175E-11	2.171E-11
Tc103	1.422E-09	1.442E-09	1.467E-09	1.466E-09
Tc104	3.052E-07	3.094E-07	3.150E-07	3.150E-07
Tc105	1.016E-08	1.032E-08	1.054E-08	1.054E-08
Tc106	6.421E-10	6.471E-10	6.566E-10	6.567E-10
Tc107	2.612E-10	2.616E-10	2.645E-10	2.648E-10
Tc108	3.268E-11	3.221E-11	3.211E-11	3.225E-11

Tc109	2.474E-12	0.000E+00	0.000E+00	0.000E+00
Ru99	4.339E-05	4.353E-05	4.365E-05	4.360E-05
Ru100	1.369E-01	1.279E-01	1.174E-01	1.173E-01
Ru101	1.123E+00	1.131E+00	1.140E+00	1.139E+00
Ru102	1.263E+00	1.268E+00	1.275E+00	1.275E+00
Ru103	5.475E-02	5.549E-02	5.642E-02	5.640E-02
Ru104	1.225E+00	1.233E+00	1.245E+00	1.245E+00
Ru105	1.609E-04	1.635E-04	1.671E-04	1.671E-04
Ru106	3.504E-01	3.530E-01	3.577E-01	3.578E-01
Ru107	3.283E-09	3.310E-09	3.375E-09	3.380E-09
Ru108	2.874E-09	2.884E-09	2.932E-09	2.942E-09
Ru109	2.444E-10	2.443E-10	2.479E-10	2.488E-10
Ru110	4.078E-11	4.065E-11	4.143E-11	4.183E-11
Ru111	3.182E-12	3.171E-12	3.227E-12	3.273E-12
Rh103	1.057E+00	1.092E+00	1.140E+00	1.139E+00
Rh103M	5.370E-05	5.448E-05	5.536E-05	5.530E-05
Rh105	1.625E-03	1.656E-03	1.698E-03	1.698E-03
Rh105M	1.220E-07	1.240E-07	1.268E-07	1.268E-07
Rh106	3.236E-07	3.259E-07	3.303E-07	3.303E-07
Rh106M	1.330E-07	1.179E-07	1.026E-07	1.026E-07
Rh107	4.599E-07	4.639E-07	4.731E-07	4.743E-07
Rh108	1.780E-10	1.785E-10	1.816E-10	1.824E-10
Rh108M	2.124E-11	2.208E-11	2.456E-11	2.493E-11
Rh109	5.883E-10	5.883E-10	5.994E-10	6.026E-10
Rh110	1.149E-11	1.145E-11	1.175E-11	1.190E-11
Rh111	1.898E-11	1.891E-11	1.993E-11	2.047E-11
Rh112	2.544E-12	2.551E-12	0.000E+00	0.000E+00
Pd104	2.043E-01	1.770E-01	1.383E-01	1.383E-01
Pd105	1.032E+00	1.043E+00	1.060E+00	1.060E+00
Pd106	6.617E-01	6.597E-01	6.603E-01	6.605E-01
Pd107	6.999E-01	7.046E-01	7.152E-01	7.159E-01
Pd108	5.023E-01	5.043E-01	5.123E-01	5.140E-01
Pd109	2.564E-04	2.547E-04	2.567E-04	2.579E-04
Pd110	1.737E-01	1.739E-01	1.787E-01	1.809E-01
Pd111	6.433E-08	6.385E-08	6.930E-08	7.267E-08
Pd111M	0.000E+00	0.000E+00	8.840E-08	1.168E-07
Pd112	3.172E-05	3.172E-05	3.463E-05	3.638E-05
Pd113	4.743E-11	4.709E-11	5.030E-11	5.291E-11
Pd114	4.579E-11	4.610E-11	4.909E-11	5.138E-11
Pd115	5.325E-12	5.419E-12	5.780E-12	5.968E-12

Pd116	2.224E-12	0.000E+00	0.000E+00	0.000E+00
Ag109	2.707E-01	2.760E-01	2.882E-01	2.895E-01
Ag110M	1.808E-03	1.768E-03	1.709E-03	1.714E-03
Ag111	6.990E-04	6.940E-04	7.291E-04	7.502E-04
Ag111M	3.015E-09	2.993E-09	3.246E-09	3.402E-09
Ag112	4.976E-06	4.975E-06	5.435E-06	5.714E-06
Ag113	3.030E-06	3.014E-06	3.224E-06	3.399E-06
Ag113M	3.353E-11	3.335E-11	3.564E-11	3.755E-11
Ag115	3.957E-09	4.032E-09	4.308E-09	4.450E-09
Ag116	3.253E-11	3.339E-11	3.489E-11	3.530E-11
Ag117	1.172E-11	1.202E-11	1.253E-11	1.264E-11
Cd110	1.365E-01	1.301E-01	1.217E-01	1.221E-01
Cd111	8.201E-02	8.191E-02	8.495E-02	8.695E-02
Cd112	3.730E-02	3.744E-02	3.972E-02	4.141E-02
Cd113	1.566E-03	2.134E-03	3.302E-03	3.468E-03
Cd113M	2.197E-05	2.949E-05	4.463E-05	4.682E-05
Cd114	3.721E-02	3.689E-02	3.746E-02	3.900E-02
Cd115	2.474E-05	2.516E-05	2.679E-05	2.770E-05
Cd115M	3.274E-05	3.324E-05	3.521E-05	3.639E-05
Cd116	1.084E-02	1.101E-02	1.132E-02	1.143E-02
Cd117	6.195E-07	6.384E-07	6.676E-07	6.729E-07
Cd117M	2.981E-08	3.221E-08	3.413E-08	3.402E-08
Cd118	6.649E-08	6.849E-08	7.146E-08	7.177E-08
Cd119	2.135E-11	2.183E-11	2.254E-11	2.260E-11
Cd119M	4.141E-12	4.305E-12	4.486E-12	0.000E+00
Cd120	7.992E-12	8.149E-12	8.377E-12	8.380E-12
In115	4.873E-03	5.493E-03	6.453E-03	6.641E-03
In117	1.613E-07	1.667E-07	1.744E-07	1.757E-07
In117M	5.470E-07	5.638E-07	5.896E-07	5.946E-07
In119	2.107E-11	2.166E-11	2.244E-11	2.247E-11
In119M	1.103E-09	1.129E-09	1.167E-09	1.170E-09
In121	3.180E-12	3.270E-12	3.373E-12	3.373E-12
In121M	1.197E-11	1.221E-11	1.251E-11	1.251E-11
Sn115	5.049E-04	5.141E-04	5.383E-04	5.531E-04
Sn116	3.162E-03	2.898E-03	2.619E-03	2.686E-03
Sn117	9.891E-03	1.008E-02	1.038E-02	1.045E-02
Sn118	8.179E-03	8.357E-03	8.631E-03	8.664E-03
Sn119	8.091E-03	8.256E-03	8.495E-03	8.510E-03
Sn120	8.188E-03	8.348E-03	8.587E-03	8.594E-03
Sn121	9.921E-06	1.018E-05	1.050E-05	1.050E-05

Sn121M	5.608E-04	5.756E-04	5.964E-04	5.962E-04
Sn122	1.081E-02	1.097E-02	1.121E-02	1.121E-02
Sn123	7.140E-04	7.240E-04	7.408E-04	7.419E-04
Sn123M	3.165E-08	3.188E-08	3.238E-08	3.242E-08
Sn124	1.752E-02	1.772E-02	1.803E-02	1.804E-02
Sn125M	1.192E-10	1.201E-10	1.218E-10	1.218E-10
Sn126	4.477E-02	4.498E-02	4.538E-02	4.537E-02
Sn127	4.187E-06	4.184E-06	4.180E-06	4.182E-06
Sn127M	1.456E-10	1.452E-10	1.446E-10	1.445E-10
Sn128	1.841E-06	1.851E-06	1.856E-06	1.856E-06
Sn129	5.041E-10	5.023E-10	5.017E-10	5.015E-10
Sn129M	6.213E-10	6.190E-10	6.175E-10	6.173E-10
Sn130	6.778E-10	6.765E-10	6.742E-10	6.730E-10
Sn131	1.267E-10	1.255E-10	1.242E-10	1.241E-10
Sn132	1.001E-10	1.008E-10	1.010E-10	1.007E-10
Sb121	8.060E-03	8.252E-03	8.508E-03	8.506E-03
Sb122	4.022E-06	3.890E-06	3.722E-06	3.718E-06
Sb123	1.033E-02	1.047E-02	1.072E-02	1.073E-02
Sb124	5.215E-05	5.069E-05	4.933E-05	4.940E-05
Sb125	1.649E-02	1.664E-02	1.690E-02	1.689E-02
Sb126	5.352E-06	5.499E-06	5.745E-06	5.739E-06
Sb127	4.744E-04	4.743E-04	4.739E-04	4.742E-04
Sb128	6.061E-05	6.093E-05	6.102E-05	6.101E-05
Sb128M	2.257E-10	2.255E-10	2.258E-10	2.257E-10
Sb129	4.923E-05	4.918E-05	4.919E-05	4.917E-05
Sb130	1.202E-06	1.206E-06	1.209E-06	1.209E-06
Sb130M	2.197E-09	2.196E-09	2.194E-09	2.191E-09
Sb131	4.808E-07	4.811E-07	4.824E-07	4.818E-07
Sb132	1.846E-09	1.862E-09	1.869E-09	1.865E-09
Sb132M	1.011E-09	1.006E-09	1.008E-09	1.008E-09
Sb133	1.412E-09	1.394E-09	1.376E-09	1.375E-09
Sb134M	1.717E-11	1.689E-11	1.659E-11	1.657E-11
Te122	6.604E-04	6.382E-04	6.119E-04	6.117E-04
Te124	3.837E-04	3.740E-04	3.669E-04	3.677E-04
Te125	7.986E-03	8.046E-03	8.157E-03	8.155E-03
Te125M	2.082E-04	2.101E-04	2.132E-04	2.132E-04
Te126	8.029E-04	8.111E-04	8.358E-04	8.356E-04
Te127	4.819E-05	4.822E-05	4.827E-05	4.826E-05
Te127M	5.709E-04	5.888E-04	6.065E-04	6.063E-04
Te128	1.704E-01	1.710E-01	1.710E-01	1.709E-01

Te129M	4.723E-05	4.272E-05	3.838E-05	3.851E-05
Te130	5.727E-01	5.730E-01	5.726E-01	5.720E-01
Te131	3.198E-06	3.199E-06	3.202E-06	3.199E-06
Te131M	2.384E-04	2.379E-04	2.373E-04	2.373E-04
Te132	4.590E-03	4.584E-03	4.576E-03	4.571E-03
Te133	4.703E-07	4.677E-07	4.657E-07	4.651E-07
Te133M	8.559E-06	8.515E-06	8.474E-06	8.463E-06
Te134	7.554E-06	7.502E-06	7.444E-06	7.438E-06
Te135	3.033E-10	3.003E-10	2.965E-10	2.965E-10
Te136	1.022E-10	9.961E-11	9.699E-11	9.687E-11
Te137	3.714E-12	3.617E-12	3.514E-12	3.508E-12
I127	1.037E-01	1.038E-01	1.039E-01	1.039E-01
I128	1.656E-08	1.604E-08	1.537E-08	1.538E-08
I129	3.179E-01	3.179E-01	3.179E-01	3.177E-01
I130	5.770E-06	5.328E-06	4.905E-06	4.904E-06
I130M	9.092E-11	8.366E-11	7.658E-11	7.656E-11
I132	1.422E-04	1.420E-04	1.418E-04	1.417E-04
I133	1.644E-03	1.641E-03	1.638E-03	1.636E-03
I133M	1.834E-11	1.884E-11	1.941E-11	1.942E-11
I134	3.537E-05	3.521E-05	3.504E-05	3.501E-05
I134M	1.148E-09	1.159E-09	1.174E-09	1.173E-09
I135	4.319E-04	4.314E-04	4.306E-04	4.301E-04
I136	1.212E-09	1.194E-09	1.179E-09	1.178E-09
I136M	4.604E-10	4.599E-10	4.597E-10	4.593E-10
I137	4.039E-10	3.997E-10	3.954E-10	3.944E-10
I138	5.549E-11	5.493E-11	5.428E-11	5.417E-11
I139	7.044E-12	6.879E-12	6.700E-12	6.695E-12
Xe128	7.844E-03	7.596E-03	7.293E-03	7.300E-03
Xe130	6.379E-03	5.990E-03	5.599E-03	5.598E-03
Xe131	7.449E-01	7.588E-01	7.760E-01	7.745E-01
Xe132	1.570E+00	1.554E+00	1.534E+00	1.532E+00
Xe133	1.019E-02	1.017E-02	1.015E-02	1.013E-02
Xe133M	5.959E-05	5.953E-05	5.950E-05	5.944E-05
Xe134	2.053E+00	2.049E+00	2.047E+00	2.045E+00
Xe135	6.164E-04	6.568E-04	6.958E-04	6.952E-04
Xe135M	1.733E-06	1.731E-06	1.729E-06	1.727E-06
Xe136	2.364E+00	2.273E+00	2.182E+00	2.180E+00
Xe137	8.422E-09	8.360E-09	8.300E-09	8.294E-09
Xe138	1.084E-07	1.075E-07	1.066E-07	1.065E-07
Xe139	8.998E-10	8.880E-10	8.762E-10	8.760E-10

Xe140	1.835E-10	1.803E-10	1.769E-10	1.768E-10
Xe141	8.774E-12	8.588E-12	8.387E-12	8.388E-12
Cs133	1.580E+00	1.595E+00	1.608E+00	1.606E+00
Cs134	1.616E-01	1.503E-01	1.396E-01	1.394E-01
Cs134M	3.743E-06	3.484E-06	3.225E-06	3.218E-06
Cs135	1.547E+00	1.629E+00	1.713E+00	1.711E+00
Cs135M	6.343E-08	6.700E-08	7.089E-08	7.083E-08
Cs136	1.248E-03	1.256E-03	1.254E-03	1.253E-03
Cs137	1.768E+00	1.762E+00	1.756E+00	1.755E+00
Cs138	7.602E-06	7.558E-06	7.512E-06	7.510E-06
Cs138M	5.241E-10	5.244E-10	5.274E-10	5.272E-10
Cs139	2.316E-08	2.296E-08	2.279E-08	2.279E-08
Cs140	1.801E-09	1.778E-09	1.758E-09	1.758E-09
Cs141	5.748E-10	5.673E-10	5.604E-10	5.602E-10
Cs142	2.185E-11	2.148E-11	2.112E-11	2.112E-11
Cs143	1.131E-11	1.112E-11	1.092E-11	1.092E-11
Ba134	7.124E-02	6.590E-02	6.106E-02	6.100E-02
Ba135	5.102E-04	4.573E-04	4.082E-04	4.079E-04
Ba136	5.881E-02	5.902E-02	5.925E-02	5.928E-02
Ba137	7.295E-02	7.280E-02	7.268E-02	7.262E-02
Ba137M	2.693E-07	2.684E-07	2.675E-07	2.674E-07
Ba138	1.748E+00	1.743E+00	1.740E+00	1.739E+00
Ba139	4.877E-05	4.834E-05	4.797E-05	4.795E-05
Ba140	2.340E-02	2.315E-02	2.292E-02	2.291E-02
Ba141	3.947E-07	3.908E-07	3.872E-07	3.871E-07
Ba142	2.970E-08	2.932E-08	2.894E-08	2.893E-08
Ba143	3.610E-10	3.565E-10	3.522E-10	3.521E-10
Ba144	2.145E-10	2.099E-10	2.054E-10	2.054E-10
Ba145	3.561E-11	3.468E-11	3.373E-11	3.372E-11
Ba146	7.220E-12	6.986E-12	6.746E-12	6.747E-12
La138	2.885E-05	2.946E-05	3.098E-05	3.107E-05
La139	1.651E+00	1.644E+00	1.640E+00	1.639E+00
La140	3.319E-03	3.281E-03	3.245E-03	3.245E-03
La141	2.183E-04	2.161E-04	2.141E-04	2.140E-04
La142	5.174E-05	5.114E-05	5.055E-05	5.050E-05
La143	1.035E-07	1.021E-07	1.008E-07	1.007E-07
La144	1.045E-09	1.031E-09	1.019E-09	1.018E-09
La145	4.510E-10	4.450E-10	4.401E-10	4.399E-10
La146	4.603E-11	4.516E-11	4.435E-11	4.437E-11
La147	2.480E-11	2.430E-11	2.387E-11	2.389E-11

La148	2.799E-12	2.702E-12	0.000E+00	0.000E+00
Ce140	1.651E+00	1.642E+00	1.633E+00	1.632E+00
Ce141	5.685E-02	5.631E-02	5.579E-02	5.578E-02
Ce142	1.468E+00	1.459E+00	1.449E+00	1.449E+00
Ce143	2.061E-03	2.034E-03	2.008E-03	2.008E-03
Ce144	3.682E-01	3.649E-01	3.620E-01	3.620E-01
Ce145	3.685E-09	3.649E-09	3.616E-09	3.615E-09
Ce146	4.488E-08	4.453E-08	4.432E-08	4.431E-08
Ce147	7.183E-10	7.139E-10	7.114E-10	7.118E-10
Ce148	4.825E-10	4.752E-10	4.714E-10	4.725E-10
Ce149	2.761E-11	2.723E-11	2.700E-11	2.706E-11
Ce150	1.103E-11	1.082E-11	1.066E-11	1.069E-11
Pr141	1.440E+00	1.433E+00	1.426E+00	1.426E+00
Pr142	2.540E-05	2.372E-05	2.206E-05	2.205E-05
Pr143	2.072E-02	2.044E-02	2.019E-02	2.018E-02
Pr144	1.551E-05	1.537E-05	1.525E-05	1.525E-05
Pr145	2.110E-04	2.090E-04	2.075E-04	2.075E-04
Pr146	1.409E-06	1.398E-06	1.391E-06	1.391E-06
Pr147	3.590E-08	3.577E-08	3.577E-08	3.578E-08
Pr148	1.339E-09	1.327E-09	1.323E-09	1.325E-09
Pr149	1.055E-09	1.055E-09	1.061E-09	1.063E-09
Pr150	3.448E-11	3.437E-11	3.459E-11	3.470E-11
Pr151	6.419E-11	6.381E-11	6.393E-11	6.406E-11
Pr152	6.147E-12	6.046E-12	6.010E-12	6.037E-12
Pr153	2.888E-12	2.811E-12	2.772E-12	0.000E+00
Nd142	1.434E-02	1.356E-02	1.275E-02	1.275E-02
Nd143	1.222E+00	1.227E+00	1.232E+00	1.232E+00
Nd144	9.109E-01	8.930E-01	8.755E-01	8.753E-01
Nd145	8.452E-01	8.459E-01	8.486E-01	8.484E-01
Nd146	8.482E-01	8.406E-01	8.341E-01	8.339E-01
Nd147	7.624E-03	7.600E-03	7.597E-03	7.599E-03
Nd148	5.084E-01	5.079E-01	5.088E-01	5.091E-01
Nd149	1.481E-05	1.483E-05	1.494E-05	1.496E-05
Nd150	2.970E-01	2.976E-01	3.002E-01	3.008E-01
Nd151	8.788E-09	8.834E-09	8.959E-09	8.970E-09
Nd152	4.420E-09	4.437E-09	4.514E-09	4.526E-09
Nd153	6.927E-11	6.920E-11	7.031E-11	7.080E-11
Nd154	3.304E-11	3.288E-11	3.313E-11	3.335E-11
Nd155	4.828E-12	4.764E-12	4.756E-12	4.788E-12
Pm147	2.369E-01	2.435E-01	2.550E-01	2.552E-01

Pm148	1.078E-03	1.038E-03	9.786E-04	9.783E-04
Pm148M	4.535E-03	4.758E-03	4.869E-03	4.863E-03
Pm149	1.065E-03	1.038E-03	1.016E-03	1.018E-03
Pm150	1.398E-07	1.232E-07	1.088E-07	1.090E-07
Pm151	2.823E-04	2.841E-04	2.883E-04	2.888E-04
Pm152	2.016E-09	2.027E-09	2.061E-09	2.068E-09
Pm152M	4.129E-11	4.338E-11	4.673E-11	4.689E-11
Pm153	7.741E-10	7.781E-10	7.981E-10	8.035E-10
Pm154	2.393E-10	2.394E-10	2.433E-10	2.449E-10
Pm154M	2.198E-11	2.276E-11	2.428E-11	2.450E-11
Pm155	4.295E-11	4.323E-11	4.446E-11	4.488E-11
Pm156	1.673E-11	1.674E-11	1.709E-11	1.720E-11
Pm157	3.506E-12	3.447E-12	3.445E-12	3.482E-12
Sm147	1.132E-01	1.170E-01	1.229E-01	1.230E-01
Sm148	2.158E-01	2.114E-01	2.020E-01	2.020E-01
Sm149	1.689E-02	2.223E-02	3.103E-02	3.104E-02
Sm150	3.630E-01	3.555E-01	3.461E-01	3.465E-01
Sm151	7.502E-02	8.732E-02	1.029E-01	1.030E-01
Sm152	1.863E-01	1.869E-01	1.897E-01	1.908E-01
Sm153	9.808E-04	9.259E-04	8.641E-04	8.652E-04
Sm154	8.500E-02	8.516E-02	8.631E-02	8.677E-02
Sm155	3.508E-08	3.540E-08	3.652E-08	3.685E-08
Sm156	1.421E-05	1.440E-05	1.494E-05	1.505E-05
Sm157	2.788E-10	2.796E-10	2.875E-10	2.912E-10
Sm158	1.044E-10	1.040E-10	1.063E-10	1.078E-10
Eu151	3.737E-04	5.137E-04	7.124E-04	7.126E-04
Eu152	2.994E-04	3.516E-04	4.011E-04	4.013E-04
Eu153	2.040E-01	1.985E-01	1.927E-01	1.929E-01
Eu154	6.449E-02	6.201E-02	5.836E-02	5.839E-02
Eu155	1.599E-02	1.653E-02	1.839E-02	1.847E-02
Eu156	2.897E-03	2.575E-03	2.297E-03	2.311E-03
Eu157	1.854E-05	1.832E-05	1.858E-05	1.881E-05
Eu158	1.261E-07	1.263E-07	1.302E-07	1.322E-07
Eu159	2.070E-09	2.069E-09	2.153E-09	2.201E-09
Eu160	3.096E-12	3.088E-12	0.000E+00	0.000E+00
Gd152	2.290E-04	2.388E-04	2.435E-04	2.437E-04
Gd154	6.036E-03	5.745E-03	5.375E-03	5.378E-03
Gd155	9.035E-04	1.203E-03	1.779E-03	1.787E-03
Gd156	1.061E-01	1.000E-01	9.420E-02	9.475E-02
Gd157	1.098E-03	1.472E-03	2.128E-03	2.150E-03

Gd158	4.864E-02	4.806E-02	4.793E-02	4.845E-02
Gd159	8.641E-06	8.567E-06	8.784E-06	8.965E-06
Gd160	3.998E-03	4.033E-03	4.256E-03	4.393E-03
Gd161	9.064E-12	9.122E-12	1.006E-11	1.060E-11
Tb159	8.276E-03	8.349E-03	8.649E-03	8.801E-03
Tb160	2.030E-04	1.953E-04	1.910E-04	1.944E-04
Tb161	1.697E-05	1.682E-05	1.813E-05	1.904E-05
Dy160	8.167E-04	8.042E-04	8.083E-04	8.217E-04
Dy161	1.550E-03	1.580E-03	1.704E-03	1.775E-03
Dy162	7.822E-04	7.970E-04	8.812E-04	9.377E-04
Dy163	6.414E-04	6.373E-04	6.928E-04	7.547E-04
Dy164	3.052E-04	3.068E-04	3.292E-04	3.662E-04
Dy166	9.255E-08	9.872E-08	1.311E-07	1.490E-07
Ho165	1.094E-04	9.678E-05	9.476E-05	1.076E-04
Er166	4.900E-05	4.833E-05	5.361E-05	6.033E-05
Er167	5.027E-06	5.805E-06	8.063E-06	9.333E-06
Er168	1.122E-05	1.147E-05	1.342E-05	1.581E-05

Appendix 3: Mid-cycle 1-group cross sections of most important actinides

n,fission 1-group cross-sections (BU 25.0 GWd/Tihm)				
Isotope	**ThPu**	**ThPuNp**	**ThPuNpAm**	**ThTRU**
IDs	*Weighted using the total neutron flux*			
U232	11.297221	11.409754	10.792016	10.535891
U233	25.624325	26.244039	23.325686	22.315271
U234	0.574392	0.572460	0.584281	0.589246
U235	10.837572	11.291779	9.631574	9.067650
U236	0.341307	0.342236	0.340738	0.340242
U238	0.122528	0.121922	0.125086	0.126495
Np237	0.634849	0.632723	0.646209	0.651839
Pu238	1.829394	1.833240	1.811600	1.804646
Pu239	17.265849	18.412745	14.282495	12.911721
Pu240	0.659802	0.657689	0.670799	0.676302
Pu241	23.810845	25.088263	20.759453	19.260329
Pu242	0.511559	0.509495	0.521065	0.525815
Pu244	0.426821	0.425093	0.434827	0.438873
Am241	0.760640	0.767218	0.741609	0.736524
Am242m	90.720905	97.814989	73.065363	65.021237
Am243	0.498474	0.497412	0.502963	0.506167
Cm242	0.440909	0.441417	0.443465	0.445373
Cm243	36.330259	37.376999	32.708495	31.000307
Cm244	0.881444	0.881995	0.884977	0.884650
Cm245	28.657279	30.131518	24.805529	23.102861
Cm246	0.655334	0.655240	0.660728	0.662595
Cm247	19.511717	20.148435	17.477527	16.630430
Cm248	0.831412	0.831803	0.831812	0.829528
Cm250	0.553797	0.551472	0.563998	0.674302
Bk249	0.881638	0.901120	0.821804	0.664738
Cf249	57.690418	59.873000	50.711591	47.610636
Cf250	8.107437	8.324759	7.408242	7.087295
Cf251	153.061261	159.861136	132.311616	123.162795
Cf252	4.157564	4.184162	3.977220	3.910114

n,gamma 1-group cross-sections (BU 25.0 GWd/Tihm)				
Isotope	ThPu	ThPuNp	ThPuNpAm	ThTRU
IDs	Weighted using the total neutron flux			
U232	8.552768	8.697246	8.053627	7.789093
U233	3.889766	3.972474	3.568508	3.423127
U234	14.192329	14.817900	13.520188	13.042619
U235	4.242637	4.342553	3.929844	3.774585
U236	7.508895	7.667902	7.068823	6.824992
U238	6.691404	6.801264	6.368601	6.180395
Np237	17.327440	17.120250	14.756766	13.955544
Pu238	6.832495	7.167515	5.922327	5.503192
Pu239	9.522648	10.182494	7.841432	7.048524
Pu240	17.867401	19.366323	14.980236	13.490532
Pu241	7.630255	8.109586	6.546473	6.006635
Pu242	9.999096	10.858934	9.023352	8.312184
Pu244	3.016774	3.030384	2.954255	2.915681
Am241	29.749295	31.202173	24.411336	22.470706
Am242m	16.673106	18.030788	13.324934	11.792603
Am243	30.893150	31.754215	25.019593	23.505751
Cm242	3.259184	3.270651	3.109805	3.043283
Cm243	5.471204	5.619340	4.941936	4.694999
Cm244	12.655989	13.661212	11.207739	9.903534
Cm245	4.238692	4.459474	3.683432	3.436991
Cm246	2.972183	3.020071	2.863421	2.787051
Cm247	9.158572	9.492036	8.055761	7.601867
Cm248	6.251534	6.321828	5.889089	5.651156
Cm250	44.088364	45.168913	41.652169	7.193324
Bk249	89.519068	93.312707	77.488659	42.055299
Cf249	20.326959	21.086465	17.833200	16.729871
Cf250	203.048733	210.993917	176.796681	165.339991
Cf251	64.008747	67.048244	54.894433	50.859183
Cf252	1.665460	1.687569	1.585092	1.545603