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HANDBOOK OF ACTIVATION DATA CALCULATED USING EASY-2007

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CONTENTS

1 INTRODUCTION

Investigation of the properties of current fusion devices such as JET, planned ones such as ITER, and conceptual power plants such as PPCS, have indicated the need for tools to predict the activation of materials. Considerable effort within the European Fusion Programme has led to the production of the European Activation System (EASY) to provide such a capability. The current version, EASY-2007, consists of an extensive library of data (EAF-2007) including neutron-, proton and deuteron-induced cross sections; decay data and biological hazard coefficients; an inventory code (FISPACT-2007); a development tool (SAFEPAQ-II) used to produce the European Activation File (EAF); and extensive documentation. EASY-2007 is widely distributed and has been used to carry out activation calculations for a large number of materials. However, it was felt that there was also a need for a comprehensive handbook of activation data that could be referred to by materials specialists and designers without the need to run codes. The present report answers this need, and updates and extends the report [1] produced about five years ago with EASY-2003 and the two reports that were produced about eleven years ago [2,3]. Since then the activation field has matured with new versions of the EAF data and FISPACT code, which improve the accuracy of the predictions. The main extension to the data is the increase of the upper energy of the energy range from 20 to 60 MeV. The 'importance diagrams' that allow a neutron-spectrum-independent summary of the activation properties of a material to be given, have also been extended to this higher energy. Using these new tools the activation properties of all the naturally occurring elements from Hydrogen to Bismuth are presented.

2 EASY-2007

An overview of EASY-2007 is available [4], which describes the various parts that make up the package, and shows how they fit together. Each of these is briefly described below.

2.1 SAFEPAQ-II

SAFEPAQ-II is the software tool used for the maintenance and development of the EAF nuclear data library by UKAEA. Maintenance of the EAF library is a complex procedure: the cross section files need to be evaluated (including choosing which of several data sources to use and adjustment of data), processed (conversion to a common format), compiled into a library, validated (against experimental data and systematics), and documented. Similarly, the decay data files need to be compiled and documented, and all the subsidiary files required as input to the inventory code FISPACT need to be generated in a consistent manner.

Several radical decisions were made when SAFEPAQ-II was designed; these include the use of relational databases rather than text files to store the data and a user-friendly application written in Visual Basic, as well as the choice to run under Windows. Full details are given in the User manual [5].

2.2 EAF-2007

The EAF-2007 data library is the result of a considerable effort over the last twenty-one years by UKAEA and collaborators. The term EAF originally described only the neutron-induced cross section library, but is now used to cover all the nuclear data libraries required for inventory calculations. The libraries contained in EAF-2007 cover:

- Cross section data for neutron-induced reactions
- Cross section data for proton-induced reactions
- Cross section data for deuteron-induced reactions
- Uncertainty data for neutron-induced reactions
- Decay data
- Fission yield data
- Biological hazard data
- Legal transport data
- Clearance data
- Charged particle ranges in materials
- Emitted particle spectral data (from neutron-induced reactions)
- Charged particle cross section data
- Gamma absorption data

Further details on the various EAF libraries are available in the neutron-induced cross section report [6], the decay data report [7], and the biological hazard report [8], while summaries of the rest are given in the overview [4].

2.3 FISPACT-2007

FISPACT is an inventory code that has been developed for neutron-induced activation calculations for materials in fusion devices. The current version is FISPACT-2007, which is the culmination of twenty-one years of development. It uses external libraries of nuclear data for all relevant nuclides to calculate the number of atoms of each species at a specified time, which can be during an irradiation or after a decay time following shutdown. The various species (nuclides) are formed either by a direct reaction on a starting material, via a series of reactions (some of which can be on radioactive targets), by a decay, by a series of decays, or via a combination of both reactions and decays. The accuracy of the calculated inventory is dependent on the quality of the input nuclear data, i.e. the cross sections and decay properties. The European Activation File (EAF), described above, is the recommended source of data.

The main items of information that must be supplied by the user are: composition and mass of the material to be irradiated, a description of the neutron spectrum, details of the irradiation, which may be either continuous or in a series of pulses, and, for the period following shutdown, a series of decay times at which inventories are required.

The many options available, and the description of the code words used, are fully explained in the FISPACT-2007 User manual [9]. This contains many examples of input, which illustrate how the user can construct input files for any particular type of run.

3 NEUTRON SPECTRA

When performing calculations of material activation due to neutron irradiation in FISPACT, the user must supply a neutron spectrum for the incident particles. FISPACT combines this with cross section data in the appropriate group structure, which is determined by the form of the user-supplied spectrum, to produce a 1-group effective cross section library for all the reactions available in EAF. This library is then used directly to perform subsequent activation calculations [9].

In the calculations performed to produce the activation data presented in this handbook, various neutron spectra are used. In the case of the importance diagrams (see 4.5 for a full description), a special set of spectra are used. Each spectrum has neutrons in a single energy group covering the range of energies for the 211-group structure. It is unnecessary to use 211 spectra in practical calculations; fifty are used with the responses of the missing energies determined by interpolation. Seven of these spectrum files are also used to produce the seven columns of pathway data, as discussed in 4.3.

The remaining activation calculations are carried out with one of five neutron spectra appropriate to fusion research. Three are taken from the recent PPCS study on fusion power plant design studies [10,11,12]. The spectra were calculated for three regions of the plant models which use various materials for the structure, tritium generation and coolant. The most technologically relevant design was used for each region, thus the first wall spectrum is from Model B, the blanket spectrum from Model C and the shield spectrum from Model A. The three spectra have neutron fluxes of 1.0431 10^{15} $ncm^{-2}s^{-1}$ for the first wall, 7.7104 10^{14} $ncm^{-2}s^{-1}$ for the blanket, and 25.272 10^{11} $ncm^{-2}s^{-1}$ for the shield, with irradiation times of 5, 5, and 25 years respectively. The use of the three spectra means that the activation responses of materials in a range of neutron spectra typical of DT fusion power plants are available. Figure 1, Figure 2, and Figure 3 are graphs of the three spectra, plotted as neutron flux per lethargy interval against energy.

Figure 4 shows the fourth spectra used. In this case a calculated spectrum from an actual fusion device was used, namely the JET (Joint European Torus) experiment. Specifically, it is the spectrum representing the average flux over the vacuum vessel wall on the inboard side of JET [13]. It is for a DD plasma source rather than the DT sources described above and so may be of more interest to fusion experimentalists. It should be noted that this spectrum has much lower fluxes than any of the other three. The details for this spectrum are: 3.46 10^{-6} $ncm^{-2}s^{-1}$, with an irradiation time of 1 year.

Figure 5 shows the fifth spectra used. In this case a calculated spectrum [14] for the high flux test module of IFMIF fusion device is used. IFMIF [15] is the planned materials test facility; it will produce an intense neutron field by the impact of 40 MeV deuterons on a flowing lithium target. Although producing a fusion relevant spectrum, there is a high energy tail extending up to about 55 MeV. It was the need to be able to calculate activation by such high energy neutrons that motivated the extension of EAF data to 60 MeV. The details for this spectrum are: 7.3219 10^{14} $ncm^{-2}s^{-1}$, with an irradiation time of 1 year (the irradiation history is 180 days on, 30 days off, 150 days on with the specified flux).

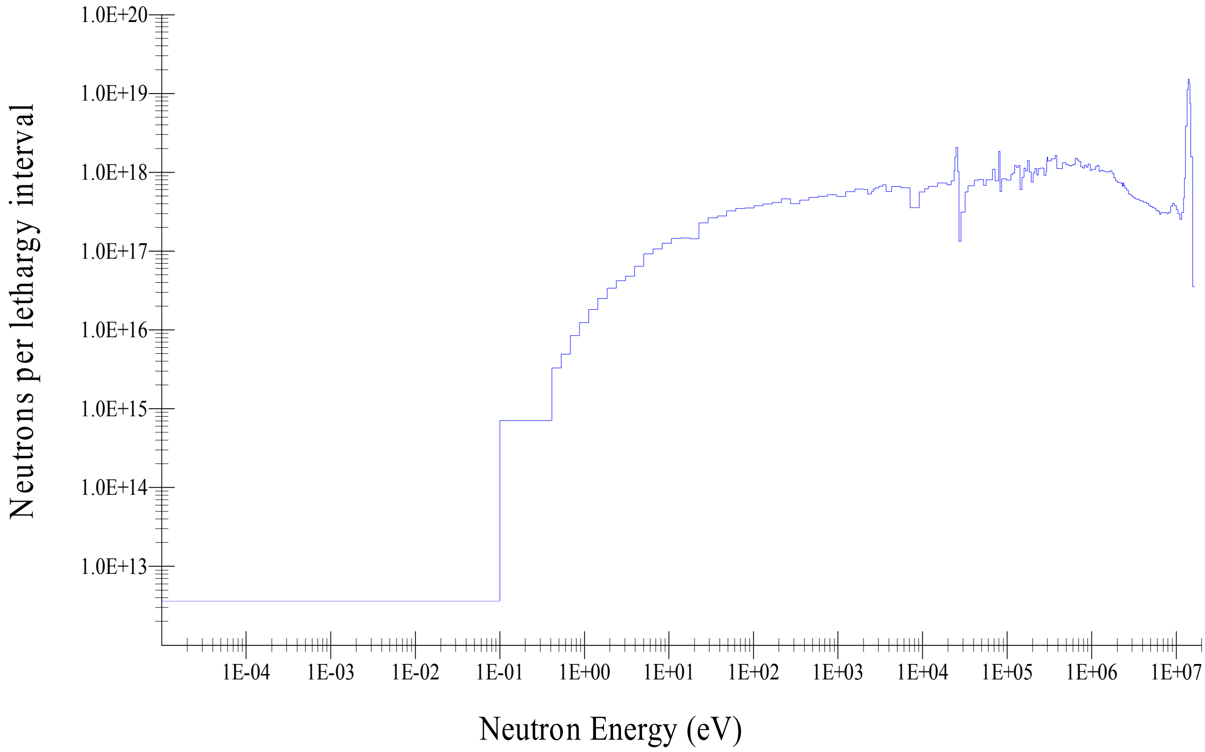

Figure 1. Neutron spectrum for the first wall of a conceptual power plant

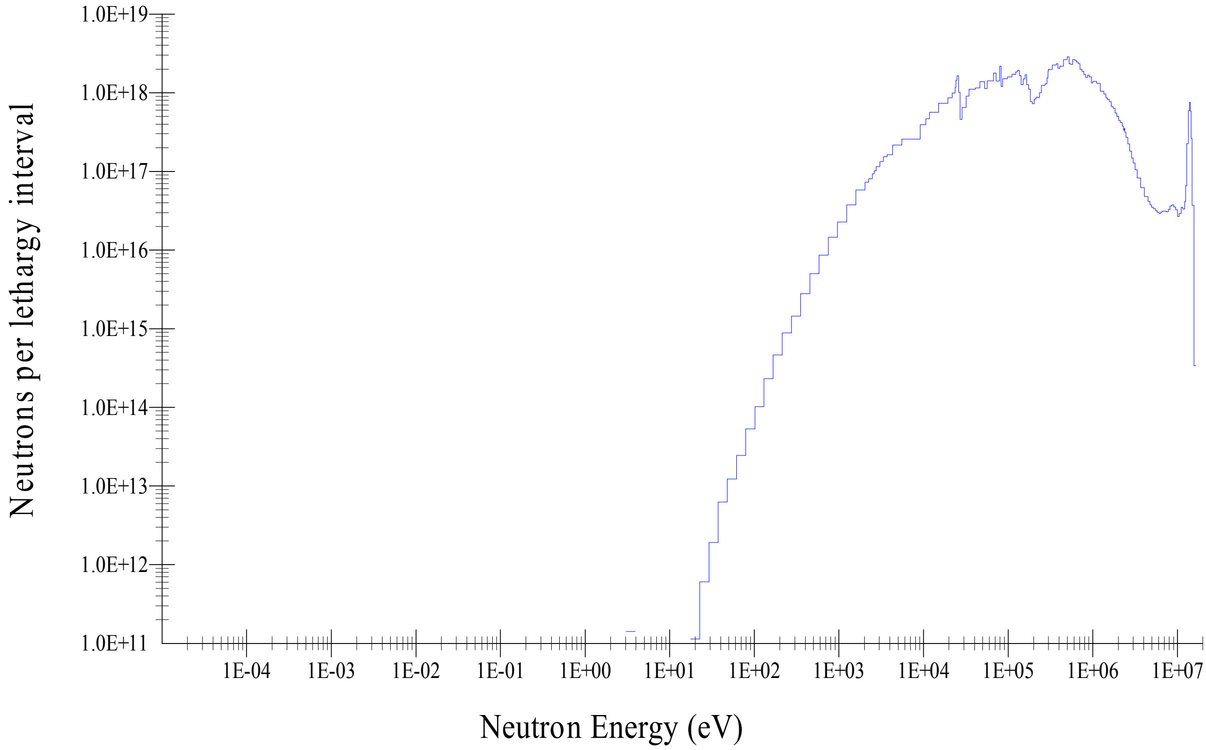

Figure 2. Neutron spectrum for the blanket of a conceptual power plant

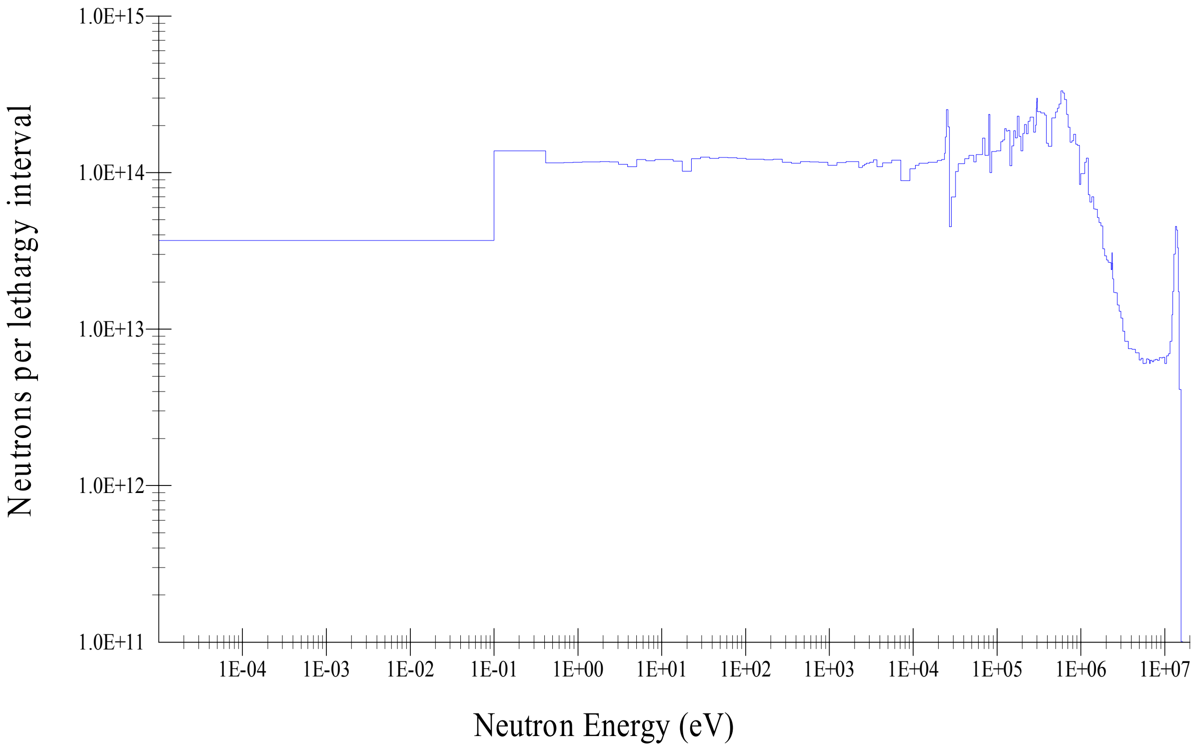

Figure 3. Neutron spectrum for the shield of a conceptual power plant

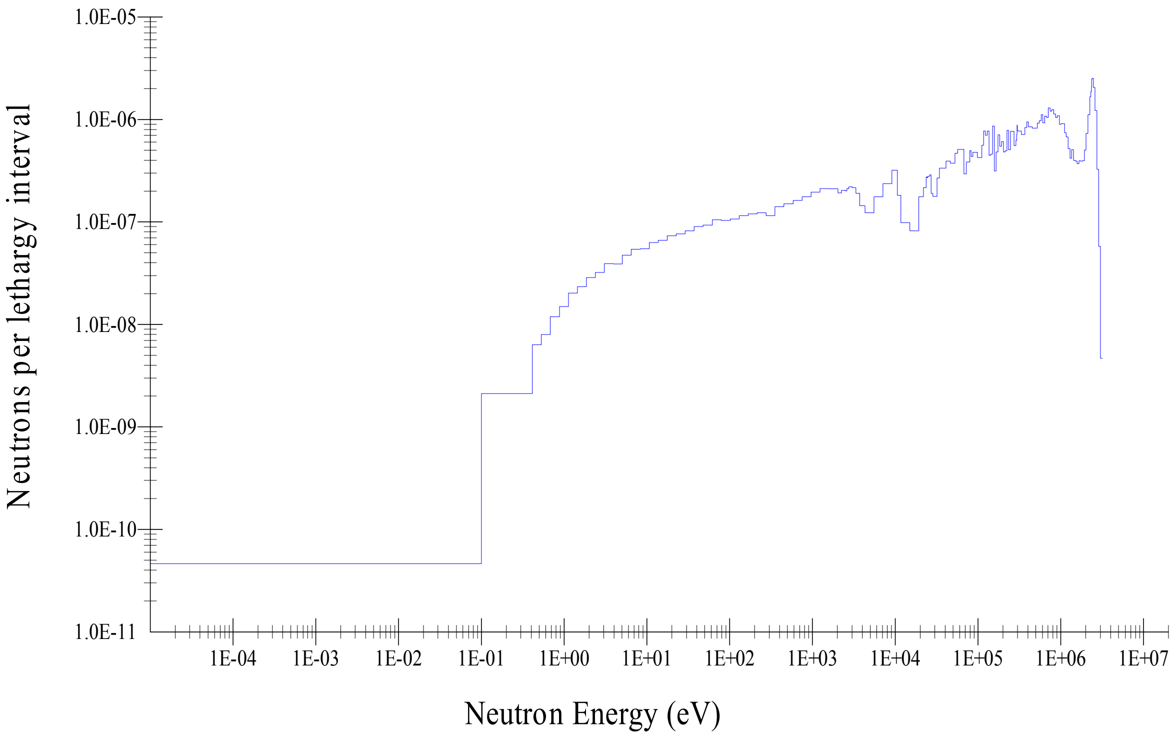

Figure 4. Neutron spectrum for the vacuum vessel wall on the inboard side of JET

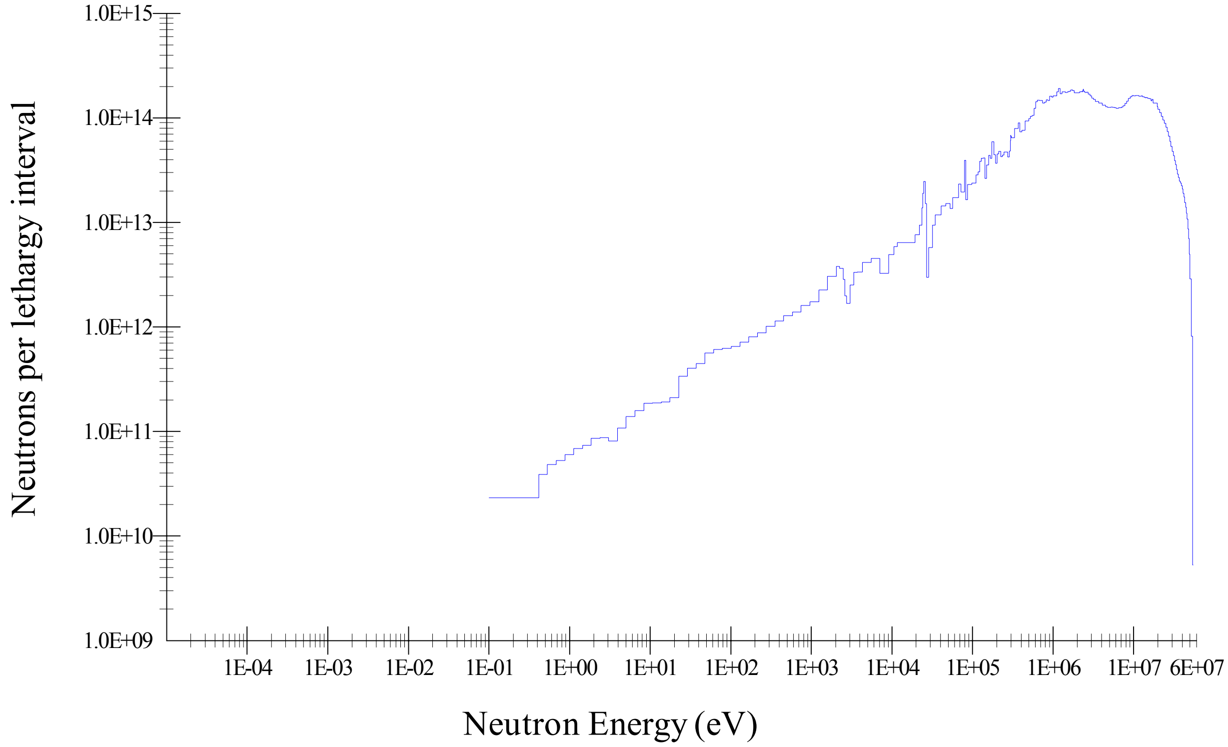

Figure 5. Neutron spectrum for the high flux target region of IFMIF.

4 EXPLANATION OF TABLES AND GRAPHS

The data for each element are split up into a number of sections. These are briefly described below.

4.1 GENERAL PROPERTIES

Basic properties of each element are given, including a list of all the naturally occurring isotopes, both stable and radioactive, with the half-lives of the radioactive ones being given in brackets. The properties included in the table are:

- Atomic number
- Crustal abundance in weight parts per million (wppm)
- Melting point in Kelvin at 101.3 kPa (1 atm)
- Boiling point in Kelvin at 101.3 kPa (1 atm)
- Density in kgm^{-3}
- Thermal Conductivity in $Wm^{-1}K^{-1}$ at 300 K
- Electrical Resistivity in Ωm
- Coefficient of linear expansion in K^{-1} at 298 K
- Crystal Structure
- Number of stable isotopes
- Mean atomic weight

Note: For the number of stable isotopes, figures in brackets indicate the number of isotopes of that particular element that occur naturally, but are also radioactive with long half-lives (as shown in the fourth column of the table).

The bulk of these data were obtained from the CRC handbook of chemistry and physics [16], together with Nuclear Wallet Cards from the National Nuclear Data Centre (USA) [17], which in the main also takes its data on elemental properties from [16]. Data on the thermal conductivity, electrical resistivity, and crystal structure have mostly been taken directly from the previous version of this handbook [1]. Notes relevant for the particular element follow below the table.

4.2 ACTIVATION PROPERTIES

The activation table presents the important radionuclides produced by the irradiation of a 1 kg pure sample of an element for 5 years in the first wall neutron spectrum (Figure 1). Data are presented for six activation quantities (the abbreviations used in the tables are shown in brackets, and the units used for these quantities are given):

1	Specific Activity (**Act**) – $Bqkg^{-1}$	2	Decay Power/Heat Output (**Heat**) – $kWkg^{-1}$
3	Gamma (γ) Dose rate (**Dose**) – Svh^{-1}	4	Inhalation dose (**Inh**) – $Svkg^{-1}$
5	Ingestion dose (**Ing**) – $Svkg^{-1}$	6	Clearance Index (**Clear**) – no units

The specific activity is the activity induced in 1 kg of the material by the neutrons; the Decay Power is the rate of heat production in 1 kg of the material due to the various decay processes. The Gamma Dose rate is the contact dose rate due to a semi-infinite slab of the material [9], the Ingestion and Inhalation doses refer to the dose received by an average person over a 50 year period from the intake of 1 kg of the material [8]. The Clearance Index of a material determines if the material can be disposed of with no special precautions according to IAEA guidelines. If less than 1 then the material can be disposed of or 'cleared' as if it were non-radioactive [8].

For each of these six properties data are presented at six different decay times following irradiation. These are: 0 years (immediately after shutdown following the irradiation); 10^{-5} years (5.26 minutes); 10^{-2} years (3.65 days); 1 year; 100 years; and 10^{5} years. Within the section of the table for each activation property, important radionuclides are listed along with their percentage contribution to the total for the given activation property at each cooling time. The nuclides are listed in descending order of contribution for the decay time where they first appear. For example, in Table 1 below, which shows the activation properties of Magnesium, in the specific activity section (Act) there are 6 nuclides listed in descending order of contribution at shutdown, with ^{24}Na contributing about 71% and ^{24m}Na contributing about 22%. ^{24}Na continues to dominate again up to 10^{-2} years, while after a decay time of 1 year, ^{3}H contributes 97% with most of the remainder coming from ^{22}Na (~3%). In the next time step ^{3}H continues to dominates (85%). In the last column, which displays the data for a decay time of 10^{5} years, 2 new nuclides, ^{26}Al and ^{14}C, produce all of the activity contributing about 60% and 40% respectively.

In most cases, nuclides are listed in these tables if their contribution to the total is greater than 1% at any time. However, there are cases where extra nuclides have been included to create symmetry with the adjacent table for any given activation property, as in the case of the Dose portion for Magnesium in Table 1, where ^{26}Na has been included to match the Ingestion dose section.

At the top of each column of percentages for each decay time, the total value of the activation property is given for that time, with units as described earlier. For instance, in the Magnesium example, at shutdown after the 5 years of first wall irradiation, the specific activity is 9.89 10^{14} $Bqkg^{-1}$. This falls as the decay times increase until, after 10^{5} years, the activity is just 1.06 10^{3} $Bqkg^{-1}$.

Note: In the case of the Gamma Dose Rate percentages, an asterisk (*) next to the percentage contribution for a given radionuclide indicates that the high-energy β^- bremsstrahlung radiation correction makes a significant contribution to the percentage. In such cases, the total dose rates (in Svh^{-1}) are adjusted to include the dose contribution from the bremsstrahlung correction. Further details of this effect and its calculation are given in reference 9.

Table 1. Activation properties of Magnesium

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	9.89E14	7.04E14	1.23E13	1.25E11	5.42E8	1.06E3	kW kg^{-1}	5.72E-1	5.27E-1	9.09E-3	1.52E-6	1.05E-9	3.18E-13
Na24	71.28	99.77	98.92				Na24	92.39	99.92	99.98			
Na24m	22.14						Na24m	2.97					
Na25	2.73	0.09					Na25	1.46	0.04				
Ne23	2.38						Ne23	1.37					
Na26	0.81						Na26	1.25					
H3	0.01	0.02	1.04	97.00	85.50		Na22			0.02	92.65		
Na22			0.04	2.94			H3				7.31	40.47	
C14				0.06	14.50	39.18	C14					59.49	1.03
Al26						59.99	Al26					0.03	98.85
Dose	**0**	10^{-5} y	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	Ing	**0**	10^{-5} y	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	9.29E5	8.95E5	1.55E4	1.97E0	5.10E-7	4.63E-7	Sv kg^{-1}	3.24E5	3.02E5	5.24E3	1.69E1	6.51E-2	2.48E-6
Na24	96.64	99.97	99.98				Na24	93.50	99.97	99.60			
Na24m	2.18						Na22			0.29	69.60		
Na26	0.58						H3			0.10	30.13	29.92	
Na22			0.02	100.0			C14					70.07	9.72
Al26					100.0	100.0	Al26						89.88
Inh	**0**	10^{-5} y	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	Clear	**0**	10^{-5} y	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	2.01E5	1.90E5	3.32E3	3.67E1	5.76E-1	1.55E-5		8.62E11	7.04E11	1.22E10	3.80E7	8.32E4	2.14E0
Na24	94.80	99.96	98.80				Na24	81.77	99.83	99.60			
H3	0.02	0.02	1.00	85.74	20.91		Na24m	12.10					
Na22			0.19	13.00			Na26	2.34					
C14				1.26	79.09	15.61	Na22			0.39	96.60		
Al26						82.40	H3			0.01	3.18	5.57	
Be10						1.99	C14				0.21	94.43	19.46
							Al26						80.53

4.3 PATHWAY ANALYSES

For each element the production pathways for the dominant radionuclides from the element's naturally occurring isotopes are listed. A nuclide's production pathways are presented if it is a 'primary nuclide', and hence appears on one of the importance diagrams (see description in Section 4.5) for the particular element. The meaning of primary nuclide will be discussed later. For each daughter radionuclide the important pathways of production are given, together with their percentage contribution to the total amount of the nuclide produced, at each of seven different neutron energies. The columns are actually labelled by the group numbers (210, 186, 151, 42, 30, 21, 6) with corresponding mid-point energies of 0.2570 eV, 148.548 eV, 37.587 keV, 14.734 MeV, 25.5 MeV, 34.5 MeV, 49.5 MeV. Clearly, some pathways have contributions at more than one energy, and in such cases the pathway is listed only once with multiple percentages input on the same row of the table. As a general rule, where many pathways contribute to the production of a particular daughter nuclide, only those contributing more than about 1% for at least one of the seven different energies are included. For many nuclides with a large amount of pathway data the minimum percentage has been raised to about 5%. Along with the pathways, the half-lives of each primary nuclide are also given. For example, in the case of Boron we have the pathway analysis shown in Table 2. For ^{11}B it can be seen that this radionuclide has a half-life of 13.81 seconds, and that at the three lowest energies the dominant pathway is B10(n,p)Be10(n,γ)Be11, while at the four highest energies the dominant pathway is B11(n,p)Be11. In the case of ^{6}He, this nuclide is only important at high energies and for these energies there are many parallel contributing pathways.

Table 2. Pathway analysis for Boron

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
He6	0.808s	B11(n,nα)Li7(n,d)He6				48.3	13.8	8.2	7.2
		B11(n,d)Be10(n,nα)He6				13.0	6.7	4.8	4.2
		B10(n,nα)Li6(n,p)He6				10.5	0.7	2.8	1.8
		B10(n,α)Li7(n,d)He6				8.1	0.5		
		B11(n,t)Be9(n,α)He6				7.8	0.8		
		B10(n,p)Be10(n,nα)He6				7.0			
		B10(n,d)Be9(n,α)He6				4.5			
		B11(n,dα)He6					76.9	81.9	85.2
		B11(n,2nα)Li6(n,p)He6						1.6	1.2
Li8	0.838 s	B10(n,α)Li7(n,γ)Li8	100.0	100.0	100.0				
		B11(n,α)Li8				99.9	43.3	23.2	8.5
		B10(n,h)Li8					38.7	52.4	66.8
		B11(n,t)Be9(n,d)Li8					9.0	19.5	20.5
		B11(n,d)Be10(n,t)Li8					6.4	2.7	2.5
		B11(n,2n)B10(n,h)Li8					1.5	1.2	0.7
		B10(n,d)Be9(n,d)Li8					0.8	0.9	0.8
Be11	13.81 s	B10(n,p)Be10(n,γ)Be11	100.0	100.0	100.0				
		B11(n,p)Be11				100.0	100.0	100.0	100.0
C11	20.37 m	B11(n,γ)B12(β^-)C12(n,2n)C11					100.0	100.0	100.0
H3	12.33 y	B10(n,2α)H3	65.4	80.3	97.6	53.0	33.0	34.3	29.1
		B10(n,2α)H3(β^-)He3(n,p)H3	21.0	19.7	2.4				
		B11(n,n2α)H3				42.1	59.0	57.4	64.0
		B11(n,nα)Li7(n,nα)H3				3.6	3.9	2.2	0.9
		B10(n,α)Li7(n,nα)H3				0.6			
		B11(n,d)Be10(n,ntα)H3					2.0	0.9	0.8
		B11(n,t)Be9(n,tα)H3					0.8	2.7	3.4
		B11(n,2n)B10(n,2α)H3					0.7		
		B10(n,nα)Li6(n,α)H3						1.1	0.7
		B11(n,2nα)Li6(n,α)H3						0.6	0.5
Be10	$1.6\ 10^6$ y	B10(n,p)Be10	100.0	100.0	100.0	34.9	3.6	3.2	2.7
		B11(n,d)Be10				64.7	96.3	96.8	97.3

There are a large number of possible types of reactions and decays that may occur along the production pathway from the parent isotope to the daughter radionuclide. The most common ones in this handbook, with typical examples, are listed below.

Reactions

(n,γ) – neutron absorbed, gamma photon emitted, e.g. Li7(n,γ)Li8

(n,2n) – neutron absorbed, two neutrons emitted, e.g. N14(n,2n)N13

(n,α) – neutron absorbed, alpha particle emitted, e.g. Mg25(n,α)Ne22

(n,p) – neutron absorbed, proton emitted, e.g. Si28(n,p)Al28

(n,n′) – neutron absorbed and emitted (inelastic scattering), e.g. Sc45(n,n′)Sc45m

(n,t) – neutron absorbed, triton emitted (or combination of 2 neutrons and a proton), e.g. Ti46(n,t)Sc44

(n,nα) – neutron absorbed, alpha particle and neutron emitted, e.g. Cl35(n,nα)P31

(n,3n) – neutron absorbed, three neutrons emitted, e.g. V51(n,3n)V49

(n,d) – neutron absorbed, deuteron emitted (or a neutron and a proton), e.g. Co59(n,d)Fe58

(n,h) – neutron absorbed, ^{3}He nucleus (helion) emitted e.g. B10(n,h)Li8

(n,2p) – neutron absorbed, two protons emitted, e.g. Ca40(n,2p)Ar39 (n,4n) – neutron absorbed, four neutrons emitted, e.g. Ag107(n,4n)Ag104. Note that other multiple neutron emission reactions such as (n,5n) and (n,6n) are also common.

(n,2nα) – neutron absorbed, alpha particle and two neutrons emitted, e.g. Cu63(n,2nα)Co58

(n,X) – neutron absorbed, heavy nucleus recoiled (important in the production of ^{3}H), e.g. Be9(n,X)H3

Decays

(β^-) – beta decay, e.g. C14(β^-)N14

(β^+) – positron decay (including electron capture), e.g. Ar37(β^+)Cl37

(α) – alpha decay, e.g. Dy152(α)Gd148

($\beta^-\alpha$) – beta decay followed by alpha emission, e.g. Be11($\beta^-\alpha$)Li7

(IT) – isomeric transition resulting in gamma ray emission, e.g. Na24m(IT)Na24

These reactions and decays can combine to form very long pathways, some of which take up several lines in the pathway analysis tables, so it was important to find ways of limiting the amount of information presented, while still providing a full picture of the production of each radionuclide. Note that in cases where a pathway occupies more than one line the symbol '_' indicates a continuation. Many of the long chain pathways include short-lived isomeric transition nuclides that simply rejoin the main pathway by decaying back to their ground state, e.g. Na24m(IT)Na24. It was decided that pathways that only differed from one another in these isomeric transition (IT) steps, should be summed together, with only the simplest or 'generic' pathway, i.e. the one that has no IT steps, displayed in the handbook. In such cases the generic pathway displayed is preceded by an ampersand in bold (**&**), with all the ground state nuclides that have an isomeric (or metastable) state, which is important in the production of the particular radionuclide daughter, printed in italics. Thus, for example, in the case of the production of ^{135}Cs from ^{132}Ba, we have the generic pathway:

&Ba132(n,γ)*Ba133*(β^+)Cs133(n,γ)*Cs134*(n,γ)*Cs135*

which contributes 94.2% of the total ^{135}Cs production for Barium at low energies. It is displayed in this form in the pathway analysis for Barium, and it can be seen that Ba133, Cs134 and Cs135 are in italics, indicating that the 94.2% is actually the sum of the contributions from these 8 pathways which include the isomeric transitions:

1. Ba132(n,γ)Ba133(β^+)Cs133(n,γ)Cs134(n,γ)Cs135 (the basic pathway)
2. Ba132(n,γ)Ba133(β^+)Cs133(n,γ)Cs134(n,γ)Cs135m(IT)Cs135
3. Ba132(n,γ)Ba133(β^+)Cs133(n,γ)Cs134m(IT)Cs134(n,γ)Cs135
4. Ba132(n,γ)Ba133(β^+)Cs133(n,γ)Cs134m(IT)Cs134(n,γ)Cs135m(IT)Cs135
5. Ba132(n,γ)Ba133m(IT)Ba133(β^+)Cs133(n,γ)Cs134(n,γ)Cs135
6. Ba132(n,γ)Ba133m(IT)Ba133(β^+)Cs133(n,γ)Cs134(n,γ)Cs135m(IT)Cs135
7. Ba132(n,γ)Ba133m(IT)Ba133(β^+)Cs133(n,γ)Cs134m(IT)Cs134(n,γ)Cs135
8. Ba132(n,γ)Ba133m(IT)Ba133(β^+)Cs133(n,γ)Cs134m(IT)Cs134(n,γ)Cs135m(IT)Cs135

It should be noted that where a metastable nuclide undergoes a reaction or decay, other than an isomeric transition to the ground state, then the pathway involved is displayed separately, and is not included in a generic pathway.

Note that in cases where the pathways for a particular nuclide span two pages, then this is shown by the symbol '►' at the bottom of the first page and '◄' at the top of the second.

The pathway data were obtained by employing the ability of FISPACT to calculate pathways, full details of which can be found in the User manual [9]. They result from the irradiation of pure samples of the elements for 5 years with the seven relevant single-energy neutron spectra described earlier, followed by a series of decay times adding up to about 10^6 years. The seven energies, listed above, were chosen to give a broad picture of the reaction behaviour of the elements when irradiated with neutrons. It should be noted that not all of the primary nuclides are produced at all seven of the energies, as can be seen in the cases of ^{6}He and ^{11}C for Boron in Table 2.

In some cases it has not been possible to find the pathways for given daughter nuclides because the pathways are so long that they exceed the limits of FISPACT (see reference 9 for details). In the standard outputs there may be no pathway data for a nuclide, or there may be only a few of the pathways presented, which do not sum to the total production (100%) for the nuclide. Wherever possible special FISPACT runs with different parameters have been made to find pathways so that the total percentage is at least 90%, but in cases where this has not been achieved, notes have been placed within the appropriate part of the table. There are also instances where no pathways have been given because the threshold for the production of a particular radionuclide falls outside the range of energies employed in the pathway analysis, even though it may still appear on the importance diagrams. This is also referred to appropriately within the main body of the handbook. Another complication arises when some of the naturally occurring isotopes are radioactive, in such cases the radionuclides are typically one of the dominant nuclides (at long times) and much of their amount is not formed but is initially present. Such cases are noted in the tables.

4.4 ACTIVATION GRAPHS

Activation calculations performed using the three neutron spectra for conceptual power plant designs, the spectrum calculated for the JET experimental device and the IFMIF high flux region (see Section 3), are presented in graphical form. For each element, there is a separate graph for all six of the activation properties presented in the activation properties table (see 4.2), with the same units as before. The graphs are colour coded (in the colour version of this report) to enable distinction between the results from the five different spectra. In each graph the solid dark blue curve represents the data produced from irradiation of the element with the first wall spectra. The dash-dotted blue curve and the dotted red curve represent results for the blanket and shield spectra, respectively. The purple dash-dot curve represents the results for the IFMIF irradiation. Finally, the solid green curve (always the lowest of the five curves, in case the graphs are being viewed in black-and-white) represents the results of calculations with the JET DD spectrum. Each graph is a log-log plot of the activation property as a function of decay time following irradiation. The decay time ranges from 10^{-6} to 10^6 years. The irradiation times used for each spectrum are as stated in Section 3. As with the activation properties, an asterisk, in this case in the title of the dose rate graph, indicates that the contribution from bremsstrahlung is significant.

Figure 6 shows, as an example graph, the plot of the specific activity of Oxygen. It shows that the five curves have a similar pattern of variation with the highest activity in the IFMIF curve, followed by the first wall, blanket, shield, and JET DD curves. Note also that error bars have been included for the data on each curve; these represent the uncertainty in the quantity due to uncertainties in the cross section and half-life data in the EAF library calculated in the standard FISPACT runs.

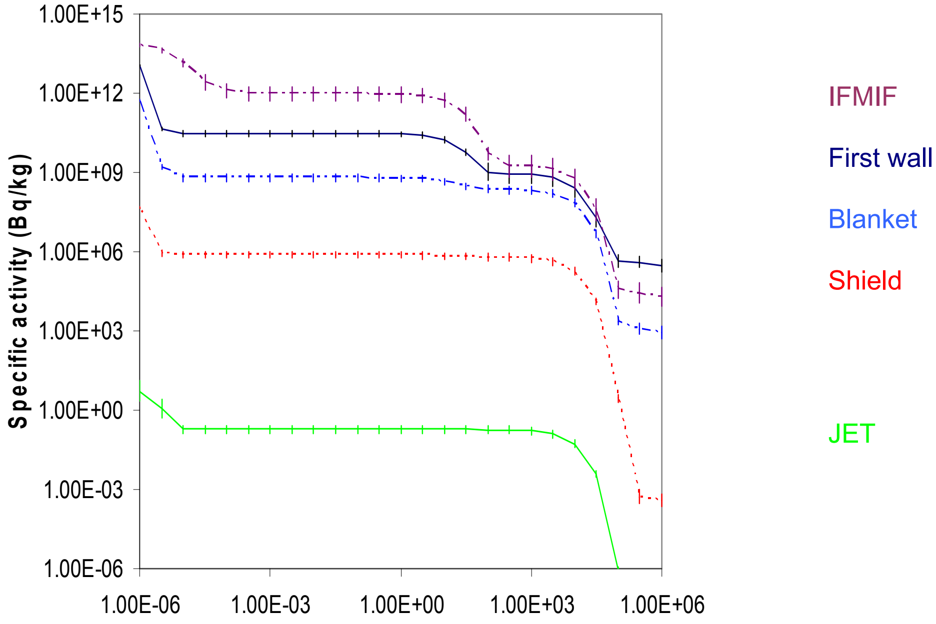

Figure 6. The activation graph for the specific activity of Oxygen, showing five curves for the neutron spectra indicated at the right

Note: In the case of the Clearance Index graph, a line indicating a Clearance Index of 1 is provided (brown line).

4.5 IMPORTANCE DIAGRAMS

In Section 3 the neutron spectra used for the above calculations are discussed. Neutron spectra are necessary to give results for a particular irradiation, but the motivation for the importance diagrams is to present activation results that do not require the definition of a neutron spectrum. To do this the response of a material to mono-energetic neutrons is considered. Results produced by such calculations allow the most important radionuclides to be identified for each neutron energy. Plotting the regions where a nuclide contributes 50% or more of the total response, at various decay times, gives an importance diagram. A full description of these diagrams is given in [18] and examples for various materials can be found in [19,20]. Figure 7 shows the dose rate importance diagram for pure iron. In this the various regions shown are labelled by a nuclide, e.g. for decay times < 1 x 10^4 s and for energies > 0.5 eV and < 40 eV the nuclide ^{56}Mn is dominant (i.e. it contributes more than 50% of the total dose rate). Note that there are three distinct regions labelled by ^{56}Mn at these short decay times, at various energies. At other energies ^{54}Mn or ^{59}Fe dominate, while at energies > 40 eV and < 400 eV no single nuclide contributes more than 50% for these short decay times. In the latter case it is usual for three nuclides to dominate. It is typical that nuclides dominate at particular decay times giving a vertical band in the diagram (e.g. ^{55}Fe dominates at about 1 x 10^8 s) although in many cases these bands are split into several distinct regions by a region for another nuclide. Also there is generally a different set of nuclides that dominant at MeV energies from those that dominate at low energy, because of the importance of threshold reactions rather than capture reactions. The importance diagram gives no information on the magnitude of the dose rate (a neutron spectrum is needed for such data), but instead summarises which nuclides will be important at particular decay times, when neutrons of various energies are present. Thus for iron in a hard spectrum, at times > 30 y (~1 10^9 s), Figure 7 shows that ^{53}Mn would dominate the dose rate, while in a soft spectrum ^{60}Co would be more important. If the importance diagram is compared with the earlier one in reference 1 calculated with EASY-2003, it can be seen that there is an additional region due to ^{44}Sc at high energies at times around 10^{10} s cooling. The appearance of new dominant nuclides at high energies is commonly seen for the various elements.

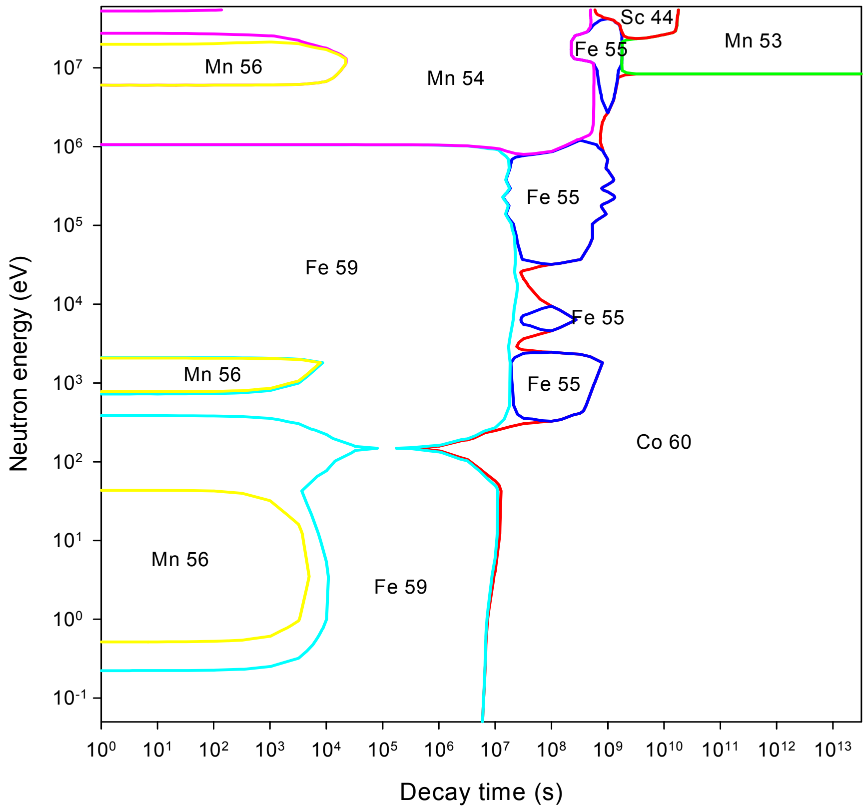

Figure 7. Dose rate importance diagram for pure iron

The nuclides shown in the importance diagrams, which appear because they contribute 50% or more of the total quantity in at least one region of the Decay time-Neutron energy plane, are termed 'primary nuclides'. These are the nuclides which have their production pathways presented in the pathways analysis tables described in 4.3. Of course, other radionuclides are produced during irradiations by mono-energetic neutrons, and those that contribute between 1% and 50% are termed 'secondary nuclides'. The pathways for these are not listed, but the nuclides themselves are listed in Table 1 of the Summary section (see Section 4.7 for a full description).

4.6 TRANSMUTATION GRAPHS

The rates of production of the most important transmutation elements, together with the burn-up of the element under consideration, are plotted as a function of time. These results are produced by irradiating the given element with the first wall spectrum described in Section 3. The curve for a particular element is generally only shown if it is produced in concentrations greater than 1 wppm (weight part per million). Exceptions include Hydrogen and Helium, where the boundary was lowered so that the graph had something other than just the starting material on it. Concentrations below this 1 wppm are not included because elements in such small amounts will generally not have any significant effect on material properties.

An example of the type of transmutation graph presented in this handbook is shown in Figure 8, which shows the results for the transmutation of Rhenium (Re). It can be seen that there is considerable burn-up of the starting material, with the major transmutation product being Osmium (Os). In fact the rate of burn-up is so great that, after around 5.0 years, the concentration of Osmium (orange line) becomes approximately equal to that of Rhenium itself (blue line). The other important products are Tungsten (W), Iridium (Ir), and Platinum (Pt).

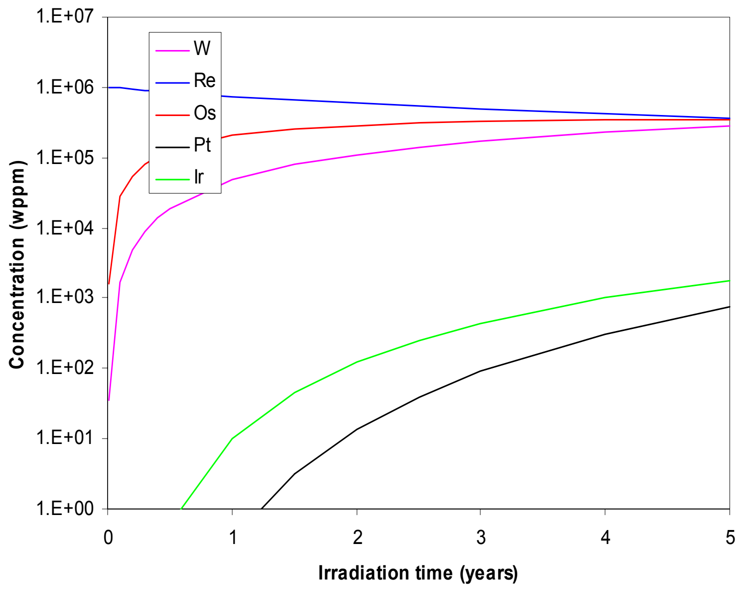

Figure 8. Transmutation graph for Rhenium

4.7 SUMMARY TABLES

In this section of the handbook three tables are presented, which summarise some of the important information in a more easily accessible format. The first of these is a table displaying both the primary and secondary nuclides (see definition of these in 4.5) of all elements considered in the handbook. The table takes the form of a list of all the radionuclides that are a primary or secondary nuclide for at least one of the elements in the main body of the handbook. For each of these radionuclides, which are displayed in increasing atomic number for easy location, their half-life is given. Two subsequent columns in the table then list the elements for which this nuclide is primary and secondary, respectively. These elements are listed in order of increasing atomic number. For example, the entry for the nuclide ^{94}Nb has the format shown in Table 3, with appropriate column headings. It shows that there are eleven elements for which ^{94}Nb is a primary nuclide, with a single other element having this radionuclide as a secondary nuclide. The information on the primary nuclides is the same as that shown in the importance diagrams and pathways analysis for each element, but this table displays it in a more concise form, with the added information on those nuclides that form the next level of importance in the activation of the elements. Some nuclides have a symbol (*, +, >, <) on the left of the first column. This shows changes compared to the previous table [1] based on EASY-2003. '*' indicates that the nuclide is a new primary nuclide, '+' indicates a new secondary nuclide, '>' indicates a nuclide that is now primary but was previously secondary and '<' indicates a nuclide that is now secondary but was previously primary. A total of 923 nuclides, out of a total of 2,231 present in EAF-2007, are listed in the table.

Table 3. Entry for ^{94}Nb in the Primary and Secondary nuclides table

Nuclide	$T_{½}$	Contributing elements	
		Primary	Secondary
Nb94	2.00 10^4 y	Zr, Nb, Mo, Ru, Rh, Pd, Ag, Cd, In, Sn, Sb	Y

The second summary table displays some of the information from the pathway analysis data, which is large and extensive. It presents the major reactions (those with importance of 5 or 4) found within the pathway tables, and gives the nuclides that have these reactions as steps in their important production chains. Every primary nuclide listed in the pathway analysis of at least one element has the major reactions from its main pathways of production listed. The format of this table is shown in Table 4.

Table 4. The initial part of the Summary of Major reactions table

Reaction	**Daughter nuclide**	**Imp**	**Score**	**Exp data**	
				Diff	**Int**
H1(n,γ)**H2**	H3	5	4*	•	
H2(n,γ)H3	H3	5	4*	•	
He3(n,p)H3	H3	5	4	•	
He4(n,2n)**He3**	H3	5	0		
Li6(n,α)H3	H3	5	4	•	
Li7(n,nα)H3	H3	5	5_3	•	•
Li7(n,γ)Li8	Li8	5	4	•	
Li7(n,d)He6	He6	5	2	•	
Be9(n,γ)Be10	H3, Li8, Be10, Be11	5	2	•	
Be9(n,d)Li8	Li8	5	4	•	
Be9(n,t)**Li7**	H3, He6, Li8	5	5_2	•	
Be9(n,α)He6	He6	5	4	•	
Be10(n,γ)Be11	Li8, Be11	5	2*	•	
B10(n,p)Be10	He6, Li8, Be10, Be11	5	2	•	
B10(n,h)Li8	Li8	5	0		
B10(n,α)**Li7**	H3, He6, Li8	5	4	•	
B10(n,2α)H3	H3	5	6	•	•

The definition of the importance values are: if the reaction is on a pathway that contributes ≥ 50%, 20%, 10%, 5%, 1% to the production of the nuclide then the importance values are 5, 4, 3, 2, 1 respectively. So, for example, in Table 2, the pathway data for the production of ^{8}Li from the naturally occurring isotopes of Boron, lists a single pathway (B10(n,α)Li7(n,γ)Li8) that contributes to the production at 0.2570 eV. It contributes 100.0%, and so the two reactions in the pathway are included in the summary table with ^{8}Li shown in the 'Daughter nuclide' column. However, the pathway B11(n,2n)B10(n,h)Li8 contributes only 1.5% at 25.5 MeV, and so its two reactions are not included in the table (actually the second reaction is present because it contributes more than 50% at 34.5 MeV), unless they are important in the production of other radionuclides, or indeed in the production of ^{8}Li from an element other than Boron. The table displays, as one group, all the major reactions with a single element's isotopes as the parents, displayed in increasing atomic number of the element. Within the group the reactions are listed in order of increasing mass number of the target nuclide. In the case of generic pathways, only the reactions for the basic pathway, i.e. excluding any isomeric transitions (IT), have been included in the summary table. Thus reactions involving metastable nuclides (e.g. ^{193m}Pt) are only included in the table if they are involved in pathways where they do not decay to the ground state nuclide via an isomeric transition. This can happen if the metastable isomer has a half-life that is long enough to allow time for reactions to occur, or if the isomer has a decay mode that is not an isomeric transition. An example of this can be seen in the production of ^{77}As from ^{76}Ge. Both ^{77}Ge and ^{77m}Ge are produced via an (n,γ) reaction from ^{76}Ge, but while in some cases the ^{77m}Ge decays to ^{77}Ge via an IT reaction, followed by beta decay to ^{77}As, in other cases the metastable nuclide beta decays directly to ^{77}As, with both pathways contributing more than 20%. Thus, in the summary table, Ge76(n,γ)Ge77m is included, along with Ge76(n,γ)Ge77.

Target nuclides that are stable or naturally occurring are printed in bold. Similarly the product nuclides that are stable are printed in bold. This is an aid to identify reactions that could be measured experimentally. Although some data on radioactive targets are available these can only be obtained at particular energies typically in a fission reactor environment. Similarly data for stable products are available, but only by employing particle counting techniques rather than the more common activation methods.

The first column of the table lists the major reactions in the order as described above. The second column has a list of all the nuclides whose major production pathways contain the reaction. Column 3 shows the importance value described above, note that since only the major reactions are listed these are always 5 or 4. Column 4 presents the 'quality score' for the reaction. The scores are listed in reference 6, and indicate the agreement of the library data with the experimental database. The meaning of the values are: 0 – no experimental data, 1 – weak disagreement with the differential data, 2 – weak agreement with the differential data, 3 – strong disagreement with the differential data, 4 – strong agreement with the differential data, 5 – discrepant integral and differential data, 6 - agreement between the library and the integral and differential data (validated reaction). The scores for discrepant reactions are subdivided to show the various combinations of integral and differential data. 5_0 – differential data are missing and there is unsatisfactory agreement with integral data, 5_1 – there is unsatisfactory agreement with differential and integral data, 5_2 – there is satisfactory agreement with differential and unsatisfactory agreement with integral data, 5_3 – differential data are missing and there is satisfactory agreement with integral data, 5_4 – there is unsatisfactory agreement with differential data and satisfactory agreement with integral data. The integral data and the results of the validation exercise on EAF-2007 are reported in reference 21. Columns five and six in the table indicate, with a bullet point, whether differential (Diff) and/or integral (Int) experimental data are available to support the data in EAF-2007 for the cross sections of each reaction listed. In cases where a single reaction rather than reactions to the two or three isomeric states is given, if the scores are not the same for all states then all the values are given; thus '2/4' means that the score is 2 for the ground state and 4 for the isomer. In cases where the scores differ from reference 6 (usually as a result of the validation exercise reported in reference 21) this is shown by an asterisk (*).

The third table shows how many reactions there are of the various types for each importance value. The reactions are shown in column 1, column 2 shows other reactions that produce the same daughter; all results from FISPACT actually refer to the sum of the reactions in the first two columns, columns 3-7 show the numbers of each reaction and column 8 shows the total number of each reaction for importance value > 0. Reactions shown in **bold** are the types included in EAF-2003, the remaining reactions are termed 'exotic'. At the bottom of columns 3-8 the number of standard and exotic reactions and the total number of reactions are shown. It can be seen from the table that for each importance value most of the reactions are of standard type; the most significant of the exotic reaction types of major importance are: (n,5n), 69; (n,6n), 41; (n,2nt), 25; (n,dα), 25; (n,tα), 14 and (n,4nα), 9.

5 ACKNOWLEDGEMENT

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PART 1:

Activation Analysis of the Naturally Occurring Elements (H - Bi)

Alphabetical list of elements

Elements ordered by atomic number

Element (Z)	Page	Element (Z)	Page	Element (Z)	Page
Hydrogen (1)	23	Nickel (28)	177	Barium (56)	365
Helium (2)	27	Copper (29)	183	Lanthanum (57)	373
Lithium (3)	31	Zinc (30)	189	Cerium (58)	381
Beryllium (4)	35	Gallium (31)	195	Praseodymium (59)	389
Boron (5)	39	Germanium (32)	201	Neodymium (60)	397
Carbon (6)	43	Arsenic (33)	209	Samarium (62)	411
Nitrogen (7)	47	Selenium (34)	217	Europium (63)	421
Oxygen (8)	51	Bromine (35)	223	Gadolinium (64)	429
Fluorine (9)	55	Krypton (36)	229	Terbium (65)	439
Neon (10)	59	Rubidium (37)	237	Dysprosium (66)	447
Sodium (11)	65	Strontium (38)	243	Holmium (67)	459
Magnesium (12)	71	Yttrium (39)	249	Erbium (68)	467
Aluminium (13)	77	Zirconium (40)	255	Thulium (69)	477
Silicon (14)	83	Niobium (41)	263	Ytterbium (70)	487
Phosphorus (15)	89	Molybdenum (42)	269	Lutetium (71)	497
Sulphur (16)	95	Ruthenium (44)	277	Hafnium (72)	505
Chlorine (17)	101	Rhodium (45)	285	Tantalum (73)	513
Argon (18)	107	Palladium (46)	291	Tungsten (74)	521
Potassium (19)	113	Silver (47)	297	Rhenium (75)	529
Calcium (20)	119	Cadmium (48)	305	Osmium (76)	535
Scandium (21)	127	Indium (49)	313	Iridium (77)	545
Titanium (22)	133	Tin (50)	319	Platinum (78)	553
Vanadium (23)	141	Antimony (51)	327	Gold (79)	561
Chromium (24)	149	Tellurium (52)	335	Mercury (80)	569
Manganese (25)	157	Iodine (53)	343	Thallium (81)	577
Iron (26)	165	Xenon (54)	351	Lead (82)	583
Cobalt (27)	171	Caesium (55)	359	Bismuth (83)	591

Hydrogen

General properties

		Isotopes	Isotopic abundances / %
Atomic number	1		
Crustal abundance / wppm	152	H1	99.985
Melting point / K	14.01	H2	0.015
Boiling point / K	20.28		
Density / kgm^{-3}	$8.988\ 10^{-2}$		
Thermal conductivity / $Wm^{-1}K^{-1}$	$1.82\ 10^{-1}$		
Electrical resistivity /Ωm	-		
Coefficient of thermal expansion / K^{-1}	-		
Crystal structure	HCP		
Number of stable isotopes	2		
Mean atomic weight	1.0079		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	2.43E8	2.43E8	2.43E8	2.30E8	8.80E5	0.00E0
H3	100.0	100.0	100.0	100.0	100.0	

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	2.22E-10	2.22E-10	2.22E-10	2.10E-10	8.04E-13	0.00E0
H3	100.0	100.0	100.0	100.0	100.0	

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.02E-2	1.02E-2	1.02E-2	9.65E-3	3.69E-5	0.00E0
H3	100.0	100.0	100.0	100.0	100.0	

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	6.32E-2	6.32E-2	6.32E-2	5.97E-2	2.29E-4	0.00E0
H3	100.0	100.0	100.0	100.0	100.0	

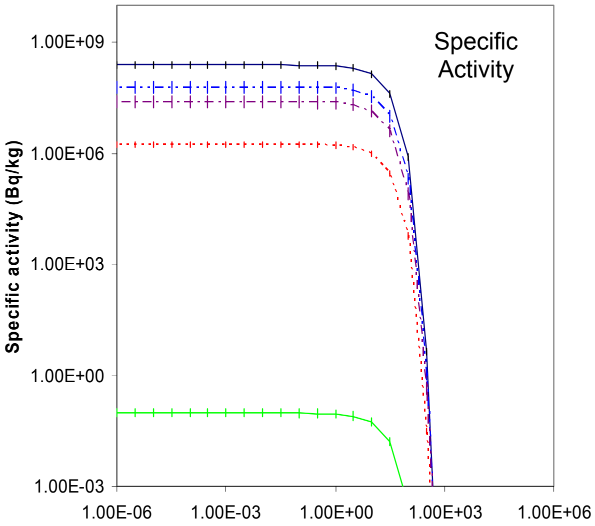
Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	2.43E3	2.43E3	2.43E3	2.30E3	8.80E0	0.00E0
H3	100.0	100.0	100.0	100.0	100.0	

Hydrogen

Pathway analysis

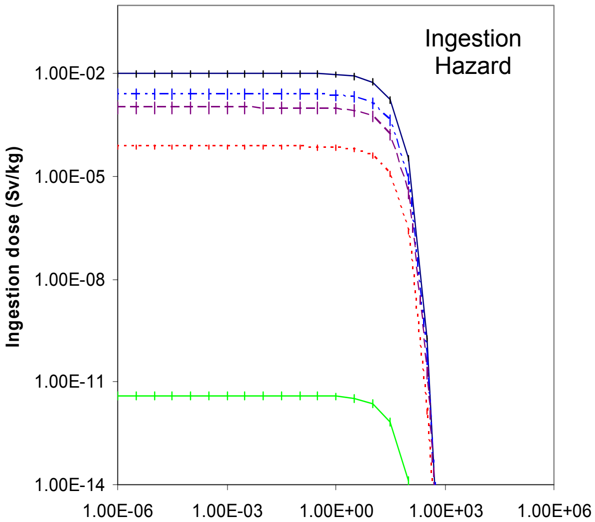
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
H3	12.33 y	H1(n,γ)H2(n,γ)H3	89.7	64.8	10.3	1.6	1.3	1.2	1.0
		H2(n,γ)H3	1.5	27.2	87.7	98.3	98.7	98.8	99.0

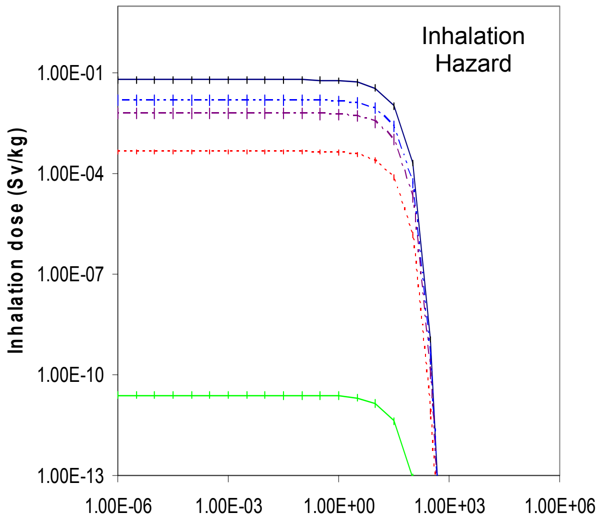
Hydrogen activation characteristics

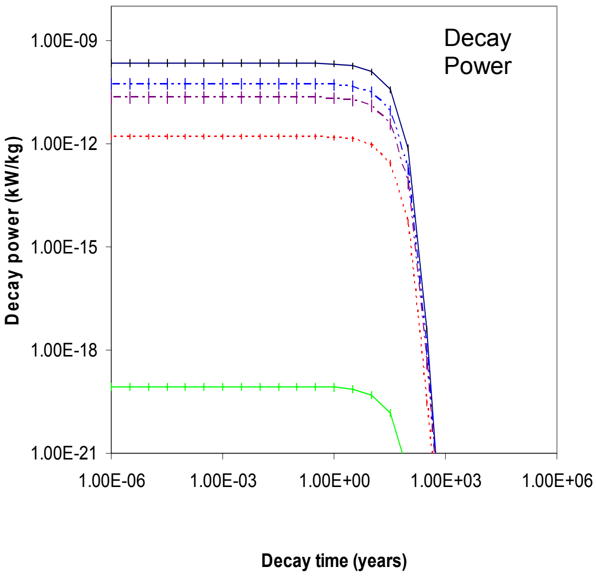


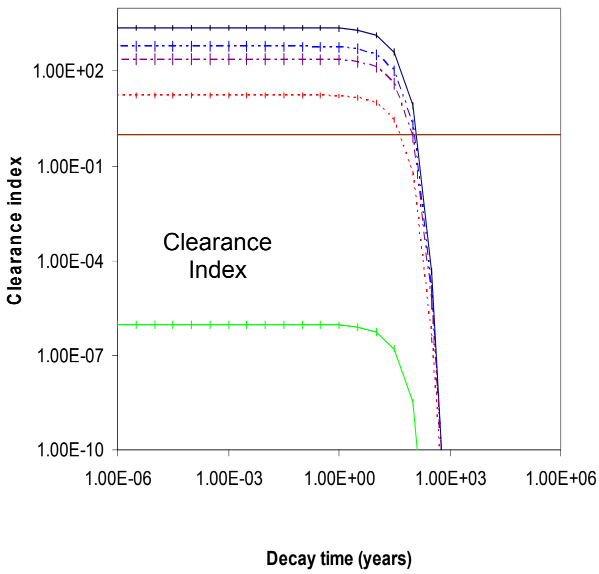
Gamma
Dose rate

There is no γ– dose from tritium



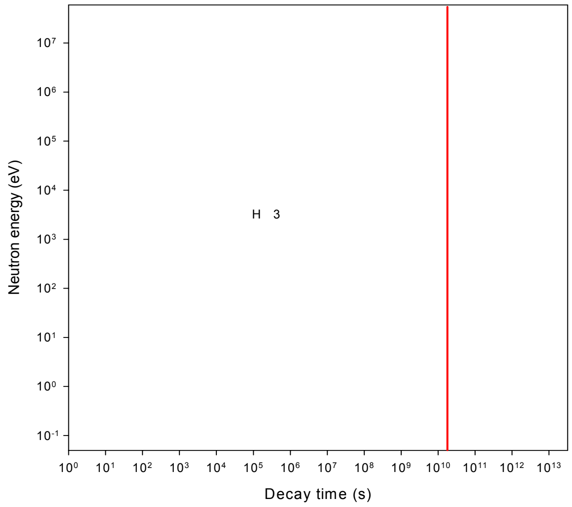






Hydrogen importance diagrams & transmutation

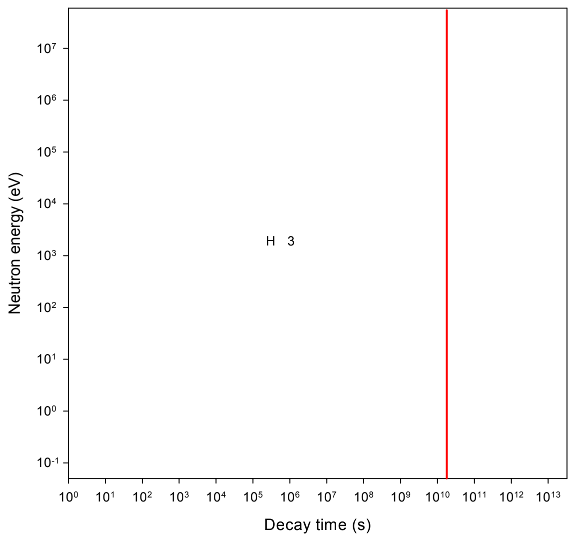
Activity



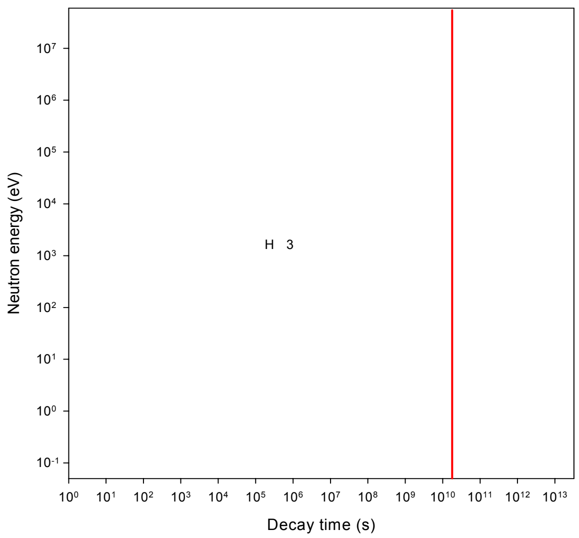
Dose rate

There is no γ– dose from tritium

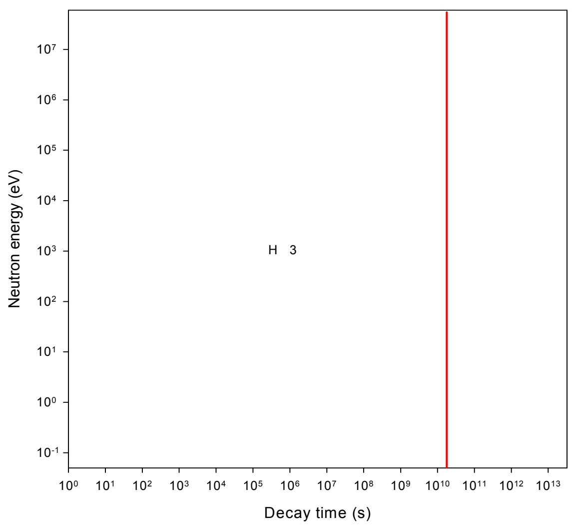
Heat output



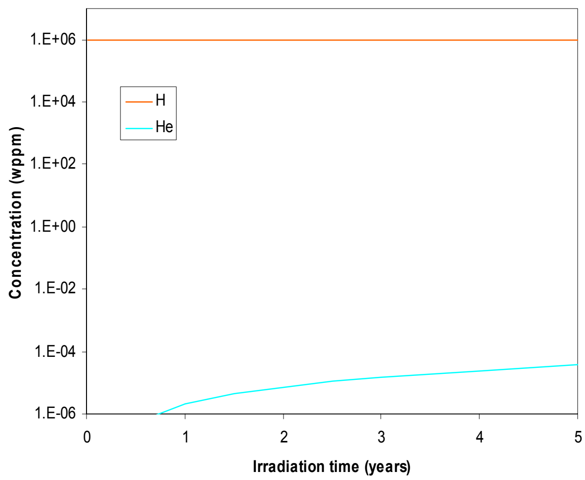
Ingestion dose



Inhalation dose



First wall transmutation



Helium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	2	He3	0.000137
Crustal abundance / wppm	8.0 10^{-3}	He4	99.999863
Melting point / K	0.95*		
Boiling point / K	4.216		
Density / kgm^{-3}	1.785 10^{-1}		
Thermal conductivity / $Wm^{-1}K^{-1}$	1.52 10^{-1}		
Electrical resistivity /Ωm	-		
Coefficient of thermal expansion / K^{-1}	-		
Crystal structure	HCP		
Number of stable isotopes	2		
Mean atomic weight	4.0026		

* *under pressure*

Activation properties

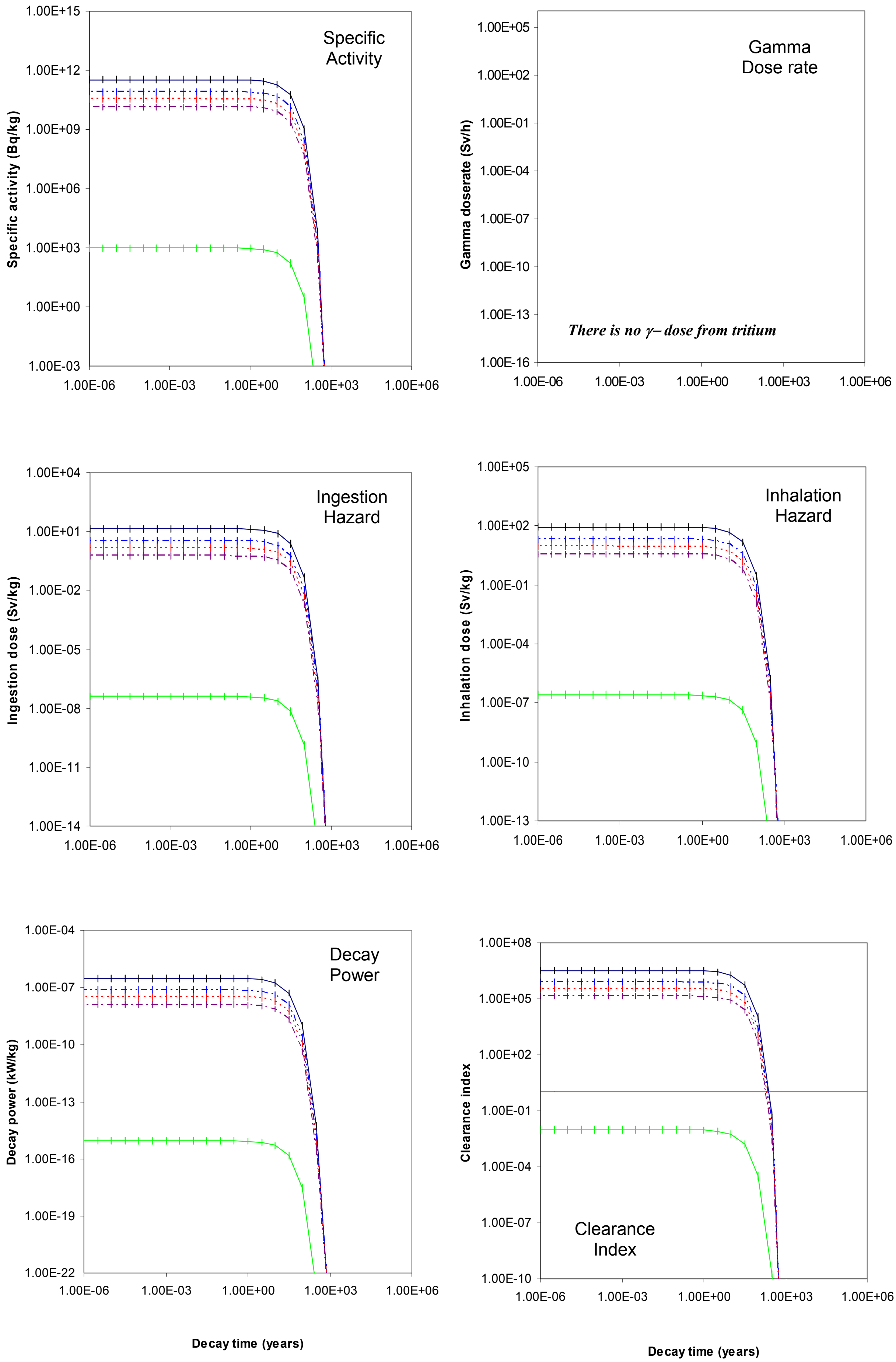
Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	3.31E11	3.31E11	3.31E11	3.13E11	1.20E9	0.00E0	kW kg^{-1}	3.03E-7	3.03E-7	3.03E-7	2.86E-7	1.10E-9	0.00E0
H3	100.0	100.0	100.0	100.0	100.0		H3	100.0	100.0	100.0	100.0	100.0	
Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	0.0E0	0.0E0	0.0E0	0.0E0	0.0E0	0.0E0	Sv kg^{-1}	1.39E1	1.39E1	1.39E1	1.31E1	5.03E-2	0.00E0
							H3	100.0	100.0	100.0	100.0	100.0	
Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	8.61E1	8.61E1	8.61E1	8.14E1	3.12E-1	0.00E0		3.31E6	3.31E6	3.31E6	3.13E6	1.20E4	0.00E0
H3	100.0	100.0	100.0	100.0	100.0		H3	100.0	100.0	100.0	100.0	100.0	

Helium

Pathway analysis

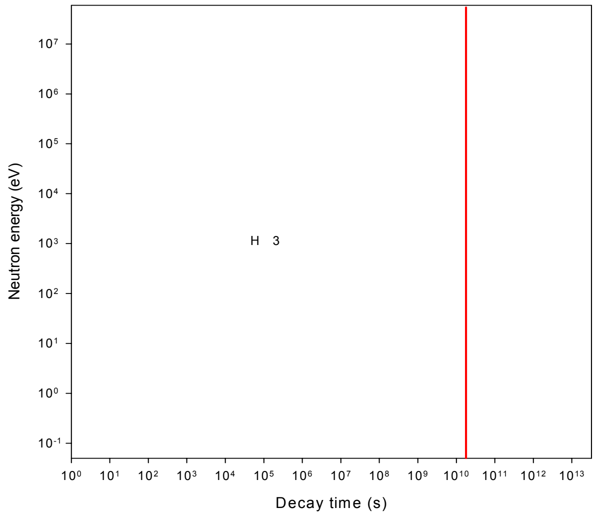
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
H3	12.33 y	He3(n,p)H3	100.0	100.0	100.0	100.0	96.6	0.9	
		He4(n,2n)He3(n,p)H3					3.4	99.1	99.5

Helium activation characteristics



Helium importance diagrams & transmutation

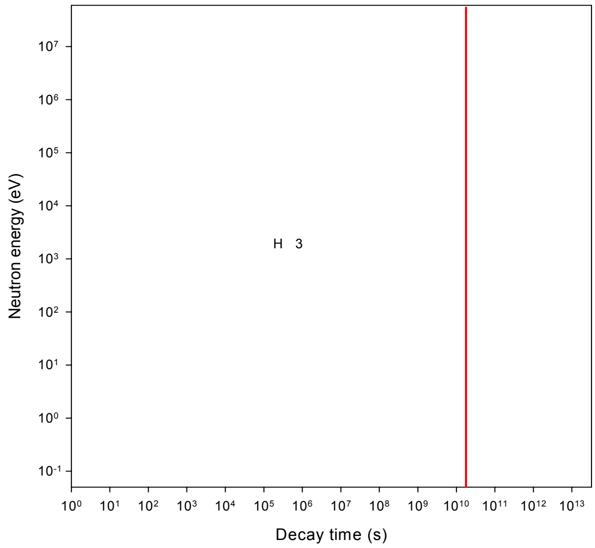
Activity



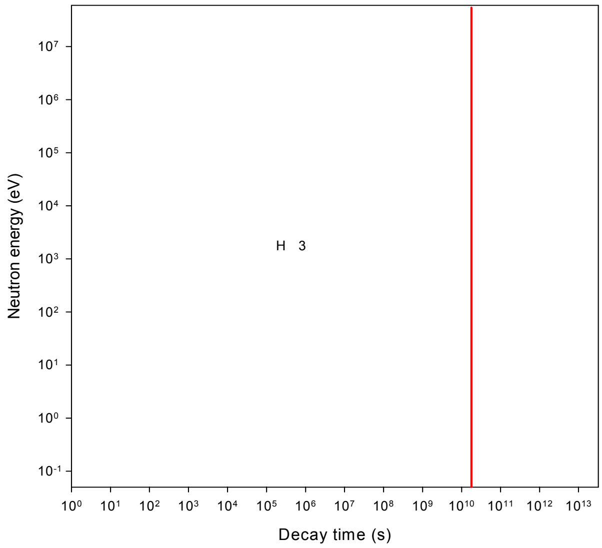
Dose rate

There is no γ– dose from tritium

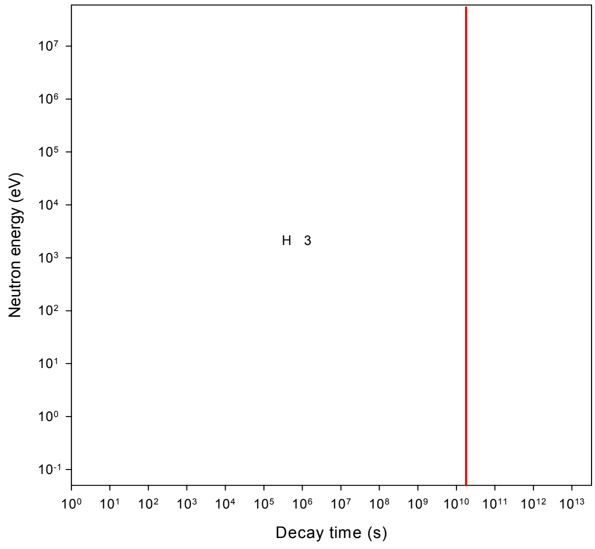
Heat output



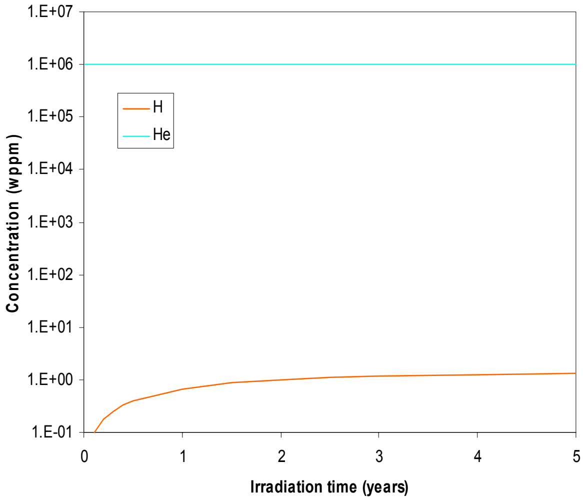
Ingestion dose



Inhalation dose



First wall transmutation



Lithium

General properties

Property	Value	Isotopes	Isotopic abundances / %
Atomic number	3	Li6	7.59
Crustal abundance / wppm	20.0	Li7	92.41
Melting point / K	453.7		
Boiling point / K	1620		
Density / kgm^{-3}	534.0		
Thermal conductivity / $Wm^{-1}K^{-1}$	84.7		
Electrical resistivity /Ωm	$8.55\ 10^{-8}$		
Coefficient of thermal expansion / K^{-1}	$5.6\ 10^{-5}$		
Crystal structure	BCC		
Number of stable isotopes	2		
Mean atomic weight	6.939		

Activation properties

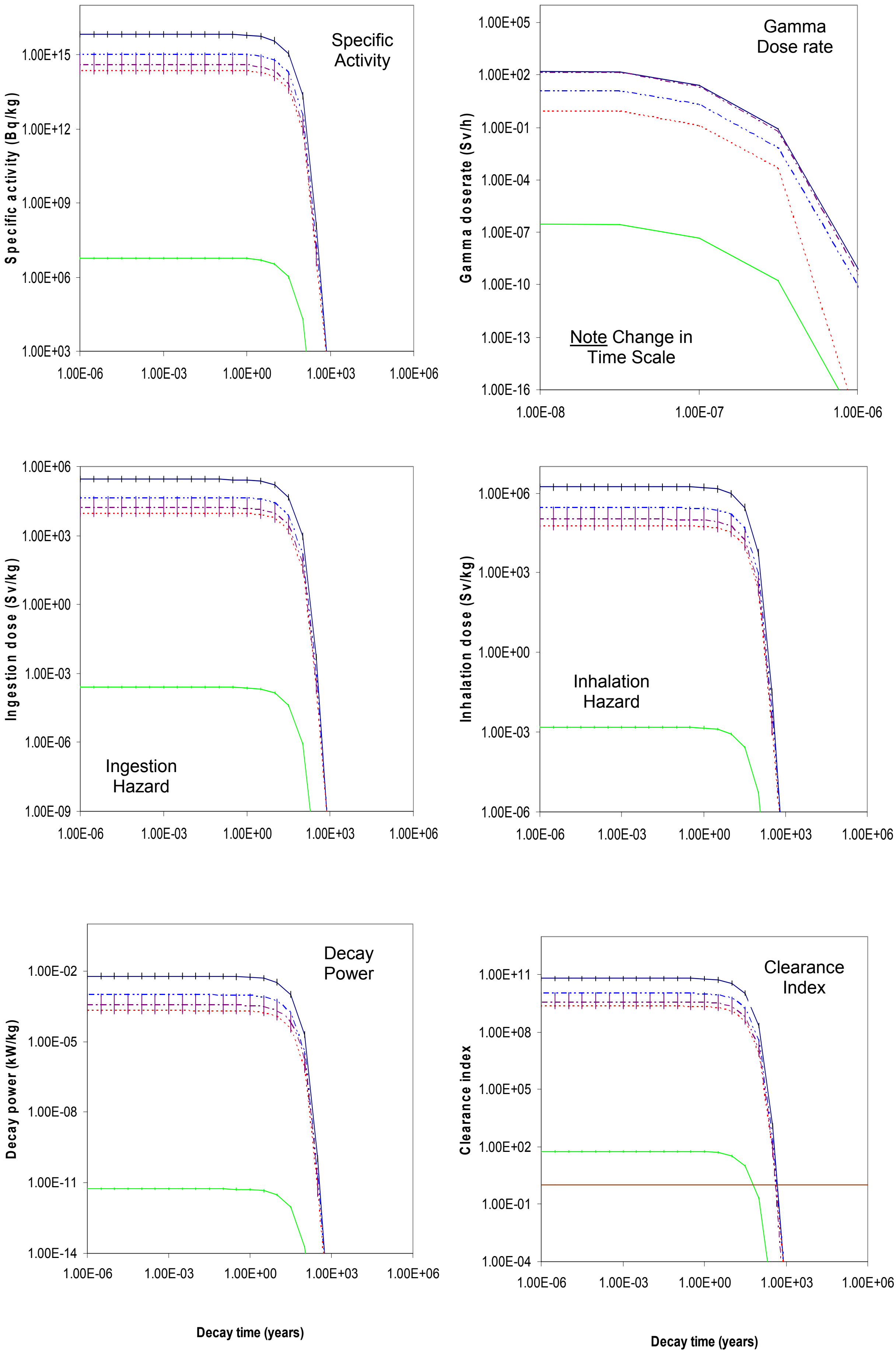
Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	6.70E15	6.53E15	6.53E15	6.17E15	2.36E13	0.00E0	kW kg^{-1}	6.74E-2	5.97E-3	5.97E-3	5.65E-3	2.16E-5	0.00E0
H3	97.50	100.0	100.0	100.0	100.0		Li8	34.43					
He6	0.23						He6	56.73					
Li8	0.02						H3	00.89	100.0	100.0	100.0	100.0	
Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	3.68E2	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	Sv kg^{-1}	2.77E5	2.74E5	2.74E5	2.59E5	9.93E2	0.00E0
Li8	45.36						H3	100.0	100.0	100.0	100.0	100.0	
He6	54.64												
Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.70E6	1.70E6	1.70E6	1.61E6	6.15E3	0.00E0		1.00E11	6.53E10	6.53E10	6.17E10	2.36E8	0.00E0
H3	100.0	100.0	100.0	100.0	100.0		H3	65.19	100.0	100.0	100.0	100.0	
							He6	24.51					
							Li8	10.29					

Lithium

Pathway analysis

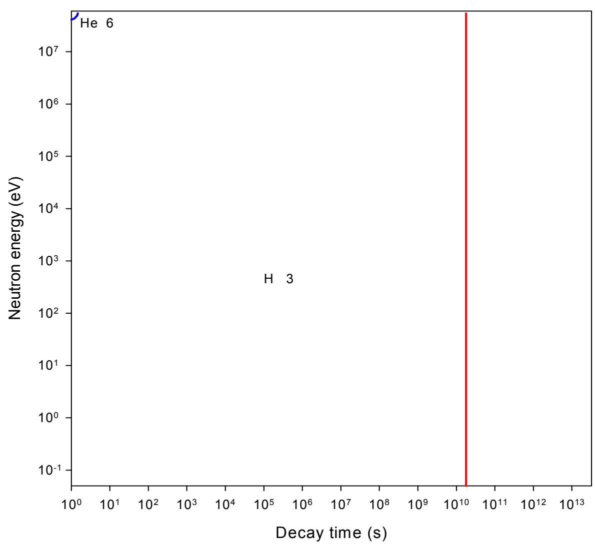
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
He6	0.808 s	Li7(n,d)He6				96.4	99.1	95.9	98.1
		Li6(n,p)He6				3.2	0.8	3.6	1.7
		Li7(n,2n)Li6(n,p)He6				0.3			
Li8	0.838 s	Li7(n,γ)Li8	100.0	100.0	100.0	100.0	100.0	100.0	100.0
H3	12.33 y	Li6(n,α)H3	76.0	85.6	97.8	0.7	0.5	5.2	5.3
		Li6(n,α)H3(β^-)He3(n,p)H3	24.0	14.4	2.2				
		Li7(n,nα)H3				99.2	99.4	94.4	94.4

Lithium activation characteristics

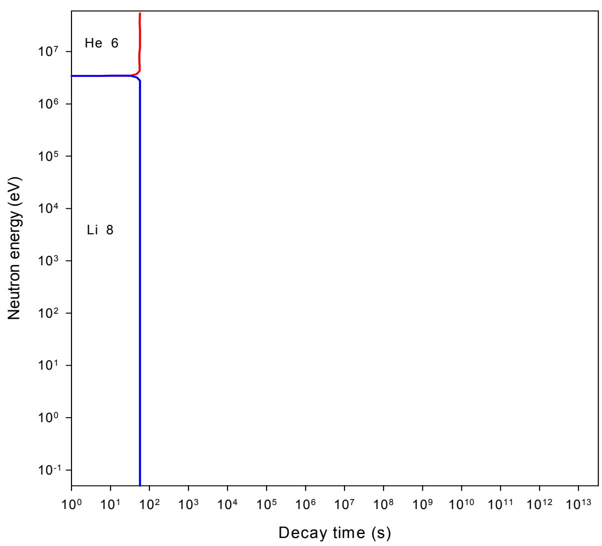


Lithium importance diagrams & transmutation

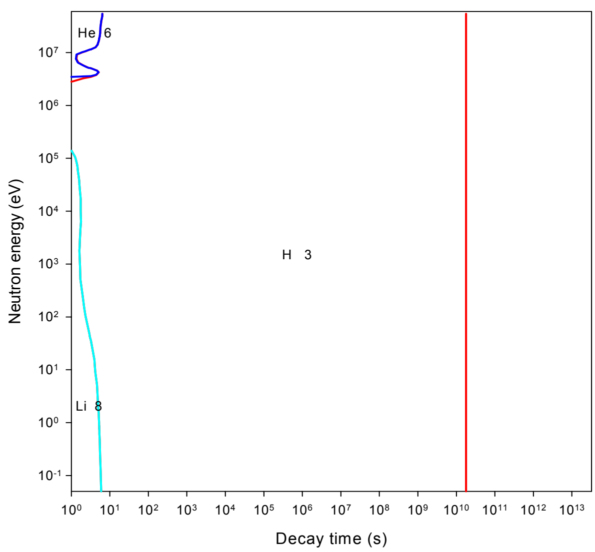
Activity



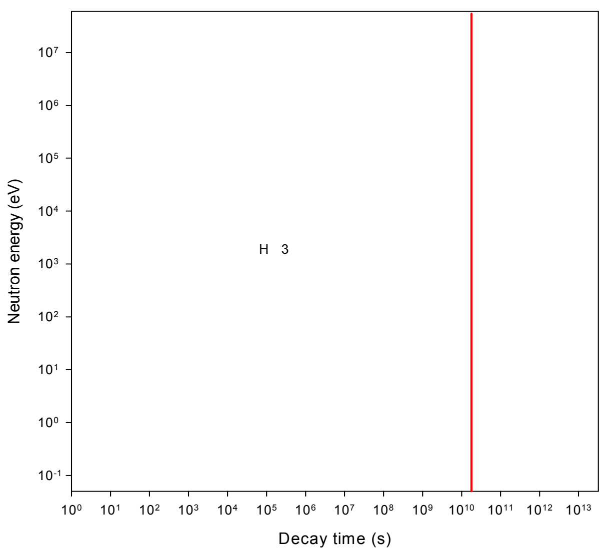
Dose rate



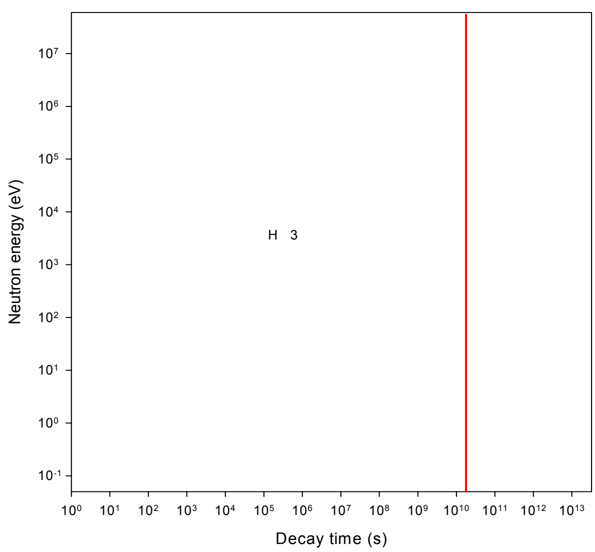
Heat output



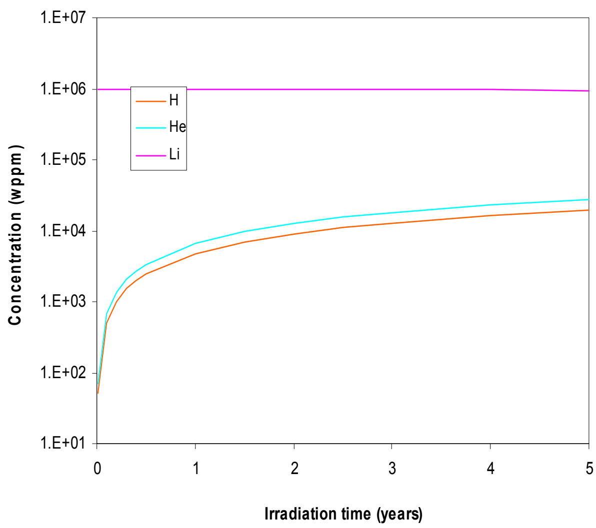
Ingestion dose



Inhalation dose



First wall transmutation



Beryllium

General properties

Atomic number	4	Isotopes	Isotopic abundances / %
Crustal abundance / wppm	2.6	Be9	100.0
Melting point / K	1551		
Boiling point / K	3243*		
Density / kgm^{-3}	1848		
Thermal conductivity / $Wm^{-1}K^{-1}$	200		
Electrical resistivity /Ωm	$4.0\ 10^{-8}$		
Coefficient of thermal expansion / K^{-1}	$1.15\ 10^{-5}$		
Crystal structure	HCP		
Number of stable isotopes	1		
Mean atomic weight	9.0122		

** under pressure*

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	5.54E14	8.37E13	8.37E13	7.91E13	3.03E11	4.92E6	kW kg^{-1}	1.19E-1	7.65E-5	7.65E-5	7.24E-5	2.77E-7	1.99E-10
He6	84.80						He6	99.58					
H3	15.12	100.0	100.0	100.0	100.0		H3	0.07	100.0	100.0	100.0	99.92	
Be10						100.0	Be10					0.07	100.0

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	5.77E2	3.38E-6	3.38E-6	3.38E-6	3.38E-6	3.24E-6	Sv kg^{-1}	1.06E4	3.52E3	3.51E3	3.32E3	1.27E1	5.42E-3
He6	99.27						H3	66.73	100.0	100.0	100.0	99.95	
Li9	0.72						He6	33.27					
Be10		100.0*	100.0*	100.0*	100.0*	100.0*	Be10					0.04	100.0

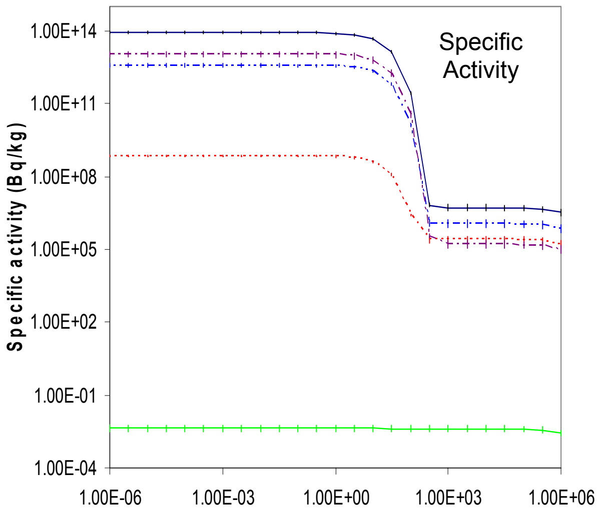
Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	2.52E4	2.18E4	2.18E4	2.06E4	7.89E1	1.72E-1		7.69E10	8.37E8	8.37E8	7.91E8	3.03E6	1.23E2
H3	99.90	100.0	100.0	100.0	99.77		He6	99.61					
He6	0.10						H3	0.04	100.0	100.0	100.0	99.87	
Be10					0.23	100.0	Be10					0.13	100.0

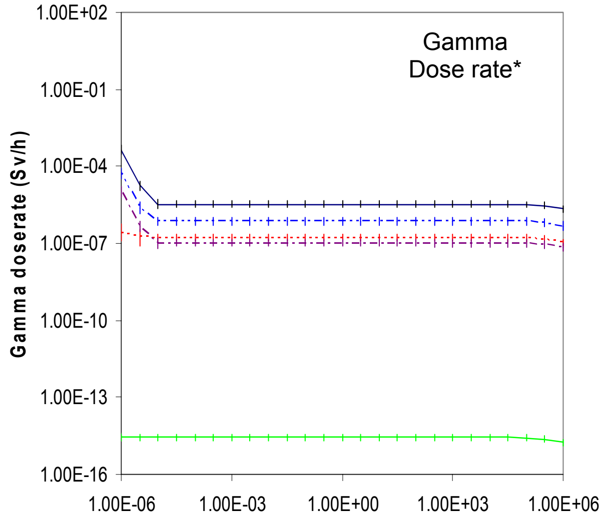
Beryllium

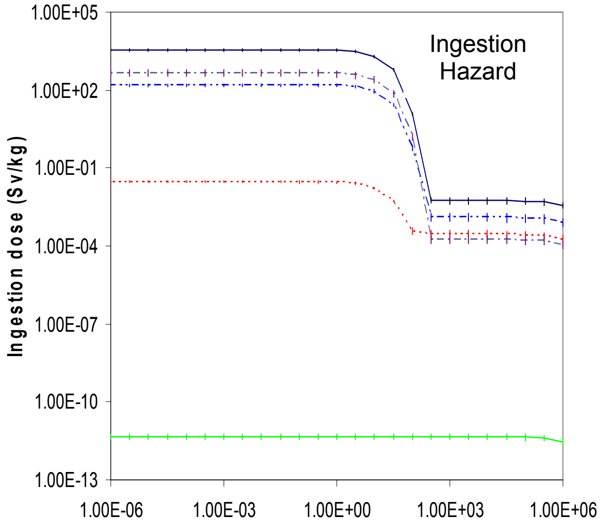
Pathway analysis

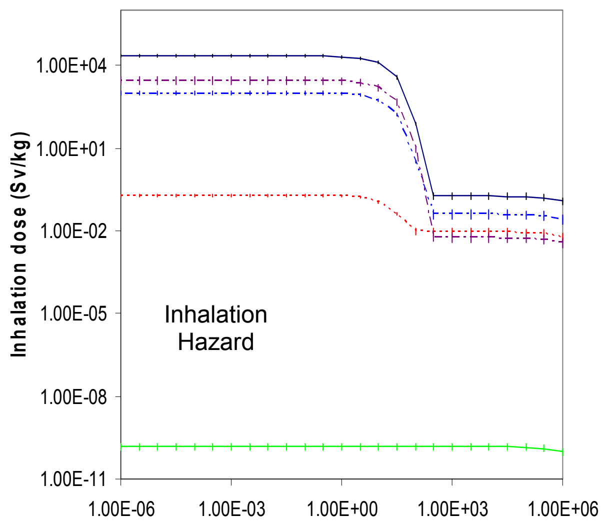
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
He6	0.808 s	Be9(n,α)He6				99.3	90.8	37.3	39.0
		Be9(n,t)Li7(n,d)He6					9.1	55.9	57.9
		Be9(n,nt)Li6(n,p)He6						6.6	3.0
Li8	0.838 s	Be9(n,γ)Be10($β^-$)B10(n,α)Li7(n,γ)Li8	57.2	96.9					
		Be9(n,γ)Be10(n,γ)Be11($β^-$α)Li7(n,γ)Li8	43.3	3.1					
		Be9(n,t)Li7(n,γ)Li8				100.0			
		Be9(n,d)Li8					100.0	100.0	100.0
Be11	13.81 s	Be9(n,γ)Be10(n,γ)Be11	100.0	100.0	100.0	100.0	100.0	100.0	100.0
H3	12.33 y	Be9(n,γ)Be10($β^-$)B10(n,2α)H3	92.3	94.0	99.3				
		Be9(n,γ)Be10($β^-$)B10(n,2α)H3($β^-$)He3(n,p)H3	8.6	6.0	0.7				
		Be9(n,X)H3				97.5	98.6	99.1	99.7
		Be9(n,t)Li7(n,nα)H3				2.3	1.4	0.7	
Be10	$1.6\ 10^6$ y	Be9(n,γ)Be10	100.0	100.0	100.0	100.0	100.0	100.0	100.0

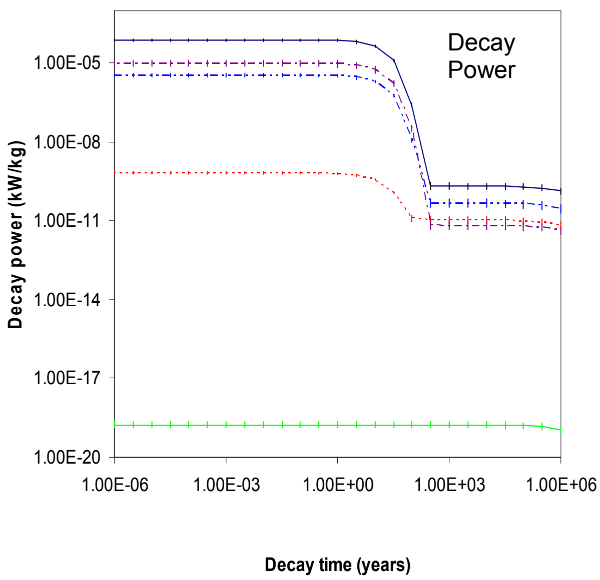
Beryllium activation characteristics

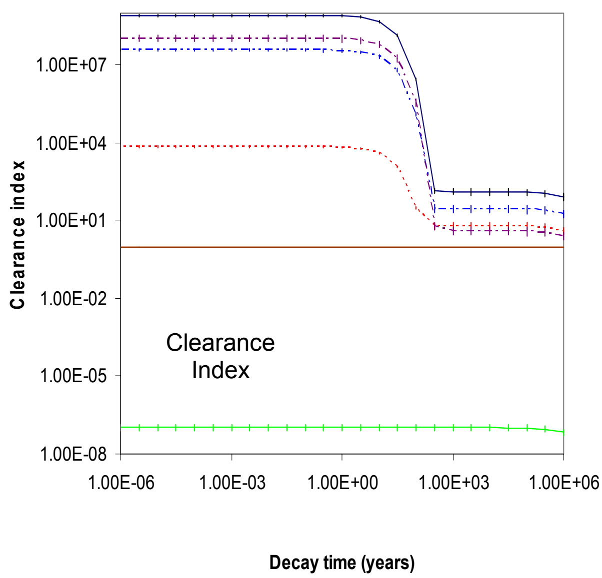






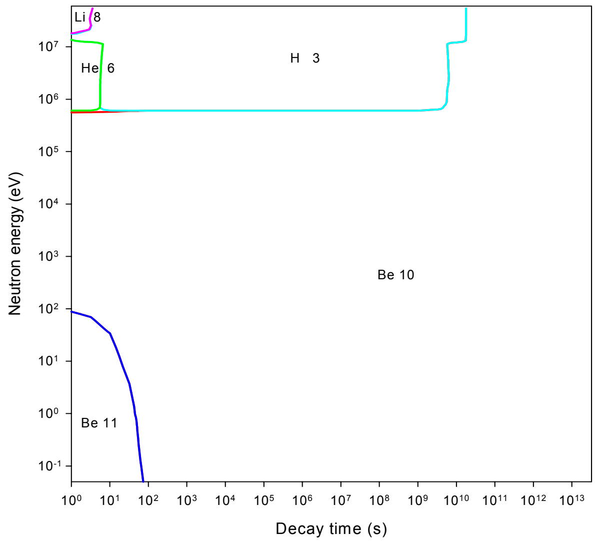




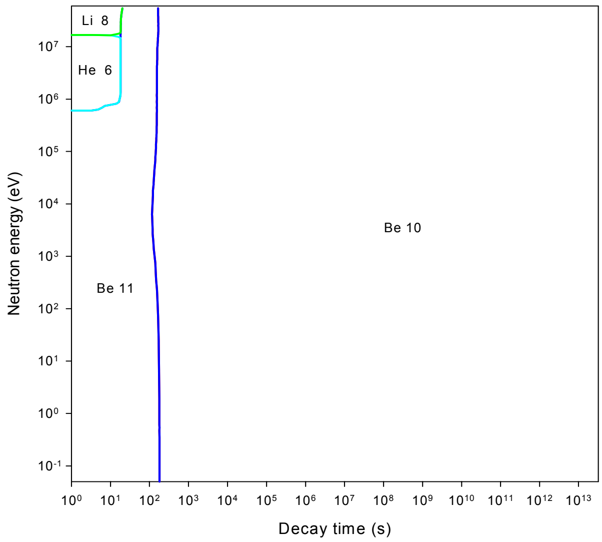


Beryllium importance diagrams & transmutation

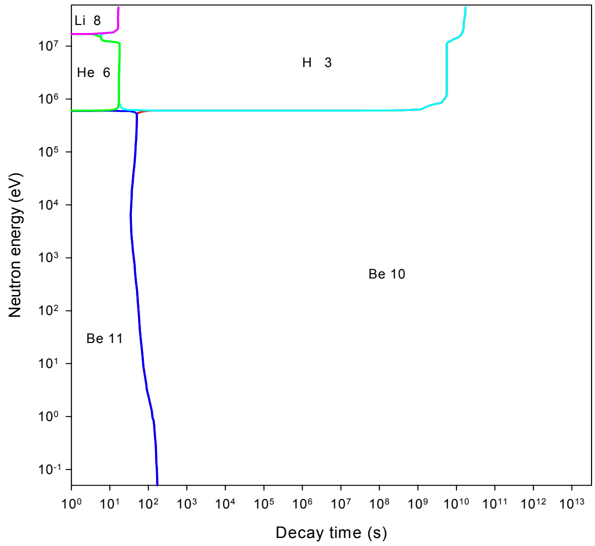
Activity



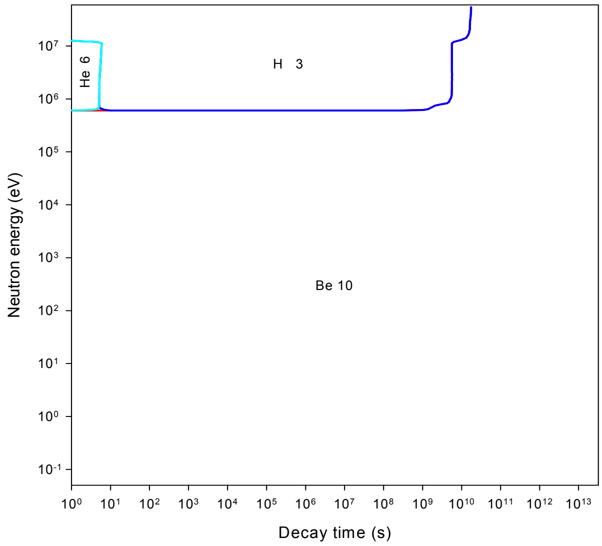
Dose rate



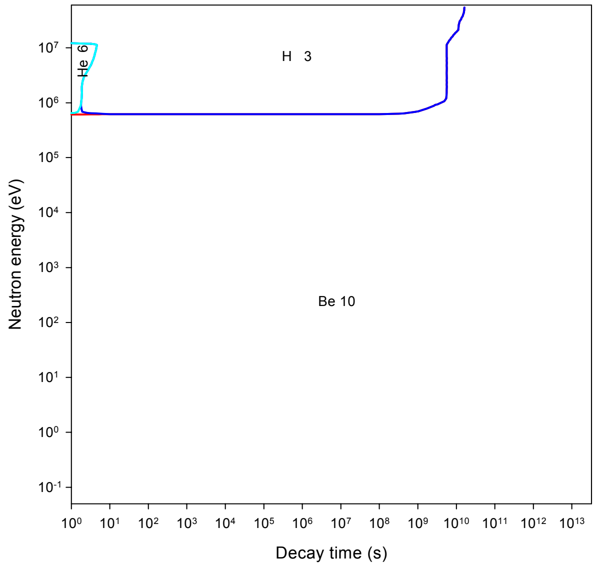
Heat output



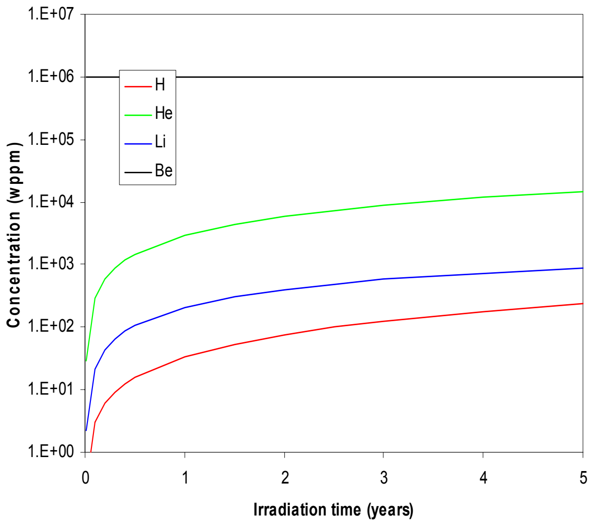
Ingestion dose



Inhalation dose



First wall transmutation



Boron

General properties

		Isotopes	Isotopic abundances / %
Atomic number	5		
Crustal abundance / wppm	10	B10	19.8
Melting point / K	2573	B11	80.2
Boiling point / K	3931		
Density / kgm^{-3}	2340		
Thermal conductivity / $Wm^{-1}K^{-1}$	27.0		
Electrical resistivity /Ωm	$1.80\ 10^{4}$		
Coefficient of thermal expansion / K^{-1}	$5.0\ 10^{-5}$		
Crystal structure	tetragonal		
Number of stable isotopes	2		
Mean atomic weight	10.811		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	4.48E14	1.71E14	1.71E14	1.62E14	6.21E11	2.16E8	kW kg^{-1}	3.72E-1	1.57E-4	1.57E-4	1.48E-4	5.76E-7	8.72E-9
Li8	49.29						Li8	88.95					
H3	38.26	100.0	100.0	100.0	99.96		Be11	9.21					
Be11	7.82						B12	0.53					
He6	4.20						H3	0.04	99.99	99.99	99.99	98.39	
Be10						100.0	Be10		0.01	0.01	0.01	1.61	100.0

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	2.10E4	2.56E-3	8.44E-5	8.44E-5	8.44E-5	8.08E-5	Sv kg^{-1}	7.52E3	7.20E3	7.20E3	6.81E3	2.63E1	2.37E-1
Be11	89.21	96.62					H3	95.80	100.0	100.0	100.0	99.04	
Li8	10.49						He6	3.76					
Be10		3.38*	100.0*	100.0*	100.0*	100.0*	Be10					0.96	100.0

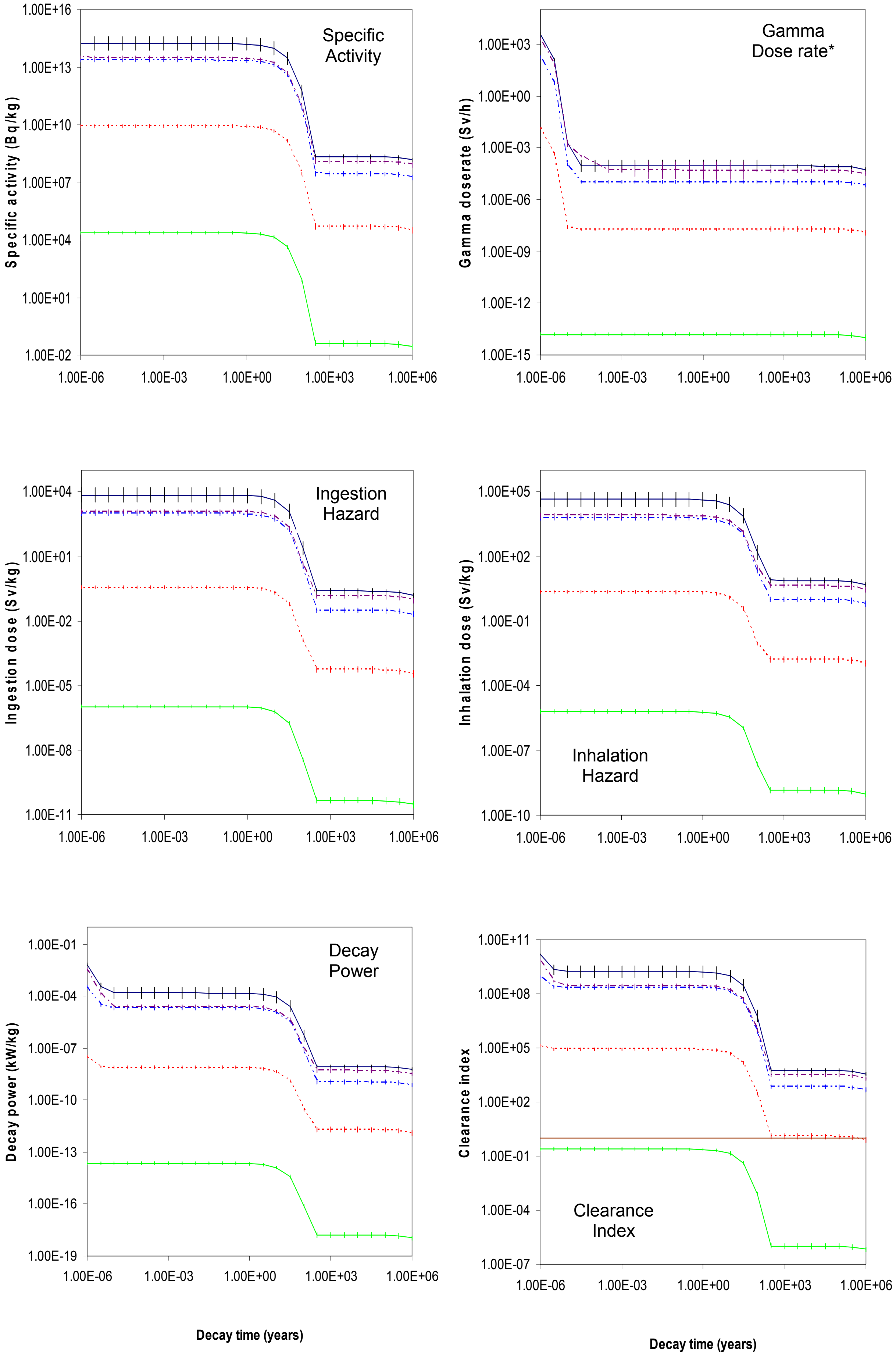
Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	4.47E4	4.46E4	4.46E4	4.21E4	1.69E2	7.55E0		2.20E11	1.71E9	1.71E9	1.62E9	6.21E6	5.40E3
H3	99.62	99.98	99.98	99.98	95.24		Li8	67.07					
He6	0.3						Be11	30.15	0.02				
Be11	0.02						H3	0.08	99.98	99.99	99.99	97.29	
Be10	0.02	0.02	0.02	0.02	4.76	100.0	Be10		0.01	0.01	0.01	2.71	100.0

Boron

Pathway analysis

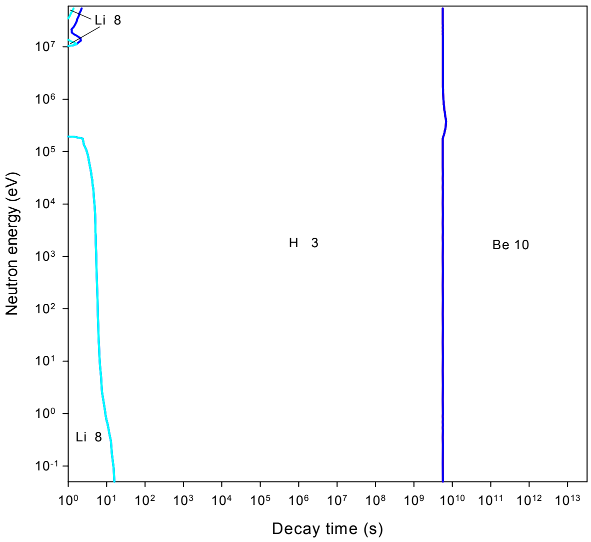
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
He6	0.808s	B11(n,nα)Li7(n,d)He6				48.3	13.8	8.2	7.2
		B11(n,d)Be10(n,nα)He6				13.0	6.7	4.8	4.2
		B10(n,nα)Li6(n,p)He6				10.5	0.7	2.8	1.8
		B10(n,α)Li7(n,d)He6				8.1	0.5		
		B11(n,t)Be9(n,α)He6				7.8	0.8		
		B10(n,p)Be10(n,nα)He6				7.0			
		B10(n,d)Be9(n,α)He6				4.5			
		B11(n,dα)He6					76.9	81.9	85.2
		B11(n,2nα)Li6(n,p)He6						1.6	1.2
Li8	0.838 s	B10(n,α)Li7(n,γ)Li8	100.0	100.0	100.0				
		B11(n,α)Li8				99.9	43.3	23.2	8.5
		B10(n,h)Li8					38.7	52.4	66.8
		B11(n,t)Be9(n,d)Li8					9.0	19.5	20.5
		B11(n,d)Be10(n,t)Li8					6.4	2.7	2.5
		B11(n,2n)B10(n,h)Li8					1.5	1.2	0.7
		B10(n,d)Be9(n,d)Li8					0.8	0.9	0.8
Be11	13.81 s	B10(n,p)Be10(n,γ)Be11	100.0	100.0	100.0				
		B11(n,p)Be11				100.0	100.0	100.0	100.0
C11	20.37 m	B11(n,γ)B12(β^-)C12(n,2n)C11					100.0	100.0	100.0
H3	12.33 y	B10(n,2α)H3	65.4	80.3	97.6	53.0	33.0	34.3	29.1
		B10(n,2α)H3(β^-)He3(n,p)H3	21.0	19.7	2.4				
		B11(n,n2α)H3				42.1	59.0	57.4	64.0
		B11(n,nα)Li7(n,nα)H3				3.6	3.9	2.2	0.9
		B10(n,α)Li7(n,nα)H3				0.6			
		B11(n,d)Be10(n,ntα)H3					2.0	0.9	0.8
		B11(n,t)Be9(n,tα)H3					0.8	2.7	3.4
		B11(n,2n)B10(n,2α)H3					0.7		
		B10(n,nα)Li6(n,α)H3						1.1	0.7
		B11(n,2nα)Li6(n,α)H3						0.6	0.5
Be10	$1.6\ 10^{6}$ y	B10(n,p)Be10	100.0	100.0	100.0	34.9	3.6	3.2	2.7
		B11(n,d)Be10				64.7	96.3	96.8	97.3

Boron activation characteristics

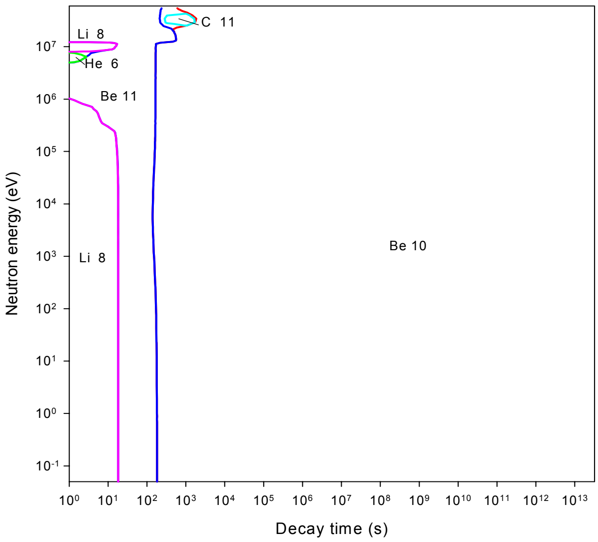


Boron importance diagrams & transmutation

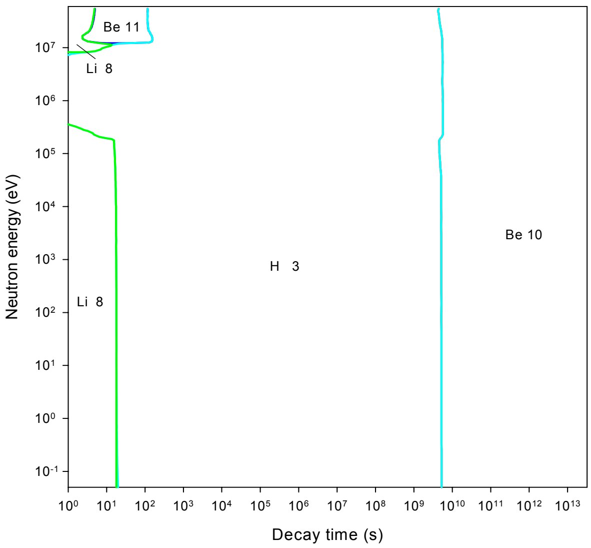
Activity



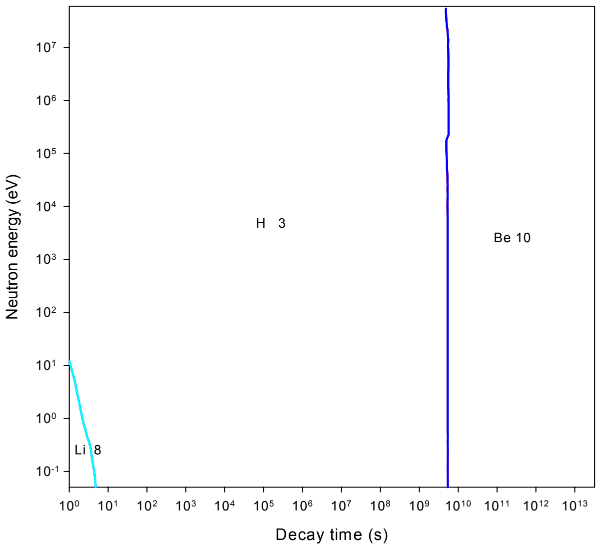
Dose rate



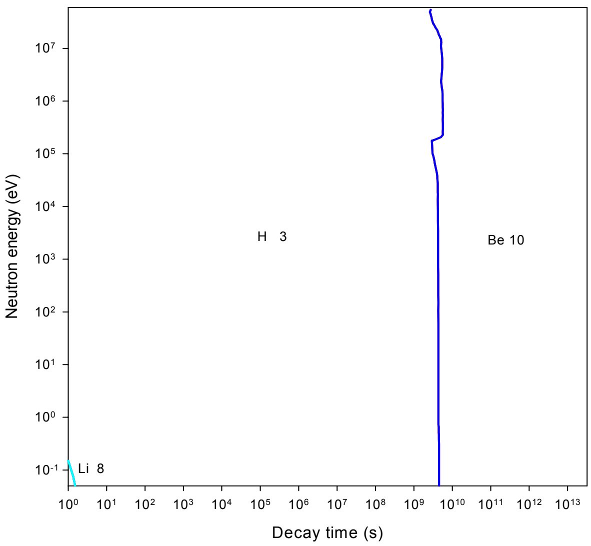
Heat output



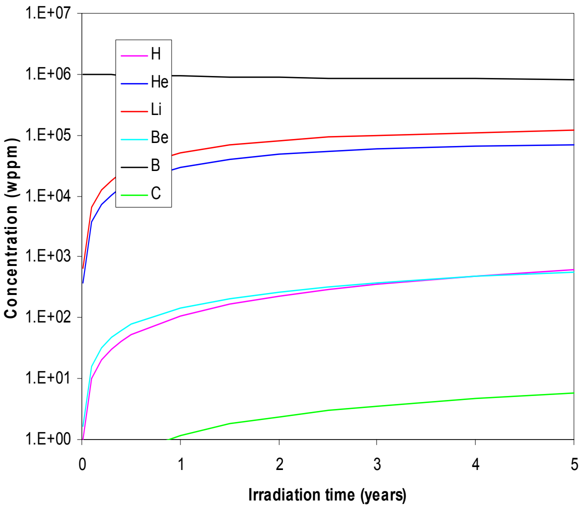
Ingestion dose



Inhalation dose



First wall transmutation



Carbon

General properties

		Isotopes	Isotopic abundances / %
Atomic number	6		
Crustal abundance / wppm	480	C12	98.89
Melting point / K	3820 (d)	C13	1.11
Boiling point / K	5100 (subl)	C14	Trace ($T_{½}$ = 5700 y)
Density / kgm^{-3}	1400 (a)		
	2260 (g)		
	3513 (d)		
Thermal conductivity / $Wm^{-1}K^{-1}$	4.2 (a)		
	5.7-1960 (g)		
	990-2320 (d)		
Electrical resistivity /Ωm	1.357 10^{-5} (g)		
	1.0 10^{11} (d)		
Coefficient of thermal expansion / K^{-1}	1.19 10^{-6} (d)		
Crystal structure	Hexagonal (g)		
	Cubic (d)		
Number of stable isotopes	2 (3)		
Mean atomic weight	12.011		

(d) = diamond, (g) = graphite, (a) = amorphous, (subl) = sublimes

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	4.93E12	1.75E11	1.74E11	1.65E11	6.73E8	3.03E6	kW kg^{-1}	4.35E-3	1.60E-7	1.60E-7	1.51E-7	1.01E-9	1.22E-10
B12	49.81						B12	57.90					
B13	31.51						B13	37.75					
He6	15.09						He6	4.29					
H3	3.54	99.98	99.98	99.97	93.87		H3		99.73	99.73	99.71	57.35	
C14		0.02	0.02	0.02	5.66		C14		0.19	0.19	0.20	29.97	
Be10		0.01	0.01	0.01	0.46	100.0	Be10		0.08	0.08	0.08	12.68	100.0

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	2.00E2	1.10E-6	7.24E-7	7.24E-7	7.24E-7	6.93E-7	Sv kg^{-1}	1.85E1	7.35E0	7.35E0	6.95E0	5.21E-2	3.33E-3
B13	74.63						He6	60.21					
B12	24.93						H3	39.57	99.65	99.65	99.63	50.92	
Be11	0.05	0.36					C14	0.12	0.30	0.30	0.32	42.40	
Be10		89.90*	100.0*	100.0*	100.0*	100.0*	B12	0.09					
N13		9.75					Be10	0.04	0.05	0.05	0.05	6.67	100.0

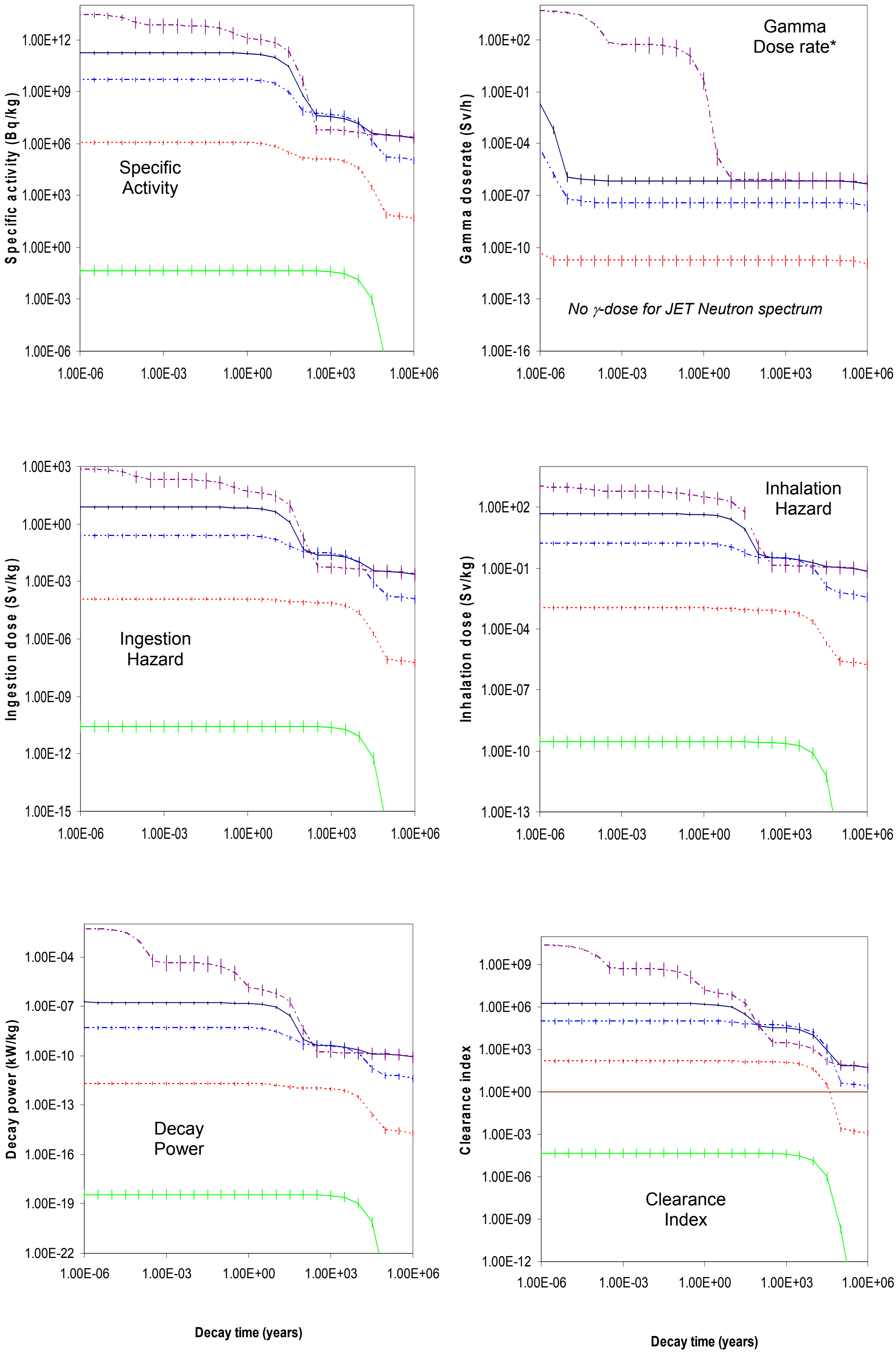
Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	5.11E1	4.57E1	4.57E1	4.32E1	4.96E-1	1.06E-1		1.78E6	1.78E6	1.69E6	4.45E4	7.58E1	3.56E2
H3	88.72	99.27	99.27	99.23	33.13		B12	53.32					
He6	10.61						B13	42.93					
C14	0.44	0.49	0.49	0.52	44.56		He6	3.67					
Be10	0.22	0.24	0.24	0..26	22.31	100.0	H3	0.05	97.83	97.83	97.71	14.20	
							C14		2.16	2.16	2.28	85.62	0.27
							Be10					0.18	99.73

Carbon

Pathway analysis

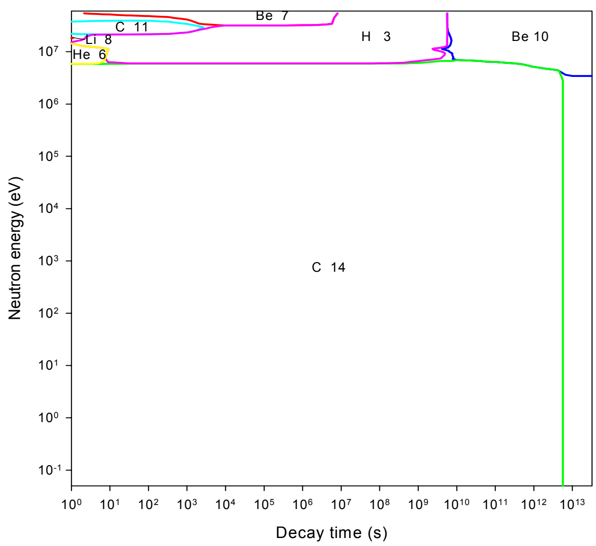
Nuclide	T½	Pathway	210	186	151	42	30	21	6
He6	0.808 s	C12(n,α)Be9(n,α)He6				98.8	2.4		0.1
		C13(n,α)Be10(n,nα)He6				0.5			
		C12(n,d)B11(n,dα)He6					59.4	10.6	2.7
		C13(n,2α)He6					12.1	1.4	0.3
		C12(n,dα)Li7(n,d)He6					7.8	42.3	38.9
		C12(n,h)Be10(n,nα)He6					5.3	3.6	6.1
		C12(n,d)B11(n,nα)Li7(n,d)He6					5.3	0.5	0.1
		C12(n,2n)C11(β^+)B11(n,dα)He6					2.8	1.2	0.4
		C12(n,d)B11(n,d)Be10(n,nα)He6					2.6	0.3	
		C12(n,hα)He6						30.3	36.2
		C12(n,2nα)Be7(β^+)Li7(n,d)He6						5.5	10.6
		C12(n,tα)Li6(n,p)He6						3.2	3.5
Li8	0.838 s	C13(n,t)B11(n,α)Li8				84.0			
		C12(n,d)B11(n,α)Li8				15.6	36.5	1.2	0.2
		C12(n,α)Be9(n,d)Li8					29.7	3.7	15.3
		C12(n,t)B10(n,h)Li8					9.4	3.7	4.6
		C12(n,h)Be10(n,t)Li8					5.6	0.8	2.6
		C13(n,nα)Be9(n,d)Li8					5.3	0.4	0.3
		C12(n,d)B11(n,t)Be9(n,d)Li8					3.8	0.5	0.2
		C12(n,pα)Li8					3.6	89.1	74.9
		C12(n,d)B11(n,d)Be10(n,t)Li8					2.8		
		C12(n,2n)C11(β^+)B11(n,α)Li8					1.7	0.1	
		C12(n,d)B11(n,2n)B10(n,h)Li8					0.6		
		C12(n,d)B11(n,α)Li8						1.2	
		C13(n,dα)Li8							1.6
C15	2.449 s	C13(n,γ)C14(n,γ)C15	99.2	100.0	100.0	99.4	98.4	99.3	99.7
		C12(n,γ)C13(n,γ)C14(n,γ)C15	0.8				0.2	0.1	
Be11	13.81 s	C13(n,t)B11(n,p)Be11				83.5	0.2		
		C12(n,d)B11(n,p)Be11				15.5	95.3	3.5	0.4
		C13(n,α)Be10(n,γ)Be11				0.5			
		C12(n,2n)C11(β^+)B11(n,p)Be11					4.4	0.4	
		C12(n,2p)Be11						95.7	97.7
		C13(n,h)Be11						0.3	1.8
C11	20.37 m	C12(n,2n)C11					99.9	99.3	98.4
		C13(n,3n)C11						0.7	1.6
Be7	53.22 d	C12(n,2nα)Be7						99.7	99.5
H3	12.33 y	C13(n,γ)C14(β^-)N14(n,X)H1(n,γ)H2(n,γ)H3	95.3	97.2					
		C12(n,α)Be9(n,X)H3				63.8	0.2	0.3	0.4
		C13(n,t2α)H3				34.7	0.6	0.8	0.7
		C12(n,α)Be9(n,t)Li7(n,nα)H3				1.0			
		C12(n,d2α)H3					95.8	93.6	97.6
		C12(n,d)B11(n,n2α)H3					2.2	0.9	0.1
		C12(n,dα)Li7(n,nα)H3					0.2	2.5	0.5
C14	5700 y	C13(n,γ)C14	99.2	100.0	100.0	99.5	98.4	99.3	99.7
		C12(n,γ)C13(n,γ)C14	0.8				0.2	0.1	
Be10	1.6 10^6 y	C13(n,α)Be10				99.5	1.2	0.3	0.6
		C12(n,h)Be10					64.9	90.6	98.0
		C12(n,d)B11(n,d)Be10					31.9	7.7	1.1
		C12(n,2n)C11(β^+)B11(n,d)Be10					1.5	0.9	0.2

Carbon activation characteristics

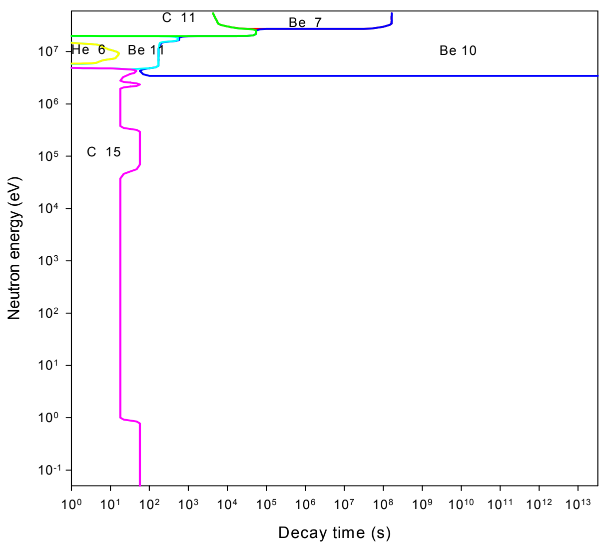


Carbon importance diagrams & transmutation

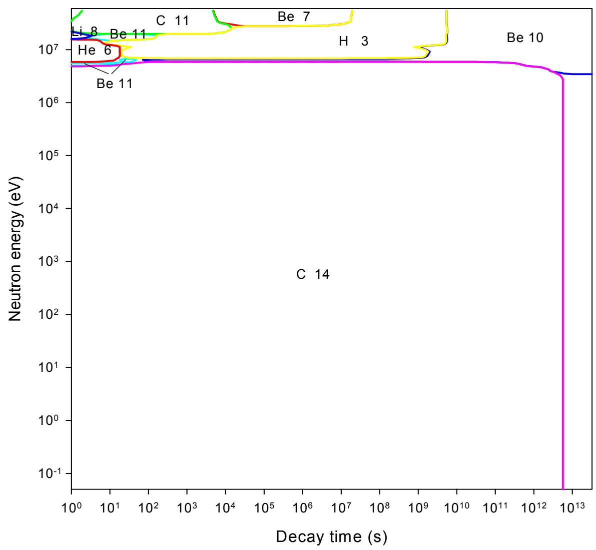
Activity



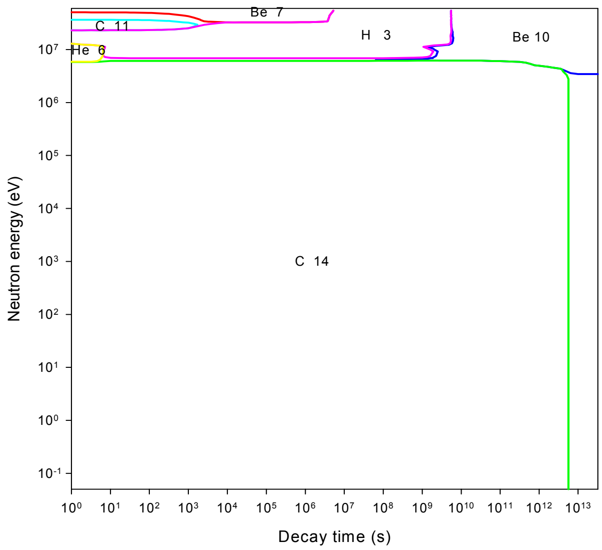
Dose rate



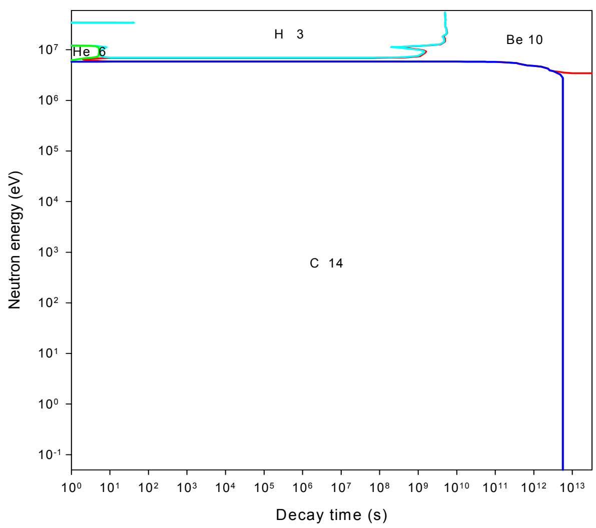
Heat output



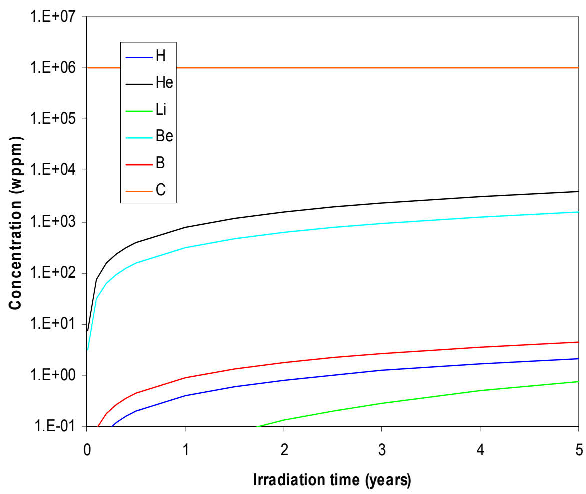
Ingestion dose



Inhalation dose



First wall transmutation



Nitrogen

General properties

		Isotopes	Isotopic abundances / %
Atomic number	7		
Crustal abundance / wppm	25	N14	99.634
Melting point / K	63.29	N15	0.366
Boiling point / K	77.4		
Density / kgm^{-3}	1.251		
Thermal conductivity / $Wm^{-1}K^{-1}$	$2.60\ 10^{-2}$		
Electrical resistivity /Ωm	-		
Coefficient of thermal expansion / K^{-1}	-		
Crystal structure	Cubic		
Number of stable isotopes	2		
Mean atomic weight	14.00674		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	9.50E13	8.06E13	5.53E13	5.24E13	8.58E11	4.95E6	kW kg^{-1}	1.25E-2	6.17E-3	5.53E-5	5.26E-5	5.41E-6	8.63E-11
H3	57.59	67.83	98.79	98.72	23.06		N13	70.31	99.10				
N13	38.35	31.34					Li8	10.63					
B13	1.03						B13	8.29					
Li8	0.93						B12	5.01					
C14	0.70	0.83	1.20	1.28	76.94	70.69	C15	3.81					
B12	0.64						H3	0.39	0.81	90.42	89.93	3.34	
C15	0.48						C14	0.04	0.09	9.58	10.07	96.66	32.12
Be10						29.31	Be10						67.88

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	8.08E3	5.04E3	2.47E-7	2.47E-7	2.47E-7	2.36E-7	Sv kg^{-1}	3.16E3	3.01E3	2.68E3	2.56E3	3.91E2	3.62E-3
N13	89.92	100.0					H3	72.70	76.23	85.56	84.86	2.13	
C15	7.59						N13	14.99	10.9				
Be11	1.04						C14	12.77	12.86	14.44	15.14	97.87	55.99
Be10			100.0*	100.0*	100.0*	100.0*	Be10						44.01

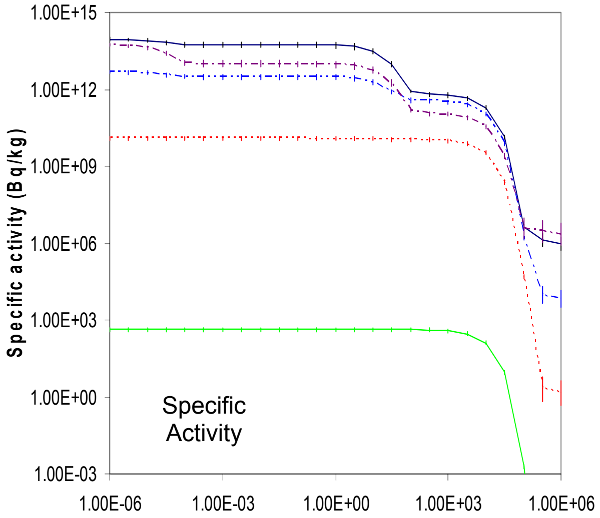
Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.84E4	1.83E4	1.81E4	1.73E4	3.88E3	7.10E-2		4.40E10	2.81E10	1.21E9	1.19E9	6.62E8	3.53E3
H3	77.10	77.55	78.57	77.62	1.33		N13	88.06	95.67				
C14	21.02	21.14	21.27	22.38	98.67	28.56	C15	4.03					
N13	1.88	1.31					B13	2.03					
Be10						71.44	C14	1.52	2.38	55.01	56.38	99.79	98.97
							Li8	1.35					
							H3	1.24	1.95	44.99	43.62	0.29	
							Be11	0.74					
							Be10						1.03

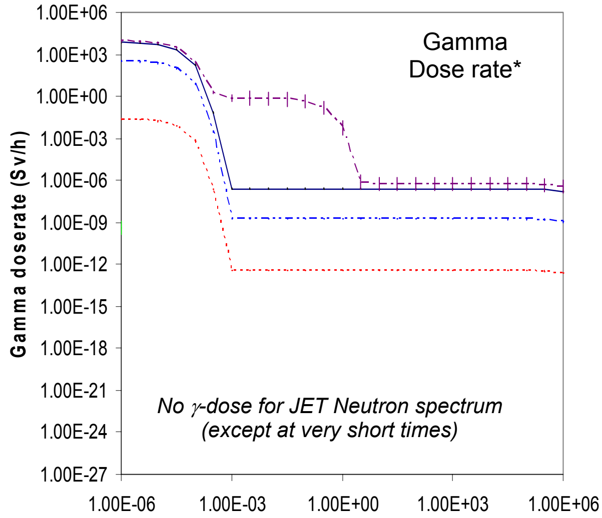
Nitrogen

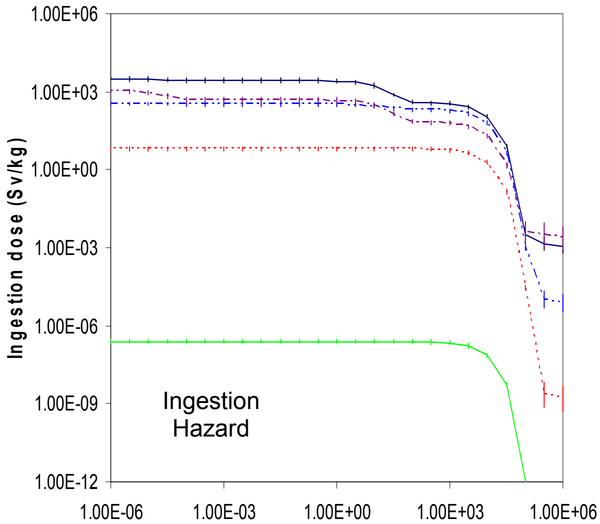
Pathway analysis

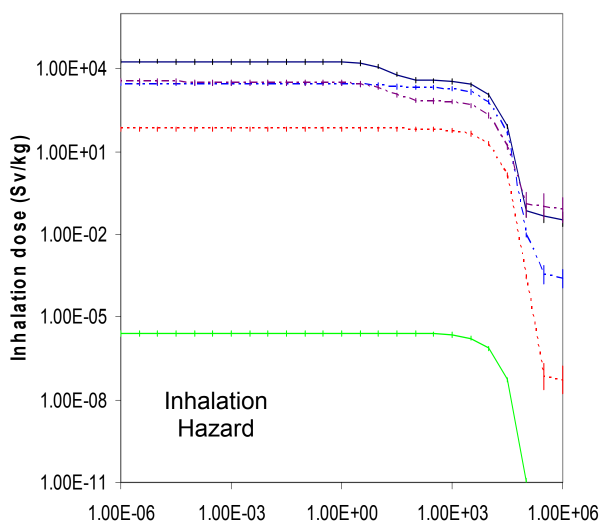
Nuclide	$T_{1/2}$	Pathway	210	186	151	42	30	21	6
Li8	0.838 s	N14(n,α)B11(n,α)Li8				99.5	4.4	0.6	0.3
		N14(n,nα)B10(n,h)Li8					51.5	19.2	7.0
		N14(n,dα)Be9(n,d)Li8					17.4	57.1	55.6
		N14(n,pα)Be10(n,t)Li8					12.3	3.7	2.4
		N14(n,d)C13(n,nα)Be9(n,d)Li8					10.2	2.4	0.5
		N14(n,t)C12(n,pα)Li8						12.2	5.2
		N14(n,d)C13(n,dα)Li8						1.2	6.3
		N14(n,hα)Li8						0.6	19.9
C15	2.449 s	N14(n,p)C14(n,γ)C15	100.0	100.0	100.0		0.6	0.5	0.1
		N15(n,p)C15				99.9	99.4	99.5	99.9
N16	7.13 s	N14(n,γ)N15(n,γ)N16	50.4	4.0	0.3				
		N15(n,γ)N16	49.6	96.0	99.7	99.1	99.9	100.0	100.0
Be11	13.81 s	N14(n,α)B11(n,p)Be11				77.5	19.0	6.7	1.1
		N14(n,p)C14(n,α)Be11				22.0	76.5	10.2	0.5
		N15(n,d)C14(n,α)Be11				0.2	1.7	0.3	
		N14(n,d)C13(n,t)B11(n,p)Be11				0.2	0.5	0.8	
		N14(n,t)C12(n,d)B11(n,p)Be11					1.5	0.9	
		N14(n,t)C12(n,2p)Be11						50.3	12.2
		N14(n,d)C13(n,h)Be11						15.2	13.1
		N15(n,pα)Be11						10.3	1.6
		N14(n,h)B12(β^-)C12(n,2p)Be11						2.2	0.9
		N14(n,nt)C11(β^+)B11(n,p)Be11						1.1	0.3
		N14(n,2n)N13(β^+)C13(n,h)Be11						0.7	0.6
		N14(n,ph)Be11							69.2
N13	9.967 m	N14(n,2n)N13				100.0	100.0	99.3	98.1
		N15(n,3n)N13						0.7	1.9
C11	20.37 m	N14(n,t)C12(n,2n)C11					82.4	14.3	2.2
		N14(n,nt)C11					7.3	75.1	95.5
		N14(n,h)B12(β^-)C12(n,2n)C11					4.7	0.6	0.2
		N14(n,d)C13(n,2n)C12(n,2n)C11					2.9	0.1	
		N14(n,d)C13(n,3n)C11					1.7	9.2	2.0
Be7	53.22 d	N14(n,t)C12(n,2nα)Be7						93.9	22.3
		N14(n,h)B12(β^-)C12(n,2nα)Be7						4.2	1.6
		N14(n,ntα)Be7						0.7	72.6
		N14(n,d)C13(n,2n)C12(n,2nα)Be7						0.7	
		N14(n,d)C13(n,3nα)Be7							2.8
H3	12.33 y	N14(n,X)H1(n,γ)H2(n,γ)H3	93.4	95.2	99.3				
		N14(n,3α)H3				94.0	79.9	91.7	94.4
		N14(n,2α)Li7(n,nα)H3				4.4	9.9	1.5	0.1
		N14(n,d)C13(n,t2α)H3				0.7	2.0	1.2	1.0
		N15(n,n3α)H3				0.2	1.3	0.9	0.6
		N14(n,nα)B10(n,2α)H3				0.1	3.1	0.8	0.1
		N14(n,t)C12(n,d2α)H3					1.5	1.6	2.2
		N14(n,dα)Be9(n,tα)H3					0.2	1.0	0.9
C14	5700 y	N14(n,p)C14	100.0	100.0	100.0	99.3	97.8	97.2	96.6
		N15(n,d)C14				0.7	2.2	2.7	3.3
Be10	$1.6\ 10^6$ y	N14(n,d)C13(n,α)Be10				76.4	1.5	0.5	1.1
		N14(n,α)B11(n,d)Be10				14.7	2.5	0.9	1.6
		N14(n,pα)Be10				5.1	92.8	95.4	91.7
		N14(n,nα)B10(n,p)Be10				1.7	1.2	0.4	0.1
		N14(n,2n)N13(β^+)C13(n,α)Be10				1.7			
		N14(n,p)C14(n,nα)Be10					1.2	0.5	0.1
		N14(n,t)C12(n,h)Be10					0.4	1.5	3.3
		N15(n,dα)Be10						0.3	1.1

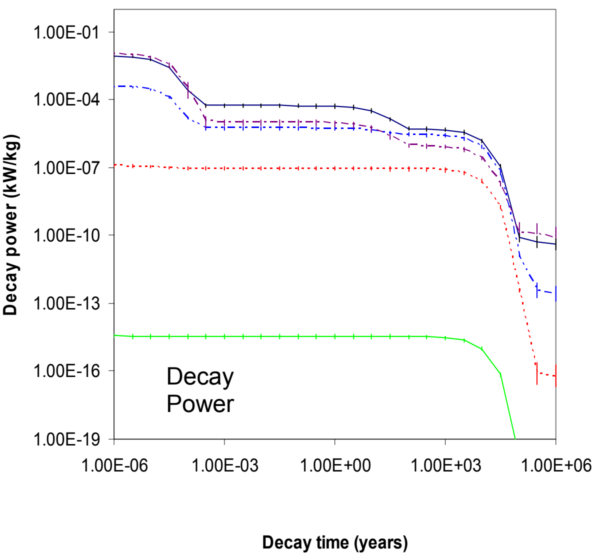
Nitrogen activation characteristics

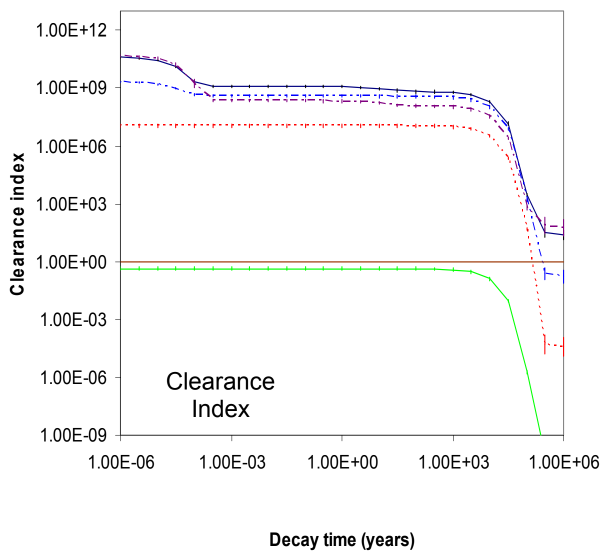






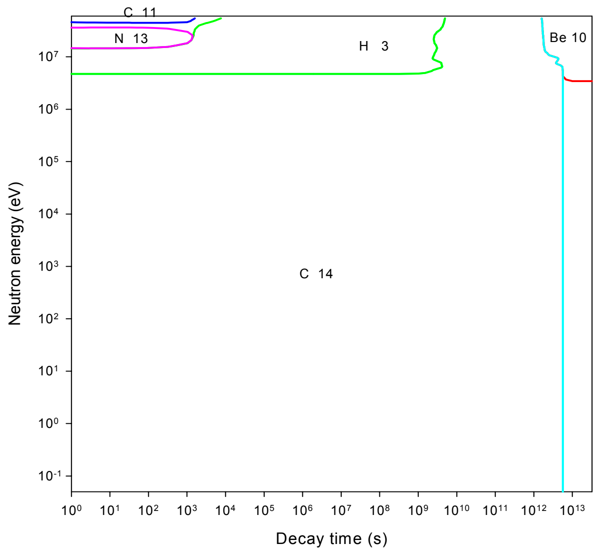




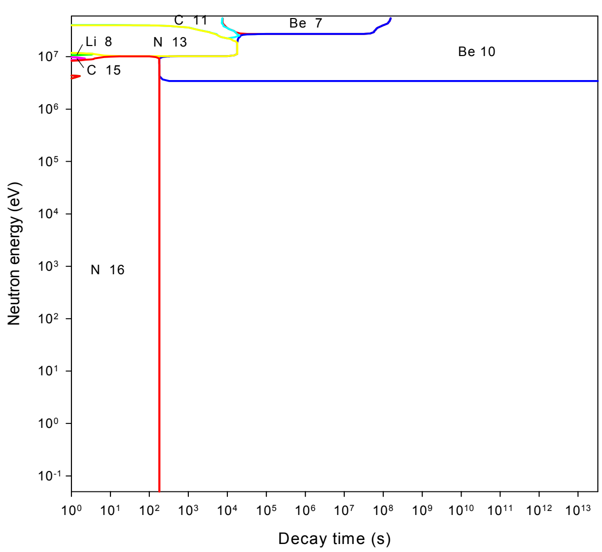


Nitrogen importance diagrams & transmutation

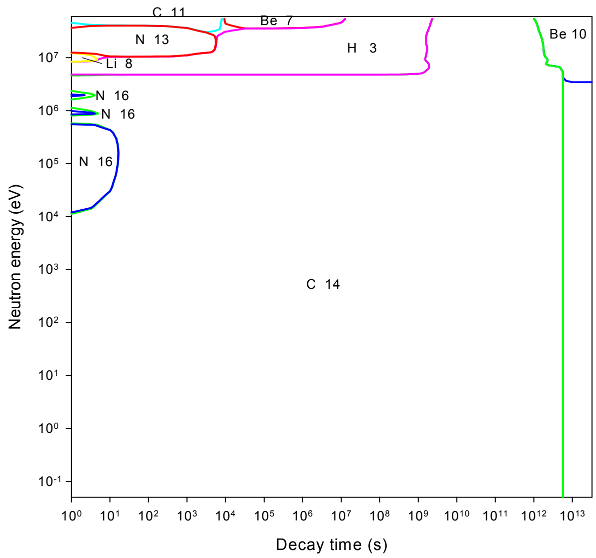
Activity



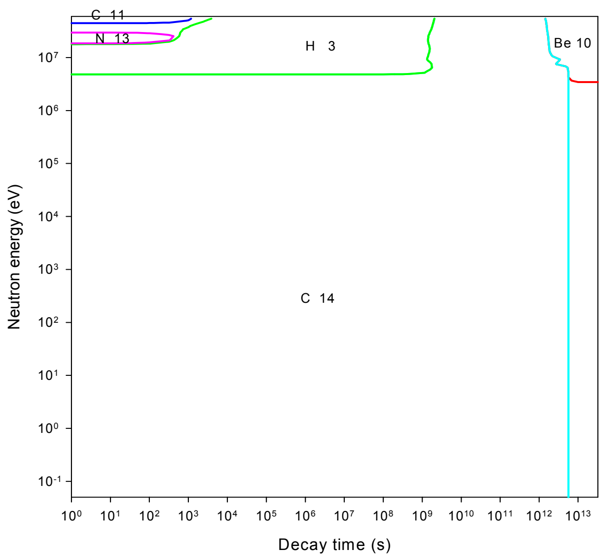
Dose rate



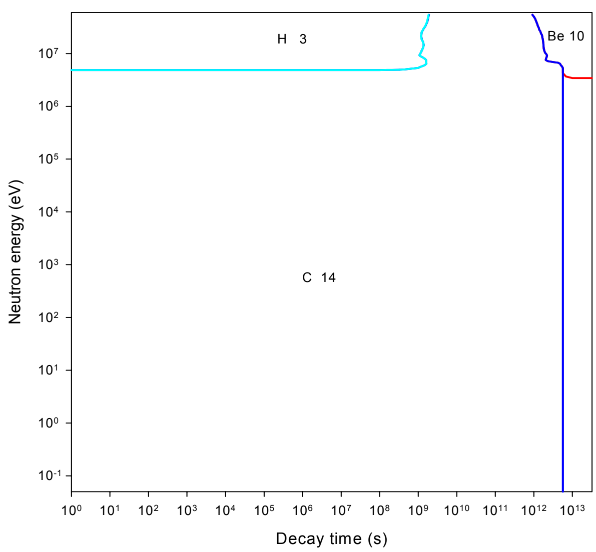
Heat output



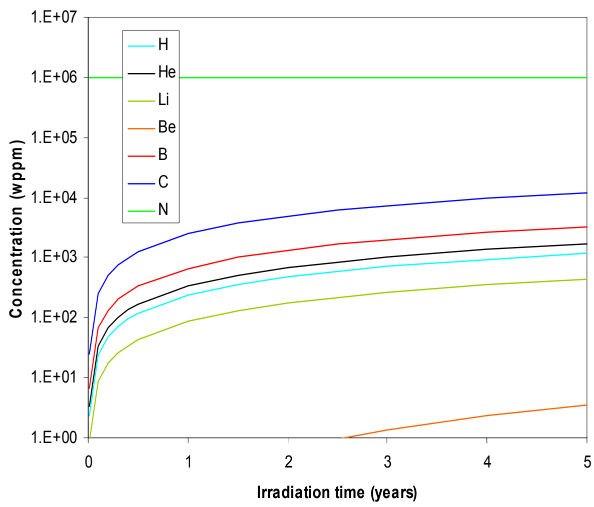
Ingestion dose



Inhalation dose



First wall transmutation



Oxygen

General properties

		Isotopes	Isotopic abundances / %
Atomic number	8		
Crustal abundance / wppm	$4.74\ 10^5$	O16	99.762
Melting point / K	54.8	O17	0.038
Boiling point / K	90.19	O18	0.20
Density / kgm^{-3}	1.429		
Thermal conductivity / $Wm^{-1}K^{-1}$	$2.67\ 10^{-1}$		
Electrical resistivity /Ωm	-		
Coefficient of thermal expansion / K^{-1}	-		
Crystal structure	Rhombic		
Number of stable isotopes	3		
Mean atomic weight	15.9994		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Bq kg^{-1}	2.41E14	3.01E10	3.01E10	2.85E10	1.04E9	4.49E5	kW kg^{-1}	2.82E-1	3.83E-8	3.42E-8	3.27E-8	7.51E-9	1.80E-11
N16	99.68						N16	99.76					
B13	0.19						H3		69.59	78.03	77.06	1.29	
H3	0.01	96.81	96.86	96.69	89.80		C14		19.53	21.91	22.88	98.47	0.22
C14		3.14	3.14	3.31	10.16	1.10	N13		9.20				
Be10					0.05	98.90	Be10		0.05	0.05	0.06	0.25	99.78

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv h^{-1}	4.04E5	3.40E-3	5.68E-8	5.68E-8	5.68E-8	5.43E-8	Sv kg^{-1}	1.78E2	1.77E0	1.77E0	1.71E0	5.46E-1	4.92E-4
N16	99.94						N16	98.92					
N13		85.28					H3	0.69	99.59	69.07	68.87	0.81	
O19		4.41					C14	0.31	0.39	30.90	32.10	99.09	0.58
Be10			100.0*	100.0*	100.0*	100.0*	Be10			0.03	0.03	0.09	99.42

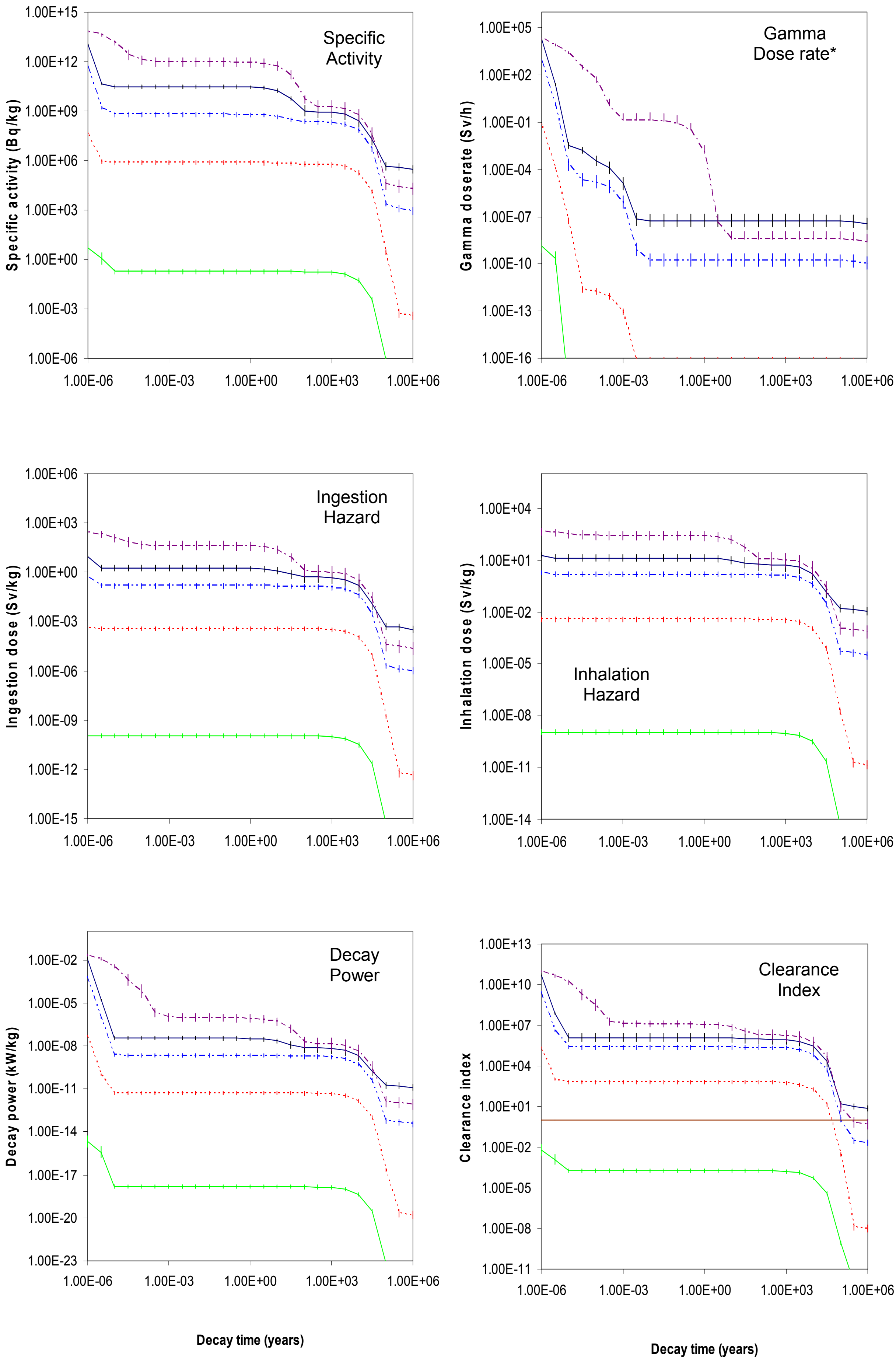
Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv kg^{-1}	1.46E2	1.31E1	1.31E1	1.27E1	5.45E0	1.56E-2		1.20E12	1.25E6	1.24E6	1.22E6	9.34E5	1.60E1
N16	90.94						N16	99.91					
H3	5.20	57.99	57.98	56.62	0.50		C14		75.40	76.41	77.40	99.89	30.78
C14	3.76	41.89	41.90	43.25	99.20	0.18	H3		23.29	23.59	22.60	0.11	
N17	0.06						N13		0.12				
Be10	0.01	0.12	0.12	0.13	0.30	99.82	Be10						69.22

Oxygen

Pathway analysis

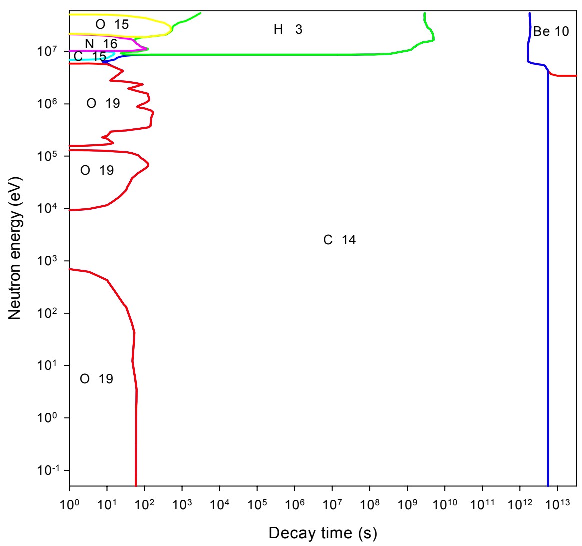
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
C15	2.449 s	O17(n,α)C14(n,γ)C15	98.6	99.9	99.5				
		O16(n,γ)O17(n,α)C14(n,γ)C15	1.4		0.5				
		O16(n,d)N15(n,p)C15				76.0	25.6	0.7	0.3
		O18(n,α)C15				23.6	2.1	0.1	0.8
		O16(n,2p)C15					53.8	98.3	98.3
		O16(n,2n)O15(β^+)N15(n,p)C15					18.2	0.8	0.4
N16	7.13 s	O17(n,α)C14(β^-)N14(n,γ)N15(n,γ)N16	93.0						
		O17(n,α)C14(n,γ)C15(β^-)N15(n,γ)N16	6.3						
		O16(n,p)N16				100.0	98.4	77.3	55.8
		O18(n,t)N16					0.6	17.9	38.8
		O17(n,d)N16					0.5	3.3	4.6
O19	26.91 s	O18(n,γ)O19	100.0	100.0	100.0	99.7	99.9	99.9	100.0
O15	2.041 m	O16(n,2n)O15					99.9	100.0	100.0
N13	9.967 m	O16(n,d)N15(n,2n)N14(n,2n)N13				99.6	4.4		
		O16(n,t)N14(n,2n)N13					67.3	3.1	0.5
		O16(n,d)N15(n,3n)N13					14.6	3.2	0.6
		O16(n,2n)O15(β^+)N15(n,3n)N13					10.4	3.7	0.7
		O16(n,2n)O15(β^+)N15(n,2n)N14(n,2n)N13					3.2		
		O16(n,nt)N13						89.9	98.1
C11	20.37 m	O16(n,nα)C12(n,2n)C11					99.4	13.7	0.8
		O16(n,2nα)C11						81.6	95.6
		O16(n,t)N14(n,nt)C11						1.6	1.6
		O16(n,α)C13(n,3n)C11						1.4	1.4
F18	1.829 h	O18(n,γ)O19(β^-)F19(n,2n)F18				100.0	100.0	100.0	100.0
Na24	14.957 h	**&**O18(n,γ)O19(β^-)F19(n,γ)F20(β^-)Ne20(n,γ)_ Ne21(n,γ)Ne22(n,γ)Ne23(β^-)Na23(n,γ)*Na24*	100.0						
Be7	53.22 d	O16(n,nα)C12(n,2nα)Be7						92.7	17.7
		O16(n,pα)B12(β^-)C12(n,2nα)Be7						5.5	0.8
		O16(n,2n2α)Be7							72.9
		O16(n,α)C13(n,3nα)Be7							4.2
		O16(n,t)N14(n,ntα)Be7							2.4
H3	12.33 y	O17(n,α)C14(β^-)N14(n,X)H1(n,γ)H2(n,γ)H3	95.1	97.1					
		O16(n,α)C13(n,t2α)H3				75.7			0.4
		O16(n,d)N15(n,n3α)H3				17.6	1.5	0.5	0.2
		O17(n,X)H3				4.1	0.3	0.2	0.3
		O16(n,X)H3					93.4	96.5	97.1
		O16(n,nα)C12(n,d2α)H3					2.1	0.6	0.5
		O16(n,2n)O15(β^+)N15(n,n3α)H3					1.1	0.6	0.2
C14	5700 y	O17(n,α)C14	98.6	99.9	99.5	5.7			
		O16(n,γ)O17(n,α)C14	1.4		0.5	0.3			
		O18(n,nα)C14				58.3	3.0	0.4	0.2
		O16(n,d)N15(n,d)C14				34.0	7.7	1.0	0.3
		O16(n,h)C14					83.3	97.1	99.0
		O16(n,2n)O15(β^+)N15(n,d)C14					5.5	1.2	0.3
Be10	$1.6\ 10^6$ y	O16(n,α)C13(n,α)Be10				99.4	4.3	0.8	3.5
		O16(n,nα)C12(n,h)Be10					37.9	16.6	5.7
		O16(n,h)C14(n,nα)Be10					23.9	23.1	3.9
		O16(n,nα)C12(n,d)B11(n,d)Be10					12.4	0.9	
		O16(n,t)N14(n,pα)Be10					6.7	11.6	3.5
		O16(n,d)N15(n,nα)B11(n,d)Be10					3.0	0.2	
		O16(n,2n)O15(β^+)N15(n,nα)B11(n,d)Be10					2.2	0.2	
		O16(n,dα)B11(n,d)Be10					1.1	24.1	8.4
		O16(n,d)N15(n,dα)Be10					0.8	4.9	2.7
		O16(n,2n)O15(β^+)N15(n,dα)Be10					0.5	5.7	3.1
		O16(n,hα)Be10						6.0	64.7
		O16(n,2nα)C11(β^+)B11(n,d)Be10						1.8	2.2

Oxygen activation characteristics

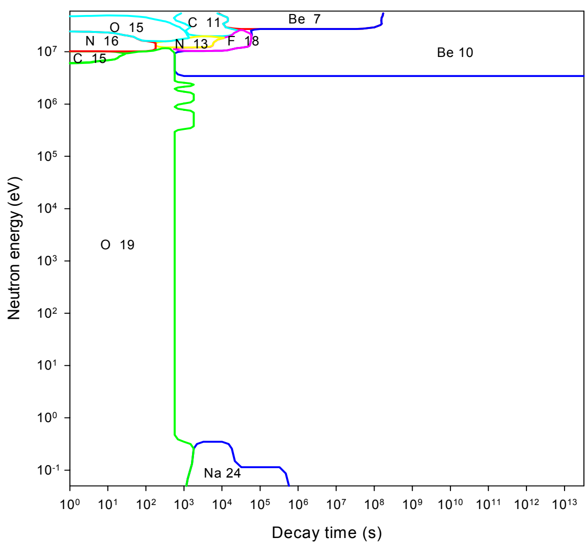


Oxygen importance diagrams & transmutation

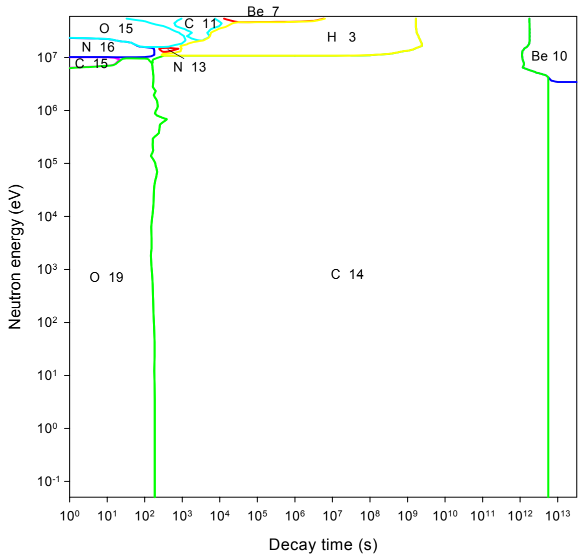
Activity



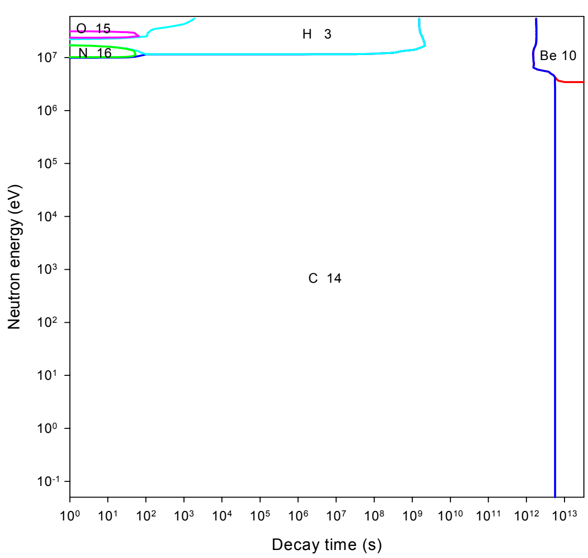
Dose rate



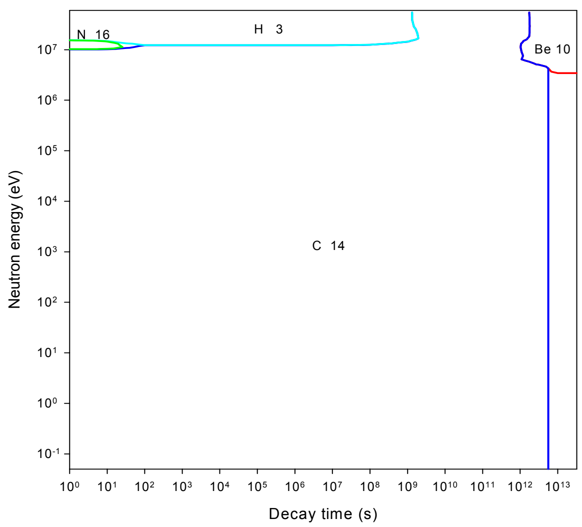
Heat output



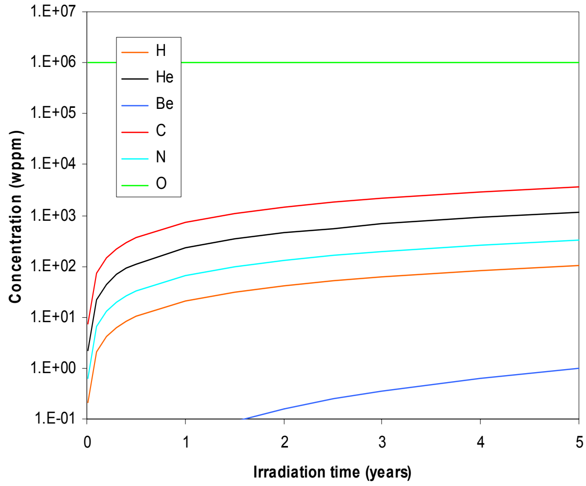
Ingestion dose



Inhalation dose



First wall transmutation



Fluorine

General properties

Atomic number	9	Isotopes	Isotopic abundances / %
Crustal abundance / wppm	950	F19	100.0
Melting point / K	53.53		
Boiling point / K	85.01		
Density / kgm^{-3}	1.696		
Thermal conductivity / $Wm^{-1}K^{-1}$	$2.79\ 10^{-2}$		
Electrical resistivity /Ωm	-		
Coefficient of thermal expansion / K^{-1}	-		
Crystal structure	Rhombic		
Number of stable isotopes	1		
Mean atomic weight	18.9984032		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	6.54E14	1.88E14	1.65E13	1.57E13	6.19E10	1.10E4	kW kg^{-1}	4.68E-1	3.39E-2	1.51E-5	1.43E-5	7.06E-8	1.03E-13
N16	46.37						N16	75.77					
F18	27.12	91.18					O19	10.78	0.04				
O19	17.75	0.02					F18	7.47	99.91				
F20	5.78						F20	5.32					
H3	2.53	8.79	99.99	99.99	96.78		H3		0.04	99.89	99.89	77.62	
C14			0.01	0.01	3.21	95.66	C14			0.11	0.11	22.38	81.21
Be10						4.34	Be10						18.79

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	6.16E5	3.50E4	5.06E-11	5.06E-11	5.06E-11	4.85E-11	Sv kg^{-1}	9.73E3	9.10E3	6.96E2	6.58E2	3.67E0	6.65E-6
N16	85.94						F18	89.27	92.35				
F18	5.88	99.97					H3	7.14	7.63	99.83	99.82	68.53	
O19	4.84	0.03					N16	2.27					
F20	3.04						C14	0.01	0.01	0.17	0.18	31.47	92.08
Be10			100.0*	100.0*	100.0*	100.0*	Be10						7.92

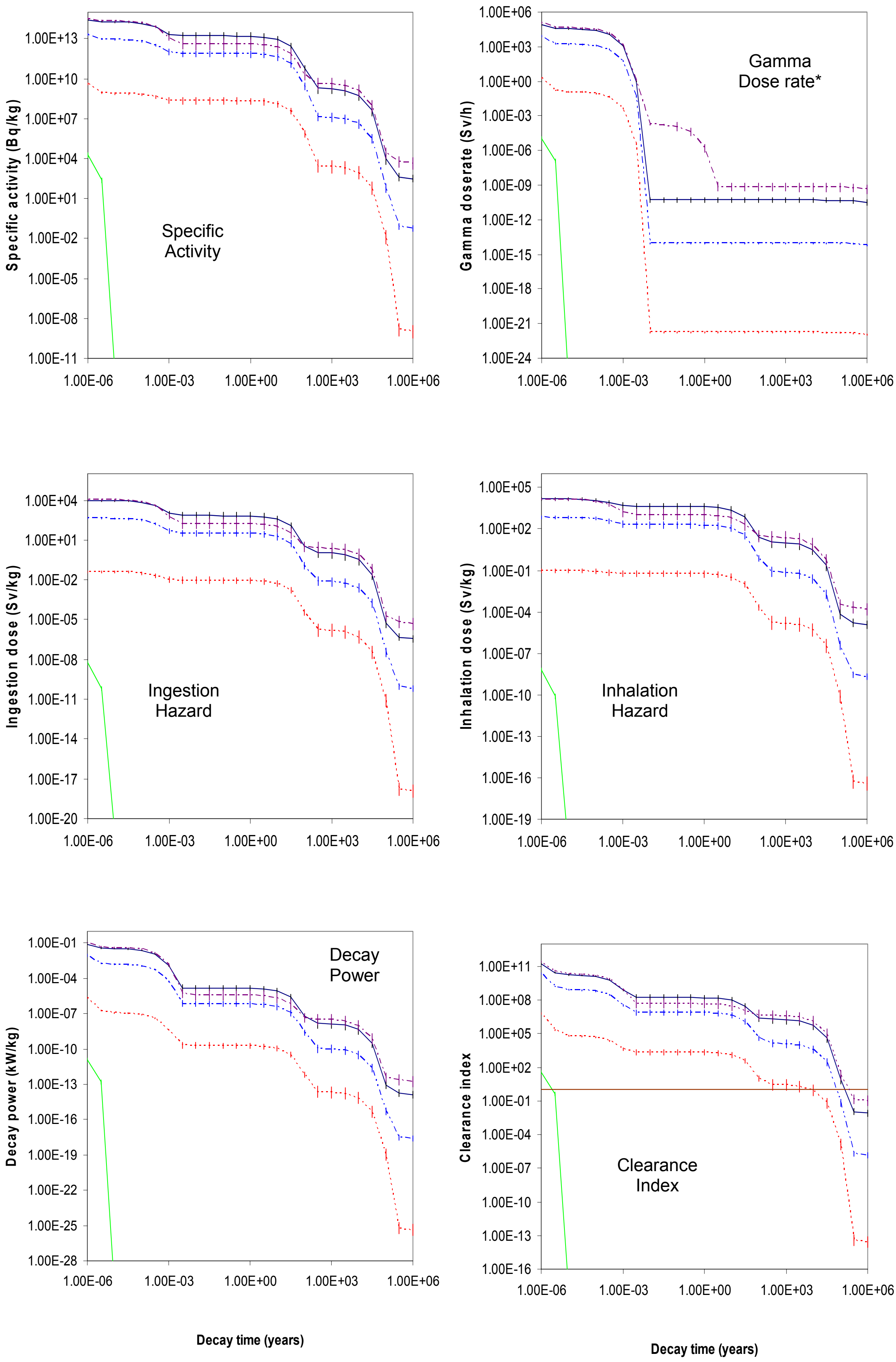
Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.50E4	1.44E4	4.31E3	4.08E3	2.71E1	7.79E-5		1.75E12	1.74E10	1.67E8	1.58E8	2.59E6	1.06E1
F18	69.54	70.11					N16	86.724					
H3	28.60	29.81	99.73	99.71	57.41		O19	7.81	0.23				
N16	1.10						F20	4.08					
O19	0.59						F18	1.01	98.80				
F20	0.08						H3		0.95	98.80	98.73	23.12	
C14			0.27	0.29	42.59	78.50	C14		0.01	1.20	1.27	76.88	99.89
Be10						21.50	Be10						0.11

Fluorine

Pathway analysis

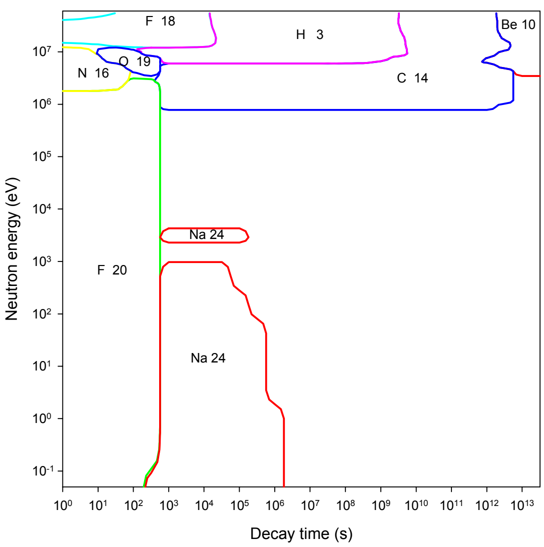
Nuclide	$T_{1/2}$	Pathway	210	186	151	42	30	21	6
N16	7.13 s	F19(n,α)N16				99.1	78.6	59.5	86.9
		F19(n,t)O17(n,d)N16					14.1	19.3	5.5
		F19(n,d)O18(n,t)N16					4.1	13.6	4.8
		F19(n,2n)F18(β^+)O18(n,t)N16					1.9	5.7	2.0
		F19(n,3n)F17(β^+)O17(n,d)N16					0.3	1.6	0.6
		F19(n,nt)O16(n,p)N16					0.3		
F20	11.03 s	F19(n,γ)F20	100.0	100.0	100.0	94.8	99.2	99.6	99.8
O19	26.91 s	F19(n,γ)F20(β^-)Ne20(n,γ)Ne21(n,α)O18_ (n,γ)O19	100.0	100.0					
		F19(n,p)O19				100.0	100.0	100.0	100.0
F18	1.829 h	F19(n,2n)F18				99.7	99.9	99.9	100.0
Na24	14.957 h	**&**F19(n,γ)F20(β^-)Ne20(n,γ)Ne21(n,γ)_ Ne22(n,γ)Ne23(β^-)Na23(n,γ)*Na24*	100.0	100.0					
Be7	53.22 d	F19(n,ntα)C12(n,2nα)Be7						27.5	23.3
		F19(n,2α)B12(β^-)C12(n,2nα)Be7						21.7	1.4
		F19(n,2nα)N14(n,t)C12(n,2nα)Be7						11.8	1.7
		F19(n,t)O17(n,2nα)C12(n,2nα)Be7						10.8	1.6
		F19(n,nt)O16(n,nα)C12(n,2nα)Be7						7.6	1.4
		F19(n,dα)C14(n,3n)C12(n,2nα)Be7						6.1	0.7
		F19(n,nα)N15(n,nt)C12(n,2nα)Be7						4.2	1.4
		F19(n,tα)C13(n,2n)C12(n,2nα)Be7						1.8	0.6
		F19(n,dα)C14(n,t)B12(β^-)C12(n,2nα)Be7						1.2	0.4
		F19(n,d)O18(n,3nα)C12(n,2nα)Be7						1.0	0.5
		F19(n,2nα)N14(n,ntα)Be7						0.2	11.3
		F19(n,tα)C13(n,3nα)Be7						0.1	34.3
		F19(n,nt)O16(n,2n2α)Be7							11.3
		F19(n,3nα)N13(β^+)C13(n,3nα)Be7							3.8
H3	12.33 y	F19(n,X)H3				95.5	94.6	93.2	93.0
		F19(n,nα)N15(n,n3α)H3				4.0	1.6	0.8	0.4
		F19(n,t)O17(n,X)H3					2.2	3.8	4.3
		F19(n,d)O18(n,X)H3					0.7	0.6	0.4
C14	5700 y	F19(n,nα)N15(n,d)C14				68.1	5.2	1.6	0.7
		F19(n,d)O18(n,nα)C14				17.9	3.4	0.9	0.4
		F19(n,2n)F18(β^+)O18(n,nα)C14				7.7	1.6	0.5	0.2
		F19(n,dα)C14				4.4	89.3	96.4	97.4
		F19(n,t)O17(n,α)C14				1.0	0.2	0.2	0.5
Be10	1.6 10^6 y	F19(n,nα)N15(n,nα)B11(n,d)Be10				41.9	4.5	0.6	
		F19(n,nα)N15(n,t)C13(n,α)Be10				23.0	0.2		
		F19(n,α)N16(β^-)O16(n,α)C13(n,α)Be10				15.8			
		F19(n,t)O17(n,nα)C13(n,α)Be10				8.3	0.2		
		F19(n,nα)N15(n,2n)N14(n,d)C13(n,α)Be10				4.2			
		F19(n,d)O18(n,2n)O17(n,nα)C13(n,α)Be10				1.5			
		F19(n,nt)O16(n,α)C13(n,α)Be10				0.9			
		F19(n,nα)N15(n,d)C14(n,nα)Be10				0.4	2.2	0.5	
		F19(n,t)O17(n,2α)Be10				0.3	10.2	8.1	1.4
		F19(n,d)O18(n,nα)C14(n,nα)Be10				0.1	1.5	0.3	
		F19(n,dα)C14(n,nα)Be10					57.6	43.2	8.3
		F19(n,2nα)N14(n,pα)Be10					9.7	9.6	2.9
		F19(n,n2α)B11(n,d)Be10					8.7	11.0	2.0
		F19(n,nα)N15(n,dα)Be10					1.1	14.6	14.5
		F19(n,tα)C13(n,α)Be10					0.6	0.9	5.2
		F19(n,d)O18(n,n2α)Be10					0.2	3.9	1.8
		F19(n,d2α)Be10						2.0	57.6
		F19(n,2n)F18(β^+)O18(n,n2α)Be10						1.6	0.8
		F19(n,ntα)C12(n,h)Be10						0.3	1.4

Fluorine activation characteristics

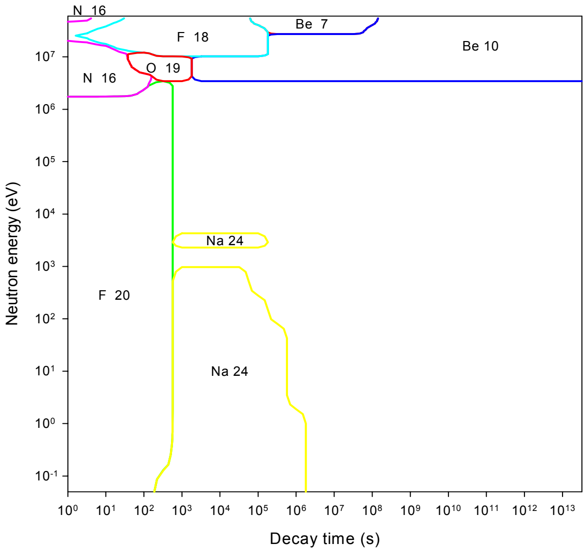


Fluorine importance diagrams & transmutation

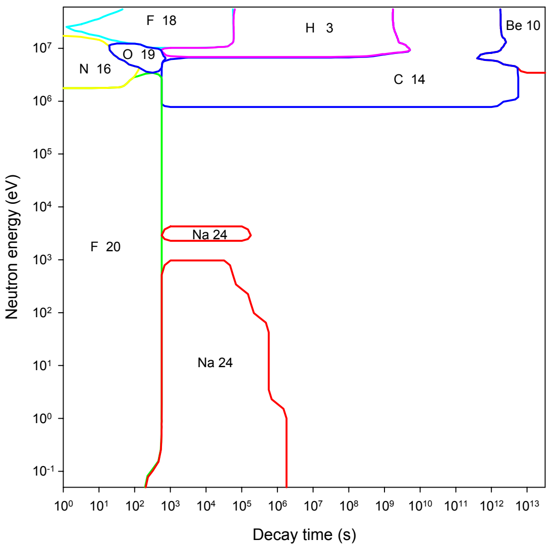
Activity



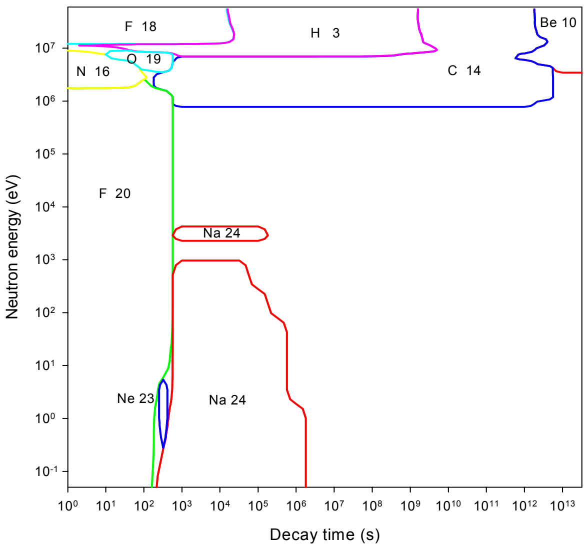
Dose rate



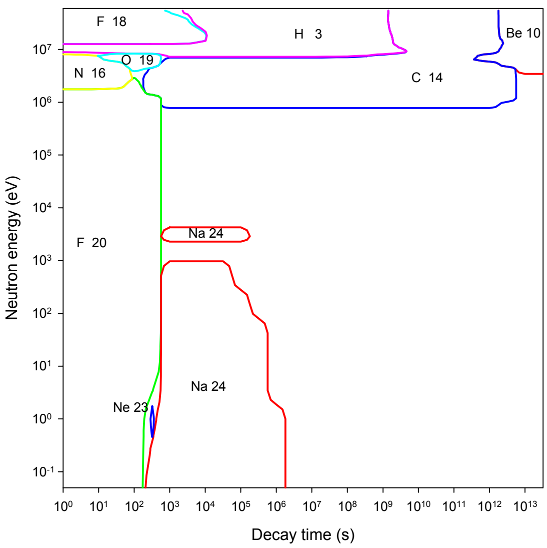
Heat output



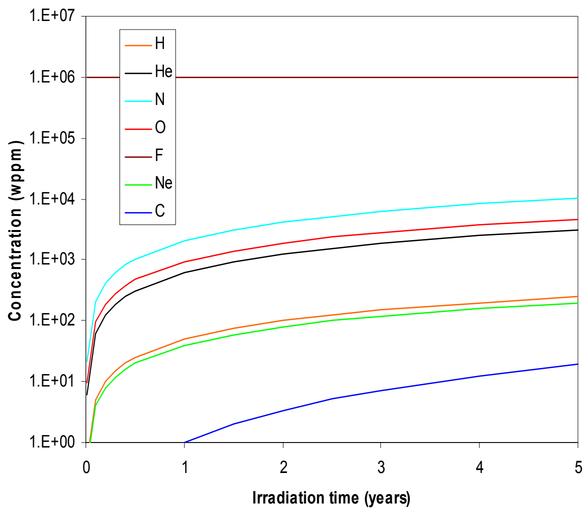
Ingestion dose



Inhalation dose



First wall transmutation



Neon

General properties

		Isotopes	Isotopic abundances / %
Atomic number	10		
Crustal abundance / wppm	$7.0\ 10^{-5}$	Ne20	90.48
Melting point / K	24.48	Ne21	0.27
Boiling point / K	27.10	Ne22	9.25
Density / kgm^{-3}	$8.999\ 10^{-1}$		
Thermal conductivity / $Wm^{-1}K^{-1}$	$4.93\ 10^{-1}$		
Electrical resistivity /Ωm	-		
Coefficient of thermal expansion / K^{-1}	-		
Crystal structure	FCC		
Number of stable isotopes	3		
Mean atomic weight	20.1797		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.38E15	1.17E11	4.25E10	4.02E10	1.58E9	2.60E4	kW kg^{-1}	9.18E-1	1.57E-5	6.12E-8	5.07E-8	1.15E-8	8.04E-13
F20	98.21						F20	97.47					
F22	0.95						F22	1.86					
O19	0.47	1.66					O19	0.31	5.34				
F21	0.13						Ne23	0.02	3.99				
N16	0.11						F18		87.61				
Ne23	0.05	1.65					Na24		2.70	11.99			
F18		59.83					H3		0.23	61.22	69.19	1.18	
H3		35.14	96.54	96.38	9.39		C14		0.07	1.86	22.63	98.81	7.47
C14		1.24	3.41	3.60	90.60	70.84	Na22		0.03	8.03	7.50		
Be10						29.16	Be10						92.53

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	6.70E5	1.49E1	1.94E-2	5.29E-3	1.51E-9	1.44E-9	Sv kg^{-1}	9.89E2	7.96E0	2.61E0	2.50E0	8.36E-1	2.46E-5
F20	95.81						Ne23	61.13	21.23				
F22	3.52						F20	37.06					
N16	0.38						O19	0.66	0.02				
O19	0.24	3.19					F18	0.36	42.98				
F21	0.03						H3	0.17	21.64	66.04	65.14	0.75	
F18		91.46					C14	0.08	10.55	32.22	33.59	99.25	17.84
Na24		4.86	64.47				Na24	0.02	3.06	0.16			
Na22		0.05	35.53	100.0			Na22		0.52	1.58	1.27		
Be10					100.0*	100.0*	Be10						82.16

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	7.81E2	2.42E1	1.91E1	1.85E1	8.34E0	6.88E-4		2.66E12	1.25E7	2.00E6	1.93E6	1.43E6	8.04E0
F20	57.41						F20	96.43					
Ne23	38.30	3.5					F22	2.91					
H3	1.37	44.08	55.87	54.51	0.46		O19	0.29	18.20				
C14	1.07	34.72	44.03	45.41	99.53	6.38	F18		55.58				
O19	0.65						Na24		4.54	0.49			
F18	0.56	17.03					H3		3.28	20.53	20.04	0.10	
F22	0.42						Na22		1.03	6.44	5.11		
N16	0.11						C14			72.53	74.85	99.90	94.27
Be10						93.61	Be10						5.73

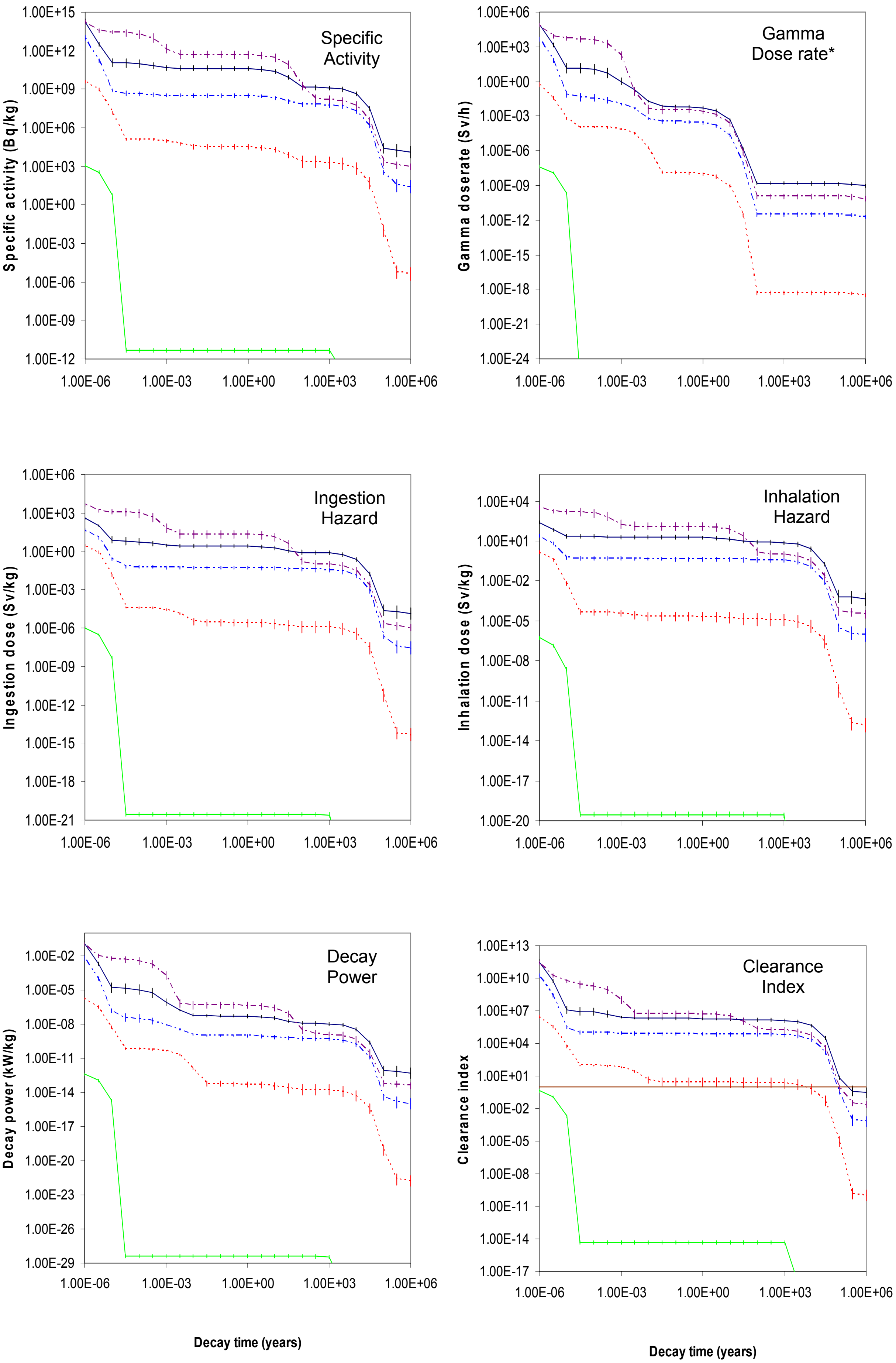
Neon

Pathway analysis

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
F21	4.158 s	Ne22(n,2n)Ne21(n,p)F21				69.7	2.9	0.8	0.2
		Ne21(n,p)F21				27.8	1.7	0.9	0.5
		Ne22(n,d)F21				1.8	94.2	97.6	98.9
F20	11.03 s	Ne21(n,α)O18(n,γ)O19(β^-)F19(n,γ)F20	82.1	99.2	100.0				
		Ne20(n,γ)Ne21(n,α)O18(n,γ)O19(β^-)_ F19(n,γ)F20	17.9	0.8					
		Ne20(n,p)F20				100.0	96.1	76.9	55.8
		Ne22(n,t)F20					1.4	20.3	41.3
		Ne22(n,2n)Ne21(n,d)F20					1.2	0.8	0.5
		Ne21(n,d)F20					0.7	0.9	1.1
Ne19	17.22 s	Ne20(n,2n)Ne19					99.0	99.2	98.3
		Ne22(n,4n)Ne19							1.1
O19	26.91 s	Ne21(n,α)O18(n,γ)O19	75.2	98.7	100.0				
		Ne20(n,γ)Ne21(n,α)O18(n,γ)O19	24.8	1.3					
		Ne22(n,α)O19				93.9	5.1	4.4	34.6
		Ne20(n,d)F19(n,p)O19				5.2	9.6	3.6	1.9
		Ne20(n,2p)O19					83.0	90.1	61.4
		Ne20(n,2n)Ne19(β^+)F19(n,p)O19					1.1	0.5	0.2
		Ne21(n,h)O19						0.3	0.8
Ne23	37.2 s	Ne22(n,γ)Ne23	99.9	100.0	100.0	98.8	99.3	99.6	99.8
F18	1.829 h	Ne20(n,d)F19(n,2n)F18				92.8	21.5	1.5	0.5
		Ne22(n,α)O19(β^-)F19(n,2n)F18				4.6			
		Ne20(n,t)F18					74.9	97.4	97.3
		Ne20(n,2n)Ne19(β^+)F19(n,2n)F18				2.5		0.2	
		Ne20(n,3n)Ne18(β^+)F18							1.3
Na24	14.957 h	&Ne22(n,γ)Ne23(β^-)Na23(n,γ)*Na24*	95.6	91.2	91.2	92.6	94.3	94.3	94.3
Be7	53.22 d	Ne20(n,n2α)C12(n,2nα)Be7						91.2	58.4
		Ne20(n,nα)O16(n,nα)C12(n,2nα)Be7						4.4	1.5
		Ne20(n,dα)N15(n,nt)C12(n,2nα)Be7						1.4	2.7
		Ne20(n,tα)N14(n,t)C12(n,2nα)Be7						0.2	1.5
		Ne20(n,nα)O16(n,2n2α)Be7							12.6
		Ne20(n,tα)N14(n,ntα)Be7							9.9
		Ne20(n,2α)C13(n,3nα)Be7							1.4
		Ne20(n,dα)N15(n,t)C13(n,3nα)Be7							1.2
Na22	2.603 y	Ne22(n,γ)Ne23(β^-)Na23(n,2n)Na22				99.8	99.8	99.9	100.0
H3	12.33 y	Ne20(n,α)O17(n,X)H3				62.7	0.6	0.7	2.9
		Ne20(n,d)F19(n,X)H3				19.0	5.0	2.3	1.0
		Ne20(n,2α)C13(n,t2α)H3				5.2	0.1		
		Ne22(n,2n)Ne21(n,X)H3				4.2	0.1		
		Ne21(n,X)H3				3.2	0.1	0.2	0.2
		Ne20(n,nα)O16(n,α)C13(n,t2α)H3				1.1			
		Ne22(n,α)O19(β^-)F19(n,X)H3				0.9			
		Ne20(n,X)H3					81.5	78.8	82.8
		Ne22(n,X)H3					6.3	10.0	7.8
		Ne20(n,nα)O16(n,X)H3					2.1	1.6	0.8
		Ne20(n,dα)N15(n,n3α)H3					1.6	2.4	1.1
C14	5700 y	Ne20(n,α)O17(n,α)C14				75.2	0.2	0.2	2.8
		Ne22(n,2n)Ne21(n,2α)C14				9.5	0.7	0.1	
		Ne21(n,2α)C14				7.7	0.8	0.9	
		Ne22(n,nα)O18(n,nα)C14				2.8	3.5	0.5	0.2
		Ne20(n,d)F19(n,nα)N15(n,d)C14				0.9	0.8	0.1	
		Ne20(n,nα)O16(n,d)N15(n,d)C14				0.4	0.3		
		Ne21(n,α)O18(n,nα)C14				0.3			
		Ne20(n,d)F19(n,d)O18(n,nα)C14				0.2	0.5		
		Ne22(n,n2α)C14					28.2	23.0	17.7
	►	Ne20(n,dα)N15(n,d)C14					24.2	24.1	14.1

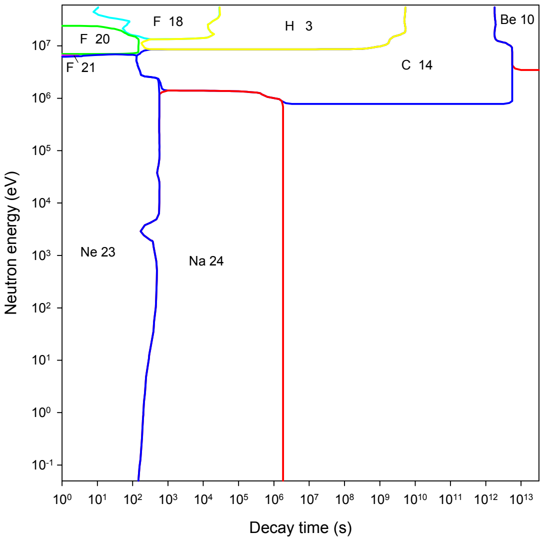
Nuclide	$T_{1/2}$	Pathway	210	186	151	42	30	21	6
	◄	Ne20(n,d)F19(n,dα)C14					21.1	11.7	8.3
		Ne20(n,nα)O16(n,h)C14					5.3	8.3	8.2
		Ne20(n,hα)C14					4.4	14.5	31.6
		Ne20(n,t)F18(β^+)O18(n,nα)C14					2.6	5.9	5.7
		Ne20(n,2n)Ne19(β^+)F19(n,dα)C14					2.5	1.6	1.0
		Ne20(n,2nα)O15(β^+)N15(n,d)C14					1.5	5.7	4.4
		Ne20(n,h)O18(n,nα)C14					1.3	2.2	2.1
Be10	1.6 10^6 y	Ne20(n,2α)C13(n,α)Be10				76.7	26.0	1.0	0.4
		Ne20(n,nα)O16(n,α)C13(n,α)Be10				15.3	0.2		
		Ne20(n,α)O17(n,nα)C13(n,α)Be10				5.8			
		Ne20(n,α)O17(n,2α)Be10				0.2	6.2	1.7	1.3
		Ne20(n,dα)N15(n,nα)B11(n,d)Be10					11.0	2.1	0.2
		Ne22(n,n2α)C14(n,nα)Be10					9.4	2.2	0.3
		Ne20(n,n2α)C12(n,h)Be10					9.2	11.4	6.5
		Ne20(n,dα)N15(n,d)C14(n,nα)Be10					5.4	1.5	0.1
		Ne20(n,d)F19(n,dα)C14(n,nα)Be10					5.4	0.8	
		Ne20(n,n2α)C12(n,d)B11(n,d)Be10					3.0	0.7	
		Ne20(n,dα)N15(n,dα)Be10					2.7	47.4	52.1
		Ne22(n,2nα)O17(n,2α)Be10					2.3	1.3	0.1
		Ne20(n,nα)O16(n,nα)C12(n,h)Be10					1.9	0.4	0.1
		Ne20(n,hα)C14(n,nα)Be10					1.5	1.4	0.5
		Ne20(n,tα)N14(n,pα)Be10					1.3	1.9	4.9
		Ne20(n,nα)O16(n,h)C14(n,nα)Be10					1.3	0.5	
		Ne20(n,dα)N15(n,2n)N14(n,pα)Be10					1.2	0.3	
		Ne20(n,d)F19(n,t)O17(n,2α)Be10					1.1		
		Ne20(n,2nα)O15(β^+)N15(n,dα)Be10					0.2	11.2	16.3
		Ne20(n,t)F18(β^+)O18(n,n2α)Be10						5.5	4.9
		Ne20(n,h)O18(n,n2α)Be10						2.0	1.8
		Ne20(n,dα)N15(n,d)C14(n,nα)Be10						1.5	
		Ne20(n,nα)O16(n,hα)Be10						0.2	2.0
		Ne22(n,n3α)Be10							1.0

Neon activation characteristics

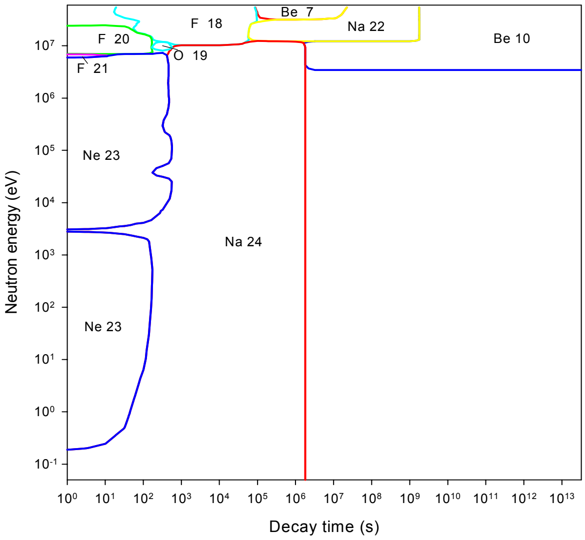


Neon importance diagrams & transmutation

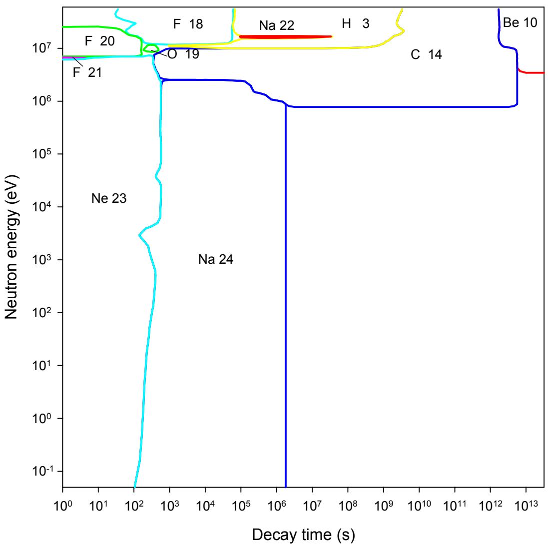
Activity



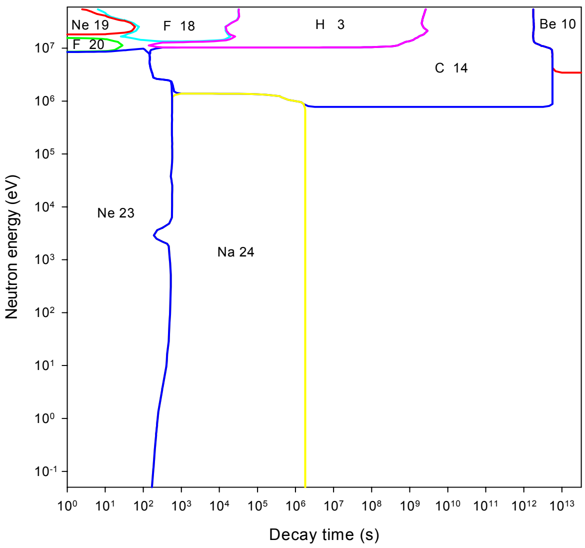
Dose rate



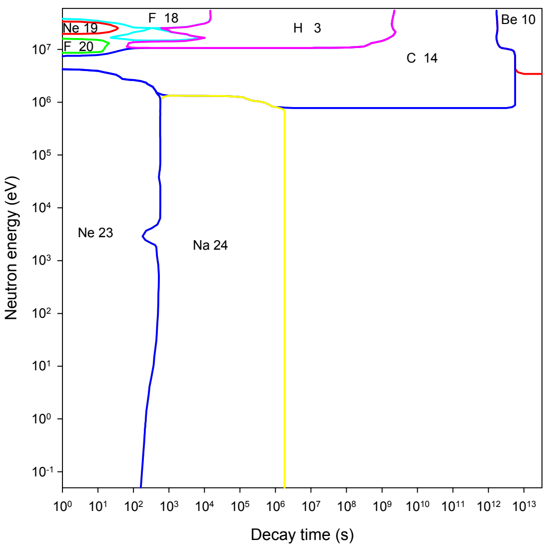
Heat output



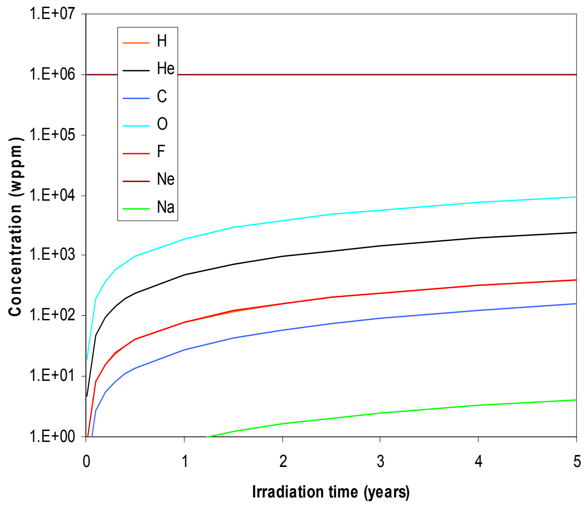
Ingestion dose



Inhalation dose



First wall transmutation



Graphs for He, F are indistinguishable

Sodium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	11	Na23	100.0
Crustal abundance / wppm	2.3 10^4		
Melting point / K	371.0		
Boiling point / K	1156		
Density / kgm^{-3}	971		
Thermal conductivity / $Wm^{-1}K^{-1}$	141		
Electrical resistivity /Ωm	4.2 10^{-8}		
Coefficient of thermal expansion / K^{-1}	7.06 10^{-5}		
Crystal structure	hexagonal		
Number of stable isotopes	1		
Mean atomic weight	22.989768		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.09E15	1.46E14	1.02E13	6.86E12	1.68E10	4.28E1	kW kg^{-1}	6.03E-1	1.05E-1	3.02E-3	9.53E-4	1.53E-8	1.07E-15
F20	58.27						F20	69.57					
Ne23	19.33	0.40					Na24	17.16	98.62	58.97			
Na24	12.64	94.18	23.23				Ne23	11.58	0.19				
Na24m	8.90						Na24m	1.25					
H3	0.42	3.17	45.20	63.81	99.98		Na22	0.21	1.19	40.89	99.58		
Na22	0.30	2.22	31.57	36.19			H3			0.14	0.42	99.80	
C14					0.02	47.38	C14					0.20	15.01
Be10						52.62	Be10						84.99
Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	5.15E5	1.83E5	4.92E3	1.38E3	1.59E-12	1.52E-12	Sv kg^{-1}	2.58E5	7.03E4	1.16E4	8.13E3	7.06E-1	3.65E-8
F20	60.64						Ne23	72.83					
Na24	35.38	99.00	63.64				Na24	23.01	84.22	8.85			
Na24m	1.81						Na22	4.01	14.75	89.47	97.74		
Ne23	1.47	0.01					H3	0.08	0.28	1.68	2.26	99.69	
Na22	0.35	0.98	36.36	100.0			C14					0.31	32.19
Be10					100.0*	100.0*	Be10						67.81
Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.36E5	4.28E4	6.05E3	4.36E3	4.38E0	9.06E-7		1.50E12	1.70E11	3.47E10	2.49E10	1.71E5	2.08E-2
Ne23	68.40						F20	80.11					
Na24	27.45	86.75	10.62				Na24	9.21	80.24	6.85			
Na22	3.01	9.83	69.48	73.93			Ne23	5.03	0.12				
H3	0.89	2.81	19.90	26.07	99.49		Na24m	3.09					
C14					0.51	12.98	Na22	2.16	19.03	93.02	99.82		
Be10						87.02	H3			0.13	0.18	97.77	
							C14					2.23	97.30
							Be10						2.70

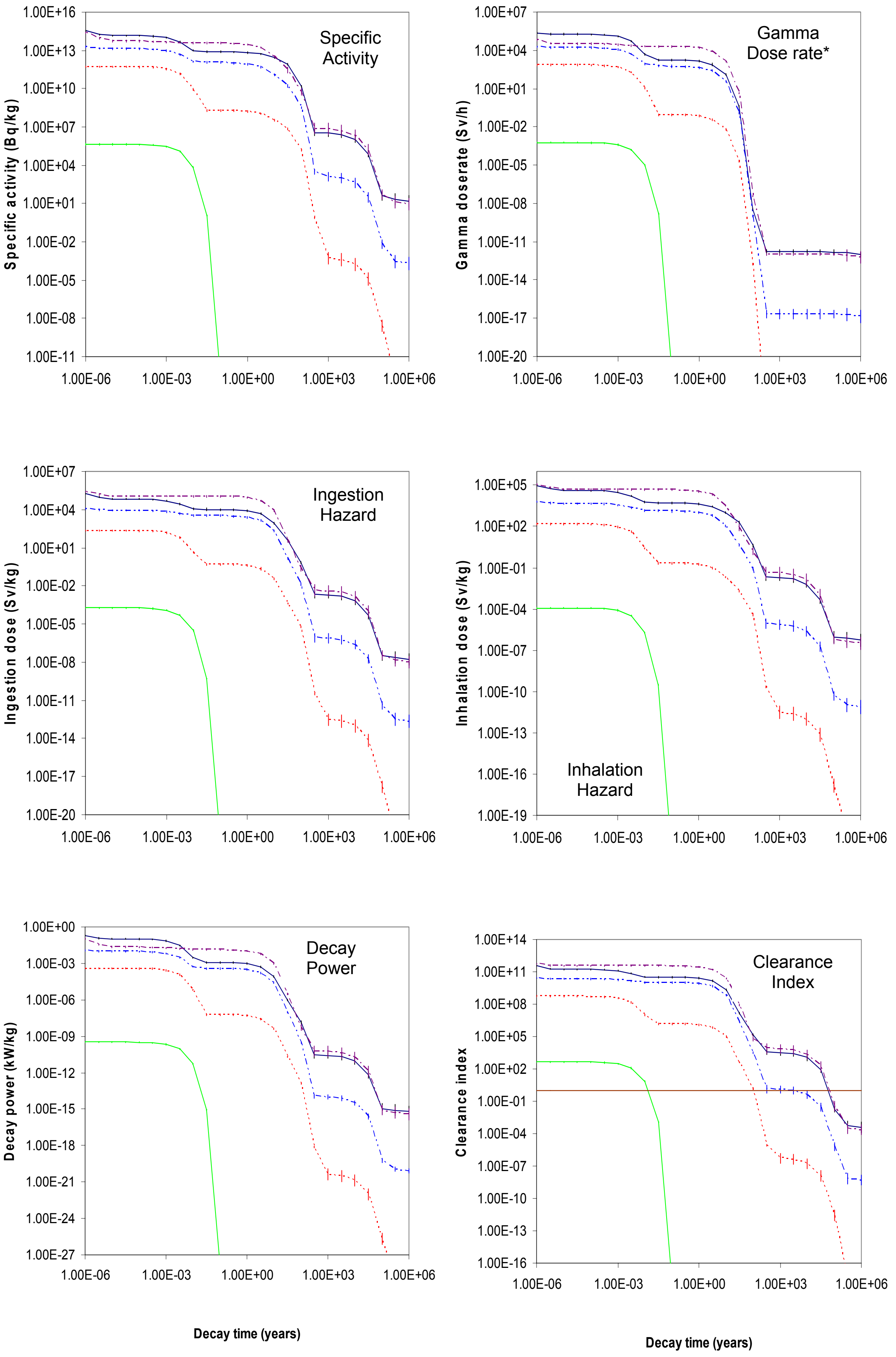
Sodium

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
F20	11.03 s	Na23(n,α)F20				94.5	84.6	48.8	77.3
		Na23(n,t)Ne21(n,d)F20					10.2	28.8	10.5
		Na23(n,d)Ne22(n,t)F20					2.0	16.0	8.2
		Na23(n,3n)Na21(β^{+})Ne21(n,d)F20						1.1	0.6
		Na23(n,2n)Na22(β^{+})Ne22(n,t)F20					0.3	2.0	1.1
Ne23	37.2 s	**&**Na23(n,γ)*Na24*(β^{-})Mg24(n,γ)Mg25(n,α)_ Ne22(n,γ)Ne23	99.5						
		Na23(n,γ)Na24m(β^{-})Mg24(n,γ)Mg25(n,α)_ Ne22(n,γ)Ne23	0.4						
		Na23(n,p)Ne23				100.0	99.7	99.9	99.9
Na24	14.957 h	**&**Na23(n,γ)*Na24*	100.0	100.0	100.0	96.8	100.0	100.0	100.0
P32	14.27 d	**&**Na23(n,γ)*Na24*(β^{-})Mg24(n,γ)Mg25(n,γ)_ Mg26(n,γ)Mg27(β^{-})Al27(n,γ)Al28(β^{-})Si28_ (n,γ)Si29(n,γ)Si30(n,γ)Si31(β^{-})P31(n,γ)P32	99.3						
Na22	2.603 y	Na23(n,2n)Na22				99.6	99.9	100.0	100.0
H3	12.33 y	Na23(n,X)H3				98.6	96.8	96.6	94.6
		Na23(n,nα)F19(n,X)H3				0.4	1.4	0.6	0.3
		Na23(n,tα)O17(n,X)H3						0.2	2.0
Si32	132.0 y	**&**Na23(n,γ)*Na24*(β^{-})Mg24(n,γ)_ Mg25(n,γ)Mg26(n,γ)Mg27(β^{-})Al27(n,γ)_ Al28(β^{-})Si28(n,γ)Si29(n,γ)Si30(n,γ)Si31_ (n,γ)Si32	100.0						
C14	5700 y	Na23(n,t)Ne21(n,2α)C14				27.3	5.8	5.3	0.9
		Na23(n,d)Ne22(n,2n)Ne21(n,2α)C14				26.8	0.3		
		Na23(n,nα)F19(n,nα)N15(n,d)C14				12.3	1.5	0.2	
		Na23(n,α)F20(β^{-})Ne20(n,α)O17(n,α)C14				11.7			
		Na23(n,d)Ne22(n,nα)O18(n,nα)C14				7.7	1.5	0.2	
		Na23(n,nα)F19(n,d)O18(n,nα)C14				3.3	1.0	0.1	
		Na23(n,2n)Na22(n,2α)N15(n,d)C14				3.3			
		Na23(n,2n)Na22(n,d)Ne21(n,2α)C14				2.1			
		Na23(n,nα)F19(n,2n)F18(β^{+})O18(n,nα)C14				1.4	0.5		
		Na23(n,nα)F19(n,dα)C14				1.2	38.7	19.9	8.3
		Na23(n,2n)Na22(n,nα)F18(β^{+})O18(n,nα)C14				0.9	0.2		
		Na23(n,t)Ne21(n,α)O18(n,nα)C14				0.6			
		Na23(n,d)Ne22(n,2n)Ne21(n,α)O18(n,nα)C14				0.5			
		Na23(n,nα)F19(n,t)O17(n,α)C14				0.2			
		Na23(n,n2α)N15(n,d)C14					27.5	22.5	5.4
		Na23(n,d)Ne22(n,n2α)C14					18.1	12.5	3.9
		Na23(n,2n)Na22(β^{+})Ne22(n,n2α)C14					1.8	1.1	0.4
		Na23(n,d)Ne22(n,nα)O18(n,nα)C14					1.5		
		Na23(n,dα)O18(n,nα)C14					0.9	7.1	4.2
		Na23(n,d2α)C14						18.2	60.3
		Na23(n,2nα)F18(β^{+})O18(n,nα)C14						8.6	4.4
		Na23(n,ntα)O16(n,h)C14						0.3	2.3
		Na23(n,tα)O17(n,α)C14						0.3	6.0
Be10	$1.6\ 10^{6}$ y	Na23(n,α)F20(β^{-})Ne20(n,2α)C13(n,α)Be10				80.9	0.1		
		Na23(n,α)F20(β^{-})Ne20(n,nα)O16(n,α)_ C13(n,α)Be10				12.1			
		Na23(n,α)F20(β^{-})Ne20(n,α)O17(n,nα)_ C13(n,α)Be10				4.5			
		Na23(n,nα)F19(n,nα)N15(n,nα)B11(n,d)Be10				0.4	1.0		
		Na23(n,n2α)N15(n,nα)B11(n,d)Be10					25.4	2.5	0.2
		Na23(n,nα)F19(n,dα)C14(n,nα)Be10					17.4	1.6	0.2
		Na23(n,n2α)N15(n,d)C14(n,nα)Be10					12.4	1.9	0.1
	►	Na23(n,d)Ne22(n,n2α)C14(n,nα)Be10					8.1	1.0	

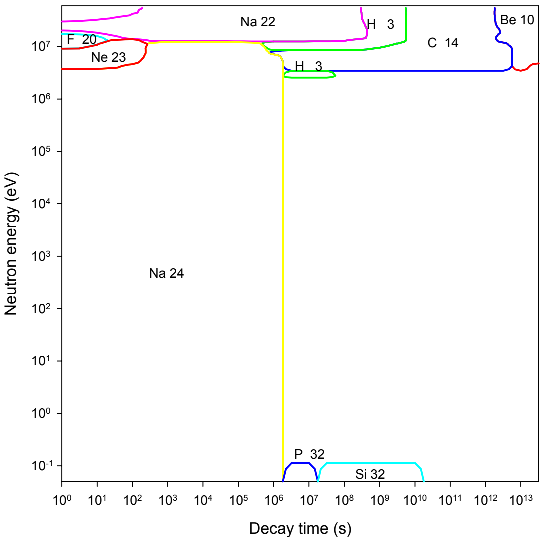
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	Na23(n,n2α)N15(n,dα)Be10					6.2	57.3	47.0
		Na23(n,nα)F19(n,t)O17(n,2α)Be10					3.1	0.3	
		Na23(n,nα)F19(n,2nα)N14(n,pα)Be10					2.9	0.4	
		Na23(n,nα)F19(n,n2α)B11(n,d)Be10					2.6	0.4	
		Na23(n,t)Ne21(n,2α)C14(n,nα)Be10					2.6	0.4	
		Na23(n,t)Ne21(n,nα)O17(n,2α)Be10					2.5	0.5	
		Na23(n,n2α)N15(n,2n)N14(n,pα)Be10					2.5	0.4	
		Na23(n,tα)O17(n,2α)Be10					2.1	3.3	6.4
		Na23(n,d)Ne22(n,2nα)O17(n,2α)Be10					2.0	0.6	
		Na23(n,n2α)N15(n,t)C13(n,α)Be10					1.0	0.3	0.2
		Na23(n,2nα)F18(β^+)O18(n,n2α)Be10						10.4	8.8
		Na23(n,dα)O18(n,n2α)Be10						8.5	8.3
		Na23(n,d2α)C14(n,nα)Be10						2.3	2.1
		Na23(n,t)Ne21(n,3α)Be10						0.9	2.4
		Na23(n,2n2α)N14(n,pα)Be10						0.5	5.1
		Na23(n,t)Ne21(n,tα)N15(n,dα)Be10						0.4	1.8
		Na23(n,nt)Ne20(n,dα)N15(n,dα)Be10						0.3	1.4
		Na23(n,nα)F19(n,d2α)Be10						0.1	2.0
		Na23(n,ntα)O16(n,hα)Be10							1.3
		Na23(n,n3α)B11(n,d)Be10							1.2

Sodium activation characteristics

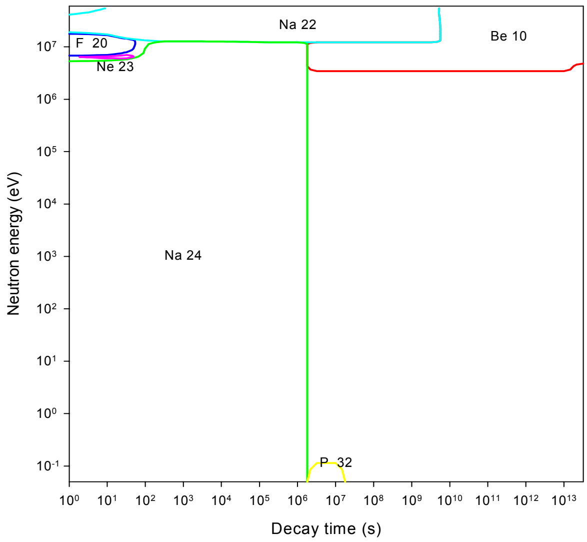


Sodium importance diagrams & transmutation

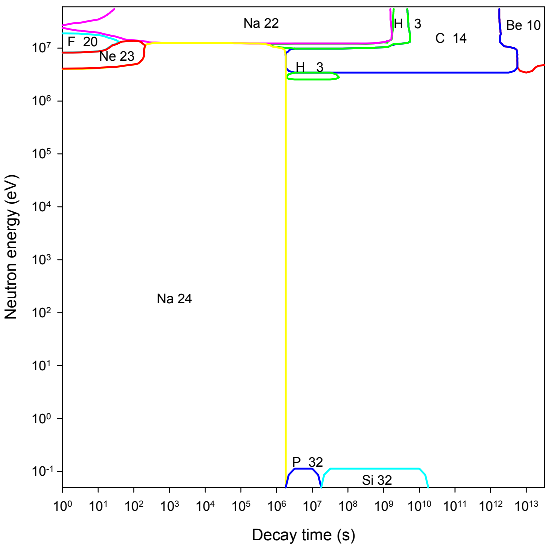
Activity



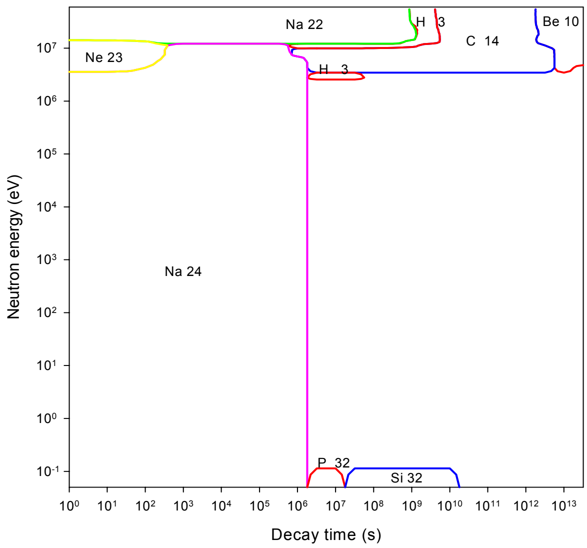
Dose rate



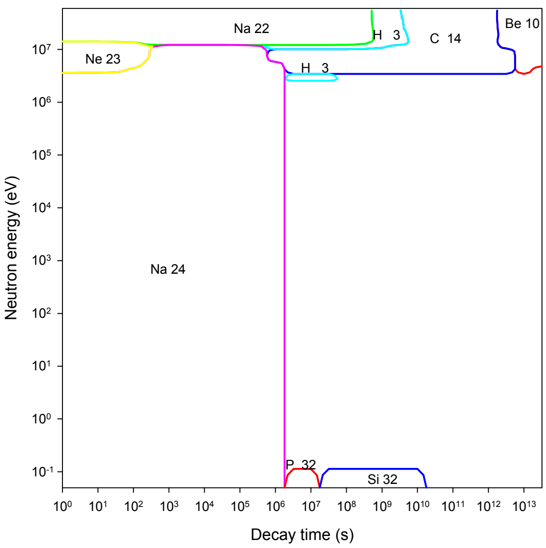
Heat output



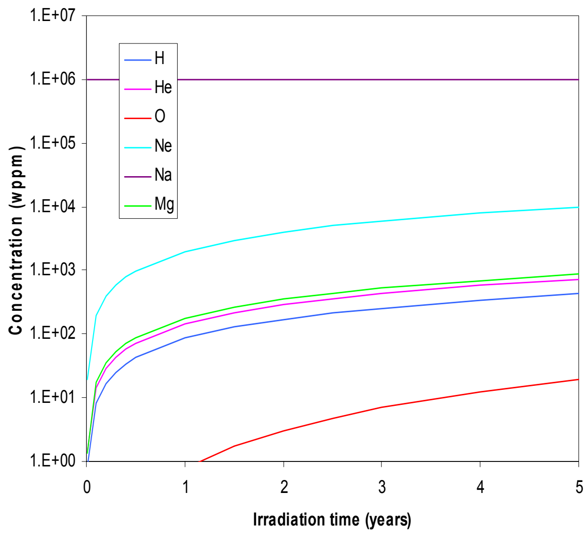
Ingestion dose



Inhalation dose



First wall transmutation



Magnesium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	12		
Crustal abundance / wppm	$2.30\ 10^{4}$	Mg24	78.99
Melting point / K	922.0	Mg25	10.00
Boiling point / K	1363	Mg26	11.01
Density / kgm^{-3}	1738		
Thermal conductivity / $Wm^{-1}K^{-1}$	156		
Electrical resistivity /Ωm	$4.38\ 10^{-8}$		
Coefficient of thermal expansion / K^{-1}	$2.61\ 10^{-5}$		
Crystal structure	HCP		
Number of stable isotopes	3		
Mean atomic weight	24.3050		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	9.89E14	7.04E14	1.23E13	1.25E11	5.42E8	1.06E3
Na24	71.28	99.77	98.92			
Na24m	22.14					
Na25	2.73	0.09				
Ne23	2.38					
Na26	0.81					
H3	0.01	0.02	1.04	97.00	85.50	
Na22			0.04	2.94		
C14				0.06	14.50	39.18
Al26						59.99

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	5.72E-1	5.27E-1	9.09E-3	1.52E-6	1.05E-9	3.18E-13
Na24	92.39	99.92	99.98			
Na24m	2.97					
Na25	1.46	0.04				
Ne23	1.37					
Na26	1.25					
Na22			0.02	92.65		
H3				7.31	40.47	
C14					59.49	1.03
Al26					0.03	98.85

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	9.29E5	8.95E5	1.55E4	1.97E0	5.10E-7	4.63E-7
Na24	96.64	99.97	99.98			
Na24m	2.18					
Na26	0.58					
Na22			0.02	100.0		
Al26					100.0	100.0

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	3.24E5	3.02E5	5.24E3	1.69E1	6.51E-2	2.48E-6
Na24	93.50	99.97	99.60			
Na22			0.29	69.60		
H3			0.10	30.13	29.92	
C14					70.07	9.72
Al26						89.88

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	2.01E5	1.90E5	3.32E3	3.67E1	5.76E-1	1.55E-5
Na24	94.80	99.96	98.80			
H3	0.02	0.02	1.00	85.74	20.91	
Na22			0.19	13.00		
C14				1.26	79.09	15.61
Al26						82.40
Be10						1.99

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	8.62E11	7.04E11	1.22E10	3.80E7	8.32E4	2.14E0
Na24	81.77	99.83	99.60			
Na24m	12.10					
Na26	2.34					
Na22			0.39	96.60		
H3			0.01	3.18	5.57	
C14				0.21	94.43	19.46
Al26						80.53

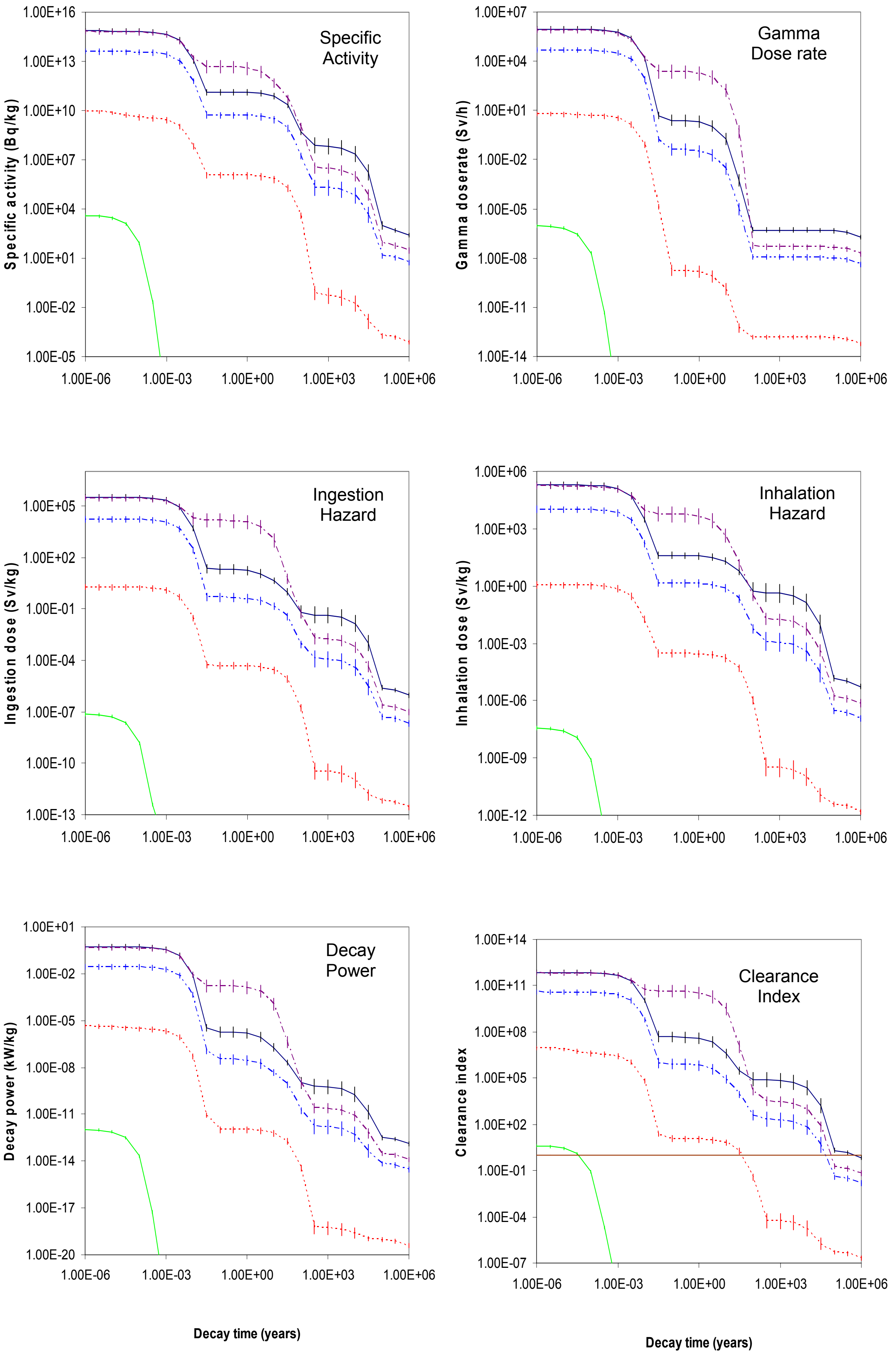
Magnesium

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Na25	59.6 s	Mg25(n,p)Na25				89.2	14.1	9.9	7.3
		Mg26(n,2n)Mg25(n,p)Na25				6.9	0.9	0.3	0.1
		Mg26(n,d)Na25				3.8	84.5	89.4	92.4
Mg27	9.46 m	Mg26(n,γ)Mg27	99.1	100.0	100.0	98.6	99.6	99.7	99.9
		Mg25(n,γ)Mg26(n,γ)Mg27	0.9						
Si31	2.62 h	Mg26(n,γ)Mg27(β^-)Al27(n,γ)Al28(β^-)_ Si28(n,γ)Si29(n,γ)Si30(n,γ)Si31	99.8	100.0					
Na24	14.96 h	**&**Mg25(n,α)Ne22(n,γ)Ne23(β^-)Na23_ (n,γ)*Na24*	99.3	100.0	100.0				
		&Mg24(n,p)*Na24*				96.5	42.2	27.0	17.5
		&Mg25(n,2n)Mg24(n,p)*Na24*				1.1	0.2		
		&Mg25(n,d)*Na24*				0.9	48.7	39.9	37.6
		&Mg26(n,2n)Mg25(n,d)*Na24*					3.0	1.2	0.6
		&Mg26(n,t)*Na24*					2.3	30.8	43.3
		Mg26(n,h)Ne24(β^-)Na24						0.5	1.2
P32	14.27 d	Mg26(n,γ)Mg27(β^-)Al27(n,γ)Al28(β^-)Si28_ (n,γ)Si29(n,γ)Si30(n,γ)Si31(β^-)P31(n,γ)P32	99.9						
Na22	2.60 y	Mg24(n,d)Na23(n,2n)Na22				92.3	39.0	1.6	0.5
		Mg26(n,α)Ne23(β^-)Na23(n,2n)Na22				5.8			
		Mg25(n,2n)Mg24(n,d)Na23(n,2n)Na22				0.4			
		Mg25(n,t)Na23(n,2n)Na22				0.2	0.9	0.1	
		Mg24(n,t)Na22					54.5	96.5	94.0
		Mg24(n,2n)Mg23(β^+)Na23(n,2n)Na22					4.1	0.2	
		Mg24(n,2p)Ne23(β^-)Na23(n,2n)Na22					0.7		
		Mg25(n,nt)Na22						0.6	3.8
		Mg24(n,3n)Mg22(β^+)Na22							0.8
H3	12.33 y	Mg25(n,X)H3				64.5	18.5	14.9	13.1
		Mg24(n,d)Na23(n,X)H3				19.9	9.1	3.2	1.2
		Mg24(n,α)Ne21(n,X)H3				9.4			0.3
		Mg26(n,2n)Mg25(n,X)H3				2.6	0.6	0.3	0.1
		Mg26(n,α)Ne23(β^-)Na23(n,X)H3				1.3			
		Mg24(n,X)H3					56.7	64.2	68.5
		Mg26(n,X)H3					9.5	12.6	13.1
		Mg24(n,nα)Ne20(n,X)H3					1.2	0.4	0.3
		Mg24(n,2α)O17(n,X)H3					1.2	0.3	
		Mg24(n,2n)Mg23(β^+)Na23(n,X)H3					1.0	0.5	0.2
Si32	132.0 y	Mg26(n,γ)Mg27(β^-)Al27(n,γ)Al28(β^-)_ Si28(n,γ)Si29(n,γ)Si30(n,γ)Si31(n,γ)Si32	100.0						
C14	5700 y	Mg24(n,α)Ne21(n,2α)C14				90.1	6.5	0.8	1.2
		Mg24(n,α)Ne21(n,nα)O17(n,α)C14				3.6			
		Mg24(n,α)Ne21(n,α)O18(n,nα)C14				2.1			
		Mg24(n,nα)Ne20(n,α)O17(n,α)C14				0.8			
		Mg25(n,nα)Ne21(n,2α)C14				1.0	8.8	0.5	
		Mg24(n,2α)O17(n,α)C14					10.5	0.9	0.5
		Mg24(n,h)Ne22(n,n2α)C14					8.3	18.2	8.4
		Mg24(n,d)Na23(n,nα)F19(n,dα)C14					7.7	0.8	0.2
		Mg24(n,n2α)O16(n,h)C14					7.6	28.1	18.0
		Mg26(n,nα)Ne22(n,n2α)C14					6.5	1.2	0.3
		Mg24(n,d)Na23(n,n2α)N15(n,d)C14					5.5	0.9	0.1
		Mg24(n,nα)Ne20(n,dα)N15(n,d)C14					5.2	1.2	0.3
		Mg25(n,2α)O18(n,nα)C14					4.8	0.5	
		Mg24(n,nα)Ne20(n,d)F19(n,dα)C14					4.5	0.6	0.2
		Mg24(n,d)Na23(n,d)Ne22(n,n2α)C14					3.6	0.5	
		Mg25(n,3α)C14					1.8	5.5	4.8
		Mg24(n,nα)Ne20(n,hα)C14					1.4	1.1	0.9
		Mg24(n,d)Na23(n,t)Ne21(n,2α)C14					1.2	0.2	
	►	Mg24(n,nα)Ne20(n,nα)O16(n,h)C14					1.1	0.4	0.2

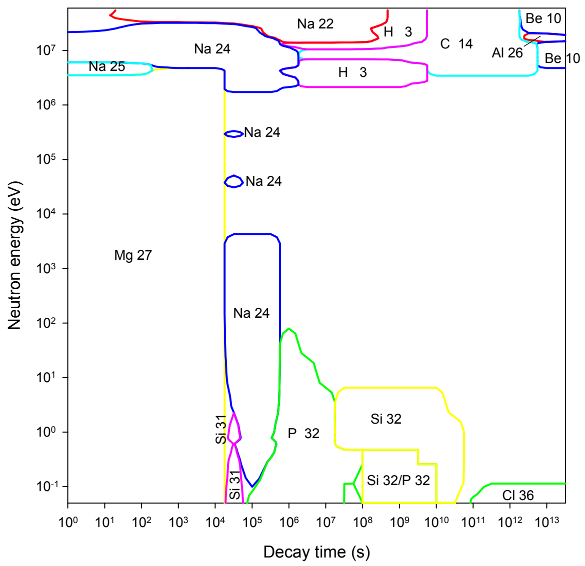
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	Mg24(n,t)Na22(β^+)Ne22(n,n2α)C14					0.9	5.1	3.7
		Mg24(n,dα)F19(n,dα)C14					0.1	22.1	23.7
		Mg24(n,d)Na23(n,d2α)C14						1.1	2.3
		Mg24(n,2nα)Ne19(β^+)F19(n,dα)C14						0.5	4.3
		Mg24(n,tα)F18(β^+)O18(n,nα)C14						0.4	5.6
		Mg24(n,d2α)N15(n,d)C14						0.4	2.8
		Mg25(n,2n2α)O16(n,h)C14						0.2	1.3
		Mg25(n,tα)F19(n,dα)C14						0.1	1.6
		Mg24(n,2n2α)O15(β^+)N15(n,d)C14							3.5
		Mg26(n,n3α)C14							6.0
Cl36	3.0 10^5 y	Mg26(n,γ)Mg27(β^-)Al27(n,γ)Al28(β^-)Si28_ (n,γ)Si29(n,γ)Si30(n,γ)Si31(β^-)P31(n,γ)P32_ (β^-)S32(n,γ)S33(n,γ)S34(n,γ)S35(β^-)Cl35_ (n,γ)Cl36	94.5						
Al26	7.2 10^5 y	Mg26(n,γ)Mg27(β^-)Al27(n,2n)Al26				99.9	99.9	100.0	100.0
Be10	1.6 10^6 y	Mg24(n,nα)Ne20(n,2α)C13(n,α)Be10				64.5	1.7	0.1	
		Mg24(n,α)Ne21(n,nα)O17(n,nα)C13(n,α)Be10				15.4			
		Mg24(n,nα)Ne20(n,nα)O16(n,α)C13(n,α)Be10				9.7			
		Mg24(n,nα)Ne20(n,α)O17(n,nα)C13(n,α)Be10				3.6			
		Mg24(n,α)Ne21(n,2n)Ne20(n,2α)C13(n,α)Be10				1.2			
		Mg24(n,2α)O17(n,2α)Be10					82.1	20.2	0.4
		Mg24(n,2α)O17(n,nα)C13(n,α)Be10					1.4	0.1	
		Mg24(n,n2α)O16(n,nα)C12(n,h)Be10					0.8	3.3	0.5
		Mg24(n,h)Ne22(n,2nα)C14(n,nα)Be10					0.6	3.0	0.1
		Mg24(n,nα)Ne20(n,n2α)C12(n,h)Be10					0.6	1.4	0.2
		Mg24(n,n2α)O16(n,h)C14(n,nα)Be10					0.5	4.6	0.3
		Mg24(n,nα)Ne20(n,dα)N15(n,dα)Be10					0.2	6.0	1.8
		Mg24(n,d)Na23(n,n2α)N15(n,dα)Be10					0.2	4.6	0.9
		Mg25(n,n2α)O17(n,2α)Be10					0.2	4.0	0.3
		Mg25(n,3α)C14(n,nα)Be10					0.2	1.4	0.1
		Mg24(n,n2α)O16(n,t)N14(n,pα)Be10					0.1	2.3	0.3
		Mg24(n,h)Ne22(n,2nα)O17(n,2α)Be10					0.1	1.8	
		Mg24(n,n2α)O16(n,dα)B11(n,d)Be10						4.8	0.7
		Mg24(n,dα)F19(n,dα)C14(n,nα)Be10						3.6	0.4
		Mg24(n,d2α)N15(n,dα)Be10						2.1	18.1
		Mg24(n,3α)C13(n,α)Be10						2.0	1.4
		Mg24(n,n2α)O16(n,hα)Be10						1.8	7.7
		Mg24(n,nα)Ne20(n,2nα)O15(β^+)N15_ (n,dα)Be10						1.4	0.6
		Mg24(n,dα)F19(n,nα)N15(n,dα)Be10						1.2	0.7
		Mg25(n,2α)O18(n,n2α)Be10						1.1	
		Mg24(n,n2α)O16(n,2n)O15(β^+)N15(n,dα)Be10						1.1	0.2
		Mg24(n,n2α)O16(n,d)N15(n,dα)Be10						1.0	0.2
		Mg24(n,tα)F18(β^+)O18(n,n2α)Be10						0.8	8.4
		Mg24(n,α)Ne21(n,3α)Be10						0.3	2.3
		Mg24(n,dα)F19(n,d2α)Be10						0.2	4..3
		Mg24(n,α)Ne21(n,tα)N15(n,dα)Be10						0.1	1.7
		Mg24(n,2n2α)O15(β^+)N15(n,dα)Be10							22.7
		Mg24(n,n3α)C12(n,h)Be10							6.5
		Mg25(n,t2α)N15(n,dα)Be10							1.3

Magnesium activation characteristics

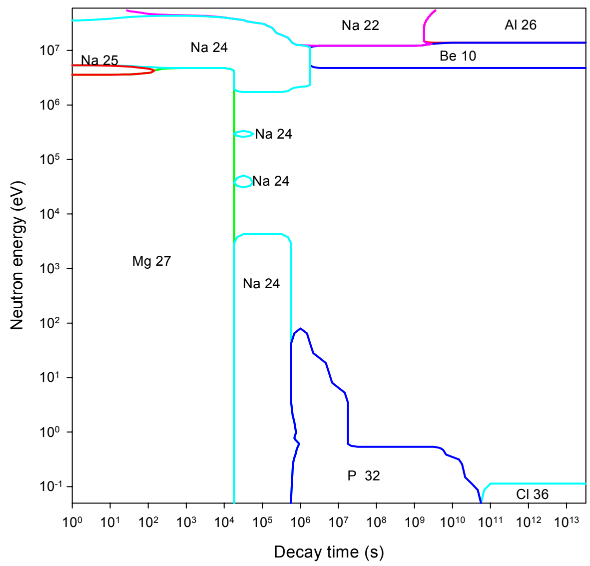


Magnesium importance diagrams & transmutation

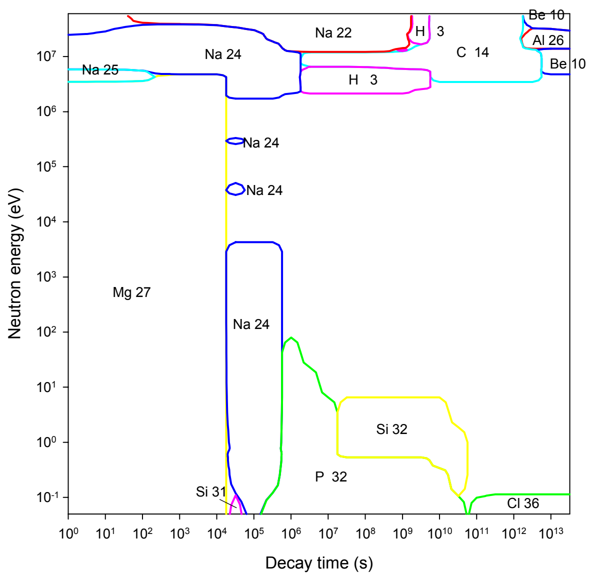
Activity



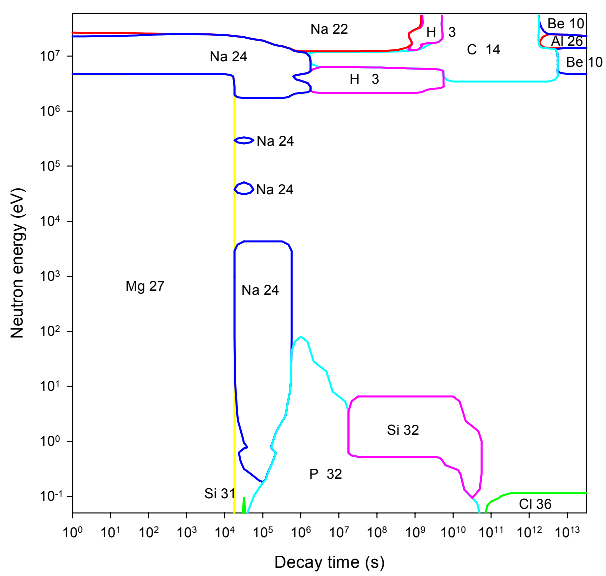
Dose rate



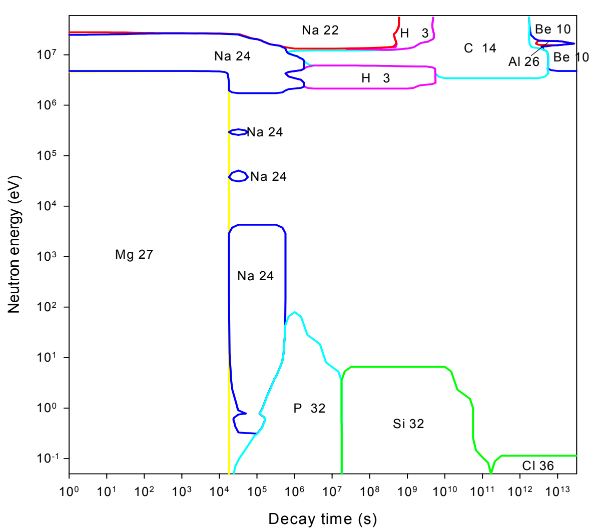
Heat output



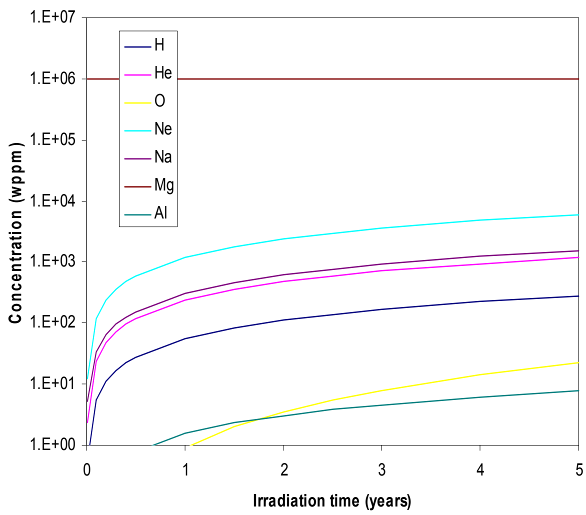
Ingestion dose



Inhalation dose



First wall transmutation



Aluminium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	13	Al27	100.0
Crustal abundance / wppm	8.20 10^4		
Melting point / K	933.5		
Boiling point / K	2740		
Density / kgm^{-3}	2698		
Thermal conductivity / $Wm^{-1}K^{-1}$	237		
Electrical resistivity /Ωm	2.655 10^2		
Coefficient of thermal expansion / K^{-1}	2.303 10^{-5}		
Crystal structure	FCC		
Number of stable isotopes	1		
Mean atomic weight	26.98154		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Bq kg^{-1}	9.11E14	6.33E14	9.22E12	1.78E12	6.97E9	1.64E8
Na24	46.79	67.04	79.63			
Mg27	31.40	30.72				
Na24m	14.53					
Al28	6.88	1.95				
H3	0.21	0.30	20.36	99.95	97.41	
Al26m	0.09					
Na22				0.04		
Al26				0.01	2.59	100.0

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
kW kg^{-1}	4.34E-1	3.74E-1	5.50E-3	1.96E-6	9.51E-8	8.07E-8
Na24	73.62	85.11	99.96			
Mg27	16.85	13.30				
Al28	6.99	1.60				
Na24m	2.37					
Al26m	0.07					
H3				82.73		
Na22				12.74		
Al26				4.53	100.0	100.0

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv h^{-1}	6.69E5	6.05E5	9.56E3	4.93E-1	1.34E-1	1.22E-1
Na24	82.96	91.43	99.99			
Mg27	9.88	7.44				
Al28	5.22	1.14				
Na24m	1.88					
Na22				72.78		
Al26				27.22	100.0	100.0

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv kg^{-1}	1.90E5	1.86E5	3.24E3	7.73E1	9.17E-1	5.73E-1
Na24	96.66	98.01	97.46			
Mg27	2.72	1.88				
Al28	0.30	0.06				
H3	0.04		2.43	96.48	31.12	
Na22			0.08	2.71		
Al26			0.02	0.82	68.88	100.0

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv kg^{-1}	1.19E5	1.17E5	2.47E3	4.66E2	5.38E0	3.28E0
Na24	96.80	97.98	80.09			
Mg27	2.21	1.53				
H3	0.41	0.42	19.72	99.04	32.86	
Al28	0.35	0.07				
Al26			0.15	0.77	67.13	100.0
Na22			0.05	0.18		

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
	8.98E11	6.43E11	7.37E9	2.48E7	5.56E5	4.43E5
Na24	47.48	66.05	99.62			
Mg27	31.86	30.26				
Al28	13.42	3.69				
Na24m	7.02					
H3			0.25	71.65	12.22	
Na22			0.11	26.38		
Al26				1.97	87.76	100.0

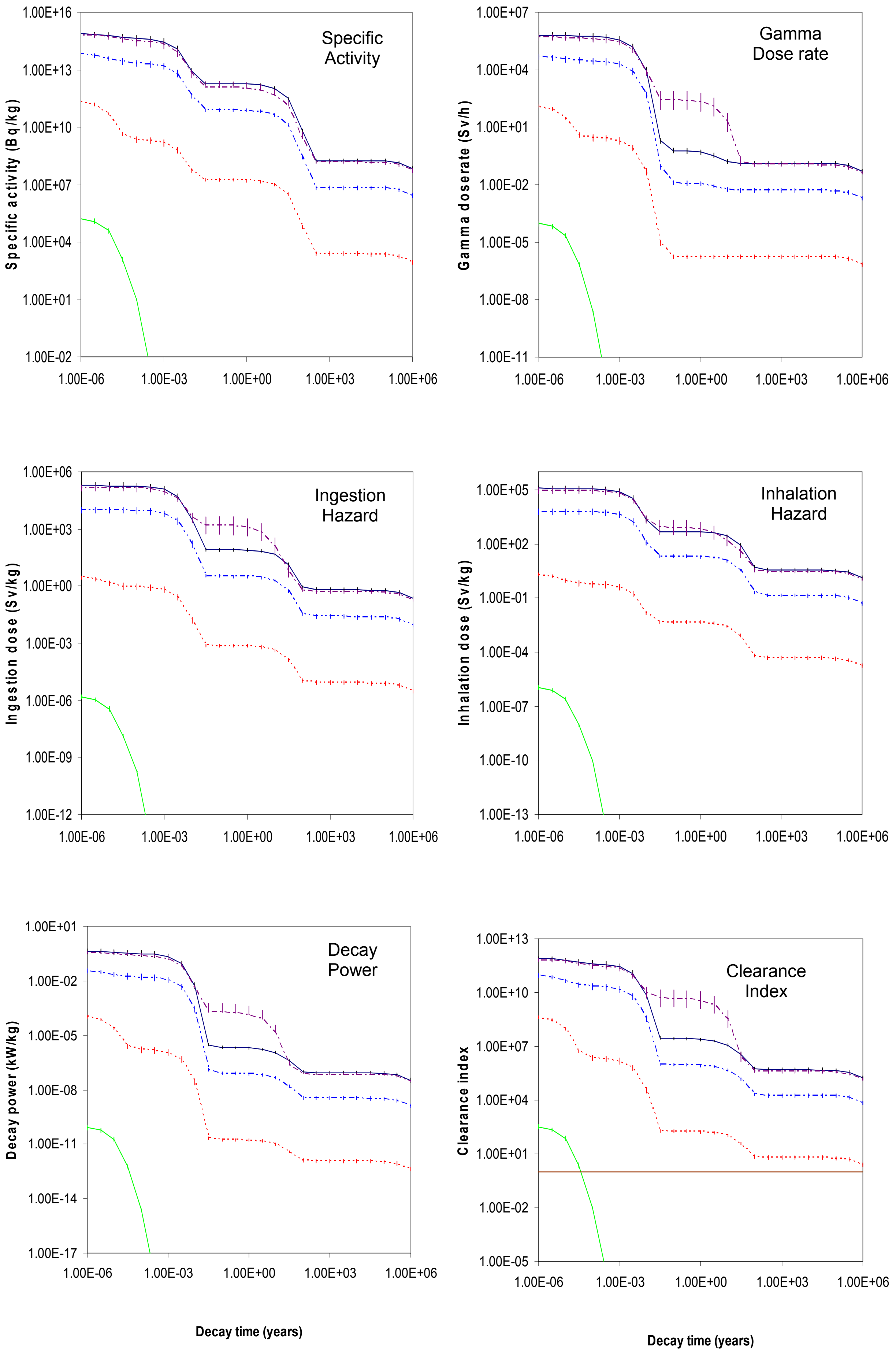
Aluminium

Pathway analysis

Nuclide	$T_{½}$	Pathway	210	186	151	46	30	21	6
Al28	2.241 m	Al27(n,γ)Al28	100.0	100.0	100.0	95.4	99.2	99.6	99.8
Mg27	9.46 m	Al27(n,p)Mg27				100.0	100.0	100.0	100.0
Si31	2.62 h	Al27(n,γ)Al28(β^-)Si28(n,γ)Si29(n,γ)_ Si30(n,γ)Si31	100.0	100.0	100.0	98.7	99.6	99.7	
Na24	14.96 h	**&**Al27(n,α)*Na24*				96.2	82.3	48.7	85.0
		&Al27(n,t)Mg25(n,d)*Na24*					13.2	32.2	8.5
		&Al27(n,d)Mg26(n,t)*Na24*					0.8	9.2	2.9
		&Al27(n,2n)Al26(n,h)*Na24*					0.4	1.5	0.5
		&Al27(n,2n)Al26m(β^+)Mg26(n,t)*Na24*					0.1	1.6	0.5
P32	14.27 d	Al27(n,γ)Al28(β^-)Si28(n,γ)Si29(n,γ)_ Si30(n,γ)Si31(β^-)P31(n,γ)P32	100.0	100.0	100.0	98.6			
Na22	2.60 y	Al27(n,nα)Na23(n,2n)Na22				66.5	54.7	2.5	0.6
		Al27(n,2n)Al26(n,nα)Na22				26.7	42.4	2.2	0.4
		&Al27(n,α)*Na24*(β^-)Mg24(n,d)Na23_ (n,2n)Na22				3.2	0.1		
		Al27(n,d)Mg26(n,α)Ne23(β^-)Na23(n,2n)Na22				1.7			
		Al27(n,2n)Al26(n,α)Na23(n,2n)Na22				1.4			
		Al27(n,pα)Ne23(β^-)Na23(n,2n)Na22					1.7	0.1	
		Al27(n,2nα)Na22						91.7	88.5
		Al27(n,nt)Mg24(n,t)Na22						1.7	5.5
		Al27(n,t)Mg25(n,nt)Na22						0.7	3.1
H3	12.33 y	Al27(n,X)H3				97.7	95.5	96.3	96.8
		Al27(n,2n)Al26(n,X)H3				1.3	1.6	0.6	0.3
		Al27(n,nα)Na23(n,X)H3				0.3	1.4	0.5	0.2
		Al27(n,t)Mg25(n,X)H3					0.6	1.5	1.2
Si32	132.0 y	Al27(n,γ)Al28(β^-)Si28(n,γ)Si29(n,γ)_ Si30(n,γ)Si31(n,γ)Si32	84.4	99.3	100.0				
C14	5700 y	**&**Al27(n,α)*Na24*(β^-)Mg24(n,α)Ne21_ (n,2α)C14				91.6			
		&Al27(n,α)*Na24*(β^-)Mg24(n,α)_ Ne21(n,nα)O17(n,α)C14				2.7			
		&Al27(n,α)*Na24*(β^-)Mg24(n,α)Ne21_ (n,α)O18(n,nα)C14				1.6			
		&Al27(n,α)*Na24*(β^-)Mg24(n,nα)_ Ne20(n,α)O17(n,α)C14				0.7			
		Al27(n,nα)Na23(n,t)Ne21(n,2α)C14				0.4	4.0	0.4	
		Al27(n,t)Mg25(n,nα)Ne21(n,2α)C14				0.2	3.9	0.4	
		Al27(n,nα)Na23(n,nα)F19(n,nα)N15(n,d)C14				0.2	0.8		
		Al27(n,nα)Na23(n,nα)F19(n,dα)C14					26.8	1.5	0.4
		Al27(n,nα)Na23(n,n2α)N15(n,d)C14					19.0	1.7	0.2
		Al27(n,nα)Na23(n,d)Ne22(n,n2α)C14					12.5	0.9	0.2
		Al27(n,dα)Ne22(n,n2α)C14					7.7	47.6	21.7
		Al27(n,d)Mg26(n,nα)Ne22(n,n2α)C14					4.1	0.3	
		Al27(n,t)Mg25(n,2α)O18(n,nα)C14					2.1	0.4	
		Al27(n,t)Mg25(n,3α)C14					1.2	6.6	4.4
		Al27(n,nα)Na23(n,nα)F19(n,d)O18(n,nα)C14					0.5		
		Al27(n,2n)Al26(n,nα)Na22(n,nα)F18(β^+)_ O18(n,nα)C14					0.1		
		Al27(n,n2α)F19(n,dα)C14						21.4	24.0
		Al27(n,2nα)Na22(β^+)Ne22(n,n2α)C14						5.7	4.7
		Al27(n,nα)Na23(n,d2α)C14						2.1	3.9
		Al27(n,tα)Ne21(n,2α)C14						0.6	3.6
		Al27(n,n3α)N15(n,d)C14							12.0
		Al27(n,2n2α)F18(β^+)O18(n,nα)C14							3.2

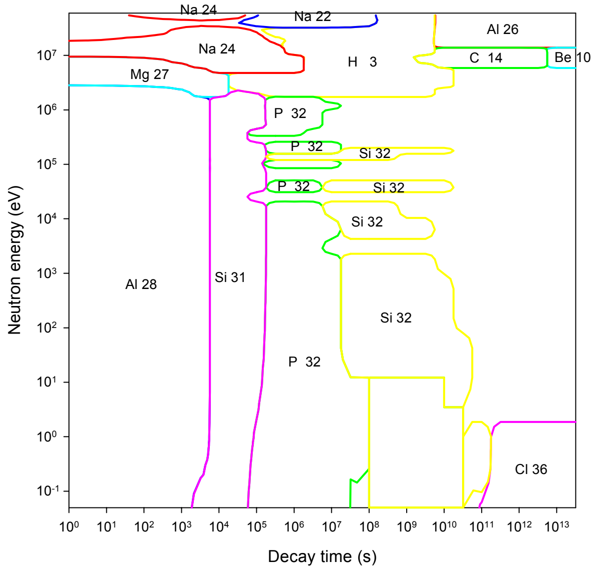
Nuclide	**$T_{1/2}$**	**Pathway**	**210**	**186**	**151**	**46**	**30**	**21**	**6**
Cl36	$3.0\ 10^5$ y	Al27(n,γ)Al28(β^-)Si28(n,γ)Si29(n,γ)Si30_ (n,γ)Si31(β^-)P31(n,γ)P32(β^-)S32(n,γ)S33_ (n,γ)S34(n,γ)S35(β^-)Cl35(n,γ)Cl36	95.1						
Al26	$7.2\ 10^5$ y	Al27(n,2n)Al26				99.5	99.9	99.9	100.0
Be10	$1.6\ 10^6$ y	**&**Al27(n,α)*Na24*(β^-)Mg24(n,nα)Ne20_ (n,2α)C13(n,α)Be10				57.6			
		Al27(n,nα)Na23(n,α)F20(β^-)Ne20(n,2α)_ C13(n,α)Be10				14.1			
		&Al27(n,α)*Na24*(β^-)Mg24(n,α)Ne21_ (n,nα)O17(n,nα)C13(n,α)Be10				11.0			
		&Al27(n,α)*Na24*(β^-)Mg24(n,nα)Ne20_ (n,nα)O16(n,α)C13(n,α)Be10				6.9			
		Al27(n,nα)Na23(n,α)F20(β^-)Ne20(n,nα)_ O16(n,α)C13(n,α)Be10				1.7			
		&Al27(n,α)*Na24*(β^-)Mg24(n,nα)Ne20_ (n,α)O17(n,nα)C13(n,α)Be10				2.6			
		Al27(n,nα)Na23(n,n2α)N15(n,nα)B11_ (n,d)Be10					16.0	0.5	
		Al27(n,nα)Na23(n,nα)F19(n,dα)C14_ (n,nα)Be10					11.0	0.3	
		Al27(n,nα)Na23(n,n2α)N15(n,d)C14_ (n,nα)Be10					7.8	0.4	
		&Al27(n,α)*Na24*(β^-)Mg24(n,2α)O17_ (n,2α)Be10					5.9		
		Al27(n,nα)Na23(n,n2α)N15(n,dα)Be10					5.3	15.2	1.2
		Al27(n,nα)Na23(n,d)Ne22(n,n2α)C14_ (n,nα)Be10					5.2	0.2	
		Al27(n,dα)Ne22(n,n2α)C14(n,nα)Be10					4.2	13.9	0.3
		Al27(n,nα)Na23(n,nα)F19(n,t)O17(n,2α)Be10					2.0		
		Al27(n,dα)Ne22(n,2nα)O17(n,2α)Be10					1.0	8.2	0.2
		Al27(n,t)Mg25(n,n2α)O17(n,2α)Be10					0.6	5.7	0.1
		Al27(n,2α)F20(β^-)Ne20(n,dα)N15(n,dα)Be10					0.1	2.6	0.1
		Al27(n,n2α)F19(n,dα)C14(n,nα)Be10						6.3	0.3
		Al27(n,nα)Na23(n,2nα)F18(β^+)O18_ (n,n2α)Be10						2.8	0.2
		Al27(n,dα)Ne22(n,nα)O18(n,n2α)Be10						2.8	0.2
		Al27(n,nα)Na23(n,dα)O18(n,n2α)Be10						2.2	0.2
		Al27(n,n2α)F19(n,nα)N15(n,dα)Be10						2.1	0.6
		Al27(n,tα)Ne21(n,3α)Be10						0.4	5.3
		Al27(n,n2α)F19(n,d2α)Be10						0.4	3.3
		Al27(n,n3α)N15(n,dα)Be10						0.2	60.7
		Al27(n,tα)Ne21(n,tα)N15(n,dα)Be10						0.2	4.0
		Al27(n,2n2α)F18(β^+)O18(n,n2α)Be10							3.7

Aluminium activation characteristics

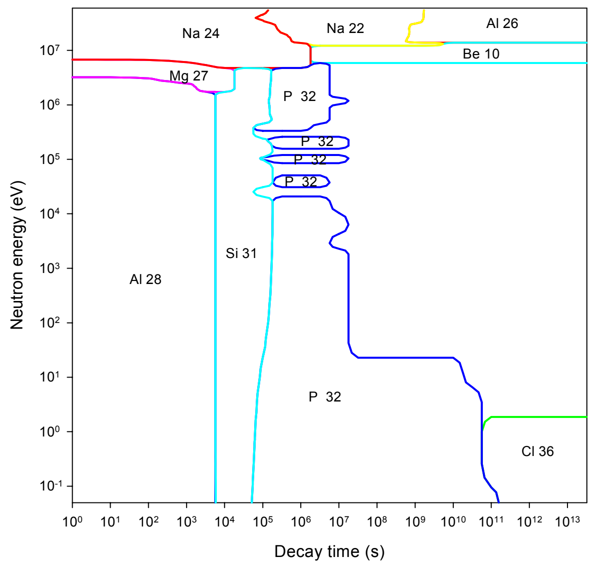


Aluminium importance diagrams & transmutation

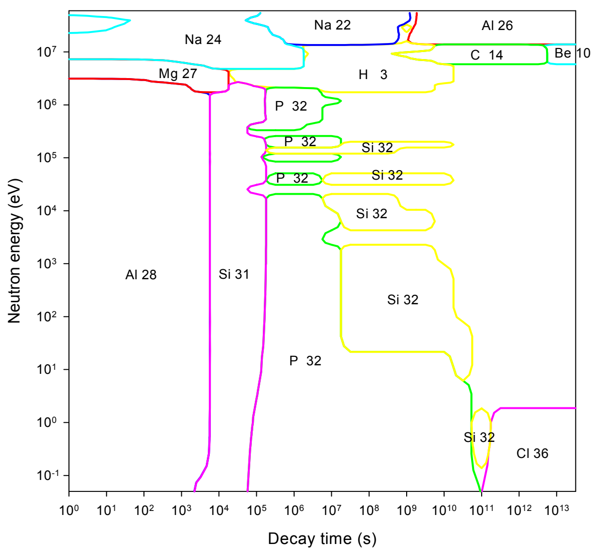
Activity



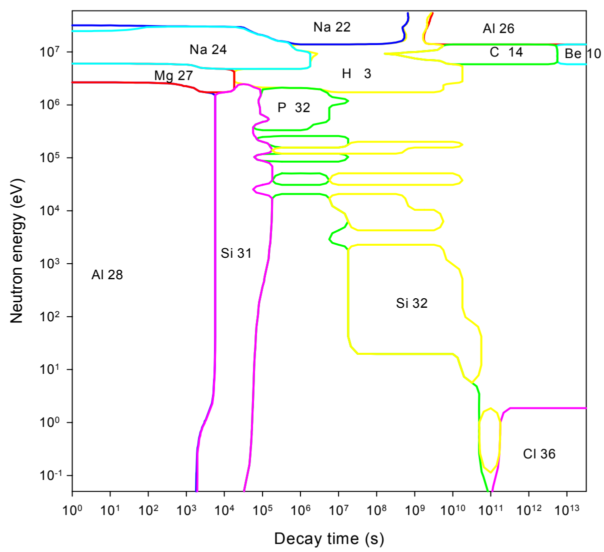
Dose rate



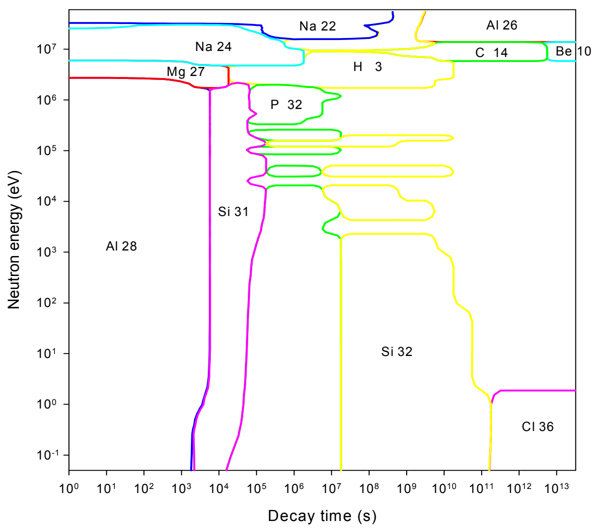
Heat output



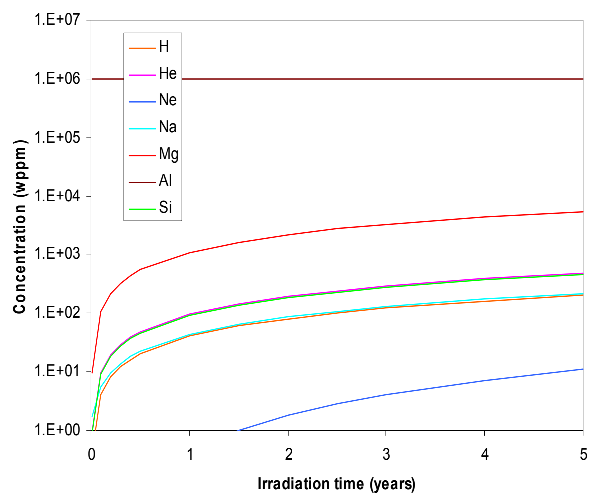
Ingestion dose



Inhalation dose



First wall transmutation



Silicon

General properties

		Isotopes	Isotopic abundances / %
Atomic number	14		
Crustal abundance / wppm	$2.77\ 10^{5}$	Si28	92.23
Melting point / K	1683	Si29	4.683
Boiling point / K	2628	Si30	3.087
Density / kgm^{-3}	2329		
Thermal conductivity / $Wm^{-1}K^{-1}$	148		
Electrical resistivity /Ωm	$1.0\ 10^{-3}$		
Coefficient of thermal expansion / K^{-1}	$4.2\ 10^{-6}$		
Crystal structure	cubic		
Number of stable isotopes	3		
Mean atomic weight	28.0855		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	9.28E14	2.14E14	4.65E10	1.69E10	6.48E7	1.76E5
Al28	93.21	79.28				
Si31	2.86	12.07				
Al29	2.31	5.74				
Mg27	0.76	2.25				
Al30	0.54					
Na24	0.15	0.64	50.90			
Na25	0.12	0.01				
H3			38.36	99.99	99.66	
P32			10.73			
Al26					0.30	100.0

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	4.37E-1	9.17E-2	1.83E-5	1.62E-8	1.55E-10	8.67E-11
Al28	95.76	89.77				
Al29	1.85	5.06				
Al30	1.07					
Si31	0.58	2.70				
Mg27	0.41	1.34				
Na24	0.24	1.12	96.87			
P32			3.03	0.02	0.41	
H3			0.09	95.18	38.03	
Na22				4.22		
Al26				0.59	61.44	100.0

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	4.83E5	9.92E4	2.97E1	1.09E-3	1.39E-4	1.26E-4
Al28	96.41	92.36				
Al29	1.72	4.81				
Al30	1.15					
Na24	0.36	1.85	99.99			
Mg27	0.33	1.09				
Na25	0.02					
Na22			0.01	87.21		
Al26				12.79	100.0	100.0

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.34E4	6.66E3	2.29E1	7.15E-1	3.42E-3	6.16E-4
Al28	59.30	23.50				
Si31	31.60	62.24				
Na24	4.41	8.85	44.42			
Al29	3.36	3.83				
Mg27	0.95	1.30				
P32	0.11	0.22	52.27			
H3		0.01	3.27	99.10	79.39	
Al26					19.84	100.0

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	8.61E3	3.79E3	2.80E1	4.40E0	2.14E-2	3.52E-3
Al28	66.35	29.60				
Si31	24.33	53.95				
Na24	4.32	9.76	22.82			
Al29	3.74	4.87				
Mg27	0.76	1.17				
P32	0.24	0.53	60.59		0.09	
H3	0.06	0.12	16.56	99.83	78.44	
Al26			0.01	0.09	18.10	100.0
Si32				0.02	2.93	

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	1.72E12	3.51E11	2.39E7	1.87E5	1.19E3	4.76E2
Al28	96.54	93.07				
Al29	1.83	5.15				
Al30	1.09					
Mg27	0.41	1.37				
Na24	0.08	0.39	99.13			
Si31		0.01				
H3			0.75	90.15	54.48	
Na22			0.10	9.56		
Al26				0.28	44.16	100.0

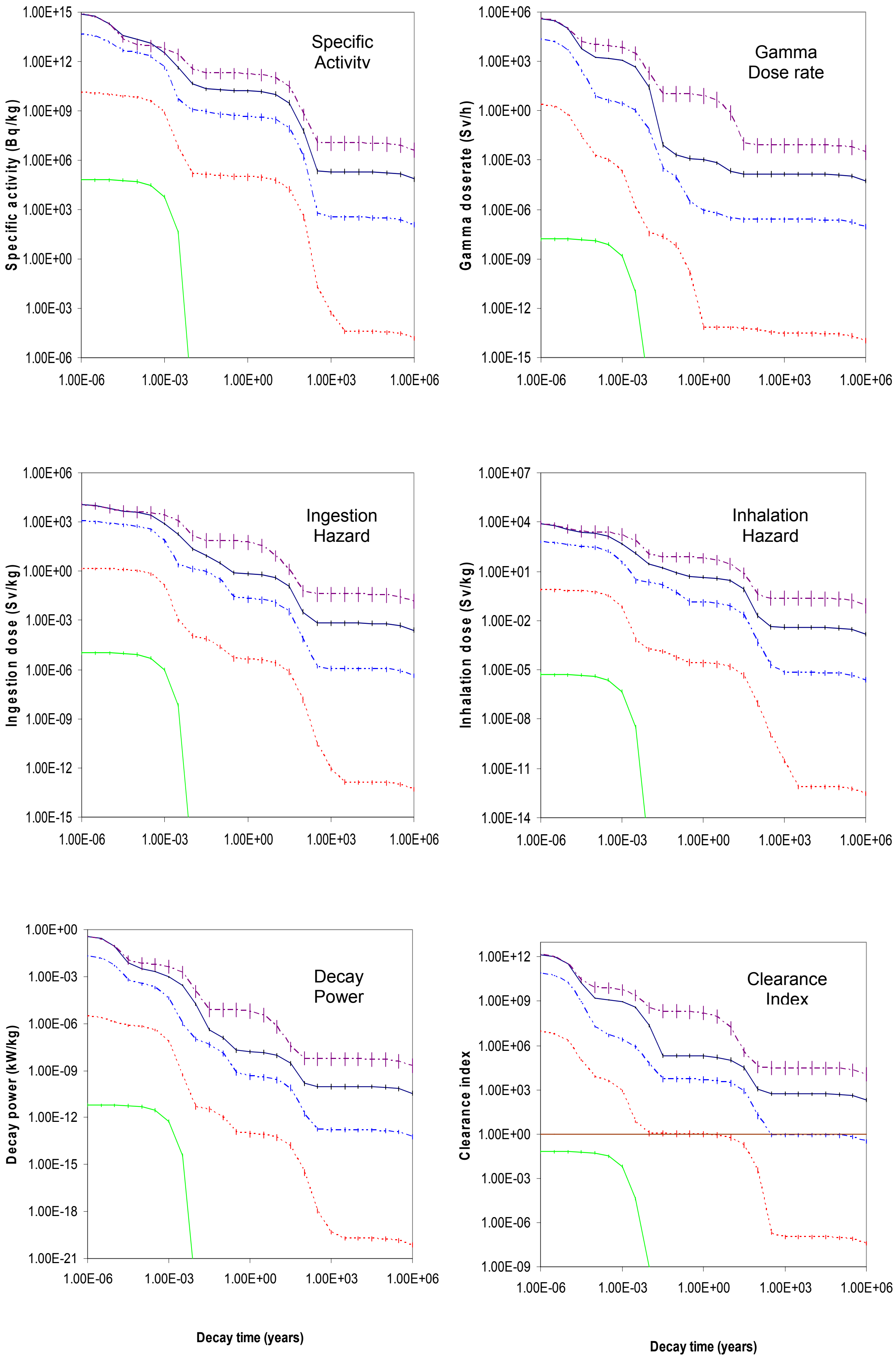
Silicon

Pathway analysis

Nuclide	$T_{1/2}$	Pathway	210	186	151	42	30	21	6
Al28	2.241 m	Si28(n,p)Al28				99.2	70.6	58.4	47.0
		Si29(n,2n)Si28(n,p)Al28				0.5	0.2		
		Si29(n,d)Al28				0.3	26.5	27.2	30.4
		Si30(n,2n)Si29(n,d)Al28					1.2	0.6	0.4
		Si30(n,t)Al28					0.6	12.6	21.0
Al29	6.56 m	Si29(n,p)Al29				93.3	23.4	18.5	13.4
		Si30(n,2n)Si29(n,p)Al29				5.0	1.0	0.4	0.2
		Si30(n,d)Al29				1.4	74.8	80.4	86.1
Si31	2.62 h	Si30(n,γ)Si31	99.1	100.0	98.9	97.7	99.0	99.4	99.7
		Si29(n,γ)Si30(n,γ)Si31	0.8		1.1				
Na24	14.96 h	**&**Si28(n,d)Al27(n,α)*Na24*				55.2	4.9	1.1	4.8
		&Si28(n,nα)Mg24(n,p)*Na24*				18.3	2.8	0.8	0.4
		&Si28(n,α)Mg25(n,d)*Na24*				9.6	2.0	1.1	11.7
		&Si28(n,α)Mg25(n,2n)Mg24(n,p)*Na24*				5.4			
		&Si30(n,α)Mg27(β^{-})Al27(n,α)*Na24*				0.8			
		&Si28(n,pα)*Na24*					86.4	80.5	42.2
		&Si28(n,h)Mg26(n,t)*Na24*					0.1	10.0	16.6
		&Si29(n,dα)*Na24*						1.0	7.9
		&Si28(n,t)Al26m(β^{+})Mg26(n,t)*Na24*						1.0	3.9
		&Si28(n,t)Al26(n,h)*Na24*						0.8	2.6
		&Si30(n,tα)*Na24*							1.7
P32	14.27 d	Si30(n,γ)Si31(β^{-})P31(n,γ)P32	100.0	100.0	100.0	98.9	100.0	100.0	100.0
Na22	2.60 y	Si28(n,nα)Mg24(n,d)Na23(n,2n)Na22				39.1	17.8	0.4	
		Si28(n,d)Al27(n,nα)Na23(n,2n)Na22				29.5	12.3	0.3	
		Si28(n,d)Al27(n,2n)Al26(n,nα)Na22				11.9	9.6	0.2	
		Si28(n,α)Mg25(n,2n)Mg24(n,d)Na23(n,2n)Na22				6.4			
		Si29(n,α)Mg26(n,α)Ne23(β^{-})Na23(n,2n)Na22				5.0			
		Si28(n,α)Mg25(n,t)Na23(n,2n)Na22				3.5	0.2		
		Si28(n,nα)Mg24(n,t)Na22					41.2	44.4	6.8
		Si28(n,t)Al26(n,nα)Na22					7.2	12.4	1.7
		&Si28(n,pα)*Na24*(β^{-})Mg24(n,t)Na22					3.6	7.4	0.6
		Si28(n,nα)Mg24(n,2n)Mg23(β^{+})Na23_ (n,2n)Na22					1.9		
		Si28(n,pα)Na24(β^{-})Mg24(n,d)Na23(n,2n)Na22					1.1		
		Si28(n,dα)Na23(n,2n)Na22					0.3	10.1	2.0
		Si29(n,2nα)Mg24(n,t)Na22					0.1	1.4	0.3
		Si28(n,d)Al27(n,2nα)Na22						15.0	2.9
		Si28(n,tα)Na22						2.4	78.6
		Si28(n,2n)Si27(β^{+})Al27(n,2nα)Na22						1.2	0.3
		Si28(n,α)Mg25(n,nt)Na22						0.2	3.8
H3	12.33 y	Si28(n,d)Al27(n,X)H3				36.1	9.3	3.3	1.4
		Si29(n,X)H3				33.8	11.3	7.2	5.9
		Si28(n,α)Mg25(n,X)H3				26.3	0.3	0.1	0.7
		Si28(n,X)H3					70.0	80.4	84.5
		Si30(n,X)H3					4.6	4.1	3.8
		Si28(n,nα)Mg24(n,X)H3					1.3	0.6	0.3
		Si28(n,h)Mg26(n,X)H3					0.2	1.3	0.9
Si32	132.0 y	Si30(n,γ)Si31(n,γ)Si32	67.4	98.2	99.4	69.7	77.9	83.2	92.7
		Si30(n,γ)Si31(β^{-})P31(n,γ)P32(n,p)Si32	32.9	1.8		29.7	22.0	16.8	7.3
		Si29(n,γ)Si30(n,γ)Si31(n,γ)Si32	0.3		0.6				
C14	5700 y	Si28(n,nα)Mg24(n,α)Ne21(n,2α)C14				51.1	1.1	0.2	
		Si28(n,α)Mg25(n,nα)Ne21(n,2α)C14				30.5	1.0		
		Si28(n,α)Mg25(n,2n)Mg24(n,α)Ne21(n,α)C14				7.8			
		Si28(n,nα)Mg24(n,α)Ne21(n,nα)O17(n,α)C14				1.5			
		Si28(n,nα)Mg24(n,α)Ne21(n,α)O18(n,nα)C14				0.9			
	►	Si28(n,α)Mg25(n,nα)Ne21(n,nα)O17(n,α)C14				0.9			

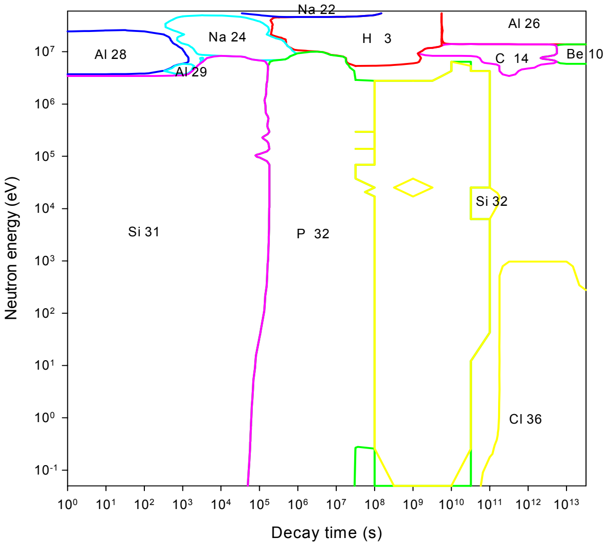
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Si28(n,2α)Ne21(n,2α)C14					75.5	16.0	0.3
		Si28(n,nα)Mg24(n,h)Ne22(n,n2α)C14					1.4	3.6	0.5
		Si28(n,nα)Mg24(n,n2α)O16(n,h)C14					1.3	5.5	1.0
		Si28(n,h)Mg26(n,nα)Ne22(n,n2α)C14					1.1	2.7	0.3
		Si28(n,d)Al27(n,dα)Ne22(n,n2α)C14					0.3	2.8	0.4
		Si28(n,α)Mg25(n,3α)C14					0.3	1.5	5.4
		Si28(n,n2α)Ne20(n,dα)N15(n,d)C14						5.5	1.1
		Si28(n,dα)Na23(n,d2α)C14						5.4	13.7
		Si28(n,n2α)Ne20(n,hα)C14						5.0	3.7
		Si28(n,dα)Na23(n,n2α)N15(n,d)C14						4.5	0.8
		Si28(n,nα)Mg24(n,dα)F19(n,dα)C14						4.3	1.3
		Si28(n,dα)Na23(n,nα)F19(n,dα)C14						4.0	1.3
		Si28(n,n2α)Ne20(n,d)F19(n,dα)C14						2.7	0.6
		Si28(n,dα)Na23(n,d)Ne22(n,n2α)C14						2.5	0.6
		Si28(n,3α)O17(n,α)C14						0.3	3.1
		Si28(n,n3α)O16(n,h)C14							23.8
		Si28(n,h)Mg26(n,n3α)C14							8.5
		Si28(n,tα)Na22(β$^+$)Ne22(n,n2α)C14							4.3
		Si28(n,d2α)F19(n,dα)C14							2.8
		Si28(n,t)Al26m(β$^+$)Mg26(n,n3α)C14							2.0
Cl36	3.0 10^5 y	Si30(n,γ)Si31(β$^-$)P31(n,γ)P32(β$^-$)S32(n,γ)_ S33(n,γ)S34(n,γ)S35(β$^-$)Cl35(n,γ)Cl36	96.5	96.4					
		Si30(n,γ)Si31(β$^-$)P31(n,γ)P32(n,γ)P33(β$^-$)_ S33(n,γ)S34(n,γ)S35(β$^-$)Cl35(n,γ)Cl36	3.2	3.4					
Al26	7.2 10^5 y	Si28(n,d)Al27(n,2n)Al26				96.8	60.4	2.3	0.6
		Si30(n,α)Mg27(β$^-$)Al27(n,2n)Al26				1.5			
		Si28(n,t)Al26					33.4	96.9	97.7
		Si29(n,nt)Al26						0.1	1.3
		Si28(n,2n)Si27(β$^+$)Al27(n,2n)Al26					2.7	0.2	
		Si28(n,2p)Mg27(β$^-$)Al27(n,2n)Al26					2.4		
Be10	1.6 10^6 y	Si28(n,nα)Mg24(n,nα)Ne20(n,2α)C13_ (n,α)Be10				55.4	0.7		
		Si28(n,nα)Mg24(n,α)Ne21(n,nα)O17_ (n,nα)C13(n,α)Be10				10.6			
		Si28(n,α)Mg25(n,2n)Mg24(n,nα)Ne20_ (n,2α)C13(n,α)Be10				6.8			
		Si28(n,nα)Mg24(n,nα)Ne20(n,nα)O16_ (n,α)C13(n,α)Be10				6.6			
		Si28(n,α)Mg25(n,nα)Ne21(n,nα)O17_ (n,nα)C13(n,α)Be10				6.3			
		Si28(n,nα)Mg24(n,nα)Ne20(n,α)O17_ (n,nα)C13(n,α)Be10				2.5			
		Si28(n,nα)Mg24(n,2α)O17(n,2α)Be10					49.4	2.7	
		Si28(n,2α)Ne21(n,2α)C14(n,nα)Be10					17.3	1.8	
		Si28(n,2α)Ne21(n,nα)O17(n,2α)Be10					16.3	2.2	
		&Si28(n,pα)*Na24*(β$^-$)Mg24(n,2α)O17_ (n,2α)Be10					4.2	0.4	
		Si28(n,n2α)Ne20(n,dα)N15(n,dα)Be10						19.0	11.2
		Si28(n,dα)Na23(n,n2α)N15(n,dα)Be10						15.4	8.3
		Si28(n,n2α)Ne20(n,n2α)C12(n,h)Be10						4.6	1.4
		Si28(n,n3α)O16(n,hα)Be10							16.0
		Si28(n,n2α)Ne20(n,2nα)O15(β$^+$)N15_ (n,dα)Be10						4.5	3.5
		Si28(n,3α)O17(n,2α)Be10						3.8	3.9
		Si28(n,d)Al27(n,n3α)N15(n,dα)Be10							2.3
		Si28(n,2α)Ne21(n,3α)Be10						3.7	1.0
		Si28(n,dα)Na23(n,2nα)F18(β$^+$)O18_ (n,n2α)Be10						2.8	1.6
		Si28(n,dα)Na23(n,dα)O18(n,n2α)Be10						2.3	1.5
		Si28(n,n2α)Ne20(n,t)F18(β$^+$)O18(n,n2α)Be10						2.2	1.1

Silicon activation characteristics

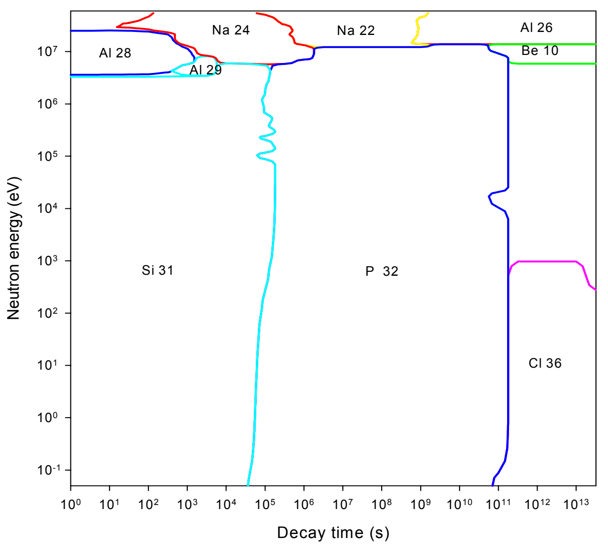


Silicon importance diagrams & transmutation

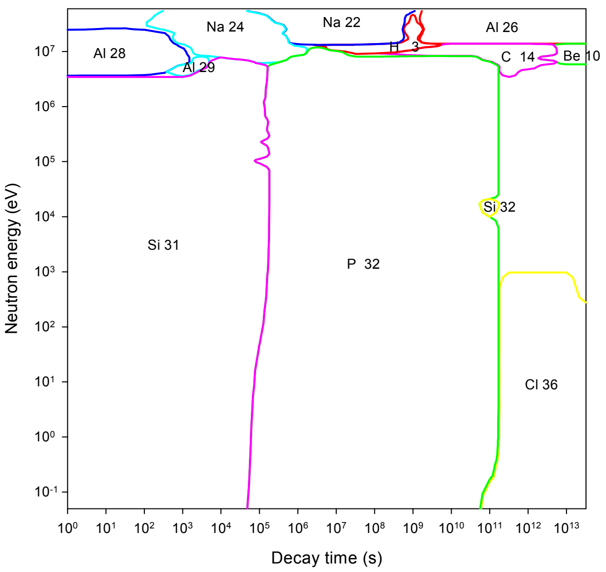
Activity



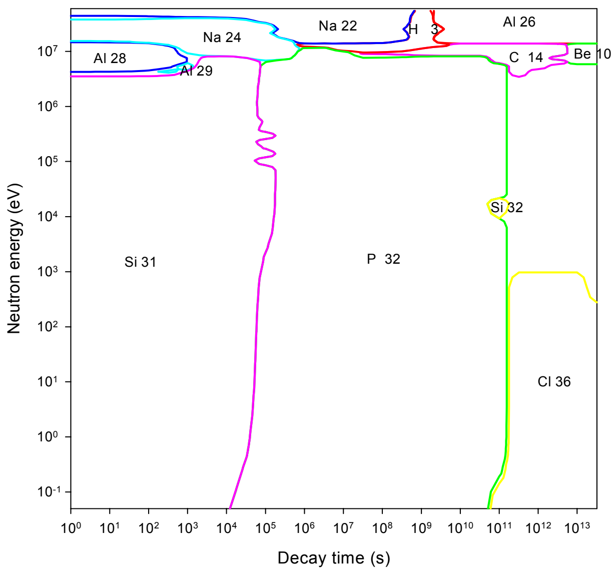
Dose rate



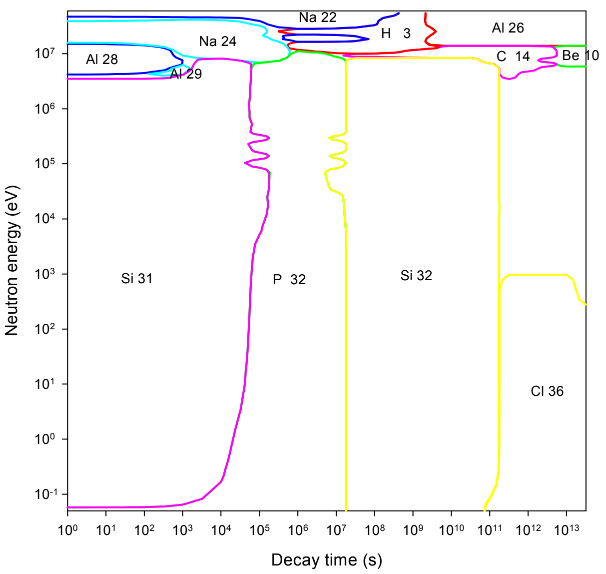
Heat output



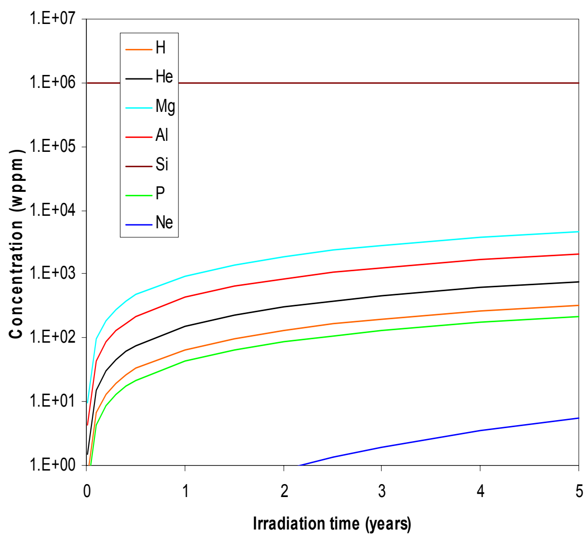
Ingestion dose



Inhalation dose



First wall transmutation



Phosphorus

General properties

		Isotopes	Isotopic abundances / %
Atomic number	15	P31	100.0
Crustal abundance / wppm	$1.00\ 10^{3}$		
Melting point / K	317.3		
Boiling point / K	553		
Density / kgm^{-3}	1820		
Thermal conductivity / $Wm^{-1}K^{-1}$	$2.35\ 10^{-1}$		
Electrical resistivity /Ωm	$1.0\ 10^{9}$		
Coefficient of thermal expansion / K^{-1}	$1.245\ 10^{-4}$		
Crystal structure	cubic		
Number of stable isotopes	1		
Mean atomic weight	30.973761		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	8.76E14	5.15E14	2.48E13	1.48E12	5.71E9	1.86E4	kW kg^{-1}	2.54E-1	8.30E-2	2.59E-3	1.36E-6	7.36E-9	9.16E-12
Al28	47.46	77.17					Al28	79.37	47.70				
Si31	46.43	15.87					Si31	15.32	45.77				
P32	3.16	5.38	93.67		0.31		P30	2.88	3.72				
P30	2.12	0.84					P32	1.22	2.05	99.90	0.25	26.92	
Mg27	0.35	0.40					H3			0.06	99.72	70.43	
H3	0.18	0.30	6.32	100.0	99.38		Si32				0.02	2.50	
Al26						100.0	Al26					0.14	100.0
Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	2.37E5	4.68E4	1.87E1	7.58E-5	2.78E-5	1.37E-5	Sv kg^{-1}	1.36E5	1.31E5	5.58E4	6.23E1	2.91E-1	6.51E-5
Al28	96.88	96.54					P32	49.00	50.75	99.88	0.12	14.69	
P30	1.60	1.89					Si31	47.95	48.54				
Na24	0.05	0.27	31.21				Al28	2.82	0.57				
P32			68.78*	10.41*	19.56*		H3	0.05	0.05	0.12	99.86	81.86	
Na22				64.57			Si32				0.03	3.43	
Al26				25.01	80.44	100.0	Al26						100.0
Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.30E5	1.27E5	7.93E4	3.89E2	3.49E0	3.72E-4		8.34E11	1.65E11	4.06E7	1.48E7	5.69E4	5.03E1
P32	72.52	74.36	99.48	0.03	1.73		Al28	95.92	95.31	57.22			
Si31	24.74	24.79					P30	2.59	3.04				
Al28	2.11	0.43					Si31	0.05	0.24				
H3	0.31	0.32	0.51	99.13	42.20		Na24	0.01	0.06	4.16			
P30	0.27	0.06					P32		0.02				
Na24	0.03	0.02					H3			38.61	99.99	99.66	
Si32				0.85	56.06		Si32					0.21	
Al26						100.0	Al26						100.0

Phosphorus

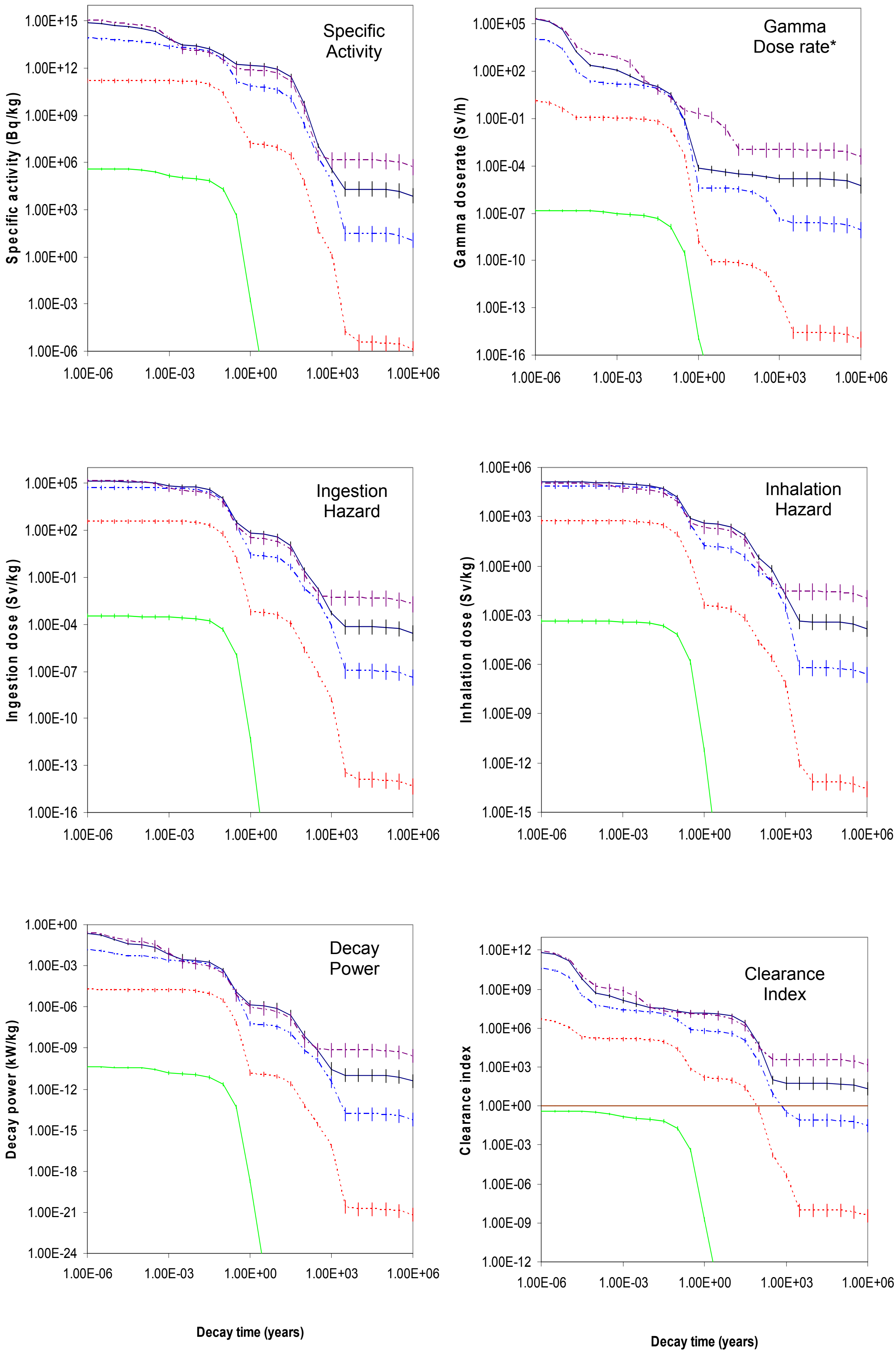
Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Al28	2.241 m	P31(n,α)Al28				94.9	51.4	28.0	79.7
		P31(n,t)Si29(n,d)Al28					35.5	35.7	8.7
		P31(n,d)Si30(n,2n)Si29(n,d)Al28					4.1	0.6	
		P31(n,d)Si30(n,t)Al28					3.9	26.9	7.9
		P31(n,d)Si30(n,d)Al29(β⁻)Si29(n,d)Al28					1.4	0.4	
		P31(n,2n)P30(β⁺)Si30(n,t)Al28					0.6	4.1	1.3
		P31(n,h)Al29(β⁻)Si29(n,d)Al28					0.3	1.7	0.7
P30	2.50 m	P31(n,2n)P30				98.7	99.5	99.7	99.8
Si31	2.62 h	P31(n,γ)P32(β⁻)S32(n,γ)S33(n,α)Si30(n,γ)_ Si31	97.5	97.6	1.8				
		P31(n,γ)P32(n,γ)P33(β⁻)S33(n,α)Si30(n,γ)_ Si31	1.7	1.6	0.1				
		P31(n,p)Si31				99.9	99.9	100.0	100.0
		P31(n,γ)P32(β⁻)S32(n,α)Si29(n,γ)Si30_ (n,γ)Si31	0.7	0.8	98.1				
Na24	14.96 h	**&**P31(n,nα)Al27(n,α)*Na24*				81.3	14.3	1.8	4.8
		&P31(n,d)Si30(n,α)Mg27(β⁻)Al27(n,α)*Na24*				11.6			
		&P31(n,α)Al28(β⁻)Si28(n,d)Al27(n,α)*Na24*				4.4			
		&P31(n,α)Al28(β⁻)Si28(n,α)Mg25(n,d)*Na24*				0.8			
		&P31(n,2α)*Na24*					75.7	62.4	17.5
		&P31(n,t)Si29(n,nα)Mg25(n,d)*Na24*					1.8	0.8	0.4
		&P31(n,nt)Si28(n,pα)*Na24*					0.4	1.8	2.3
		&P31(n,dα)Mg26(n,t)*Na24*						17.0	18.5
		&P31(n,t)Si29(n,dα)*Na24*						5.3	18.6
		&P31(n,2nα)Al26m(β⁺)Mg26(n,t)*Na24*						0.8	2.8
		&P31(n,2nα)Al26(n,h)*Na24*						0.7	1.4
		&P31(n,tα)Mg25(n,d)*Na24*						0.4	12.3
		&P31(n,h)Al29(β⁻)Si29(n,dα)*Na24*						0.2	1.5
		&P31(n,d)Si30(n,tα)*Na24*							5.3
P32	14.27 d	P31(n,γ)P32	100.0	100.0	100.0	95.3	98.6	99.2	99.5
S35	87.32 d	P31(n,γ)P32(β⁻)S32(n,γ)S33(n,γ)S34(n,γ)_ S35	97.8	98.1	92.6	95.1	97.4	97.8	97.5
		P31(n,γ)P32(n,γ)P33(β⁻)S33(n,γ)S34(n,γ)_ S35	1.8	1.9	5.9	3.2	2.1	1.9	2.2
		P31(n,γ)P32(n,γ)P33(n,γ)P34(β⁻)S34(n,γ)S35			1.5	0.1	0.1		0.1
Na22	2.60 y	P31(n,nα)Al27(n,nα)Na23(n,2n)Na22				57.4	47.2	0.7	
		P31(n,nα)Al27(n,2n)Al26(n,nα)Na22				23.2	36.7	0.6	
		P31(n,d)Si30(n,α)Mg27(β⁻)Al27(n,nα)_ Na23(n,2n)Na22				5.1			
		P31(n,α)Al28(β⁻)Si28(n,nα)Mg24(n,d)_ Na23(n,2n)Na22				2.6			
		P31(n,d)Si30(n,α)Mg27(β⁻)Al27(n,2n)_ Al26(n,nα)Na22				2.1			
		P31(n,α)Al28(β⁻)Si28(n,d)Al27(n,nα)_ Na23(n,2n)Na22				2.0			
		P31(n,nα)Al27(n,α)Na24(β⁻)Mg24(n,d)_ Na23(n,2n)Na22				1.4			
		P31(n,nα)Al27(n,pα)Ne23(β⁻)Na23_ (n,2n)Na22				1.4			
		P31(n,nα)Al27(n,d)Mg26(n,α)Ne23(β⁻)_ Na23(n,2n)Na22				1.1			
		P31(n,α)Al28(β⁻)Si28(n,d)Al27(n,2n)_ Al26(n,nα)Na22				0.8			
		&P31(n,2α)*Na24*(β⁻)Mg24(n,t)Na22					4.2	9.9	0.7
		P31(n,pα)Mg27(β⁻)Al27(n,nα)Na23(n,2n)Na22					2.7		
	►	P31(n,pα)Mg27(β⁻)Al27(n,2n)Al26(n,nα)Na22					2.1		

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**P31(n,2α)*Na24*(β^-)Mg24(n,d)Na23_ (n,2n)Na22					1.8		
		P31(n,nα)Al27(n,pα)Ne23(β^-)Na23(n,2n)Na22					1.4		
		P31(n,t)Si29(n,2nα)Mg24(n,t)Na22					0.2	4.6	1.0
		P31(n,nα)Al27(n,2nα)Na22						41.5	10.1
		P31(n,2nα)Al26(n,nα)Na22						19.8	3.2
		P31(n,n2α)Na23(n,2n)Na22						7.5	2.3
		P31(n,pα)Mg27(β^-)Al27(n,2nα)Na22						2.4	0.4
		P31(n,t)Si29(n,t)Al27(n,2nα)Na22						2.3	0.6
		P31(n,dα)Mg26(n,3n)Mg24(n,t)Na22						2.0	0.4
		P31(n,tα)Mg25(n,nt)Na22						0.2	13.6
		P31(n,2n2α)Na22							41.4
		P31(n,nt)Si28(n,tα)Na22							9.8
		P31(n,α)Al28(β^-)Si28(n,tα)Na22							3.4
		P31(n,ntα)Mg24(n,t)Na22							2.5
		P31(n,dα)Mg26(n,2nt)Na22							1.2
H3	12.33 y	P31(n,X)H3				99.0	96.6	95.9	96.0
		P31(n,nα)Al27(n,X)H3				0.2	0.7	0.4	0.2
		P31(n,d)Si30(n,X)H3					1.3	1.3	1.0
		P31(n,t)Si29(n,X)H3					0.6	1.4	1.2
Si32	132.0 y	P31(n,γ)P32(n,p)Si32	100.0	100.0	100.0	97.0	99.3	99.7	99.8
		P31(n,p)Si31(n,γ)Si32				1.5	0.8	0.8	1.0
C14	5700 y	P31(n,α)Al28(β^-)Si28(n,nα)Mg24(n,α)_ Ne21(n,2α)C14				36.4			
		&P31(n,nα)Al27(n,α)*Na24*(β^-)Mg24_ (n,α)Ne21(n,2α)C14				27.5			
		P31(n,α)Al28(β^-)Si28(n,α)Mg25(n,nα)_ Ne21(n,2α)C14				21.7			
		P31(n,α)Al28(β^-)Si28(n,α)Mg25(n,2n)_ Mg24(n,α)Ne21(n,2α)C14				4.5			
		P31(n,α)Al28(β^-)Si28(n,nα)Mg24(n,α)_ Ne21(n,α)O18(n,nα)C14				0.5			
		P31(n,nα)Al27(n,α)Na24(β^-)Mg24(n,α)_ Ne21(n,nα)O17(n,α)C14				0.5			
		&P31(n,nα)Al27(n,α)*Na24*(β^-)Mg24_ (n,α)Ne21(n,α)O18(n,nα)C14				0.4			
		P31(n,α)Al28(β^-)Si28(n,α)Mg25(n,nα)_ Ne21(n,α)O18(n,nα)C14				0.3			
		P31(n,α)Al28(β^-)Si28(n,nα)Mg24(n,nα)_ Ne20(n,α)O17(n,α)C14				0.2			
		P31(n,nα)Al27(n,nα)Na23(n,t)Ne21(n,2α)C14				0.1	2.0		
		P31(n,nα)Al27(n,nα)Na23(n,nα)F19_ (n,dα)C14					13.6	0.3	
		P31(n,t)Si29(n,2α)Ne22(n,n2α)C14					9.7	4.5	0.2
		P31(n,nα)Al27(n,nα)Na23(n,n2α)N15(n,d)C14					9.6	0.3	
		P31(n,dα)Mg26(n,nα)Ne22(n,n2α)C14					6.4	11.2	0.8
		P31(n,nα)Al27(n,nα)Na23(n,d)Ne22_ (n,n2α)C14					6.3	0.2	
		P31(n,d)Si30(n,nα)Mg26(n,nα)Ne22_ (n,n2α)C14					5.9	0.2	
		P31(n,nα)Al27(n,dα)Ne22(n,n2α)C14					5.2	11.0	1.0
		P31(n,t)Si29(n,nα)Mg25(n,nα)Ne21(n,2α)C14					3.0		
		P31(n,nα)Al27(n,d)Mg26(n,nα)Ne22_ (n,n2α)C14					2.1		
		P31(n,nα)Al27(n,t)Mg25(n,nα)Ne21(n,2α)C14					2.0		
		P31(n,n2α)Na23(n,d2α)C14						5.7	11.8
		P31(n,nα)Al27(n,n2α)F19(n,dα)C14						4.9	1.1
		P31(n,n2α)Na23(n,n2α)N15(n,d)C14						4.7	0.7
		P31(n,dα)Mg26(n,2nα)Ne21(n,2α)C14						4.7	0.2
		P31(n,n2α)Na23(n,nα)F19(n,dα)C14						4.1	1.1
	►	P31(n,n2α)Na23(n,d)Ne22(n,n2α)C14						2.6	0.5

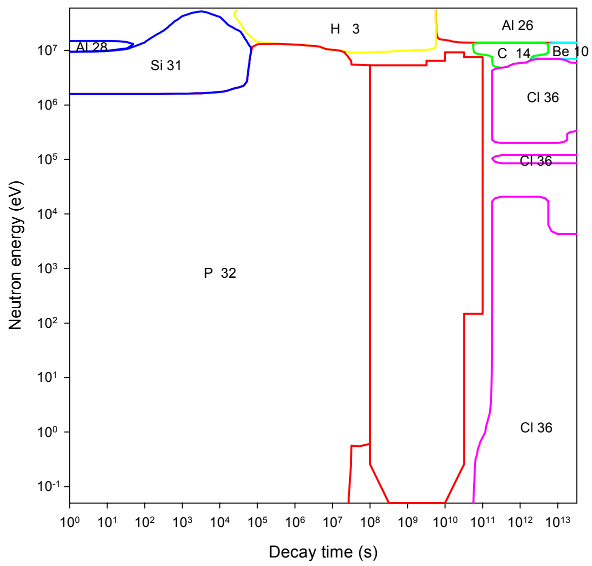
Nuclide	$T_{1/2}$	Pathway	210	186	151	42	30	21	6
	◄	P31(n,tα)Mg25(n,3α)C14						1.4	14.0
		P31(n,dα)Mg26(n,n3α)C14							23.0
		P31(n,2nα)Al26m(β^+)Mg26(n,n3α)C14							3.6
		P31(n,tα)Mg25(n,tα)F19(n,dα)C14							3.2
		P31(n,tα)Mg25(n,2n2α)O16(n,h)C14							2.6
Cl36	3.0 10^5 y	P31(n,γ)P32(β^-)S32(n,γ)S33(n,γ)S34(n,γ)_ S35(β^-)Cl35(n,γ)Cl36	97.2	97.0		93.7	96.1		
		P31(n,γ)P32(n,γ)P33(β^-)S33(n,γ)S34(n,γ)_ S35(β^-)Cl35(n,γ)Cl36	2.7	2.9		5.0	3.3		
Al26	7.2 10^5 y	P31(n,nα)Al27(n,2n)Al26				85.7	93.2	3.8	1.0
		P31(n,d)Si30(n,α)Mg27(β^-)Al27(n,2n)Al26				9.6	0.2		
		P31(n,α)Al28(β^-)Si28(n,d)Al27(n,2n)Al26				3.7	0.1		
		P31(n,pα)Mg27(β^-)Al27(n,2n)Al26					5.4	0.2	
		P31(n,α)Al28(β^-)Si28(n,t)Al26					0.1	0.3	1.7
		P31(n,2nα)Al26						93.1	88.7
		P31(n,nt)Si28(n,t)Al26						1.2	4.9
		P31(n,t)Si29(n,nt)Al26						0.4	2.7
Be10	1.6 10^6 y	P31(n,α)Al28(β^-)Si28(n,nα)Mg24(n,nα)_ Ne20(n,2α)C13(n,α)Be10				33.5			
		&P31(n,nα)Al27(n,α)*Na24*(β^-)Mg24_ (n,nα)Ne20(n,2α)C13(n,α)Be10				25.3			
		P31(n,nα)Al27(n,nα)Na23(n,α)F20(β^-)_ Ne20(n,2α)C13(n,α)Be10				6.2			
		P31(n,α)Al28(β^-)Si28(n,nα)Mg24(n,α)_ Ne21(n,nα)O17(n,nα)C13(n,α)Be10				5.3			
		&P31(n,nα)Al27(n,α)*Na24*(β^-)Mg24_ (n,α)Ne21(n,nα)O17(n,nα)C13(n,α)Be10				4.0			
		P31(n,α)Al28(β^-)Si28(n,α)Mg25(n,2n)_ Mg24(n,nα)Ne20(n,2α)C13(n,α)Be10				3.4			
		P31(n,α)Al28(β^-)Si28(n,nα)Mg24(n,nα)_ Ne20(n,nα)O16(n,α)C13(n,α)Be10				3.3			
		P31(n,α)Al28(β^-)Si28(n,α)Mg25(n,nα)_ Ne21(n,nα)O17(n,nα)C13(n,α)Be10				3.2			
		&P31(n,nα)Al27(n,α)*Na24*(β^-)Mg24_ (n,nα)Ne20(n,nα)O16(n,α)C13(n,α)Be10				2.5			
		P31(n,α)Al28(β^-)Si28(n,nα)Mg24(n,nα)_ Ne20(n,α)O17(n,nα)C13(n,α)Be10				1.3			
		&P31(n,nα)Al27(n,α)*Na24*(β^-)Mg24_ (n,nα)Ne20(n,α)O17(n,nα)C13(n,α)Be10				1.0			
		P31(n,nα)Al27(n,nα)Na23(n,α)F20(β^-)_ Ne20(n,nα)O16(n,α)C13(n,α)Be10				0.6			
		&P31(n,2α)*Na24*(β^-)Mg24(n,2α)O17_ (n,2α)Be10					41.8	1.4	
		P31(n,nα)Al27(n,nα)Na23(n,n2α)N15_ (n,nα)B11(n,d)Be10					4.5		
		P31(n,nα)Al27(n,nα)Na23(n,nα)F19_ (n,dα)C14(n,nα)Be10					3.1		
		P31(n,t)Si29(n,2α)Ne22(n,n2α)C14(n,nα)Be10					2.8	0.6	
		P31(n,nα)Al27(n,nα)Na23(n,n2α)N15_ (n,d)C14(n,nα)Be10					2.2		
		P31(n,n2α)Na23(n,n2α)N15(n,dα)Be10						26.2	10.8
		P31(n,2nα)Al26(n,3α)N15(n,dα)Be10						5.1	1.4
		P31(n,n2α)Na23(n,2nα)F18(β^+)O18_ (n,n2α)Be10						4.8	2.0
		P31(n,dα)Mg26(n,n2α)O18(n,n2α)Be10						4.7	2.3
		P31(n,n2α)Na23(n,dα)O18(n,n2α)Be10						3.9	1.9
		P31(n,nα)Al27(n,n3α)N15(n,dα)Be10							8.4
		P31(n,tα)Mg25(n,t2α)N15(n,dα)Be10							5.8
		P31(n,tα)Mg25(n,2n2α)O16(n,hα)Be10							2.6

Phosphorus activation characteristics

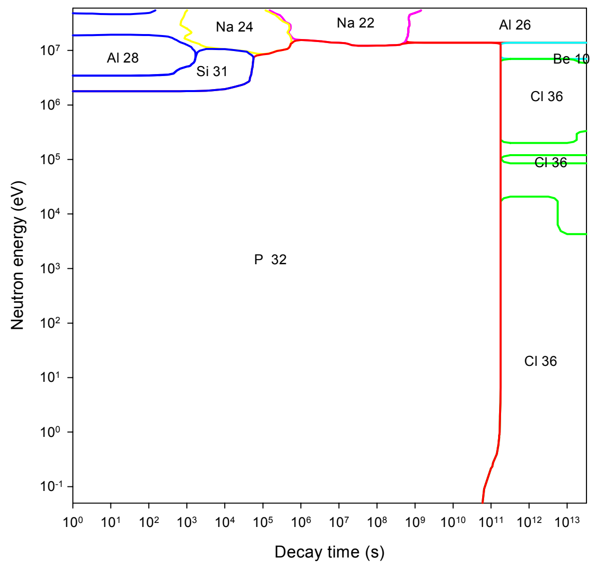


Phosphorus importance diagrams & transmutation

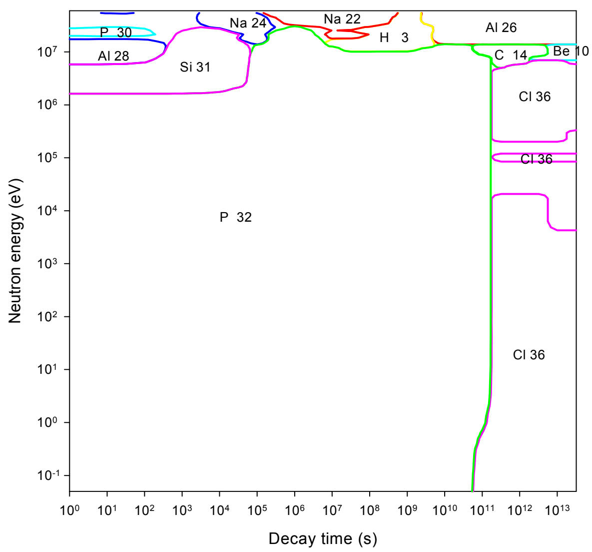
Activity



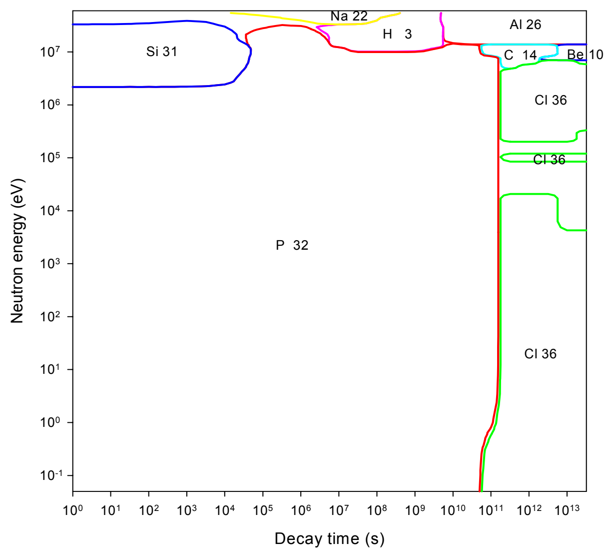
Dose rate



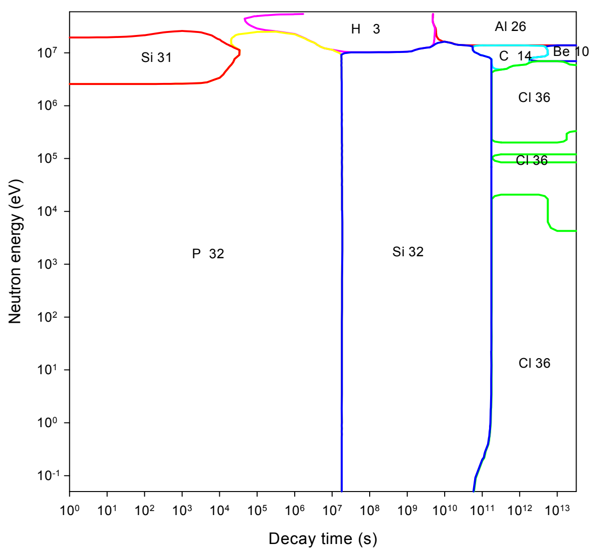
Heat output



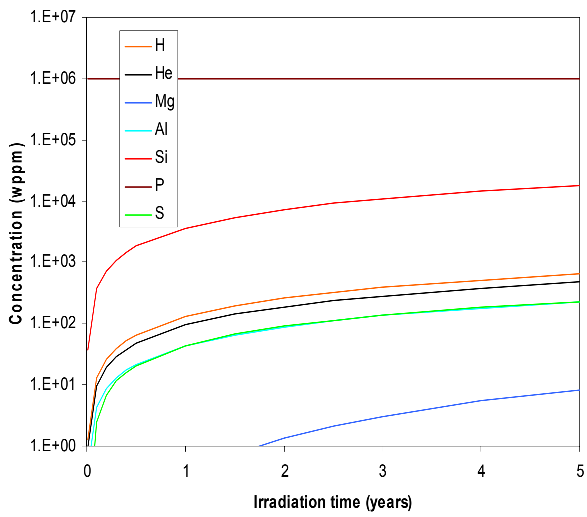
Ingestion dose



Inhalation dose



First wall transmutation



Sulphur

General properties

		Isotopes	Isotopic abundances / %
Atomic number	16		
Crustal abundance / wppm	260	S32	95.02
Melting point / K	386.0	S33	0.75
Boiling point / K	717.8	S34	4.21
Density / kgm^{-3}	2070	S36	0.02
Thermal conductivity / $Wm^{-1}K^{-1}$	$2.69\ 10^{-1}$		
Electrical resistivity /Ωm	$2.0\ 10^{15}$		
Coefficient of thermal expansion / K^{-1}	$7.433\ 10^{-5}$		
Crystal structure	orthorhombic		
Number of stable isotopes	4		
Mean atomic weight	32.066		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.02E15	1.00E15	8.13E14	1.87E11	2.05E9	1.17E5	kW kg^{-1}	1.18E-1	1.11E-1	8.95E-2	8.31E-7	9.92E-8	5.22E-12
P32	94.40	95.98	98.85	0.74	39.52		P32	90.61	96.45	99.88	18.53	91.12	
Si31	2.72	2.70					P34	3.57					
P34	0.98						Al28	2.42	0.51				
P33	0.87	0.88	0.98				Si31	2.24	2.33				
Al28	0.58						S35			0.01	66.80		
S35	0.13	0.13	0.15	38.10			H3				12.37	0.39	
H3	0.01	0.02	0.01	60.21	20.96		Si32				1.70	8.48	
Si32				0.73	39.51		Cl36						97.50
Cl36						99.77	Al26						2.50

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	6.10E3	1.93E3	5.15E2	8.95E-4	5.21E-4	1.95E-7	Sv kg^{-1}	2.31E6	2.31E6	1.93E6	6.37E1	2.42E0	1.09E-4
Al28	55.70	44.35					P32	99.67	99.68	99.85	5.21	80.48	
Al29	20.45	41.40					Si31	0.19	0.19				
P34	18.48						S35	0.04	0.04	0.05	86.01		
P32	3.30*	12.49*	99.96*	97.28*	99.87*		H3				7.42	0.74	
Na22				2.64			Si32				1.20	18.77	
Al26				0.75	0.14	99.81	Cl36						99.15
Cl36						0.19*	Al26						0.85

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	3.28E6	3.28E6	2.75E6	3.20E2	9.21E1	8.54E-4		2.31E10	5.84E9	8.25E8	1.85E6	1.07E4	1.17E2
P32	99.45	99.45	99.47	1.47	3.0		Al28	49.09	38.09				
P33	0.42	0.40	0.44	0.19			P34	25.45					
S35	0.07	0.07	0.09	42.26			Al29	19.10	43.35				
Si31	0.07	0.07					P32	4.16	16.42	97.36	0.07	7.60	
Si32				46.94	96.88		Si31	0.12	0.46				
H3				9.14	0.12		S35	0.06	0.22	1.52	38.52		
Cl36						99.38	P33	0.04	0.15	0.97	0.02		
Al26						0.62	H3			0.14	60.85	40.33	
							Si32				0.49	50.69	
							Cl36						99.39
							Al26						0.61

Sulphur

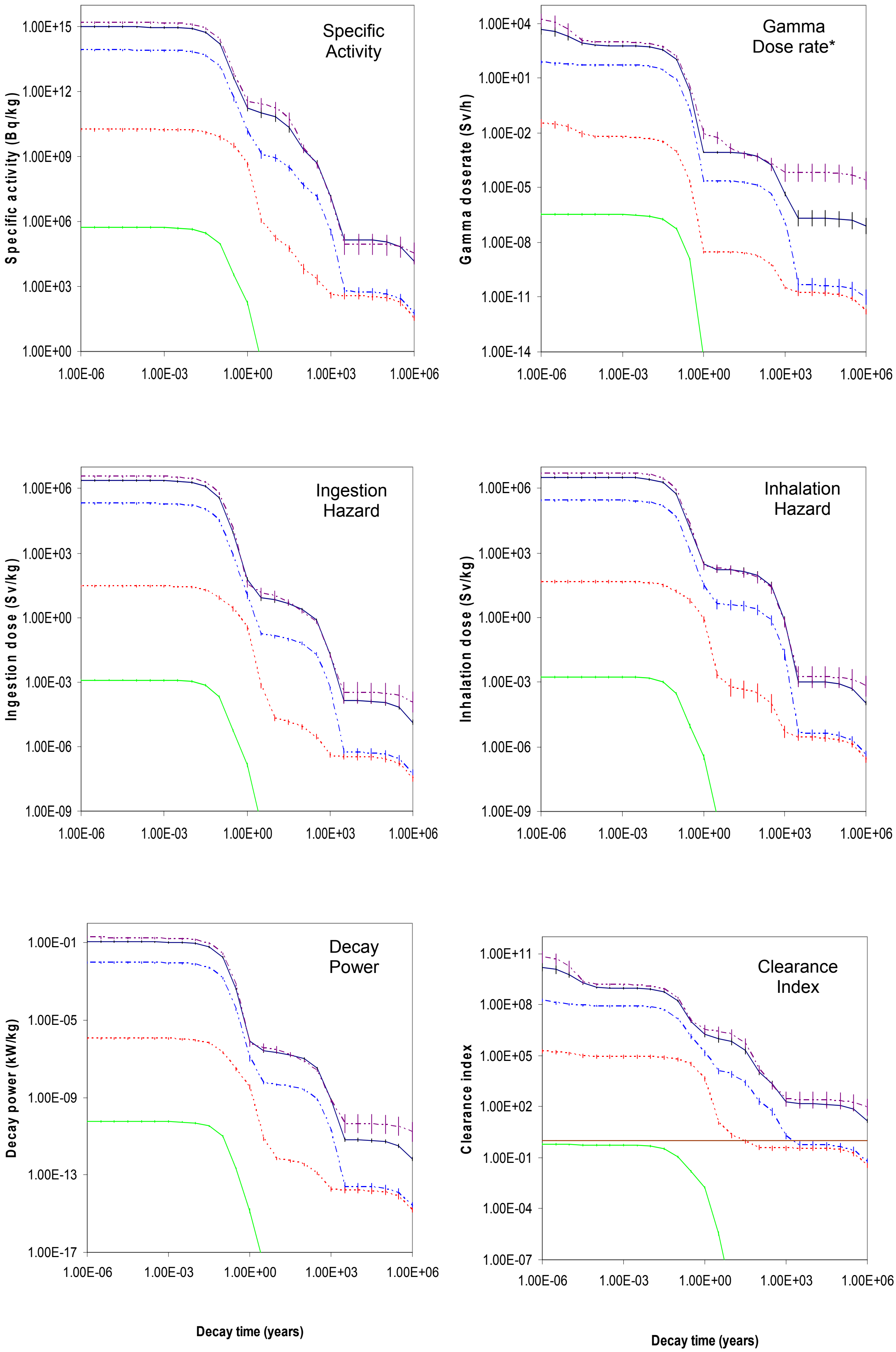
Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Al28	2.241 m	S32(n,nα)Si28(n,p)Al28				53.7	2.7	1.2	0.6
		S32(n,d)P31(n,α)Al28				36.0	1.2	0.8	4.3
		S32(n,α)Si29(n,d)Al28				3.6	2.6	2.9	13.6
		S32(n,α)Si29(n,2n)Si28(n,p)Al28				2.5			
		S32(n,pα)Al28					90.0	67.4	44.3
		S32(n,h)Si30(n,t)Al28					0.5	16.1	17.7
		S32(n,t)P30(β^+)Si30(n,t)Al28						7.0	11.1
P30	2.50 m	S32(n,d)P31(n,2n)P30				90.2	25.0	1.5	0.6
		S32(n,t)P30				4.1	72.0	97.6	98.3
		S34(n,α)Si31(β^-)P31(n,2n)P30				1.8			
		S32(n,2p)Si31(β^-)P31(n,2n)P30				1.4	1.7		
S37	4.99 m	S36(n,γ)S37	99.7	100.0	100.0	99.1	98.9	99.3	99.7
Al29	6.56 m	S32(n,α)Si29(n,p)Al29				96.7	2.6	1.1	2.6
		S32(n,d)P31(n,d)Si30(n,d)Al29				0.2	7.0	1.3	0.4
		S32(n,h)Si30(n,d)Al29					72.5	58.4	31.0
		S32(n,t)P30(β^+)Si30(n,d)Al29					6.4	25.3	19.5
		S34(n,nα)Si30(n,d)Al29					3.5	0.8	0.4
		S32(n,d)P31(n,h)Al29					1.5	6.1	5.4
		S34(n,dα)Al29						2.2	6.5
		S32(n,ph)Al29						1.5	31.9
Cl38	37.2 m	**&**S34(n,γ)S35(β^-)Cl35(n,γ)Cl36(n,γ)Cl37_ (n,γ)*Cl38*	94.4	0.4					
		&S36(n,γ)S37(β^-)Cl37(n,γ)*Cl38*	4.2	98.1	98.5	87.9	87.9	87.8	88.1
Si31	2.62 h	S32(n,γ)S33(n,α)Si30(n,γ)Si31	63.3	6.3	0.3				
		S33(n,α)Si30(n,γ)Si31	36.3	93.6	83.9				
		S32(n,α)Si29(n,γ)Si30(n,γ)Si31	0.5		15.8				
		S34(n,α)Si31				40.1	0.6	1.8	17.0
		S32(n,2p)Si31				30.0	90.8	87.1	74.4
		S32(n,d)P31(n,p)Si31				26.5	6.8	7.0	3.9
		S33(n,h)Si31					0.1	2.0	3.0
Na24	14.96 h	**&**S32(n,nα)Si28(n,d)Al27(n,α)*Na24*				45.8	1.3	0.2	0.2
		&S32(n,nα)Si28(n,nα)Mg24(n,p)*Na24*				15.3	0.8	0.1	
		&S32(n,d)P31(n,nα)Al27(n,α)*Na24*				9.2	0.8		
		&S32(n,nα)Si28(n,α)Mg25(n,d)*Na24*				8.1	0.5	0.2	0.6
		&S32(n,nα)Si28(n,α)Mg25(n,2n)Mg24_ (n,p)*Na24*				3.1			
		&S32(n,α)Si29(n,2n)Si28(n,d)Al27(n,α)*Na24*				1.4			
		&S34(n,nα)Si30(n,α)Mg27(β^-)Al27(n,α)*Na24*				0.5			
		&S32(n,α)Si29(n,t)Al27(n,α)*Na24*				0.2			0.5
		&S32(n,nα)Si28(n,pα)*Na24*					46.6	34.7	4.2
		&S32(n,2α)Mg25(n,d)*Na24*					20.8	11.2	1.5
		&S32(n,d)P31(n,2α)*Na24*					8.4	8.2	0.8
		&S32(n,pα)Al28(β^-)Si28(n,pα)*Na24*					8.4	5.5	0.4
		&S32(n,dα)Al27(n,α)*Na24*					0.4	7.0	16.7
		&S32(n,α)Si29(n,dα)*Na24*						2.3	27.2
		&S32(n,h)Si30(n,tα)*Na24*						0.1	11.1
		&S32(n,t)P30(β^+)Si30(n,tα)*Na24*							6.9
P32	14.27 d	S32(n,γ)S33(n,α)Si30(n,γ)Si31(β^-)P31_ (n,γ)P32	44.4	0.6					
		S33(n,α)Si30(n,γ)Si31(β^-)P31(n,γ)P32	39.4	12.2	25.1				
		S34(n,γ)S35(β^-)Cl35(n,α)P32	16.5	87.5	72.3				
		S32(n,α)Si29(n,γ)Si30(n,γ)Si31(β^-)P31_ (n,γ)P32	0.3		3.2				
		S32(n,p)P32				98.9	90.4	73.1	63.3
		S33(n,d)P32				0.7	4.6	4.3	4.9
	►	S34(n,2n)S33(n,d)P32				0.2	1.5	0.7	0.5

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	S34(n,t)P32					2.2	20.9	30.5
P33	25.38 d	S34(n,γ)S35(β^-)Cl35(n,γ)Cl36(n,α)P33	55.2	0.5					
		S32(n,γ)S33(n,p)P33	35.5	11.9	0.7	0.3			
		S33(n,p)P33	10.1	87.9	99.3	29.4	1.8	1.6	1.1
		S34(n,d)P33				59.2	96.6	97.3	97.8
		S34(n,2n)S33(n,p)P33				8.9	0.6	0.3	0.1
S35	87.32 d	S34(n,γ)S35	98.3	100.0	100.0	10.9	12.2	11.6	8.9
		S32(n,γ)S33(n,γ)S34(n,γ)S35	0.5						
		S36(n,2n)S35				86.7	74.0	64.6	62.4
		S36(n,d)P35(β^-)S35				0.2	12.5	23.0	28.2
Na22	2.60 y	S32(n,α)Si29(n,α)Mg26(n,α)Ne23(β^-)_ Na23(n,2n)Na22				47.6			
		S32(n,nα)Si28(n,nα)Mg24(n,d)Na23_ (n,2n)Na22				19.1	8.6		
		S32(n,nα)Si28(n,d)Al27(n,nα)Na23(n,2n)Na22				14.4	6.0		
		S32(n,nα)Si28(n,d)Al27(n,2n)Al26(n,nα)Na22				5.8	4.7		
		S32(n,d)P31(n,nα)Al27(n,nα)Na23(n,2n)Na22				2.9	3.6		
		S32(n,nα)Si28(n,α)Mg25(n,2n)Mg24_ (n,d)Na23(n,2n)Na22				2.4			
		S32(n,d)P31(n,nα)Al27(n,2n)Al26(n,nα)Na22				1.2	2.8		
		S32(n,nα)Si28(n,nα)Mg24(n,t)Na22					27.8	3.6	0.8
		S32(n,2α)Mg25(n,t)Na23(n,2n)Na22					8.1	0.2	
		S32(n,nα)Si28(n,t)Al26(n,nα)Na22					4.9	1.0	0.2
		S32(n,pα)Al28(β^-)Si28(n,nα)Mg24(n,t)Na22					4.9	0.6	
		S32(n,dα)Al27(n,nα)Na23(n,2n)Na22					3.7	0.7	0.1
		S32(n,dα)Al27(n,2n)Al26(n,nα)Na22					2.8	0.6	
		S32(n,2α)Mg25(n,2n)Mg24(n,t)Na22					2.2	0.3	
		S32(n,n2α)Mg24(n,t)Na22					1.0	36.4	24.7
		S32(n,dα)Al27(n,2nα)Na22						44.6	31.0
		S32(n,nα)Si28(n,tα)Na22						0.3	15.3
		S32(n,tα)Al26(n,nα)Na22						0.2	3.8
H3	12.33 y	S34(n,γ)S35(β^-)Cl35(n,X)H1(n,γ)H2(n,γ)H3	49.4	2.6					
		S33(n,X)H1(n,γ)H2(n,γ)H3	22.8	89.6	99.1				
		S32(n,γ)S33(n,X)H1(n,γ)H2(n,γ)H3	20.1	3.1	0.2				
		S34(n,γ)S35(β^-)Cl35(n,γ)Cl36(n,X)H1_ (n,γ)H2(n,γ)H3	2.0						
		S32(n,d)P31(n,X)H3				49.7	4.7	2.1	1.2
		S32(n,X)H3				18.8	86.6	88.4	89.3
		S33(n,X)H3				11.5	1.4	1.0	0.9
		S32(n,α)Si29(n,X)H3				8.2	0.2	0.2	0.8
		S32(n,p)P32(n,X)H3				2.2			
		S32(n,X)He3(n,p)H3				1.8	0.2	0.2	0.1
		S34(n,2n)S33(n,X)H3				1.8	0.2		
		S34(n,X)H3				1.5	3.9	4.3	4.4
		S34(n,α)Si31(β^-)P31(n,X)H3				1.0			
		S32(n,h)Si30(n,X)H3					0.7	1.3	1.0
Si32	132.0 y	S32(n,γ)S33(n,α)Si30(n,γ)Si31(n,γ)Si32	38.6	3.6					
		S33(n,α)Si30(n,γ)Si31(n,γ)Si32	33.2	79.0	36.9				
		S33(n,α)Si30(n,γ)Si31(β^-)P31(n,γ)P32_ (n,p)Si32	10.4	0.9					
		S32(n,γ)S33(n,α)Si30(n,γ)Si31(β^-)P31_ (n,γ)P32(n,p)Si32	9.0						
		S34(n,γ)S35(β^-)Cl35(n,α)P32(n,p)Si32	8.3	9.6					
		S32(n,α)Si29(n,γ)Si30(n,γ)Si31(n,γ)Si32	0.3		4.7				
		S34(n,γ)S35(n,α)Si32	0.1	6.8	58.3				
		S32(n,p)P32(n,p)Si32				77.8	2.5	0.3	
		S33(n,2p)Si32				14.1	37.4	7.1	3.3
		S36(n,nα)Si32				3.4	6.0	1.0	0.5
		S34(n,2n)S33(n,2p)Si32				2.2	6.0	0.6	0.2
		S34(n,d)P33(n,d)Si32				0.8	3.0	0.6	0.2
		S34(n,d)P33(β^-)S33(n,2p)Si32				0.3	3.6	0.5	0.1
		S34(n,h)Si32					40.9	89.6	95.4

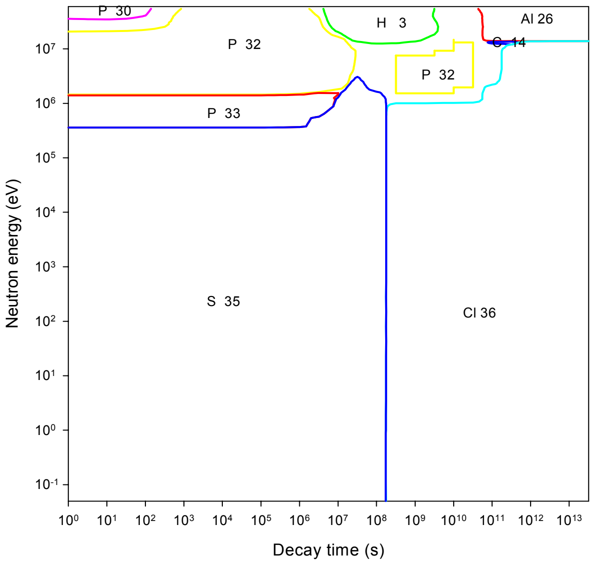
Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ar39	269.0 y	**&**S34(n,γ)S35(β^-)Cl35(n,γ)Cl36(n,γ)_ Cl37(n,γ)*Cl38*(β^-)Ar38(n,γ)Ar39	91.7	0.1					
		&S36(n,γ)S37(β^-)Cl37(n,γ)*Cl38*(β^-)_ Ar38(n,γ)Ar39	8.2	99.9	100.0	99.4	99.5	99.8	99.9
C14	5700 y	S32(n,nα)Si28(n,nα)Mg24(n,α)Ne21(n,2α)C14				51.1	0.4		
		S32(n,nα)Si28(n,α)Mg25(n,nα)Ne21(n,2α)C14				30.5	0.3		
		S32(n,nα)Si28(n,α)Mg25(n,2n)Mg24_ (n,α)Ne21(n,2α)C14				6.3			
		S32(n,nα)Si28(n,2α)Ne21(n,2α)C14					33.0	2.2	
		S32(n,2α)Mg25(n,nα)Ne21(n,2α)C14					22.8	0.9	
		S32(n,2α)Mg25(n,2α)O18(n,nα)C14					12.4	0.8	
		S32(n,2α)Mg25(n,3α)C14					7.1	14.6	2.3
		S32(n,pα)Al28(β^-)Si28(n,2α)Ne21(n,2α)C14					5.9	0.4	
		S32(n,dα)Al27(n,dα)Ne22(n,n2α)C14						15.7	4.9
		S32(n,n2α)Mg24(n,n2α)O16(n,h)C14						8.5	4.2
		S32(n,dα)Al27(n,n2α)F19(n,dα)C14						7.1	5.4
		S32(n,n2α)Mg24(n,dα)F19(n,dα)C14						6.7	5.5
		S32(n,n2α)Mg24(n,h)Ne22(n,n2α)C14						5.5	1.9
		S32(n,dα)Al27(n,t)Mg25(n,3α)C14						2.2	1.0
		S32(n,3α)Ne21(n,2α)C14						0.2	2.0
		S32(n,tα)Al26m(β^+)Mg26(n,n3α)C14							4.4
		S32(n,nα)Si28(n,n3α)O16(n,h)C14							2.9
		S32(n,dα)Al27(n,n3α)N15(n,d)C14							2.7
		S32(n,hα)Mg26(n,n3α)C14							2.5
		S32(n,n3α)Ne20(n,hα)C14							2.3
Cl36	$3.0\ 10^5$ y	S34(n,γ)S35(β^-)Cl35(n,γ)Cl36	99.7	100.0	100.0	6.6	4.2	4.6	3.8
		S36(n,2n)S35(β^-)Cl35(n,γ)Cl36				52.7	25.6	26.1	26.4
		S36(n,γ)S37(β^-)Cl37(n,2n)Cl36				40.3	65.6	59.8	57.8
Al26	$7.2\ 10^5$ y	S32(n,nα)Si28(n,d)Al27(n,2n)Al26				76.8	28.4	0.7	
		S32(n,d)P31(n,nα)Al27(n,2n)Al26				15.5	16.9	0.3	
		S32(n,α)Si29(n,2n)Si28(n,d)Al27(n,2n)Al26				1.8			
		S34(n,nα)Si30(n,α)Mg27(β^-)Al27(n,2n)Al26				0.9			
		S32(n,α)Si29(n,t)Al27(n,2n)Al26				0.3	0.6	0.1	
		S32(n,nα)Si28(n,t)Al26					23.6	41.9	6.2
		S32(n,dα)Al27(n,2n)Al26					13.8	26.3	2.4
		S32(n,pα)Al28(β^-)Si28(n,d)Al27(n,2n)Al26					5.1	0.1	
		S32(n,pα)Al28(β^-)Si28(n,t)Al26					4.2	6.6	0.6
		S32(n,d)P31(n,2nα)Al26						11.8	1.6
		S32(n,tα)Al26						7.2	84.2
		S32(n,α)Si29(n,nt)Al26						0.3	2.9

Sulphur activation characteristics

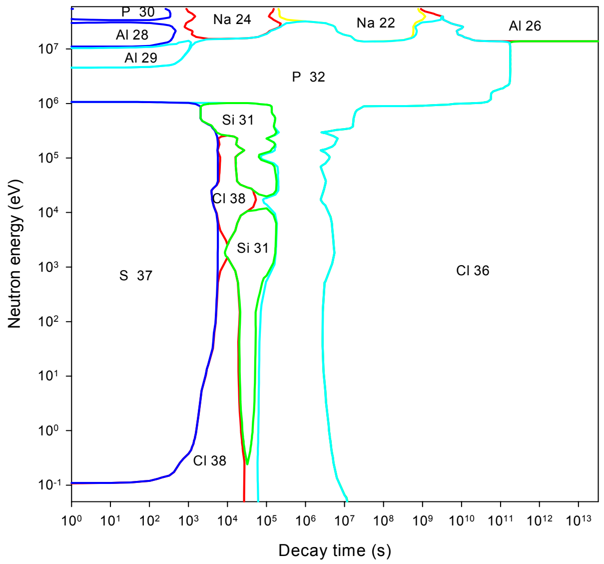


Sulphur importance diagrams & transmutation

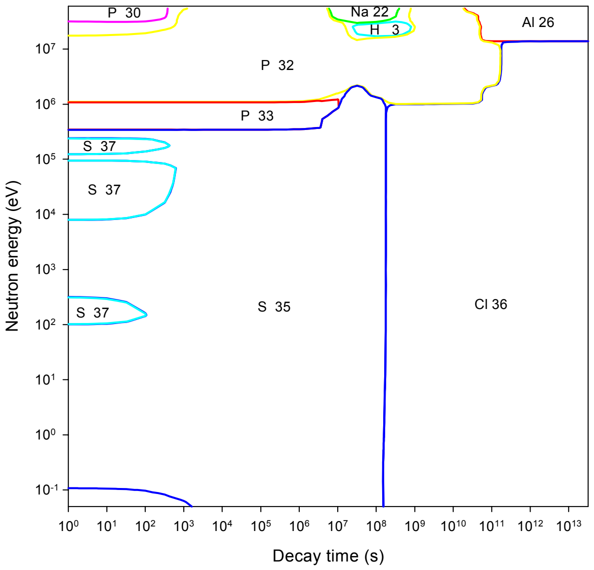
Activity



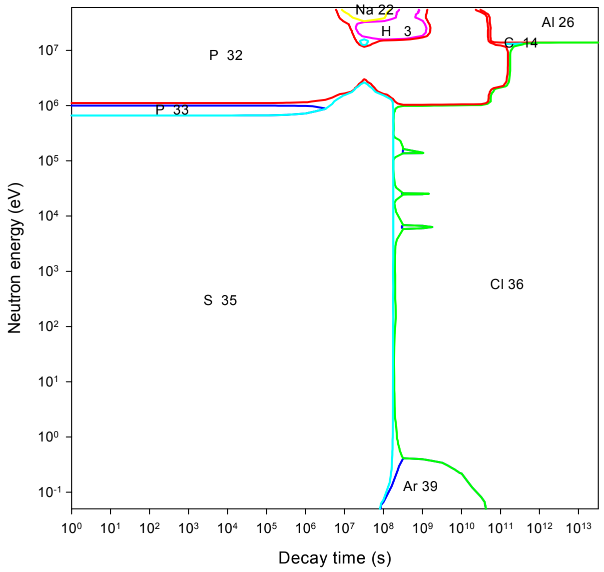
Dose rate



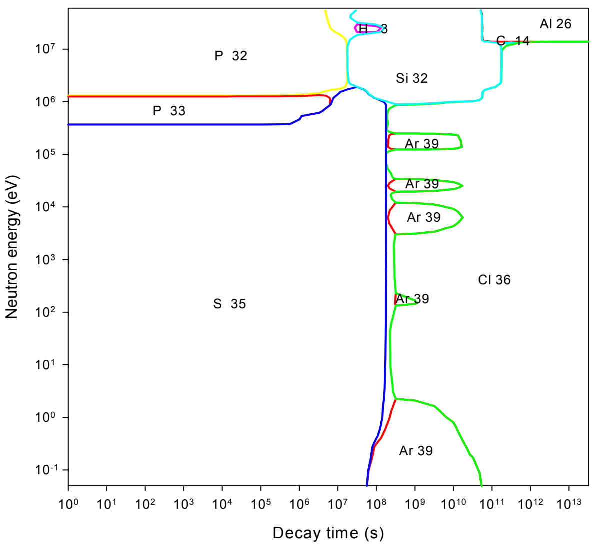
Heat output



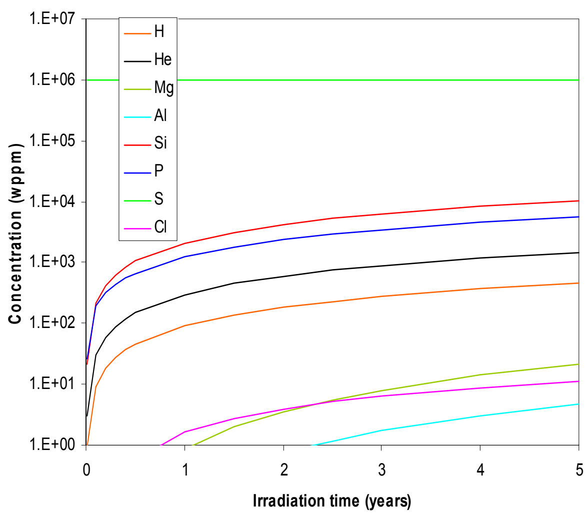
Ingestion dose



Inhalation dose



First wall transmutation



Chlorine

General properties

		Isotopes	Isotopic abundances / %
Atomic number	17		
Crustal abundance / wppm	130	Cl35	75.77
Melting point / K	172.2	Cl37	24.23
Boiling point / K	239.2		
Density / kgm^{-3}	3.214		
Thermal conductivity / $Wm^{-1}K^{-1}$	$8.9\ 10^{-3}$		
Electrical resistivity /Ωm	-		
Coefficient of thermal expansion / K^{-1}	-		
Crystal structure	tetragonal		
Number of stable isotopes	2		
Mean atomic weight	35.4527		

Activation properties

Act	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Bq kg^{-1}	1.12E15	1.08E15	9.68E14	3.87E13	2.85E10	1.94E10
S35	61.75	64.02	69.36	98.25		
P32	30.09	31.19	29.14		2.59	
P34	2.07					
S37	1.56					
P33	1.37	1.42	1.43			
H3	0.06	0.06	0.07	1.68	8.75	
Cl36				0.06	85.98	100.0
Si32					2.59	

Heat	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
kW kg^{-1}	7.64E-2	5.83E-2	3.68E-2	2.99E-4	1.16E-6	8.51E-7
P32	49.04	64.30	85.30	0.05	7.05	
S37	13.61	8.60				
P34	12.78					
S35	7.06	9.26	14.24	99.39		
Cl38	6.61	7.86				
Cl34	4.71					
Cl34m	4.58	5.36				
Cl36				0.36	92.02	100.0

Dose	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv h^{-1}	3.19E4	1.82E4	1.76E2	1.89E-3	1.57E-3	8.78E-4
S37	54.03	45.67				
Cl34m	15.84	24.81				
Cl38	15.35	24.44				
P34	7.95					
Cl34	4.75	4.40				
P32	0.21*	0.37*	100.0*	75.49*	64.67*	
Cl36				24.40*	35.33*	100.0*

Ing	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	1.35E6	1.35E6	1.20E6	2.94E4	5.10E1	1.81E1
P32	59.97	59.98	56.52		3.47	
S35	39.48	39.49	43.17	99.70		
P33	2.72	2.72	0.27			
Ar39				0.11	50.94	
H3				0.09	0.21	
Cl36					44.58	100.0
Si32					0.81	

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	2.49E6	2.48E6	2.26E6	7.39E4	1.16E3	1.42E2
S35	52.82	52.83	56.49	97.77		
P32	46.06	46.06	42.47		0.22	
P33	9.23	9.30	0.92			
Cl38	0.02	0.02				
Ar39			0.05	1.57	77.36	
Cl36				0.24	15.38	100.0
H3				0.23	0.06	
Si32				0.18	6.99	

Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
	1.04E11	5.50E10	7.04E9	4.11E8	2.45E7	1.94E7
S37	50.52	46.16				
Cl34m	17.63	29.84				
P34	13.05					
Cl34	8.65	8.67				
S35	6.62	12.55	95.35	92.47		
Cl38		1.72				
P32		0.61	4.01			
Cl36		0.04	0.35	5.95	99.87	100.0
H3		0.01	0.09	1.58	0.10	
Si32					0.02	

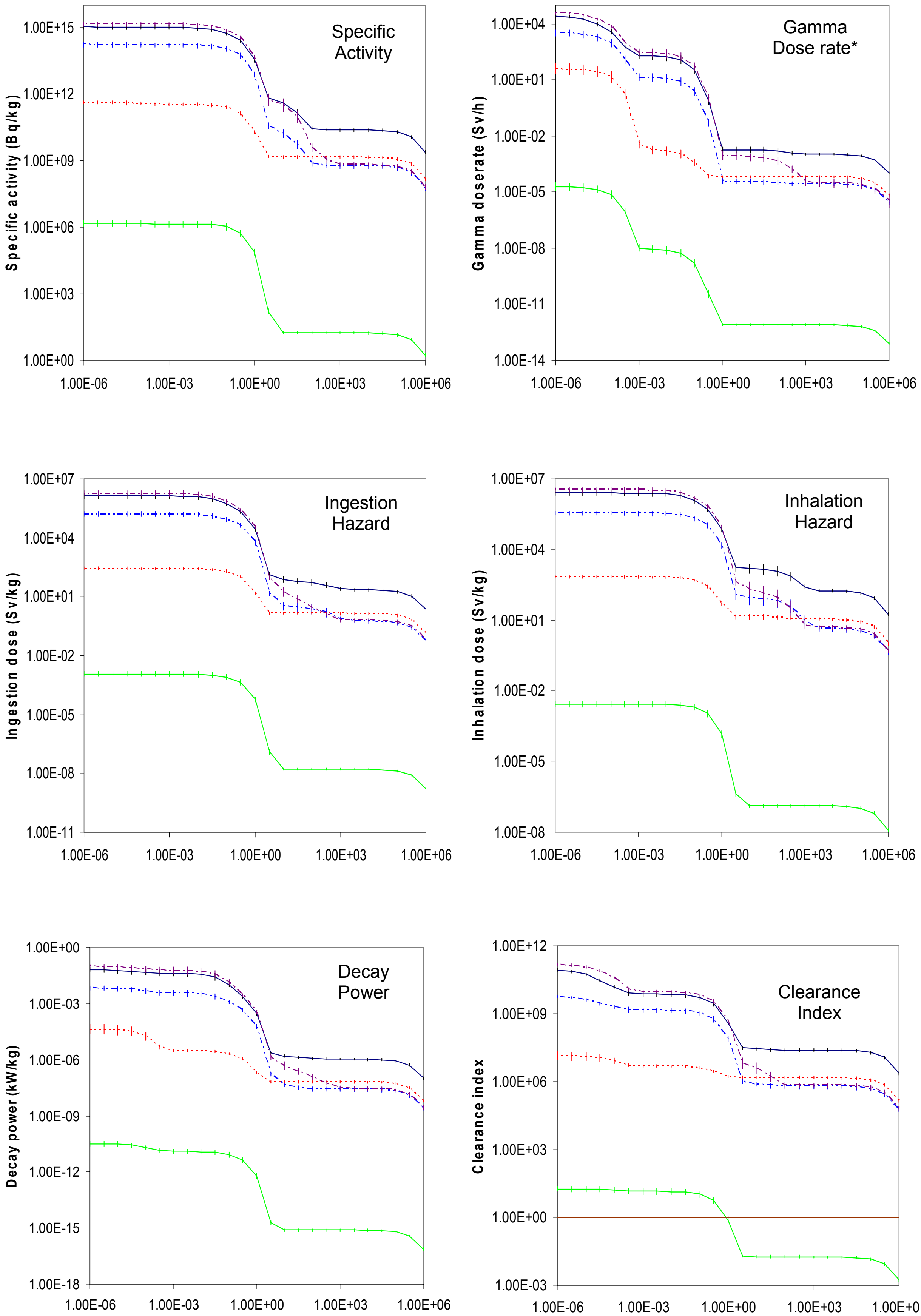
Chlorine

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
S37	4.99 m	Cl35(n,γ)Cl36(n,p)S36(n,γ)S37	97.8	99.0	3.7				
		Cl35(n,p)S35(n,γ)S36(n,γ)S37	0.6	0.4	96.1				
		Cl37(n,p)S37				100.0	99.9	99.9	100.0
Cl34m	32.1 m	Cl35(n,2n)Cl34m				98.1	98.3	97.6	91.8
		Cl37(n,4n)Cl34m							6.8
Cl38	37.2 m	Cl37(n,γ)Cl38	48.4	88.0	88.1	46.9	44.3	43.7	45.4
		&Cl35(n,γ)Cl36(n,γ)Cl37(n,γ)*Cl38*	44.7						
		Cl37(n,γ)Cl38m(IT)Cl38	6.6	11.9	11.9	52.4	55.7	56.3	54.6
Ar41	1.827 h	**&**Cl37(n,γ)*Cl38*(β^{-})Ar38(n,γ)Ar39(n,γ)_ Ar40(n,γ)Ar41	84.7	100.0	100.0	99.2	99.7		
		&Cl35(n,γ)Cl36(n,γ)Cl37(n,γ)*Cl38*(β^{-})_ Ar38(n,γ)Ar39(n,γ)Ar40(n,γ)Ar41	15.3						
K42	12.36 h	**&**Cl37(n,γ)*Cl38*(β^{-})Ar38(n,γ)Ar39(n,γ)_ Ar40(n,γ)Ar41(β^{-})K41(n,γ)K42	89.4	99.9					
		&Cl35(n,γ)Cl36(n,γ)Cl37(n,γ)*Cl38*(β^{-})_ Ar38(n,γ)Ar39(n,γ)Ar40(n,γ)Ar41(β^{-})_ K41(n,γ)K42	10.6						
Na24	14.96 h	**&**Cl35(n,nα)P31(n,nα)Al27(n,α)*Na24*				56.0	4.8	0.2	
		Cl35(n,d)S34(n,nα)Si30(n,α)Mg27(β^{-})_ Al27(n,α)Na24				6.0			
		Cl35(n,nα)P31(n,d)Si30(n,α)Mg27(β^{-})_ Al27(n,α)Na24				4.8			
		Cl35(n,α)P32(β^{-})S32(n,nα)Si28(n,d)_ Al27(n,α)Na24				3.9			
		&Cl35(n,nα)P31(n,2α)*Na24*					49.6	20.8	0.8
		&Cl35(n,2α)Al28(β^{-})Si28(n,pα)*Na24*					17.3	8.1	0.1
		&Cl35(n,pα)Si31(β^{-})P31(n,2α)*Na24*					5.7	1.9	
		&Cl35(n,t)S33(n,2nα)Si28(n,pα)*Na24*					1.2	3.4	
		&Cl35(n,dα)Si30(n,nα)Mg26(n,t)*Na24*					0.6	5.5	0.5
		&Cl35(n,dα)Si30(n,2nα)Mg25(n,d)*Na24*						5.9	0.5
		&Cl35(n,n2α)Al27(n,α)*Na24*						5.0	5.3
		&Cl35(n,tα)Si29(n,dα)*Na24*						2.6	30.4
		&Cl35(n,dα)Si30(n,tα)*Na24*						0.7	11.7
		&Cl35(n,3α)*Na24*						0.2	21.0
P32	14.27 d	Cl35(n,α)P32	97.2	99.9	100.0	92.9	40.8	22.9	70.6
		Cl37(n,2n)Cl36(n,nα)P32				1.1	9.2	1.2	0.3
		Cl35(n,d)S34(n,2n)S33(n,d)P32				0.5	2.6	0.3	
		Cl37(n,nα)P33(β^{-})S33(n,d)P32				0.2	4.2	0.6	0.1
		Cl35(n,t)S33(n,d)P32					21.6	14.9	4.8
		Cl35(n,d)S34(n,t)P32					7.7	16.6	5.4
		Cl37(n,2nα)P32					7.5	36.4	13.7
		Cl35(n,h)P33(β^{-})S33(n,d)P32					1.4	2.0	0.7
P33	25.38 d	Cl35(n,γ)Cl36(n,α)P33	99.1	100.0	100.0				
		Cl37(n,nα)P33				50.5	44.5	18.5	15.0
		Cl35(n,d)S34(n,d)P33				31.8	33.1	13.8	7.6
		Cl37(n,2n)Cl36(n,α)P33				11.1	0.4	0.2	0.5
		Cl35(n,d)S34(n,2n)S33(n,p)P33				2.4			
		Cl35(n,h)P33				0.1	15.1	61.6	70.5
		Cl37(n,nt)S34(n,d)P33						0.7	2.2
S35	87.32 d	Cl35(n,p)S35	100.0	99.9	100.0	92.7	58.4	29.5	22.1
		Cl37(n,d)S36(n,2n)S35				3.4	4.7	1.5	0.8
		Cl37(n,2n)Cl36(n,d)S35				3.2	6.4	1.9	1.1
		Cl37(n,t)S35				0.2	28.7	65.3	73.6
		Cl37(n,h)P35(β^{-})S35					0.2	0.8	1.7
Na22	2.60 y ►	Cl35(n,nα)P31(n,nα)Al27(n,nα)Na23_ (n,2n)Na22				43.7	26.2		

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Cl35(n,nα)P31(n,nα)Al27(n,2n)Al26(n,nα)Na22				17.7	20.4		
		Cl35(n,α)P32(β^-)S32(n,α)Si29(n,α)_ Mg26(n,α)Ne23(β^-)Na23(n,2n)Na22				8.0			
		Cl35(n,d)S34(n,nα)Si30(n,α)Mg27(β^-)_ Al27(n,nα)Na23(n,2n)Na22				3.8			
		Cl35(n,α)P32(β^-)S32(n,nα)Si28(n,nα)_ Mg24(n,d)Na23(n,2n)Na22				3.2			
		Cl35(n,nα)P31(n,d)Si30(n,α)Mg27(β^-)_ Al27(n,nα)Na23(n,2n)Na22				3.1			
		Cl35(n,pα)Si31(β^-)P31(n,nα)Al27(n,nα)_ Na23(n,2n)Na22				0.3	3.0		
		Cl35(n,2α)Al28(β^-)Si28(n,nα)Mg24(n,t)Na22					12.8	1.8	
		Cl35(n,2α)Al28(β^-)Si28(n,nα)Mg24(n,d)_ Na23(n,2n)Na22					4.0		
		Cl35(n,n2α)Al27(n,2nα)Na22						66.2	29.9
		Cl35(n,nα)P31(n,nα)Al27(n,2nα)Na22						3.2	0.5
		Cl35(n,tα)Si29(n,2nα)Mg24(n,t)Na22						1.3	4.4
		Cl35(n,ntα)Si28(n,tα)Na22							5.9
		Cl35(n,nα)P31(n,2n2α)Na22							3.6
H3	12.33 y	Cl35(n,X)H1(n,γ)H2(n,γ)H3	87.8	94.9	99.3				
		Cl35(n,γ)Cl36(n,X)H1(n,γ)H2(n,γ)H3	4.8	0.3					
		Cl35(n,X)H3				80.3	71.7	69.5	68.4
		Cl37(n,X)H3				11.8	22.2	24.5	26.3
		Cl37(n,2n)Cl36(n,X)H3				5.4	1.4	0.6	0.3
		Cl35(n,t)S33(n,X)H3					0.7	1.4	1.1
Si32	132.0 y	Cl35(n,α)P32(n,p)Si32	99.2	100.0	99.9	24.4	0.2		
		Cl35(n,p)S35(n,α)Si32			0.1	35.7	0.4		
		Cl37(n,d)S36(n,nα)Si32				28.8	38.8	3.6	0.8
		Cl37(n,2n)Cl36(n,pα)Si32				3.5	10.7	1.0	0.2
		Cl37(n,nα)P33(n,d)Si32				1.7	2.5	0.2	
		Cl35(n,t)S33(n,2p)Si32				0.1	15.3	4.2	0.9
		Cl35(n,d)S34(n,h)Si32					12.5	12.2	5.1
		Cl37(n,dα)Si32					8.3	67.0	50.3
		Cl35(n,ph)Si32						6.9	39.3
Ar39	269.0 y	**&**Cl37(n,γ)*Cl38*(β^-)Ar38(n,γ)Ar39	75.6	100.0	100.0	99.2	99.7	99.8	99.9
		&Cl35(n,γ)Cl36(n,γ)Cl37(n,γ)*Cl38*(β^-)_ Ar38(n,γ)Ar39	24.3						
Cl36	3.0 10^5 y	Cl35(n,γ)Cl36	99.1	100.0	100.0	0.3	0.1	0.1	0.1
		Cl37(n,2n)Cl36				99.5	99.8	99.8	99.9
Al26	7.2 10^5 y	Cl35(n,nα)P31(n,nα)Al27(n,2n)Al26				72.4	66.1	1.0	
		Cl35(n,d)S34(n,nα)Si30(n,α)Mg27(β^-)_ Al27(n,2n)Al26				7.5	0.1		
		Cl35(n,nα)P31(n,d)Si30(n,α)Mg27(β^-)_ Al27(n,2n)Al26				6.1	0.1		
		Cl35(n,α)P32(β^-)S32(n,nα)Si28(n,d)_ Al27(n,2n)Al26				4.9	0.1		
		Cl35(n,pα)Si31(β^-)P31(n,nα)Al27(n,2n)Al26				0.6	7.6		
		Cl35(n,2α)Al28(β^-)Si28(n,d)Al27(n,2n)Al26					6.9	0.2	
		Cl35(n,2α)Al28(β^-)Si28(n,t)Al26					5.8	12.3	0.8
		Cl35(n,nα)P31(n,pα)Mg27(β^-)Al27(n,2n)Al26					3.8		
		Cl35(n,n2α)Al27(n,2n)Al26					1.1	23.5	2.9
		Cl35(n,t)S33(n,2nα)Si28(n,t)Al26					0.3	3.6	0.5
		Cl35(n,nα)P31(n,2nα)Al26						37.6	6.6
		Cl35(n,pα)Si31(β^-)P31(n,2nα)Al26						3.3	0.5
		Cl35(n,tα)Si29(n,nt)Al26						0.4	12.4
		Cl35(n,ntα)Si28(n,t)Al26						0.3	3.1
		Cl35(n,2n2α)Al26							51.2
		Cl35(n,nt)S32(n,tα)Al26							4.7
		Cl35(n,α)P32(β^-)S32(n,tα)Al26							4.6

Chlorine activation characteristics

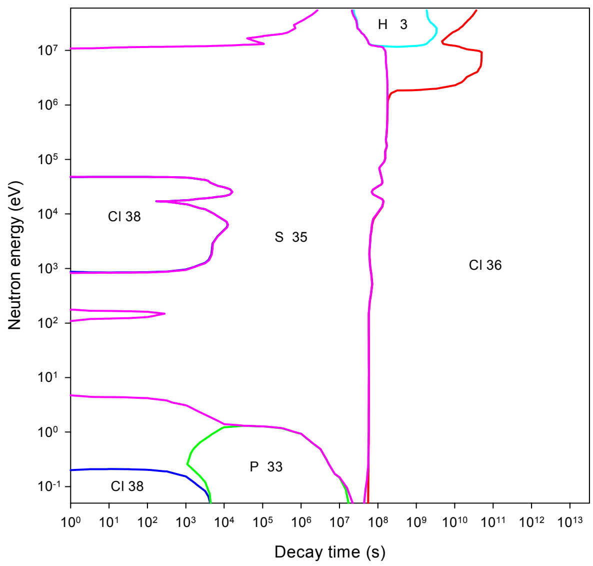


Decay time (years)

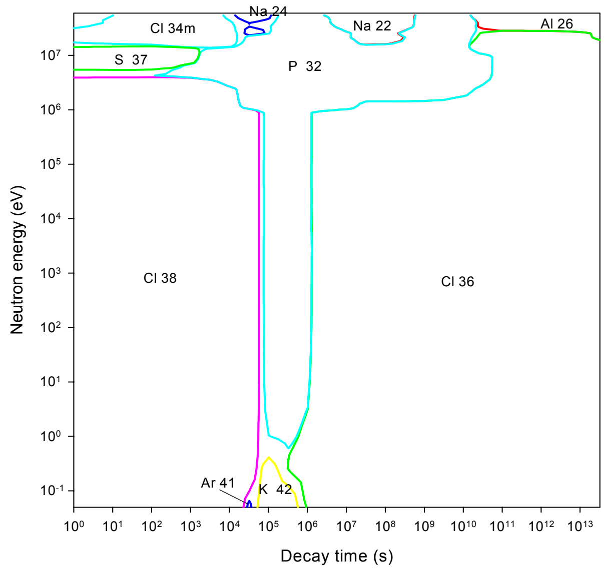
Decay time (years)

Chlorine importance diagrams & transmutation

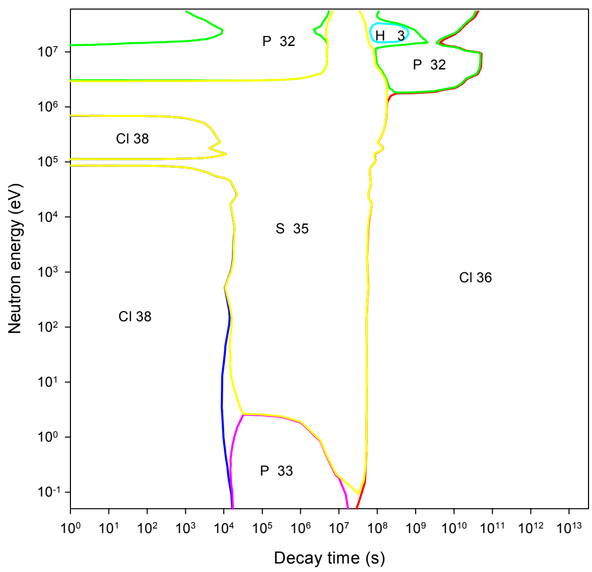
Activity



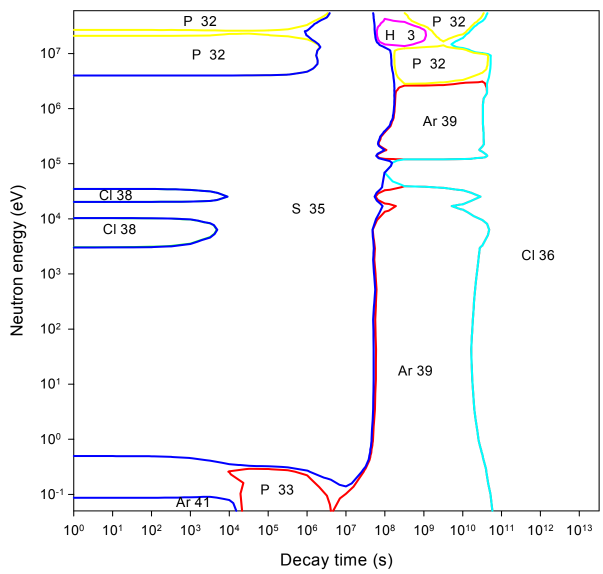
Dose rate



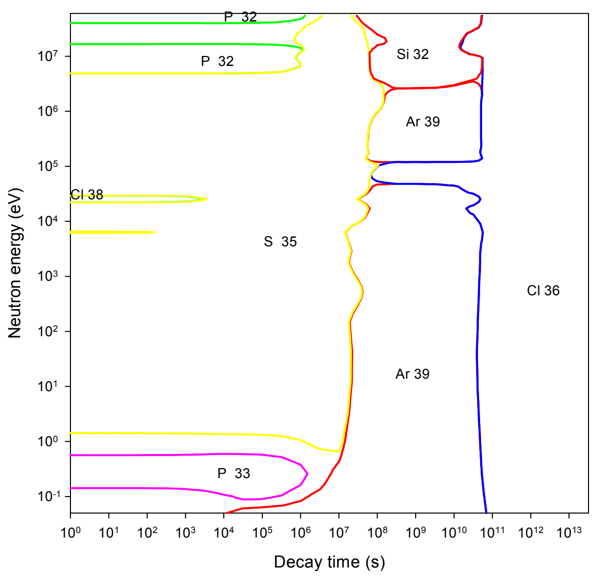
Heat output



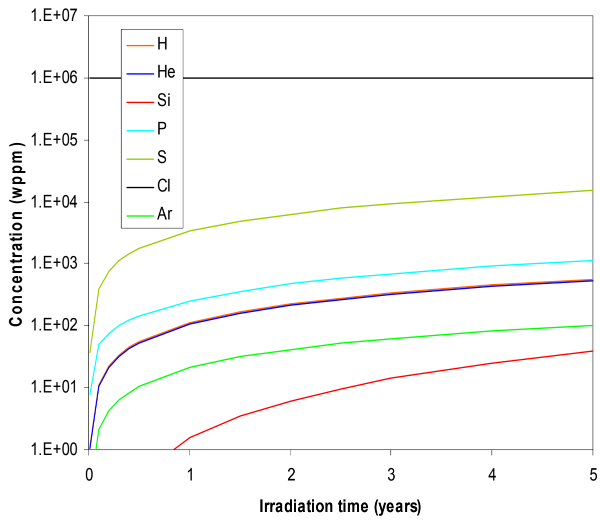
Ingestion dose



Inhalation dose



First wall transmutation



Graphs for H, He are indistinguishable

Argon

General properties

Property	Value	Isotopes	Isotopic abundances / %
Atomic number	18		
Crustal abundance / wppm	1.2	Ar36	0.3365
Melting point / K	83.78	Ar38	0.0632
Boiling point / K	87.29	Ar40	99.6003
Density / kgm^{-3}	1.784		
Thermal conductivity / Wm^{-1}K^{-1}	1.77 10^{-2}		
Electrical resistivity /Ωm	-		
Coefficient of thermal expansion / K^{-1}	-		
Crystal structure	FCC		
Number of stable isotopes	3		
Mean atomic weight	39.948		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.55E14	1.03E14	1.81E13	1.46E13	1.12E13	3.85E7	kW kg^{-1}	7.11E-2	3.16E-2	5.32E-4	5.07E-4	3.92E-4	1.69E-9
Ar41	40.11	58.37					Cl40	41.75	6.32				
S37	22.94	16.62					S37	29.93	32.45				
Cl40	21.32	2.16					Ar41	24.52	53.41				
Ar39	9.33	14.03	79.92	99.03	100.0		Cl39	2.22	4.69				
Cl39	2.79	3.93					Ar39	0.71	1.60	95.38	99.79	100.0	
S35	1.56	2.34	12.97	0.91			Cl38	0.44	0.90				
Ar37	0.82	1.24	6.59				K42	0.25	0.55	0.24			
Cl38	0.42	0.57					S35	0.03	0.06	3.45	0.20		
Cl36						99.97	Cl36						99.99

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	1.09E5	4.66E4	7.66E-1	2.97E-1	2.30E-1	1.76E-6	Sv kg^{-1}	2.40E7	2.38E7	1.59E7	1.59E7	1.23E7	3.58E-2
Cl40	41.52	6.54					Ar39	66.26	67.00	99.91	100.0	100.0	
S37	33.99	38.37					Ar41	33.68	32.94				
Ar41	22.32	50.60					S35			0.01			
Cl39	1.71						Cl36						99.98
Cl38	0.30	0.63											
K42		0.12*	95.04*	37.34*	17.83*								
Ar37			3.27	26.85									
P32			1.69*	35.28*	80.15*								
Cl36				0.40*	1.54*	71.79*							
K40				0.13	0.47	28.09							

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	5.55E8	5.54E8	5.50E8	5.49E8	4.25E8	2.81E-1		3.37E11	1.49E11	7.87E8	7.62E8	5.89E8	3.85E4
Ar39	99.24	99.26	99.99	100.0	100.0		Cl40	40.94	6.23				
Ar41	0.75	0.72					S37	32.03	34.95				
Cl36						100.0	Ar41	24.65	54.01				
							Cl39	1.98	4.20				
							Ar39	0.22	0.51	96.85	99.81	99.99	
							Cl36			0.01	0.01	0.01	100.0

Argon

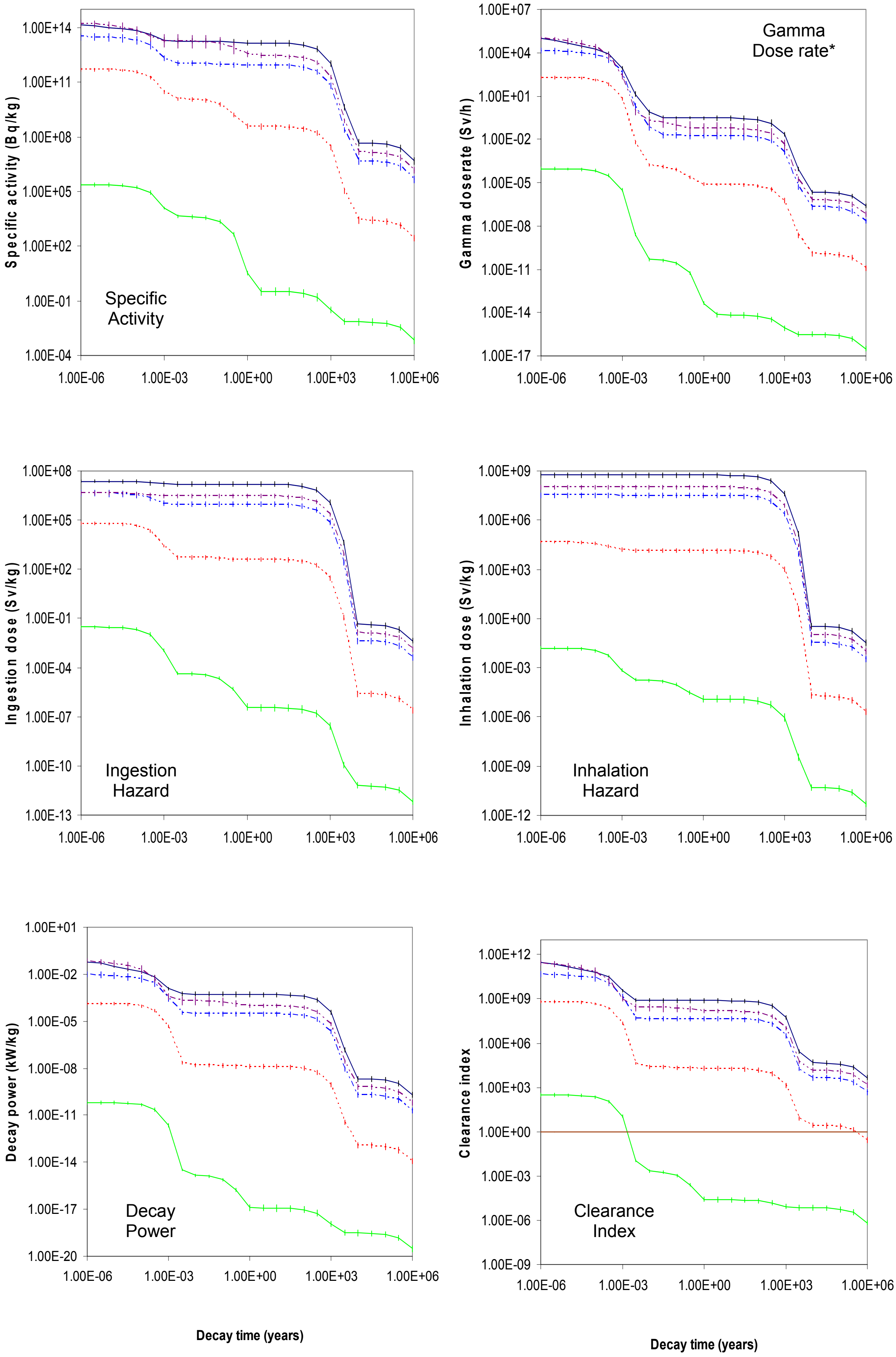
Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Cl40	1.35 m	Ar40(n,p)Cl40				100.0	100.0	100.0	100.0
S37	4.99 m	Ar38(n,γ)Ar39(n,α)S36(n,γ)S37	99.7	100.0	98.0				
		Ar36(n,p)Cl36(n,p)S36(n,γ)S37			1.9				
		Ar40(n,α)S37				99.3	95.7	92.4	96.5
		Ar40(n,3n)Ar38(n,2p)S37					1.4	1.4	0.2
		Ar40(n,2n)Ar39(n,h)S37					1.0	2.3	0.7
		Ar40(n,d)Cl39(β^-)Ar39(n,h)S37					0.2	1.0	0.4
		Ar40(n,nt)Cl37(n,p)S37					0.1	1.1	1.4
Cl38	37.2 m	**&**Ar36(n,γ)Ar37(β^+)Cl37(n,γ)*Cl38*	90.7	99.4	96.7				
		&Ar36(n,γ)Ar37(n,p)Cl37(n,γ)*Cl38*	8.5	0.3					
		&Ar40(n,2n)Ar39(n,d)*Cl38*				66.7	29.1	2.6	1.4
		&Ar40(n,2n)Ar39(n,2n)Ar38(n,p)*Cl38*				21.6			
		&Ar38(n,p)*Cl38*				2.5			
		&Ar40(n,t)*Cl38*				0.3	55.9	94.9	96.8
		&Ar40(n,d)Cl39(β^-)Ar39(n,d)*Cl38*				0.1	6.8	1.1	0.5
		&Ar40(n,3n)Ar38(n,p)*Cl38*					3.5	0.5	
		Ar40(n,h)S38(β^-)Cl38					1.0	1.0	1.6
Cl39	55.6 m	Ar40(n,2n)Ar39(n,p)Cl39				77.0	2.4	0.9	0.3
		Ar40(n,d)Cl39				22.6	96.9	98.7	99.5
Ar41	1.827 h	Ar40(n,γ)Ar41	100.0	100.0	100.0	99.0	99.7	99.8	99.9
K42	12.36 h	Ar40(n,γ)Ar41(β^-)K41(n,γ)K42	100.0	100.0	100.0	98.5	99.7	99.8	99.9
P32	14.27 d	Ar36(n,γ)Ar37(n,α)S34(n,γ)S35(β^-)Cl35_ (n,α)P32	98.9	99.3					
		Ar36(n,α)S33(n,α)Si30(n,γ)Si31(β^-)P31_ (n,γ)P32	1.1	0.6					
		Ar40(n,2n)Ar39(n,nα)S35(β^-)Cl35(n,α)P32				26.8	0.9		
		Ar36(n,d)Cl35(n,α)P32				22.1	0.7	0.1	0.1
		Ar40(n,nα)S36(n,2n)S35(β^-)Cl35(n,α)P32				16.6	0.6		
		Ar36(n,α)S33(n,d)P32				8.1	0.7	0.2	0.2
		Ar36(n,nα)S32(n,p)P32				6.2	0.7		
		Ar36(n,pα)P32				5.5	50.2	5.1	1.1
		Ar36(n,p)Cl36(n,nα)P32				4.3	0.7		
		Ar40(n,α)S37(β^-)Cl37(n,2n)Cl36(n,nα)P32				2.9	0.4		
		Ar40(n,2nα)S35(β^-)Cl35(n,α)P32					4.4	6.1	5.5
		Ar40(n,3n)Ar38(n,nα)S34(n,t)P32					4.3	3.8	0.4
		Ar40(n,3n)Ar38(n,t)Cl36(n,nα)P32					3.6	3.0	0.3
		Ar40(n,2n)Ar39(n,2nα)S34(n,t)P32					2.9	3.5	0.4
		Ar40(n,3n)Ar38(n,2nα)S33(n,d)P32					2.3	3.1	0.3
		Ar40(n,nt)Cl37(n,2nα)P32					0.6	16.0	18.3
		Ar40(n,3nα)S34(n,t)P32						18.7	29.9
		Ar40(n,4n)Ar37(β^+)Cl37(n,2nα)P32						3.4	6.1
		Ar40(n,3n)Ar38(n,tα)P32						1.5	11.5
		&Ar40(n,t)*Cl38*(β^-)Ar38(n,tα)P32						0.6	6.9
P33	25.38 d	Ar36(n,γ)Ar37(n,α)S34(n,γ)S35(β^-)Cl35_ (n,γ)Cl36(n,α)P33	86.3						
		Ar36(n,p)Cl36(n,α)P33	13.4	98.1	100.0	6.6			
		Ar36(n,α)S33(n,p)P33	0.3	1.9		6.9			
		Ar40(n,α)S37(β^-)Cl37(n,nα)P33				40.5	3.9	0.5	0.3
		Ar40(n,nα)S36(n,α)Si33(β^-)P33				30.1	0.8	0.1	
		Ar40(n,α)S37(β^-)Cl37(n,2n)Cl36(n,α)P33				4.3			
		Ar40(n,2n)Ar39(n,2n)Ar38(n,nα)S34(n,d)P33				2.6	0.5		
		Ar40(n,2n)Ar39(n,α)S36(n,α)Si33(β^-)P33				1.8			
		Ar40(n,2n)Ar39(n,t)Cl37(n,nα)P33				0.3	4.1	0.8	0.1
		Ar40(n,3n)Ar38(n,nα)S34(n,d)P33					17.3	2.4	0.3
	►	Ar40(n,2n)Ar39(n,2nα)S34(n,d)P33					11.5	2.2	0.3

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Ar40(n,3n)Ar38(n,d)Cl37(n,nα)P33					9.6	1.1	0.1
		Ar40(n,3n)Ar38(n,2n)Ar37(β^{+})Cl37(n,nα)P33					9.4	0.9	
		Ar40(n,2α)Si33(β^{-})P33					7.3	2.4	0.3
		Ar40(n,nα)S36(n,3n)S34(n,d)P33					5.6	0.7	
		Ar40(n,nt)Cl37(n,nα)P33					3.5	6.4	10.2
		Ar40(n,2n)Ar39(n,3n)Ar37(β^{+})Cl37(n,nα)P33					3.2	0.5	
		Ar40(n,2nα)S35(β^{-})Cl35(n,h)P33					1.6	12.8	2.6
		Ar40(n,nα)S36(n,nt)P33					1.3	2.5	5.8
		Ar40(n,3n)Ar38(n,dα)P33					0.9	26.9	8.3
		Ar40(n,2nα)S35(n,t)P33					0.8	4.5	1.0
		Ar40(n,2n)Ar39(n,tα)P33					0.1	0.9	5.9
		Ar40(n,3nα)S34(n,d)P33						12.2	21.1
		&Ar40(n,t)*Cl38*(β^{-})Ar38(n,dα)P33						9.6	5.0
		Ar40(n,4n)Ar37(β^{+})Cl37(n,nα)P33						1.4	3.4
		Ar40(n,d)Cl39(β^{-})Ar39(n,tα)P33						0.4	3.2
		Ar40(n,ntα)P33						0.1	22.5
Ar37	35.04 d	Ar36(n,γ)Ar37	99.8	100.0	100.0	0.1			
		Ar40(n,2n)Ar39(n,2n)Ar38(n,2n)Ar37				87.2	2.8	0.3	
		Ar38(n,2n)Ar37				8.7	0.9	0.5	0.1
		&Ar40(n,2n)Ar39(n,d)*Cl38*(β^{-})Ar38(n,2n)Ar37				2.2	0.6	0.1	
		Ar40(n,3n)Ar38(n,2n)Ar37					65.4	35.5	4.8
		Ar40(n,2n)Ar39(n,3n)Ar37					22.3	18.3	2.9
		Ar40(n,d)Cl39(β^{-})Ar39(n,3n)Ar37					5.2	7.8	1.6
		&Ar40(n,t)*Cl38*(β^{-})Ar38(n,2n)Ar37					3.1	12.6	2.9
		Ar40(n,4n)Ar37						25.5	87.5
Sc46	83.79 d	**&**Ar40(n,γ)Ar41(β^{-})K41(n,γ)K42(β^{-})_ Ca42(n,γ)Ca43(n,γ)Ca44(n,γ)Ca45(β^{-})_ Sc45(n,γ)*Sc46*	99.5	99.5	99.9				
S35	87.32 d	Ar36(n,γ)Ar37(n,α)S34(n,γ)S35	99.4	100.0	100.0				
		Ar40(n,2n)Ar39(n,nα)S35				55.4	21.5	1.9	1.2
		Ar40(n,nα)S36(n,2n)S35				34.5	14.4	1.1	0.7
		Ar40(n,2n)Ar39(n,2n)Ar38(n,α)S35				4.0			
		Ar40(n,2n)Ar39(n,α)S36(n,2n)S35				2.0			
		Ar36(n,2p)S35				1.0	0.9		
		Ar40(n,d)Cl39(β^{-})Ar39(n,nα)S35				0.2	5.0	0.8	0.6
		Ar40(n,2nα)S35					52.4	91.8	77.8
		Ar40(n,nα)S36(n,d)P35(β^{-})S35					2.4	0.4	0.3
		Ar40(n,nt)Cl37(n,t)S35						1.0	6.9
		Ar40(n,4n)Ar37(β^{+})Cl37(n,t)S35						0.2	2.3
Na22	2.60 y	Ar36(n,2α)Si29(n,α)Mg26(n,α)Ne23(β^{-})_ Na23(n,2n)Na22				36.0			
		Ar36(n,nα)S32(n,α)Si29(n,α)Mg26(n,α)_ Ne23(β^{-})Na23(n,2n)Na22				15.5			
		Ar36(n,α)S33(n,nα)Si29(n,α)Mg26(n,α)_ Ne23(β^{-})Na23(n,2n)Na22				14.6			
		Ar36(n,nα)S32(n,nα)Si28(n,nα)Mg24_ (n,d)Na23(n,2n)Na22				6.2	0.9		
		Ar36(n,nα)S32(n,nα)Si28(n,d)Al27_ (n,nα)Na23(n,2n)Na22				4.7	0.6		
		Ar36(n,n2α)Si28(n,nα)Mg24(n,t)Na22					12.3	5.6	0.2
		Ar36(n,dα)P31(n,nα)Al27(n,nα)Na23_ (n,2n)Na22					4.1		
		Ar36(n,nα)S32(n,nα)Si28(n,nα)Mg24(n,t)Na22					3.8	0.1	
		Ar36(n,n2α)Si28(n,nα)Mg24(n,d)Na23_ (n,2n)Na22					3.8		
		Ar36(n,2α)Si29(n,2nα)Mg24(n,t)Na22					3.3	1.5	
		Ar36(n,dα)P31(n,nα)Al27(n,2n)Al26(n,nα)Na22					3.2		
		Ar40(n,2nα)S35(β^{-})Cl35(n,nα)P31(n,nα)_ Al27(n,nα)Na23(n,2n)Na22					3.0		
	►	Ar40(n,2nα)S35(β^{-})Cl35(n,n2α)Al27_ (n,2nα)Na22						33.4	2.5

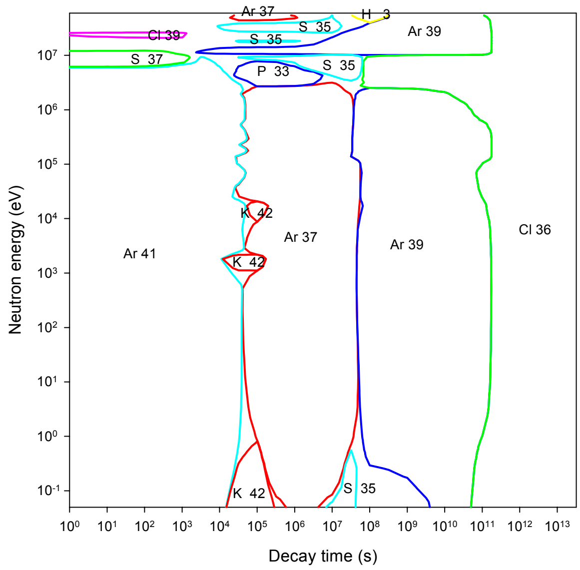
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Ar36(n,dα)P31(n,nα)Al27(n,2nα)Na22						3.2	0.2
		Ar36(n,n2α)Si28(n,tα)Na22						0.5	4.5
		Ar40(n,3nα)S34(n,3nα)Si28(n,tα)Na22							10.3
		Ar40(n,2n2α)Si31(β$^-$)P31(n,2n2α)Na22							7.6
		Ar40(n,3nα)S34(n,tα)Al28(β$^-$)Si28(n,tα)Na22							4.4
		Ar40(n,3nα)S34(n,2n2α)Mg25(n,nt)Na22							3.0
H3	12.33 y	Ar36(n,γ)Ar37(n,X)H1(n,γ)H2(n,γ)H3	92.2	86.8	61.6				
		Ar36(n,X)H1(n,γ)H2(n,γ)H3	1.2	8.6	37.8				
		Ar40(n,2n)Ar39(n,X)H3				88.1	5.7	2.1	1.0
		Ar40(n,X)H3				8.8	89.5	92.8	94.4
		Ar40(n,d)Cl39(β$^-$)Ar39(n,X)H3				0.3	1.3	0.9	0.5
		Ar40(n,3n)Ar38(n,X)H3					2.0	1.9	0.9
Ar42	33.0 y	Ar40(n,γ)Ar41(n,γ)Ar42	100.0	100.0	100.0	97.0	97.9	98.7	99.4
		Ar40(n,γ)Ar41(β$^-$)K41(n,γ)K42(n,p)Ar42				2.3	1.5	0.9	0.4
Ar39	269 y	Ar38(n,γ)Ar39	99.6	100.0	100.0				
		Ar40(n,2n)Ar39				99.0	80.8	70.1	64.9
		Ar40(n,d)Cl39(β$^-$)Ar39				0.3	19.0	29.7	35.0
Cl36	3.0 10^5 y	Ar36(n,γ)Ar37(n,α)S34(n,γ)S35(β$^-$)Cl35_ (n,γ)Cl36	87.0						
		Ar36(n,p)Cl36	13.0	99.9	100.0	57.7	8.7	1.1	0.2
		Ar40(n,α)S37(β$^-$)Cl37(n,2n)Cl36				38.5	5.1	0.4	0.2
		Ar40(n,2n)Ar39(n,t)Cl37(n,2n)Cl36				0.2	3.6	0.4	
		Ar40(n,3n)Ar38(n,t)Cl36					43.2	57.8	7.9
		Ar40(n,3n)Ar38(n,d)Cl37(n,2n)Cl36					8.6	0.6	
		Ar40(n,3n)Ar38(n,2n)Ar37(β$^+$)Cl37(n,2n)Cl36					8.1	0.5	
		Ar40(n,nt)Cl37(n,2n)Cl36					4.5	5.0	5.5
		Ar40(n,2n)Ar39(n,nt)Cl36					4.0	3.9	4.4
		Ar40(n,2n)Ar39(n,3n)Ar37(β$^+$)Cl37(n,2n)Cl36					2.8	0.3	
		&Ar40(n,t)*Cl38*(β$^-$)Ar38(n,t)Cl36					2.1	20.6	4.7
		Ar40(n,d)Cl39(β$^-$)Ar39(n,nt)Cl36					0.9	1.6	2.4
		Ar40(n,2nt)Cl36						2.8	72.0
Al26	7.2 10^5 y	Ar36(n,nα)S32(n,nα)Si28(n,d)Al27(n,2n)Al26				29.7	2.4		
		Ar36(n,α)S33(n,α)Si30(n,α)Mg27(β$^-$)_ Al27(n,2n)Al26				16.7			
		Ar36(n,d)Cl35(n,nα)P31(n,nα)Al27(n,2n)Al26				13.1	2.2		
		Ar36(n,nα)S32(n,d)P31(n,nα)Al27(n,2n)Al26				6.0	1.4		
		Ar40(n,2n)Ar39(n,nα)S35(β$^-$)Cl35(n,nα)_ P31(n,nα)Al27(n,2n)Al26				5.3	1.0		
		Ar38(n,nα)S34(n,nα)Si30(n,α)Mg27(β$^-$)_ Al27(n,2n)Al26				3.6			
		Ar40(n,nα)S36(n,2n)S35(β$^-$)Cl35(n,nα)_ P31(n,nα)Al27(n,2n)Al26				3.3	0.7		
		Ar36(n,2α)Si29(n,t)Al27(n,2n)Al26				0.3	6.6	0.1	
		Ar36(n,dα)P31(n,nα)Al27(n,2n)Al26					13.0	0.6	
		Ar40(n,2nα)S35(β$^-$)Cl35(n,nα)P31(n,nα)_ Al27(n,2n)Al26					11.9	0.2	
		Ar36(n,n2α)Si28(n,d)Al27(n,2n)Al26					8.3	0.4	
		Ar36(n,n2α)Si28(n,t)Al26					6.9	23.0	3.2
		Ar40(n,3n)Ar38(n,2α)Si31(β$^-$)P31(n,nα)_ Al27(n,2n)Al26					5.5		
		Ar40(n,2nα)S35(β$^-$)Cl35(n,2α)Al28(β$^-$)_ Si28(n,t)Al26					1.5	3.3	
		Ar40(n,2nα)S35(β$^-$)Cl35(n,n2α)Al27(n,2n)Al26					0.3	6.3	0.3
		Ar36(n,dα)P31(n,2nα)Al26						22.4	3.1
		Ar40(n,2nα)S35(β$^-$)Cl35(n,nα)P31(n,2nα)Al26						10.1	0.7
		Ar40(n,3nα)S34(n,nt)P31(n,2nα)Al26						0.5	4.2
		Ar40(n,3nα)S34(n,2nα)Si29(n,nt)Al26						0.5	3.4
		Ar40(n,3nα)S34(n,3nα)Si28(n,t)Al26						0.2	6.6
		Ar40(n,nt)Cl37(n,3nα)P31(n,2nα)Al26						0.1	3.2
		Ar40(n,2n2α)Si31(β$^-$)P31(n,2nα)Al26							18.8
		Ar40(n,2nα)S35(β$^-$)Cl35(n,2n2α)Al26							8.2

Argon activation characteristics

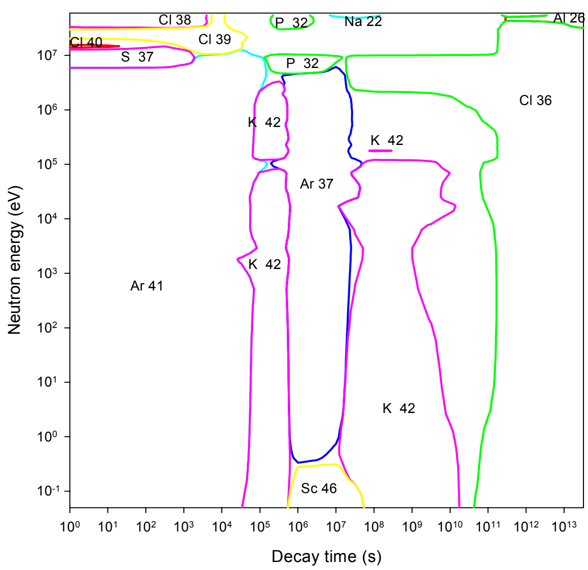


Argon importance diagrams & transmutation

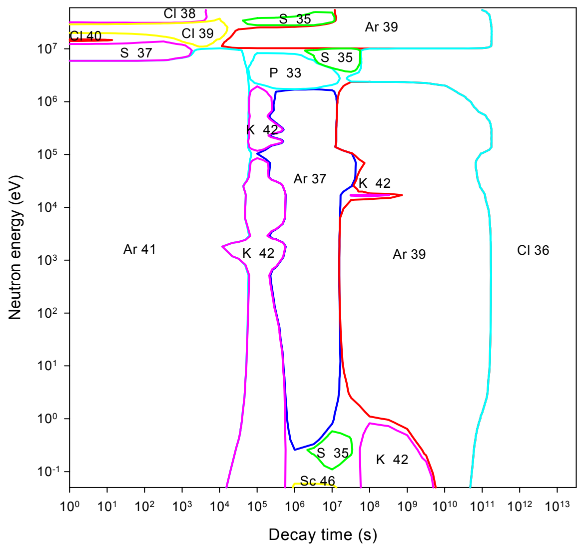
Activity



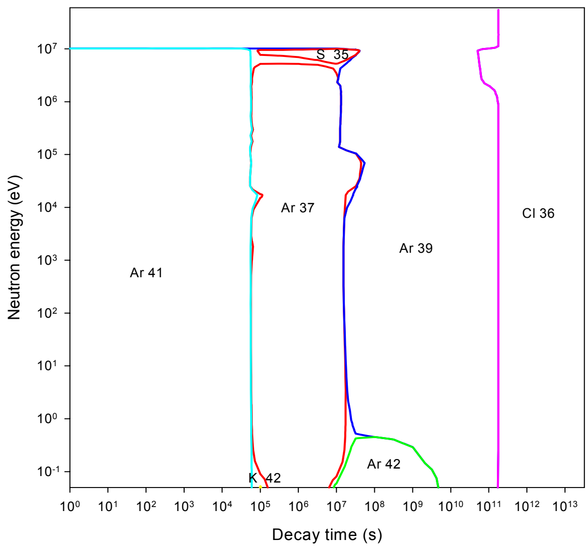
Dose rate



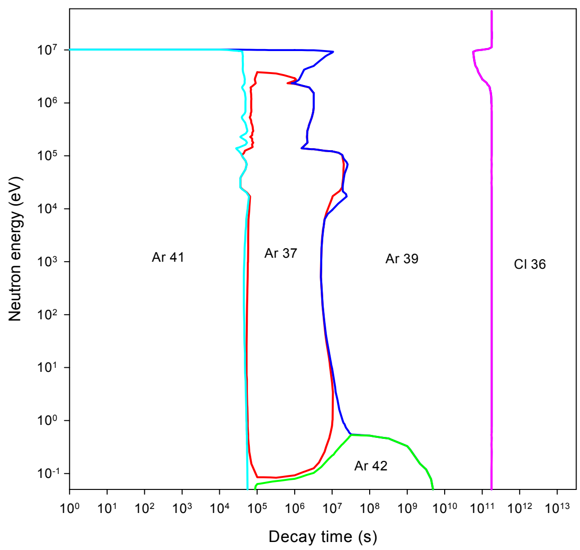
Heat output



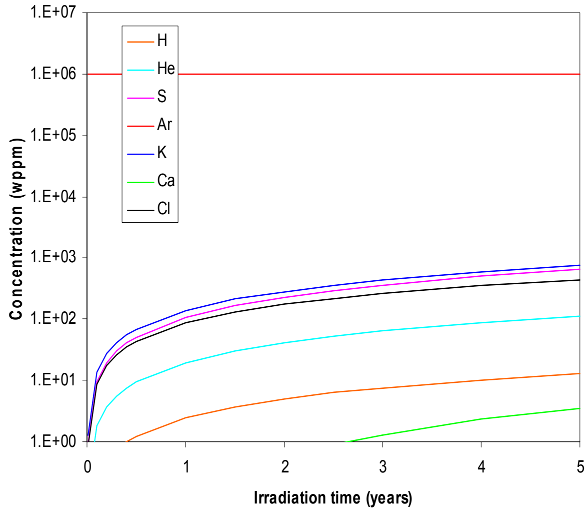
Ingestion dose



Inhalation dose



First wall transmutation



Potassium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	19		
Crustal abundance / wppm	2.09 10^4	K39	93.2581
Melting point / K	336.5	K40	0.0117 ($T_{½}$ = 1.26 10^9 y)
Boiling point / K	1032	K41	6.7302
Density / kgm^{-3}	862		
Thermal conductivity / $Wm^{-1}K^{-1}$	102		
Electrical resistivity /Ωm	6.15 10^{-8}		
Coefficient of thermal expansion / K^{-1}	8.3 10^{-5}		
Crystal structure	BCC		
Number of stable isotopes	2 (3)		
Mean atomic weight	39.0983		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Bq kg^{-1}	1.40E14	1.30E14	3.76E13	2.18E13	1.63E13	2.92E9
K42	48.24	51.43	1.31			
Ar39	15.13	16.21	56.16	96.38	99.96	
Cl38	7.90	7.67				
S35	7.02	7.52	25.32	2.47		
Ar41	6.61	6.85				
K38	4.33	2.87				
Ar37	3.89	4.17	13.45	0.01		
Cl38m	2.90					
Cl39	1.95	1.96				
P33	0.58	0.62	1.95			
P32	0.35	0.38	1.10			
Cl36			0.01	0.01	0.02	99.85

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
kW kg^{-1}	3.35E-2	3.00E-2	1.01E-3	7.42E-4	5.72E-4	1.28E-7
K42	54.64	60.59	13.33			
Cl38	15.91	16.08				
K38	12.69	8.76				
Ar41	7.72	8.32				
Cl39	2.97	3.10				
Ar39	2.20	2.46	73.56	99.38	99.97	
K38m	1.37					
Cl38m	1.30					
S35	0.22	0.25	7.39	0.56		
P32	0.16	0.18	4.60			
P33	0.03	0.03	0.89			
Cl36			0.02	0.02	0.03	99.93

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv h^{-1}	2.17E4	1.79E4	4.22E1	3.73E-1	2.89E-1	1.54E-4
K42	25.38*	30.64*	99.67*	72.96	36.52	
K38	25.03	18.81				
Cl38	23.60	25.96				
Ar41	15.61	18.32				
Cl39	5.06	5.75				
Cl38m	2.88					
Cl40	0.73	0.06				
K40				11.48*	45.97*	82.06*
Cl36				3.13*	12.56*	17.81*

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv kg^{-1}	2.45E7	2.45E7	2.33E7	2.32E7	1.79E7	2.72E0
Ar39	94.72	94.87	99.74	100.00	100.00	
Ar41	4.89	4.74				
K42	0.11	0.11				
S35	0.03	0.03	0.03			
P32	0.01	0.01				
Cl38	0.01	0.01				
Cl36						99.76
K40						0.21

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv kg^{-1}	8.03E8	8.03E8	8.02E8	8.00E8	6.20E8	2.13E1
Ar39	99.89	99.89	99.97	100.00	100.00	
Cl36						99.99

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
	5.06E10	3.75E10	1.27E9	1.12E9	8.62E8	2.92E6
K38	39.77	33.25				
Ar41	24.32	31.75				
K42	13.29	17.85	3.89			
Cl39	8.28	10.47				
Cl38m	5.33					
Ar39	2.19	2.96	87.79	98.97	99.57	
Cl38	2.17	2.66				
K38m	2.15					
Cl36	0.01	0.01	0.29	0.32	0.42	99.99

Potassium

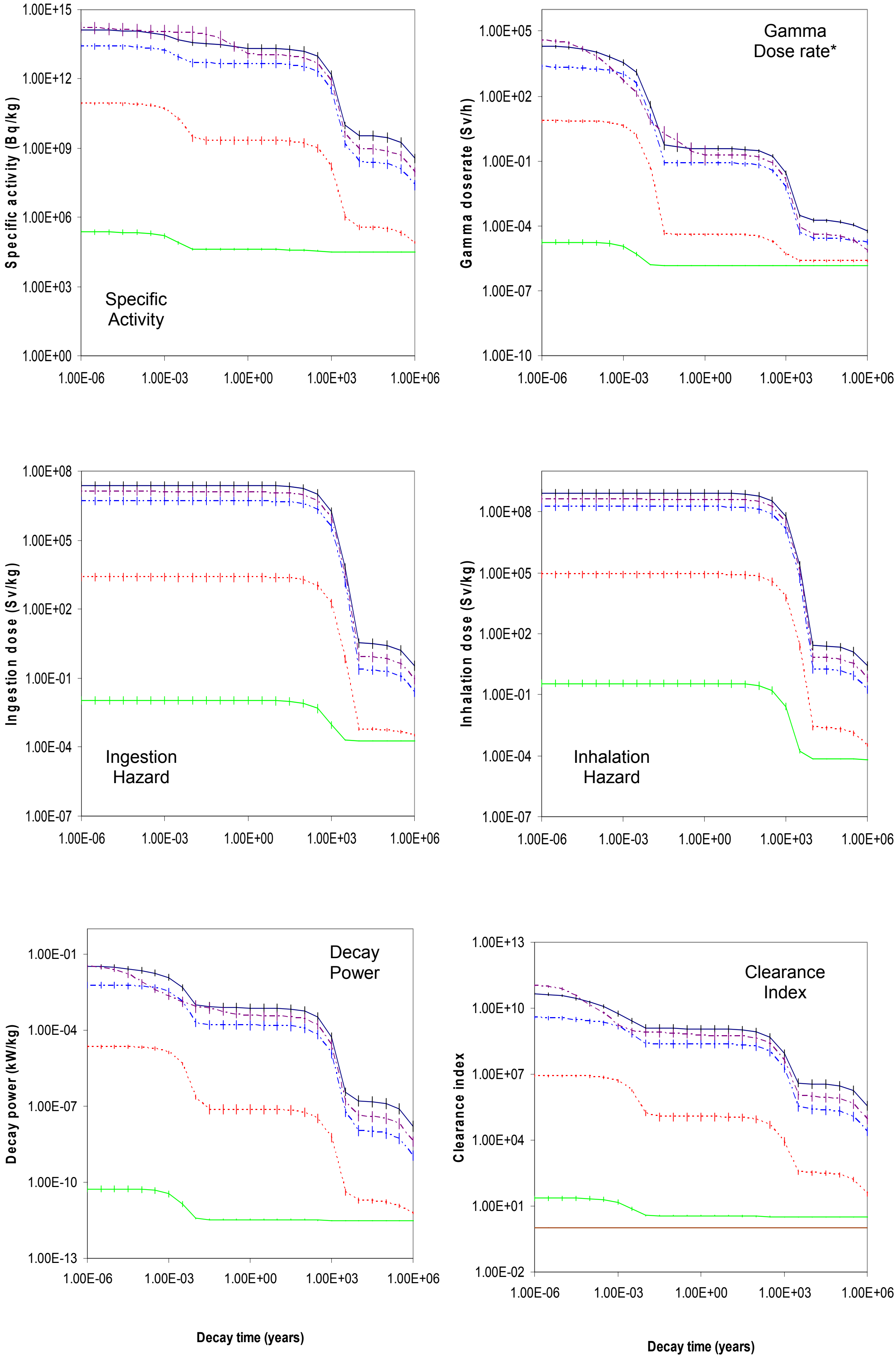
Pathway analysis

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
K38	7.61 m	K39(n,2n)K38				99.9	99.8	99.7	98.1
		K41(n,4n)K38							1.7
Cl38	37.2 m	**&**K39(n,γ)K40(n,α)Cl37(n,γ)*Cl38*	89.8	85.6	69.7				
		&K39(n,α)Cl36(n,γ)Cl37(n,γ)*Cl38*	6.7	5.0	0.7				
		&K40(n,α)Cl37(n,γ)*Cl38*	0.7	6.2	21.1				
		&K39(n,d)Ar38(n,p)*Cl38*				71.1	8.5	8.1	4.3
		&K41(n,α)*Cl38*				14.4	2.8	4.6	23.5
		&K39(n,p)Ar39(n,d)*Cl38*				5.9	9.5	11.7	6.9
		&K39(n,p)Ar39(n,2n)Ar38(n,p)*Cl38*				1.9			
		&K39(n,2p)*Cl38*				0.2	76.3	67.6	59.0
		&K41(n,t)Ar39(n,d)*Cl38*					0.7	2.6	2.1
		&K41(n,d)Ar40(n,t)*Cl38*					0.1	1.8	1.9
Cl39	55.6 m	K39(n,p)Ar39(n,p)Cl39				99.5	67.4	37.7	13.3
		K41(n,d)Ar40(n,d)Cl39					20.5	20.2	18.1
		K41(n,t)Ar39(n,p)Cl39					5.4	8.3	4.0
		K41(n,h)Cl39					5.3	33.0	64.1
Ar41	1.827 h	K39(n,γ)K40(n,p)Ar40(n,γ)Ar41	99.8	94.2	75.9				
		K40(n,p)Ar40(n,γ)Ar41	0.2	5.8	24.1				
		K41(n,p)Ar41				100.0	99.9	100.0	100.0
K42	12.36 h	K41(n,γ)K42	58.2	99.8	100.0	96.5	99.1	99.4	99.7
		K39(n,γ)K40(n,γ)K41(n,γ)K42	41.6	0.2					
P32	14.27 d	K39(n,α)Cl36(n,α)P33(β^-)S33(n,α)Si30_ (n,γ)Si31(β^-)P31(n,γ)P32	99.9	100.0					
		K39(n,α)Cl36(n,nα)P32				44.0	2.2	1.1	6.1
		K39(n,nα)Cl35(n,α)P32				39.0	0.5	0.2	2.5
		K39(n,α)Cl36(n,2n)Cl35(n,α)P32				4.4			
		K39(n,pα)S35(β^-)Cl35(n,α)P32				3.3	0.5	0.1	0.6
		K39(n,d)Ar38(n,α)S35(β^-)Cl35(n,α)P32				3.1			
		K39(n,p)Ar39(n,nα)S35(β^-)Cl35(n,α)P32				1.3			
		K39(n,α)Cl36(n,d)S35(β^-)Cl35(n,α)P32				1.2			
		K39(n,2α)P32				0.3	85.9	36.7	15.0
		K39(n,dα)S34(n,t)P32					2.9	27.0	22.4
		K39(n,t)Ar37(β^+)Cl37(n,2nα)P32					1.0	18.9	13.1
		K39(n,dα)S34(n,2n)S33(n,d)P32					1.0	0.5	0.2
		K39(n,h)Cl37(n,2nα)P32					0.3	5.4	3.8
		K39(n,tα)S33(n,d)P32					0.1	0.8	11.7
		K39(n,d)Ar38(n,tα)P32						0.2	8.7
		K41(n,2n2α)P32							2.8
P33	25.38 d	K39(n,α)Cl36(n,α)P33	100.0	100.0	100.0	78.6	0.4	0.4	9.5
		K39(n,d)Ar38(n,nα)S34(n,d)P33				7.2	5.6	0.9	0.3
		K39(n,d)Ar38(n,2n)Ar37(β^+)Cl37(n,nα)P33				3.7	3.1	0.4	0.1
		K39(n,d)Ar38(n,d)Cl37(n,nα)P33				3.1	3.1	0.4	0.1
		K41(n,nα)Cl37(n,nα)P33				2.1	1.6	0.2	0.1
		K39(n,t)Ar37(β^+)Cl37(n,nα)P33				0.2	23.3	19.8	12.9
		K39(n,dα)S34(n,d)P33					48.5	46.7	28.1
		K39(n,h)Cl37(n,nα)P33					6.9	5.7	3.7
		K39(n,nα)Cl35(n,h)P33					0.7	1.2	2.2
		K39(n,d)Ar38(n,dα)P33					0.3	10.4	11.1
		K41(n,n2α)P33						2.3	3.1
		K39(n,hα)P33						1.8	11.1
Ar37	35.04 d	K39(n,α)Cl36(β^-)Ar36(n,γ)Ar37	100.0	100.0	100.0				
		K39(n,d)Ar38(n,2n)Ar37				94.1	20.7	3.5	1.8
		K39(n,p)Ar39(n,2n)Ar38(n,2n)Ar37				2.8	0.1		
		K39(n,t)Ar37				2.6	75.7	94.7	96.0
		K39(n,2n)K38(β^+)Ar38(n,2n)Ar37				0.9	1.1	0.2	0.1
		K39(n,p)Ar39(n,3n)Ar37					1.0	0.5	0.2

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Sc46	83.79 d	&K41(n,γ)K42(β^-)Ca42(n,γ)Ca43(n,γ)_ Ca44(n,γ)Ca45(β^-)Sc45(n,γ)*Sc46*	94.5	99.6	99.9	98.8			
		&K39(n,γ)K40(n,γ)K41(n,γ)K42(β^-)_ Ca42(n,γ)Ca43(n,γ)Ca44(n,γ)Ca45(β^-)_ Sc45(n,γ)*Sc46*	5.0						
		&K41(n,γ)K42(n,γ)K43(β^-)Ca43(n,γ)_ Ca44(n,γ)Ca45(β^-)Sc45(n,γ)*Sc46*	0.4	0.4		0.1			
S35	87.32 d	K39(n,α)Cl36(n,α)P33(β^-)S33(n,γ)S34_ (n,γ)S35	96.5	95.1	61.2				
		K39(n,α)Cl36(n,α)P33(n,γ)P34(β^-)S34_ (n,γ)S35	2.6	2.8	23.0				
		K39(n,α)Cl36(β^-)Ar36(n,γ)Ar37(n,α)S34_ (n,γ)S35	0.6	2.1	15.8				
		K39(n,d)Ar38(n,α)S35				39.5	1.3	1.5	7.2
		K39(n,pα)S35				20.5	86.2	49.9	39.9
		K39(n,p)Ar39(n,nα)S35				16.0	4.1	1.9	0.7
		K39(n,α)Cl36(n,d)S35				14.6	1.0	1.6	8.0
		K39(n,nα)Cl35(n,p)S35				4.1	0.4	0.2	0.2
		K39(n,p)Ar39(n,2n)Ar38(n,α)S35				1.2			
		K39(n,t)Ar37(β^+)Cl37(n,t)S35					2.6	29.1	22.5
		K39(n,h)Cl37(n,t)S35					0.7	8.2	6.4
Ca45	163.0 d	K41(n,γ)K42(β^-)Ca42(n,γ)Ca43(n,γ)Ca44_ (n,γ)Ca45	92.3	99.7	99.9	99.0	99.4	99.6	99.7
		K39(n,γ)K40(n,γ)K41(n,γ)K42(β^-)Ca42_ (n,γ)Ca43(n,γ)Ca44(n,γ)Ca45	7.4						
Na22	2.60 y	K39(n,nα)Cl35(n,nα)P31(n,nα)Al27_ (n,nα)Na23(n,2n)Na22				25.1	2.1		
		K39(n,d)Ar38(n,nα)S34(n,nα)Si30(n,α)_ Mg27(β^-)Al27(n,nα)Na23(n,2n)Na22				10.7			
		K39(n,nα)Cl35(n,nα)P31(n,nα)Al27_ (n,2n)Al26(n,nα)Na22				10.2	1.7		
		K39(n,d)Ar38(n,nα)S34(n,nα)Si30(n,α)_ Mg27(β^-)Al27(n,2n)Al26(n,nα)Na22				4.3			
		K39(n,α)Cl36(n,nα)P32(β^-)S32(n,α)Si29_ (n,α)Mg26(n,α)Ne23(β^-)Na23(n,2n)Na22				4.2			
		K39(n,d)Ar38(n,nα)S34(n,α)Si31(β^-)P31_ (n,nα)Al27(n,nα)Na23(n,2n)Na22				3.8			
		K39(n,nα)Cl35(n,α)P32(β^-)S32(n,α)Si29_ (n,α)Mg26(n,α)Ne23(β^-)Na23(n,2n)Na22				3.8			
		K39(n,α)Cl36(n,α)P33(β^-)S33(n,nα)Si29_ (n,α)Mg26(n,α)Ne23(β^-)Na23(n,2n)Na22				3.1			
		K39(n,2α)P32(β^-)S32(n,nα)Si28(n,nα)_ Mg24(n,t)Na22					16.0	0.5	
		K39(n,2α)P32(β^-)S32(n,2α)Mg25(n,t)_ Na23(n,2n)Na22					4.7		
		K39(n,n2α)P31(n,nα)Al27(n,nα)Na23_ (n,2n)Na22					4.2	0.2	
		K39(n,2α)P32(β^-)S32(n,nα)Si28(n,nα)_ Mg24(n,d)Na23(n,2n)Na22					3.9		
		K39(n,dα)S34(n,2α)Mg27(β^-)Al27_ (n,nα)Na23(n,2n)Na22					3.9		
		K39(n,n2α)P31(n,nα)Al27(n,2n)Al26_ (n,nα)Na22					3.3	0.2	
		K39(n,dα)S34(n,2α)Mg27(β^-)Al27(n,2n)_ Al26(n,nα)Na22					3.0		
		K39(n,2α)P32(β^-)S32(n,n2α)Mg24(n,t)Na22					0.8	7.3	0.3
		K39(n,dα)S34(n,2nα)Si29(n,2nα)Mg24(n,t)Na22					0.4	5.8	0.3
		K39(n,n2α)P31(n,2α)Na24(β^-)Mg24(n,t)Na22					0.4	3.0	
		K39(n,n2α)P31(n,nα)Al27(n,2nα)Na22						18.2	1.6
		K39(n,2α)P32(β^-)S32(n,dα)Al27(n,2nα)Na22						8.9	0.4
	►	K39(n,n2α)P31(n,2nα)Al26(n,nα)Na22						8.7	0.5

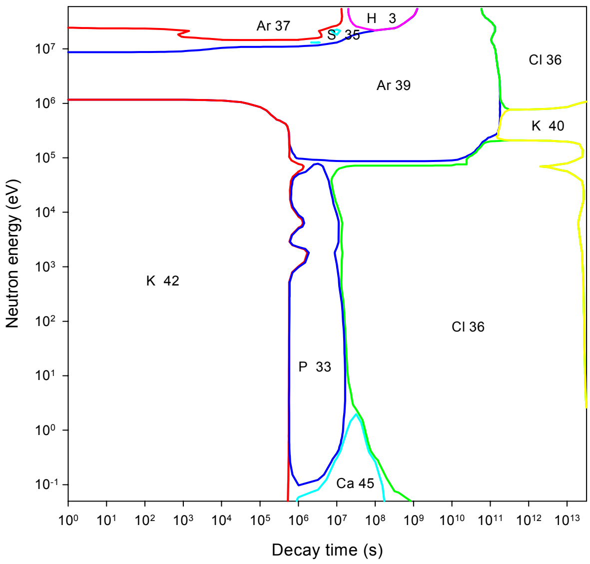
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	K39(n,n2α)P31(n,n2α)Na23(n,2n)Na22						3.3	0.4
		K39(n,dα)S34(n,2α)Mg27(β^-)Al27(n,2nα)Na22						3.2	
		K39(n,nα)Cl35(n,n2α)Al27(n,2nα)Na22						2.3	0.7
		K39(n,tα)S33(n,tα)Al27(n,2nα)Na22						0.1	7.9
		K39(n,n2α)P31(n,2n2α)Na22							10.7
		K39(n,n3α)Al27(n,2nα)Na22							7.7
		K39(n,tα)S33(n,2nα)Si28(n,tα)Na22							5.2
		K39(n,tα)S33(n,2n2α)Mg24(n,t)Na22							4.9
		K39(n,3α)Al28(β^-)Si28(n,tα)Na22							4.9
		K39(n,dα)S34(n,3nα)Si28(n,tα)Na22							4.3
H3	12.33 y	K39(n,γ)K40(n,X)H1(n,γ)H2(n,γ)H3	94.0	85.8	61.1				
		K40(n,X)H1(n,γ)H2(n,γ)H3	0.4	10.5	38.4				
		K39(n,X)H3				75.3	86.9	86.5	86.8
		K41(n,X)H3				8.2	7.1	7.2	7.4
		K39(n,α)Cl36(n,X)H3				6.2	0.1	0.1	0.7
		K39(n,p)Ar39(n,X)H3				5.5	0.9	0.5	0.3
		K41(n,2n)K40(n,X)H3				3.4	0.4	0.2	
		K39(n,d)Ar38(n,X)H3				0.2	2.2	1.7	1.2
		K39(n,t)Ar37(β^+)Cl37(n,X)H3					0.6	1.5	1.2
Ar42	33.0 y	K39(n,γ)K40(n,p)Ar40(n,γ)Ar41(n,γ)Ar42	99.7	91.6	67.9				
		K40(n,p)Ar40(n,γ)Ar41(n,γ)Ar42	0.3	8.4	32.1				
		K41(n,γ)K42(n,p)Ar42				85.0	90.1	89.9	89.9
		K41(n,p)Ar41(n,γ)Ar42				13.4	9.1	9.5	9.8
Ar39	269.0 y	**&**K39(n,γ)K40(n,α)Cl37(n,γ)*Cl38*(β^-)_ Ar38(n,γ)Ar39	93.3	85.1	60.7				
		&K39(n,α)Cl36(n,γ)Cl37(n,γ)*Cl38*(β^-)_ Ar38(n,γ)Ar39	6.4	5.0	0.7				
		&K40(n,α)Cl37(n,γ)*Cl38*(β^-)Ar38(n,γ)Ar39	0.3	9.9	34.0				
		K39(n,p)Ar39				99.0	91.3	81.1	76.1
		K41(n,t)Ar39					7.3	17.8	22.7
Cl36	$3.0\ 10^5$ y	K39(n,α)Cl36	100.0	100.0	100.0	98.7	57.1	46.4	90.3
		K39(n,t)Ar37(β^+)Cl37(n,2n)Cl36					16.5	12.4	2.0
		K39(n,d)Ar38(n,t)Cl36					7.8	18.0	3.1
		K41(n,2nα)Cl36					5.4	15.1	2.8
		K39(n,h)Cl37(n,2n)Cl36					5.0	3.6	0.6
Al26	$7.2\ 10^5$ y	K39(n,nα)Cl35(n,nα)P31(n,nα)Al27(n,2n)Al26				42.3	7.5		
		K39(n,d)Ar38(n,nα)S34(n,nα)Si30(n,α)_ Mg27(β^-)Al27(n,2n)Al26				21.1			
		K39(n,d)Ar38(n,nα)S34(n,α)Si31(β^-)P31_ (n,nα)Al27(n,2n)Al26				7.5			
		K39(n,nα)Cl35(n,d)S34(n,nα)Si30(n,α)_ Mg27(β^-)Al27(n,2n)Al26				3.5			
		K39(n,pα)S35(β^-)Cl35(n,nα)P31(n,nα)_ Al27(n,2n)Al26				3.0	5.8		
		K39(n,n2α)P31(n,nα)Al27(n,2n)Al26					12.3	2.1	0.2
		K39(n,dα)S34(n,2α)Mg27(β^-)Al27(n,2n)Al26					11.4	0.4	
		K39(n,2α)P32(β^-)S32(n,nα)Si28(n,t)Al26					10.7	1.6	0.1
		K39(n,2α)P32(β^-)S32(n,nα)Si28(n,d)_ Al27(n,2n)Al26					9.5		
		K39(n,2α)P32(β^-)S32(n,dα)Al27(n,2n)Al26					6.2	1.0	
		K39(n,2α)P32(β^-)S32(n,d)P31(n,nα)_ Al27(n,2n)Al26					5.7		
		K39(n,n2α)P31(n,2nα)Al26						77.3	31.4
		K39(n,2α)P32(β^-)S32(n,tα)Al26						0.4	3.0
		K39(n,3α)Al28(β^-)Si28(n,t)Al26						0.3	4.1
		K39(n,dα)S34(n,3nα)Si28(n,t)Al26						0.3	3.3
		K39(n,tα)S33(n,ntα)Al26							3.7
		K39(n,ntα)S32(n,tα)Al26							3.2
K40	$1.3\ 10^9$ y	K39(n,γ)K40	100.0	97.1	86.3	1.2	0.7	0.6	0.6
		K41(n,2n)K40				96.6	96.2	94.1	91.5
		Nuclide also present in starting material		2.9	13.7	2.2	3.1	5.3	7.9

Potassium activation characteristics

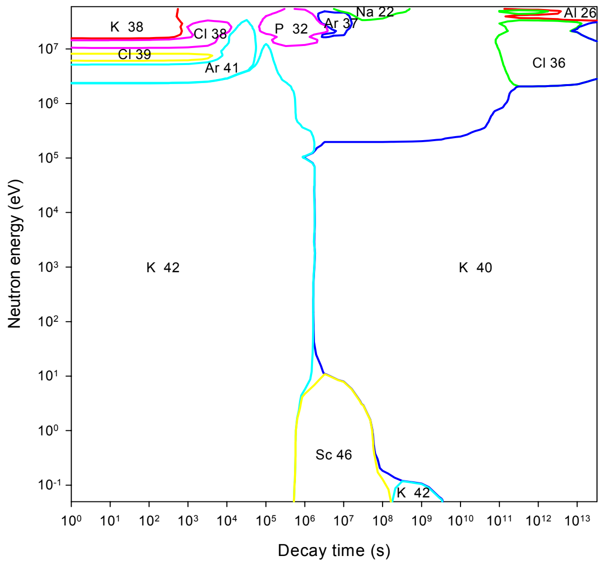


Potassium importance diagrams & transmutation

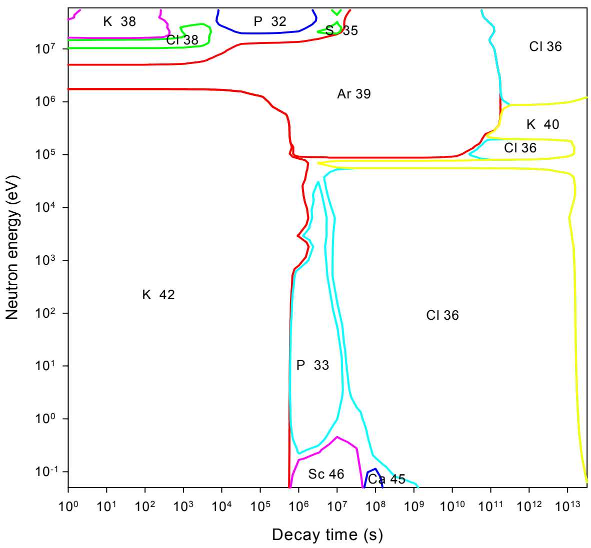
Activity



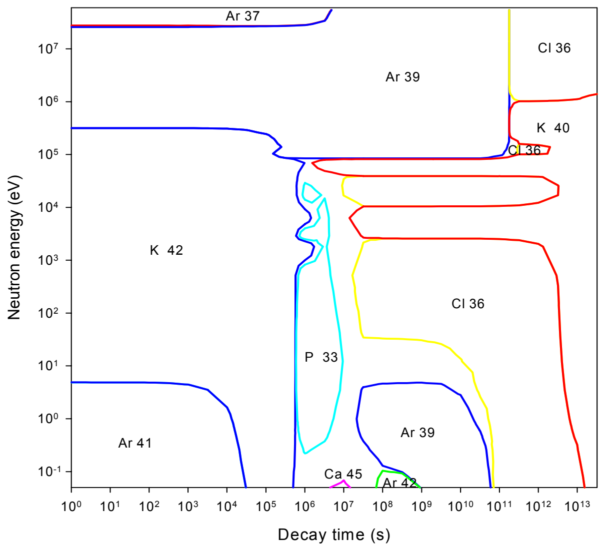
Dose rate



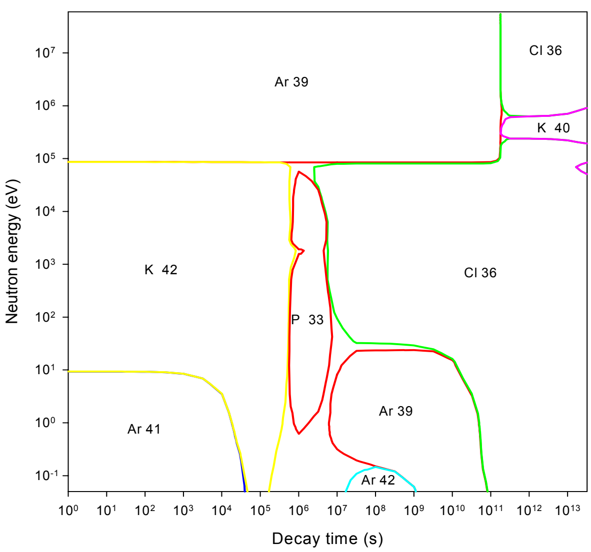
Heat output



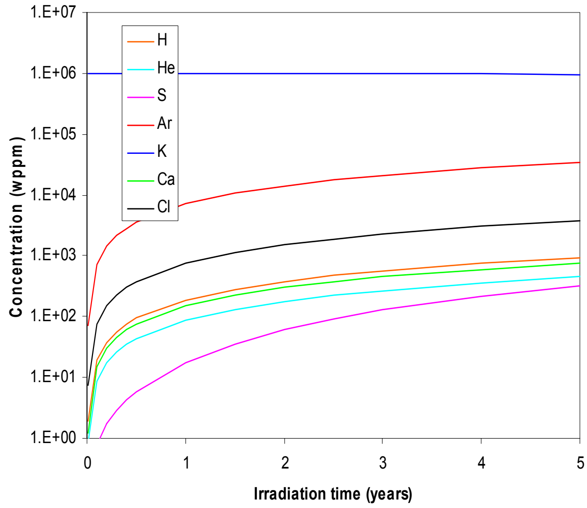
Ingestion dose



Inhalation dose



First wall transmutation



Calcium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	20	Ca40	96.941
Crustal abundance / wppm	4.10 10^4	Ca42	0.647
Melting point / K	1112	Ca43	0.135
Boiling point / K	1757	Ca44	2.086
Density / kgm^{-3}	1550	Ca46	0.004
Thermal conductivity / $Wm^{-1}K^{-1}$	200	Ca48	0.187 ($T_{½}$ = 5.30 10^{19} y)
Electrical resistivity /Ωm	3.43 10^{-8}		
Coefficient of thermal expansion / K^{-1}	2.2 10^{-5}		
Crystal structure	FCC		
Number of stable isotopes	5 (6)		
Mean atomic weight	40.078		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Bq kg^{-1}	4.74E14	4.73E14	4.32E14	2.14E12	9.96E11	1.10E9
Ar37	96.05	96.28	98.01	15.51		
Sc47	0.70	0.70	0.66			
Ca47	0.70	0.70	0.44			
K42	0.67	0.67				
Ca45	0.42	0.42	0.46	20.01		
K44	0.27	0.30				
Ar39	0.27	0.27		59.96	99.76	
Ar41	0.26	0.25				
H3	0.02	0.02	0.02	3.70	0.03	
S35		0.05	0.06	0.65		
Ca41				0.09	0.20	90.81
Cl36					0.01	8.93
K40						0.26

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
kW kg^{-1}	4.20E-3	3.67E-3	7.94E-4	5.10E-5	3.48E-5	5.12E-9
K44	24.51	23.78				
K42	20.68	23.53	0.80			
Ca47	17.65	20.18	53.40			
Ar41	8.18	9.05				
S37	4.48	2.47				
P34	3.98					
Ar37	3.78	4.32	18.57			
Sc47	3.42	3.91	15.55			
Cl38	3.12	3.23				
K43	2.22	2.54	0.76			
Ca49	1.82	1.37				
K38	1.32	0.93				
Ar39	1.07	1.23	5.67	87.99	99.98	
Ca45	0.60	0.68	3.10	10.37		
Sc46	0.26	0.30	1.34	1.04		
Cl36				0.01	0.02	84.20
Ca41						10.28
K40						5.52

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv h^{-1}	3.67E3	3.17E3	5.95E2	8.21E-1	1.61E-2	1.48E-4
K44	31.46	30.84				
Ca47	25.83	29.84	90.90			
Ar41	11.83	13.23				
S37	8.01	4.46				
K42	6.58*	7.90*	0.31		25.51	
Cl38	3.31	3.46				
Ca49	3.24	2.47				
K43	2.36	2.72	0.94			
K38	1.86	1.33				
Cl39	1.76	1.90				
P34	1.13					
Sc47	0.84	0.97	4.45			
Sc46	0.44	0.52	2.67	99.58		
K40				0.02	60.09*	89.11*
Ca41					14.10	10.68
Cl36					0.18*	0.21*

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv kg^{-1}	6.09E6	6.09E6	5.61E6	1.41E6	1.09E6	3.00E-1
Ar37	74.00	74.07	74.71	0.23		
Ar39	23.21	23.23	25.18	99.74	100.0	
Ar41	2.62	2.53				
Ca47	0.09	0.08	0.05			
Sc47	0.03	0.03	0.03			
Ca45	0.02	0.02	0.03	0.02		
K42	0.02	0.02				
K44		44.59				
S37		5.62				
Ca41						63.47
Cl36						30.54
K40						5.99

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y	Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	6.62E7	6.62E7	6.49E7	4.87E7	3.77E7	9.06E-1		9.98E9	8.18E9	8.67E8	8.86E7	5.24E7	9.95E4
Ar39	73.72	73.73	75.19	99.97	100.0		K44	43.09	44.59				
Ar37	26.12	26.12	24.79	0.03			Ar41	16.38	19.33				
Ar41	0.12						S37	9.56	5.62				
Ca45	0.01	0.01	0.01				K43	4.57	5.56	3.41			
Ca47	0.01	0.01					Ca49	3.82	3.07				
Cl36						79.41	Ca47	3.30	4.02	21.72			
Ca41						19.92	Sc46	3.22	3.93	35.98	17.68		
K40						0.67	K42	3.20	3.88				
							K38	2.62	1.98				
							Sc47	0.33	0.40	3.28			
							Cl38	0.27	0.29				
							Cl39		2.93				
							Ar37		2.78	24.42	0.19		
							P34		2.33				
							Ar39		0.83	7.80	76.11	99.75	
							Cl36				0.14	0.23	98.99
							Ca41						0.72
							K40						0.29

Calcium

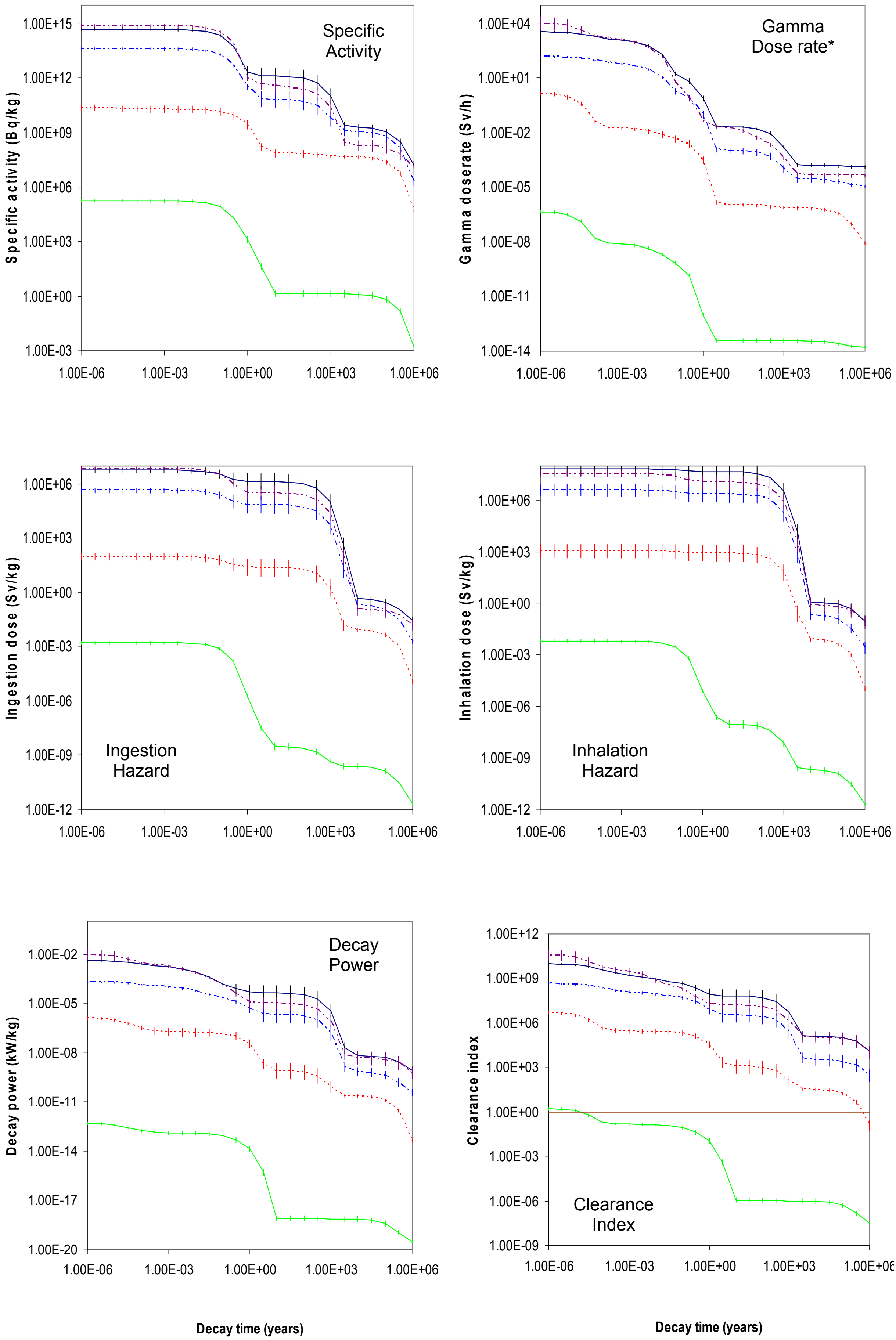
Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ca39	0.86 s	Ca40(n,2n)Ca39					100.0	100.0	100.0
S37	4.99 m	Ca40(n,γ)Ca41(n,α)Ar38(n,γ)Ar39(n,α)_ S36(n,γ)S37	86.5	82.4					
		&Ca40(n,α)Ar37(β^+)Cl37(n,γ)*Cl38*(β^-)_ Ar38(n,γ)Ar39(n,α)S36(n,γ)S37	5.7	12.3					
		Ca40(n,α)Ar37(n,α)S34(n,γ)S35(n,γ)_ S36(n,γ)S37	4.9	2.2					
		Ca40(n,α)Ar37(n,α)S34(n,γ)S35(β^-)Cl35_ (n,γ)Cl36(n,p)S36(n,γ)S37	1.8						
		Ca40(n,α)Ar37(n,γ)Ar38(n,γ)Ar39(n,α)_ S36(n,γ)S37	0.6	2.1					
		Ca40(n,α)Ar37(β^+)Cl37(n,p)S37				98.9	32.5	25.0	67.4
		Ca40(n,p)K40(n,α)Cl37(n,p)S37				1.1			
		Ca40(n,h)Ar38(n,2p)S37					29.1	34.9	11.2
		Ca40(n,h)Ar38(n,d)Cl37(n,p)S37					7.0	4.7	1.0
		Ca40(n,h)Ar38(n,2n)Ar37(β^+)Cl37(n,p)S37					6.8	4.1	0.9
		Ca40(n,2p)Ar39(n,h)S37					5.7	6.0	2.9
		Ca40(n,d)K39(n,t)Ar37(β^+)Cl37(n,p)S37					5.5	5.5	1.3
		Ca40(n,d)K39(n,d)Ar38(n,2p)S37					3.2	0.9	0.2
		Ca40(n,d)K39(n,h)Cl37(n,p)S37					1.6	1.6	0.4
		Ca44(n,2α)S37					0.9	2.1	0.6
		Ca40(n,t)K38(β^+)Ar38(n,2p)S37					0.6	4.4	2.5
		Ca40(n,t)K38m(β^+)Ar38(n,2p)S37					0.3	1.5	0.8
		Ca40(n,d)K39(n,3p)S37						2.7	2.3
		Ca40(n,ph)Cl37(n,p)S37						1.2	6.6
K38	7.61 m	Ca40(n,d)K39(n,2n)K38				98.5	35.4	2.4	0.9
		Ca40(n,p)K40(n,2n)K39(n,2n)K38				1.4			
		Ca40(n,t)K38					61.3	97.3	98.9
		Ca40(n,2n)Ca39(β^+)K39(n,2n)K38					2.9	0.2	
Ca49	8.72 m	Ca48(n,γ)Ca49	100.0	100.0	100.0	100.0	99.9	99.9	99.9
Cl38	37.2 m	**&**Ca40(n,α)Ar37(β^+)Cl37(n,γ)*Cl38*	89.3	96.1	96.7	0.9			
		&Ca40(n,α)Ar37(n,p)Cl37(n,γ)*Cl38*	8.4	0.3					
		&Ca40(n,d)K39(n,d)Ar38(n,p)*Cl38*				47.5	1.6	0.6	
		&Ca40(n,2p)Ar39(n,d)*Cl38*				19.0	35.7	11.3	5.8
		&Ca40(n,2p)Ar39(n,2n)Ar38(n,p)*Cl38*				6.5			
		&Ca40(n,d)K39(n,p)Ar39(n,d)*Cl38*				4.5	2.0	0.8	0.2
		&Ca42(n,nα)Ar38(n,p)*Cl38*				1.5			
		&Ca40(n,p)K40(n,d)Ar39(n,d)*Cl38*				1.3	0.3	0.1	
		&Ca40(n,d)K39(n,p)Ar39(n,2n)Ar38(n,p)*Cl38*				1.0			
		&Ca40(n,d)K39(n,2p)*Cl38*				0.4	31.6	8.3	4.1
		&Ca40(n,h)Ar38(n,p)*Cl38*				0.4	15.7	21.5	10.8
		&Ca40(n,2n)Ca39(β^+)K39(n,2p)*Cl38*					2.5	0.7	0.2
		&Ca42(n,pα)*Cl38*					1.0	0.9	0.6
		&Ca40(n,t)K38(β^+)Ar38(n,p)*Cl38*					0.4	2.7	2.4
		&Ca40(n,p)K40(n,h)*Cl38*					0.2	1.5	1.3
		&Ca40(n,3p)*Cl38*						43.7	64.3
		&Ca44(n,tα)*Cl38*							4.1
K42	12.36 h	Ca40(n,γ)Ca41(n,p)K41(n,γ)K42	91.6	30.0	4.7				
		Ca40(n,γ)Ca41(β^+)K41(n,γ)K42	8.4	70.0	95.3				
		Ca42(n,p)K42				88.8	20.2	4.9	2.7
		Ca44(n,2n)Ca43(n,d)K42				4.4	31.2	3.7	1.9
		Ca43(n,d)K42				2.7	24.0	6.0	5.1
		Ca43(n,2n)Ca42(n,p)K42				2.1	0.3		
		Ca44(n,2n)Ca43(n,2n)Ca42(n,p)K42				1.7	0.2		
		Ca44(n,t)K42					13.3	82.1	88.1
		Ca44(n,d)K43(β^-)Ca43(n,d)K42					8.3	1.8	1.1
		Ca44(n,3n)Ca42(n,p)K42					1.7	0.7	0.2

Nuclide	T½	Pathway	210	186	151	42	30	21	6
K43	22.2 h	Ca40(n,γ)Ca41(n,p)K41(n,γ)K42(n,γ)K43	91.6	30.0	4.8				
		Ca40(n,γ)Ca41(β^{+})K41(n,γ)K42(n,γ)K43	8.4	70.0	95.2				
		Ca44(n,2n)Ca43(n,p)K43				52.2	2.5	0.9	0.3
		Ca43(n,p)K43				32.3	1.9	1.5	0.9
		Ca44(n,d)K43				14.9	94.4	96.5	97.0
Ca47	4.538 d	Ca44(n,γ)Ca45(n,γ)Ca46(n,γ)Ca47	65.8	0.5					
		Ca46(n,γ)Ca47	33.6	99.5	100.0				
		Ca48(n,2n)Ca47				100.0	94.3	79.4	70.0
		Ca48(n,d)K47(β^{-})Ca47					5.7	22.0	30.0
P32	14.27 d	Ca40(n,α)Ar37(n,α)S34(n,γ)S35(β^{-})_ Cl35(n,α)P32	100.0	100.0					
		Ca40(n,α)Ar37(β^{+})Cl37(n,2n)Cl36(n,nα)P32				16.8	0.4	0.2	0.2
		Ca40(n,pα)Cl36(n,nα)P32				12.6	37.9	11.6	2.5
		Ca40(n,d)K39(n,α)Cl36(n,nα)P32				11.9	0.2	0.2	0.2
		Ca40(n,d)K39(n,nα)Cl35(n,α)P32				10.6			
		Ca40(n,nα)Ar36(n,d)Cl35(n,α)P32				9.5	0.1		
		Ca40(n,2α)S33(n,d)P32				7.4	17.9	9.0	1.0
		Ca40(n,nα)Ar36(n,pα)P32				4.7	16.5	5.4	1.4
		Ca40(n,nα)Ar36(n,α)S33(n,d)P32				3.5	0.1	0.1	0.2
		Ca40(n,p)K40(n,nα)Cl36(n,nα)P32				3.3	0.2		
		Ca40(n,d)K39(n,2α)P32				0.2	19.5	10.6	1.1
		Ca40(n,α)Ar37(β^{+})Cl37(n,2nα)P32					0.7	11.9	23.6
		Ca40(n,dα)Cl35(n,α)P32					0.7	8.3	17.2
		Ca40(n,h)Ar38(n,nα)S34(n,t)P32					0.4	3.2	0.7
		Ca40(n,d)K39(n,dα)S34(n,t)P32					0.3	3.9	0.8
		Ca40(n,h)Ar38(n,tα)P32						1.2	21.6
		Ca40(n,t)K38(β^{+})Ar38(n,tα)P32						0.2	4.8
Ar37	35.04 d	Ca40(n,α)Ar37	100.0	100.0	100.0	98.7	51.5	51.5	91.3
		Ca40(n,d)K39(n,d)Ar38(n,2n)Ar37				0.7	2.4	0.4	
		Ca40(n,h)Ar38(n,2n)Ar37					22.7	17.5	2.4
		Ca40(n,d)K39(n,t)Ar37					18.2	23.7	3.8
		Ca40(n,2p)Ar39(n,3n)Ar37					2.2	0.9	
		Ca40(n,2n)Ca39(β^{+})K39(n,t)Ar37					1.5	2.1	0.3
		Ca40(n,t)K38(β^{+})Ar38(n,2n)Ar37					0.5	2.2	0.5
Sc46	83.79 d	**&**Ca44(n,γ)Ca45(β^{-})Sc45(n,γ)*Sc46*	99.0	99.9	100.0				
		&Ca43(n,γ)Ca44(n,γ)Ca45(β^{-})Sc45(n,γ)*Sc46*	0.9						
		&Ca48(n,2n)Ca47(β^{-})Sc47(β^{-})Ti47(n,d)*Sc46*				77.6	92.5	78.4	70.4
		&Ca48(n,2n)Ca47(β^{-})Sc47(β^{-})Ti47_ (n,2n)Ti46(n,p)*Sc46*				17.6	0.9	0.3	0.1
		&Ca48(n,2n)Ca47(β^{-})Sc47(n,2n)*Sc46*				3.3	0.4	0.3	0.2
		&Ca48(n,d)K47(β^{-})Ca47(β^{-})Sc47(β^{-})_ Ti47(n,d)*Sc46*					5.5	20.2	28.6
Ca45	163.0 d	Ca44(n,γ)Ca45	98.3	99.9	100.0	23.7	3.7	0.8	0.2
		Ca43(n,γ)Ca44(n,γ)Ca45	1.6						
		Ca46(n,2n)Ca45				72.3	19.0	3.9	1.1
		Ca48(n,α)Ar45(β^{-})K45(β^{-})Ca45				2.7	8.5	1.7	0.6
		Ca48(n,3n)Ca46(n,2n)Ca45					58.2	12.6	1.4
		Ca48(n,3n)Ca46(n,d)K45(β^{-})Ca45					6.9	4.3	0.7
		Ca46(n,d)K45(β^{-})Ca45					2.3	1.3	0.5
		Ca48(n,4n)Ca45						71.1	80.3
		Ca48(n,nt)K45(β^{-})Ca45						2.7	14.3
H3	12.33 y	Ca40(n,α)Ar37(n,X)H1(n,γ)H2(n,γ)H3	56.8	79.6	74.0				
		Ca40(n,γ)Ca41(n,X)H1(n,γ)H2(n,γ)H3	36.9	16.0	24.8				
		Ca40(n,p)K40(n,X)H3				72.6	1.2	0.4	0.2
		Ca40(n,d)K39(n,X)H3				13.2	7.7	3.4	2.0
		Ca40(n,2p)Ar39(n,X)H3				4.1	1.4	0.3	0.1
		Ca40(n,α)Ar37(β^{+})Cl37(n,X)H3				3.4	0.3	0.2	1.3
		Ca40(n,pα)Cl36(n,X)H3				1.1	1.7	0.4	0.2
		Ca40(n,X)He3(n,p)H3				0.9	0.4	0.2	0.2
		Ca40(n,X)H3					80.3	87.0	88.2
	►	Ca40(n,h)Ar38(n,X)H3					1.7	2.5	1.8

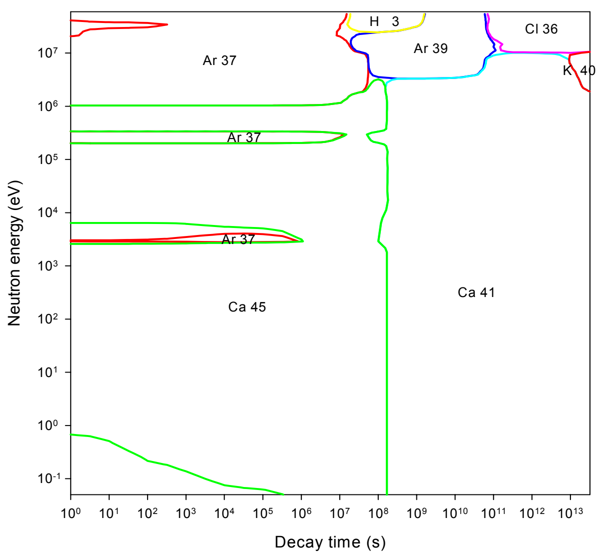
Nuclide	$T_{1/2}$	Pathway	210	186	151	42	30	21	6
	◄	Ca44(n,X)H3					1.7	2.0	2.6
Ar39	269.0 y	Ca40(n,γ)Ca41(n,α)Ar38(n,γ)Ar39	92.7	84.4	93.8				
		Ca40(n,α)Ar37(β^{+})Cl37(n,γ)Cl38(β^{-})_ Ar38(n,γ)Ar39	5.5	12.2	1.3				
		Ca40(n,α)Ar37(n,γ)Ar38(n,γ)Ar39	0.4	1.6	4.7				
		Ca40(n,2p)Ar39				75.6	92.5	87.9	87.3
		Ca40(n,d)K39(n,p)Ar39				17.5	5.3	6.2	3.9
		Ca40(n,p)K40(n,d)Ar39				5.5	1.0	1.3	0.8
		Ca42(n,α)Ar39				0.6		0.2	2.8
		Ca44(n,2nα)Ar39						3.1	3.4
Ca41	$1.0\,10^{5}$ y	Ca40(n,γ)Ca41	100.0	100.0	100.0	18.9	7.6	5.7	2.6
		Ca42(n,2n)Ca41				78.5	77.8	67.7	36.2
		Ca43(n,3n)Ca41					5.3	10.3	5.0
		Ca44(n,2n)Ca43(n,3n)Ca41					3.5	3.2	0.9
		Ca44(n,3n)Ca42(n,2n)Ca41					3.3	4.7	1.2
		Ca44(n,d)K43(β^{-})Ca43(n,3n)Ca41					0.9	1.5	0.6
		Ca44(n,t)K42(β^{-})Ca42(n,2n)Ca41					0.2	2.2	1.0
		Ca44(n,4n)Ca41						4.0	52.2
Cl36	$3.0\ 10^{5}$ y	Ca40(n,α)Ar37(n,α)S34(n,γ)S35(β^{-})_ Cl35(n,γ)Cl36	100.0	100.0	100.0				
		Ca40(n,α)Ar37(β^{+})Cl37(n,2n)Cl36				36.0	1.0	1.2	6.3
		Ca40(n,pα)Cl36				26.4	95.9	76.4	66.0
		Ca40(n,d)K39(n,α)Cl36				25.0	0.6	1.1	6.0
		Ca40(n,p)K40(n,nα)Cl36				7.0	0.6	0.3	0.2
		Ca40(n,nα)Ar36(n,p)Cl36				3.9	0.3	0.2	0.1
		Ca40(n,α)Ar37(n,d)Cl36				1.1			0.4
		Ca40(n,h)Ar38(n,t)Cl36					0.8	16.3	13.6
		Ca40(n,t)K38(β^{+})Ar38(n,t)Cl36						2.1	3.0
Al26	$7.2\ 10^{5}$ y	Ca40(n,2α)S33(n,α)Si30(n,α)Mg27(β^{-})_ Al27(n,2n)Al26				24.7	0.2		
		Ca40(n,α)Ar37(n,2α)Si30(n,α)Mg27(β^{-})_ Al27(n,2n)Al26				22.7			
		Ca40(n,nα)Ar36(n,nα)S32(n,nα)Si28_ (n,d)Al27(n,2n)Al26				8.3	0.7		
		Ca40(n,dα)Cl35(n,nα)P31(n,nα)Al27(n,2n)Al26					9.9	0.3	
		Ca40(n,pα)Cl36(n,2nα)P31(n,nα)Al27_ (n,2n)Al26					9.8		
		Ca40(n,2α)S33(n,2nα)Si28(n,t)Al26					8.2	6.0	0.3
		Ca40(n,2α)S33(n,t)P31(n,nα)Al27(n,2n)Al26					8.1		
		Ca40(n,2α)S33(n,2nα)Si28(n,d)Al27(n,2n)Al26					7.4		
		Ca40(n,nα)Ar36(n,n2α)Si28(n,t)Al26					3.2	6.7	0.7
		Ca40(n,n2α)S32(n,nα)Si28(n,t)Al26					0.6	8.1	1.1
		Ca40(n,n2α)S32(n,dα)Al27(n,2n)Al26					0.3	5.1	0.4
		Ca40(n,dα)Cl35(n,n2α)Al27(n,2n)Al26					0.2	7.9	0.6
		Ca40(n,dα)Cl35(n,nα)P31(n,2nα)Al26						12.7	1.3
		Ca40(n,nα)Ar36(n,dα)P31(n,2nα)Al26						6.5	0.7
		Ca40(n,d)K39(n,n2α)P31(n,2nα)Al26						5.6	0.6
		Ca40(n,n2α)S32(n,tα)Al26						2.1	21.4
		Ca40(n,n3α)Si28(n,t)Al26							21.4
		Ca40(n,dα)Cl35(n,2n2α)Al26							14.6
K40	$1.3\,10^{9}$ y	Ca40(n,γ)Ca41(n,α)Ar38(n,γ)Ar39(β^{-})_ K39(n,γ)K40	92.6	84.1	91.3				
		&Ca40(n,α)Ar37(β^{+})Cl37(n,γ)*Cl38*(β^{-})_ Ar38(n,γ)Ar39(β^{-})K39(n,γ)K40	6.0	13.2	1.4				
		Ca40(n,α)Ar37(n,γ)Ar38(n,γ)Ar39(β^{-})_ K39(n,γ)K40	0.7	2.7	7.3				
		Ca40(n,p)K40				99.9	98.7	92.7	87.6
		Ca42(n,t)K40					0.8	6.2	8.1
		Ca44(n,2nt)K40							1.7
		Ca43(n,nt)K40							1.2

Calcium activation characteristics

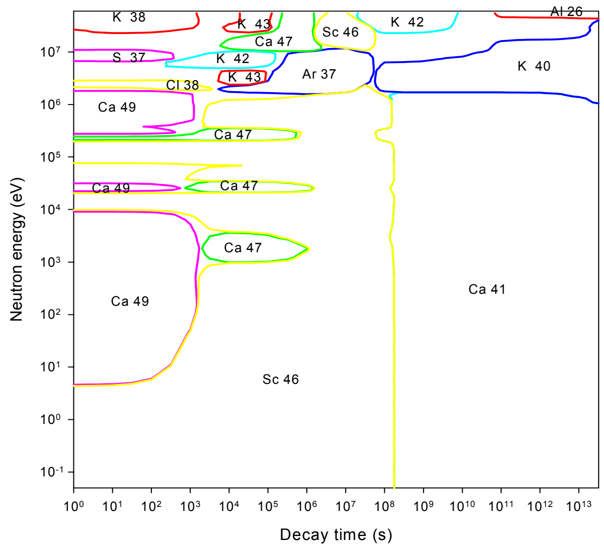


Calcium importance diagrams & transmutation

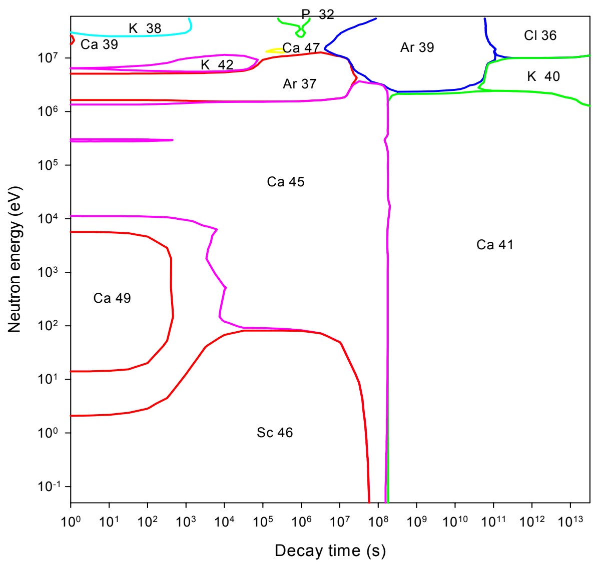
Activity



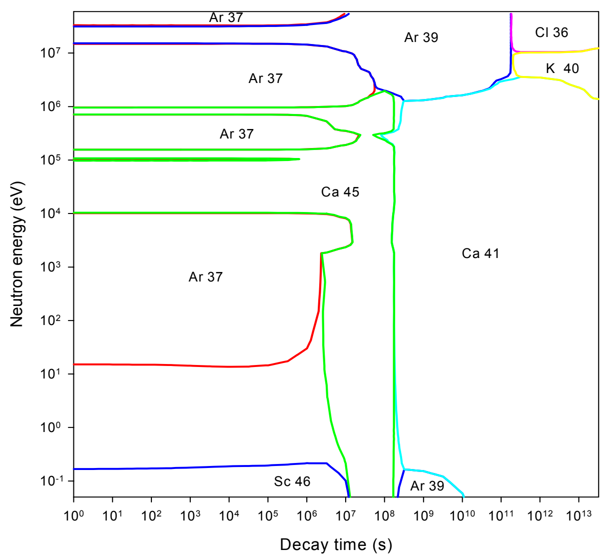
Dose rate



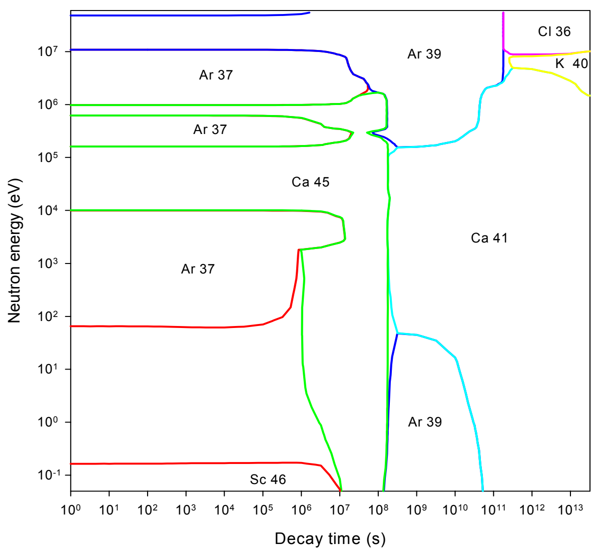
Heat output



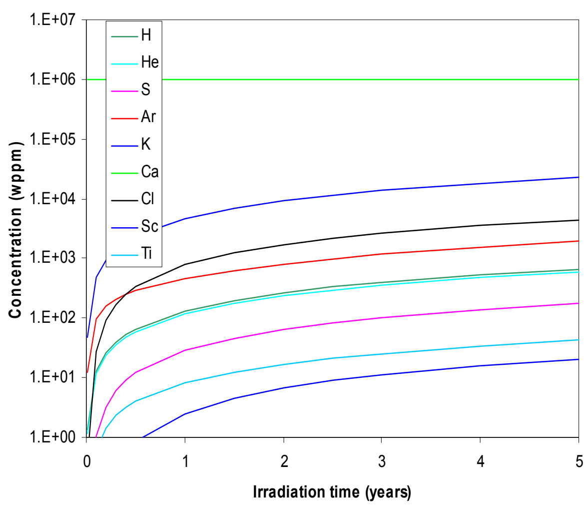
Ingestion dose



Inhalation dose



First wall transmutation



Scandium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	21	Sc45	100.0
Crustal abundance / wppm	22		
Melting point / K	1814		
Boiling point / K	3103		
Density / kgm^{-3}	2989		
Thermal conductivity / $Wm^{-1}K^{-1}$	15.8		
Electrical resistivity /Ωm	$6.10\ 10^{-7}$		
Coefficient of thermal expansion / K^{-1}	$1.02\ 10^{-5}$		
Crystal structure	HCP		
Number of stable isotopes	1		
Mean atomic weight	44.95591		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	4.57E15	2.40E15	1.73E15	1.02E14	1.71E9	5.49E6
Sc46	33.14	63.03	86.68	71.18		
Sc45m	32.61					
Sc46m	14.70					
Sc44	10.12	19.08	3.91			
Sc44m	3.95	7.52	3.69			
Ca45	2.92	5.57	7.59	27.69		
K42	2.42	4.59	0.04		2.62	
H3				0.11	27.42	
Ar39					66.71	
Ar42					2.62	
Ca41					0.42	99.99

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	7.76E-1	7.57E-1	5.34E-1	2.54E-2	5.41E-8	2.91E-12
Sc46	66.29	68.01	93.48	98.62		
Sc44	26.08	26.50	5.56			
K42	3.88	3.96	0.04		22.46	
Sc46m	1.96					
Sc44m	1.15	1.78	0.59			
Sc45m	0.28					
Ca45	0.21		0.30	1.37		
Ar39					73.66	
Ar42					3.08	
H3					0.79	
Ca41					0.01	99.13

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	1.09E6	1.08E6	8.35E5	4.00E4	3.93E-3	8.57E-8
Sc46	75.57	76.09	95.40	100.0		
Sc44	22.29	22.23	4.26			
K42	0.85	0.85			99.99*	
Sc44m	0.72	0.72	0.33			
Sc46m	0.45					
K44	0.06	0.05				
Ca41						94.35
K40						5.64

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	3.11E6	3.10E6	2.48E6	1.34E5	1.43E3	1.04E-3
Sc46	72.95	73.29	88.90	82.70		
Sc44m	13.94	13.99	6.20			
Sc44	5.20	5.17	0.95			
Ca45	3.05	3.06	3.77	15.02		
K42	1.53	1.53	0.01			
Ar39	0.05	0.05	0.06	1.20	87.50	
Ar42	0.03	0.04	0.05	1.06	12.50	
Ca41						99.91

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.13E7	1.13E7	1.07E7	7.19E5	5.04E4	9.91E-4
Sc46	91.06	91.11	93.41	69.73		
Ca45	4.37	4.38	4.55	14.56		
Sc44m	2.23	2.23	0.83			
Sc44	0.73	0.72	0.11			
Ar42	0.51	0.51	0.05	7.95	14.19	
Ar39	0.49	0.49	0.06	7.75	85.81	
Ca41						99.72

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	1.63E13	1.62E13	1.49E13	7.38E11	7.80E4	4.28E0
Sc46	93.02	93.44	98.88	99.96		
Sc44	6.17	6.14	0.99			
Sc46m	0.37					
Sc44m	0.30	0.30	0.11			
K42	0.06	0.06			5.73	
Ar39					76.79	
Ar42					11.46	
Ca41						91.56
Cl36						8.20
K 40						0.24

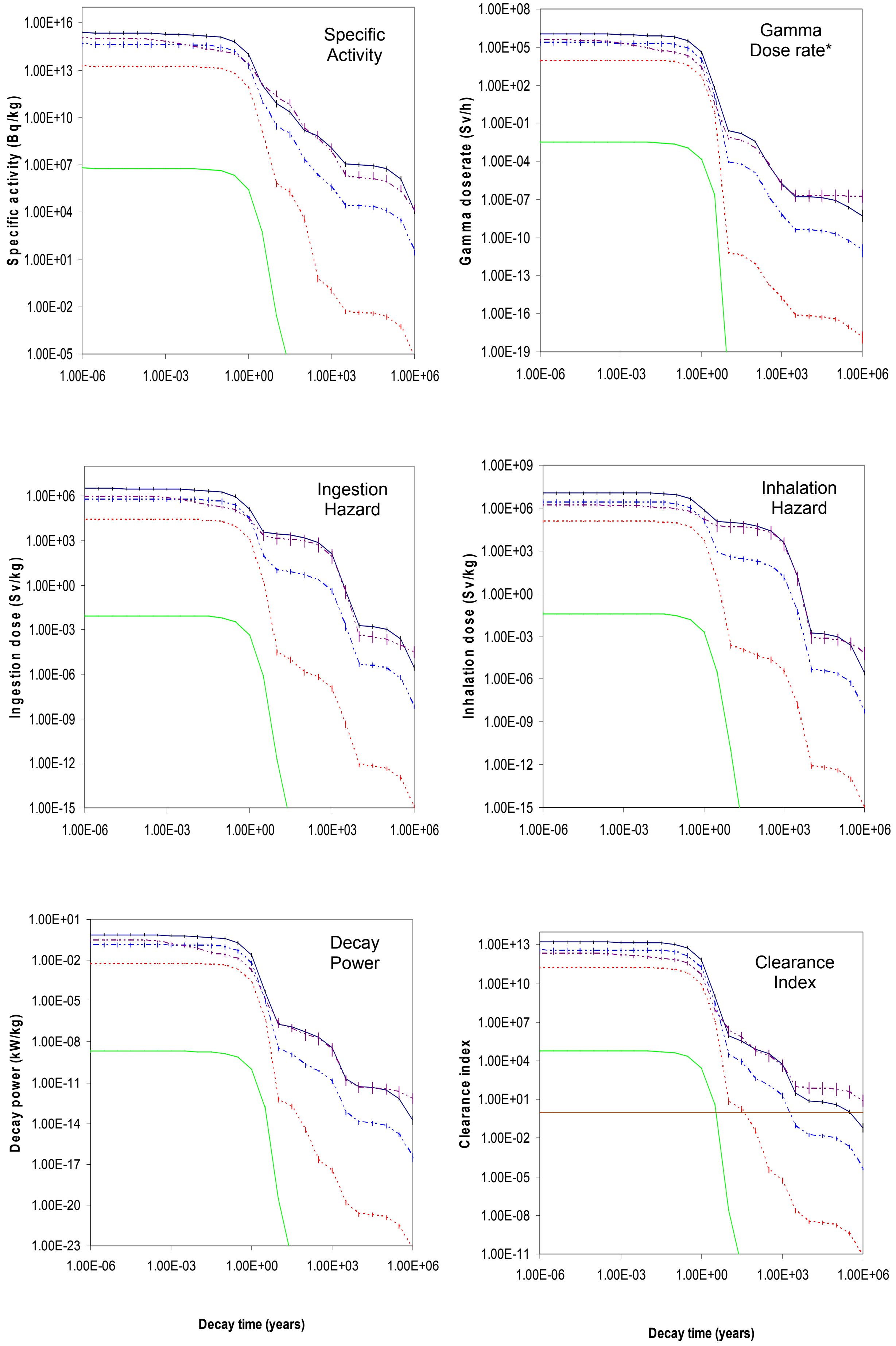
Scandium

Pathway analysis

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Sc45m	0.316 s	Sc45(n,p)Ca45(β^-)Sc45m	100.0	99.9					
		Sc45(n,n′)Sc45m			100.0	99.3	99.7	99.8	99.9
Sc44	3.97 h	**&**Sc45(n,2n)*Sc44*				99.9	100.0	100.0	100.0
K42	12.36 h	Sc45(n,α)K42				96.3	55.9	28.1	76.1
		Sc45(n,d)Ca44(n,2n)Ca43(n,d)K42				0.1	2.0	0.4	
		Sc45(n,t)Ca43(n,d)K42					28.7	28.2	7.9
		Sc45(n,3n)Sc43(β^+)Ca43(n,d)K42					4.2	7.3	1.7
		&Sc45(n,2n)*Sc44*(β^+)Ca44(n,2n)Ca43(n,d)K42					2.6	0.4	
		&Sc45(n,2n)*Sc44*(β^+)Ca44(n,t)K42					2.1	17.0	6.5
		Sc45(n,d)Ca44(n,t)K42					1.7	16.1	6.0
Sc44m	2.442 d	Sc45(n,2n)Sc44m				99.3	99.7	99.8	99.9
Sc46	83.79 d	**&**Sc45(n,γ)*Sc46*	100.0	100.0	100.0	99.3	98.8	99.2	99.7
Ca45	163.0 d	Sc45(n,p)Ca45	100.0	99.9	100.0	99.8	99.9	99.9	100.0
Co60	5.271 y	Very long pathways of (n,γ), β^-	100.0						
H3	12.33 y	**&**Sc45(n,γ)*Sc46*(n,X)H1(n,γ)H2(n,γ)H3	51.5	7.6	25.9				
		Sc45(n,X)H1(n,γ)H2(n,γ)H3	41.7	87.6	73.5				
		Sc45(n,X)H3				99.2	95.5	94.4	94.9
		Sc45(n,t)Ca43(n,X)H3					1.2	2.0	1.2
Ar42	33.0 y	Sc45(n,p)Ca45(n,α)Ar42				98.2	8.7	1.0	0.4
		Sc45(n,α)K42(n,p)Ar42				1.6			
		&Sc45(n,2n)*Sc44*(β^+)Ca44(n,h)Ar42					39.0	42.1	21.9
		Sc45(n,d)Ca44(n,h)Ar42					31.2	39.8	20.4
		Sc45(n,t)Ca43(n,2p)Ar42					15.4	10.5	2.5
		Sc45(n,3n)Sc43(β^+)Ca43(n,2p)Ar42					2.2	2.7	0.5
		Sc45(n,ph)Ar42						2.6	53.6
Ar39	269.0 y	Sc45(n,α)K42(β^-)Ca42(n,α)Ar39				87.6	0.4	0.1	0.7
		&Sc45(n,2n)*Sc44*(β^+)Ca44(n,2n)Ca43_ (n,nα)Ar39				3.8	2.6	0.1	
		Sc45(n,d)Ca44(n,2n)Ca43(n,nα)Ar39				3.7	2.0	0.2	
		Sc45(n,t)Ca43(n,nα)Ar39				0.2	43.3	17.7	1.6
		Sc45(n,nα)K41(n,t)Ar39				0.1	30.8	12.3	1.1
		Sc45(n,3n)Sc43(β^+)Ca43(n,nα)Ar39					6.3	4.6	0.4
		Sc45(n,2nα)K40(n,d)Ar39					1.8	16.1	1.1
		&Sc45(n,2n)*Sc44*(β^+)Ca44(n,2nα)Ar39					1.3	15.9	1.2
		Sc45(n,d)Ca44(n,2nα)Ar39					1.0	15.0	1.1
		Sc45(n,tα)Ar39						7.2	86.9
Ca41	1.0 10^5 y	Sc45(n,α)K42(β^-)Ca42(n,2n)Ca41				98.6	11.3	1.9	1.5
		Sc45(n,d)Ca44(n,2n)Ca43(n,2n)Ca42(n,2n)Ca41				0.6	0.1		
		Sc45(n,t)Ca43(n,3n)Ca41					56.9	61.5	6.4
		Sc45(n,3n)Sc43(β^+)Ca43(n,3n)Ca41					8.3	15.9	1.4
		Sc45(n,t)Ca43(n,2n)Ca42(n,2n)Ca41					3.7	1.0	
		&Sc45(n,2n)*Sc44*(β^+)Ca44(n,2n)Ca43_ (n,3n)Ca41					3.4	0.5	
		&Sc45(n,2n)*Sc44*(β^+)Ca44(n,3n)Ca42_ (n,2n)Ca41					3.2	0.8	
		Sc45(n,nt)Ca42(n,2n)Ca41					2.0	8.6	8.1
		Sc45(n,2nt)Ca41						1.9	75.4
		&Sc45(n,2n)*Sc44*(β^+)Ca44(n,4n)Ca41						1.1	3.2
Cl36	3.0 10^5 y	Sc45(n,nα)K41(n,nα)Cl37(n,2n)Cl36				37.7	8.0	0.2	
		Sc45(n,nα)K41(n,2n)K40(n,nα)Cl36				29.1	9.4	0.3	
		Sc45(n,α)K42(β^-)Ca42(n,nα)Ar38_ (n,2n)Ar37(β^+)Cl37(n,2n)Cl36				5.3			
		Sc45(n,α)K42(β^-)Ca42(n,nα)Ar38(n,d)_ Cl37(n,2n)Cl36				4.6			
	►	Sc45(n,α)K42(β^-)Ca42(n,2n)Ca41_ (n,nα)Ar37(β^+)Cl37(n,2n)Cl36				3.0			

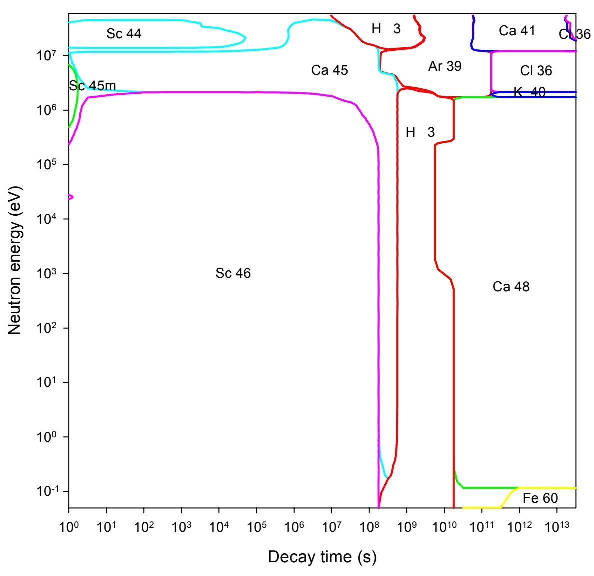
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◀	Sc45(n,α)K42(β^-)Ca42(n,2n)Ca41(n,d)_ K40(n,nα)Cl36				2.8			
		&Sc45(n,2n)*Sc44*(β^+)Ca44(n,α)Ar41_ (β^-)K41(n,nα)Cl37(n,2n)Cl36				2.6			
		Sc45(n,d)Ca44(n,α)Ar41(β^-)K41(n,nα)_ Cl37(n,2n)Cl36				2.5			
		Sc45(n,d)Ca44(n,α)Ar41(β^-)K41(n,2n)_ K40(n,nα)Cl36				1.9			
		&Sc45(n,2n)*Sc44*(β^+)Ca44(n,α)Ar41_ (β^-)K41(n,2n)K40(n,nα)Cl36				1.9			
		Sc45(n,α)K42(β^-)Ca42(n,d)K41(n,nα)_ Cl37(n,2n)Cl36				1.8			
		Sc45(n,α)K42(β^-)Ca42(n,d)K41(n,2n)_ K40(n,nα)Cl36				1.4			
		Sc45(n,α)K42(β^-)Ca42(n,2n)Ca41_ (n,pα)Cl37(n,2n)Cl36				0.9			
		Sc45(n,nα)K41(n,2nα)Cl36					57.5	29.1	1.6
		Sc45(n,2nα)K40(n,nα)Cl36					14.0	39.5	2.0
		Sc45(n,n2α)Cl37(n,2n)Cl36					2.5	6.5	0.6
		Sc45(n,t)Ca43(n,2nα)Ar38(n,t)Cl36					1.0	4.3	0.2
		Sc45(n,t)Ca43(n,t)K41(n,2nα)Cl36					0.5	3.3	0.1
		Sc45(n,2nα)K40(n,t)Ar38(n,t)Cl36						2.6	0.1
		Sc45(n,ntα)Ar38(n,t)Cl36						0.3	2.0
		Sc45(n,nt)Ca42(n,tα)Cl36						0.2	9.1
		Sc45(n,3nα)K39(n,α)Cl36						0.1	3.7
		Sc45(n,2n2α)Cl36							69.2
		Sc45(n,tα)Ar39(n,nt)Cl36							4.1
Fe60	1.5 10^6 y	Very long pathways of (n,γ), β^-	100.0						
K40	1.3 10^9 y	Sc45(n,nα)K41(n,2n)K40				72.1	47.5	1.0	0.7
		Sc45(n,α)K42(β^-)Ca42(n,2n)Ca41(n,d)K40				9.2	0.1		
		Sc45(n,d)Ca44(n,α)Ar41(β^-)K41(n,2n)K40				6.4	0.1		
		Sc45(n,α)K42(β^-)Ca42(n,d)K41(n,2n)K40				4.6	0.1		
		Sc45(n,2n)Sc44(β^+)Ca44(n,α)Ar41(β^-)_ K41(n,2n)K40				4.0			
		Sc45(n,2n)Sc44m(n,nα)K40				0.5			
		Sc45(n,2nα)K40					47.1	95.4	81.7
		Sc45(n,α)K42(β^-)Ca42(n,t)K40					1.0	0.3	1.3
		Sc45(n,t)Ca43(n,nt)K40					0.3	0.8	5.7
		Sc45(n,nt)Ca42(n,t)K40					0.2	1.2	7.0
		Sc45(n,3n)Sc43(β^+)Ca43(n,nt)K40						0.2	1.2
Ca48	5.3 10^{19} y	**&**Sc45(n,γ)*Sc46*(n,p)Ca46(n,γ)Ca47(n,γ)_ Ca48	94.5	95.6	99.9	55.8	62.4	62.8	63.4
		Sc45(n,p)Ca45(n,γ)Ca46(n,γ)Ca47(n,γ)Ca48	5.5	4.4		43.1	36.7	36.4	36.0
		Sc45(n,γ)Sc46(n,γ)Sc47(n,p)Ca47(n,γ)Ca48				0.1	0.2	0.2	0.2

Scandium activation characteristics

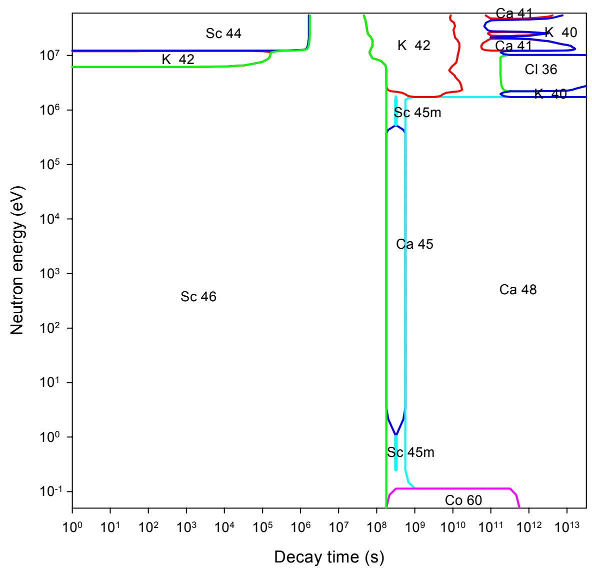


Scandium importance diagrams & transmutation

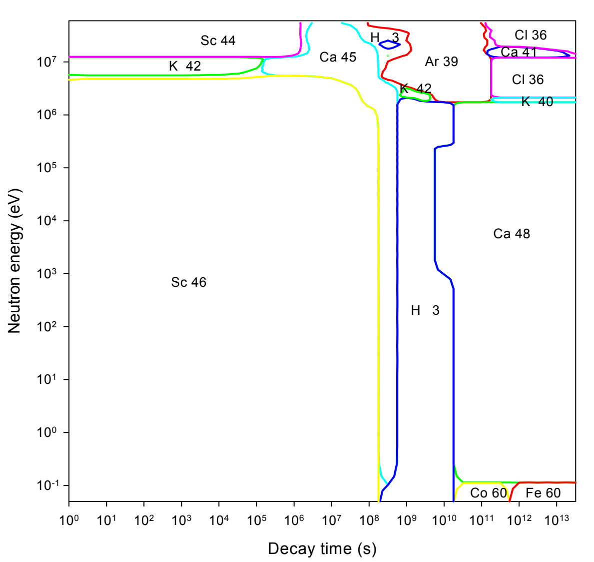
Activity



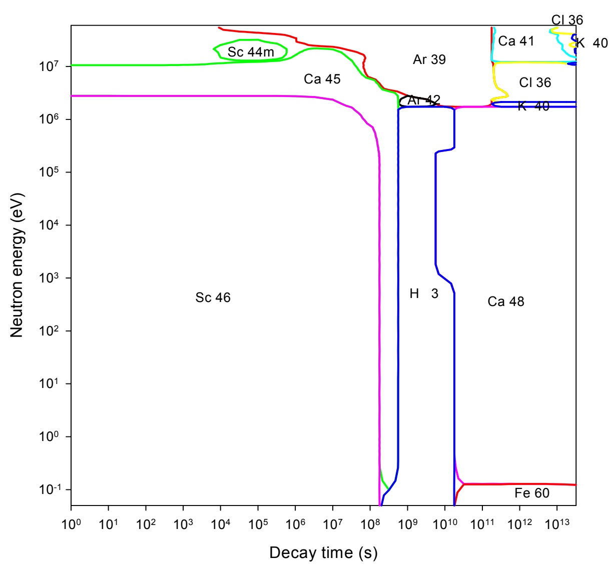
Dose rate



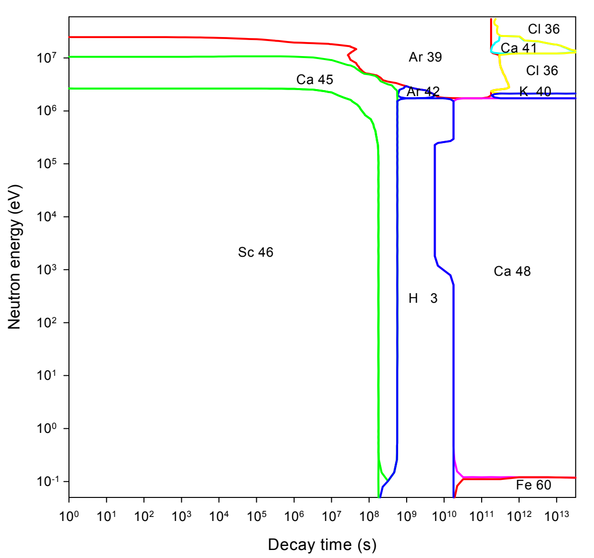
Heat output



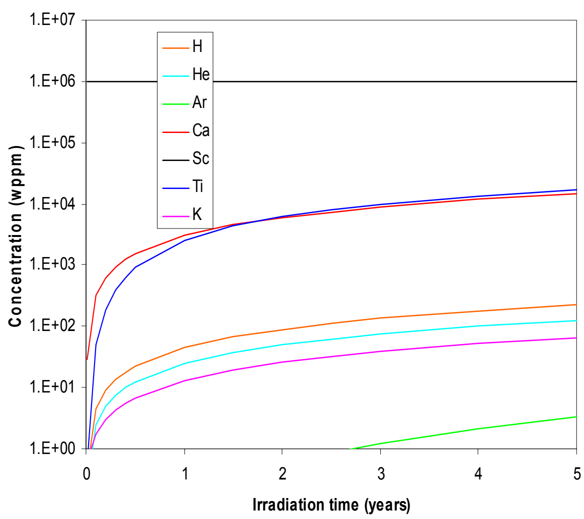
Ingestion dose



Inhalation dose



First wall transmutation



Titanium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	22		
Crustal abundance / wppm	$5.65\ 10^{3}$	Ti46	8.25
Melting point / K	1941	Ti47	7.44
Boiling point / K	3560	Ti48	73.72
Density / kgm^{-3}	4540	Ti49	5.41
Thermal conductivity / $Wm^{-1}K^{-1}$	21.9	Ti50	5.18
Electrical resistivity /Ωm	$4.2\ 10^{-7}$		
Coefficient of thermal expansion / K^{-1}	$8.60\ 10^{-6}$		
Crystal structure	HCP		
Number of stable isotopes	5		
Mean atomic weight	47.867		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	2.54E14	2.28E14	1.31E14	1.09E13	5.39E7	3.72E4
Sc48	34.51	38.40	16.72			
Sc46	20.18	22.48	38.13	22.93		
Sc47	15.92	17.73	14.79			
Ca45	15.62	17.40	29.94	77.05		
Sc45m	5.23					
Sc46m	4.20					
Sc49	1.57	1.64				
Ti45	1.32	1.44				
K42	0.04	0.03			24.10	
H3				0.01	10.53	
Ar39					41.11	
Ar42					24.10	
Ca41					0.13	100.0

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	7.28E-2	7.15E-2	3.08E-2	9.53E-4	4.80E-9	1.96E-14
Sc48	68.93	70.05	40.46			
Sc46	23.95	24.38	54.85	89.10		
Sc47	2.41	2.45	2.71			
Sc50	1.24	0.14				
Ti45	0.92	0.91				
Sc49	0.72	0.69				
Ca45	0.67	0.68	1.56	10.89		
Ca47	0.23	0.23	0.31			
K42	0.03	0.03			73.57	
Ar39					16.17	
Ar42					10.09	
H3					0.10	
Ca41						99.87

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	1.14E5	1.13E5	4.84E4	1.38E3	1.16E-3	5.09E-10
Sc48	72.84	73.50	42.63			
Sc46	24.81	25.07	56.65	100.0		
Sc50	9.35	0.11				
Ti45	0.53	0.53				
Sc47	0.33	0.33	0.37			
Ca47	0.20	0.20	0.27			
Sc44	0.18	0.18	0.06		0.25	
K42					99.74*	
Ca41						99.28

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	2.83E5	2.80E5	1.51E5	1.02E4	7.63E1	7.07E-6
Sc48	52.69	53.21	24.53			
Sc46	27.18	27.49	49.37	36.90		
Ca45	9.95	10.07	18.35	58.70		
Sc47	7.72	7.83	6.89			
Ar42	0.14	0.15	0.28	4.09	68.06	
Ar39	0.01	0.01	0.02	0.30	31.93	
K42	0.01	0.01				
Ca41						99.99

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	6.44E5	6.42E5	5.40E5	6.58E4	2.92E3	6.70E-6
Sc46	54.19	54.29	62.65	25.84		
Ca45	22.82	22.86	26.77	47.24		
Sc48	14.99	15.00	4.44			
Sc47	4.59	4.59	2.60			
Ar42	2.63	2.64	2.34	25.27	71.17	
Ca47	0.24	0.24	0.16			
Ar39	0.16	0.16	0.20	1.65	28.83	
Ca41						99.95

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	6.11E11	6.06E11	5.20E11	2.51E10	5.13E03	2.70E-2
Sc46	83.92	84.59	95.66	99.66		
Sc48	14.35	14.45	4.19			
Sc47	0.06	0.06	0.03			
Ar42					50.62	
K42					25.31	
Ar39					22.72	
H3					1.10	
Ca41						98.37

Titanium

Pathway analysis

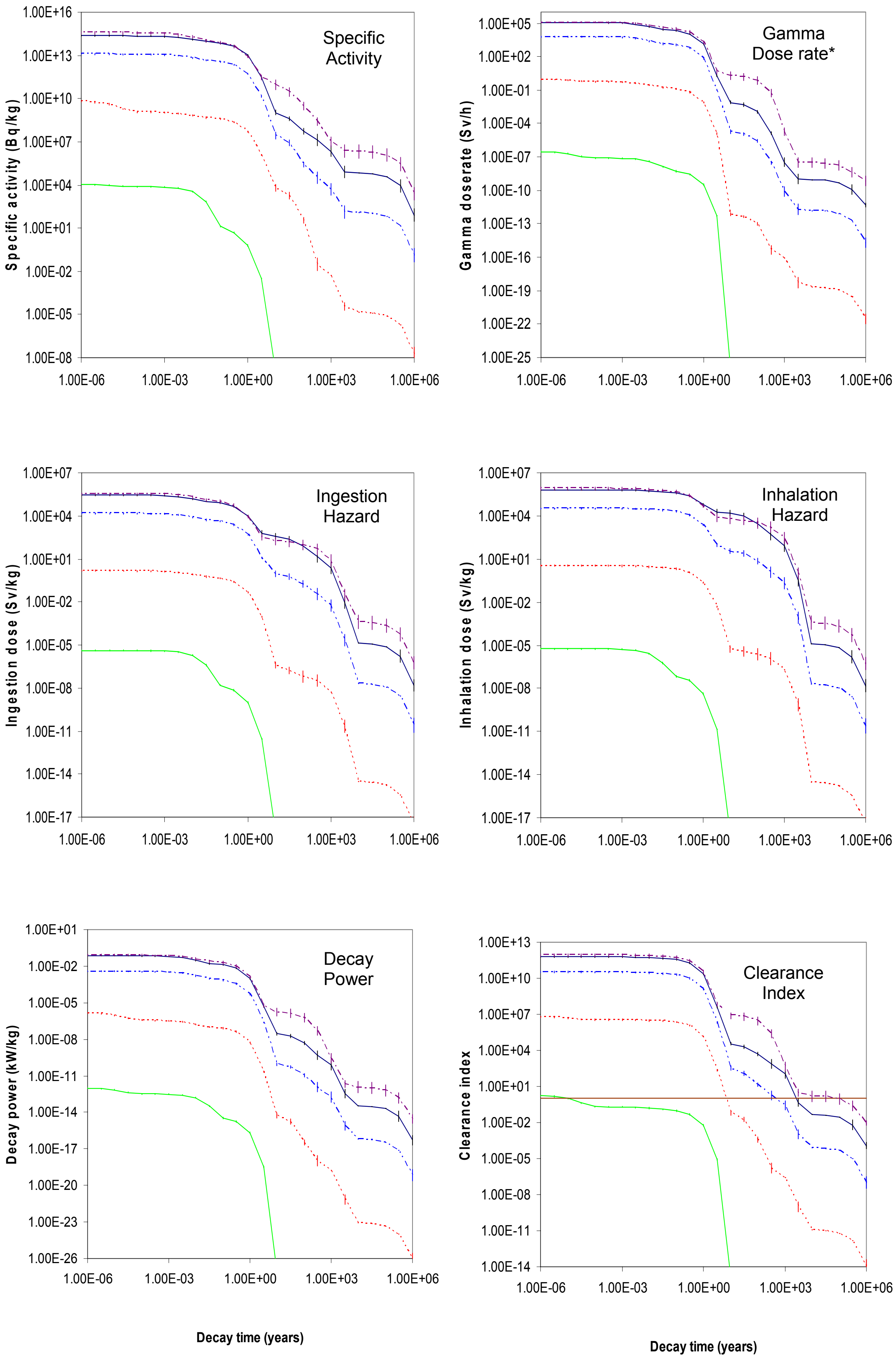
Nuclide	T½	Pathway	240	186	151	42	30	21	6
V52	3.745 m	Ti50(n,γ)Ti51(β^-)V51(n,γ)V52	85.7	99.9	99.9	99.3	99.7	99.8	99.9
		Ti48(n,γ)Ti49(n,γ)Ti50(n,γ)Ti51(β^-)V51_ (n,γ)V52	9.1						
		Ti49(n,γ)Ti50(n,γ)Ti51(β^-)V51(n,γ)V52	5.2	0.1	0.1				
Ti51	5.8 m	Ti50(n,γ)Ti51	71.2	99.7	99.8	99.3	99.6	99.7	99.9
		Ti48(n,γ)Ti49(n,γ)Ti50(n,γ)Ti51	20.5						
		Ti49(n,γ)Ti50(n,γ)Ti51	8.2	0.3	0.2				
Mn56	2.582 h	Ti50(n,γ)Ti51(β^-)V51(n,γ)V52(β^-)Cr52(n,γ)_ Cr53(n,γ)Cr54(n,γ)Cr55(β^-)Mn55(n,γ)Mn56	96.4	100.0					
		Ti49(n,γ)Ti50(n,γ)Ti51(β^-)V51(n,γ)V52_ (β^-)Cr52(n,γ)Cr53(n,γ)Cr54(n,γ)Cr55(β^-)_ Mn55(n,γ)Mn56	2.0						
		Ti48(n,γ)Ti49(n,γ)Ti50(n,γ)Ti51(β^-)V51_ (n,γ)V52(β^-)Cr52(n,γ)Cr53(n,γ)Cr54(n,γ)_ Cr55(β^-)Mn55(n,γ)Mn56	1.6						
Sc44	3.97 h	**&**Ti46(n,d)*Sc45*(n,2n)*Sc44*				45.0	34.1	1.8	0.7
		&Ti48(n,α)Ca45(β^-)Sc45(n,2n)*Sc44*				37.6	5.4	0.2	0.5
		&Ti46(n,2n)Ti45(β^+)Sc45(n,2n)*Sc44*				7.1	13.7	0.8	0.2
		&Ti46(n,t)*Sc44*					18.0	56.8	38.3
		&Ti47(n,t)*Sc45*(n,2n)*Sc44*					5.4	1.5	0.7
		&Ti48(n,3n)Ti46(n,t)*Sc44*					2.0	16.4	5.7
		&Ti48(n,t)Sc46(β^-)Ti46(n,t)*Sc44*						8.4	5.0
		&Ti47(n,nt)*Sc44*						1.1	20.2
		&Ti48(n,2n)Ti47(n,nt)*Sc44*						0.3	3.7
		&Ti48(n,nt)*Sc45*(n,2n)*Sc44*						0.2	5.2
		&Ti48(n,d)Sc47(β^-)Ti47(n,nt)*Sc44*						0.2	3.4
		&Ti48(n,2nt)*Sc44*							7.4
K42	12.36 h	**&**Ti46(n,d)*Sc45*(n,α)K42				41.2	5.2	0.7	1.1
		Ti48(n,α)Ca45(β^-)Sc45(n,α)K42				33.8	0.8		0.7
		Ti46(n,2n)Ti45(β^+)Sc45(n,α)K42				6.6	2.2	0.3	0.4
		Ti46(n,α)Ca43(n,d)K42				5.9	3.3	0.7	2.2
		Ti46(n,nα)Ca42(n,p)K42				2.9	2.9	0.4	
		Ti46(n,pα)K42					37.8	18.0	3.2
		Ti47(n,nα)Ca43(n,d)K42					11.1	1.6	0.4
		Ti48(n,3n)Ti46(n,pα)K42					4.6	5.6	0.5
		Ti48(n,2n)Ti47(n,nα)Ca43(n,d)K42					4.2	0.3	
		Ti48(n,nα)Ca44(n,t)K42					2.5	11.4	3.2
		Ti46(n,h)Ca44(n,t)K42					0.2	3.9	1.2
		&Ti46(n,t)*Sc44*(β^+)Ca44(n,t)K42						12.7	4.4
		Ti48(n,2nα)Ca43(n,d)K42						12.3	4.2
		Ti47(n,dα)K42						6.1	10.1
		Ti48(n,tα)K42						0.1	38.1
		Ti48(n,nt)Sc45(n,α)K42							5.4
Sc48	1.820 d	**&**Ti47(n,α)Ca44(n,γ)Ca45(β^-)Sc45(n,γ)_ *Sc46*(n,γ)Sc47(n,γ)Sc48	78.3	69.3					
		Ti47(n,α)Ca44(n,γ)Ca45(n,γ)Ca46(n,γ)_ Ca47(β^-)Sc47(n,γ)Sc48	11.5	18.9					
		&Ti46(n,γ)Ti47(n,α)Ca44(n,γ)Ca45(β^-)_ Sc45(n,γ)*Sc46*(n,γ)Sc47(n,γ)Sc48	0.9						
		Ti48(n,p)Sc48				98.2	70.0	55.3	38.8
		Ti49(n,2n)Ti48(n,p)Sc48				1.0	0.4	0.2	
		Ti49(n,d)Sc48				0.7	25.5	26.0	29.4
		Ti50(n,2n)Ti49(n,d)Sc48					2.4	1.1	0.7
		Ti50(n,t)Sc48					0.9	16.5	30.3
Sc47	3.351 d ►	**&**Ti47(n,α)Ca44(n,γ)Ca45(β^-)Sc45(n,γ)_ *Sc46*(n,γ)Sc47	84.7	76.4	95.7				

Nuclide	T½	Pathway	240	186	151	42	30	21	6
	◄	Ti47(n,α)Ca44(n,γ)Ca45(n,γ)Ca46(n,γ)_ Ca47(β$^-$)Sc47	12.4	20.4	3.6				
		Ti48(n,d)Sc47				37.0	93.0	88.8	84.4
		Ti47(n,p)Sc47				33.1	2.1	2.0	1.3
		Ti48(n,2n)Ti47(n,p)Sc47				26.4	1.6	0.6	0.3
		Ti50(n,α)Ca47(β$^-$)Sc47				1.5	0.2	0.1	0.3
		Ti49(n,t)Sc47					0.7	5.7	6.9
		Ti50(n,nt)Sc47						0.2	5.3
Sc46	83.79 d	**&**Ti47(n,α)Ca44(n,γ)Ca45(β$^-$)Sc45(n,γ)*Sc46*	99.0	99.9	99.9				
		Ti46(n,γ)Ti47(n,α)Ca44(n,γ)Ca45(β$^-$)_ Sc45(n,γ)Sc46	0.6						
		&Ti46(n,p)*Sc46*				67.1	10.9	2.8	1.6
		&Ti47(n,d)*Sc46*				12.8	36.5	9.1	7.5
		&Ti48(n,2n)Ti47(n,d)*Sc46*				9.6	26.1	2.7	1.4
		&Ti47(n,2n)Ti46(n,p)*Sc46*				5.9	0.6		
		&Ti48(n,d)Sc47(β$^-$)Ti47(n,d)*Sc46*				0.3	12.4	2.2	1.3
		&Ti48(n,t)*Sc46*					9.3	79.9	81.2
		&Ti49(n,nt)*Sc46*						0.2	5.0
Ca45	163.0 d	Ti47(n,α)Ca44(n,γ)Ca45	98.4	99.9	99.8				
		Ti46(n,γ)Ti47(n,α)Ca44(n,γ)Ca45	1.5		0.2				
		Ti48(n,α)Ca45				96.1	66.3	46.1	78.9
		Ti49(n,2n)Ti48(n,α)Ca45				0.8	0.4	0.1	0.1
		&Ti46(n,d)*Sc45*(n,p)Ca45				0.7	1.0	0.5	
		Ti49(n,nα)Ca45					13.9	13.2	3.9
		Ti46(n,2p)Ca45					9.3	5.6	1.3
		Ti47(n,h)Ca45					0.8	10.8	5.1
		Ti48(n,2n)Ti47(n,h)Ca45					0.5	3.1	0.9
		Ti48(n,d)Sc47(β$^-$)Ti47(n,h)Ca45					0.3	2.4	0.8
		Ti48(n,h)Ca46(n,2n)Ca45					0.3	1.5	0.6
		Ti50(n,2nα)Ca45						7.3	4.7
Co60	5.271 y	Very long pathways of (n,γ), β$^-$	100.0						
H3	12.33 y	**&**Ti47(n,α)Ca44(n,γ)Ca45(β$^-$)Sc45(n,γ)_ *Sc46*(n,X)H1(n,γ)H2(n,γ)H3	49.5						
		Ti47(n,α)Ca44(n,γ)Ca45(β$^-$)Sc45(n,X)H1_ (n,γ)H2(n,γ)H3	45.9						
		Ti47(n,X)H3				42.3	11.6	9.4	7.9
		Ti48(n,2n)Ti47(n,X)H3				17.2	4.5	1.6	0.8
		Ti49(n,X)H3				12.3	7.9	6.6	6.1
		Ti46(n,d)Sc45(n,X)H3				8.0	0.7	0.2	
		Ti48(n,α)Ca45(β$^-$)Sc45(n,X)H3				5.9	0.1		
		Ti46(n,p)Sc46(n,X)H3				5.2			
		Ti46(n,α)Ca43(n,X)H3				2.4			
		Ti46(n,2n)Ti45(β$^+$)Sc45(n,X)H3				1.3	0.3	0.1	
		Ti48(n,d)Sc47(β$^-$)Ti47(n,X)H3				0.5	2.2	1.2	0.7
		Ti48(n,X)H3					58.7	64.3	67.7
		Ti46(n,X)H3					7.1	7.3	6.8
		Ti50(n,X)H3					3.5	4.4	4.9
Ar42	33.0 y	Ti48(n,α)Ca45(n,α)Ar42				97.8	18.3	1.3	3.8
		Ti48(n,nα)Ca44(n,h)Ar42					17.7	18.6	8.2
		Ti50(n,nα)Ca46(n,nα)Ar42					15.7	4.0	0.7
		Ti48(n,h)Ca46(n,nα)Ar42					11.8	19.5	6.8
		Ti49(n,α)Ca46(n,nα)Ar42					9.0	1.3	0.8
		Ti49(n,nα)Ca45(n,α)Ar42					3.9	0.4	0.2
		Ti47(n,2p)Ca46(n,nα)Ar42					3.5	0.6	
		Ti49(n,2α)Ar42					1.6	7.9	3.0
		Ti46(n,h)Ca44(n,h)Ar42					1.4	6.4	3.2
		&Ti46(n,t)*Sc44*(β$^+$)Ca44(n,h)Ar42					0.7	20.8	11.3
		Ti47(n,α)Ca44(n,h)Ar42					0.6	1.0	3.2
		&Ti47(n,nt)*Sc44*(β$^+$)Ca44(n,h)Ar42						0.4	6.0
		Ti48(n,hα)Ar42							19.8
		Ti50(n,n2α)Ar42							15.5
Ar39	269.0 y►	Ti46(n,α)Ca43(n,nα)Ar39				54.1	4.6	0.6	1.3

Nuclide	T½	Pathway	240	186	151	42	30	21	6
	◄	Ti46(n,nα)Ca42(n,α)Ar39				18.3	3.3	0.5	0.9
		Ti46(n,α)Ca43(n,2n)Ca42(n,α)Ar39				9.5			
		Ti46(n,α)Ca43(n,α)Ar40(n,2n)Ar39				4.8			
		&Ti46(n,d)*Sc45*(n,α)K42(β^-)Ca42(n,α)Ar39				2.5			
		Ti48(n,α)Ca45(β^-)Sc45(n,α)K42(β^-)_ Ca42(n,α)Ar39				1.6			
		Ti47(n,nα)Ca43(n,nα)Ar39				0.5	15.3	1.2	0.3
		Ti48(n,2n)Ti47(n,nα)Ca43(n,nα)Ar39				0.1	3.9	0.1	
		Ti46(n,2α)Ar39					46.4	17.1	1.6
		Ti48(n,nα)Ca44(n,2nα)Ar39					1.4	12.7	1.6
		Ti46(n,h)Ca44(n,2nα)Ar39					0.1	4.3	0.6
		&Ti46(n,t)*Sc44*(β^+)Ca44(n,2nα)Ar39						14.1	2.2
		Ti48(n,2nα)Ca43(n,nα)Ar39						9.2	2.4
		Ti47(n,n2α)Ar39						7.7	8.7
		Ti46(n,dα)K41(n,t)Ar39						3.6	1.5
		Ti46(n,2nα)Ca41(n,h)Ar39						3.3	0.6
		Ti48(n,2n2α)Ar39							33.5
		&Ti48(n,nt)*Sc45*(n,tα)Ar39							11.8
		Ti48(n,3nα)Ca42(n,α)Ar39							5.6
Ca41	1.0 10^5 y	Ti46(n,nα)Ca42(n,2n)Ca41				52.6	47.1	1.1	0.5
		Ti46(n,α)Ca43(n,2n)Ca42(n,2n)Ca41				27.4	0.2		
		&Ti46(n,d)*Sc45*(n,α)K42(β^-)Ca42(n,2n)Ca41				7.1	0.1		
		Ti48(n,α)Ca45(β^-)Sc45(n,α)K42(β^-)_ Ca42(n,2n)Ca41				4.7			
		Ti46(n,2nα)Ca41					12.9	69.1	40.4
		Ti47(n,nα)Ca43(n,3n)Ca41					10.4	0.6	0.2
		Ti46(n,pα)K42(β^-)Ca42(n,2n)Ca41					3.6	0.2	
		Ti46(n,α)Ca43(n,3n)Ca41					3.1	0.3	1.2
		Ti48(n,3n)Ti46(n,2nα)Ca41					0.8	10.8	3.3
		Ti48(n,t)Sc46(β^-)Ti46(n,2nα)Ca41						4.9	2.5
		Ti48(n,2nα)Ca43(n,3n)Ca41						4.7	2.2
		Ti47(n,3nα)Ca41							24.9
		Ti48(n,3nα)Ca42(n,2n)Ca41							3.0
Cl36	3.0 10^5 y	Ti46(n,nα)Ca42(n,nα)Ar38(n,2n)Ar37_ (β^+)Cl37(n,2n)Cl36				9.4	1.0		
		Ti46(n,nα)Ca42(n,nα)Ar38(n,d)Cl37_ (n,2n)Cl36				8.3	1.0		
		&Ti46(n,d)*Sc45*(n,nα)K41(n,nα)Cl37_ (n,2n)Cl36				6.8	1.0		
		Ti46(n,nα)Ca42(n,2n)Ca41(n,nα)Ar37_ (β^+)Cl37(n,2n)Cl36				5.4	0.7		
		&Ti46(n,d)*Sc45*(n,nα)K41(n,2n)K40_ (n,nα)Cl36				5.3	1.2		
		&Ti46(n,d)*Sc45*(n,nα)K41(n,2n)K40_ (n,nα)Cl36				5.3	1.2		
		Ti47(n,α)Ca44(n,α)Ar41(β^-)K41(n,nα)_ Cl37(n,2n)Cl36				5.3			
		Ti46(n,nα)Ca42(n,2n)Ca41(n,d)K40(n,nα)Cl36				5.0	0.9		
		Ti48(n,α)Ca45(β^-)Sc45(n,nα)K41(n,nα)_ Cl37(n,2n)Cl36				4.1	0.1		
		Ti47(n,α)Ca44(n,α)Ar41(β^-)K41(n,2n)_ K40(n,nα)Cl36				4.1			
		Ti46(n,nα)Ca42(n,d)K41(n,nα)Cl37(n,2n)Cl36				3.2	0.9		
		Ti48(n,α)Ca45(β^-)Sc45(n,nα)K41(n,2n)_ K40(n,nα)Cl36				3.2	0.1		
		Ti46(n,nα)Ca42(n,d)K41(n,2n)K40(n,nα)Cl36				2.5	1.0		
		Ti46(n,nα)Ca42(n,2n)Ca41(n,pα)Cl37_ (n,2n)Cl36				1.7	0.2		
		Ti46(n,α)Ca43(n,2n)Ca42(n,2n)Ca41_ (n,d)K40(n,nα)Cl36				1.6			
	►	Ti46(n,nα)Ca42(n,t)K40(n,nα)Cl36					8.7	0.5	

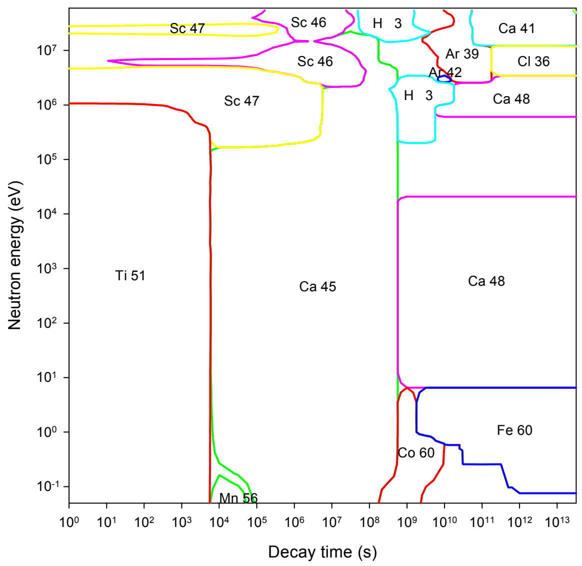
Nuclide	T½	Pathway	240	186	151	42	30	21	6
	◄	Ti46(n,nα)Ca42(n,d)K41(n,2nα)Cl36					8.2	0.5	
		Ti46(n,nα)Ca42(n,nα)Ar38(n,t)Cl36					6.9	0.5	
		Ti46(n,n2α)Ar38(n,t)Cl36					2.7	18.0	2.8
		Ti46(n,2nα)Ca41(n,dα)Cl36					0.8	24.4	3.3
		Ti46(n,dα)K41(n,2nα)Cl36						14.6	2.8
		Ti48(n,3nα)Ca42(n,tα)Cl36							19.4
		Ti48(n,nt)Sc45(n,2n2α)Cl36							9.3
Fe60	1.5 10^6 y	Very long pathways of (n,γ), β^-	100.0						
K40	1.3 10^9 y	**&**Ti46(n,d)*Sc45*(n,nα)K41(n,2n)K40				17.9	6.2		
		Ti46(n,nα)Ca42(n,2n)Ca41(n,d)K40				16.8	4.7		
		Ti47(n,α)Ca44(n,α)Ar41(β^-)K41(n,2n)K40				13.8			
		Ti48(n,α)Ca45(β^-)Sc45(n,nα)K41(n,2n)K40				11.8	0.8		
		Ti46(n,nα)Ca42(n,d)K41(n,2n)K40				8.4	5.5		
		Ti46(n,α)Ca43(n,2n)Ca42(n,2n)Ca41(n,d)K40				6.6			
		Ti46(n,α)Ca43(n,2n)Ca42(n,d)K41(n,2n)K40				3.3			
		Ti48(n,2n)Ti47(n,α)Ca44(n,α)Ar41(β^-)_ K41(n,2n)K40				2.7			
		&Ti46(n,d)*Sc45*(n,α)K42(β^-)Ca42(n,2n)_ Ca41(n,d)K40				1.1			
		&Ti46(n,d)*Sc45*(n,d)Ca44(n,α)Ar41(β^-)_ K41(n,2n)K40				0.8			
		Ti46(n,nα)Ca42(n,t)K40					35.5	10.3	1.0
		&Ti46(n,d)*Sc45*(n,2nα)K40					9.4	12.9	0.8
		Ti46(n,2n)Ti45(β^+)Sc45(n,2nα)K40					3.8	5.2	0.4
		Ti46(n,2nα)Ca41(n,d)K40					2.0	8.5	0.7
		&Ti47(n,t)*Sc45*(n,2nα)K40					1.5	11.5	0.8
		Ti47(n,2nα)Ca42(n,t)K40					1.0	9.8	0.9
		Ti48(n,2nα)Ca43(n,nt)K40						3.5	4.8
		Ti48(n,nt)Sc45(n,2nα)K40						1.5	4.5
		Ti46(n,tα)K40						1.2	50.6
		Ti48(n,3nα)Ca42(n,t)K40							6.1
		Ti48(n,t)Sc46(β^-)Ti46(n,tα)K40							3.2
Ca48	5.3 10^{19} y	Ti47(n,α)Ca44(n,γ)Ca45(n,γ)Ca46(n,γ)_ Ca47(n,γ)Ca48	99.2	100.0					
		Ti48(n,p)Sc48(n,p)Ca48				59.2	0.3		
		Ti49(n,2p)Ca48				37.5	29.4	10.7	8.3
		Ti50(n,2n)Ti49(n,2p)Ca48				2.4	1.4	0.2	0.1
		Ti50(n,h)Ca48					68.4	88.8	91.4

Titanium activation characteristics

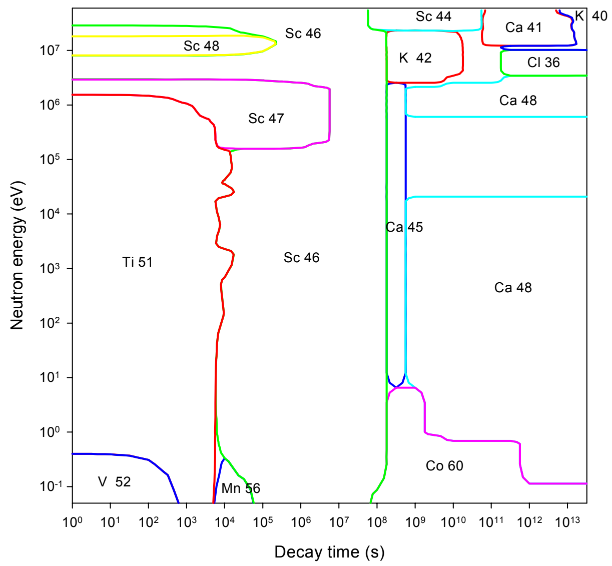


Titanium importance diagrams & transmutation

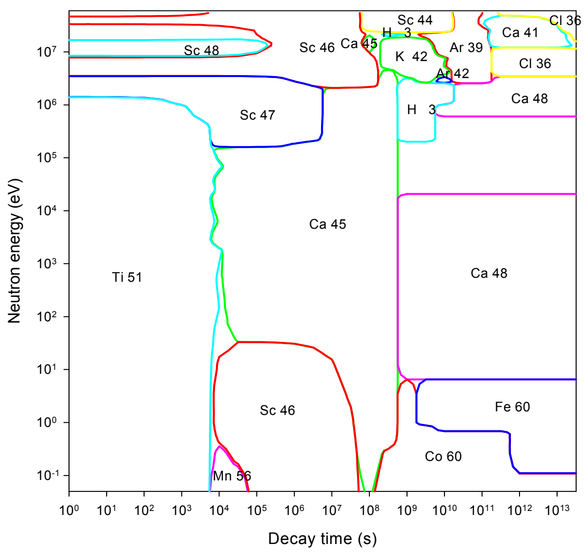
Activity



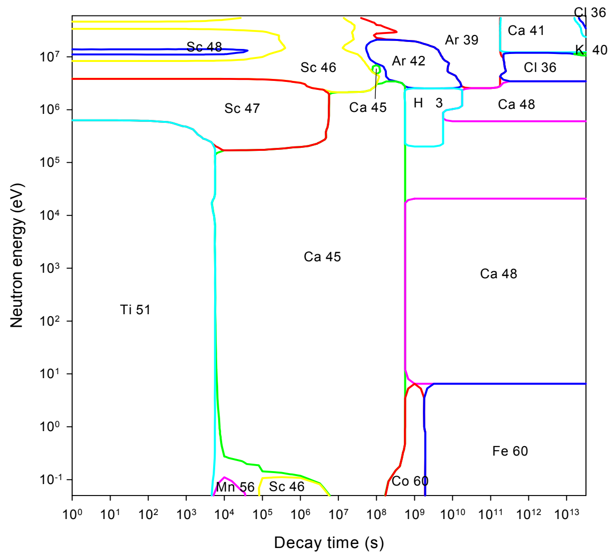
Dose rate



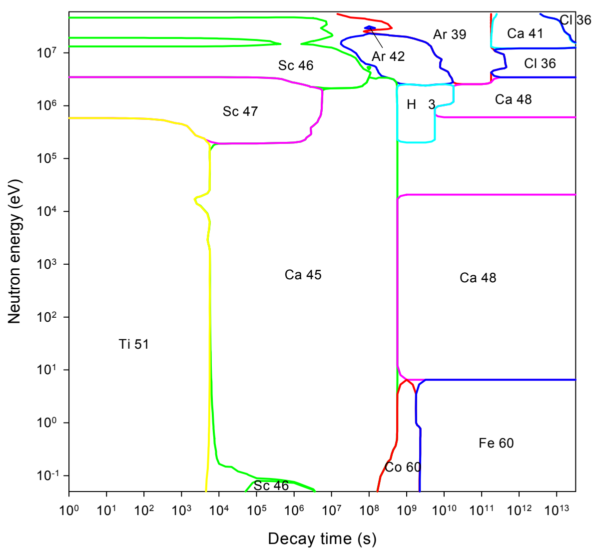
Heat output



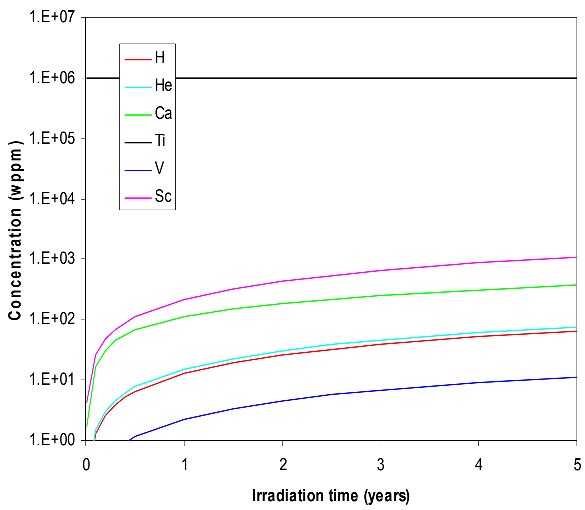
Ingestion dose



Inhalation dose



First wall transmutation



Vanadium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	23	V50	0.25 ($T_{½}$ = 1.40 10^{17} y)
Crustal abundance / wppm	120	V51	99.75
Melting point / K	2183		
Boiling point / K	3680		
Density / kgm^{-3}	6110		
Thermal conductivity / $Wm^{-1}K^{-1}$	30.7		
Electrical resistivity /Ωm	2.48 10^{-7}		
Coefficient of thermal expansion / K^{-1}	8.4 10^{-6}		
Crystal structure	BCC		
Number of stable isotopes	1 (2)		
Mean atomic weight	50.9415		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	5.92E14	2.59E14	2.22E13	5.78E12	5.49E7	9.64E-2
V52	83.07	71.67				
Ti51	9.66	11.77				
Sc48	4.47	10.21	29.78			
V49	2.09	4.78	55.56	99.68		
Cr51	0.50	1.15	12.29			
Sc47	0.16	0.36	2.07			
H3			0.06	0.24	99.99	
Ca45				0.05		
Ca41						74.36
V50						25.63

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	2.25E-1	9.61E-2	3.83E-3	4.32E-6	5.11E-11	5.74E-18
V52	88.16	77.87				
Sc48	6.75	15.67	98.49			
Ti51	5.03	6.27				
V49			0.23	96.69		
Sc46			0.04	2.00		
Ca45				0.96		
H3				0.30	98.37	
K42					1.43	
V50						99.34
Ca41						0.65

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	2.45E5	1.09E5	6.39E3	1.40E0	2.49E-7	1.08E-11
V52	87.96	74.67				
Sc48	10.40	23.55	99.32			
Ti51	1.60	1.92				
Sc50	0.01	0.01				
Cr51			0.24	0.13		
V49			0.04	89.65		
Sc46			0.04	10.12		
K42					99.99*	
V50						99.93
Ca41						0.06

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	5.39E4	4.91E4	1.19E4	1.07E2	1.31E-2	1.72E-10
Sc48	83.67	91.80	94.54			
V52	12.78	5.30				
Ti51	1.59	0.93				
Sc47	0.95	1.05	2.08			
V49	0.41	0.45	1.87	96.76		
Ca45	0.02	0.02	0.09	2.22		
Sc46	0.01	0.01	0.06	0.35		
H3				0.56	17.58	
Ar42				0.01	82.22	
V50						92.06
Ca41						7.92

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	3.58E4	3.26E4	8.28E3	2.17E2	4.47E-1	2.85E-10
Sc48	81.50	89.33	87.65			
V52	12.64	5.24				
Sc47	1.95	2.14	4.04			
Ti51	1.75	1.03				
V49	1.17	0.45	5.05	90.16		
Cr51	0.21	0.33	1.21			
Ca45	0.16	0.18	0.69	5.72		
Sc46	0.09	0.10	0.41	0.79		
H3	0.01	0.01	0.04	1.71	3.18	
Ar42		0.01	0.04	1.59	96.61	
V50						95.46
Ca41						4.53

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	8.22E11	3.31E11	6.71E9	1.02E7	5.50E2	3.54E-5
V52	93.57	87.76				
Sc48	3.22	8.00	98.26			
Ti51	3.16	4.19				
Sc46		0.01	0.75	24.96		
Cr51			0.40	0.03		
V49			0.23	73.27		
Sc47			0.06			
H3				1.40	99.85	
Ar42					0.09	
K42					0.04	
V50						99.84
Ca41						0.14

Vanadium

Pathway analysis

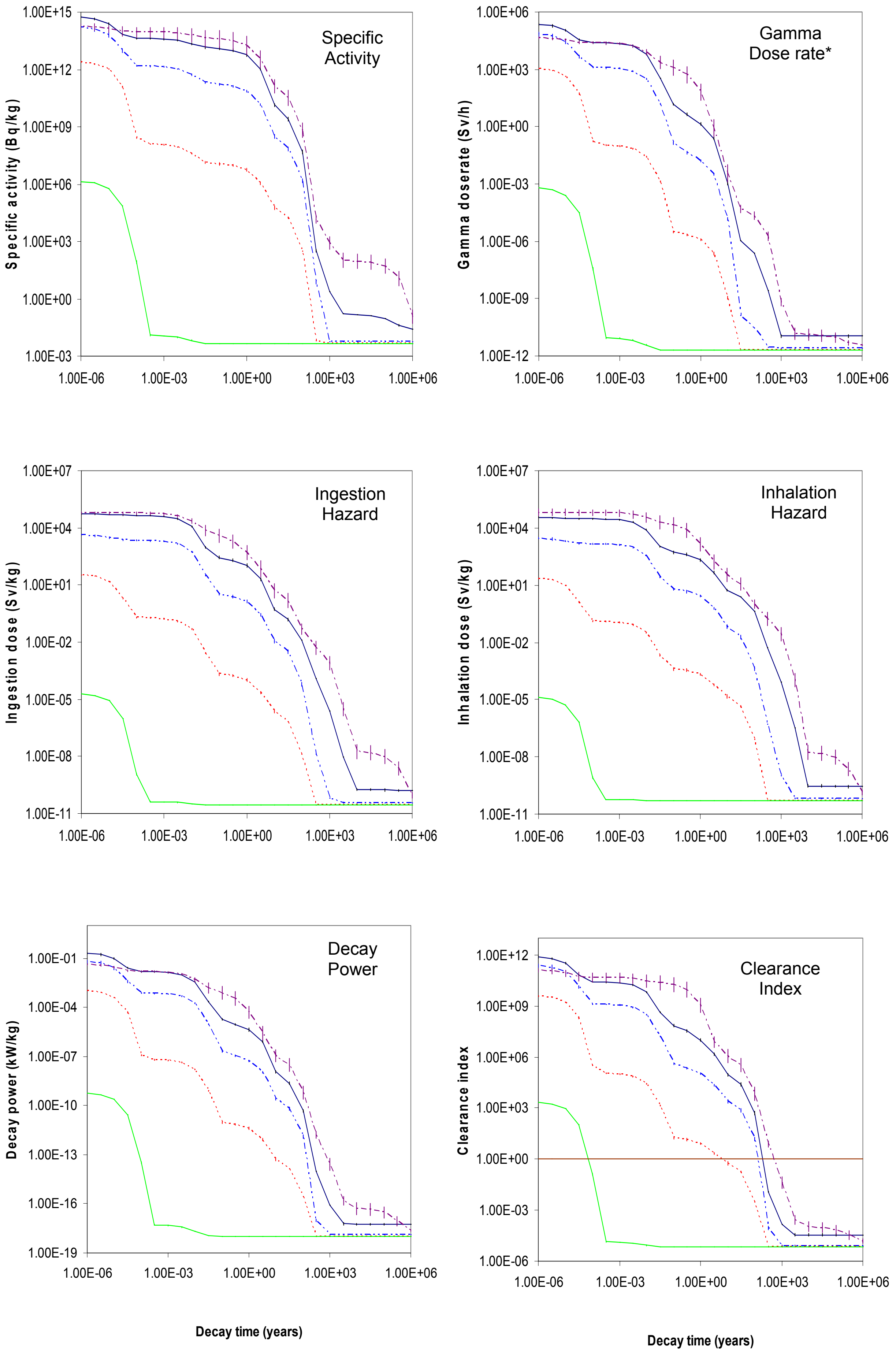
Nuclide	T½	Pathway	210	186	151	42	31	21	6
V52	3.745 m	V51(n,γ)V52	99.8	99.8	100.0	98.3	99.4	99.6	99.8
		V50(n,γ)V51(n,γ)V52	0.2	0.2					
Ti51	5.8 m	V50(n,p)Ti50(n,γ)Ti51	100.0	100.0	100.0				
		V51(n,p)Ti51				100.0	100.0	100.0	100.0
Mn56	2.582 h	V51(n,γ)V52(β^-)Cr52(n,γ)Cr53(n,γ)Cr54_ (n,γ)Cr55(β^-)Mn55(n,γ)Mn56	99.9	99.8	100.0				
Sc44	3.97 h	**&**V51(n,3n)V49(n,nα)*Sc45*(n,2n)*Sc44*					18.9	0.5	
		&V51(n,nα)Sc47(β^-)Ti47(n,t)*Sc45*(n,2n)*Sc44*					17.8	1.5	
		V51(n,3n)V49(β^+)Ti49(n,nα)Ca45(β^-)_ Sc45(n,2n)Sc44					8.0	0.3	
		&V51(n,nα)Sc47(β^-)Ti47(n,2n)Ti46(n,t)*Sc44*					3.9	2.0	0.1
		&V51(n,t)Ti49(n,nα)Ca45(β^-)Sc45(n,2n)*Sc44*					3.8	0.5	
		&V51(n,2n)V50(n,nα)Sc46(n,3n)*Sc44*					3.7		
		&V51(n,2n)V50(n,nα)Sc46(β^-)Ti46(n,t)*Sc44*					3.4	1.3	
		&V51(n,2nα)*Sc46*(β^-)Ti46(n,t)*Sc44*						50.0	19.3
		&V51(n,3n)V49(n,2nα)*Sc44*						21.2	4.1
		&V51(n,3nα)*Sc45*(n,2n)*Sc44*							12.3
		&V51(n,2n)V50(n,3nα)*Sc44*							10.6
		&V51(n,2nt)Ti47(n,nt)*Sc44*							9.9
		&V51(n,nt)Ti48(n,2nt)*Sc44*							3.3
K42	12.36 h	V51(n,α)Sc48(β^-)Ti48(n,α)Ca45(β^-)Sc45_ (n,α)K42				82.2			
		V51(n,nα)Sc47(β^-)Ti47(n,nα)Ca43(n,d)K42					36.5	1.8	
		V51(n,2n)V50(n,nα)Sc46(n,nα)K42					7.2	0.2	
		V51(n,3n)V49(n,2α)K42					4.3	6.7	0.2
		V51(n,2nα)Sc46(β^-)Ti46(n,pα)K42						14.2	1.2
		V51(n,nα)Sc47(β^-)Ti47(n,dα)K42						13.5	4.1
		V51(n,t)Ti49(n,2nα)Ca44(n,t)K42						6.4	0.8
		V51(n,3n)V49(β^+)Ti49(n,2nα)Ca44(n,t)K42						5.9	0.5
		V51(n,2n2α)K42							17.6
		V51(n,nt)Ti48(n,tα)K42							15.4
		V51(n,3nα)Sc45(n,α)K42							11.3
		V51(n,2nt)Ti47(n,dα)K42							4.6
Sc48	1.82 d	V51(n,α)Sc48				98.2	63.6	30.6	69.6
		V51(n,3n)V49(β^+)Ti49(n,d)Sc48					22.2	29.1	8.3
		V51(n,t)Ti49(n,d)Sc48					6.0	25.7	11.6
		V51(n,d)Ti50(n,t)Sc48					0.7	9.5	6.8
Sc47	3.351 d	V51(n,2n)V50(n,α)Sc47				70.1	1.3	0.4	2.1
		V51(n,nα)Sc47				20.4	93.2	74.6	58.5
		V51(n,d)Ti50(n,α)Ca47(β^-)Sc47				2.8	0.2		0.2
		V50(n,α)Sc47				1.6			0.2
		V51(n,α)Sc48(β^-)Ti48(n,d)Sc47				1.5	0.5	0.2	0.7
		V51(n,3n)V49(β^+)Ti49(n,t)Sc47					1.0	10.1	7.3
		V51(n,t)Ti49(n,t)Sc47					0.3	8.9	10.2
		V51(n,nt)Ti48(n,d)Sc47						1.1	10.6
		V51(n,d)Ti50(n,nt)Sc47						0.2	4.4
		V51(n,4n)V48(β^+)Ti48(n,d)Sc47							2.4
V48	15.97 d	V51(n,2n)V50(n,2n)V49(n,2n)V48				96.8	4.5	0.6	
		V50(n,2n)V49(n,2n)V48				3.0	0.2		
		V51(n,2n)V50(n,3n)V48					65.1	68.0	5.2
		V51(n,3n)V49(n,2n)V48					28.6	20.9	1.7
		V50(n,3n)V48					2.0	4.5	0.6
		V51(n,4n)V48						6.5	92.3
Fe59	44.495 d	V51(n,γ)V52(β^-)Cr52(n,γ)Cr53(n,γ)Cr54_ (n,γ)Cr55(β^-)Mn55(n,γ)Mn56(β^-)Fe56_ (n,γ)Fe57(n,γ)Fe58(n,γ)Fe59	99.9	99.8					

Nuclide	**T½**	**Pathway**	**210**	**186**	**151**	**42**	**31**	**21**	**6**
Sc46	83.79 d	&V51(n,2n)V50(n,2n)V49(n,α)*Sc46*				78.7	0.1		
		&V51(n,2n)V50(n,α)Sc47(β^-)Ti47(n,d)*Sc46*				4.8	0.2		
		&V51(n,α)Sc48(β^-)Ti48(n,2n)Ti47(n,d)*Sc46*				3.3	0.1		
		&V51(n,nα)Sc47(β^-)Ti47(n,d)*Sc46*				3.0	31.1	3.9	0.9
		&V50(n,2n)V49(n,α)*Sc46*				2.6			
		&V51(n,2n)V50(n,nα)*Sc46*				2.5	60.0	4.7	1.1
		& V50(n,nα)*Sc46*					1.8	0.5	0.1
		& V51(n,2nα)*Sc46*						81.3	69.0
		& V51(n,nt)Ti48(n,t)*Sc46*						1.9	9.8
		& V51(n,3n)V49(β^+)Ti49(n,nt)*Sc46*						1.0	4.9
		& V51(n,t)Ti49(n,nt)*Sc46*						0.8	7.0
		& V51(n,4n)V48(β^+)Ti48(n,t)*Sc46*							2.3
Ca45	163.0 d	V51(n,α)Sc48(β^-)Ti48(n,α)Ca45				86.0	1.2	0.2	0.7
		V51(n,2n)V50(n,2n)V49(β^+)Ti49(n,2n)_ Ti48(n,α)Ca45				3.4			
		V51(n,2n)V50(n,d)Ti49(n,2n)Ti48(n,α)Ca45				1.6			
		V51(n,3n)V49(β^+)Ti49(n,nα)Ca45					58.0	35.5	4.1
		V51(n,t)Ti49(n,nα)Ca45					16.4	32.6	5.9
		V51(n,2n)V50(n,2n)V49(β^+)Ti49(n,nα)Ca45					4.4	0.5	
		V51(n,2n)V50(n,d)Ti49(n,nα)Ca45					4.4	0.5	
		V51(n,nα)Sc47(β^-)Ti47(n,h)Ca45					0.9	3.7	0.7
		V51(n,d)Ti50(n,2nα)Ca45						10.5	4.0
		V51(n,2n)V50(n,dα)Ca45						3.4	2.0
		V51(n,nt)Ti48(n,α)Ca45						0.9	10.2
		V51(n,tα)Ca45						0.3	63.9
V49	330.0 d	V51(n,2n)V50(n,2n)V49				96.9	13.7	2.7	2.2
		V50(n,2n)V49				3.0	0.6	0.2	0.3
		V51(n,3n)V49					85.6	97.0	97.4
Co60	5.271 y	Very long pathways of (n,γ), β^-, see Fe59	100.0						
H3	12.33 y	V50(n,X)H1(n,γ)H2(n,γ)H3	92.9	93.7	99.3				
		V51(n,2n)V50(n,X)H3				60.6	8.5	2.7	1.3
		V51(n,X)H3				36.2	87.8	92.1	94.1
		V50(n,X)H3				2.8	0.5	0.4	0.3
		V51(n,3n)V49(β^+)Ti49(n,X)H3					0.8	1.2	0.6
		V51(n,t)Ti49(n,X)H3					0.3	1.3	0.9
Ar42	33.0 y	V51(n,α)Sc48(β^-)Ti48(n,α)Ca45(n,α)Ar42				91.9	0.2		
		V51(n,2n)V50(n,d)Ti49(n,2n)Ti48(n,α)_ Ca45(n,α)Ar42				0.9			
		V51(n,d)Ti50(n,nα)Ca46(n,nα)Ar42					37.8	4.5	0.5
		V51(n,3n)V49(β^+)Ti49(n,α)Ca46(n,nα)Ar42					15.2	2.0	0.6
		V51(n,3n)V49(β^+)Ti49(n,nα)Ca45(n,α)Ar42					9.9	0.8	0.2
		V51(n,t)Ti49(n,α)Ca46(n,nα)Ar42					5.9	2.5	1.1
		V51(n,3n)V49(β^+)Ti49(n,2α)Ar42					4.8	21.5	3.8
		V51(n,t)Ti49(n,2α)Ar42					1.6	23.0	6.5
		V51(n,dα)Ca46(n,nα)Ar42						23.5	24.8
		V51(n,d)Ti50(n,n2α)Ar42						0.1	19.2
		V51(n,tα)Ca45(n,α)Ar42							7.7
Ni63	100.6 y	Very long pathways of (n,γ), β^-, see Fe59	100.0						
Ar39	269.0 y	V51(n,α)Sc48(β^-)Ti48(n,α)Ca45(β^-)Sc45_ (n,α)K42(β^-)Ca42(n,α)Ar39				22.2			
		V51(n,nα)Sc47(β^-)Ti47(n,2n)Ti46(n,α)_ Ca43(n,nα)Ar39				8.6	0.3		
		&V51(n,2n)V50(n,2n)V49(n,α)*Sc46*(β^-)_ Ti46(n,α)Ca43(n,nα)Ar39				8.2			
		V51(n,2n)V50(n,α)Sc47(β^-)Ti47(n,2n)_ Ti46(n,α)Ca43(n,nα)Ar39				5.9			
		V51(n,nα)Sc47(β^-)Ti47(n,α)Ca44(n,2n)_ Ca43(n,nα)Ar39				4.5	0.3		
		V51(n,α)Sc48(β^-)Ti48(n,2n)Ti47(n,2n)_ Ti46(n,α)Ca43(n,nα)Ar39				4.1			
	►	V51(n,nα)Sc47(β^-)Ti47(n,nα)Ca43(n,nα)Ar39				3.5	63.9	1.6	

Nuclide	T½	Pathway	210	186	151	42	31	21	6
	◄	V51(n,2n)V50(n,α)Sc47(β^-)Ti47(n,nα)_ Ca43(n,nα)Ar39				3.1	0.2		
		V51(n,2n)V50(n,α)Sc47(β^-)Ti47(n,α)_ Ca44(n,2n)Ca43(n,nα)Ar39				3.1			
		&V51(n,2n)V50(n,2n)V49(n,α)*Sc46*(β^-)_ Ti46(n,nα)Ca42(n,α)Ar39				2.7			
		V51(n,α)Sc48(β^-)Ti48(n,2n)Ti47(n,α)_ Ca44(n,2n)Ca43(n,nα)Ar39				2.2			
		V51(n,α)Sc48(β^-)Ti48(n,2n)Ti47(n,nα)_ Ca43(n,nα)Ar39				2.1	0.2		
		V51(n,2n)V50(n,α)Sc47(β^-)Ti47(n,2n)_ Ti46(n,nα)Ca42(n,α)Ar39				2.0			
		V51(n,α)Sc48(β^-)Ti48(n,α)Ca45(n,2n)_ Ca44(n,2n)Ca43(n,nα)Ar39				1.1			
		&V51(n,2n)V50(n,nα)*Sc46*(β^-)Ti46(n,α)_ Ca43(n,nα)Ar39				0.4	0.2		
		&V51(n,2n)V50(n,nα)*Sc46*(β^-)Ti46_ (n,nα)Ca42(n,α)Ar39				0.1	0.9		
		V51(n,nα)Sc47(β^-)Ti47(n,2n)Ti46(n,2α)Ar39					6.5	0.4	
		V51(n,2n)V50(n,nα)Sc46(β^-)Ti46(n,2α)Ar39					5.1	0.2	
		V51(n,nα)Sc47(β^-)Ti47(n,n2α)Ar39						15.5	2.9
		V51(n,2nα)Sc46(β^-)Ti46(n,2α)Ar39						11.7	0.5
		V51(n,t)Ti49(n,2nα)Ca44(n,2nα)Ar39						8.6	0.5
		V51(n,3n)V49(β^+)Ti49(n,2nα)Ca44(n,2nα)Ar39						6.9	0.2
		&V51(n,3n)V49(n,2nα)*Sc44*(β^+)Ca44_ (n,2nα)Ar39						6.3	0.1
		V51(n,2nα)Sc46(β^-)Ti46(n,t)Sc44(β^+)_ Ca44(n,2nα)Ar39						4.0	0.3
		&V51(n,3nα)*Sc45*(n,tα)Ar39							39.8
		V51(n,nt)Ti48(n,2n2α)Ar39							11.2
Ca41	1.0 10^5 y	V51(n,α)Sc48(β^-)Ti48(n,α)Ca45(β^-)_ Sc45(n,α)K42(β^-)Ca42(n,2n)Ca41				54.5			
		V51(n,nα)Sc47(β^-)Ti47(n,2n)Ti46(n,nα)_ Ca42(n,2n)Ca41				7.1	4.3		
		&V51(n,2n)V50(n,2n)V49(n,α)*Sc46*(β^-)_ Ti46(n,nα)Ca42(n,2n)Ca41				6.8			
		V51(n,2n)V50(n,α)Sc47(β^-)Ti47(n,2n)_ Ti46(n,nα)Ca42(n,2n)Ca41				4.9			
		V51(n,α)Sc48(β^-)Ti48(n,2n)Ti47(n,2n)_ Ti46(n,nα)Ca42(n,2n)Ca41				3.4			
		V51(n,nα)Sc47(β^-)Ti47(n,2n)Ti46(n,α)_ Ca43(n,2n)Ca42(n,2n)Ca41				2.2			
		V51(n,nα)Sc47(β^-)Ti47(n,nα)Ca43(n,2n)_ Ca42(n,2n)Ca41				1.1	2.7		
		V51(n,2n)V50(n,α)Sc47(β^-)Ti47(n,nα)_ Ca43(n,2n)Ca42(n,2n)Ca41				0.8			
		&V51(n,2n)V50(n,nα)*Sc46*(β^-)Ti46_ (n,nα)Ca42(n,2n)Ca41				0.3	3.2		
		V51(n,nα)Sc47(β^-)Ti47(n,nα)Ca43(n,3n)Ca41					56.7	1.2	
		V51(n,nα)Sc47(β^-)Ti47(n,2nα)Ca42(n,2n)Ca41					7.1	2.1	0.2
		V51(n,nα)Sc47(β^-)Ti47(n,2n)Ti46(n,2nα)Ca41					2.4	2.4	0.2
		V51(n,2nα)Sc46(β^-)Ti46(n,2nα)Ca41						66.0	18.2
		V51(n,nα)Sc47(β^-)Ti47(n,3nα)Ca41						0.2	13.1
		V51(n,2nt)Ti47(n,3nα)Ca41							14.7
		&V51(n,3nα)*Sc45*(n,2nt)Ca41							12.6
Cl36	3.0 10^5 y	V51(n,α)Sc48(β^-)Ti48(n,α)Ca45(β^-)Sc45_ (n,nα)K41(n,nα)Cl37(n,2n)Cl36				20.6			
		V51(n,α)Sc48(β^-)Ti48(n,α)Ca45(β^-)Sc45_ (n,nα)K41(n,2n)K40(n,nα)Cl36				15.9			
	►	V51(n,nα)Sc47(β^-)Ti47(n,α)Ca44(n,α)_ Ar41(β^-)K41(n,nα)Cl37(n,2n)Cl36				9.5			

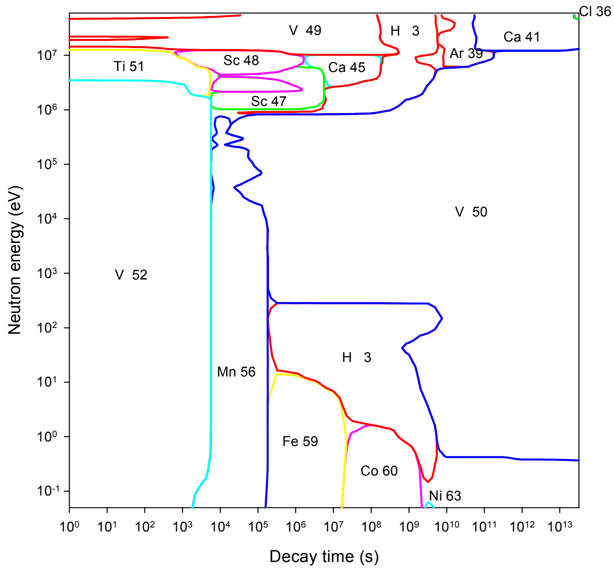
Nuclide	$T_{½}$	Pathway	210	186	151	42	31	21	6
	◄	V51(n,nα)Sc47(β^-)Ti47(n,α)Ca44(n,α)_ Ar41(β^-)K41(n,2n)K40(n,nα)Cl36				7.3			
		V51(n,nα)Sc47(β^-)Ti47(n,nα)Ca43_ (n,2nα)Ar38(n,t)Cl36					11.2	0.9	
		&V51(n,3n)V49(n,nα)*Sc45*(n,nα)K41_ (n,2nα)Cl36					10.9	0.3	
		V51(n,nα)Sc47(β^-)Ti47(n,t)Sc45(n,nα)_ K41(n,2nα)Cl36					6.2	0.6	
		V51(n,nα)Sc47(β^-)Ti47(n,nα)Ca43(n,t)_ K41(n,2nα)Cl36					5.0	0.7	
		V51(n,2nα)Sc46(β^-)Ti46(n,2nα)Ca41_ (n,dα)Cl36						17.9	0.6
		V51(n,2nα)Sc46(β^-)Ti46(n,n2α)Ar38(n,t)Cl36						13.1	0.5
		V51(n,2nα)Sc46(β^-)Ti46(n,dα)K41(n,2nα)Cl36						10.7	0.5
		&V51(n,3nα)*Sc45*(n,2n2α)Cl36							42.5
		V51(n,nt)Ti48(n,3nα)Ca42(n,tα)Cl36							4.2
		V51(n,tα)Ca45(β^-)Sc45(n,2n2α)Cl36							4.0
Fe60	1.5 10^6 y	V51(n,γ)V52(β^-)Cr52(n,γ)Cr53(n,γ)Cr54_ (n,γ)Cr55(β^-)Mn55(n,γ)Mn56(β^-)Fe56_ (n,γ)Fe57(n,γ)Fe58(n,γ)Fe59(n,γ)Fe60	100.0						
K40	1.3 10^9 y	V51(n,α)Sc48(β^-)Ti48(n,α)Ca45(β^-)Sc45_ (n,nα)K41(n,2n)K40				38.7			
		V51(n,nα)Sc47(β^-)Ti47(n,α)Ca44(n,α)_ Ar41(β^-)K41(n,2n)K40				16.4			
		V51(n,2n)V50(n,α)Sc47(β^-)Ti47(n,α)_ Ca44(n,α)Ar41(β^-)K41(n,2n)K40				11.4			
		V51(n,α)Sc48(β^-)Ti48(n,2n)Ti47(n,α)_ Ca44(n,α)Ar41(β^-)K41(n,2n)K40				7.8			
		V51(n,α)Sc48(β^-)Ti48(n,α)Ca45(n,2n)_ Ca44(n,α)Ar41(β^-)K41(n,2n)K40				3.9			
		&V51(n,3n)V49(n,nα)*Sc45*(n,2nα)K40					11.5	5.7	
		&V51(n,nα)Sc47(β^-)Ti47(n,t)*Sc45*(n,2nα)K40					9.9	13.9	0.2
		&V51(n,3n)V49(n,nα)*Sc45*(n,nα)K41_ (n,2n)K40					6.6		
		V51(n,nα)Sc47(β^-)Ti47(n,2nα)Ca42(n,t)K40					6.4	12.0	0.3
		V51(n,nα)Sc47(β^-)Ti47(n,nα)Ca43(n,3n)_ Ca41(n,d)K40					5.1		
		V51(n,3n)V49(β^+)Ti49(n,nα)Ca45(β^-)_ Sc45(n,2nα)K40					4.2	2.7	
		V51(n,2n)V50(n,2nα)Sc45(n,2nα)K40					0.2	8.3	0.3
		&V51(n,2nα)Sc46(β^-)Ti46(n,d)*Sc45*_ (n,2nα)K40						5.0	0.2
		&V51(n,2nα)*Sc46*(β^-)Ti46(n,nα)Ca42(n,t)K40						4.7	0.2
		&V51(n,2nα)*Sc46*(β^-)Ti46(n,tα)K40						0.8	23.2
		&V51(n,3nα)*Sc45*(n,2nα)K40							28.2
V50	1.4 10^{17} y	V51(n,2n)V50				97.5	96.9	93.7	90.0
		Nuclide also present in starting material	100.0	100.0	100.0	2.5	3.1	6.3	10.0

Vanadium activation characteristics

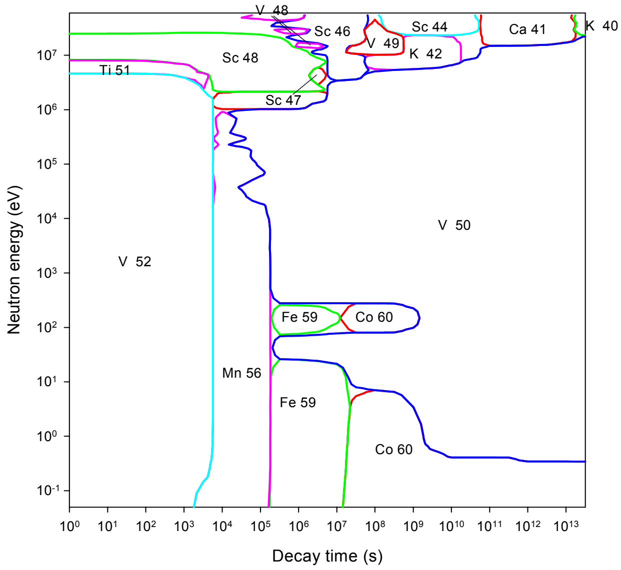


Vanadium importance diagrams & transmutation

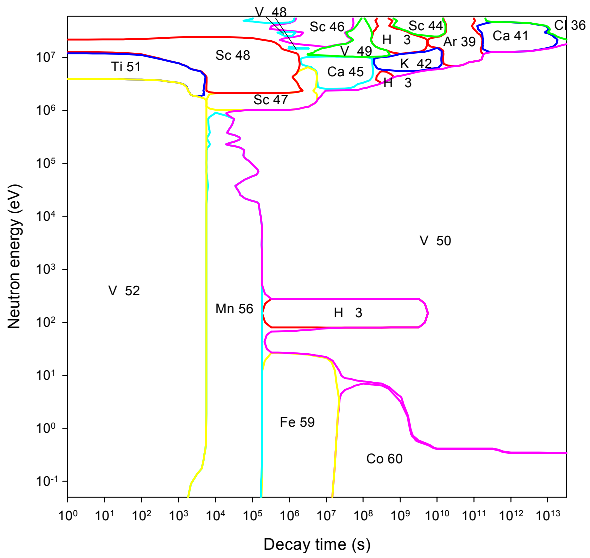
Activity



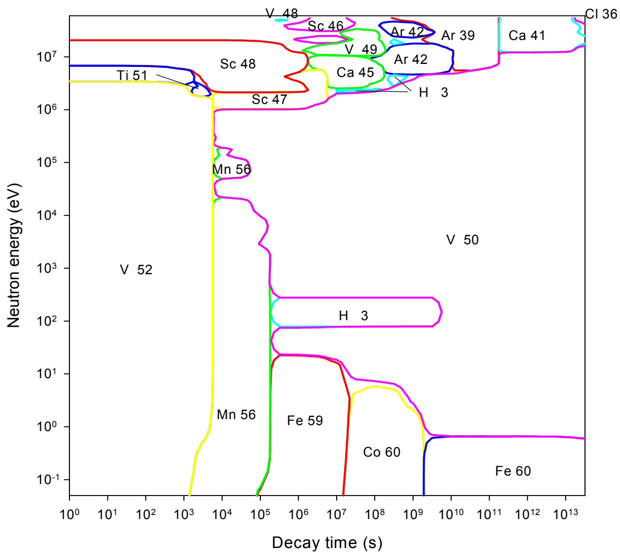
Dose rate



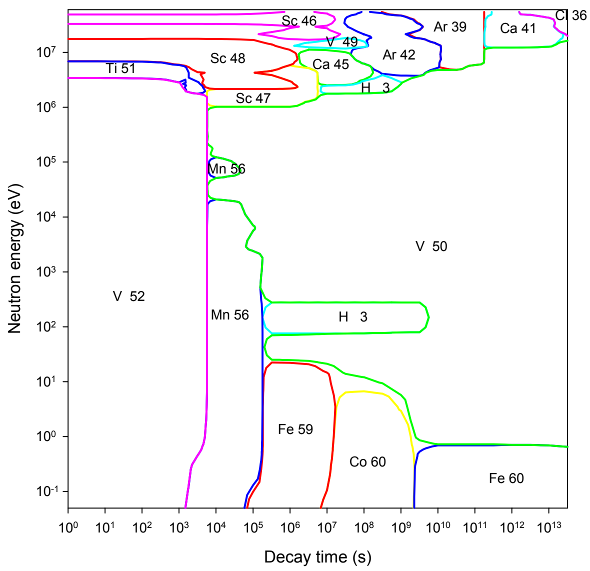
Heat output



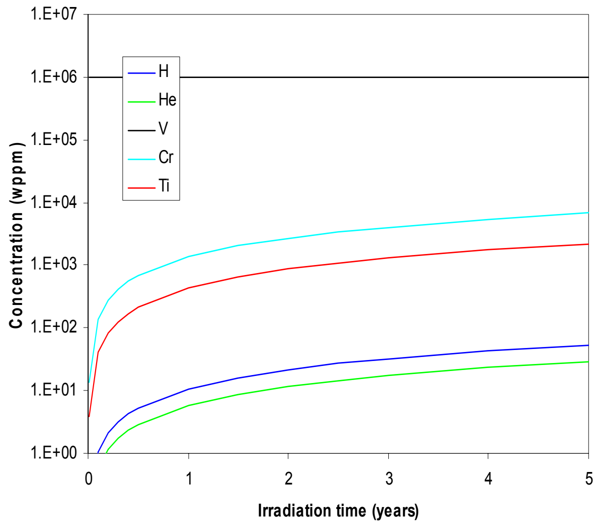
Ingestion dose



Inhalation dose



First wall transmutation



Chromium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	24	Cr50	4.345 ($T_{½}$ = 1.80 10^{17} y)
Crustal abundance / wppm	102	Cr52	83.789
Melting point / K	2180	Cr53	9.501
Boiling point / K	2944	Cr54	2.365
Density / kgm^{-3}	7190		
Thermal conductivity / $Wm^{-1}K^{-1}$	93.7		
Electrical resistivity /Ωm	1.27 10^{-7}		
Coefficient of thermal expansion / K^{-1}	4.9 10^{-6}		
Crystal structure	BCC		
Number of stable isotopes	3 (4)		
Mean atomic weight	51.9961		

Activation properties

Act	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Bq kg^{-1}	5.70E14	4.85E14	3.99E14	7.54E12	1.29E7	2.15E1
Cr51	73.58	86.50	95.96	5.97		
V52	21.67	9.62				
V49	2.82	3.32	4.00	99.28		
V53	1.29	0.16				
Ti51	0.16	0.10				
Cr55	0.16	0.07				
Cr49	0.13	0.14				
Sc48	0.03	0.04	0.01			
H3				0.04	100.0	
Mn53						99.33
V50						0.67

Heat	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
kW kg^{-1}	5.58E-2	2.20E-2	2.29E-3	6.59E-6	1.18E-11	2.99E-17
V52	89.12	85.40				
Cr51	4.38	11.11	97.56	3.98		
V53	4.34	1.16				
Cr49	0.35	0.82				
Sc48	0.19	0.50	1.12			
V49		0.05	0.50	82.39		
Sc46		0.01	0.13	2.38		
Mn54			0.07	11.17		
H3				0.04	99.78	
Mn53						94.13
V50						5.75
Ca41						0.11

Dose	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv h^{-1}	5.86E4	2.30E4	2.22E3	3.11E0	6.76E-9	6.50E-12
V52	90.37	86.99				
Cr51	4.01	10.22	96.67	8.12		
V53	3.70	0.99				
V54	1.15	0.03				
Sc48	0.31	0.79	2.05			
Sc46		0.02	0.22	8.15		
V49		0.01	0.13	45.06		
Mn54		0.01	0.12	38.67		
K42					99.72*	
Mn53					0.09	94.13
V50					0.01	5.76
Ca41						0.39

Ing	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	1.85E4	1.74E4	1.50E4	1.41E2	9.25E-4	7.39E-10
Cr51	86.10	91.70	97.00	1.21		
V52	9.34	3.75				
Sc48	1.78	1.90	0.54			
V49	1.56	1.66	1.91	95.37		
Sc46	0.07	0.08	0.09	0.49		
Mn54	0.04	0.05	0.05	2.75		
H3				0.09	58.37	
Ar42					32.23	
Ar39					9.39	
Mn53						86.61
Cr50						10.46
Ca41						2.12
V50						0.76

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	1.77E4	1.69E4	1.49E4	2.69E2	1.83E-2	1.25E-9
Cr51	87.80	91.65	94.97	0.62		
V52	6.43	2.53				
V49	3.09	3.23	3.64	94.61		
Sc48	1.21	1.26	0.35			
Sc46	0.36	0.38	0.41	1.16		
V48	0.34	0.35	0.34			
Sc47	0.18	0.18	0.10			
Mn54	0.10	0.10	0.12	3.05		
H3				0.32	18.29	
Ar42				0.03	65.28	
Ar39					16.43	
Mn53						91.85
Ca41						1.21
V50						0.76

Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
	2.10E11	7.95E10	4.13E9	6.95E7	1.29E2	2.21E-4
V52	90.02	91.67				
V53	4.00	1.11				
Cr51	1.99	5.27	92.61	0.64		
V54	1.09	0.03				
Cr49	0.39	0.95				
Sc48	0.09	0.24	1.17			
Mn54	0.05	0.15	2.95	78.69		
Sc46	0.04	0.11	2.22	6.64		
V49		0.02	0.50	13.97		
H3				0.04	99.98	
Mn53						96.28
Cr50						3.12
V50						0.56
Ca41						0.02

Chromium

Pathway analysis

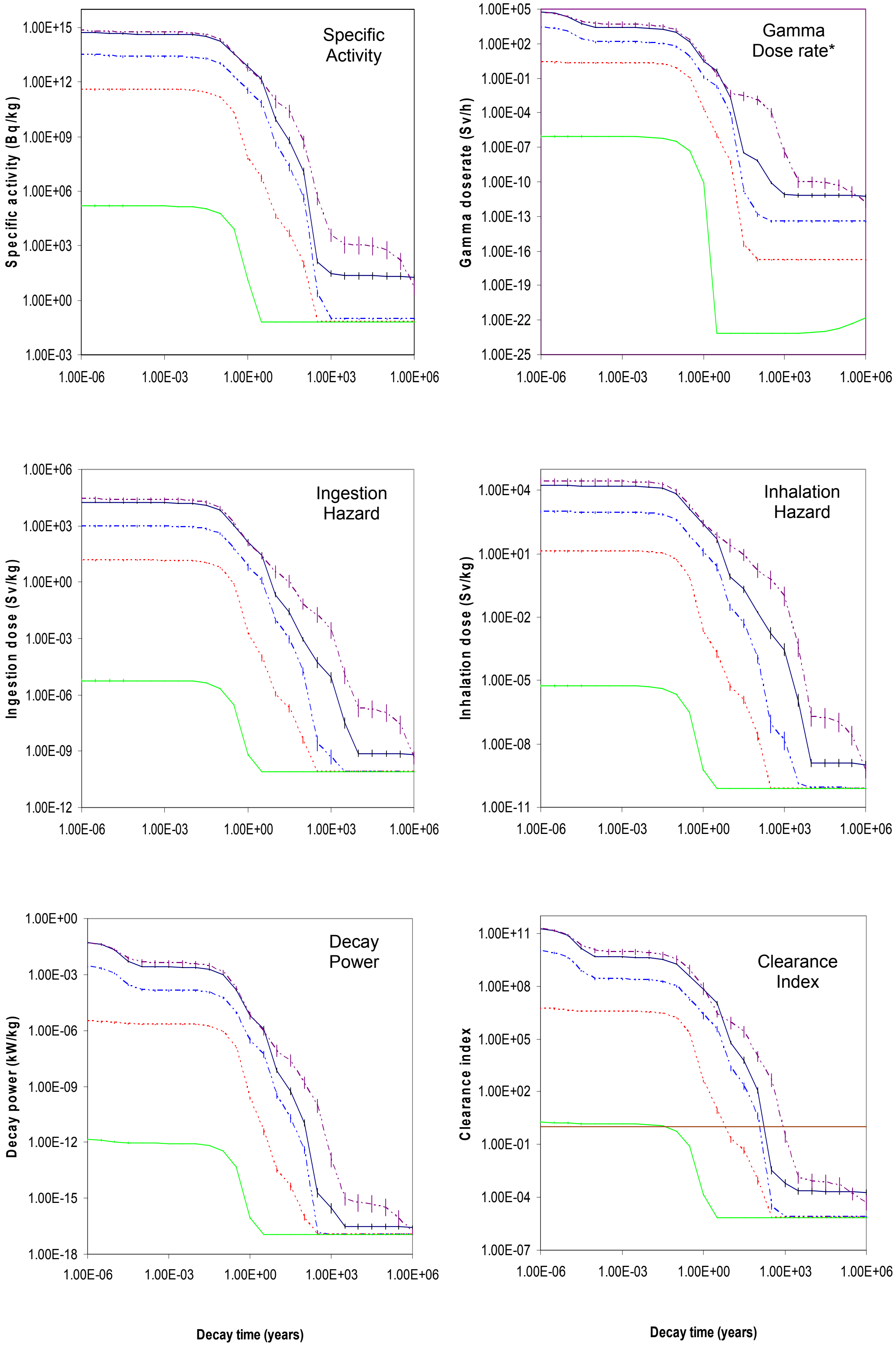
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Cr55	3.54 m	Cr53(n,γ)Cr54(n,γ)Cr55	62.4	12.3	0.7				
		Cr54(n,γ)Cr55	25.1	87.7	99.3	99.2	99.3	99.5	99.8
		Cr52(n,γ)Cr53(n,γ)Cr54(n,γ)Cr55	12.6						
V52	3.745 m	Cr50(n,γ)Cr51(β^+)V51(n,γ)V52	99.7	100.0	100.0				
		Cr52(n,p)V52				97.2	59.7	50.0	38.1
		Cr53(n,2n)Cr52(n,p)V52				1.6	0.3	0.3	0.1
		Cr53(n,d)V52				1.0	37.7	40.1	48.6
		Cr54(n,t)V52					0.7	8.6	12.4
Mn56	2.582 h	Cr53(n,γ)Cr54(n,γ)Cr55(β^-)Mn55(n,γ)Mn56	56.5	6.6	0.3				
		Cr54(n,γ)Cr55(β^-)Mn55(n,γ)Mn56	35.9	93.4	99.7	99.0	99.6	99.7	99.9
		Cr52(n,γ)Cr53(n,γ)Cr54(n,γ)Cr55(β^-)_ Mn55(n,γ)Mn56	7.5						
Sc44	3.97 h	&Cr50(n,α)Ti47(n,2n)Ti46(n,d)*Sc45*(n,2n)*Sc44*				21.0			
		&Cr52(n,α)Ti49(n,2n)Ti48(n,α)Ca45(β^-)_ Sc45(n,2n)*Sc44*				20.1			
		&Cr52(n,α)Ti49(n,α)Ca46(n,2n)Ca45_ (β^-)Sc45(n,2n)*Sc44*				9.8			
		&Cr50(n,nα)Ti46(n,d)*Sc45*(n,2n)*Sc44*				4.8	17.2	1.2	
		&Cr52(n,nα)Ti48(n,α)Ca45(β^-)Sc45(n,2n)*Sc44*				1.7	6.6		
		&Cr50(n,nα)Ti46(n,2n)Ti45(β^+)Sc45(n,2n)*Sc44*				0.8	7.1		
		&Cr50(n,nα)Ti46(n,t)*Sc44*					18.8	17.4	1.2
		&Cr52(n,nα)Ti48(n,3n)Ti46(n,t)*Sc44*					2.7	7.7	0.2
		&Cr52(n,3n)Cr50(n,nα)Ti46(n,t)*Sc44*					1.3	5.0	0.1
		&Cr52(n,2nα)Ti47(n,nt)*Sc44*						3.1	11.3
		&Cr52(n,nt)V49(n,2nα)*Sc44*						0.9	4.4
		&Cr50(n,tα)*Sc44*							19.5
		&Cr52(n,3nα)Ti46(n,t)*Sc44*							11.2
		&Cr52(n,t)V50(n,3nα)*Sc44*							9.7
		&Cr52(n,3n)Cr50(n,tα)*Sc44*							6.0
K42	12.36 h	&Cr50(n,α)Ti47(n,2n)Ti46(n,d)*Sc45*(n,α)K42				21.1			
		Cr52(n,α)Ti49(n,2n)Ti48(n,α)Ca45(β^-)_ Sc45(n,α)K42				19.4			
		Cr52(n,α)Ti49(n,α)Ca46(n,2n)Ca45(β^-)_ Sc45(n,α)K42				9.5			
		&Cr50(n,nα)Ti46(n,d)*Sc45*(n,α)K42				4.9	2.6		
		Cr50(n,α)Ti47(n,2n)Ti46(n,2n)Ti45(β^+)_ Sc45(n,α)K42				3.4			
		Cr50(n,α)Ti47(n,2n)Ti46(n,α)Ca43(n,d)K42				3.0			
		Cr50(n,nα)Ti46(n,pα)K42					37.0	5.4	0.2
		Cr52(n,nα)Ti48(n,3n)Ti46(n,pα)K42					5.8	2.5	
		Cr52(n,nα)Ti48(n,2n)Ti47(n,nα)Ca43(n,d)K42					3.6		
		Cr50(n,2α)Ca43(n,d)K42					3.3	1.9	
		Cr52(n,nα)Ti48(n,nα)Ca44(n,t)K42					3.2	5.1	0.2
		Cr52(n,2nα)Ti47(n,dα)K42						16.0	11.9
		Cr52(n,nα)Ti48(n,2nα)Ca43(n,d)K42						5.5	0.3
		Cr52(n,t)V50(n,n2α)K42						1.6	7.5
		Cr52(n,n2α)Ca44(n,t)K42						0.8	5.0
		Cr50(n,α)Ti47(n,dα)K42						0.5	3.6
		Cr52(n,nα)Ti48(n,tα)K42							5.4
Sc47	3.351 d	Cr50(n,α)Ti47(n,p)Sc47				29.1			0.1
		Cr52(n,2n)Cr51(β^+)V51(n,2n)V50(n,α)Sc47				20.8	0.3		
		Cr50(n,p)V50(n,α)Sc47				17.1			
		Cr52(n,2n)Cr51(β^+)V51(n,nα)Sc47				12.4	37.5	16.6	2.5
		Cr52(n,d)V51(n,2n)V50(n,α)Sc47				6.2	0.1		
	►	Cr52(n,d)V51(n,nα)Sc47				3.6	17.6	10.5	1.7

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Cr52(n,nα)Ti48(n,d)Sc47				0.1	34.4	21.7	3.5
		Cr52(n,α)Ti49(n,t)Sc47					0.6	2.3	4.5
		Cr50(n,t)V48(β^{+})Ti48(n,d)Sc47					0.4	4.7	1.3
		Cr52(n,t)V50(n,α)Sc47					0.2	2.1	4.2
		Cr52(n,dα)Sc47						14.4	48.5
		Cr52(n,nt)V49(β^{+})Ti49(n,t)Sc47						1.1	16.4
V48	15.97 d	Cr50(n,d)V49(n,2n)V48				75.8	8.2	0.2	0.1
		Cr50(n,p)V50(n,2n)V49(n,2n)V48				7.6			
		Cr52(n,2n)Cr51(β^{+})V51(n,2n)V50(n,2n)_ V49(n,2n)V48				7.4	0.5		
		Cr50(n,2n)Cr49(β^{+})V49(n,2n)V48				6.6	3.6		
		Cr50(n,t)V48					48.5	49.0	46.3
		Cr52(n,2n)Cr51(β^{+})V51(n,2n)V50(n,3n)V48					8.5	0.4	
		Cr52(n,3n)Cr50(n,t)V48					7.2	28.9	15.5
		Cr52(n,2n)Cr51(β^{+})V51(n,3n)V49(n,2n)V48					5.8	0.2	
		Cr52(n,t)V50(n,3n)V48					5.7	17.6	9.6
		Cr52(n,2nt)V48							12.5
Cr51	27.703 d	Cr50(n,γ)Cr51	100.0	99.9	100.0				
		Cr52(n,2n)Cr51				97.0	93.8	87.1	88.7
		Cr53(n,2n)Cr52(n,2n)Cr51				1.6	1.0	0.5	0.3
		Cr53(n,3n)Cr51					4.1	11.1	8.1
		Cr54(n,4n)Cr51						0.2	2.2
Sc46	83.79 d	**&**Cr50(n,d)V49(n,α)*Sc46*				38.7	0.6		
		&Cr50(n,α)Ti47(n,d)*Sc46*				35.9	1.9	0.2	1.2
		&Cr50(n,α)Ti47(n,2n)Ti46(n,p)*Sc46*				8.2			
		&Cr52(n,2n)Cr51(β^{+})V51(n,2n)V50(n,nα)*Sc46*				0.1	10.3	0.3	
		&Cr50(n,pα)*Sc46*					27.4	8.4	1.7
		&Cr52(n,nα)Ti48(n,2n)Ti47(n,d)*Sc46*					10.4	0.3	
		&Cr52(n,nα)Ti48(n,t)*Sc46*					7.3	23.9	5.3
		&Cr52(n,t)V50(n,nα)*Sc46*					7.1	14.2	3.6
		&Cr52(n,2n)Cr51(β^{+})V51(n,2nα)*Sc46*						10.3	4.4
		&Cr52(n,2nα)Ti47(n,d)*Sc46*						8.1	4.1
		&Cr52(n,d)V51(n,2nα)*Sc46*						6.7	3.1
		&Cr52(n,tα)*Sc46*							32.3
		&Cr52(n,nt)V49(β^{+})Ti49(n,nt)*Sc46*							17.9
Ca45	163.0 d	Cr52(n,α)Ti49(n,2n)Ti48(n,α)Ca45				40.2	0.2		0.1
		Cr52(n,α)Ti49(n,α)Ca46(n,2n)Ca45				19.6	0.2		
		Cr50(n,d)V49(β^{+})Ti49(n,2n)Ti48(n,α)Ca45				8.8	0.1		
		Cr52(n,2n)Cr51(β^{+})V51(n,α)Sc48(β^{-})_ Ti48(n,α)Ca45				8.4			
		Cr50(n,d)V49(β^{+})Ti49(n,α)Ca46(n,2n)Ca45				4.3			
		Cr52(n,nα)Ti48(n,α)Ca45				2.2	35.1	9.5	7.7
		Cr52(n,α)Ti49(n,nα)Ca45				0.3	17.6	4.5	6.0
		Cr50(n,d)V49(β^{+})Ti49(n,nα)Ca45					11.5	3.4	0.7
		Cr53(n,nα)Ti49(n,nα)Ca45					5.3	1.9	0.3
		Cr50(n,2n)Cr49(β^{+})V49(β^{+})Ti49(n,2nα)Ca45					5.0	1.0	0.2
		Cr52(n,2α)Ca45					1.8	29.7	7.1
		Cr52(n,t)V50(n,dα)Ca45						8.6	9.1
		Cr52(n,2nα)Ti47(n,h)Ca45						6.6	4.2
		Cr52(n,h)Ti50(n,2nα)Ca45						4.8	3.0
		Cr52(n,nt)V49(β^{+})Ti49(n,nα)Ca45						2.1	20.9
		Cr53(n,n2α)Ca45						0.2	4.4
		Cr52(n,2n)Cr51(β^{+})V51(n,tα)Ca45							5.3
V49	330.0 d	Cr50(n,d)V49				75.5	34.8	19.8	2.8
		Cr50(n,p)V50(n,2n)V49				7.7	0.1		
		Cr52(n,2n)Cr51(β^{+})V51(n,2n)V50(n,2n)V49				7.6	2.1	0.3	
		Cr50(n,2n)Cr49(β^{+})V49				6.6	15.2	6.0	0.7
		Cr52(n,2n)Cr51(β^{+})V51(n,3n)V49					24.9	18.1	1.2
		Cr52(n,d)V51(n,3n)V49					11.7	11.8	0.8
		Cr52(n,3n)Cr50(n,d)V49					4.0	8.9	0.7
	►	Cr52(n,t)V50(n,2n)V49					1.7	14.5	1.7

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	Cr52(n,nt)V49						12.2	83.6
		Cr52(n,4n)Cr49(β^+)V49							6.1
Co60	5.271 y	**&**Cr54(n,γ)Cr55(β^-)Mn55(n,γ)Mn56(β^-)_ Fe56(n,γ)Fe57(n,γ)Fe58(n,γ)Fe59(β^-)_ Co59(n,γ)*Co60*	65.5	97.8	99.9				
		&Cr53(n,γ)Cr54(n,γ)Cr55(β^-)Mn55(n,γ)_ Mn56(β^-)Fe56(n,γ)Fe57(n,γ)Fe58(n,γ)_ Fe59(β^-)Co59(n,γ)*Co60*	33.0	2.2					
H3	12.33 y	Cr50(n,γ)Cr51(n,X)H1(n,γ)H2(n,γ)H3	93.3	95.3	99.4				
		Cr53(n,X)H3				69.7	16.3	12.6	11.0
		Cr50(n,p)V50(n,X)H3				8.9			
		Cr52(n,2n)Cr51(β^+)V51(n,X)H3				6.7	4.1	1.7	1.1
		Cr52(n,d)V51(n,2n)V50(n,X)H3				2.2	0.1		
		Cr52(n,d)V51(n,X)H3				2.0	2.0	1.1	0.8
		Cr52(n,X)H3					67.8	72.3	75.4
		Cr50(n,X)H3					4.0	3.9	3.8
		Cr54(n,X)H3					2.2	2.4	2.4
		Cr52(n,t)V50(n,X)H3					0.3	2.2	1.4
Ar42	33.0 y	Cr52(n,α)Ti49(n,2n)Ti48(n,α)Ca45(n,α)Ar42				40.2			
		Cr52(n,α)Ti49(n,α)Ca46(n,2n)Ca45(n,α)Ar42				19.6			
		Cr50(n,d)V49(β^+)Ti49(n,2n)Ti48(n,α)_ Ca45(n,α)Ar42				7.6			
		Cr50(n,d)V49(n,d)Ti48(n,α)Ca45(n,α)Ar42				3.8			
		Cr50(n,d)V49(β^+)Ti49(n,α)Ca46(n,2n)_ Ca45(n,α)Ar42				3.7			
		Cr52(n,nα)Ti48(n,α)Ca45(n,α)Ar42				3.2	12.1	0.6	0.3
		Cr52(n,α)Ti49(n,nα)Ca45(n,α)Ar42				0.5	6.1	0.3	0.2
		Cr52(n,α)Ti49(n,α)Ca46(n,nα)Ar42					10.4	0.7	0.6
		Cr52(n,nα)Ti48(n,nα)Ca44(n,h)Ar42					8.7	6.3	0.4
		Cr52(n,nα)Ti48(n,h)Ca46(n,nα)Ar42					5.8	6.6	0.4
		Cr50(n,d)V49(β^+)Ti49(n,α)Ca46(n,nα)Ar42					5.0	0.4	
		Cr52(n,h)Ti50(n,nα)Ca46(n,nα)Ar42					4.2	4.3	0.2
		Cr52(n,α)Ti49(n,2α)Ar42					2.8	6.6	3.7
		Cr50(n,d)V49(β^+)Ti49(n,2α)Ar42					1.6	4.3	0.4
		Cr52(n,2α)Ca45(n,α)Ar42					1.2	3.5	0.5
		Cr52(n,nt)V49(β^+)Ti49(n,2α)Ar42						2.7	11.0
		Cr52(n,n2α)Ca44(n,h)Ar42						1.4	14.1
		Cr52(n,h)Ti50(n,n2α)Ar42						0.1	8.0
		&Cr50(n,tα)*Sc44*(β^+)Ca44(n,h)Ar42							12.1
Ni63	100.6 y	Very long pathways of (n,γ), β^-	100.0	100.0					
Ar39	269.0 y	Cr50(n,α)Ti47(n,2n)Ti46(n,α)Ca43(n,nα)Ar39				27.0			
		Cr50(n,α)Ti47(n,α)Ca44(n,2n)Ca43(n,nα)Ar39				14.3			
		Cr50(n,α)Ti47(n,nα)Ca43(n,nα)Ar39				11.1	1.5		
		Cr50(n,α)Ti47(n,2n)Ti46(n,nα)Ca42(n,α)Ar39				9.1			
		Cr50(n,nα)Ti46(n,α)Ca43(n,nα)Ar39				8.3	2.7	0.1	
		Cr50(n,nα)Ti46(n,2α)Ar39					47.8	4.7	0.1
		Cr50(n,2α)Ca43(n,nα)Ar39					8.3	2.6	
		Cr52(n,nα)Ti48(n,nα)Ca44(n,2nα)Ar39					2.2	6.9	0.1
		Cr52(n,2nα)Ti47(n,n2α)Ar39						18.5	9.5
Ca41	1.0 10^5 y	Cr50(n,α)Ti47(n,2n)Ti46(n,nα)Ca42(n,2n)Ca41				35.9			
		Cr50(n,α)Ti47(n,2n)Ti46(n,α)Ca43(n,2n)_ Ca42(n,2n)Ca41				11.2			
		Cr50(n,nα)Ti46(n,nα)Ca42(n,2n)Ca41				11.1	34.2	0.3	
		Cr50(n,α)Ti47(n,α)Ca44(n,2n)Ca43_ (n,2n)Ca42(n,2n)Ca41				5.9			
		Cr50(n,α)Ti47(n,nα)Ca43(n,2n)Ca42(n,2n)Ca41				5.8			
		Cr50(n,nα)Ti46(n,2nα)Ca41					14.2	30.0	1.6
		Cr50(n,2α)Ca43(n,3n)Ca41					6.8	2.1	
		Cr52(n,nα)Ti48(n,3n)Ti46(n,2nα)Ca41					1.5	9.3	0.2
		Cr52(n,3n)Cr50(n,nα)Ti46(n,2nα)Ca41					0.7	6.0	0.2
	►	Cr52(n,2nα)Ti47(n,3nα)Ca41						0.2	17.3

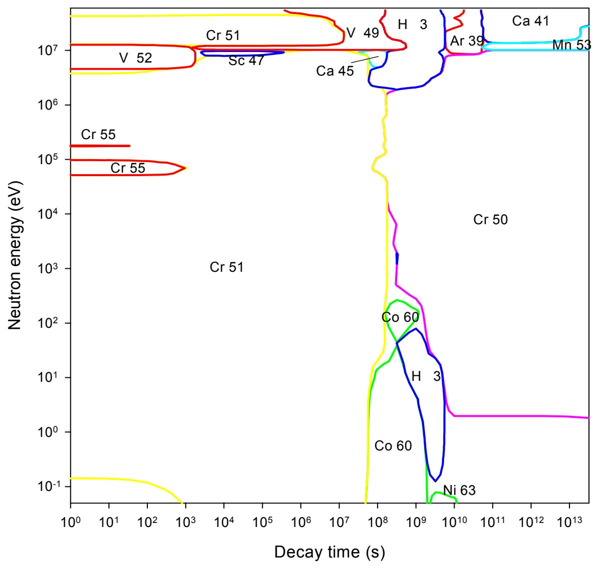
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Cr50(n,2n2α)Ca41							18.0
		Cr52(n,3nα)Ti46(n,2nα)Ca41							14.7
		Cr52(n,dα)Sc47(β^-)Ti47(n,3nα)Ca41							5.3
		Cr50(n,α)Ti47(n,3nα)Ca41							5.2
Cl36	3.0 10^5 y	**&**Cr50(n,nα)Ti46(n,d)*Sc45*(n,nα)K41_ (n,2nα)Cl36					6.8		
		Cr50(n,nα)Ti46(n,nα)Ca42(n,t)K40(n,nα)Cl36					6.3		
		Cr50(n,nα)Ti46(n,nα)Ca42(n,d)K41_ (n,2nα)Cl36					5.9	0.1	
		Cr50(n,nα)Ti46(n,nα)Ca42(n,nα)Ar38_ (n,t)Cl36					5.0	0.1	
		Cr50(n,nα)Ti46(n,n2α)Ar38(n,t)Cl36					2.6	5.0	0.1
		Cr50(n,nα)Ti46(n,nα)Ca42(n,3n)Ca40_ (n,pα)Cl36					2.3		
		Cr52(n,nα)Ti48(n,α)Ca45(β^-)Sc45(n,nα)_ K41(n,2nα)Cl36					2.0		
		Cr50(n,nα)Ti46(n,2nα)Ca41(n,dα)Cl36					0.7	6.8	0.2
		Cr50(n,nα)Ti46(n,dα)K41(n,2nα)Cl36						4.0	0.1
		Cr50(n,dα)Sc45(n,2nα)K40(n,nα)Cl36						3.2	0.1
		Cr50(n,dα)Sc45(n,nα)K41(n,2nα)Cl36						2.4	
		Cr50(n,2nα)Ti45(β^+)Sc45(n,2nα)K40_ (n,nα)Cl36						2.4	
		Cr52(n,nα)Ti48(n,2nα)Ca43(n,2nα)Ar38 (n,t)Cl36						2.4	
		Cr52(n,2nα)Ti47(n,2nα)Ca42(n,tα)Cl36						0.7	2.4
		Cr50(n,n2α)Ca42(n,tα)Cl36						0.3	7.4
		Cr50(n,dα)Sc45(n,2n2α)Cl36							5.6
		Cr50(n,2nα)Ti45(β^+)Sc45(n,2n2α)Cl36							3.8
		Cr50(n,2n2α)Ca41(n,dα)Cl36							2.5
Fe60	1.5 10^6 y	Cr54(n,γ)Cr55(β^-)Mn55(n,γ)Mn56(β^-)_ Fe56(n,γ)Fe57(n,γ)Fe58(n,γ)Fe59(n,γ)Fe60	63.0	97.8	99.9				
		Cr53(n,γ)Cr54(n,γ)Cr55(β^-)Mn55(n,γ)_ Mn56(β^-)Fe56(n,γ)Fe57(n,γ)Fe58(n,γ)_ Fe59(n,γ)Fe60	35.2	2.2	0.1				
		Cr52(n,γ)Cr53(n,γ)Cr54(n,γ)Cr55(β^-)_ Mn55(n,γ)Mn56(β^-)Fe56(n,γ)Fe57(n,γ)_ Fe58(n,γ)Fe59(n,γ)Fe60	1.8						
Mn53	3.7 10^6 y	Cr54(n,γ)Cr55(β^-)Mn55(n,2n)Mn54(n,2n)Mn53				99.9	2.0	0.6	0.5
		Cr54(n,γ)Cr55(β^-)Mn55(n,3n)Mn53					97.9	99.3	99.5
K40	1.26 10^9 y	Cr50(n,α)Ti47(n,α)Ca44(n,α)Ar41(β^-)_ K41(n,2n)K40				80.5			
		Cr50(n,nα)Ti46(n,nα)Ca42(n,t)K40					28.2	0.8	
		Cr50(n,nα)Ti46(n,d)Sc45(n,2nα)K40					5.1	0.7	
		&Cr50(n,dα)*Sc45*(n,2nα)K40						24.4	3.5
		Cr50(n,2nα)Ti45(β^+)Sc45(n,2nα)K40						13.2	1.7
		Cr52(n,2nα)Ti47(n,2nα)Ca42(n,t)K40						6.8	0.7
		Cr52(n,t)V50(n,2nα)Sc45(n,2nα)K40						6.7	0.5
		Cr52(n,2nα)Ti47(n,t)Sc45(n,2nα)K40						5.8	0.5
		Cr52(n,3nα)Ti46(n,tα)K40							30.4
		Cr52(n,nt)V49(n,2n2α)K40							5.5
		Cr52(n,tα)Sc46(β^-)Ti46(n,tα)K40							5.4
V50	1.4 10^{17} y	Cr50(β^+)V50	100.0	99.9	100.0				
		Cr52(n,2n)Cr51(β^+)V51(n,2n)V50				46.5	43.8	2.1	
		Cr50(n,p)V50				38.3	2.1	0.3	
		Cr52(n,d)V51(n,2n)V50				13.8	20.9	1.4	
		Cr52(n,t)V50					28.4	94.3	88.6
		Cr53(n,nt)V50						0.6	8.6
Cr50	1.8 10^{17} y	Cr52(n,3n)Cr50					13.0	37.0	24.6
		Cr53(n,4n)Cr50						0.2	2.0
		Nuclide also present in starting material	100.0	100.0	100.0	99.8	86.8	62.8	73.4

Chromium activation characteristics

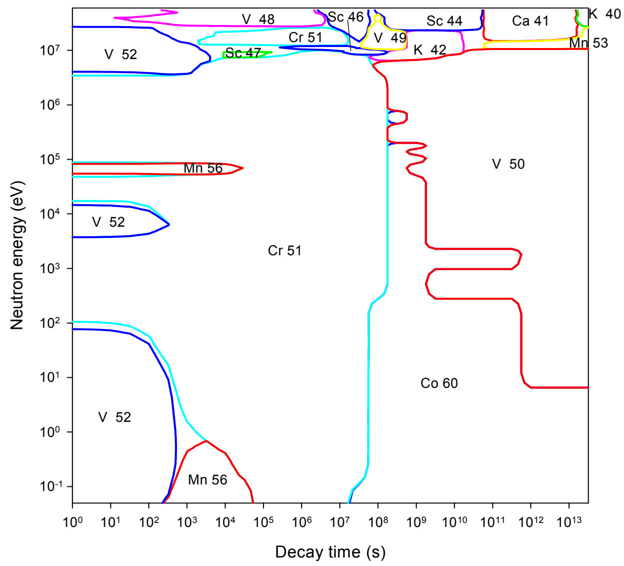


Chromium importance diagrams & transmutation

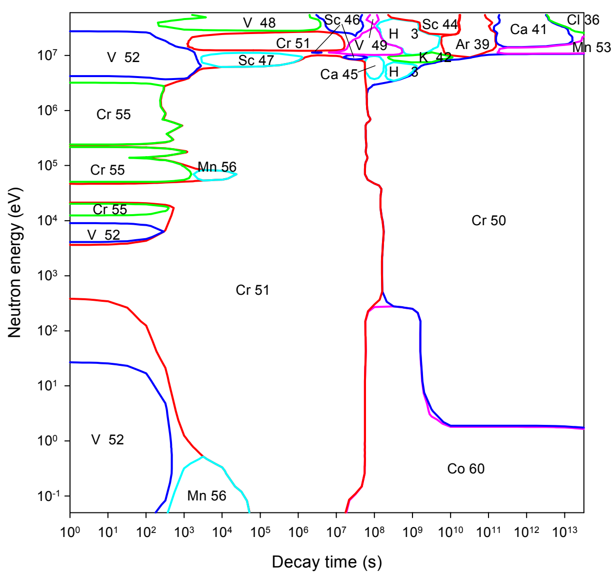
Activity



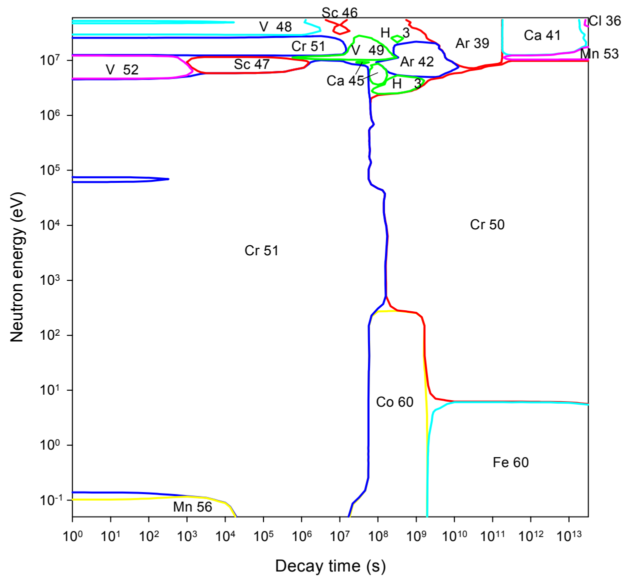
Dose rate



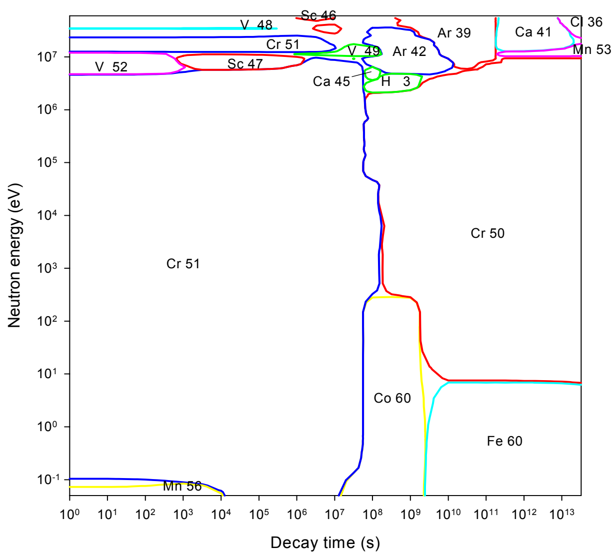
Heat output



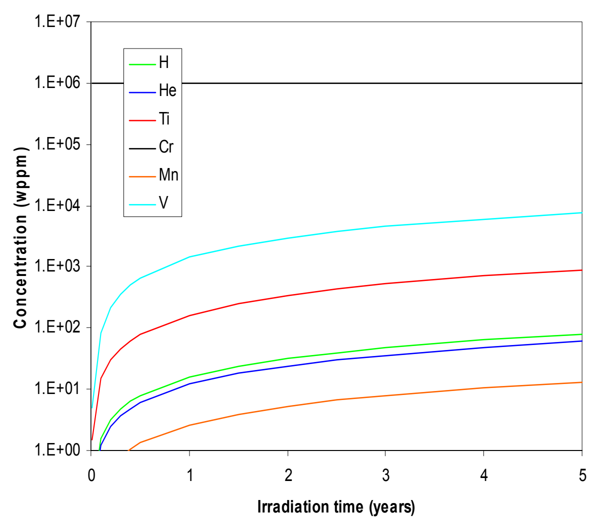
Ingestion dose



Inhalation dose



First wall transmutation



Manganese

General properties

		Isotopes	Isotopic abundances / %
Atomic number	25		
Crustal abundance / wppm	950	Mn55	100.0
Melting point / K	1519		
Boiling point / K	2234		
Density / kgm^{-3}	7440		
Thermal conductivity / $Wm^{-1}K^{-1}$	7.82		
Electrical resistivity /Ωm	$1.85\ 10^{-6}$		
Coefficient of thermal expansion / K^{-1}	$2.17\ 10^{-5}$		
Crystal structure	BCC		
Number of stable isotopes	1		
Mean atomic weight	54.93805		

Activation properties

Act	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Bq kg^{-1}	4.35E15	4.22E15	1.16E15	5.23E14	1.28E9	3.77E6
Mn56	70.91	71.46				
Mn54	26.55	27.39	98.87	98.08		
Cr55	1.41	0.52				
Fe55	0.28	0.29	1.07	1.85		
H3			0.03	0.06	99.70	
Mn53					0.29	100.0

Heat	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
kW kg^{-1}	1.43E0	1.39E0	1.54E-1	6.91E-2	1.17E-9	3.28E-12
Mn56	87.37	88.12				
Mn54	10.68	11.21	99.99	99.99		
V52	0.99	0.38				
Cr55	0.75	0.27				
H3					99.71	
Mn53					0.28	100.0

Dose	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv h^{-1}	1.85E6	1.80E6	2.55E5	1.14E5	9.85E-7	9.65E-7
Mn56	85.25	85.42				
Mn54	13.90	14.26	100.0	100.0	99.90	
V52	0.82	0.32				
Co60					0.09	
Mn53						100.0

Ing	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	1.60E6	1.58E6	8.17E5	3.68E5	5.38E-2	1.13E-4
Mn54	51.38	51.98	99.49	99.12		
Mn56	48.32	47.74				
Fe55	0.25	0.26	0.50	0.87		
H3					99.79	
Mn53					0.21	100.0

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	2.11E6	2.10E6	1.73E6	7.77E5	3.32E-1	2.04E-4
Mn54	82.00	82.34	99.44	99.03		
Mn56	17.52	17.18				
Fe55	0.45	0.45	0.55	0.96		
H3				0.01	99.94	
Mn53					0.06	100.0

Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
	1.19E13	1.19E13	1.15E13	5.13E12	1.28E4	3.77E1
Mn54	96.88	97.27	100.0	100.0		
Mn56	2.58	2.53				
V52	0.46	0.17				
H3					99.70	
Mn53					0.29	100.0

Manganese

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Cr55	3.54 m	Mn55(n,γ)Mn56(β^-)Fe56(n,γ)Fe57(n,α)_Cr54(n,γ)Cr55	100.0	100.0					
		Mn55(n,p)Cr55				99.8	99.8	99.9	99.9
V52	3.745 m	Mn55(n,α)V52				97.9	63.8	27.2	70.8
		Mn55(n,t)Cr53(n,d)V52					13.9	26.4	9.5
		Mn55(n,2n)Mn54(β^+)Cr54(n,t)V52					6.4	25.0	9.4
		Mn55(n,3n)Mn53(n,2p)V52					4.2	1.4	0.2
		Mn55(n,d)Cr54(n,t)V52					2.7	15.2	7.0
Mn56	2.582 h	Mn55(n,γ)Mn56	100.0	100.0	100.0	97.8	99.2	99.5	99.8
Sc44	3.97 h	**&**Mn55(n,α)V52(β^-)Cr52(n,α)Ti49_(n,2n)Ti48(n,α)Ca45(β^-)Sc45(n,2n)*Sc44*				24.3			
		&Mn55(n,nα)V51(n,α)Sc48(β^-)Ti48_(n,α)Ca45(β^-)Sc45(n,2n)*Sc44*				22.5			
		&Mn55(n,α)V52(β^-)Cr52(n,α)Ti49(n,α)_Ca46(n,2n)Ca45(β^-)Sc45(n,2n)*Sc44*				11.8			
		&Mn55(n,2n)Mn54(n,α)V51(n,α)Sc48_(β^-)Ti48(n,α)Ca45(β^-)Sc45(n,2n)*Sc44*				10.6			
		&Mn55(n,3n)Mn53(n,nα)V49(n,nα)_*Sc45*(n,2n)*Sc44*					23.3		
		&Mn55(n,nα)V51(n,3n)V49(n,nα)*Sc45*_(n,2n)*Sc44*					9.4		
		&Mn55(n,nα)V51(n,nα)Sc47(β^-)Ti47_(n,t)Sc45(n,2n)*Sc44*					7.2		
		Mn55(n,3n)Mn53(n,nα)V49(β^+)Ti49_(n,nα)Ca45(β^-)Sc45(n,2n)Sc44					6.3		
		&Mn55(n,2nα)V50(n,nα)Sc46(β^-)Ti46_(n,t)*Sc44*						11.8	0.2
		&Mn55(n,2nα)V50(n,2nα)*Sc45*(n,2n)*Sc44*						11.4	0.3
		&Mn55(n,3n)Mn53(n,nα)V49(n,2nα)*Sc44*						7.5	0.1
		&Mn55(n,nα)V51(n,2nα)Sc46(β^-)Ti46_(n,t)*Sc44*						5.7	0.2
		&Mn55(n,2nα)V50(n,2n)V49(n,2nα)*Sc44*						5.1	0.1
		&Mn55(n,nα)V51(n,3n)V49(n,2nα)*Sc44*						4.4	
		&Mn55(n,2nα)V50(n,3nα)*Sc44*							22.4
		&Mn55(n,3nα)V49(n,2nα)*Sc44*							9.5
		Other pathways				30.8	53.8	54.1	67.2
K42	12.36 h	Mn55(n,α)V52(β^-)Cr52(n,α)Ti49(n,2n)_Ti48(n,α)Ca45(β^-)Sc45(n,α)K42				25.6			
		Mn55(n,nα)V51(n,α)Sc48(β^-)Ti48(n,α)_Ca45(β^-)Sc45(n,α)K42				24.1			
		Mn55(n,α)V52(β^-)Cr52(n,α)Ti49(n,α)_Ca46(n,2n)Ca45(β^-)Sc45(n,α)K42				12.5			
		Mn55(n,2n)Mn54(n,α)V51(n,α)Sc48(β^-)_Ti48(n,α)Ca45(β^-)Sc45(n,α)K42				10.7			
		Mn55(n,nα)V51(n,nα)Sc47(β^-)Ti47_(n,nα)Ca43(n,d)K42					17.9	0.2	
		Mn55(n,3n)Mn53(n,nα)V49(n,2α)K42					11.8	2.5	
		Mn55(n,nα)V51(n,3n)V49(n,2α)K42					4.8	1.5	
		Mn55(n,nα)V51(n,nα)Sc47(β^-)Ti47_(n,2n)Ti46(n,pα)K42					4.1		
		Mn55(n,2nα)V50(n,n2α)K42						8.6	14.9
		Mn55(n,2nα)V50(n,2nα)Sc45(n,α)K42						3.7	0.9
		Mn55(n,n2α)Sc47(β^-)Ti47(n,dα)K42						0.8	4.0
		Other pathways				27.1	61.4	82.7	80.2
Sc48	1.820 d	Mn55(n,nα)V51(n,α)Sc48				35.6	43.4	3.9	3.5
	►	Mn55(n,2n)Mn54(n,α)V51(n,α)Sc48				23.5			

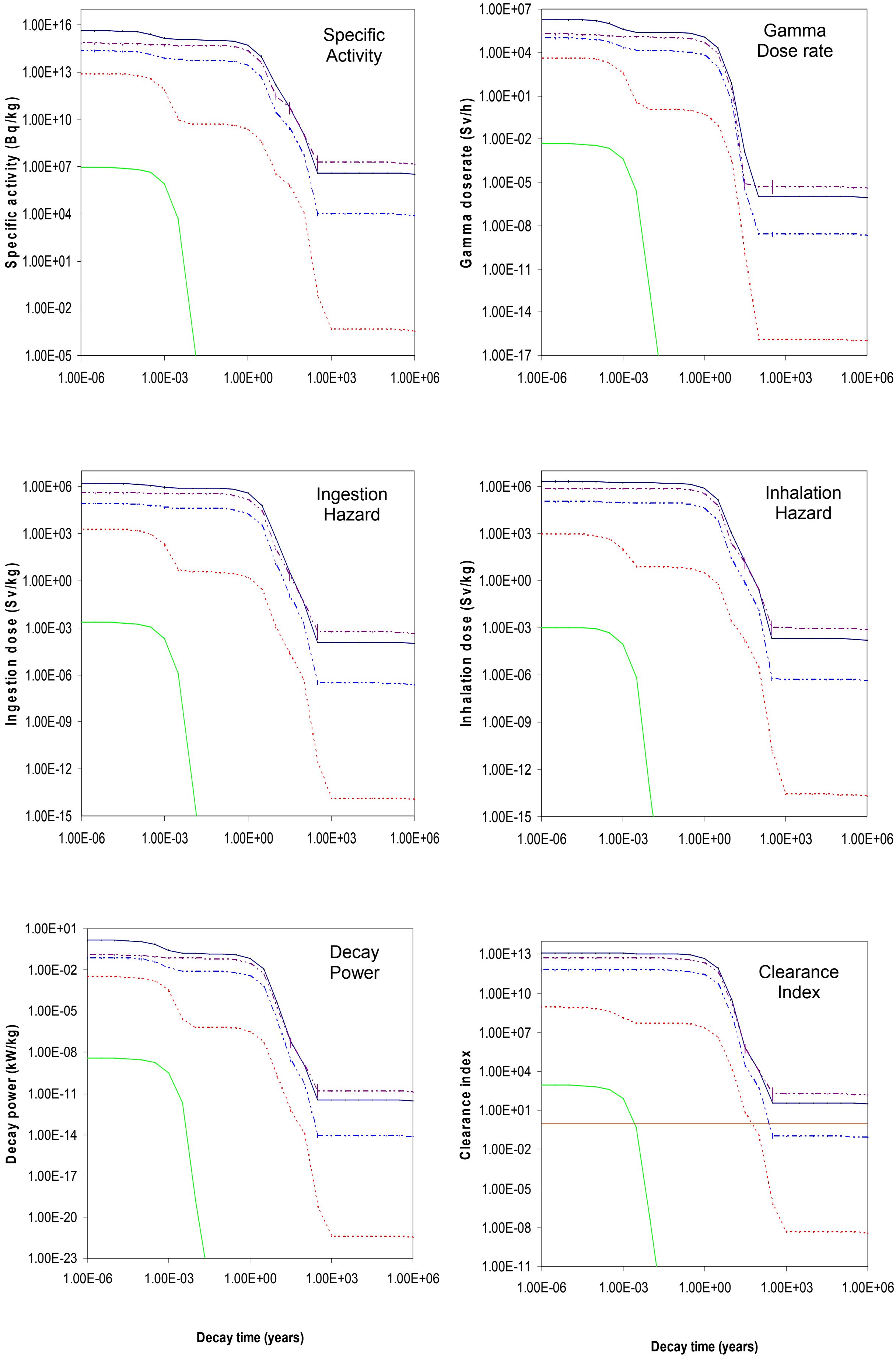
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Mn55(n,α)V52(β^-)Cr52(n,2n)Cr51(β^+)_ V51(n,α)Sc48				17.5	0.2		
		Mn55(n,2n)Mn54(β^+)Cr54(n,α)Ti51(β^-)_ V51(n,α)Sc48				13.4			
		Mn55(n,α)V52(β^-)Cr52(n,d)V51(n,α)Sc48				5.2			
		Mn55(n,3n)Mn53(n,nα)V49(β^+)Ti49(n,d)Sc48					15.5	2.6	0.3
		Mn55(n,2α)Sc48					6.2	42.8	8.9
		Mn55(n,nα)V51(n,3n)V49(β^+)Ti49(n,d)Sc48					6.2	1.5	
		Mn55(n,dα)Ti50(n,t)Sc48						8.6	5.9
		Mn55(n,2nα)V50(n,h)Sc48						6.5	3.1
		Mn55(n,t)Cr53(n,dα)Sc48						2.7	5.9
		Mn55(n,3nα)V49(β^+)Ti49(n,d)Sc48							30.2
		Mn55(n,tα)Ti49(n,d)Sc48							11.0
		Mn55(n,2nt)Cr51(β^+)V51(n,α)Sc48							6.3
		Other pathways				4.8	28.5	31.4	24.9
Ca47	4.538 d	Mn55(n,2n)Mn54(β^+)Cr54(n,2n)Cr53_ (n,α)Ti50(n,α)Ca47				51.3	0.4		
		Mn55(n,2n)Mn54(β^+)Cr54(n,nα)Ti50(n,α)Ca47				13.0	25.5	2.0	0.5
		Mn55(n,2n)Mn54(n,pα)Ti50(n,α)Ca47				6.4	1.5		
		Mn55(n,d)Cr54(n,2n)Cr53(n,α)Ti50(n,α)Ca47				6.1	0.2		
		Mn55(n,2n)Mn54(n,d)Cr53(n,α)Ti50(n,α)Ca47				5.6			
		Mn55(n,nα)V51(n,d)Ti50(n,α)Ca47				5.5	16.6	1.6	0.5
		Mn55(n,2n)Mn54(n,α)V51(n,d)Ti50(n,α)Ca47				3.0			
		Mn55(n,t)Cr53(n,α)Ti50(n,α)Ca47				2.6	3.0	1.1	1.0
		Mn55(n,d)Cr54(n,nα)Ti50(n,α)Ca47				1.3	13.3	1.5	0.5
		Mn55(n,nα)V51(n,pα)Ca47					18.7	17.8	2.6
		Mn55(n,dα)Ti50(n,α)Ca47					5.3	22.4	17.7
		Mn55(n,2n)Mn54(β^+)Cr54(n,2α)Ca47					2.1	8.5	1.6
		Mn55(n,3n)Mn53(n,t)Cr51(β^+)V51(n,pα)Ca47					1.5	6.7	0.4
		Mn55(n,d)Cr54(n,2α)Ca47					0.9	5.2	1.2
		Mn55(n,3nα)V49(β^+)Ti49(n,h)Ca47							35.5
		Mn55(n,tα)Ti49(n,h)Ca47							12.9
		Mn55(n,2nt)Cr51(β^+)V51(n,pα)Ca47							4.6
		Mn55(n,nt)Cr52(n,nt)V49(β^+)Ti49(n,h)Ca47							3.3
		Other pathways				5.2	11.0	33.2	17.7
Fe59	44.495 d	Mn55(n,γ)Mn56(β^-)Fe56(n,γ)Fe57(n,γ)_ Fe58(n,γ)Fe59	100.0	100.0	100.0	99.4	99.7	99.8	99.9
Sc46	83.79 d	**&**Mn55(n,nα)V51(n,2n)V50(n,2n)V49_ (n,α)*Sc46*				25.6			
		&Mn55(n,2n)Mn54(n,2n)Mn53(n,α)V50_ (n,2n)V49(n,α)*Sc46*				25.6			
		&Mn55(n,2n)Mn54(n,nα)V50(n,nα)*Sc46*				14.6	0.2		
		&Mn55(n,2n)Mn54(n,α)V51(n,2n)V50_ (n,2n)V49(n,α)*Sc46*				12.6			
		&Mn55(n,α)V52(β^-)Cr52(n,2n)Cr51(β^+)_ V51(n,2n)V50(n,2n)V49(n,α)*Sc46*				6.4			
		&Mn55(n,nα)V51(n,nα)Sc47(β^-)Ti47(n,d)*Sc46*				1.2	16.8	0.3	
		&Mn55(n,nα)V51(n,2n)V50(n,nα)*Sc46*				0.9	32.6	0.4	
		&Mn55(n,3n)Mn53(n,2α)*Sc46*					9.8	7.7	0.3
		&Mn55(n,3n)Mn53(n,α)V50(n,nα)*Sc46*					5.9	0.2	0.1
		&Mn55(n,2nα)V50(n,nα)*Sc46*					1.7	34.2	4.6
		&Mn55(n,nα)V51(n,2nα)*Sc46*						17.0	4.1
		&Mn55(n,3n)Mn53(n,t)Cr51(β^+)V51_ (n,2nα)*Sc46*						6.0	0.5
		&Mn55(n,3nα)V49(β^+)Ti49(n,nt)*Sc46*							22.2
		&Mn55(n,2n2α)*Sc46*							12.9
		&Mn55(n,nt)Cr52(n,tα)*Sc46*							8.5
		&Mn55(n,tα)Ti49(n,nt)*Sc46*							8.3
		&Mn55(n,2nt)Cr51(β^+)V51(n,2nα)*Sc46*							7.1
		Other pathways				13.1	33.0	34.2	31.4

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ca45	163.0 d	Mn55(n,α)V52(β⁻)Cr52(n,α)Ti49(n,2n)_ Ti48(n,α)Ca45				29.1			
		Mn55(n,nα)V51(n,α)Sc48(β⁻)Ti48(n,α)Ca45				20.8	0.4		
		Mn55(n,α)V52(β⁻)Cr52(n,α)Ti49(n,α)_ Ca46(n,2n)Ca45				14.2			
		Mn55(n,2n)Mn54(n,α)V51(n,α)Sc48(β⁻)_ Ti48(n,α)Ca45				10.8			
		Mn55(n,α)V52(β⁻)Cr52(n,2n)Cr51(β⁺)_ V51(n,α)Sc48(β⁻)Ti48(n,α)Ca45				5.9			
		Mn55(n,3n)Mn53(n,nα)V49(β⁺)Ti49_ (n,nα)Ca45					36.9	4.6	0.2
		Mn55(n,nα)V51(n,3n)V49(β⁺)Ti49(n,nα)Ca45					14.8	2.7	0.1
		Mn55(n,t)Cr53(n,nα)Ti49(n,nα)Ca45					8.4	3.7	0.2
		Mn55(n,nα)V51(n,t)Ti49(n,nα)Ca45					5.1	3.0	0.2
		Mn55(n,2nα)V50(n,dα)Ca45						22.5	10.4
		Mn55(n,dα)Ti50(n,2nα)Ca45						15.3	5.4
		Mn55(n,3n)Mn53(n,pα)Ti49(n,nα)Ca45						8.0	1.5
		Mn55(n,tα)Ti49(n,nα)Ca45						0.2	8.7
		Mn55(n,3nα)V49(β⁺)Ti49(n,nα)Ca45							22.9
		Mn55(n,2nt)Cr51(β⁺)V51(n,tα)Ca45							7.7
		Mn55(n,nα)V51(n,tα)Ca45							4.4
		Other pathways				19.2	34.4	40.0	38.3
Mn54	312.1 d	Mn55(n,2n)Mn54				99.6	99.8	99.9	99.9
Co60	5.271 y	**&**Mn55(n,γ)Mn56(β⁻)Fe56(n,γ)Fe57(n,γ)_ Fe58(n,γ)Fe59(β⁻)Co59(n,γ)*Co60*	100.0	100.0	100.0	99.7	99.8		
H3	12.33 y	Mn55(n,X)H3				94.4	93.7	93.6	94.3
		Mn55(n,2n)Mn54(n,X)H3				5.2	2.0	0.9	0.5
		Mn55(n,3n)Mn53(n,X)H3					1.6	2.0	0.9
		Mn55(n,2n)Mn54(β⁺)Cr54(n,X)H3					1.0	0.8	0.6
		Mn55(n,t)Cr53(n,X)H3					0.4	1.2	0.8
		Mn55(n,nt)Cr52(n,X)H3						0.2	1.1
Ar42	33.0 y	Mn55(n,α)V52(β⁻)Cr52(n,α)Ti49(n,2n)_ Ti48(n,α)Ca45(n,α)Ar42				27.3			
		Mn55(n,nα)V51(n,α)Sc48(β⁻)Ti48(n,α)_ Ca45(n,α)Ar42				25.6			
		Mn55(n,α)V52(β⁻)Cr52(n,α)Ti49(n,α)_ Ca46(n,2n)Ca45(n,α)Ar42				13.4			
		Mn55(n,2n)Mn54(n,α)V51(n,α)Sc48(β⁻)_ Ti48(n,α)Ca45(n,α)Ar42				11.5			
		Mn55(n,α)V52(β⁻)Cr52(n,2n)Cr51(β⁺)_ V51(n,α)Sc48(β⁻)Ti48(n,α)Ca45(n,α)Ar42				5.4			
		Mn55(n,2n)Mn54(β⁺)Cr54(n,nα)Ti50_ (n,nα)Ca46(n,nα)Ar42					12.0	0.5	
		Mn55(n,nα)V51(n,d)Ti50(n,nα)Ca46(n,nα)Ar42					10.3	0.5	
		Mn55(n,3n)Mn53(n,nα)V49(β⁺)Ti49_ (n,α)Ca46(n,nα)Ar42					9.0	0.4	
		Mn55(n,d)Cr54(n,nα)Ti50(n,nα)Ca46_ (n,nα)Ar42					8.3	0.5	
		Mn55(n,3n)Mn53(n,nα)V49(β⁺)Ti49_ (n,nα)Ca45(n,α)Ar42					6.9	0.2	
		Mn55(n,dα)Ti50(n,nα)Ca46(n,nα)Ar42					6.5	14.8	0.6
		Mn55(n,3n)Mn53(n,nα)V49(β⁺)Ti49_ (n,2α)Ar42					3.7	5.0	0.1
		Mn55(n,t)Cr53(n,nα)Ti49(n,2α)Ar42					0.9	4.4	0.1
		Mn55(n,2nα)V50(n,pα)Ca46(n,nα)Ar42					0.1	6.5	0.2
		Mn55(n,2nα)V50(n,d)Ti49(n,2α)Ar42						4.4	0.2
		Mn55(n,dα)Ti50(n,n2α)Ar42						0.4	20.7
		Mn55(n,tα)Ti49(n,2α)Ar42						0.3	7.7
		Mn55(n,3nα)V49(β⁺)Ti49(n,2α)Ar42							17.3
		Other pathways				16.8	42.3	62.1	53.1

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ni63	100.6 y	**&**Mn55(n,γ)Mn56(β^-)Fe56(n,γ)Fe57(n,γ)_ Fe58(n,γ)Fe59(β^-)Co59(n,γ)*Co60*(n,γ)_ Co61(β^-)Ni61(n,γ)Ni62(n,γ)Ni63	86.4	93.2					
		&Mn55(n,γ)Mn56(β^-)Fe56(n,γ)Fe57(n,γ)_ Fe58(n,γ)Fe59(β^-)Co59(n,γ)*Co60*(β^-)_ Ni60(n,γ)Ni61(n,γ)Ni62(n,γ)Ni63	9.4	6.7					
		Mn55(n,γ)Mn56(β^-)Fe56(n,γ)Fe57(n,γ)_ Fe58(n,γ)Fe59(n,γ)Fe60(n,γ)Fe61(β^-)_ Co61(β^-)Ni61(n,γ)Ni62(n,γ)Ni63	4.1						
Ar39	269.0 y	Mn55(n,nα)V51(n,α)Sc48(β^-)Ti48(n,α)_ Ca45(β^-)Sc45(n,α)K42(β^-)Ca42(n,α)Ar39				8.9			
		Mn55(n,α)V52(β^-)Cr52(n,α)Ti49(n,α)_ Ca46(n,α)Ar43(β^-)K43(β^-)Ca43(n,nα)Ar39				5.7			
		Mn55(n,nα)V51(n,nα)Sc47(β^-)Ti47_ (n,2n)Ti46(n,α)Ca43(n,nα)Ar39				3.7	0.2		
		Mn55(n,nα)V51(n,2n)V50(n,α)Sc47(β^-)_ Ti47(n,2n)Ti46(n,α)Ca43(n,nα)Ar39				2.2			
		Mn55(n,nα)V51(n,2n)V50(n,2n)V49_ (n,α)Sc46(β^-)Ti46(n,α)Ca43(n,nα)Ar39				2.1			
		Mn55(n,nα)V51(n,nα)Sc47(β^-)Ti47_ (n,nα)Ca43(n,nα)Ar39				1.9	46.3	0.2	
		Mn55(n,nα)V51(n,nα)Sc47(β^-)Ti47_ (n,2n)Ti46(n,2α)Ar39					4.7		
		Mn55(n,nα)V51(n,2n)V50(n,nα)Sc46_ (β^-)Ti46(n,2α)Ar39					3.5		
		Mn55(n,2n)Mn54(n,nα)V50(n,nα)Sc46_ (β^-)Ti46(n,2α)Ar39					2.2		
		Mn55(n,3n)Mn53(n,2α)Sc46(β^-)Ti46_ (n,2α)Ar39					2.1	0.8	
		Mn55(n,2nα)V50(n,nα)Sc46(β^-)Ti46_ (n,2α)Ar39					0.4	3.6	
		Mn55(n,nt)Cr52(n,2nα)Ti47(n,n2α)Ar39						2.8	2.3
		Mn55(n,nα)V51(n,nα)Sc47(β^-)Ti47_ (n,n2α)Ar39						2.5	0.1
		Mn55(n,n2α)Sc47(β^-)Ti47(n,n2α)Ar39						1.5	5.3
		Mn55(n,2nα)V50(n,2nα)Sc45(n,tα)Ar39						1.2	3.0
		Mn55(n,2nt)Cr51(β^+)V51(n,3nα)Sc45_ (n,tα)Ar39							2.0
		Mn55(n,3nα)V49(β^+)Ti49(n,2nα)Ca44_ (n,2nα)Ar39							2.0
		Other pathways				75.5	40.6	87.4	85.3
Cl36	$3.0\,10^5$ y	Mn55(n,nα)V51(n,α)Sc48(β^-)Ti48(n,α)Ca45_ (β^-)Sc45(n,nα)K41(n,nα)Cl37(n,2n)Cl36				9.1			
		Mn55(n,nα)V51(n,α)Sc48(β^-)Ti48(n,α)Ca45_ (β^-)Sc45(n,nα)K41(n,2n)K40(n,nα)Cl36				7.1			
		Mn55(n,nα)V51(n,nα)Sc47(β^-)Ti47(n,α)_ Ca44(n,α)Ar41(β^-)K41(n,nα)Cl37(n,2n)Cl36				4.5			
		Mn55(n,nα)V51(n,nα)Sc47(β^-)Ti47(n,α)_ Ca44(n,α)Ar41(β^-)K41(n,2n)K40(n,nα)Cl36				3.5			
		&Mn55(n,3n)Mn53(n,nα)V49(n,nα)_ *Sc45*(n,nα)K41(n,2nα)Cl36					15.5		
		Mn55(n,nα)V51(n,nα)Sc47(β^-)Ti47_ (n,nα)Ca43(n,2nα)Ar38(n,t)Cl36					5.9		
		Mn55(n,nα)V51(n,3n)V49(n,nα)Sc45_ (n,nα)K41(n,2nα)Cl36					4.5		
		Mn55(n,nα)V51(n,nα)Sc47(β^-)Ti47(n,t)_ Sc45(n,nα)K41(n,2nα)Cl36					3.2		
	►	Mn55(n,2nα)V50(n,2nα)Sc45(n,2nα)_ K40(n,nα)Cl36						9.6	

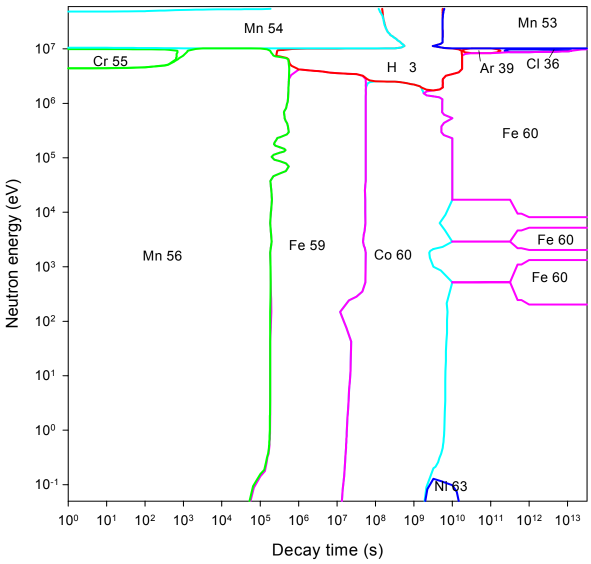
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Mn55(n,2nα)V50(n,2nα)Sc45(n,nα)K41_ (n,2nα)Cl36						7.1	
		Mn55(n,2nα)V50(n,nα)Sc46(β^-)Ti46_ (n,2nα)Ca41(n,dα)Cl36						4.3	
		Mn55(n,2nα)V50(n,nα)Sc46(β^-)Ti46_ (n,n2α)Ar38(n,t)Cl36						3.2	
		Mn55(n,2nα)V50(n,2nα)Sc45(n,2n2α)Cl36							4.1
		Mn55(n,2nt)Cr51(β^+)V51(n,3nα)Sc45_ (n,2n2α)Cl36							2.7
		Other pathways using (n,α), (n,nα), β^-				75.8	70.9	75.8	91.2
Fe60	1.5 10^6 y	Mn55(n,γ)Mn56(β^-)Fe56(n,γ)Fe57(n,γ)_ Fe58(n,γ)Fe59(n,γ)Fe60	100.0	100.0	100.0	98.7	99.3		
Mn53	3.7 10^6 y	Mn55(n,2n)Mn54(n,2n)Mn53				99.8	2.4	0.7	0.6
		Mn55(n,3n)Mn53					97.5	99.2	99.4
Ca48	5.3 10^{19} y	Mn55(n,nα)V51(n,α)Sc48(n,p)Ca48				29.5	0.2		
		Mn55(n,α)V52(β^-)Cr52(n,α)Ti49(n,2p)Ca48				29.0			
		Mn55(n,2n)Mn54(n,α)V51(n,α)Sc48(n,p)Ca48				16.1			
		Mn55(n,α)V52(β^-)Cr52(n,2n)Cr51(β^+)_ V51(n,α)Sc48(n,p)Ca48				9.4			
		Mn55(n,2n)Mn54(β^+)Cr54(n,α)Ti51(β^-)_ V51(n,α)Sc48(n,p)Ca48				6.3			
		Mn55(n,2n)Mn54(β^+)Cr54(n,nα)Ti50(n,h)Ca48					22.4	3.8	0.8
		Mn55(n,nα)V51(n,d)Ti50(n,h)Ca48					17.0	3.5	0.9
		Mn55(n,d)Cr54(n,nα)Ti50(n,h)Ca48					13.6	3.3	0.8
		Mn55(n,3n)Mn53(n,nα)V49(β^+)Ti49(n,2p)Ca48					12.8	1.0	
		Mn55(n,dα)Ti50(n,h)Ca48					8.1	73.6	45.8
		Mn55(n,nα)V51(n,3n)V49(β^+)Ti49(n,2p)Ca48					5.1	0.6	
		Mn55(n,3nα)V49(β^+)Ti49(n,2p)Ca48							18.2
		Mn55(n,tα)Ti49(n,2p)Ca48							8.1
		Other pathways				9.7	20.8	14.2	25.4

Manganese activation characteristics

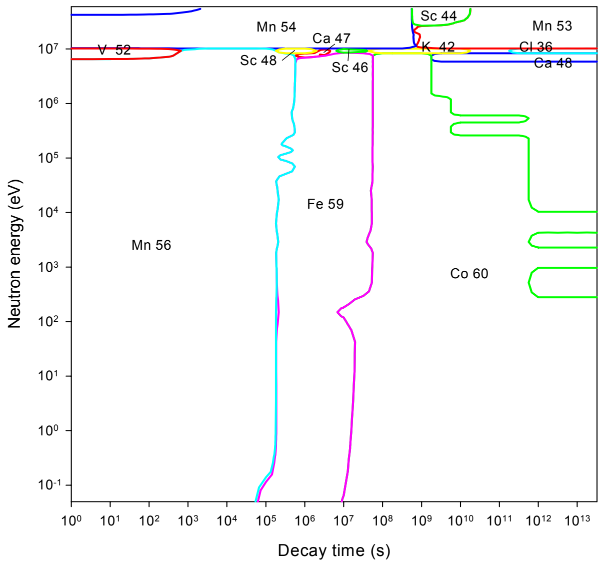


Manganese importance diagrams & transmutation

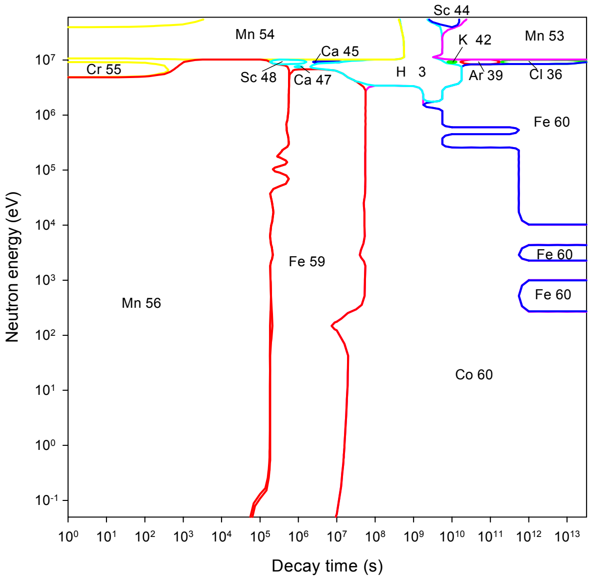
Activity



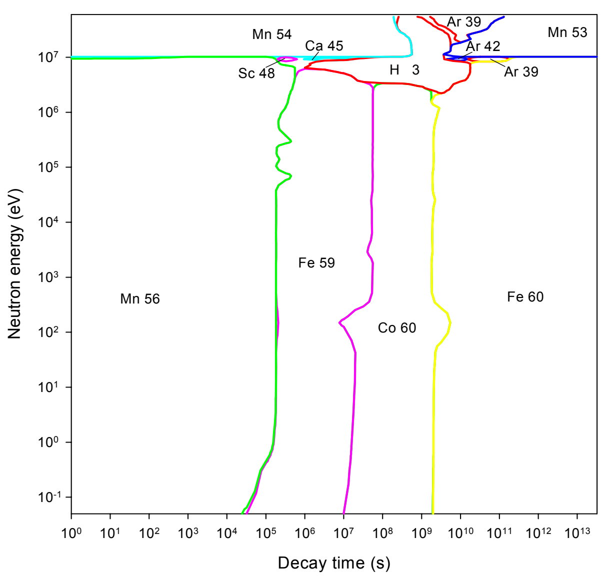
Dose rate



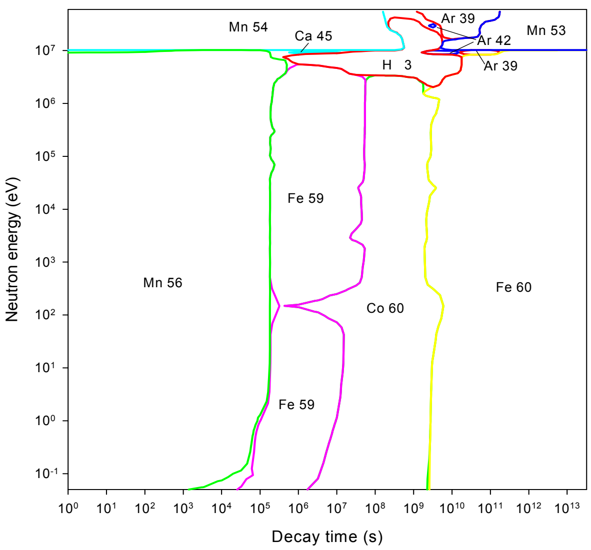
Heat output



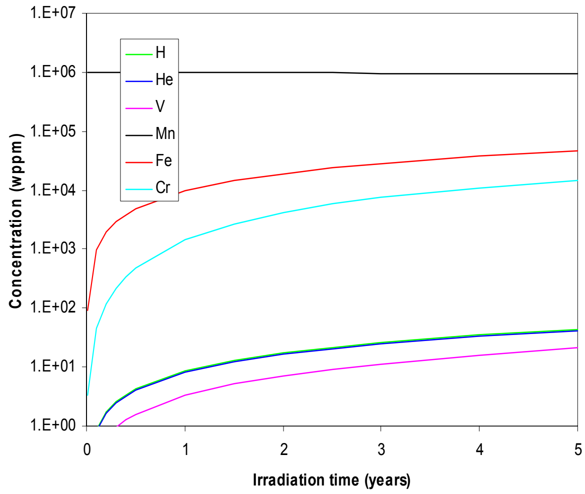
Ingestion dose



Inhalation dose



First wall transmutation



Graphs for H, He are indistinguishable

Iron

General properties

		Isotopes	Isotopic abundances / %
Atomic number	26		
Crustal abundance / wppm	$5.63\ 10^{4}$	Fe54	5.845
Melting point / K	1811	Fe56	91.754
Boiling point / K	3134	Fe57	2.119
Density / kgm^{-3}	7874	Fe58	0.282
Thermal conductivity / $Wm^{-1}K^{-1}$	80.2		
Electrical resistivity /Ωm	$9.71\ 10^{-8}$		
Coefficient of thermal expansion / K^{-1}	$1.18\ 10^{-5}$		
Crystal structure	BCC		
Number of stable isotopes	4		
Mean atomic weight	55.845		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	6.67E14	6.60E14	4.70E14	3.41E14	6.66E7	2.06E7	kW kg^{-1}	8.68E-2	8.43E-2	8.10E-3	3.60E-3	1.64E-10	1.85E-11
Fe55	61.02	61.71	86.50	92.83			Mn56	89.52	90.00				
Mn56	28.69	28.34					Mn54	8.47	8.72	90.09	90.70		
Mn54	8.18	8.286	11.547	7.13			Fe55	0.42	0.44	4.55	7.96		
Cr51	1.24	1.25	1.61				Fe59	0.38	0.39	3.84	0.03		
Co60	0.02	0.02	0.03	0.03	0.38	0.01	Co60	0.06	0.06	0.66	1.30	63.58	3.35
H3					68.16		H3					25.30	
Mn53					31.45	99.97	Mn53					11.09	96.45
Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	1.09E5	1.06E5	1.25E4	5.44E3	1.84E-4	5.62E-6	Sv kg^{-1}	2.25E5	2.24E5	1.76E5	1.22E5	3.56E-3	7.86E-4
Mn56	87.98	87.91					Fe55	59.79	60.09	76.17	85.55		
Mn54	10.92	11.17	93.75	96.92			Mn56	21.30	20.91				
Fe59	0.49	0.05	3.99	0.03			Mn54	17.25	17.34	21.86	14.13		
V52	0.11	0.04					Fe59	1.26	1.26	1.52	0.01		
Fe55	0.10	0.10	0.87	1.56			Co60	0.19	0.19	0.26	0.31	23.92	0.64
Co60	0.08	0.09	0.73	1.49	97.48	19.00	H3					53.56	
Mn52	0.05	0.06	0.30				Mn53					17.65	78.45
Mn53					2.52	80.95	Fe60					4.83	20.93
Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	4.29E5	4.29E5	4.04E5	2.83E5	2.12E-2	1.57E-3		5.71E11	5.69E11	5.45E11	2.44E11	3.17E3	2.20E2
Fe55	73.06	73.16	77.36	85.91			Mn54	95.73	96.00	99.40	99.41		
Mn54	19.09	19.11	20.10	12.85			Mn56	3.36	3.29				
Mn56	5.35	5.24					Fe59	0.27	0.28	0.27			
Fe59	1.46	1.46	1.47	0.01			Co60	0.22	0.22	0.23	0.46	79.05	6.76
Co60	0.92	0.92	0.98	1.23	36.67	2.93	Fe55	0.07	0.07	0.07	0.13		
H3					55.76		Cr51	0.01	0.01	0.01			
Mn53					5.34	70.46	H3					14.33	
Fe60					2.07	26.57	Mn53					6.61	93.23

Iron

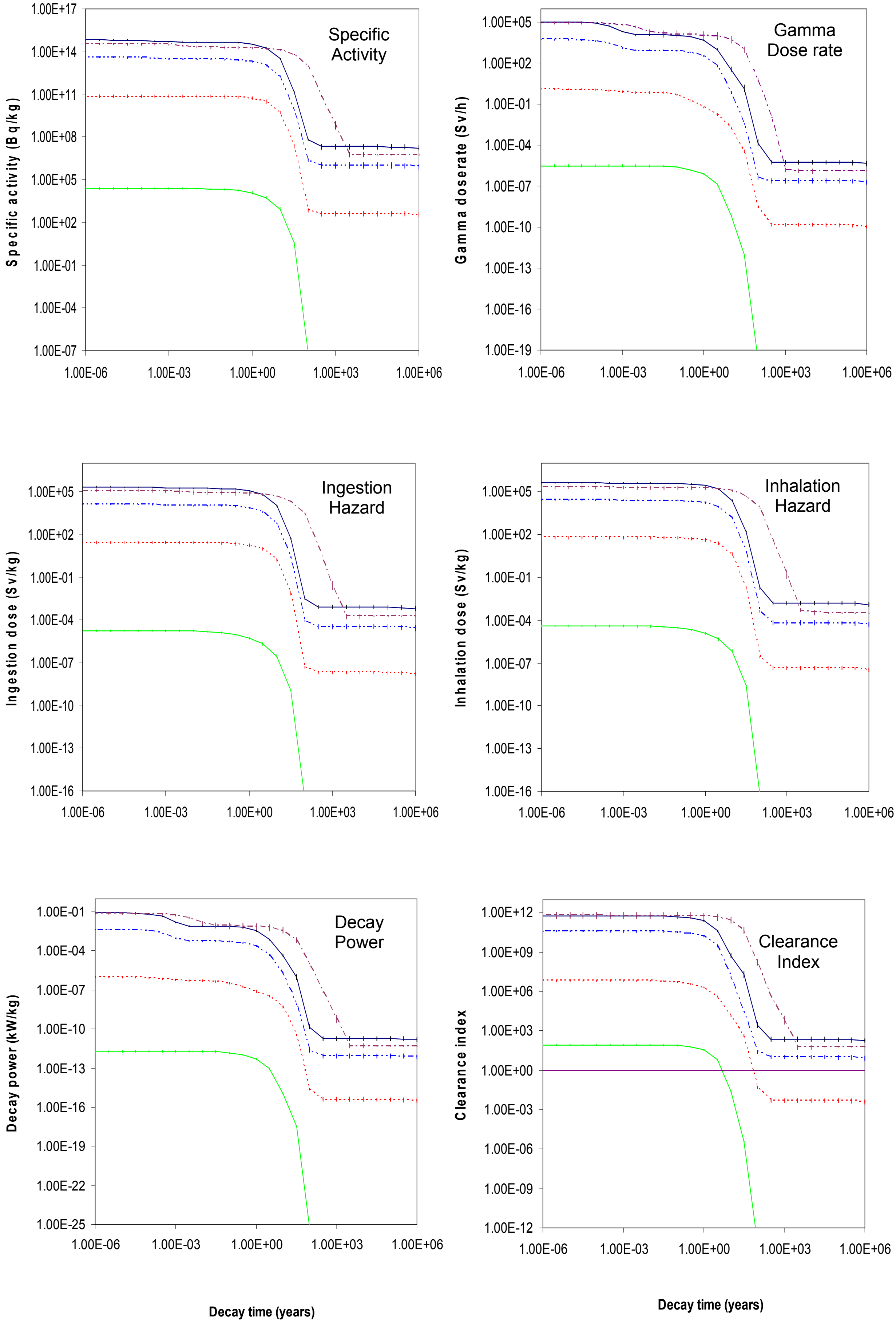
Pathway analysis

Nuclide	$T_{1/2}$	Pathway	210	186	151	42	60	21	6
Mn56	2.582 h	Fe54(n,γ)Fe55(β^+)Mn55(n,γ)Mn56	96.9	99.9	100.0				
		Fe56(n,γ)Fe57(n,γ)Fe58(n,γ)Fe59(n,α)_ Cr56(β^-)Mn56	1.6						
		Fe58(n,γ)Fe59(n,α)Cr56(β^-)Mn56	0.7						
		Fe57(n,γ)Fe58(n,γ)Fe59(n,α)Cr56(β^-)Mn56	0.6						
		Fe56(n,p)Mn56				99.3	90.0	87.5	81.1
		Fe57(n,d)Mn56				0.3	9.5	10.7	16.3
		Fe57(n,2n)Fe56(n,p)Mn56				0.3	0.2		
		Fe58(n,t)Mn56						1.5	2.3
Sc44	3.97 h	**&**Fe54(n,α)Cr51(β^+)V51(n,α)Sc48(β^-)_ Ti48(n,α)Ca45(β^-)Sc45(n,2n)*Sc44*				58.4			
		&Fe54(n,α)Cr51(n,α)Ti48(n,α)Ca45(β^-)_ Sc45(n,2n)*Sc44*				15.7			
		&Fe54(n,nα)Cr50(n,nα)Ti46(n,d)*Sc45*_ (n,2n)*Sc44*				0.3	15.2		
		&Fe54(n,nα)Cr50(n,nα)Ti46(n,t)*Sc44*					22.6	6.1	
		&Fe54(n,nα)Cr50(n,nα)Ti46(n,2n)Ti45_ (β^+)Sc45(n,2n)*Sc44*					6.2		
		&Fe54(n,dα)V49(n,2nα)*Sc44*						14.2	0.9
		&Fe56(n,2nα)Cr51(β^+)V51(n,2nα)Sc46_ (β^-)Ti46(n,t)*Sc44*						8.6	
		&Fe56(n,2nα)Cr51(β^+)V51(n,3n)V49_ (n,2nα)*Sc44*						6.9	
		&Fe56(n,3n)Fe54(n,dα)V49(n,2nα)*Sc44*						3.5	
		&Fe56(n,3nα)Cr50(n,tα)*Sc44*							17.7
		&Fe56(n,tα)V50(n,3nα)*Sc44*							12.7
		&Fe56(n,nt)Mn53(n,2n2α)*Sc44*							3.9
		&Fe54(n,nα)Cr50(n,tα)*Sc44*							3.6
		&Fe56(n,nt)Mn53(n,tα)Ti47(n,nt)*Sc44*							3.2
		Other pathways				25.6	56.0	60.7	58.0
Fe59	44.495 d	Fe56(n,γ)Fe57(n,γ)Fe58(n,γ)Fe59	56.9	0.3					
		Fe58(n,γ)Fe59	22.8	97.0	97.4	98.6	98.9	99.1	99.4
		Fe57(n,γ)Fe58(n,γ)Fe59	20.3	2.7	2.5				
Mn54	312.13 d	Fe54(n,p)Mn54				35.2	4.3	0.8	0.6
		Fe56(n,2n)Fe55(β^+)Mn55(n,2n)Mn54				31.3	12.0	0.9	
		Fe56(n,d)Mn55(n,2n)Mn54				16.0	16.1	1.4	0.9
		Fe56(n,2n)Fe55(n,d)Mn54				15.5	18.4	1.5	1.0
		Fe56(n,t)Mn54				0.1	47.6	94.5	94.5
		Fe57(n,nt)Mn54						0.1	1.9
Fe55	2.735 y	Fe54(n,γ)Fe55	100.0	100.0	100.0				
		Fe56(n,2n)Fe55				98.8	98.6	97.5	97.9
		Fe57(n,2n)Fe56(n,2n)Fe55				0.2	0.1		
		Fe57(n,3n)Fe55					0.9	2.1	1.7
Co60	5.271 y	**&**Fe58(n,γ)Fe59(β^-)Co59(n,γ)*Co60*	51.4	98.4	99.1	99.8	99.8	99.8	99.9
		&Fe56(n,γ)Fe57(n,γ)Fe58(n,γ)Fe59(β^-)_ Co59(n,γ)*Co60*	29.7						
		&Fe57(n,γ)Fe58(n,γ)Fe59(β^-)Co59(n,γ)_ *Co60*	18.9	1.4	0.9				
H3	12.33 y	Fe54(n,γ)Fe55(n,X)H1(n,γ)H2(n,γ)H3	93.8	96.2	99.5				
		Fe56(n,X)H3				63.9	84.9	85.7	85.7
		Fe56(n,2n)Fe55(β^+)Mn55(n,X)H3				12.8	1.5	0.7	
		Fe56(n,d)Mn55(n,X)H3				7.7	2.4	1.2	0.8
		Fe57(n,X)H3				6.3	2.5	2.3	2.2
		Fe56(n,2n)Fe55(n,X)H3				4.5	2.9	1.3	0.8
		Fe54(n,p)Mn54(n,X)H3				1.4			
	►	Fe54(n,X)H3					3.3	1.4	4.6

Nuclide	T½	Pathway	210	186	151	42	60	21	6
	◄	Fe56(n,t)Mn54(n,X)H3					0.2	1.1	0.6
		Fe56(n,t)Mn54(β$^+$)Cr54(n,X)H3					0.1	1.0	0.8
		Fe56(n,nt)Mn53(n,X)H3							1.4
Ar42	33.0 y	Fe54(n,α)Cr51(β$^+$)V51(n,α)Sc48(β$^-$)_ Ti48(n,α)Ca45(n,α)Ar42				66.3			
		Fe54(n,α)Cr51(n,α)Ti48(n,α)Ca45(n,α)Ar42				17.3			
		Fe56(n,nα)Cr52(n,nα)Ti48(n,α)Ca45(n,α)Ar42				0.2	6.0		
		Fe56(n,nα)Cr52(n,α)Ti49(n,α)Ca46(n,nα)Ar42					4.3		
		Fe54(n,nα)Cr50(n,d)V49(β$^+$)Ti49(n,α)_ Ca46(n,nα)Ar42					4.0		
		Fe56(n,t)Mn54(β$^+$)Cr54(n,nα)Ti50(n,nα)_ Ca46(n,nα)Ar42					3.7	0.8	
		Fe56(n,2α)Ti49(n,α)Ca46(n,nα)Ar42					3.6	0.8	
		Fe56(n,nα)Cr52(n,nα)Ti48(n,nα)Ca44_ (n,h)Ar42					3.6	0.3	
		Fe54(n,nα)Cr50(n,d)V49(β$^+$)Ti49(n,nα)_ Ca45(n,α)Ar42					3.1		
		Fe56(n,nα)Cr52(n,α)Ti49(n,nα)Ca45(n,α)Ar42					3.0		
		Fe54(n,dα)V49(β$^+$)Ti49(n,2α)Ar42						22.0	5.2
		Fe56(n,2nα)Cr51(β$^+$)V51(n,dα)Ca46_ (n,nα)Ar42						5.1	2.7
		Fe56(n,2nα)Cr51(β$^+$)V51(n,t)Ti49(n,2α)Ar42						5.0	0.7
		Fe54(n,2nα)Cr49(β$^+$)V49(β$^+$)Ti49(n,2α)Ar42						4.1	1.4
		Fe56(n,2nα)Cr51(β$^+$)V51(n,3n)V49(β$^+$)_ Ti49(n,2α)Ar42						3.9	
		Fe56(n,t)Mn54(β$^+$)Cr54(n,2nα)Ti49(n,2α)Ar42						3.8	
		&Fe56(n,3nα)Cr50(n,tα)*Sc44*(β$^+$)Ca44_ (n,h)Ar42							6.3
Ni63	100.6 y	**&**Fe58(n,γ)Fe59(β$^-$)Co59(n,γ)*Co60*(n,γ)_ Co61(β$^-$)Ni61(n,γ)Ni62(n,γ)Ni63	63.4	89.0	84.0	76.6			
		&Fe58(n,γ)Fe59(β$^-$)Co59(n,γ)*Co60*(β$^-$)_ Ni60(n,γ)Ni61(n,γ)Ni62(n,γ)Ni63	10.8	10.3	11.3	11.1			
		&Fe57(n,γ)Fe58(n,γ)Fe59(β$^-$)Co59(n,γ)_ *Co60*(n,γ)Co61(β$^-$)Ni61(n,γ)Ni62(n,γ)Ni63	10.8	0.5	0.4				
		&Fe56(n,γ)Fe57(n,γ)Fe58(n,γ)Fe59(β$^-$)_ Co59(n,γ)*Co60*(n,γ)Co61(β$^-$)Ni61(n,γ)_ Ni62(n,γ)Ni63	9.4						
		Fe58(n,γ)Fe59(n,γ)Fe60(n,γ)Fe61(β$^-$)_ Co61(β$^-$)Ni61(n,γ)Ni62(n,γ)Ni63	2.1		4.0	11.8			
		&Fe57(n,γ)Fe58(n,γ)Fe59(β$^-$)Co59(n,γ)_ *Co60*(β$^-$)Ni60(n,γ)Ni61(n,γ)Ni62(n,γ)Ni63	1.5						
Ar39	269.0 y	Fe54(n,nα)Cr50(n,α)Ti47(n,2n)Ti46(n,α)_ Ca43(n,nα)Ar39				9.4			
		Fe54(n,nα)Cr50(n,α)Ti47(n,nα)Ca43_ (n,nα)Ar39				4.8	1.3		
		Fe54(n,α)Cr51(n,α)Ti48(n,α)Ca45(β$^-$)_ Sc45(n,α)K42(β$^-$)Ca42(n,α)Ar39				4.3			
		Fe54(n,α)Cr51(β$^+$)V51(n,nα)Sc47(β$^-$)_ Ti47(n,2n)Ti46(n,α)Ca43(n,nα)Ar39				4.2			
		Fe54(n,nα)Cr50(n,nα)Ti46(n,α)Ca43_ (n,nα)Ar39				3.6	2.4		
		Fe54(n,nα)Cr50(n,α)Ti47(n,2n)Ti46_ (n,nα)Ca42(n,α)Ar39				3.2			
		Fe54(n,nα)Cr50(n,nα)Ti46(n,2α)Ar39					49.8	1.9	
		Fe54(n,nα)Cr50(n,2α)Ca43(n,nα)Ar39					9.9	1.0	
		Fe54(n,dα)V49(β$^+$)Ti49(n,2nα)Ca44_ (n,2nα)Ar39						6.6	
		Fe54(n,dα)V49(n,2nα)Sc44(β$^+$)Ca44_ (n,2nα)Ar39						4.0	
	►	Fe56(n,2nα)Cr51(β$^+$)V51(n,nα)Sc47(β$^-$)_ Ti47(n,n2α)Ar39						3.1	

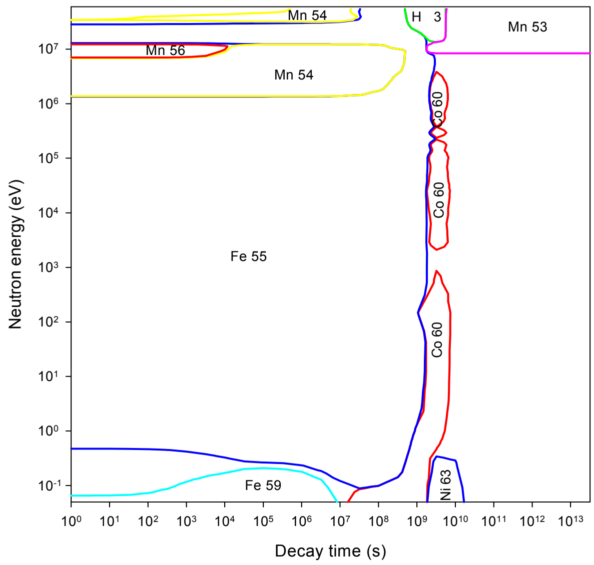
Nuclide	$T_{½}$	Pathway	210	186	151	42	60	21	6
	◄	Fe56(n,nα)Cr52(n,2nα)Ti47(n,n2α)Ar39						3.1	
		Fe56(n,n2α)Ti48(n,2n2α)Ar39							5.5
		Fe54(n,tα)V48($β^+$)Ti48(n,2n2α)Ar39							4.1
		Other pathways				70.5	36.6	80.3	90.4
Fe60	1.5 10^6 y	Fe58(n,γ)Fe59(n,γ)Fe60	43.7	100.0	100.0	95.8	98.0	100.0	100.0
		Fe56(n,γ)Fe57(n,γ)Fe58(n,γ)Fe59(n,γ)Fe60	36.7						
		Fe57(n,γ)Fe58(n,γ)Fe59(n,γ)Fe60	19.6						
		&Fe58(n,γ)Fe59($β^-$)Co59(n,γ)*Co60*(n,p)Fe60				3.5	1.0		
Mn53	3.7 10^6 y	Fe54(n,d)Mn53				90.1	42.3	24.1	3.0
		&Fe54(n,2n)*Fe53*($β^+$)Mn53				4.2	19.1	12.7	1.9
		Fe54(n,p)Mn54(n,2n)Mn53				2.4	0.1		
		Fe56(n,2n)Fe55(n,2n)Fe54(n,d)Mn53				1.0	0.3		
		Fe56(n,d)Mn55(n,3n)Mn53					12.2	8.0	0.5
		Fe56(n,2n)Fe55(n,t)Mn53					10.3	11.8	1.1
		Fe56(n,2n)Fe55($β^+$)Mn55(n,3n)Mn53					7.6	4.4	
		Fe56(n,3n)Fe54(n,d)Mn53					3.4	4.3	
		&Fe56(n,3n)Fe54(n,2n)*Fe53*($β^+$)Mn53					1.5	2.3	
		Fe56(n,t)Mn54(n,2n)Mn53					1.3	5.6	
		Fe56(n,nt)Mn53					0.3	25.0	89.0
		Fe56(n,4n)Fe53($β^+$)Mn53							2.3

Iron activation characteristics

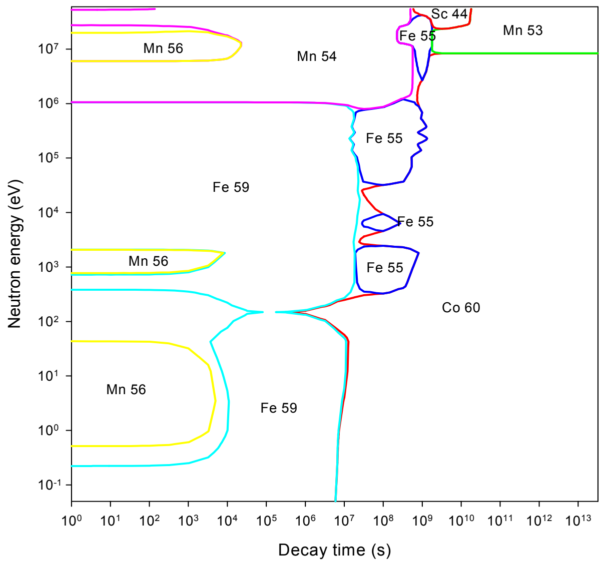


Iron importance diagrams & transmutation

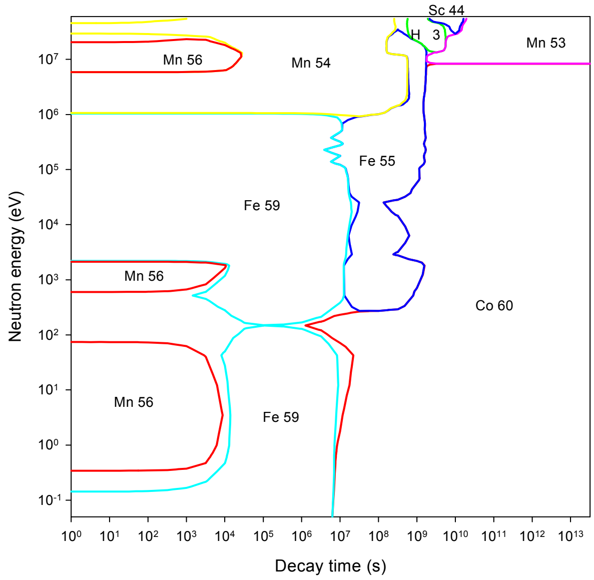
Activity



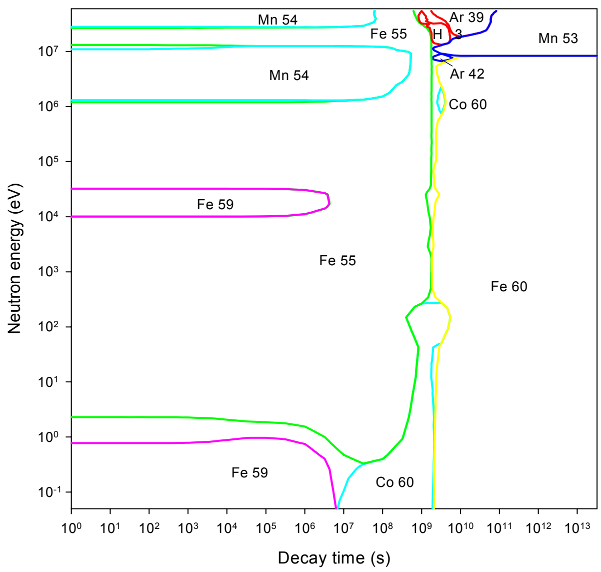
Dose rate



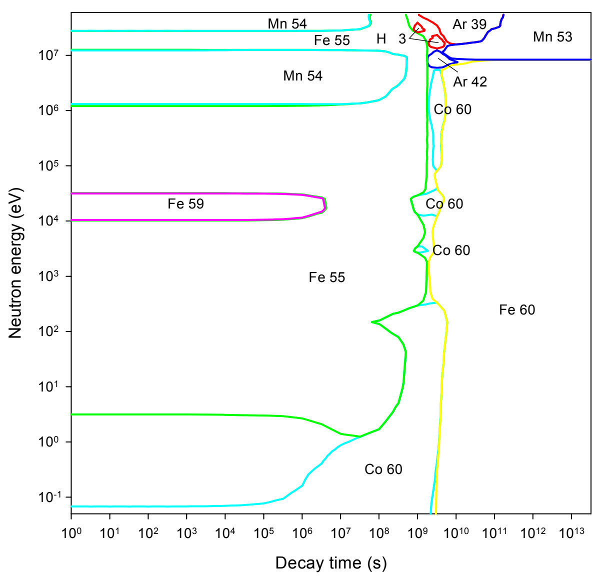
Heat output



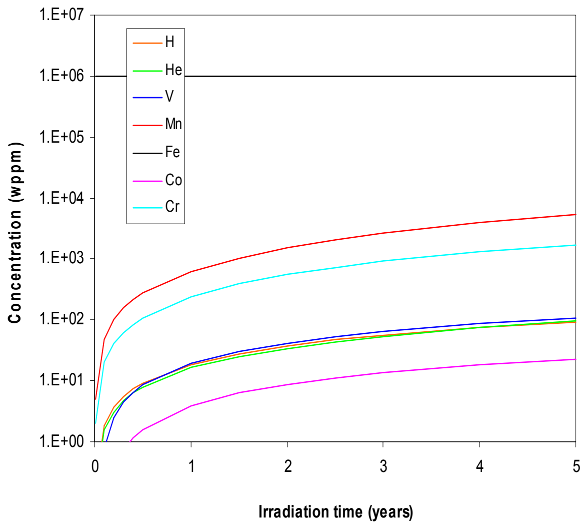
Ingestion dose



Inhalation dose



First wall transmutation



Cobalt

General properties

		Isotopes	Isotopic abundances / %
Atomic number	27	Co59	100.0
Crustal abundance / wppm	25		
Melting point / K	1768		
Boiling point / K	3200		
Density / kgm^{-3}	8900		
Thermal conductivity / $Wm^{-1}K^{-1}$	100.0		
Electrical resistivity /Ωm	$6.24\ 10^{-8}$		
Coefficient of thermal expansion / K^{-1}	$1.336\ 10^{-5}$		
Crystal structure	BCC		
Number of stable isotopes	1		
Mean atomic weight	58.9332		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	2.02E16	1.74E16	9.77E15	8.19E15	1.98E10	3.35E8	kW kg^{-1}	4.12E0	4.08E0	3.96E0	3.41E0	7.57E-6	1.03E-8
Co60m	47.06	38.62			0.12	6.81	Co60	94.43	95.14	98.05	99.94	99.97	91.73
Co60	46.12	53.40	95.32	99.85	91.52	6.79	Co60m	2.31	1.64				2.20
Co58m	2.22	2.57					Co58	1.57	1.58	1.59	0.05		
Co61	2.05	2.29					Co61	0.90	0.88				
Co58	1.98	2.30	3.98	0.13			Fe59	0.36	0.36	0.35			
H3					4.74		Mn56	0.33	0.32				
Ni59					3.34	79.59	Ni59					0.01	2.66
Fe60					0.12	6.81	Fe60						3.10
Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	6.94E6	6.93E6	6.89E6	5.95E6	1.32E1	1.67E-2	Sv kg^{-1}	3.22E7	3.22E7	3.21E7	2.78E7	6.45E1	2.60E0
Co60	97.70	97.77	98.26	99.95	100.0	99.26	Co60	98.48	98.49	98.72	99.97	95.79	2.97
Co58	1.43	1.43	1.40	0.04			Co58	0.92	0.92	0.89	0.03		
Fe59	0.35	0.35	0.33				Fe59	0.39	0.39	0.37			
Co60m	0.18	0.13				0.18	Fe60					4.07	96.38
Ni59						0.55	Ni59					0.06	0.64
Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	2.90E8	2.90E8	2.90E8	2.54E8	5.70E2	7.21E0		9.38E13	9.38E13	9.36E13	8.18E13	1.82E8	2.30E5
Co60	99.60	99.60	99.63	99.99	98.73	9.78	Co60	99.48	99.48	99.51	99.99	99.99	98.74
Co58	0.29	0.29	0.28				Co58	0.42	0.42	0.41	0.01		
Fe60					1.17	88.59	Co60m	0.01					
Ni59					0.05	1.62	Ni59						1.15

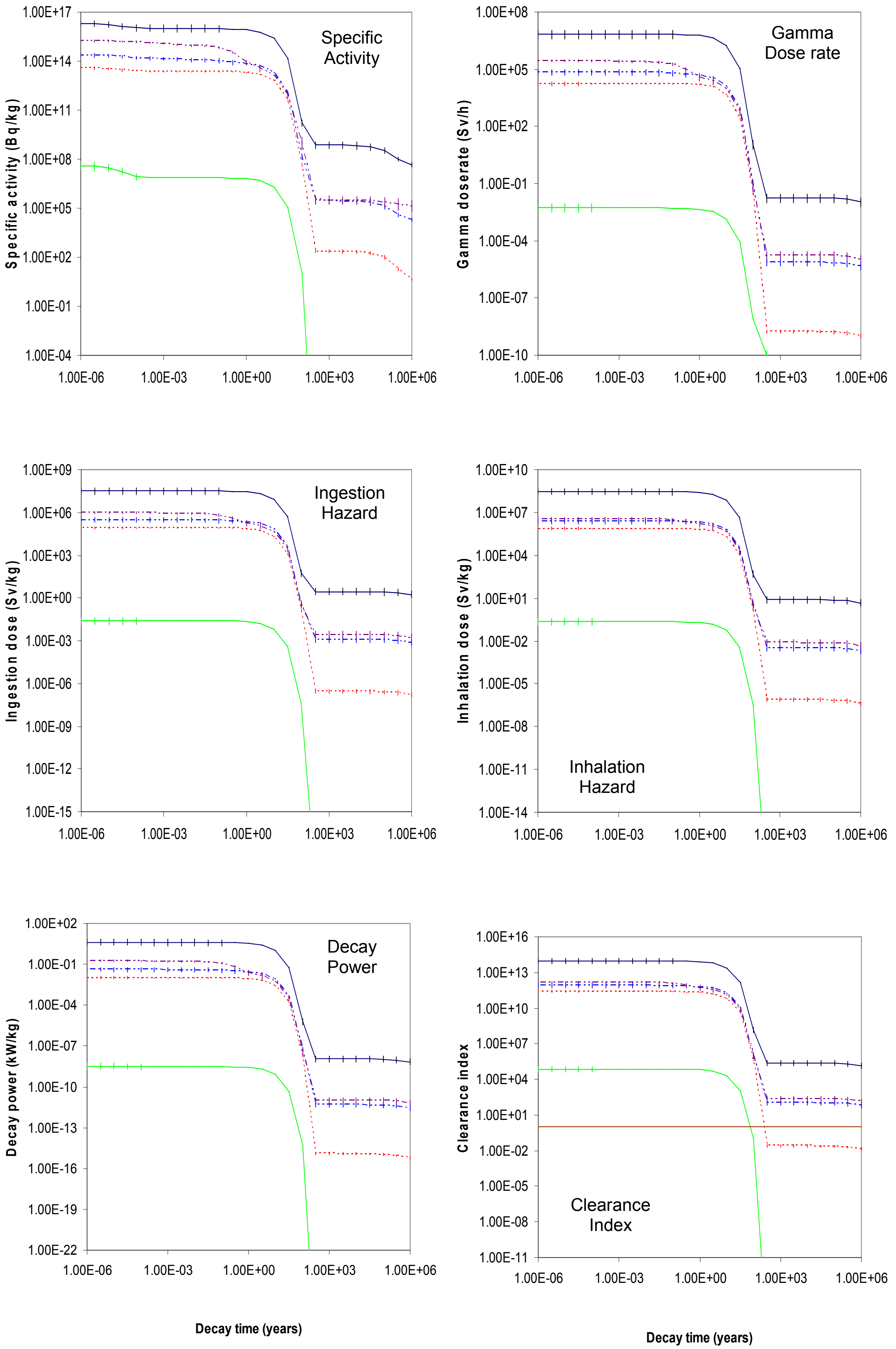
Cobalt

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Co60m	10.47 m	Co59(n,γ)Co60m	100.0	100.0	100.0	96.6	98.5	99.0	99.5
		Co59(n,γ)Co60(n,n′)Co60m				1.1	0.5	0.3	
		Co59(n,γ)Co60(β^-)Ni60(n,p)Co60m				0.3			
Sc44	3.97 h	**&**Co59(n,nα)Mn55(n,nα)V51(n,α)Sc48_ (β^-)Ti48(n,α)Ca45(β^-)Sc45(n,2n)*Sc44*				12.4			
		&Co59(n,nα)Mn55(n,α)V52(β^-)Cr52(n,α)_ Ti49(n,2n)Ti48(n,α)Ca45(β^-)Sc45(n,2n)*Sc44*				10.6			
		Co59(n,α)Mn56(β^-)Fe56(n,nα)Cr52(n,α)_ Ti49(n,2n)Ti48(n,α)Ca45(β^-)Sc45(n,2n)Sc44				5.1			
		&Co59(n,nα)Mn55(n,3n)Mn53(n,nα)_ V49(n,nα)*Sc45*(n,2n)*Sc44*					14.4		
		&Co59(n,3n)Co57(n,nα)Mn53(n,nα)V49_ (n,nα)*Sc45*(n,2n)*Sc44*					7.3		
		&Co59(n,nα)Mn55(n,nα)V51(n,3n)V49_ (n,nα)*Sc45*(n,2n)*Sc44*					5.8		
		&Co59(n,2nα)Mn54(n,2nα)V49(n,2nα)*Sc44*						23.4	0.2
		&Co59(n,2n2α)V50(n,3nα)*Sc44*							9.4
		&Co59(n,3nα)Mn53(n,2n2α)*Sc44*							8.2
		&Co59(n,3nα)Mn53(n,tα)Ti47(n,nt)*Sc44*							6.8
		&Co59(n,3nα)Mn53(n,nt)Cr50(n,tα)*Sc44*							6.2
		&Co59(n,nt)Fe56(n,3nα)Cr50(n,tα)*Sc44*							4.4
		Other pathways				71.9	72.5	76.6	64.8
Fe59	44.495 d	**&**Co59(n,γ)*Co60*(n,γ)Co61(β^-)Ni61(n,α)_ Fe58(n,γ)Fe59	79.4	83.5	82.7				
		&Co59(n,γ)*Co60*(β^-)Ni60(n,γ)Ni61(n,α)_ Fe58(n,γ)Fe59	20.3	16.4	17.1				
		Co59(n,p)Fe59				99.8	99.4	99.5	99.6
		Co59(n,2n)Co58m(IT)Co58(β^+)Fe58(n,γ)Fe59				0.1			
Co58	70.86 d	**&**Co59(n,2n)*Co58*				99.3	99.7	99.8	99.9
Co57	271.8 d	**&**Co59(n,2n)*Co58*(n,2n)Co57				99.1	0.9	0.2	
		Co59(n,2n)Co58m(n,2n)Co57				0.4			
		Co59(n,3n)Co57					98.8	99.6	99.7
Mn54	312.13 d	Co59(n,nα)Mn55(n,2n)Mn54				61.5	60.9	1.6	0.9
		&Co59(n,2n)*Co58*(β^+)Fe58(n,α)Cr55(β^-)_ Mn55(n,2n)Mn54				12.9			
		&Co59(n,2n)*Co58*(n,nα)Mn54				6.3	5.9	0.1	
		Co59(n,α)Mn56(β^-)Fe56(n,2n)Fe55(β^+)_ Mn55(n,2n)Mn54				4.2			
		&Co59(n,2n)*Co58*(n,α)Mn55(n,2n)Mn54				4.1			
		Co59(n,α)Mn56(β^-)Fe56(n,2n)Fe55(n,d)Mn54				3.2	0.1		
		Co59(n,α)Mn56(β^-)Fe56(n,d)Mn55(n,2n)Mn54				2.9			
		Co59(n,d)Fe58(n,α)Cr55(β^-)Mn55(n,2n)Mn54				2.1	0.1		
		Co59(n,2nα)Mn54					19.7	88.1	65.6
		Co59(n,nt)Fe56(n,t)Mn54					0.2	4.5	13.5
		Co59(n,t)Fe57(n,nt)Mn54					0.1	1.0	6.8
Fe55	2.735 y	Co59(n,α)Mn56(β^-)Fe56(n,2n)Fe55				94.0	3.5	0.6	0.8
		Co59(n,3n)Co57(β^+)Fe57(n,3n)Fe55					35.3	25.1	2.4
		Co59(n,t)Fe57(n,3n)Fe55					21.4	33.4	4.0
		Co59(n,3n)Co57(n,t)Fe55					12.4	16.0	1.9
		&Co59(n,2n)*Co58*(β^+)Fe58(n,3n)Fe56_ (n,2n)Fe55					6.5	0.9	
		&Co59(n,2n)*Co58*(β^+)Fe58(n,2n)Fe57_ (n,3n)Fe55					3.1	0.5	
		Co59(n,nt)Fe56(n,2n)Fe55					1.5	10.1	9.2
		&Co59(n,2n)Co58(β^+)Fe58(n,4n)Fe55						3.6	4.4
		Co59(n,2nt)Fe55						0.7	71.1

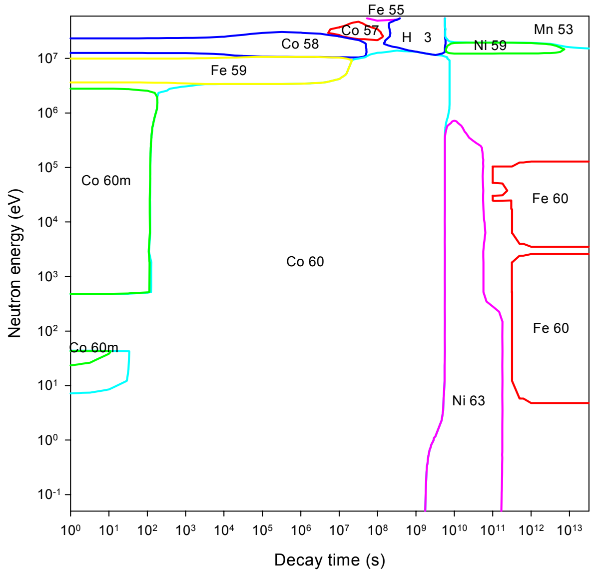
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Co60	5.271 y	**&**Co59(n,γ)*Co60*	100.0	100.0	100.0	99.4	99.8	99.8	99.9
H3	12.33 y	Co59(n,X)H3				95.7	92.5	92.7	93.5
		&Co59(n,2n)*Co58*(n,X)H3				3.5	0.9	0.3	
		Co59(n,3n)Co57(β^+)Fe57(n,X)H3					1.1	1.2	0.5
		Co59(n,t)Fe57(n,X)H3					0.7	1.6	0.9
		Co59(n,nt)Fe56(n,X)H3						0.4	1.5
Ni63	100.6 y	**&**Co59(n,γ)*Co60*(n,γ)Co61(β^-)Ni61(n,γ)_ Ni62(n,γ)Ni63	81.8	86.7	85.4	84.1	83.3	84.2	84.8
		&Co59(n,γ)*Co60*(β^-)Ni60(n,γ)Ni61(n,γ)_ Ni62(n,γ)Ni63	18.0	13.1	14.4	15.2	16.1	15.4	14.9
		Co59(n,γ)Co60m(β^-)Ni60(n,γ)Ni61(n,γ)_ Ni62(n,γ)Ni63	0.2	0.1	0.2	0.2	0.2	0.2	0.2
Ar39	269.0 y	Co59(n,nα)Mn55(n,nα)V51(n,nα)Sc47_ (β^-)Ti47(n,2n)Ti46(n,α)Ca43(n,nα)Ar39				1.9			
		Co59(n,nα)Mn55(n,nα)V51(n,nα)Sc47_ (β^-)Ti47(n,nα)Ca43(n,nα)Ar39				1.2	30.7		
		Co59(n,nα)Mn55(n,nα)V51(n,nα)Sc47_ (β^-)Ti47(n,α)Ca44(n,2n)Ca43(n,nα)Ar39				1.0			
		Co59(n,nα)Mn55(n,nα)V51(n,nα)Sc47_ (β^-)Ti47(n,2n)Ti46(n,2α)Ar39					3.1		
		Co59(n,nα)Mn55(n,nα)V51(n,2n)V50_ (n,nα)Sc46(β^-)Ti46(n,2α)Ar39					2.2		
		Co59(n,2nα)Mn54(β^+)Cr54(n,2nα)Ti49_ (n,2nα)Ca44(n,2nα)Ar39						8.0	
		&Co59(n,2nα)Mn54(n,2nα)V49(n,2nα)_ *Sc44*(β^+)Ca44(n,2nα)Ar39						7.3	
		Co59(n,2nα)Mn54(n,2nα)V49(β^+)Ti49_ (n,2nα)Ca44(n,2nα)Ar39						6.8	
		Co59(n,2nα)Mn54(n,2nα)V49(n,dα)_ Ca44(n,2nα)Ar39						3.3	
		Co59(n,3nα)Mn53(n,tα)Ti47(n,n2α)Ar39							7.1
		Co59(n,3nα)Mn53(n,n2α)Sc45(n,tα)Ar39							5.2
		Co59(n,3nα)Mn53(n,2nα)V48(β^+)Ti48_ (n,2n2α)Ar39							3.2
		Co59(n,3nα)Mn53(n,dα)Ti48(n,2n2α)Ar39							2.5
		&Co59(n,n2α)V51(n,3nα)*Sc45*(n,tα)Ar39							2.1
		Co59(n,tα)Cr53(n,3nα)Ti47(n,n2α)Ar39							2.0
		Other pathways				95.9	64.0	74.6	77.9
Ni59	7.6 10^4 y	**&**Co59(n,γ)*Co60*(β^-)Ni60(n,2n)Ni59				99.1	99.2	99.2	99.3
		Co59(n,γ)Co60m(β^-)Ni60(n,2n)Ni59				0.6	0.7	0.7	0.7
Fe60	1.5 10^6 y	**&**Co59(n,γ)*Co60*(n,γ)Co61(β^-)Ni61(n,α)_ Fe58(n,γ)Fe59(n,γ)Fe60	82.1	87.3					
		&Co59(n,γ)*Co60*(β^-)Ni60(n,γ)Ni61(n,α)_ Fe58(n,γ)Fe59(n,γ)Fe60	16.2	12.6					
		&Co59(n,γ)*Co60*(n,p)Fe60	1.4		100.0	93.5	88.6	89.0	89.5
		Co59(n,p)Fe59(n,γ)Fe60				6.1	11.0	10.7	10.5
Mn53	3.7 10^6 y	Co59(n,nα)Mn55(n,2n)Mn54(n,2n)Mn53				56.8	1.3	0.2	
		&Co59(n,2n)*Co58*(n,nα)Mn54(n,2n)Mn53				10.1	0.2		
		&Co59(n,2n)*Co58*(β^+)Fe58(n,α)Cr55(β^-)_ Mn55(n,2n)Mn54(n,2n)Mn53				7.8			
		&Co59(n,2n)*Co58*(n,α)Mn55(n,2n)Mn54_ (n,2n)Mn53				3.6			
		Co59(n,α)Mn56(β^-)Fe56(n,2n)Fe55_ (n,2n)Fe54(n,d)Mn53				2.7			
		Co59(n,nα)Mn55(n,3n)Mn53					66.1	31.7	0.6
		Co59(n,3n)Co57(n,nα)Mn53					24.0	12.4	
		&Co59(n,2n)*Co58*(n,2nα)Mn53					1.0	4.9	
		Co59(n,2nα)Mn54(n,2n)Mn53					0.8	18.4	
		Co59(n,3nα)Mn53						6.4	82.3
		Co59(n,nt)Fe56(n,nt)Mn53						2.7	9.9

Cobalt activation characteristics

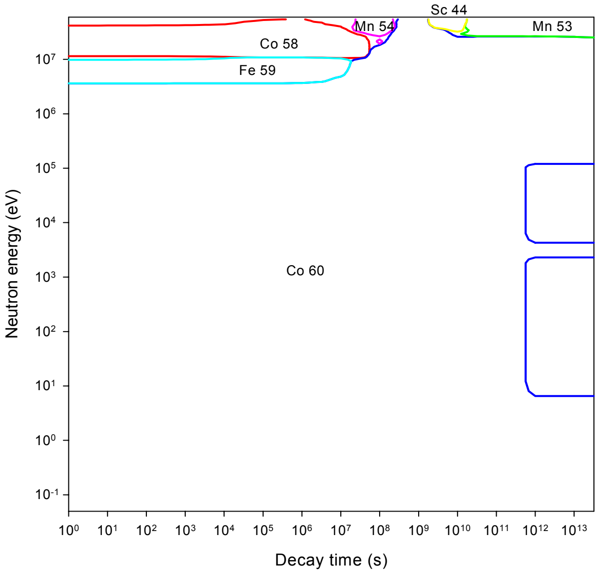


Cobalt importance diagrams & transmutation

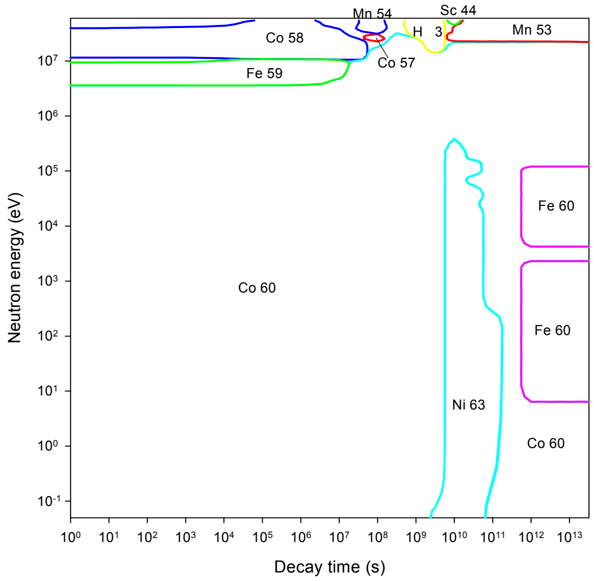
Activity



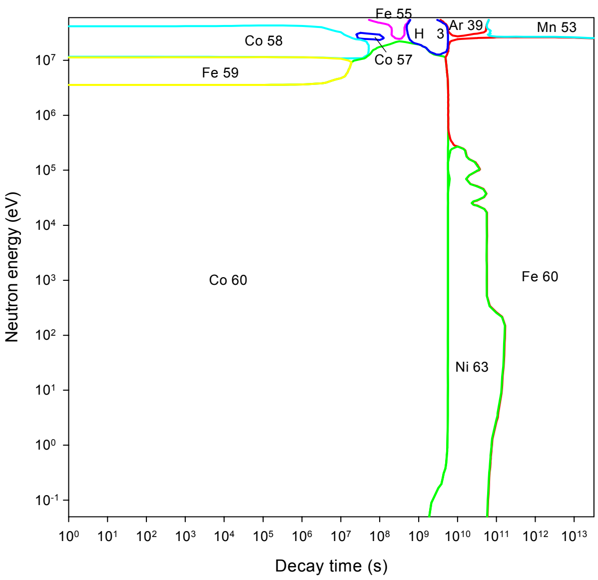
Dose rate



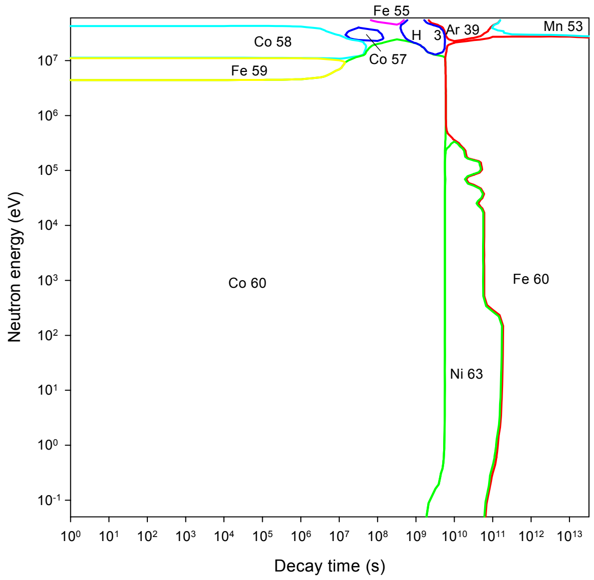
Heat output



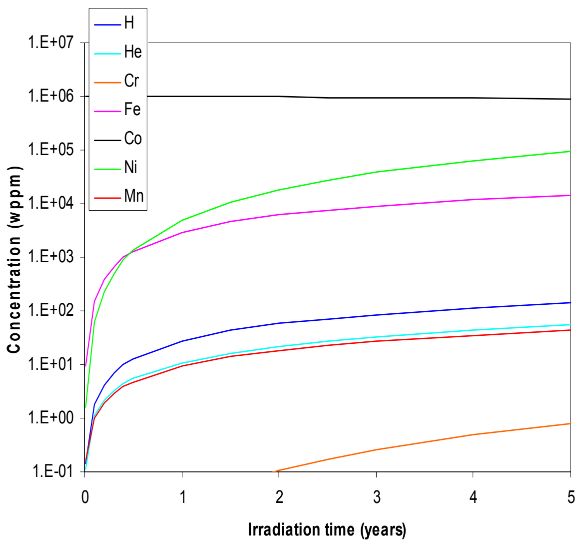
Ingestion dose



Inhalation dose



First wall transmutation



Nickel

General properties

Property	Value	Isotopes	Isotopic abundances / %
Atomic number	28	Ni58	68.077 ($T_{½}$ = 7.00 10^{20} y)
Crustal abundance / wppm	84	Ni60	26.223
Melting point / K	1728	Ni61	1.14
Boiling point / K	3186	Ni62	3.634
Density / kgm^{-3}	8902	Ni64	0.926
Thermal conductivity / $Wm^{-1}K^{-1}$	90.7		
Electrical resistivity /Ωm	6.84 10^{-8}		
Coefficient of thermal expansion / K^{-1}	1.34 10^{-5}		
Crystal structure	FCC		
Number of stable isotopes	4 (5)		
Mean atomic weight	58.69		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.43E15	1.41E15	1.07E15	3.43E14	7.53E11	4.49E9
Co57	41.25	41.83	54.86	67.94		
Co58	25.05	25.40	32.57	2.95		
Co58m	18.49	18.63	0.02			
Fe55	5.75	5.83	7.70	18.66		
Co60m	3.64	2.60				
Co60	2.67	2.71	3.58	9.81		
Ni57	1.68	1.70	0.41			
Ni63	0.10	0.10	0.13	0.42	98.50	
Ni59					1.48	99.99

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	1.02E-1	1.01E-1	8.89E-2	2.12E-2	2.11E-6	5.20E-9
Co58	56.80	57.47	63.32	7.73		
Co60	15.62	15.80	17.95	66.18	1.47	0.82
Co57	13.28	13.44	15.15	25.29		
Ni57	7.94	8.02	1.68			
Fe59	1.15	1.17	1.25	0.01		
Mn56	1.03	1.10				
Co58m	0.99	1.00				
Ni63				0.01	97.92	
Ni59					0.60	99.12

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	1.35E5	1.35E5	1.19E5	2.80E4	5.54E-2	1.42E-3
Co58	63.11	63.47	69.37	8.59		
Co60	19.75	19.87	22.39	83.72	93.96	5.09
Ni57	9.26	9.30	1.93			
Co57	3.70	3.72	4.16	7.04		
Fe59	1.37	1.37	1.46	0.02		
Mn56	0.93	0.91				
Co62m	0.51	0.40				
Co56	0.37	0.37	0.41	0.06		
Mn54	0.23	0.23	0.26	0.49		
Ni59					6.03	94.90

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	5.94E5	5.89E5	5.54E5	1.93E5	1.12E2	2.95E-1
Co58	44.69	45.09	46.48	3.88		
Co60	21.94	22.13	23.53	59.36	0.22	0.11
Co57	20.88	21.07	22.22	25.39		
Fe55	4.57	4.61	4.90	10.96		
Ni57	3.54	3.56	0.69			
Fe59	1.71	1.72	1.73	0.01		
Co58m	1.07	1.07				
Ni63	0.03	0.03	0.04	0.11	99.14	
Ni59					0.62	96.00
Fe60					0.01	3.87

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	2.65E6	2.65E6	2.60E6	1.35E6	9.72E2	2.01E0
Co60	44.87	44.94	45.71	77.28	0.23	0.15
Co58	28.45	28.49	28.11	1.57		
Co57	22.30	22.34	22.55	17.26		
Fe55	2.39	2.39	2.43	3.65		
Fe59	0.85	0.85	0.82			
Ni63	0.07	0.07	0.07	0.14	99.25	
Ni59					0.50	98.39
Fe60						1.44

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	1.41E12	1.41E12	1.35E12	5.86E11	8.28E6	4.59E4
Co57	41.93	42.00	43.38	39.73		
Co60	27.21	27.26	28.37	57.37	9.02	2.25
Co58	25.46	25.51	25.75	1.72		
Ni57	3.36	3.36	0.64			
Mn54	0.01	1.01	1.09	1.12		
Mn56	0.01	0.01				
Ni63					89.62	
Ni59					1.34	97.74

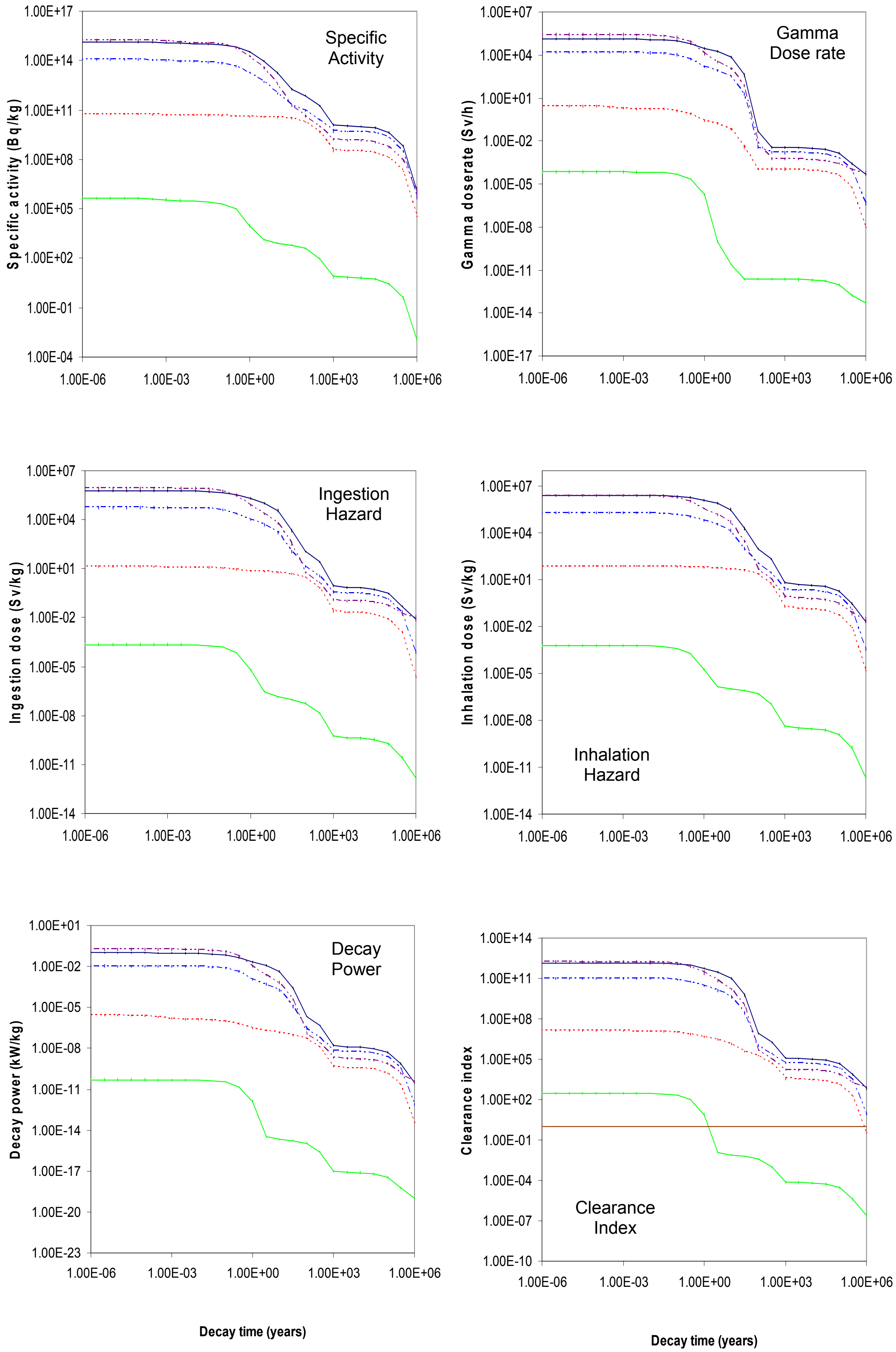
Nickel

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ni65	2.52 h	Ni62(n,γ)Ni63(n,γ)Ni64(n,γ)Ni65	49.4	0.6					
		Ni64(n,γ)Ni65	48.9	99.4	100.0	99.5	99.4	99.6	99.8
		Ni61(n,γ)Ni62(n,γ)Ni63(n,γ)Ni64(n,γ)Ni65	0.8						
Cu64	12.701 h	Ni62(n,γ)Ni63(β$^-$)Cu63(n,γ)Cu64	96.9	99.9	99.9				
		Ni61(n,γ)Ni62(n,γ)Ni63(β$^-$)Cu63(n,γ)Cu64	1.5						
		Ni64(n,γ)Ni65(β$^-$)Cu65(n,2n)Cu64				93.3	94.4	93.5	90.9
		Ni64(n,2n)Ni63(β$^-$)Cu63(n,γ)Cu64				6.1	4.8	5.2	6.9
		Ni64(n,d)Co63(β$^-$)Ni63(β$^-$)Cu63(n,γ)Cu64					0.4	1.1	2.1
Co58	70.86 d	&Ni58(n,p)*Co58*	99.8	100.0	100.0	93.2	45.9	17.3	14.7
		&Ni60(n,2n)Ni59(n,d)*Co58*				3.8	12.5	2.0	1.4
		&Ni60(n,d)Co59(n,2n)*Co58*				2.5	11.3	1.6	0.8
		&Ni60(n,t)*Co58*					28.2	77.1	76.4
		&Ni61(n,nt)*Co58*						0.2	2.9
Co56	77.31 d	Ni58(n,d)Co57(n,2n)Co56				93.7	9.7	0.7	
		Ni58(n,2n)Ni57(β$^+$)Co57(n,2n)Co56				5.4	1.3	0.1	
		Ni58(n,t)Co56				0.5	87.4	97.2	95.6
		Ni58(n,3n)Ni56(β$^+$)Co56					1.0	1.3	1.9
Co57	271.78 d	Ni58(n,d)Co57				94.3	86.7	83.2	68.1
		Ni58(n,2n)Ni57(β$^+$)Co57				5.4	11.8	13.4	9.0
		Ni60(n,2n)Ni59(n,t)Co57					0.6	1.0	0.5
		Ni60(n,nt)Co57						1.2	21.1
Fe55	2.735 y	Ni58(n,α)Fe55	100.0	100.0	100.0	97.5	34.3	33.6	78.9
		Ni60(n,nα)Fe56(n,2n)Fe55				0.3	4.5	0.8	
		Ni58(n,d)Co57(β$^+$)Fe57(n,3n)Fe55					19.3	9.4	0.8
		Ni58(n,h)Fe56(n,2n)Fe55					16.2	10.4	1.0
		Ni58(n,d)Co57(n,t)Fe55					6.7	5.9	0.7
		Ni58(n,t)Co56(β$^+$)Fe56(n,2n)Fe55					3.8	7.4	0.9
		Ni60(n,2nα)Fe55					0.3	21.6	4.4
		Ni58(n,nt)Co55(β$^+$)Fe55						2.7	10.8
Co60	5.271 y	&Ni58(n,γ)Ni59(n,p)Co59(n,γ)*Co60*	100.0	99.9	97.8				
		&Ni58(n,γ)Ni59(β$^+$)Co59(n,γ)*Co60*			2.2				
		&Ni60(n,p)*Co60*				98.4	75.3	45.1	33.6
		&Ni62(n,2n)Ni61(n,d)*Co60*				1.2	1.7	0.7	
		&Ni61(n,d)*Co60*				0.9	16.2	9.9	12.5
		&Ni62(n,t)*Co60*					4.6	42.9	49.1
		&Ni64(n,2nt)*Co60*							2.9
H3	12.33 y	Ni58(n,γ)Ni59(n,X)H1(n,γ)H2(n,γ)H3	94.1	96.0	99.6				
		Ni58(n,X)H3				25.6	44.6	56.1	59.5
		Ni60(n,X)H3				12.2	29.5	25.9	25.5
		&Ni60(n,p)*Co60*(n,X)H3				11.5	0.1		
		Ni58(n,d)Co57(β$^+$)Fe57(n,X)H3				10.1	4.3	1.7	1.0
		&Ni58(n,p)*Co58*(n,X)H3				8.4			
		Ni58(n,d)Co57(n,X)H3				8.0	2.4	0.9	0.5
		Ni61(n,X)H3				5.7	2.4	1.6	1.4
		Ni60(n,2n)Ni59(n,X)H3				5.3	2.0	0.7	
		Ni60(n,d)Co59(n,X)H3				3.3	1.3	0.2	
		Ni58(n,α)Fe55(β$^+$)Mn55(n,X)H3				2.7			
		Ni62(n,X)H3					3.4	3.4	3.6
		Ni58(n,nα)Fe54(n,X)H3					2.0	0.9	
Ni63	100.6 y	Ni62(n,γ)Ni63	93.6	99.9	99.9	0.3	0.2	0.2	
		Ni60(n,γ)Ni61(n,γ)Ni62(n,γ)Ni63	3.5						
		Ni61(n,γ)Ni62(n,γ)Ni63	2.6						
		Ni64(n,2n)Ni63				99.4	90.9	82.0	76.9
		Ni64(n,d)Co63(β$^-$)Ni63					8.5	17.5	22.9
Ar39	269.0 y ►	Ni58(n,nα)Fe54(n,nα)Cr50(n,α)Ti47_ (n,2n)Ti46(n,α)Ca43(n,nα)Ar39				9.1			

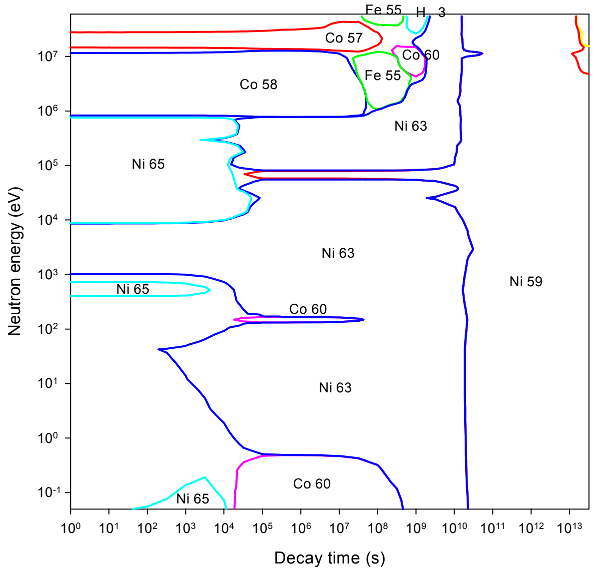
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Ni58(n,nα)Fe54(n,nα)Cr50(n,α)Ti47_ (n,nα)Ca43(n,nα)Ar39				5.6	1.3		
		Ni58(n,nα)Fe54(n,nα)Cr50(n,α)Ti47_ (n,α)Ca44(n,2n)Ca43(n,nα)Ar39				4.8			
		Ni58(n,nα)Fe54(n,α)Cr51(n,α)Ti48(n,α)_ Ca45(β$^-$)Sc45(n,α)K42(β$^-$)Ca42(n,α)Ar39				4.5			
		Ni58(n,nα)Fe54(n,nα)Cr50(n,nα)Ti46_ (n,α)Ca43(n,nα)Ar39				4.2	2.3		
		Ni58(n,nα)Fe54(n,α)Cr51(β$^+$)V51(n,nα)_ Sc47(β$^-$)Ti47(n,2n)Ti46(n,α)Ca43(n,nα)Ar39				4.0			
		Ni58(n,nα)Fe54(n,nα)Cr50(n,α)Ti47_ (n,2n)Ti46(n,nα)Ca42(n,α)Ar39				3.1			
		Ni58(n,nα)Fe54(n,α)Cr51(β$^+$)V51(n,nα)_ Sc47(β$^-$)Ti47(n,nα)Ca43(n,nα)Ar39				2.5			
		Ni58(n,nα)Fe54(n,nα)Cr50(n,nα)Ti46(n,2α)Ar39					59.0	1.7	
		Ni58(n,nα)Fe54(n,nα)Cr50(n,2α)Ca43_ (n,nα)Ar39					11.7	1.0	
		Ni58(n,nα)Fe54(n,nα)Cr50(n,pα)Sc46_ (β$^-$)Ti46(n,2α)Ar39					3.1	0.2	
		Ni58(n,nα)Fe54(n,2α)Ti47(n,nα)Ca43_ (n,nα)Ar39					2.8	0.3	
		&Ni58(n,nα)Fe54(n,dα)V49(n,2nα)*Sc44*_ (β$^+$)Ca44(n,2nα)Ar39						6.4	
		Ni58(n,nα)Fe54(n,dα)V49(β$^+$)Ti49_ (n,2nα)Ca44(n,2nα)Ar39						5.4	
		Ni58(n,nα)Fe54(n,2α)Ti47(n,n2α)Ar39						3.6	
		Ni58(n,nα)Fe54(n,dα)V49(n,dα)Ca44_ (n,2nα)Ar39						2.9	
		Ni58(n,dα)Mn53(n,tα)Ti47(n,n2α)Ar39							4.2
		Ni58(n,dα)Mn53(n,n2α)Sc45(n,tα)Ar39							3.1
		Ni58(n,n2α)Cr50(n,3α)Ar39							3.0
		Ni58(n,n2α)Cr50(n,dα)Sc45(n,tα)Ar39							2.7
		Ni58(n,nα)Fe54(n,tα)V48(β$^+$)Ti48(n,2n2α)Ar39							2.4
		Other pathways				71.3	19.8	78.5	84.6
Ni59	7.6 10^4 y	Ni58(n,γ)Ni59	100.0	100.0	100.0	0.3	0.3	0.3	
		Ni60(n,2n)Ni59				99.1	97.2	94.3	88.7
		Ni61(n,3n)Ni59					1.6	3.8	2.8
		Ni62(n,4n)Ni59						0.7	7.6
Fe60	1.5 10^6 y	Ni58(n,γ)Ni59(n,α)Fe56(n,γ)Fe57(n,γ)_ Fe58(n,γ)Fe59(n,γ)Fe60	99.7	38.8					
		Ni61(n,α)Fe58(n,γ)Fe59(n,γ)Fe60	0.1	58.8	98.5				
		Ni60(n,γ)Ni61(n,α)Fe58(n,γ)Fe59(n,γ)Fe60	0.1	2.1	1.2				
		&Ni60(n,p)*Co60*(n,p)Fe60				87.9	2.3	1.2	
		Ni64(n,2n)Ni63(n,α)Fe60				7.6	0.3		
		Ni64(n,nα)Fe60				3.1	93.4	84.5	67.0
		Ni62(n,h)Fe60					1.4	11.2	29.6
Mn53	3.7 10^6 y	Ni58(n,nα)Fe54(n,d)Mn53				71.7	52.4	4.8	1.3
		Ni58(n,d)Co57(n,nα)Mn53				9.7	7.7	0.7	
		&Ni58(n,nα)Fe54(n,2n)*Fe53*(β$^+$)Mn53				3.4	23.7	2.5	0.5
		Ni58(n,α)Fe55(n,2n)Fe54(n,d)Mn53				3.4			
		Ni58(n,α)Fe55(β$^+$)Mn55(n,2n)Mn54(n,2n)Mn53				3.0			
		Ni58(n,d)Co57(n,α)Mn54(n,2n)Mn53				2.5			
		Ni58(n,nα)Fe54(n,p)Mn54(n,2n)Mn53				1.6	0.1		
		Ni58(n,pα)Mn54(n,2n)Mn53				0.8	7.6	0.8	
		Ni58(n,2n)Ni57(β$^+$)Co57(n,nα)Mn53				0.6	1.1	0.1	
		Ni58(n,dα)Mn53					3.2	79.4	68.7
		Ni58(n,α)Fe55(n,t)Mn53					0.8	0.8	4.4
		&Ni58(n,2nα)*Fe53*(β$^+$)Mn53						6.9	9.4
		Ni58(n,h)Fe56(n,nt)Mn53						0.4	4.0
		Ni58(n,t)Co56(β$^+$)Fe56(n,nt)Mn53						0.3	3.6

Nickel activation characteristics

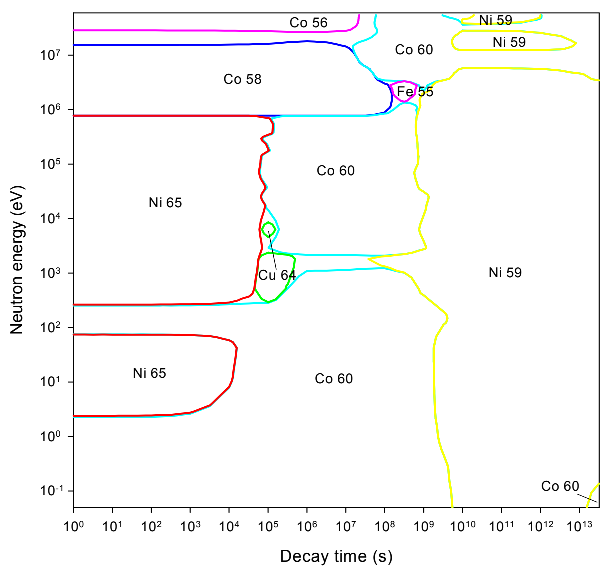


Nickel importance diagrams & transmutation

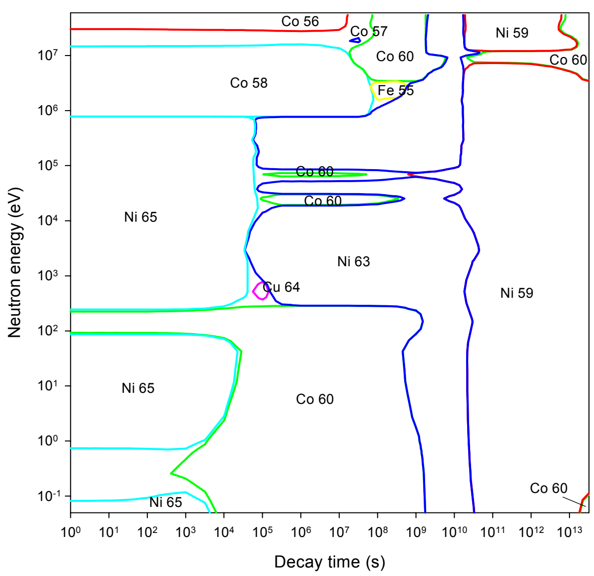
Activity



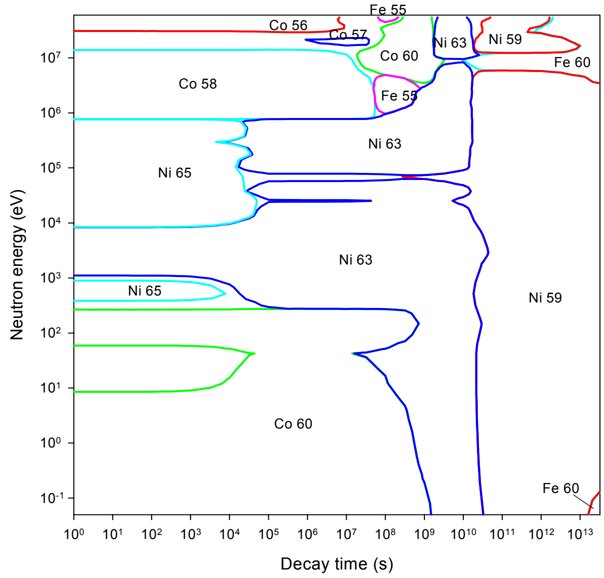
Dose rate



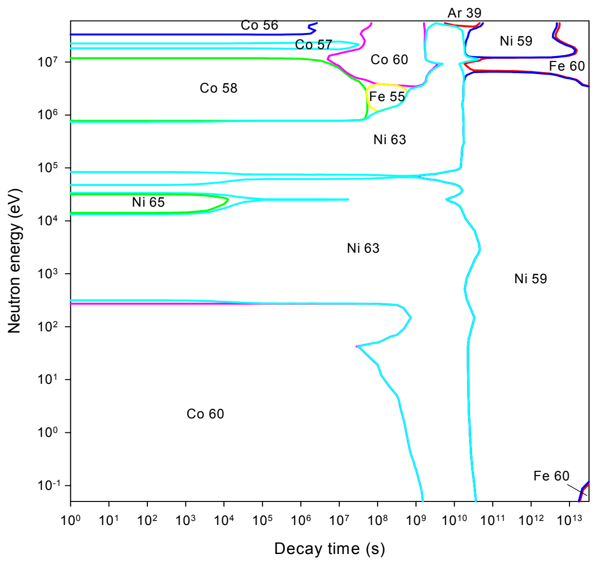
Heat output



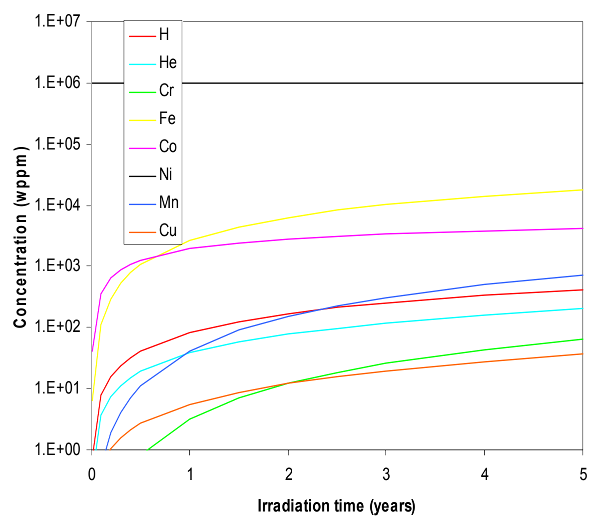
Ingestion dose



Inhalation dose



First wall transmutation



Copper

General properties

		Isotopes	Isotopic abundances / %
Atomic number	29		
Crustal abundance / wppm	60	Cu63	69.17
Melting point / K	1357.8	Cu65	30.83
Boiling point / K	2925		
Density / kgm^{-3}	8960		
Thermal conductivity / $Wm^{-1}K^{-1}$	401		
Electrical resistivity /Ωm	$1.673\ 10^{-8}$		
Coefficient of thermal expansion / K^{-1}	$1.65\ 10^{-5}$		
Crystal structure	FCC		
Number of stable isotopes	2		
Mean atomic weight	63.546		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Bq kg^{-1}	2.18E15	1.93E15	4.68E13	2.69E13	1.73E12	8.93E5
Cu64	68.16	76.69	26.60			
Cu62	18.91	14.71				
Cu66	9.66	5.34				
Co60	1.09	1.23	50.94	77.94		9.95
Co60m	0.67	0.54				9.98
Ni65	0.56	0.62				
Zn65	0.29	0.33	13.54	8.45		
Ni63	0.15	0.17	7.36	12.74	99.95	
Ni59						70.08
Fe60						9.98

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
kW kg^{-1}	2.83E-1	2.14E-1	1.13E-2	8.94E-3	4.85E-6	3.99E-11
Cu62	53.56	48.86				
Cu64	26.58	35.07	5.59			
Cu66	13.75	8.92				
Co60	3.50	4.65	88.15	97.49	0.39	92.83
Ni65	0.82	1.06				
Zn65	0.21	0.28	5.30	2.39		
Co60m	0.05	0.04				2.23
Ni63			0.08	0.10	99.58	
Fe60						3.13
Ni59						1.80

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv h^{-1}	1.73E5	1.42E5	1.90E4	1.56E4	3.39E-2	6.50E-5
Cu62	49.14	41.00				
Cu64	33.75	40.95	2.56			
Co60	10.04	12.23	91.19	97.63	100.0	99.95
Cu66	2.69	1.60				
Co62m	1.47	1.38				
Ni65	1.16	1.38				
Zn65	0.60	0.73	5.41	2.37		
Fe59	0.08	0.09	0.69			

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv kg^{-1}	3.32E5	3.08E5	1.09E5	8.05E4	2.60E2	1.01E-2
Cu64	53.82	57.69	1.37			
Co60	24.54	26.34	74.66	88.35	0.06	2.97
Cu62	7.59	5.62				
Zn65	7.52	8.10	22.77	10.99		
Cu66	1.01	0.53				
Ni65	0.67	0.70				
Ni63	0.15	0.16	0.47	0.63	99.92	
Fe60						96.63

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv kg^{-1}	9.70E5	9.52E5	7.61E5	6.58E5	2.25E3	2.80E-2
Co60	76.27	77.69	97.14	98.55	0.06	9.84
Cu64	18.41	18.66	0.19			
Cu62	1.61	1.13				
Zn65	1.45	1.47	1.83	0.75		
Ni63	0.46	0.47	0.58	0.67	99.92	
Fe59	0.16	0.17	0.20			
Fe60						89.17
Ni59						0.98

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
	8.36E11	6.64E11	3.02E11	2.32E11	1.78E7	8.97E2
Cu62	56.14	48.61				
Co60	28.55	35.94	78.83	90.20	2.61	99.20
Zn65	7.66	9.64	20.96	9.78		
Cu66	4.76	2.93				
Cu64	1.78	2.23	0.04			
Ni65	0.14	0.18				
Co62m	0.03	0.03				
Ni63			0.01	0.01	97.33	

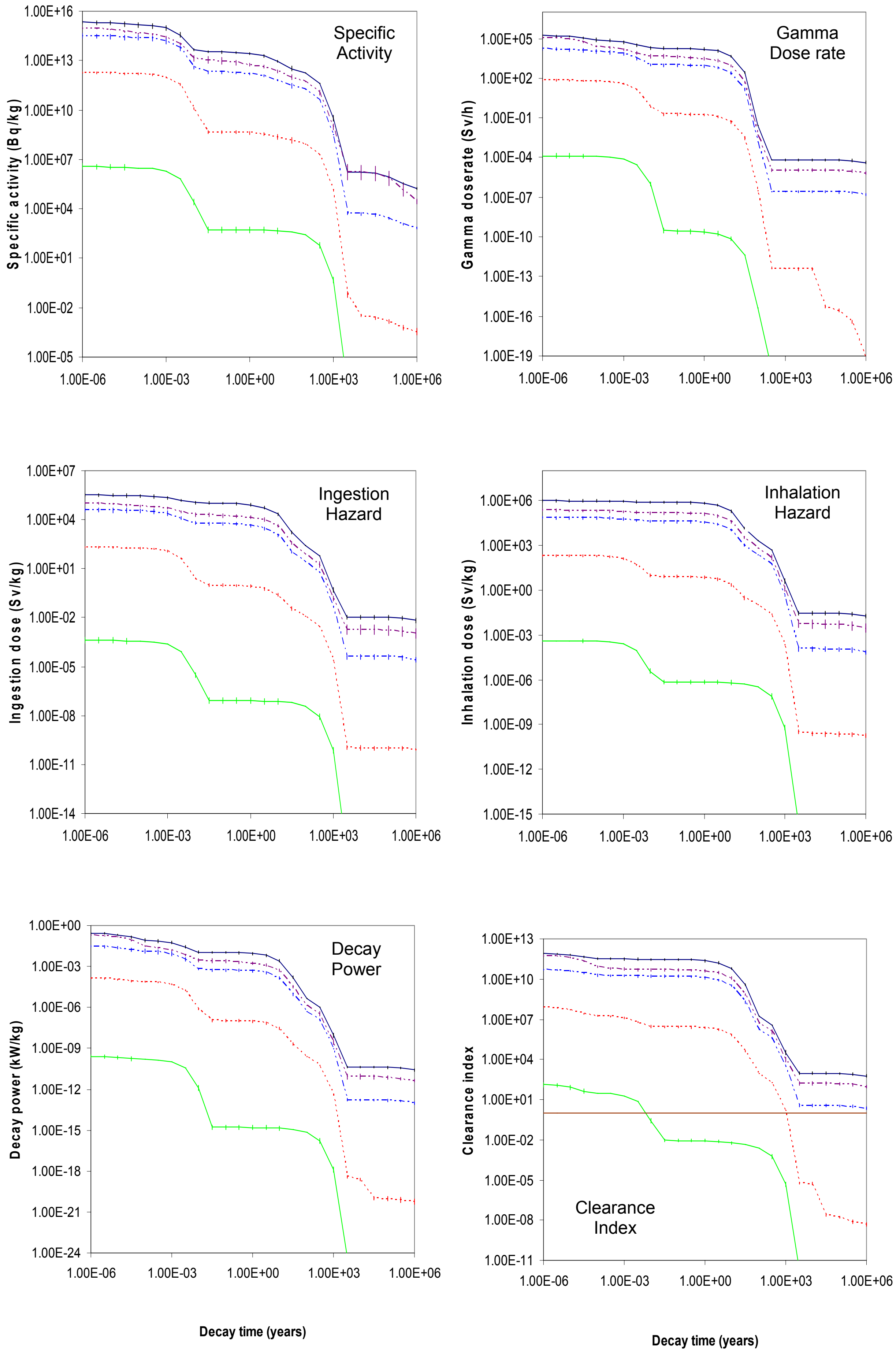
Copper

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Cu66	5.1 m	Cu65(n,γ)Cu66	98.4	100.0	100.0	98.5	99.2	99.4	99.7
		Cu63(n,γ)Cu64(β^+)Ni64(n,γ)Ni65(β^-)_ Cu65(n,γ)Cu66	1.2						
		Cu63(n,γ)Cu64(n,γ)Cu65(n,γ)Cu66	0.3						
		Cu63(n,γ)Cu64(β^-)Zn64(n,γ)Zn65(β^+)_ Cu65(n,γ)Cu66	0.1						
Cu62	9.75 m	Cu63(n,2n)Cu62				99.8	97.0	92.7	79.2
		Cu65(n,3n)Cu63(n,2n)Cu62					2.4	2.4	
		Cu65(n,2n)Cu64(β^-)Zn64(n,t)Cu62					0.4	0.9	
		Cu65(n,4n)Cu62						3.9	19.4
Cu64	12.701 h	Cu63(n,γ)Cu64	100.0	100.0	100.0	0.6	0.4	0.5	
		Cu65(n,2n)Cu64				98.1	99.0	99.1	99.3
Co58	70.86 d	&Cu63(n,nα)Co59(n,2n)Co58				81.2	55.3	2.3	1.5
		&Cu63(n,α)*Co60*(n,2n)Co59(n,2n)*Co58*				11.5			
		&Cu63(n,2nα)*Co58*					28.6	82.1	55.7
		&Cu63(n,t)Ni61(n,nt)*Co58*					0.2	1.9	10.5
		&Cu63(n,nt)Ni60(n,t)*Co58*					0.1	5.2	13.3
		&Cu63(n,3n)Cu61(β^+)Ni61(n,nt)*Co58*						0.7	3.0
		&Cu65(n,4nα)*Co58*							2.4
Zn65	244.15 d	Cu63(n,γ)Cu64(β^-)Zn64(n,γ)Zn65	100.0	100.0	100.0	0.3			
		Cu65(n,γ)Cu66(β^-)Zn66(n,2n)Zn65				51.9	84.7	84.7	85.0
		Cu65(n,2n)Cu64(β^-)Zn64(n,γ)Zn65				47.7	15.1	15.2	14.9
Co60	5.271 y	&Cu63(n,γ)Cu64(β^-)Zn64(n,α)Ni61(n,α)_ Fe58(n,γ)Fe59(β^-)Co59(n,γ)*Co60*	97.7	97.0	100.0				
		&Cu63(n,γ)Cu64(n,α)Co61(β^-)Ni61(n,α)_ Fe58(n,γ)Fe59(β^-)Co59(n,γ)*Co60*	2.2	3.0					
		&Cu63(n,α)*Co60*				99.4	46.6	17.0	69.2
		&Cu63(n,t)Ni61(n,d)*Co60*					27.8	11.6	3.4
		&Cu63(n,3n)Cu61(β^+)Ni61(n,d)*Co60*					6.6	3.9	0.6
		&Cu65(n,2nα)*Co60*					5.6	45.1	15.0
		&Cu63(n,2n)Cu62(β^+)Ni62(n,t)*Co60*					4.2	11.8	3.7
		&Cu65(n,nα)Co61(β^-)Ni61(n,d)*Co60*					2.0	0.3	
		&Cu63(n,d)Ni62(n,t)*Co60*					1.8	5.4	1.7
		&Cu63(n,2n)Cu62(β^+)Ni62(n,2n)Ni61_ (n,d)*Co60*					1.5		
		&Cu65(n,nt)Ni62(n,t)*Co60*						1.4	1.6
Ni63	100.6 y	Cu63(n,γ)Cu64(β^-)Zn64(n,γ)Zn65(n,α)_ Ni62(n,γ)Ni63	98.5	0.8					
		Cu63(n,p)Ni63	1.4	99.2	99.9	70.9	46.0	22.8	16.3
		Cu65(n,2n)Cu64(β^+)Ni64(n,2n)Ni63				26.5	9.7	2.0	1.2
		Cu65(n,d)Ni64(n,2n)Ni63				1.6	3.4	1.2	0.8
		Cu65(n,t)Ni63				0.2	38.3	71.9	79.3
		Cu65(n,h)Co63(β^-)Ni63					0.2	0.8	1.4
Ni59	7.6 10^4 y	&Cu63(n,α)*Co60*(β^-)Ni60(n,2n)Ni59				79.3	0.7	0.1	
		Cu63(n,2n)Cu62(β^+)Ni62(n,2n)Ni61_ (n,2n)Ni60(n,2n)Ni59				8.1	0.2		
		Cu65(n,2n)Cu64(β^-)Zn64(n,nα)Ni60_ (n,2n)Ni59				6.5	0.4		
		Cu63(n,d)Ni62(n,2n)Ni61(n,2n)Ni60_ (n,2n)Ni59				4.4			
		Cu63(n,t)Ni61(n,2n)Ni60(n,2n)Ni59				0.6	4.0	0.9	
		Cu63(n,t)Ni61(n,3n)Ni59					59.2	54.5	4.9
		Cu63(n,3n)Cu61(β^+)Ni61(n,3n)Ni59					14.1	18.0	1.4
		Cu65(n,nα)Co61(β^-)Ni61(n,3n)Ni59					4.2	1.5	
	►	Cu63(n,2n)Cu62(β^+)Ni62(n,3n)Ni60_ (n,2n)Ni59					4.2	0.9	

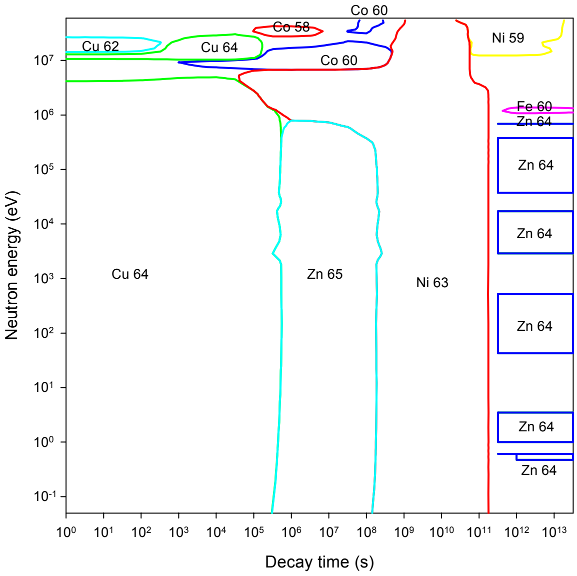
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	Cu63(n,2n)Cu62(β^+)Ni62(n,2n)Ni61(n,3n)Ni59					3.0	0.6	
		Cu63(n,nt)Ni60(n,2n)Ni59					1.4	11.2	7.3
		Cu63(n,2n)Cu62(β^+)Ni62(n,4n)Ni59						2.3	3.7
		Cu63(n,2nt)Ni59						1.2	75.2
Fe60	1.5 10^6 y	Cu63(n,γ)Cu64(β^-)Zn64(n,α)Ni61(n,α)_ Fe58(n,γ)Fe59(n,γ)Fe60	98.1	97.0	100.0				
		Cu63(n,γ)Cu64(n,α)Co61(β^-)Ni61(n,α)_ Fe58(n,γ)Fe59(n,γ)Fe60	1.9	3.0					
		Cu65(n,2n)Cu64(β^+)Ni64(n,2n)Ni63(n,α)Fe60				62.7	1.0	0.8	2.9
		&Cu63(n,α)*Co60*(n,p)Fe60				57.7			
		Cu63(n,p)Ni63(n,α)Fe60				25.8	1.0	0.5	0.6
		Cu65(n,2n)Cu64(β^+)Ni64(n,2n)Ni63(n,α)Fe60				6.4	0.1		
		Cu65(n,2n)Cu64(β^+)Ni64(n,nα)Fe60				3.9	68.8	44.8	13.8
		Cu65(n,d)Ni64(n,nα)Fe60				0.2	24.0	25.3	9.5
		Cu63(n,2n)Cu62(β^+)Ni62(n,h)Fe60					0.8	5.0	5.5
		Cu65(n,t)Ni63(n,α)Fe60					0.8	1.7	2.8
		Cu65(n,dα)Fe60						12.4	40.4
		Cu63(n,ph)Fe60						0.2	15.4
Zn64	2.3 10^{18} y	Cu63(n,γ)Cu64(β^-)Zn64	100.0	100.0	100.0	0.6	0.4	0.5	
		Cu65(n,2n)Cu64(β^-)Zn64				99.2	99.4	99.4	99.5

Copper activation characteristics

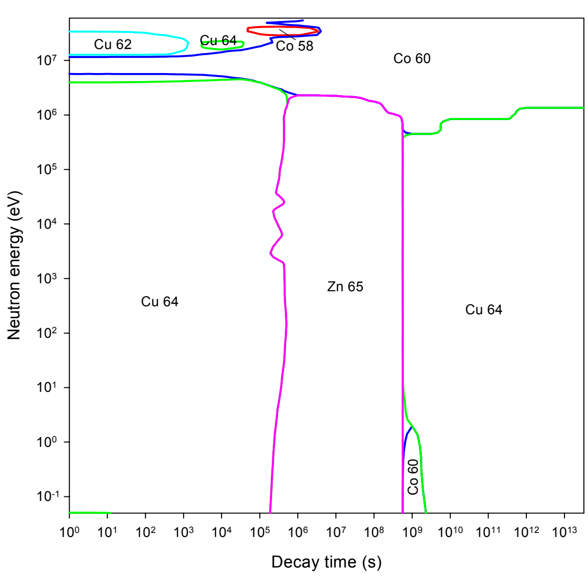


Copper importance diagrams & transmutation

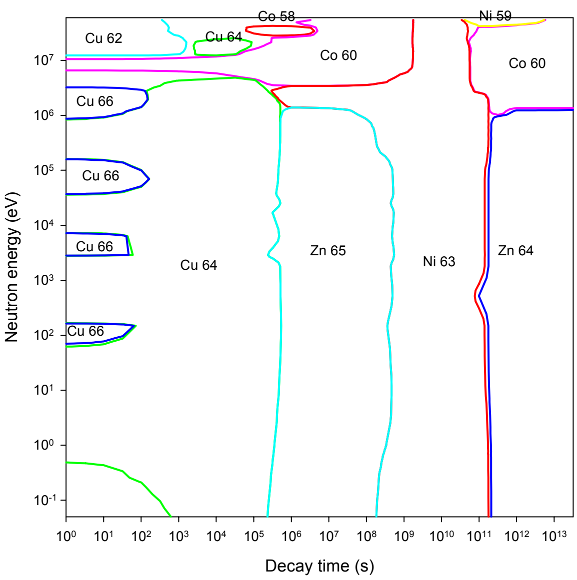
Activity



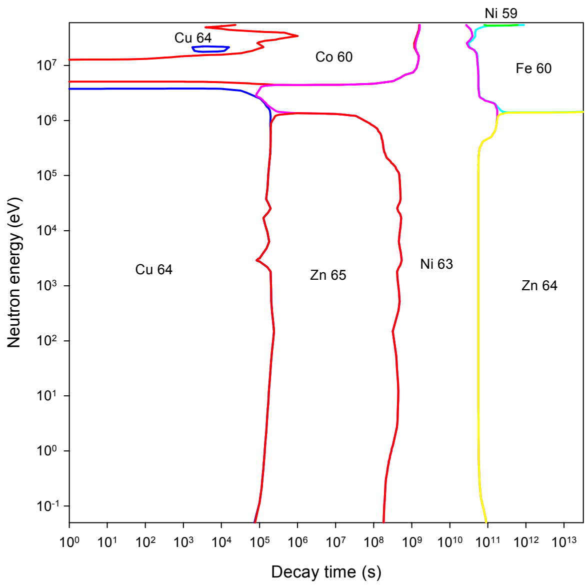
Dose rate



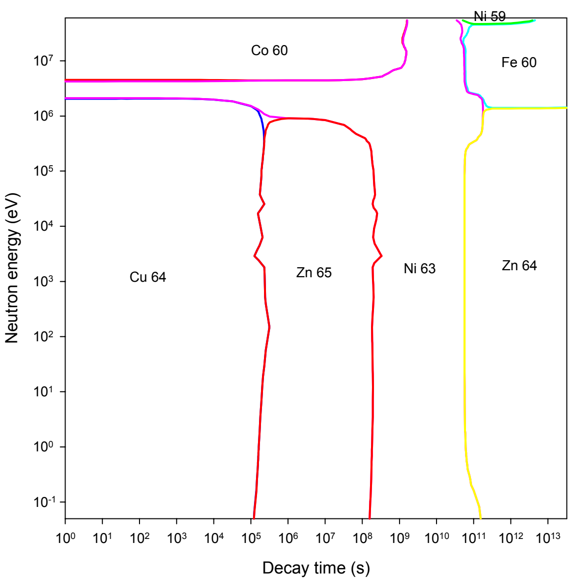
Heat output



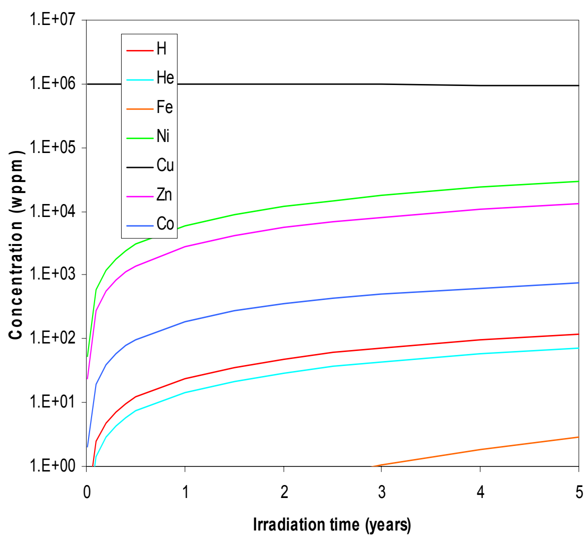
Ingestion dose



Inhalation dose



First wall transmutation



Zinc

General properties

		Isotopes	Isotopic abundances / %
Atomic number	30		
Crustal abundance / wppm	70	Zn64	48.63 ($T_{½}$ = 2.30 10^{18} y)
Melting point / K	692.7	Zn66	27.90
Boiling point / K	1180	Zn67	4.10
Density / kgm^{-3}	7133	Zn68	18.75
Thermal conductivity / $Wm^{-1}K^{-1}$	116	Zn70	0.62
Electrical resistivity /Ωm	5.916 10^{-8}		
Coefficient of thermal expansion / K^{-1}	3.02 10^{-5}		
Crystal structure	HCP		
Number of stable isotopes	4 (5)		
Mean atomic weight	65.39		

Activation properties

Act	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Bq kg^{-1}	1.01E15	9.65E14	4.33E14	1.54E14	2.78E11	3.01E6
Zn65	42.69	44.84	99.00	99.52		
Zn69	22.54	22.34	0.06			
Cu64	17.25	18.04	0.33			
Zn63	7.17	6.85				
Cu66	3.61	1.85				
Ga70	2.25	1.99				
Zn69m	2.24	2.34	0.06			
Ga68	0.41	0.41				
Cu62	0.41	0.29				
Cu67	0.35	0.37	0.31			
Ni65	0.35					
Ni63	0.05	0.03	0.12	0.35	99.97	
Co60	0.01	0.02	0.04	0.11		0.19
Ni59						99.49

Heat	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
kW kg^{-1}	1.01E-1	9.26E-2	4.07E-2	1.46E-2	7.75E-7	5.98E-12
Zn65	40.30	44.09	99.37	99.50		
Zn63	23.24	23.12				
Zn69	11.67	12.05	0.03			
Cu64	8.73	9.51	0.18			
Cu66	6.68	3.57				
Ga70	2.35	2.16				
Zn69m	1.57	1.17	0.04			
Cu68	1.32	0.21				
Cu62	1.15	1.14				
Ga68	1.13	1.17				
Co60	0.07	0.08		0.48	0.02	40.17
Ni63				0.01	99.97	
Ni59						57.50
Fe60						1.35

Dose	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv h^{-1}	1.00E5	9.68E4	6.94E4	2.49E4	2.79E-4	4.94E-6
Zn65	69.73	72.20	99.65	99.51		
Zn63	16.77	15.79				
Cu64	6.77	6.98	0.08			
Zn69m	1.90	1.96	0.03			
Cu68	0.98	0.15				
Co60	0.13	0.14	0.20	0.49	99.32	84.49
Ni59					0.67	15.36

Ing	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	1.74E6	1.73E6	1.67E6	5.99E5	4.16E1	8.45E-4
Zn65	97.15	97.39	99.91	99.89		
Cu64	1.20	1.20	0.01			
Zn69m	0.43	0.43				
Co60	0.03	0.03	0.03	0.09		2.32
Ni63				0.01	99.99	
Fe60						75.29
Ni59						22.34

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	1.00E6	9.99E5	9.50E5	3.44E5	3.61E2	3.12E-3
Zn65	95.07	95.37	99.17	98.26		
Cu64	2.09	2.09	0.01			
Zn69	0.63	0.60				
Zn69m	0.61	0.61				
Co60	0.59	0.60	0.63	1.53		5.73
Ni63	0.07		0.07	0.20		
Ni59					99.99	42.29
Fe60						51.95

Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
	4.45E12	4.43E12	4.29E12	1.54E12	2.78E6	8.77E1
Zn65	97.63	97.76	99.95	99.89		
Zn63	1.94	1.77				
Zn69m	0.05	0.05				
Co60	0.04	0.04	0.04	0.11	0.13	65.77
Cu64	0.03	0.03				
Zn69	0.01	0.01				
Ni63					99.83	
Ni59						34.16

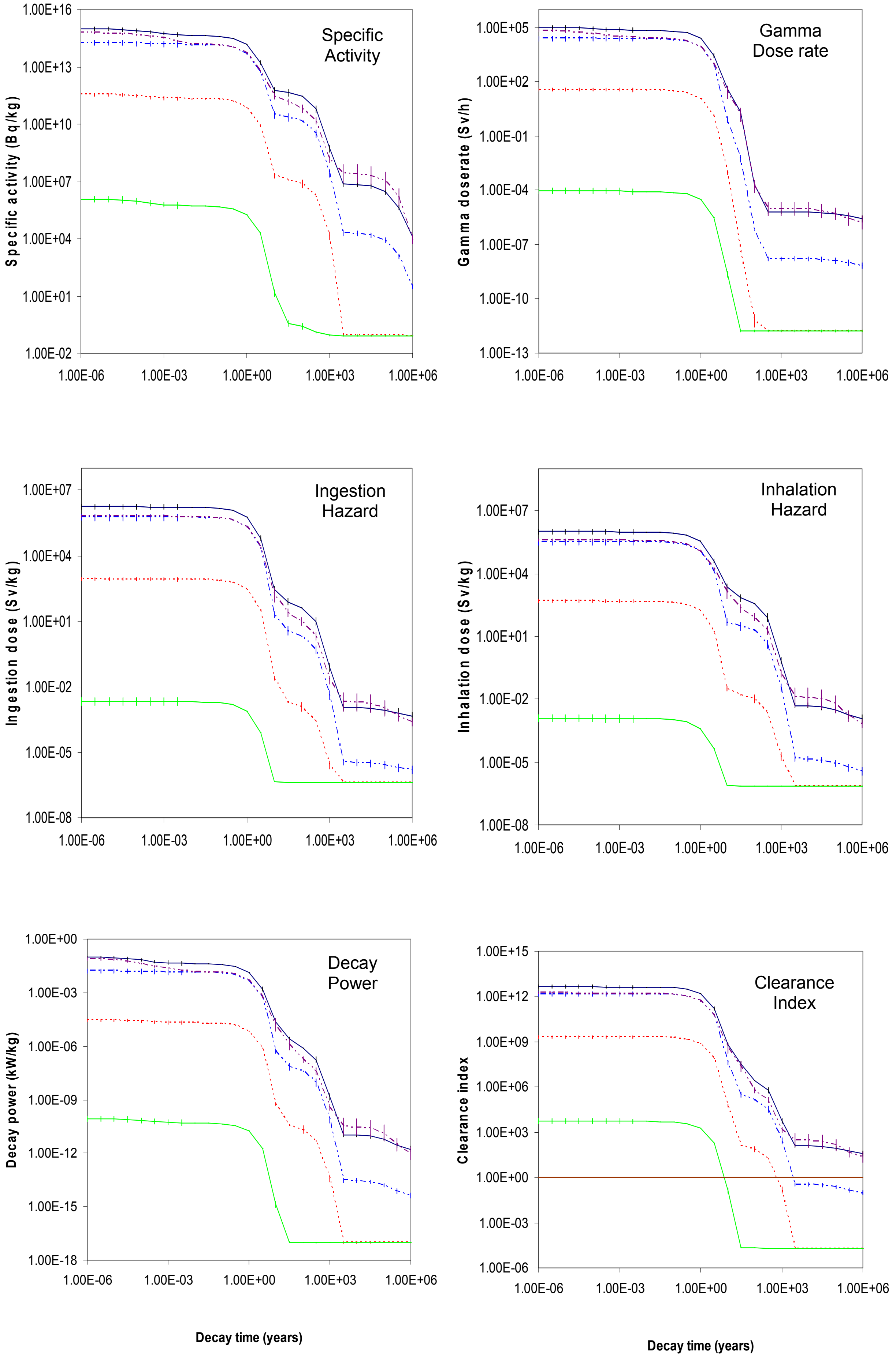
Zinc

Pathway analysis

Nuclide	$T_{1/2}$	Pathway	210	186	151	42	30	21	6
Cu62	9.75 m	Zn64(n,d)Cu63(n,2n)Cu62				76.4	18.9	2.7	2.0
		Zn64(n,2n)Zn63(β^+)Cu63(n,2n)Cu62				22.8	8.7	1.3	
		Zn64(n,t)Cu62				0.2	64.1	83.3	80.4
		Zn64(n,3n)Zn62(β^+)Cu62					5.9	8.8	6.0
		Zn66(n,3n)Zn64(n,t)Cu62					1.1	2.0	0.9
		Zn66(n,nt)Cu63(n,2n)Cu62						0.2	1.4
		Zn66(n,2nt)Cu62							4.6
Ga70	21.14 m	&Zn68(n,γ)*Zn69*(β^-)Ga69(n,γ)Ga70	96.2	99.5	99.7	1.0	0.7	0.7	0.6
		&Zn67(n,γ)Zn68(n,γ)*Zn69*(β^-)Ga69(n,γ)_ Ga70	3.4	0.4	0.2				
		Zn66(n,γ)Zn67(n,γ)Zn68(n,γ)Zn69(β^-)_ Ga69(n,γ)Ga70	0.3						
		&Zn70(n,2n)*Zn69*(β^-)Ga69(n,γ)Ga70				48.1	42.2	40.9	40.1
		Zn70(n,γ)Zn71m(β^-)Ga71(n,2n)Ga70				29.8	29.4	25.4	22.7
		Zn70(n,γ)Zn71(β^-)Ga71(n,2n)Ga70				20.3	21.2	19.6	18.7
		Zn70(n,d)Cu69(β^-)Zn69(β^-)Ga69(n,γ)Ga70					6.3	13.2	17.8
Zn69	56.4 m	&Zn68(n,γ)*Zn69*	92.9	99.1	99.5	2.0	1.4	1.2	0.6
		&Zn67(n,γ)Zn68(n,γ)*Zn69*	6.2	0.8	0.4				
		Zn66(n,γ)Zn67(n,γ)Zn68(n,γ)Zn69	0.9						
		&Zn70(n,2n)*Zn69*				97.9	85.7	74.5	68.7
		Zn70(n,d)Cu69(β^-)Zn69				0.1	12.9	24.3	30.7
Cu64	12.701 h	Zn64(n,γ)Zn65(n,α)Ni62(n,γ)Ni63(β^-)_ Cu63(n,γ)Cu64	99.9	94.9	5.9				
		Zn66(n,α)Ni63(β^-)Cu63(n,γ)Cu64		5.1	94.1				
		Zn64(n,p)Cu64				71.0	39.2	16.7	11.2
		Zn66(n,2n)Zn65(β^+)Cu65(n,2n)Cu64				23.8	19.7	3.3	1.9
		Zn66(n,d)Cu65(n,2n)Cu64				2.9	9.9	2.1	1.4
		Zn66(n,t)Cu64					22.2	68.0	60.4
		Zn68(n,3n)Zn66(n,t)Cu64					1.1	3.4	1.2
		Zn66(n,2n)Zn65(n,d)Cu64					1.0	2.1	0.4
		Zn67(n,nt)Cu64					0.1	1.3	8.9
		Zn68(n,2nt)Cu64							8.5
Zn69m	13.78 h	Zn68(n,γ)Zn69m	92.8	99.1	99.5	2.3	1.4	1.4	1.3
		Zn67(n,γ)Zn68(n,γ)Zn69m	6.2	0.9	0.4				
		Zn66(n,γ)Zn67(n,γ)Zn68(n,γ)Zn69m	1.0						
		Zn70(n,2n)Zn69m				96.9	98.0	98.2	98.5
		Zn70(n,2n)Zn69(β^-)Ga69(n,p)Zn69m				0.3	0.1		
Zn65	244.15 d	Zn64(n,γ)Zn65	100.0	100.0	100.0	0.2			
		Zn66(n,2n)Zn65				96.4	85.4	73.3	58.9
		Zn67(n,2n)Zn66(n,2n)Zn65				1.8	0.8	0.4	
		Zn67(n,3n)Zn65					6.8	10.8	6.2
		Zn68(n,3n)Zn66(n,2n)Zn65					3.4	2.9	
		Zn68(n,2n)Zn67(n,3n)Zn65					2.1	1.7	
		Zn68(n,4n)Zn65						8.8	31.9
Co60	5.271 y	&Zn64(n,α)Ni61(n,α)Fe58(n,γ)Fe59(β^-)_ Co59(n,γ)*Co60*	100.0	100.0	100.0				
		&Zn64(n,d)Cu63(n,α)*Co60*				54.4	3.3	1.0	3.5
		&Zn64(n,nα)Ni60(n,p)*Co60*				23.5	4.6	1.0	
		&Zn64(n,2n)Zn63(β^+)Cu63(n,α)*Co60*				16.2	1.6	0.4	1.8
		&Zn64(n,α)Ni61(n,d)*Co60*				4.2	1.8	2.0	7.3
		&Zn64(n,pα)*Co60*					76.4	29.0	16.2
		&Zn64(n,t)Cu62(β^+)Ni62(n,t)*Co60*					1.9	35.0	13.9
		&n64(n,h)Ni62(n,t)*Co60*					1.2	10.4	3.7
		&Zn64(n,3n)Zn62(β^+)Cu62(β^+)Ni62(n,t)*Co60*					0.1	3.6	0.6
		&Zn64(n,nt)Cu61(β^+)Ni61(n,d)*Co60*						0.6	4.6
		&Zn66(n,tα)*Co60*							30.4

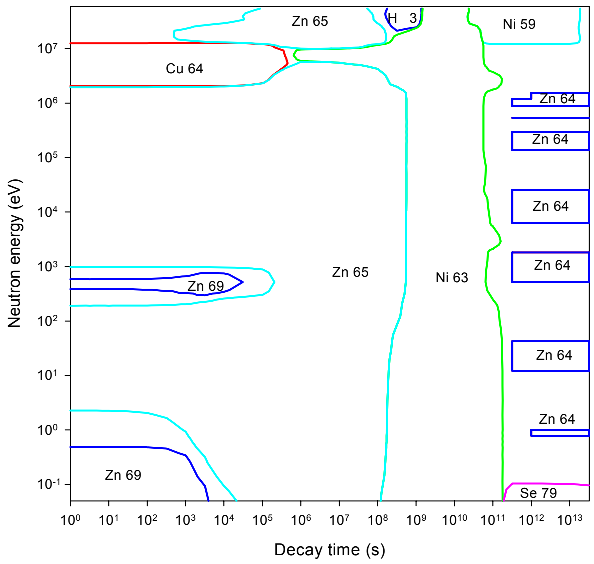
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
H3	12.33 y	Zn64(n,γ)Zn65(n,X)H1(n,γ)H2(n,γ)H3	93.5	94.5	95.9				
		Zn67(n,X)H1(n,γ)H2(n,γ)H3	0.2	0.9	3.5				
		Zn64(n,X)H3				28.1	58.4	52.1	46.1
		Zn67(n,X)H3				26.6	4.9	4.5	4.5
		Zn64(n,d)Cu63(n,X)H3				17.7	2.1	1.0	0.7
		Zn68(n,2n)Zn67(n,X)H3				9.4	0.9	0.5	
		Zn64(n,2n)Zn63(β^+)Cu63(n,X)H3				5.3	0.9	0.5	
		Zn66(n,2n)Zn65(n,X)H3				3.9	0.5	0.2	
		Zn66(n,X)H3				3.3	16.8	21.1	24.1
		Zn66(n,2n)Zn65(β^+)Cu65(n,X)H3				2.4	0.9	0.5	
		Zn68(n,X)H3				0.9	10.6	13.9	17.0
Ni63	100.6 y	Zn64(n,γ)Zn65(n,α)Ni62(n,γ)Ni63	100.0	96.9	9.8				
		Zn66(n,α)Ni63		3.1	90.2	53.8	12.5	10.3	46.3
		Zn64(n,p)Cu64(β^+)Ni64(n,2n)Ni63				22.1	4.2	1.5	
		Zn64(n,d)Cu63(n,p)Ni63				7.4	3.7	1.4	
		Zn64(n,2p)Ni63				5.6	41.3	14.2	7.5
		Zn67(n,nα)Ni63				3.1	14.3	7.2	5.3
		Zn64(n,2n)Zn63(β^+)Cu63(n,p)Ni63				2.2	1.7	0.7	
		Zn66(n,2n)Zn65(β^+)Cu65(n,2n)Cu64(β^+)_ Ni64(n,2n)Ni63				1.9	0.5		
		Zn68(n,2n)Zn67(n,nα)Ni63				1.1	2.7	0.7	
		Zn68(n,2nα)Ni63					4.4	41.6	23.0
		Zn66(n,2n)Zn65(β^+)Cu65(n,t)Ni63					3.5	4.6	2.3
		Zn66(n,t)Cu64(β^+)Ni64(n,2n)Ni63					2.4	6.3	2.6
		Zn66(n,d)Cu65(n,t)Ni63					2.1	3.5	1.9
Ni59	7.6 10^4 y	Zn64(n,nα)Ni60(n,2n)Ni59				95.2	38.0	2.3	2.0
		Zn64(n,α)Ni61(n,2n)Ni60(n,2n)Ni59				3.9			
		Zn64(n,2nα)Ni59					54.4	91.4	77.9
		Zn64(n,α)Ni61(n,3n)Ni59					1.2	0.9	3.2
		Zn64(n,t)Cu62(β^+)Ni62(n,4n)Ni59						0.6	4.1
Se79	1.1 10^6 y	Very long pathways of (n,γ), β^-	100.0						
Fe60	1.5 10^6 y	Zn64(n,α)Ni61(n,α)Fe58(n,γ)Fe59(n,γ)_ Fe60	100.0	100.0	100.0				
		Zn66(n,α)Ni63(n,α)Fe60				44.8	0.4		1.7
		Zn64(n,p)Cu64(β^+)Ni64(n,2n)Ni63(n,α)Fe60				12.3			
		&Zn64(n,d)Cu63(n,α)*Co60*(n,p)Fe60				10.4			
		Zn64(n,p)Cu64(β^+)Ni64(n,nα)Fe60				7.4	38.5	13.7	5.7
		Zn64(n,2p)Ni63(n,α)Fe60				4.7	1.2	0.1	
		&Zn64(n,nα)Ni60(n,p)*Co60*(n,p)Fe60				4.4			
		Zn64(n,d)Cu63(n,p)Ni63(n,α)Fe60				4.1			
		&Zn64(n,2n)Zn63(β^+)Cu63(n,α)*Co60*_ (n,p)Fe60				3.1			
		Zn67(n,nα)Ni63(n,α)Fe60				2.6	0.4		
		Zn66(n,2n)Zn65(β^+)Cu65(n,2n)Cu64(β^+)_ Ni64(n,nα)Fe60				0.6	4.8	0.7	
		Zn66(n,t)Cu64(β^+)Ni64(n,nα)Fe60					22.1	56.6	31.0
		Zn68(n,nα)Ni64(n,nα)Fe60					14.4	4.1	2.6
		Zn66(n,d)Cu65(n,2n)Cu64(β^+)Ni64(n,nα)Fe60					3.3	0.6	
		Zn64(n,t)Cu62(β^+)Ni62(n,h)Fe60					0.6	7.6	13.1
		Zn64(n,h)Ni62(n,h)Fe60					0.4	2.3	3.5
		Zn67(n,nt)Cu64(β^+)Ni64(n,nα)Fe60					0.1	1.0	4.6
		Zn68(n,n2α)Fe60						0.5	10.4
		Zn68(n,2nt)Cu64(β^+)Ni64(n,nα)Fe60							4.4
Zn64	2.3 10^{18} y	Zn66(n,2n)Zn65(β^+)Cu65(n,2n)Cu64(β^-)Zn64				0.1			
		Zn66(n,2n)Zn65(n,2n)Zn64				0.1			
		Zn66(n,3n)Zn64					1.6	2.3	1.1
		Zn66(n,t)Cu64(β^-)Zn64					0.2	0.8	0.5
		Zn68(n,5n)Zn64							0.2
		Zn67(n,4n)Zn64							0.1
		Nuclide also present in starting material	100.0	100.0	100.0	99.8	98.2	96.9	98.1

Zinc activation characteristics

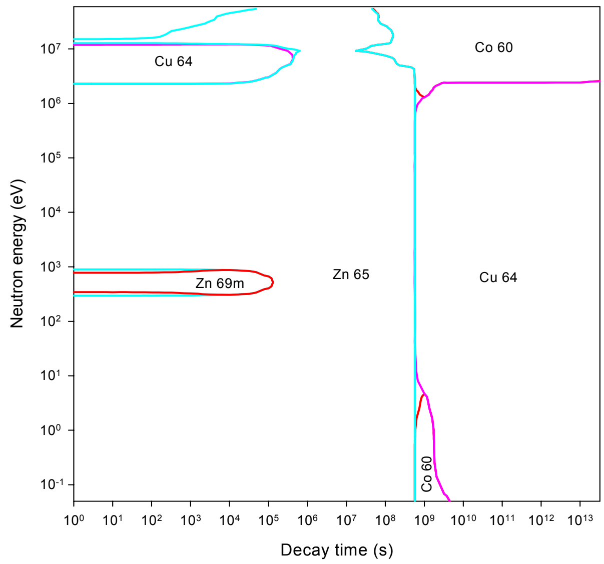


Zinc importance diagrams & transmutation

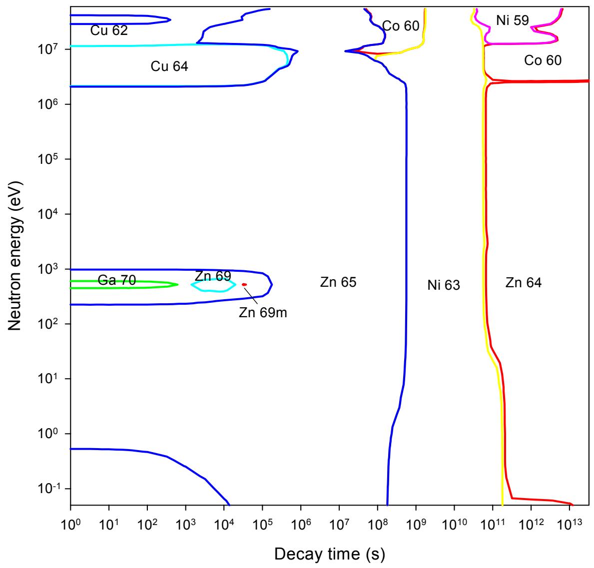
Activity



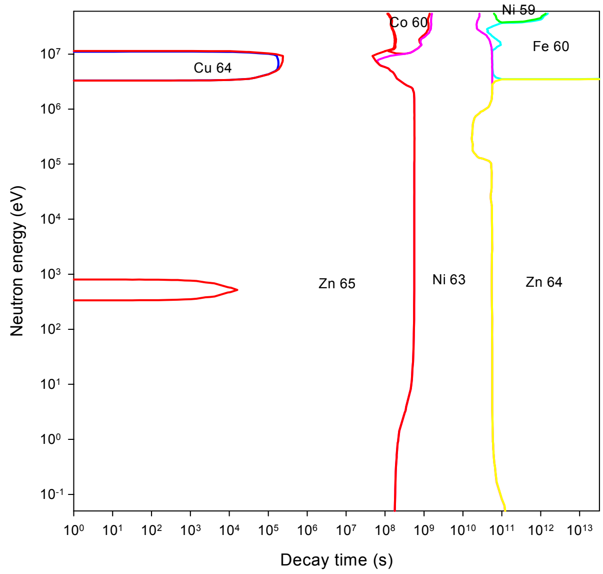
Dose rate



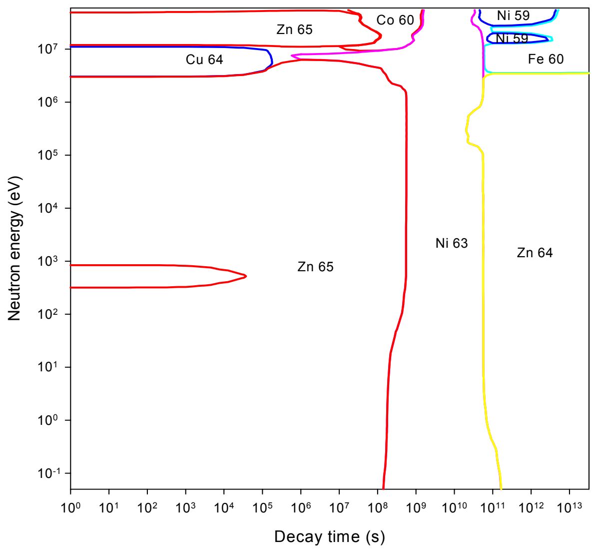
Heat output



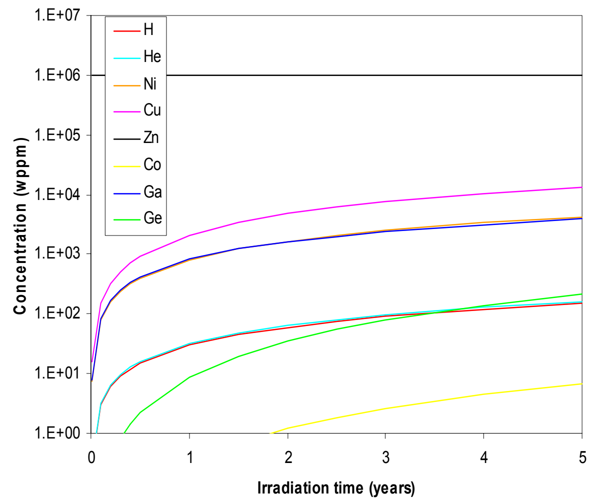
Ingestion dose



Inhalation dose



First wall transmutation



Graphs for H, He and Ga, Ni are indistinguishable

Gallium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	31	Ga69	60.108
Crustal abundance / wppm	19	Ga71	39.892
Melting point / K	302.9		
Boiling point / K	2477		
Density / kgm^{-3}	5904		
Thermal conductivity / $Wm^{-1}K^{-1}$	40.6		
Electrical resistivity /Ωm	$2.7\ 10^{-7}$		
Coefficient of thermal expansion / K^{-1}	$1.2\ 10^{-5}$		
Crystal structure	Orthorhombic		
Number of stable isotopes	2		
Mean atomic weight	69.723		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	7.89E15	7.26E15	1.58E14	2.02E11	6.62E8	7.32E0
Ga72	44.64	48.34	29.91			
Ga70	44.52	40.75				
Ga68	7.23	7.46		0.09		
Ge71	1.60	1.74	64.02			
Ge69	0.51	0.56	5.40			
Zn65			0.13	35.76		
H3			0.09	63.89	74.67	
Ni63				0.16	25.33	
Co60m						30.39
Fe60						30.39
Co60						30.31
Ni59						8.91

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	2.35E0	2.28E0	2.60E-2	6.99E-6	9.20E-10	9.79E-16
Ga72	77.04	79.35	93.58			
Ga70	15.59	13.57				
Ga68	6.57	6.44		0.70		
Ge69	0.30	0.31	5.63			
Zn69	0.11	0.11	0.05			
Ge71	0.01	0.01	0.56			
Zn65			0.07	97.59		
H3				1.69	49.13	
Ni63					50.87	
Co60						94.46
Fe60						3.19
Co60m						2.28

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	3.02E6	2.99E6	4.09E4	1.21E1	1.93E-9	1.66E-9
Ga72	95.46	95.72	94.61			
Ga68	3.79	3.62		0.30		
Ge69	0.33	0.33	5.16			
Ga70	0.23	0.20				
Zn69m	0.06	0.06	0.05			
Zn71m	0.06	0.06				
Ge71			0.09			
Zn65			0.08	99.69		
Co60					99.83	99.82
Co60m					0.15	0.17

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	4.10E6	4.03E6	5.63E4	2.88E2	4.59E-2	2.52E-7
Ga72	94.61	95.66	92.49			
Ga70	2.66	2.27				
Ga68	1.39	1.34		0.01		
Ge69	0.24	0.24	3.64			
Ge71	0.04	0.04	2.16			
Zn65	0.02	0.02	1.40	98.01		
H3			0.01	1.89	45.22	
Ni63				0.02	54.78	
Fe60						96.99
Co60						2.99

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	2.00E6	1.96E6	2.94E4	1.96E2	3.46E-1	6.92E-7
Ga72	93.40	94.83	85.39			
Ga70	2.81	2.41				
Ga68	1.40	1.35		0.01		
Ge69	0.59	0.60	8.44			
Ge71	0.07	0.07	3.79			
Zn65	0.02	0.02	1.51	81.31		
H3			0.12	17.17	37.09	
Ge68			0.02	1.29		
Ni63				0.22	62.91	
Fe60						90.02
Co60						9.94

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	1.25E12	1.17E12	1.54E10	7.24E8	6.62E3	2.22E-2
Ga68	46.63	47.20		0.03		
Ga72	28.20	29.99	30.81			
Ga70	20.09	18.06				
Ge69	3.24	3.46	55.63			
Zn65	0.16	0.17	13.12	99.80		
Ge71			0.07			
H3			0.01	0.18	74.67	
Ni63					25.33	
Co60						99.87
Fe60						0.09
Co60m						0.01

Gallium

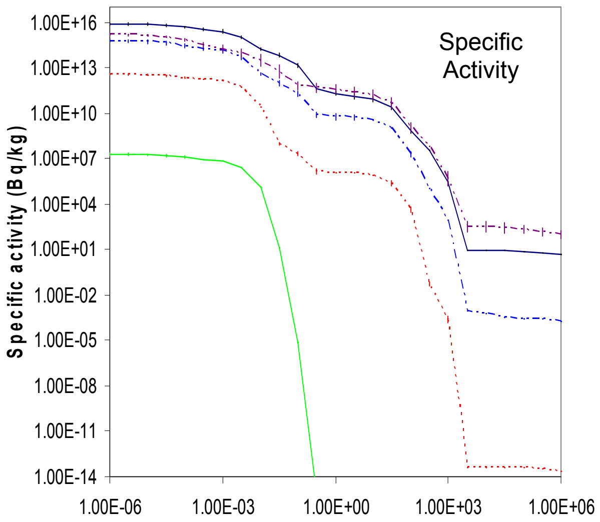
Pathway analysis

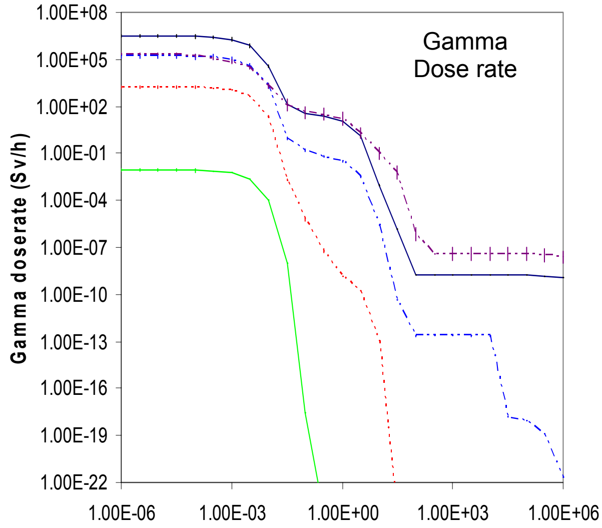
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Zn71	2.45 m	Ga69(n,γ)Ga70(β^+)Zn70(n,γ)Zn71	100.0	100.0	100.0				
		Ga71(n,p)Zn71				99.8	99.8	99.9	99.9
Ga70	21.14 m	Ga69(n,γ)Ga70	100.0	100.0	100.0				
		Ga71(n,2n)Ga70				98.4	99.4	99.6	99.7
Zn69	56.4 m	**&**Ga69(n,γ)Ga70(β^-)Ge70(n,γ)Ge71(n,α)_ Zn68(n,γ)*Zn69*	97.3	97.0	96.8				
		&Ga69(n,p)*Zn69*				95.1	46.3	18.9	11.0
		&Ga71(n,d)Zn70(n,2n)*Zn69*				4.1	8.5	3.0	0.6
		&Ga71(n,t)*Zn69*				0.5	42.0	76.0	85.7
		&Ga71(n,3n)Ga69(n,p)Zn69					2.4	0.6	
		Ga71(n,h)Cu69(β^-)Zn69					0.4	1.2	1.5
Ga68	1.128 h	Ga69(n,2n)Ga68				98.6	92.4	77.3	60.4
		Ga71(n,3n)Ga69(n,2n)Ga68					5.2	4.0	1.3
		Ga71(n,2n)Ga70(β^-)Ge70(n,t)Ga68					0.6	2.3	1.0
		Ga71(n,4n)Ga68						14.3	36.3
Ga66	9.49 h	Ga71(n,2n)Ga70(β^-)Ge70(n,2n)Ge69_ (n,2n)Ge68(n,d)Ga67(n,2n)Ga66				68.2			
		Ga71(n,2n)Ga70(β^-)Ge70(n,2n)Ge69_ (n,2n)Ge68(n,t)Ga66				10.1			
		Ga71(n,2n)Ga70(β^-)Ge70(n,2n)Ge69(n,t)_ Ga67(n,2n)Ga66				7.1			
		Ga71(n,2n)Ga70(β^-)Ge70(n,2n)Ge69(n,2n)_ Ge68(n,2n)Ge67(β^+)Ga67(n,2n)Ga66				4.0			
		Ga69(n,3n)Ga67(n,2n)Ga66					69.4	0.4	
		Ga71(n,2n)Ga70(β^-)Ge70(n,3n)Ge68(n,t)Ga66					29.0	0.8	
		Ga71(n,3n)Ga69(n,3n)Ga67(n,2n)Ga66					3.4		
		Ga69(n,4n)Ga66						92.7	96.6
		Ga71(n,3n)Ga69(n,4n)Ga66						4.8	2.0
Zn69m	13.78 h	Ga69(n,γ)Ga70(β^-)Ge70(n,γ)Ge71(n,α)_ Zn68(n,γ)Zn69m	100.0	100.0	99.8				
		Ga69(n,p)Zn69m				93.2	45.9	19.0	11.7
		Ga71(n,d)Zn70(n,2n)Zn69m				3.9	9.7	3.3	2.1
		Ga71(n,2n)Ga70(β^+)Zn70(n,2n)Zn69m				1.0	0.2		
		Ga71(n,t)Zn69m				0.3	40.7	76.3	85.7
		Ga71(n,3n)Ga69(n,p)Zn69m					2.6	1.0	
Ga72	14.1 h	Ga71(n,γ)Ga72	98.8	100.0	100.0	99.0	99.5	99.7	99.8
		Ga69(n,γ)Ga70(β^-)Ge70(n,γ)Ge71(β^+)_ Ga71(n,γ)Ga72	1.2						
Ge69	1.627 d	Ga71(n,2n)Ga70(β^-)Ge70(n,2n)Ge69				99.7	99.8	99.8	99.8
Ga67	3.261 d	Ga71(n,2n)Ga70(β^-)Ge70(n,2n)Ge69_ (n,2n)Ge68(n,d)Ga67				84.5			
		Ga71(n,2n)Ga70(β^-)Ge70(n,2n)Ge69(n,t)Ga67				9.0			
		Ga69(n,3n)Ga67					93.7	93.6	72.1
		Ga71(n,3n)Ga69(n,3n)Ga67					5.3	4.8	1.5
		Ga71(n,2n)Ga70(β^-)Ge70(n,nt)Ga67						0.3	2.2
		Ga71(n,5n)Ga67							23.2
Ge71	11.43 d	Ga69(n,γ)Ga70(β^-)Ge70(n,γ)Ge71	100.0	100.0	100.0				
		Ga71(n,2n)Ga70(β^-)Ge70(n,γ)Ge71				52.2	47.1	47.4	47.6
		Ga71(n,γ)Ga72(β^-)Ge72(n,2n)Ge71				47.6	52.8	52.5	52.3
Fe59	44.495 d	Ga69(n,α)Cu66(β^-)Zn66(n,nα)Ni62(n,α)Fe59				50.9	0.1		
		Ga69(n,nα)Cu65(n,α)Co62m(β^-)Ni62(n,α)Fe59				9.3			
		Ga69(n,nα)Cu65(n,α)Co62(β^-)Ni62(n,α)Fe59				7.9			
		Ga69(n,2n)Ga68(β^+)Zn68(n,2n)Zn67_ (n,2n)Zn66(n,nα)Ni62(n,α)Fe59				4.1			
	►	Ga69(n,3n)Ga67(β^+)Zn67(n,nα)Ni63_ (n,nα)Fe59					28.5	1.1	0.2

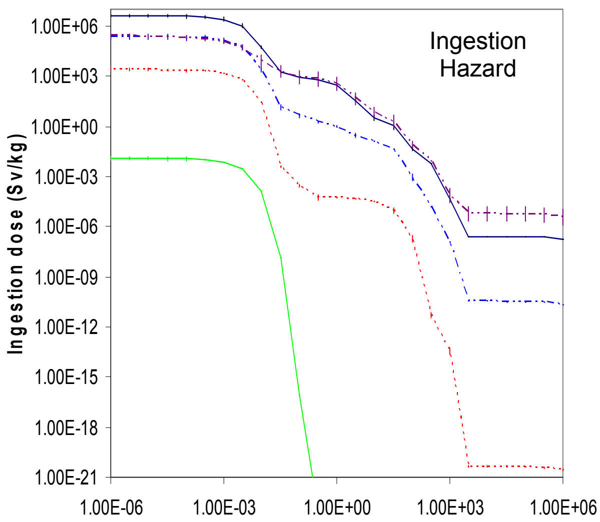
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Ga69(n,t)Zn67(n,nα)Ni63(n,nα)Fe59					9.0	0.7	0.1
		Ga69(n,2nα)Cu64(β^{+})Ni64(n,nα)Fe60_ (n,2n)Fe59					8.1	3.8	0.3
		Ga69(n,nα)Cu65(n,t)Ni63(n,nα)Fe59					5.3	0.5	0.1
		Ga69(n,2nα)Cu64(β^{+})Ni64(n,2nα)Fe59					1.0	59.5	14.5
		Ga69(n,tα)Ni63(n,nα)Fe59						0.2	5.0
		Ga69(n,2nt)Zn65(β^{+})Cu65(n,tα)Fe59							8.7
		Ga71(n,3nα)Cu65(n,tα)Fe59							4.1
		Other pathways				27.8	48.0	34.2	67.0
Zn65	244.15 d	Ga69(n,α)Cu66(β^{-})Zn66(n,α)Ni63(β^{-})_ Cu63(n,γ)Cu64(β^{-})Zn64(n,γ)Zn65	100.0						
		Ga69(n,α)Cu66(β^{-})Zn66(n,2n)Zn65				80.1	1.6	0.5	0.5
		Ga69(n,2n)Ga68(β^{+})Zn68(n,2n)Zn67_ (n,2n)Zn66(n,2n)Zn65				10.2	0.2		
		Ga71(n,2n)Ga70(β^{-})Ge70(n,nα)Zn66_ (n,2n)Zn65				6.6	0.5		
		Ga69(n,3n)Ga67(β^{+})Zn67(n,3n)Zn65					51.9	37.4	3.0
		Ga69(n,t)Zn67(n,3n)Zn65					16.3	22.7	2.7
		Ga69(n,2n)Ga68(β^{+})Zn68(n,3n)Zn66_ (n,2n)Zn65					6.0	1.2	
		Ga69(n,2n)Ga68(β^{+})Zn68(n,2n)Zn67_ (n,3n)Zn65					3.7	0.7	
		Ga71(n,2n)Ga70(β^{-})Ge70(n,2nα)Zn65					2.1	4.0	0.5
		Ga69(n,nt)Zn66(n,2n)Zn65					0.9	10.0	6.4
		Ga69(n,2n)Ga68(β^{+})Zn68(n,4n)Zn65						6.6	5.0
		Ga69(n,2nt)Zn65						1.1	64.5
Ge68	270.95 d	Ga71(n,2n)Ga70(β^{-})Ge70(n,2n)Ge69_ (n,2n)Ge68				99.8			
		Ga71(n,2n)Ga70(β^{-})Ge70(n,3n)Ge68					99.7	99.8	99.9
Co60	5.271 y	**&**Ga69(n,nα)Cu65(n,2n)Cu64(β^{-})Zn64_ (n,d)Cu63(n,α)*Co60*				38.5			
		&Ga69(n,nα)Cu65(n,2n)Cu64(β^{-})Zn64_ (n,nα)Ni60(n,p)*Co60*				16.6			
		&Ga69(n,nα)Cu65(n,2n)Cu64(β^{-})Zn64_ (n,2n)Zn63(β^{+})Cu63(n,α)*Co60*				11.4			
		&Ga69(n,nα)Cu65(n,nα)Co61(β^{-})Ni61_ (n,d)*Co60*				4.8	10.0		
		&Ga69(n,nα)Cu65(n,2nα)*Co60*					44.6	31.4	1.8
		&Ga69(n,2nα)Cu64(β^{-})Zn64(n,pα)*Co60*					7.7	3.1	
		&Ga69(n,3n)Ga67(β^{+})Zn67(n,3n)Zn65_ (β^{+})Cu65(n,2nα)*Co60*					2.9	4.4	
		&Ga69(n,3n)Ga67(β^{+})Zn67(n,2nα)Ni62_ (n,t)*Co60*					2.7	6.8	0.1
		&Ga69(n,2nα)Cu64(β^{+})Ni64(n,3n)Ni62_ (n,t)*Co60*					0.8	5.4	
		&Ga69(n,3nα)Cu63(n,α)*Co60*						0.8	7.8
		&Ga69(n,2n2α)*Co60*							46.2
		&Ga69(n,nt)Zn66(n,tα)*Co60*							9.2
		Other pathways				28.7	31.3	48.1	34.9
Kr85	10.752 y	Very long pathways of (n,γ), β^{-}	100.0						
H3	12.33 y	Ga69(n,γ)Ga70(β^{-})Ge70(n,γ)Ge71(n,X)_ H1(n,γ)H2(n,γ)H3	94.7	96.4					
		Ga69(n,X)H3				81.7	57.7	55.6	54.8
		Ga71(n,X)H3				17.1	34.3	36.2	37.7
		Ga69(n,3n)Ga67(β^{+})Zn67(n,X)H3					1.6	1.6	0.6
		Ga71(n,3n)Ga69(n,X)H3					1.6	1.5	0.6
		Ga69(n,2n)Ga68(β^{+})Zn68(n,X)H3					1.6	1.1	0.8
Ni63	100.6 y	Ga69(n,α)Cu66(β^{-})Zn66(n,α)Ni63	100.0	100.0	100.0	31.6			
		Ga69(n,2n)Ga68(β^{+})Zn68(n,2n)Zn67(n,nα)Ni63				26.4	2.5	0.2	
		Ga69(n,nα)Cu65(n,2n)Cu64(β^{+})Ni64(n,2n)Ni63				19.4	1.4	0.1	
	►	Ga69(n,2n)Ga68(β^{+})Zn68(n,nα)Ni64(n,2n)Ni63				6.1	1.4	0.1	

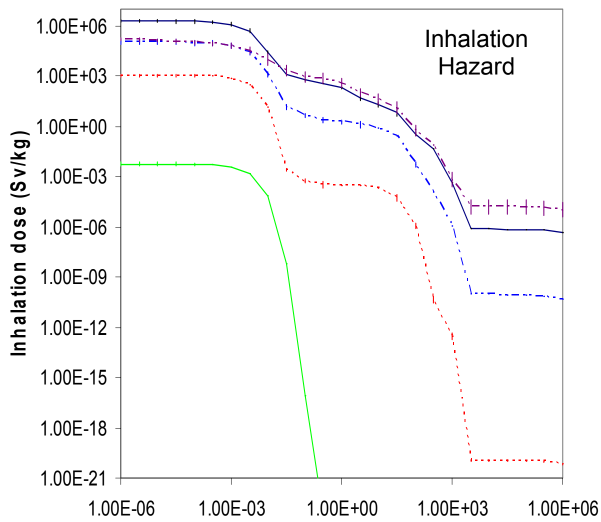
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Ga69(n,t)Zn67(n,nα)Ni63				0.5	14.3	9.4	1.8
		Ga69(n,nα)Cu65(n,t)Ni63				0.2	8.5	6.5	1.7
		Ga69(n,3n)Ga67(β^+)Zn67(n,nα)Ni63					45.4	15.5	2.1
		Ga69(n,2n)Ga68(β^+)Zn68(n,2nα)Ni63					6.2	19.4	2.9
		Ga69(n,2nα)Cu64(β^+)Ni64(n,2n)Ni63					6.1	16.6	2.2
		Ga69(n,d)Zn68(n,2nα)Ni63					1.6	7.4	1.3
		Ga69(n,tα)Ni63						2.4	65.4
Ni59	7.6 10^4 y	Ga69(n,nα)Cu65(n,2n)Cu64(β^-)Zn64_ (n,nα)Ni60(n,2n)Ni59				79.4	1.6		
		Ga69(n,nα)Cu65(n,nα)Co61(β^-)Ni61_ (n,2n)Ni60(n,2n)Ni59				4.1	1.2		
		Ga69(n,nα)Cu65(n,nα)Co61(β^-)Ni61_ (n,3n)Ni59					23.3	0.4	
		Ga69(n,2nα)Cu64(β^-)Zn64(n,2nα)Ni59					19.2	60.0	5.7
		Ga69(n,2nα)Cu64(β^-)Zn64(n,nα)Ni60_ (n,2n)Ni59					8.9	1.0	
		Ga69(n,nα)Cu65(n,2n)Cu64(β^-)Zn64_ (n,2nα)Ni59					4.5	0.4	
		Ga69(n,3nα)Cu63(n,2nt)Ni59							23.1
		Ga69(n,2nt)Zn65(n,3nα)Ni59							8.8
		Ga69(n,ntα)Ni62(n,4n)Ni59							7.0
		Ga69(n,nt)Zn66(n,4nα)Ni59							5.5
		Ga69(n,4nα)Cu62(β^+)Ni62(n,4n)Ni59							4.5
Kr81	2.1 10^5 y	Very long pathways of (n,γ), β^-	100.0						
Se79	1.1 10^6 y	&Ga71(n,γ)Ga72(β^-)Ge72(n,γ)*Ge73*(n,γ)_ Ge74(n,γ)*Ge75*(β^-)As75(n,γ)As76(β^-)_ Se76(n,γ)*Se77*(n,γ)Se78(n,γ)*Se79*	95.7	15.7	96.7				
		&Ga71(n,γ)Ga72(n,γ)Ga73(β^-)*Ge73*(n,γ)_ Ge74(n,γ)*Ge75*(β^-)As75(n,γ)As76(β^-)_ Se76(n,γ)*Se77*(n,γ)Se78(n,γ)*Se79*	4.0	72.1	1.2				
Fe60	1.5 10^6 y	Ga69(n,α)Cu66(β^-)Zn66(n,α)Ni63(n,α)Fe60				31.3			
		Ga69(n,2n)Ga68(β^+)Zn68(n,2n)Zn67_ (n,nα)Ni63(n,α)Fe60				19.7			
		Ga69(n,nα)Cu65(n,2n)Cu64(β^+)Ni64_ (n,2n)Ni63(n,α)Fe60				14.4			
		Ga69(n,nα)Cu65(n,2n)Cu64(β^+)Ni64_ (n,nα)Fe60				11.6	12.8	0.6	0.4
		Ga69(n,2n)Ga68(β^+)Zn68(n,nα)Ni64_ (n,2n)Ni63(n,α)Fe60				4.5			
		Ga69(n,2n)Ga68(β^+)Zn68(n,nα)Ni64_ (n,nα)Fe60				3.6	12.9	0.7	0.4
		Ga69(n,nα)Cu65(n,d)Ni64(n,nα)Fe60				0.7	4.5	0.4	0.2
		Ga69(n,2nα)Cu64(β^+)Ni64(n,nα)Fe60					54.3	83.3	44.9
		Ga69(n,dα)Ni64(n,nα)Fe60					1.9	4.2	4.6
		Ga71(n,4nα)Cu64(β^+)Ni64(n,nα)Fe60							6.7
		Ga69(n,tα)Ni63(n,α)Fe60							4.1
		Other pathways				14.2	13.6	10.8	38.7
Zn64	2.3 10^{18} y	Ga69(n,α)Cu66(β^-)Zn66(n,α)Ni63(β^-)_ Cu63(n,γ)Cu64(β^-)Zn64	100.0	100.0	100.0				
		Ga69(n,nα)Cu65(n,2n)Cu64(β^-)Zn64				86.5	19.5	0.8	
		Ga69(n,2nα)Cu64(β^-)Zn64					55.3	71.0	39.7
		Ga69(n,2n)Ga68(β^+)Zn68(n,3n)Zn66_ (n,3n)Zn64					4.7	0.6	
		Ga69(n,nt)Zn66(n,3n)Zn64					0.9	6.6	8.5
		Ga69(n,3n)Ga67(β^+)Zn67(n,4n)Zn64						4.7	4.4
		Ga69(n,t)Zn67(n,4n)Zn64						2.8	3.9
		Ga69(n,nt)Zn66(n,t)Cu64(β^-)Zn64						2.3	4.1
		Ga71(n,4nα)Cu64(β^-)Zn64							5.9

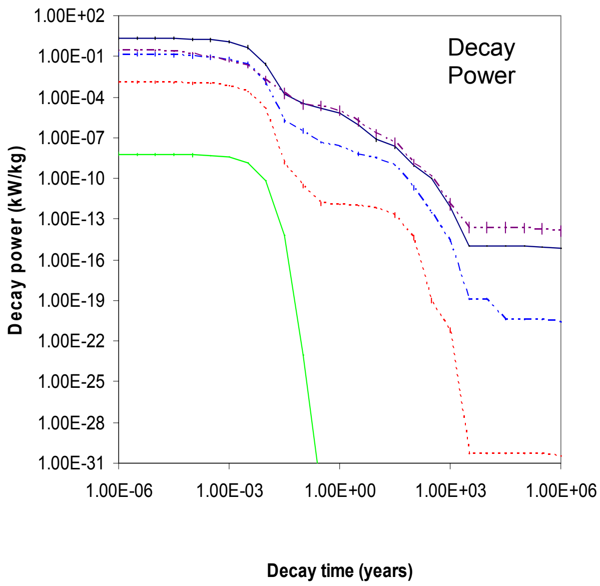
Gallium activation characteristics

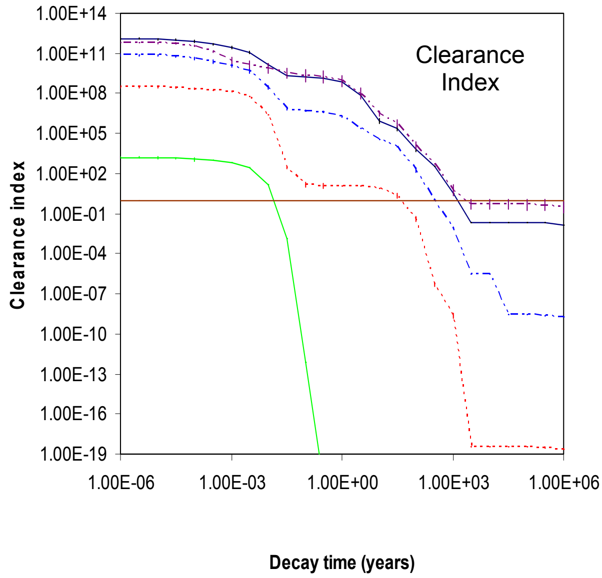






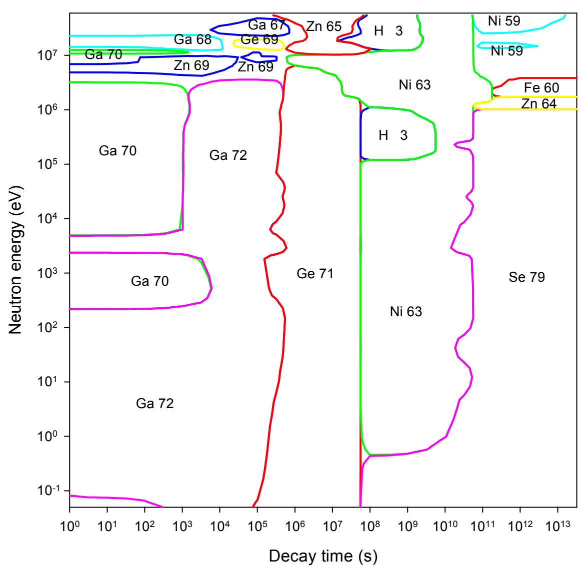




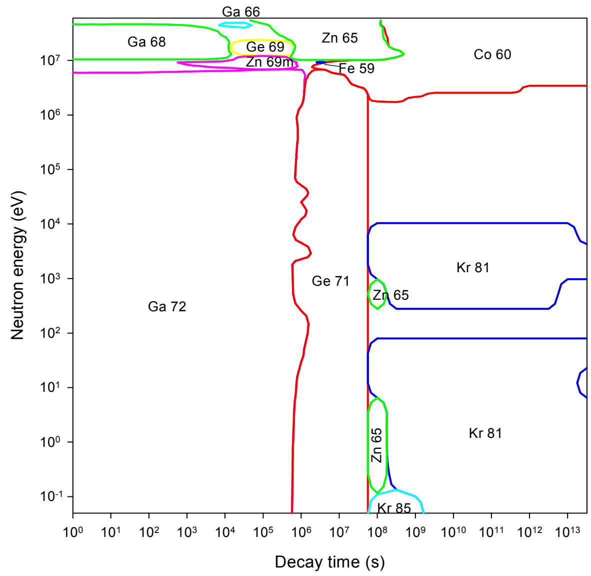


Gallium importance diagrams & transmutation

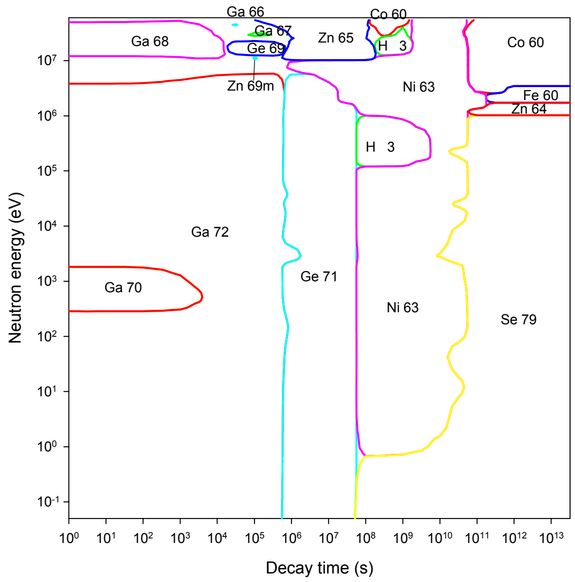
Activity



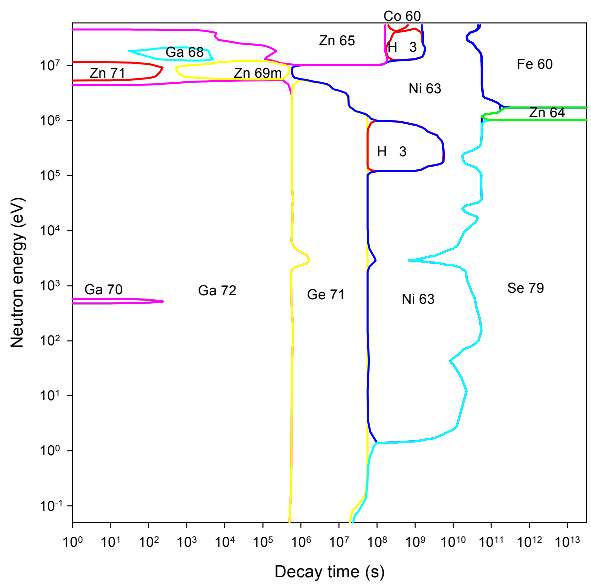
Dose rate



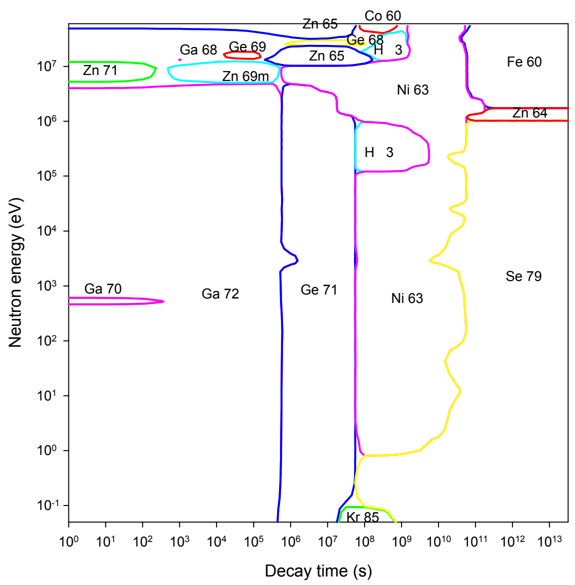
Heat output



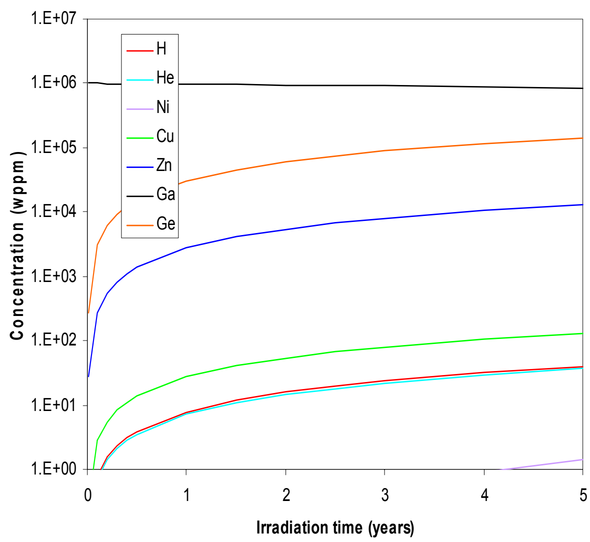
Ingestion dose



Inhalation dose



First wall transmutation



Germanium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	32	Ge70	20.37
Crustal abundance / wppm	1.5	Ge72	27.31
Melting point / K	1211.4	Ge73	7.76
Boiling point / K	3106	Ge74	36.73
Density / kgm^{-3}	5323	Ge76	7.83 ($T_{½}$ = 1.58 10^{21} y)
Thermal conductivity / $Wm^{-1}K^{-1}$	59.9		
Electrical resistivity /Ωm	4.6 10^{-1}		
Coefficient of thermal expansion / K^{-1}	5.57 10^{-6}		
Crystal structure	Cubic		
Number of stable isotopes	4 (5)		
Mean atomic weight	72.64		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.40E15	9.85E14	3.85E14	1.56E11	1.19E8	1.03E5	kW kg^{-1}	1.23E-1	1.10E-1	7.48E-3	1.08E-5	2.79E-10	9.18E-13
Ge71	30.19	43.03	88.31				Ga72	38.61	42.98	8.54			
Ge73m	19.19	0.20					Ge69	15.93	17.78	55.29			
Ge75	12.88	17.67					Ge75	10.73	11.54	16.70			
Ge69	8.14	11.59	6.26				As76	10.28	11.47				
Ge75m	7.37	0.10					Ge77	4.66	5.18	0.35			
Ga72	6.57	9.33	0.32				Ga70	4.05	3.81				
As76	3.79	5.40	1.36				Ga74	3.92	2.81				
Ga70	3.40	4.08					Ge77m	3.27	0.05				
As77	2.88	4.10	2.65				Ge73m	2.26	0.01				
Ge77m	1.72	0.03					Ge75m	1.87	0.02				
Ge77	1.48	2.10	0.02				As77	1.23	1.37	5.10			
Ga74	0.53	0.49					Ga68	0.63	0.67		1.59		
Zn69	0.34	0.47					Ge71	0.49	0.55	6.53			
As74	0.24	0.34	0.76				As74	0.45	0.50	6.50			
Se75		0.09	0.23	70.65			Se75		0.05	0.77	66.21		
Zn65			0.02	23.55			Zn65			0.12	32.10		
H3				4.72	23.78		H3				0.06	9.25	
Ni63				0.11	76.12		Ni63					90.40	
Se79					0.09	99.99	Se79					0.35	99.95
Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	1.26E5	1.22E5	8.22E3	1.11E1	9.32E-10	8.35E-10	Sv kg^{-1}	2.96E5	2.75E5	3.04E4	4.31E2	1.50E-2	2.98E-4
Ga72	60.49	62.20	12.43				Ga72	34.31	36.75	4.5			
Ge69	22.60	23.31	72.89				As76	28.83	30.93	27.75			
Ga74	5.45	3.61					Ge69	9.26	9.94	19.07			
As76	4.20	4.32	6.34				As77	5.46	5.87	13.45			
Ge77	3.93	4.04	0.27				Ge75	2.81	2.90				
Ge75	0.62	0.61					Ge77	2.31	2.48				
Ga68	0.46	0.45		1.15			Ge71	1.71	1.84	13.43			
As74	0.43	0.45	5.80				As74	1.49	1.60	12.66			
Zn71m	0.41	0.42					Se75	0.80	0.86	7.67	66.47		
Ge71	0.11	0.11	1.39				Zn65	0.13	0.14	1.31	33.23		
Se75	0.03	0.03	0.47	43.21			H3				0.07	7.87	
Zn65		0.01	0.20	55.64			Ni63					90.01	
Co60					99.79	99.79	Se79					2.10	99.92

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y	Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	1.90E5	1.75E5	2.69E4	2.36E2	1.25E-1	7.03E-4		2.20E11	1.93E11	2.71E10	4.79E8	1.19E3	5.82E-1
Ga72	25.83	27.89	2.44				Ge69	52.06	59.25	88.85			
As76	20.83	22.53	14.46				Ge77	10.77	12.21	0.40			
Ge69	17.49	18.93	25.96				Ga74	10.75	7.86				
As77	8.32	90.17	14.77				Ge75	6.33	6.95				
Ge77	4.06	4.38	0.13				Ga72	4.20	4.77	0.45			
As74	3.77	4.09	23.04				Ge75m	3.14	0.03				
Ge75	3.43	3.58					Ga68	1.35	1.45		0.13		
Ge71	2.46	2.66	13.87				Zn65	0.47	0.53	3.78	76.81		
Se75	0.62	0.68	4.32	60.87			Se75	0.41	0.47	3.30	23.04		
Ga70	0.40	0.36					As74	0.15		1.08			
Zn65	0.12	0.13	0.83	34.34			As76		2.76	1.94			
Ge68		0.01	0.08	3.76			Ge71		0.02	0.12			
H3				0.81	5.84		H3				0.01	23.79	
Ni63				0.09	93.56		Ni63					76.15	
Se79					0.59	99.31	Se79					0.05	98.09

Germanium

Pathway analysis

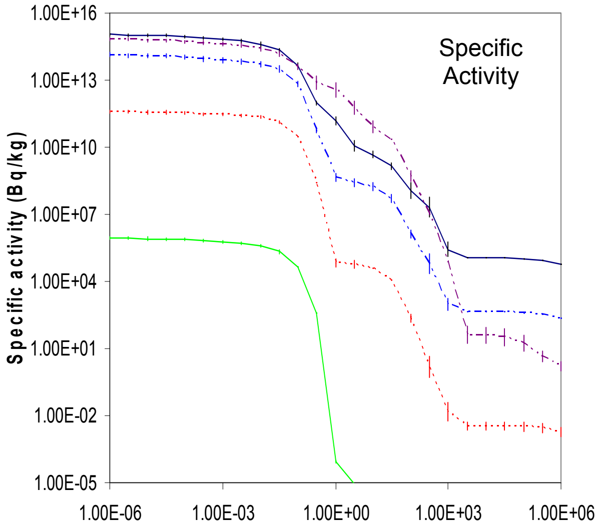
Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ga70	21.14 m	**&**Ge70(n,γ)Ge71(n,α)Zn68(n,γ)*Zn69*(β^-)_ Ga69(n,γ)Ga70	100.0	91.7	91.6				
		Ge72(n,2n)Ge71(β^+)Ga71(n,2n)Ga70				70.7	37.5	5.6	2.1
		Ge70(n,p)Ga70				24.3	13.1	4.7	2.2
		Ge72(n,d)Ga71(n,2n)Ga70				0.8	8.9	2.4	1.2
		Ge72(n,t)Ga70					17.2	64.2	47.6
		Ge73(n,2n)Ge72(n,2n)Ge71(β^+)Ga71_ (n,2n)Ga70					10.5	2.6	
		Ge74(n,3n)Ge72(n,2n)Ge71(β^+)Ga71_ (n,2n)Ga70					2.5	0.3	
		Ge74(n,3n)Ge72(n,t)Ga70					2.3	7.1	2.1
		Ge73(n,nt)Ga70					0.4	2.7	15.5
		Ge74(n,4n)Ge71(β^+)Ga71(n,2n)Ga70						4.0	3.8
		Ge74(n,2nt)Ga70							15.9
Ga68	1.128 h	Ge70(n,2n)Ge69(β^+)Ga69(n,2n)Ga68				75.5	16.9	2.3	1.4
		Ge70(n,d)Ga69(n,2n)Ga68				20.3	9.4	1.5	1.0
		Ge70(n,3n)Ge68(β^+)Ga68					39.1	28.5	19.0
		Ge70(n,t)Ga68					24.5	52.2	41.7
		Ge72(n,3n)Ge70(n,t)Ga68					2.2	5.1	1.6
		Ge72(n,2nt)Ga68							10.3
		Ge72(n,5n)Ge68(β^+)Ga68							6.0
Ge75	1.380 h	**&**Ge74(n,γ)*Ge75*	88.7	98.2	99.2	0.2	0.2	0.1	
		&Ge73(n,γ)Ge74(n,γ)*Ge75*	10.3	1.8	0.7				
		&Ge72(n,γ)*Ge73*(n,γ)Ge74(n,γ)*Ge75*	0.8						
		&Ge76(n,2n)*Ge75*				99.8	90.5	70.7	74.2
		Ge76(n,d)Ga75(β^-)Ge75					9.3	19.2	25.8
Ge77	11.3 h	**&**Ge76(n,γ)*Ge77*	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Ga72	14.1 h	Ge70(n,γ)Ge71(β^+)Ga71(n,γ)Ga72	100.0	100.0	100.0				
		Ge72(n,p)Ga72				83.0	23.0	8.4	4.0
		Ge73(n,2n)Ge72(n,p)Ga72				4.5	0.5	0.1	
		&Ge74(n,2n)*Ge73*(n,d)Ga72				4.3	15.3	4.6	1.7
		Ge73(n,d)Ga72				4.0	36.4	19.2	14.8
		&Ge74(n,2n)*Ge73*(n,2n)Ge72(n,p)Ga72				2.5			
		Ge74(n,t)Ga72					13.7	59.7	69.7
		Ge76(n,nα)Zn72(β^-)Ga72					4.2	1.8	1.2
		Ge74(n,3n)Ge72(n,p)Ga72					3.0	0.9	
		Ge76(n,2nt)Ga72							4.2
As76	1.093 d	**&**Ge74(n,γ)*Ge75*(β^-)As75(n,γ)As76	93.3	99.0	99.6	0.2	0.1		
		&Ge73(n,γ)Ge74(n,γ)*Ge75*(β^-)As75(n,γ)_ As76	6.3	0.9	0.4				
		&Ge76(n,2n)*Ge75*(β^-)As75(n,γ)As76				97.1	64.8	52.8	46.6
		&Ge76(n,γ)*Ge77*(β^-)As77(β^-)Se77(n,d)As76					21.9	26.5	28.8
		&Ge76(n,d)Ga75(β^-)*Ge75*(β^-)As75(n,γ)As76					6.5	12.6	16.3
		Ge76(n,γ)Ge77m(β^-)As77(β^-)Se77(n,d)As76					5.5	6.9	7.6
As77	1.618 d	**&**Ge76(n,γ)*Ge77*(β^-)As77	51.5	51.4	51.5	80.2	79.9	79.5	79.2
		Ge76(n,γ)Ge77m(β^-)As77	48.6	48.6	48.6	19.8	20.1	20.5	20.8
		&Ge74(n,γ)*Ge75*(β^-)As75(n,γ)As76(n,γ)_ As77	0.2						
Ge69	1.627 d	Ge70(n,2n)Ge69				96.9	89.9	76.2	41.6
		Ge72(n,2n)Ge71(β^+)Ga71(n,2n)Ga70(β^-)_ Ge70(n,2n)Ge69				1.8	0.4		
		Ge72(n,3n)Ge70(n,2n)Ge69					7.9	7.4	1.6
		Ge72(n,t)Ga70(β^-)Ge70(n,2n)Ge69					0.4	2.2	
		Ge72(n,4n)Ge69						10.6	44.2
		Ge74(n,3n)Ge72(n,4n)Ge69						1.2	1.9
		Ge73(n,5n)Ge69							3.9
		Ge74(n,5n)Ge70(n,2n)Ge69							1.3

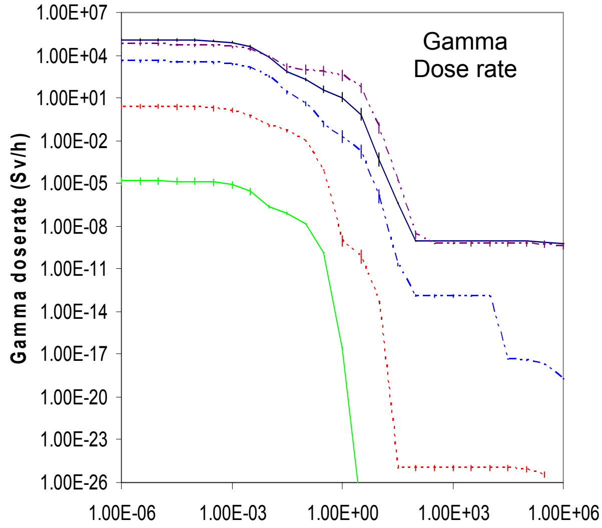
Nuclide	$T_{1/2}$	Pathway	210	186	151	42	30	21	6
Ge71	11.43 d	Ge70(n,γ)Ge71	100.0	100.0	100.0				
		Ge72(n,2n)Ge71				91.5	63.0	40.2	30.7
		Ge73(n,2n)Ge72(n,2n)Ge71				5.0	1.5	0.5	
		&Ge74(n,2n)*Ge73*(n,2n)Ge72(n,2n)Ge71				2.7	0.2		
		Ge73(n,3n)Ge71					17.5	18.2	9.1
		Ge74(n,3n)Ge72(n,2n)Ge71					8.3	4.4	1.3
		&Ge74(n,2n)*Ge73*(n,3n)Ge71					7.3	4.3	1.1
		Ge74(n,4n)Ge71						28.3	54.2
As74	17.78 d	**&**Ge76(n,2n)*Ge75*(β^-)As75(n,2n)As74				99.6	90.5	80.3	74.0
		&Ge76(n,d)Ga75(β^-)*Ge75*(β^-)As75(n,2n)As74					9.2	19.3	25.8
Zn65	244.15 d	Ge70(n,nα)Zn66(n,2n)Zn65				90.3	24.6	1.7	1.8
		Ge70(n,α)Zn67(n,2n)Zn66(n,2n)Zn65				4.8			
		Ge70(n,2n)Ge69(β^+)Ga69(n,α)Cu66(β^-)_ Zn66(n,2n)Zn65				2.2			
		Ge70(n,2nα)Zn65					53.9	74.6	44.0
		Ge72(n,3n)Ge70(n,2nα)Zn65					3.9	5.9	1.4
		Ge70(n,2n)Ge69(β^+)Ga69(n,3n)Ga67(β^+)_ Zn67(n,3n)Zn65					2.2	0.3	
		Ge72(n,2nα)Zn67(n,3n)Zn65					0.7	2.2	0.7
		Ge70(n,t)Ga68(β^+)Zn68(n,4n)Zn65						33.0	5.5
		Ge70(n,nt)Ga67(β^+)Zn67(n,3n)Zn65						1.7	6.2
		Ge72(n,4nα)Zn65							9.9
		Ge72(n,nt)Ga69(n,2nt)Zn65							2.3
		Ge72(n,4n)Ge69(β^+)Ga69(n,2nt)Zn65							2.1
Ge68	270.95 d	Ge70(n,2n)Ge69(n,2n)Ge68				97.8			
		Ge70(n,3n)Ge68					92.0	89.4	69.5
		Ge72(n,3n)Ge70(n,3n)Ge68					6.5	6.9	2.2
		Ge72(n,5n)Ge68							21.8
Co60	5.271 y	**&**Ge70(n,nα)Zn66(n,2n)Zn65(n,nα)Ni61_ (n,d)*Co60*				15.7	0.7		
		&Ge70(n,nα)Zn66(n,nα)Ni62(n,2n)Ni61_ (n,d)*Co60*				22.9	1.4		
		&Ge70(n,nα)Zn66(n,α)Ni63(β^-)Cu63_ (n,α)*Co60*				11.3			
		&Ge70(n,nα)Zn66(n,2n)Zn65(n,2n)Zn64_ (n,d)Cu63(n,α)*Co60*				7.6			
		&Ge70(n,2nα)Zn65(β^+)Cu65(n,2nα)*Co60*					20.5	55.2	6.9
		&Ge70(n,nα)Zn66(n,2nα)Ni61(n,d)*Co60*					7.7	0.5	
		&Ge70(n,nα)Zn66(n,3n)Zn64(n,pα)*Co60*					6.2		
		&Ge70(n,nα)Zn66(n,nα)Ni62(n,t)*Co60*					5.5	0.4	
		&Ge70(n,2nα)Zn65(n,nα)Ni61(n,d)*Co60*					4.6	0.2	
		&Ge70(n,n2α)Ni62(n,t)*Co60*					3.0	6.4	1.5
		&Ge70(n,dα)Cu65(n,2nα)*Co60*					0.7	7.2	1.3
		&Ge70(n,2nα)Zn65(n,dα)*Co60*					0.5	5.0	
		&Ge72(n,3nα)Zn66(n,tα)*Co60*							7.7
		&Ge70(n,nα)Zn66(n,tα)*Co60*							7.3
		&Ge70(n,tα)Cu64(β^+)Ni64(n,2nt)*Co60*							4.5
		Other pathways				42.5	49.2	25.1	70.8
Kr85	10.752 y	Very long pathways of (n,γ), β^-	100.0	100.0	100.0				
H3	12.33 y	Ge70(n,γ)Ge71(n,X)H1(n,γ)H2(n,γ)H3	92.1	95.1	99.2				
		Ge73(n,X)H3				45.1	12.9	10.2	9.1
		&Ge74(n,2n)*Ge73*(n,X)H3				25.0	2.8	1.2	
		Ge70(n,2n)Ge69(β^+)Ga69(n,X)H3				11.2	1.5	0.6	
		Ge72(n,2n)Ge71(β^+)Ga71(n,X)H3				7.9	1.8	0.7	
		Ge70(n,d)Ga69(n,X)H3				3.0	0.9	0.4	
		Ge70(n,X)H3				2.0	18.7	19.1	17.8
		Ge72(n,X)H3				1.3	24.0	25.4	25.5
		Ge74(n,X)H3				0.1	26.2	28.6	31.6
		Ge76(n,X)H3					4.3	5.7	6.6
		Ge74(n,3n)Ge72(n,X)H3					1.6	1.4	
Ni63	100.6 y ►	**&**Ge70(n,γ)Ge71(n,α)Zn68(n,γ)*Zn69*(β^-)_ Ga69(n,α)Cu66(β^-)Zn66(n,α)Ni63	91.6						

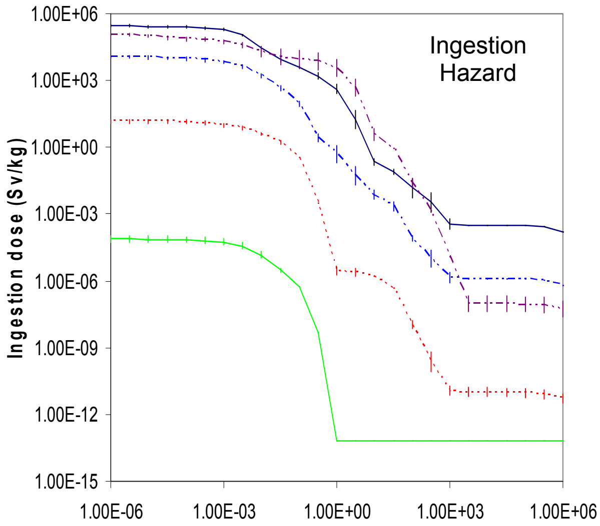
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	Ge70(n,α)Zn67(n,α)Ni64(n,γ)Ni65(β^-)_ Cu65(n,γ)Cu66(β^-)Zn66(n,α)Ni63	7.8						
		Ge70(n,nα)Zn66(n,α)Ni63				67.6	6.0	0.5	2.7
		Ge70(n,α)Zn67(n,nα)Ni63				20.6	5.5	0.6	1.7
		Ge70(n,2α)Ni63				0.2	29.3	6.2	1.5
		Ge70(n,2nα)Zn65(β^+)Cu65(n,t)Ni63					6.0	17.5	5.4
		Ge70(n,2n)Ge69(β^+)Ga69(n,3n)Ga67(β^+)_ Zn67(n,nα)Ni63					5.9	0.4	
		Ge70(n,3n)Ge68(β^+)Ga68(β^+)Zn68(n,2nα)Ni63					3.7	11.8	2.4
		Ge70(n,t)Ga68(β^+)Zn68(n,2nα)Ni63					3.5	32.1	7.7
		Ge70(n,nt)Ga67(β^+)Zn67(n,nα)Ni63					0.3	2.7	10.3
		Ge72(n,2n2α)Ni63							16.6
Ni59	7.6 10^4 y	Ge70(n,nα)Zn66(n,2n)Zn65(n,2n)Zn64_ (n,nα)Ni60(n,2n)Ni59				23.4			
		Ge70(n,nα)Zn66(n,nα)Ni62(n,2n)Ni61_ (n,2n)Ni60(n,2n)Ni59				22.6			
		Ge70(n,nα)Zn66(n,2n)Zn65(n,nα)Ni61_ (n,2n)Ni60(n,2n)Ni59				17.5			
		Ge70(n,nα)Zn66(n,2n)Zn65(β^+)Cu65_ (n,2n)Cu64(β^-)Zn64(n,nα)Ni60(n,2n)Ni59				12.3			
		Ge70(n,2n)Ge69(β^+)Ga69(n,nα)Cu65_ (n,2n)Cu64(β^-)Zn64(n,nα)Ni60(n,2n)Ni59				7.7			
		Ge70(n,nα)Zn66(n,2nα)Ni61(n,3n)Ni59					11.9	4.1	
		Ge70(n,nα)Zn66(n,3n)Zn64(n,2nα)Ni59					9.5	4.7	
		Ge70(n,2nα)Zn65(n,2nα)Ni60(n,2n)Ni59					9.2	4.6	
		Ge70(n,2nα)Zn65(n,nα)Ni61(n,3n)Ni59					7.2	2.2	
		Ge70(n,2nα)Zn65(β^+)Cu65(n,nα)Co61_ (β^-)Ni61(n,3n)Ni59					6.0	1.9	
		Ge70(n,3nα)Zn64(n,2nα)Ni59						22.4	28.9
		Ge70(n,2nα)Zn65(n,3nα)Ni59						5.9	6.8
Kr81	2.1 10^5 y	**&**Ge76(n,γ)Ge77m(β^-)As77(β^-)Se77_ (n,γ)Se78(n,γ)Se79m(β^-)Br79(n,γ)*Br80*_ (β^-)Kr80(n,γ)*Kr81*	38.7	44.3	48.3				
		&Ge76(n,γ)Ge77(β^-)As77(β^-)Se77(n,γ)_ Se78(n,γ)Se79m(β^-)Br79(n,γ)*Br80*(β^-)_ Kr80(n,γ)*Kr81*	31.8	36.4	39.9				
		&Ge74(n,γ)Ge75(β^-)As75(n,γ)As76(β^-)_ Se76(n,γ)Se77(n,γ)Se78(n,γ)Se79m(β^-)_ Br79(n,γ)*Br80*(β^-)Kr80(n,γ)*Kr81*	12.7						
		&Ge76(n,γ)Ge77m(β^-)As77(n,γ)As78_ (β^-)Se78(n,γ)Se79m(β^-)Br79(n,γ)*Br80*_ (β^-)Kr80(n,γ)*Kr81*		4.3					
		&Ge76(n,γ)Ge77(β^-)As77(n,γ)As78(β^-)_ Se78(n,γ)Se79m(β^-)Br79(n,γ)*Br80*(β^-)_ Kr80(n,γ)*Kr81*		3.5					
Se79	1.1 10^6 y	**&**Ge76(n,γ)Ge77m(β^-)As77(β^-)Se77_ (n,γ)Se78(n,γ)*Se79*	32.9	45.9	48.5	19.7	20.1	20.5	20.8
		&Ge74(n,γ)*Ge75*(β^-)As75(n,γ)As76(β^-)_ Se76(n,γ)*Se77*(n,γ)Se78(n,γ)*Se79*	31.1						
		&Ge76(n,γ)*Ge77*(β^-)As77(β^-)Se77(n,γ)_ Se78(n,γ)*Se79*	27.2	37.8	40.0	79.9	79.6	78.2	79.9
		&Ge76(n,γ)Ge77m(β^-)As77(n,γ)As78_ (β^-)Se78(n,γ)*Se79*		2.6					
		&Ge76(n,γ)Ge77(β^-)As77(n,γ)As78(β^-)_ Se78(n,γ)*Se79*		2.2					
Fe60	1.5 10^6 y	Ge70(n,nα)Zn66(n,α)Ni63(n,α)Fe60				68.3	0.2		
		Ge70(n,α)Zn67(n,nα)Ni63(n,α)Fe60				20.8	0.1		
		Ge70(n,2nα)Zn65(β^+)Cu65(n,2n)Cu64_ (β^+)Ni64(n,nα)Fe60					11.4	9.1	
	►	Ge70(n,t)Ga68(β^+)Zn68(n,nα)Ni64(n,nα)Fe60					10.5	7.4	

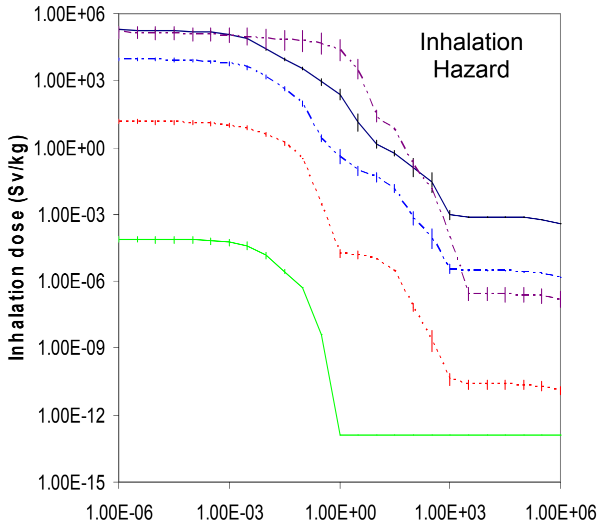
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Ge70(n,2n)Ge69(β^+)Ga69(n,2nα)Cu64_ (β^+)Ni64(n,nα)Fe60					10.3	12.5	
		Ge70(n,nα)Zn66(n,t)Cu64(β^+)Ni64(n,nα)Fe60					9.7	6.8	1.3
		Ge70(n,3n)Ge68(β^+)Ga68(β^+)Zn68(n,nα)_ Ni64(n,nα)Fe60					9.7	2.3	
		Ge72(n,nα)Zn68(n,nα)Ni64(n,nα)Fe60					5.9	0.6	
		Ge70(n,d)Ga69(n,2nα)Cu64(β^+)Ni64_ (n,nα)Fe60					5.7	8.0	
		Ge70(n,tα)Cu64(β^+)Ni64(n,nα)Fe60						1.7	45.1
		Ge70(n,nt)Ga67(β^+)Zn67(n,nt)Cu64(β^+)_ Ni64(n,nα)Fe60						0.9	6.1

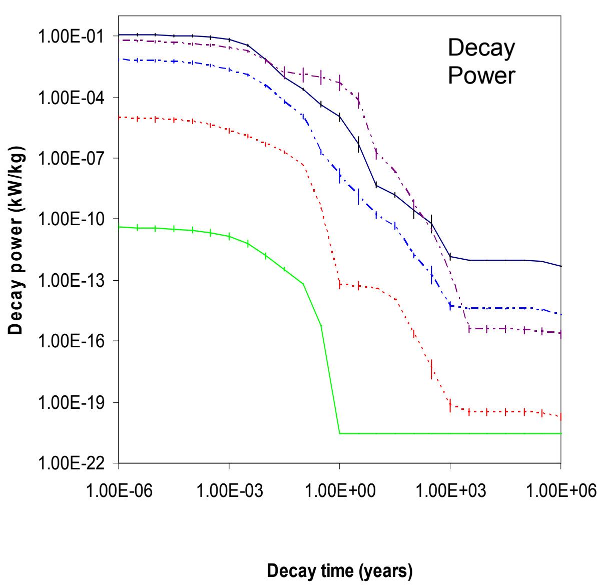
Germanium activation characteristics

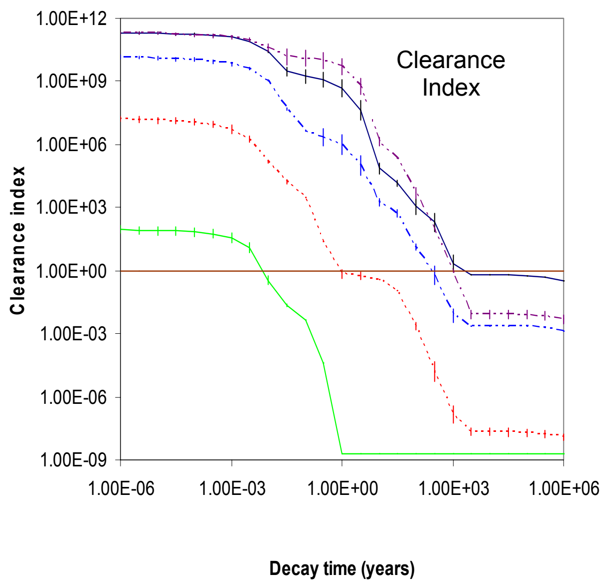






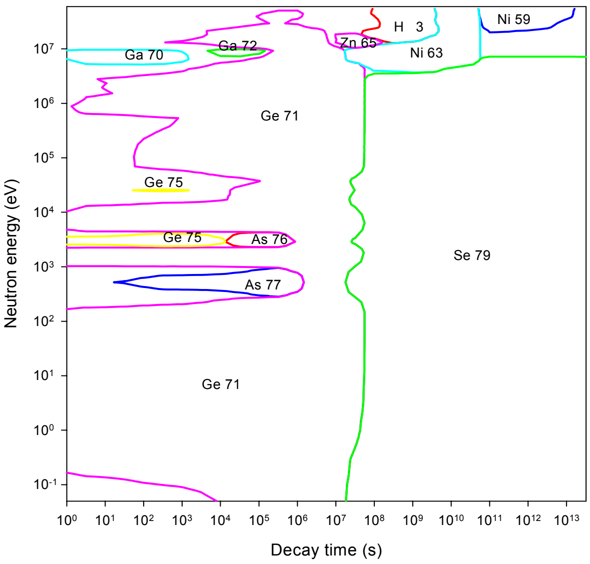




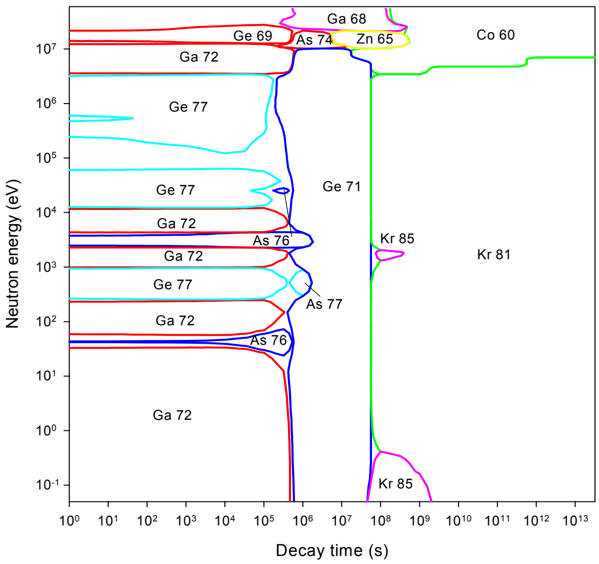


Germanium importance diagrams & transmutation

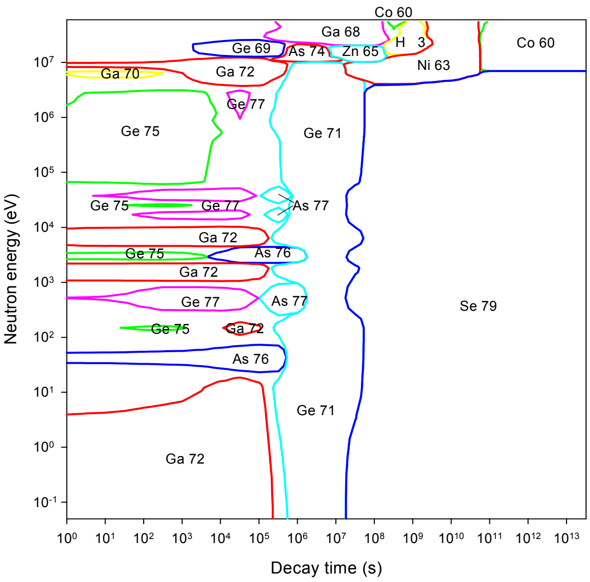
Activity



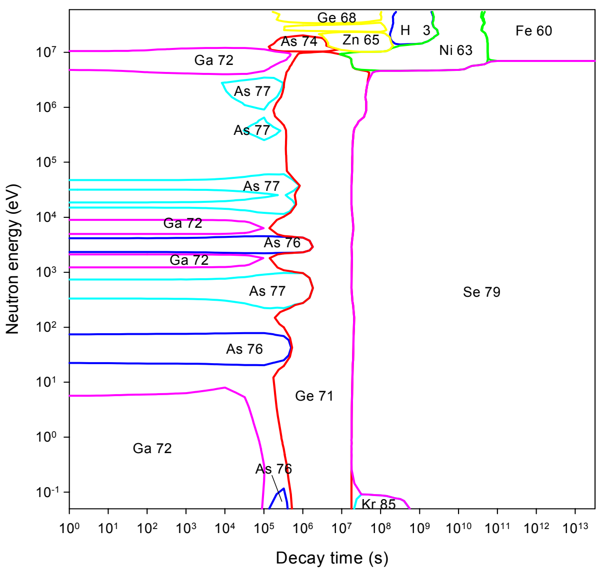
Dose rate



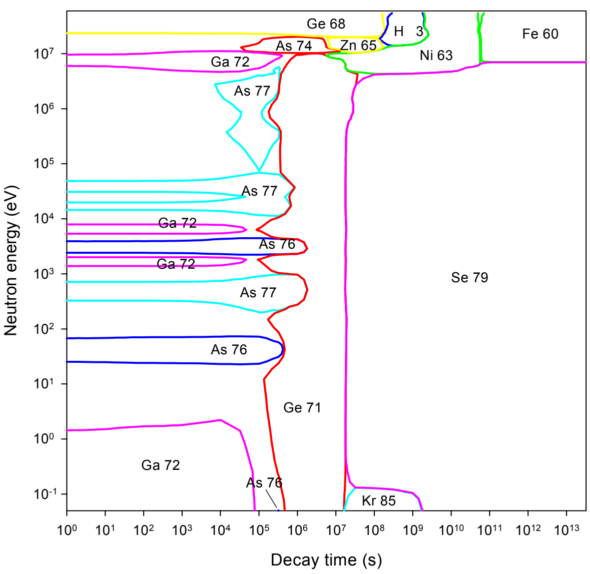
Heat output



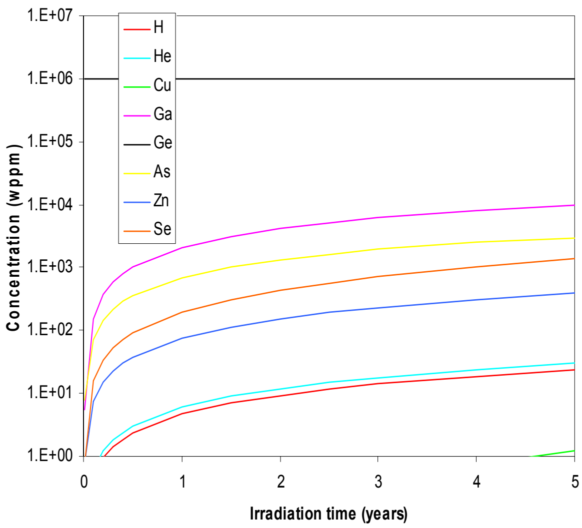
Ingestion dose



Inhalation dose



First wall transmutation



Arsenic

General properties

Property	Value	Isotopes	Isotopic abundances / %
Atomic number	33		
Crustal abundance / wppm	1.8	As75	100.0
Melting point / K	1090		
Boiling point / K	887 (sublimes)		
Density / kgm^{-3}	5730		
Thermal conductivity / $Wm^{-1}K^{-1}$	50		
Electrical resistivity /Ωm	$2.6\ 10^{-7}$		
Coefficient of thermal expansion / K^{-1}	$4.7\ 10^{-6}$		
Crystal structure	rhombohedral		
Number of stable isotopes	1		
Mean atomic weight	74.9216		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.41E16	1.36E16	2.35E15	5.32E13	1.08E8	1.10E6
As76	87.69	90.54	51.90			
As74	5.69	5.89	29.60			
Se75	3.11	3.22	18.30	99.77		
Se77m	3.01					
H3				0.05	98.92	
Se79					1.07	100.0

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	3.12E0	3.10E0	4.33E-1	3.44E-3	1.08E-10	9.80E-12
As76	94.24	94.58	66.98			
As74	4.24	4.27	26.52			
Se75	0.91	0.92	6.48	99.97		
Se77m	0.35					
H3					90.37	
Se79					9.63	100.0

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	1.38E6	1.37E6	2.51E5	2.25E3	3.21E-12	2.31E-12
As76	88.55	88.67	48.03			
As74	9.37	9.40	44.64			
Se75	1.35	1.36	7.29	99.99		
Ga72	0.53	0.53	0.03			
Kr81					99.95	100.0

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	2.24E7	2.20E7	3.98E6	1.38E5	7.89E-3	3.18E-3
As76	88.59	89.96	49.08			
Se75	5.12	5.21	28.13	99.98		
As74	4.67	4.75	22.75			
H3					57.04	
Se79					42.94	99.97

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.18E7	1.14E7	2.93E6	6.91E4	3.58E-2	7.49E-3
As76	77.86	80.09	30.85			
As74	14.35	14.79	49.94			
Se75	4.86	5.01	19.11	99.85		
As77	0.03	0.03	0.02			
As73	0.01	0.01	0.07	0.13		
H3				0.01	77.71	
Se79					22.16	99.55

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	1.81E12	1.76E12	6.23E11	5.30E10	1.08E3	6.09E0
As76	68.52	70.18	19.62			
Se75	24.36	25.01	69.19	100.0		
As74	4.45	4.56	11.19			
Se77m	2.35	0.05				
Ga72	0.04					
H3					99.40	
Se79					0.60	100.0

Arsenic

Pathway analysis

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Se77m	17.36 s	As75(n,γ)As76(β^-)Se76(n,γ)Se77m	100.0	100.0	100.0	95.8	97.2	97.9	98.7
		As75(n,γ)As76(β^-)Se76(n,γ)Se77(n,n′)Se77m				1.3	0.9	0.7	0.4
Se79m	3.90 m	**&**As75(n,γ)As76(β^-)Se76(n,γ)*Se77*(n,γ)_ Se78(n,γ)Se79m	99.8	94.7	99.2	98.2	98.6	99.2	99.5
		As75(n,γ)As76(n,γ)As77(β^-)Se77(n,γ)_ Se78(n,γ)Se79m	0.1	5.1	0.8	0.1			
Ga68	1.128 h	As75(n,2n)As74(β^-)Se74(n,nα)Ge70_ (n,2n)Ge69(β^+)Ga69(n,2n)Ga68				23.4	0.4		
		&As75(n,α)Ga72(β^-)Ge72(n,α)*Zn69*(β^-)_ Ga69(n,2n)Ga68				19.0			
		&As75(n,2n)As74(β^+)Ge74(n,2n)Ge73_ (n,nα)*Zn69*(β^-)Ga69(n,2n)Ga68				8.9			
		As75(n,nα)Ga71(n,2n)Ga70(β^-)Ge70_ (n,2n)Ge69(β^+)Ga69(n,2n)Ga68				6.9	0.6		
		As75(n,2n)As74(β^-)Se74(n,nα)Ge70(n,d)_ Ga69(n,2n)Ga68				6.3	0.2		
		As75(n,nα)Ga71(n,3n)Ga69(n,2n)Ga68					20.1	0.7	
		&As75(n,3n)As73(β^+)Ge73(n,nα)*Zn69*_ (β^-)Ga69(n,2n)Ga68					19.7	0.8	
		As75(n,3n)As73(β^+)Ge73(n,3n)Ge71(β^+)_ Ga71(n,3n)Ga69(n,2n)Ga68					8.2	0.4	
		As75(n,3n)As73(n,nα)Ga69(n,2n)Ga68					4.9	0.1	
		As75(n,3n)As73(n,2nα)Ga68					4.6	5.9	0.4
		As75(n,2nα)Ga70(β^-)Ge70(n,3n)Ge68(β^+)Ga68					4.1	14.5	1.4
		As75(n,2nα)Ga70(β^-)Ge70(n,t)Ga68					3.3	33.3	3.7
		As75(n,3n)As73(β^+)Ge73(n,4n)Ge70(n,t)Ga68						5.2	0.6
		As75(n,nα)Ga71(n,4n)Ga68						5.1	2.7
		As75(n,3n)As73(β^+)Ge73(n,3n)Ge71(β^+)_ Ga71(n,4n)Ga68						4.7	0.5
		As75(n,3nα)Ga69(n,2n)Ga68						1.5	8.5
		As75(n,2nt)Ge71(β^+)Ga71(n,4n)Ga68						0.1	14.3
		As75(n,4nα)Ga68							23.9
		As75(n,4n)As72(β^+)Ge72(n,2nt)Ga68							6.8
		As75(n,nt)Ge72(n,2nt)Ga68							6.5
		As75(n,5n)As71(β^+)Ge71(β^+)Ga71(n,4n)Ga68							5.8
		Other pathways				35.5	33.9	27.7	24.9
Ge75	1.380 h	**&**As75(n,γ)As76(β^-)Se76(n,γ)*Se77*(n,α)_ Ge74(n,γ)*Ge75*	96.3	84.6	88.4				
		&As75(n,γ)As76(n,γ)As77(β^-)Se77(n,α)_ Ge74(n,γ)*Ge75*		4.6	0.7				
		&As75(n,p)*Ge75*				100.0	100.0	100.0	100.0
Ga72	14.10 h	As75(n,α)Ga72				97.5	31.3	18.1	53.4
		As75(n,3n)As73(β^+)Ge73(n,d)Ga72					53.9	46.9	16.2
		&As75(n,t)*Ge73*(n,d)Ga72					5.3	12.9	9.2
		As75(n,2n)As74(β^+)Ge74(n,t)Ga72					2.9	11.0	9.6
		As75(n,d)Ge74(n,t)Ga72					1.1	7.5	8.1
As72	1.083 d	As75(n,2n)As74(β^-)Se74(n,d)As73(n,2n)As72				46.8	0.8		
		&As75(n,2n)As74(β^-)Se74(n,2n)*Se73m*_ (β^+)As73(n,2n)As72				25.6	0.1		
		As75(n,2n)As74(β^-)Se74(n,2n)Se73(β^+)_ As73(n,2n)As72				21.9	0.6		
		As75(n,2n)As74(n,2n)As73(n,2n)As72				5.2			
		As75(n,3n)As73(n,2n)As72					39.9	2.9	0.2
		As75(n,2n)As74(β^-)Se74(n,3n)Se72(β^+)As72					25.8	3.7	
		As75(n,2n)As74(β^-)Se74(n,t)As72					25.0	11.7	1.0
	►	As75(n,2n)As74(n,3n)As72					5.0	0.4	

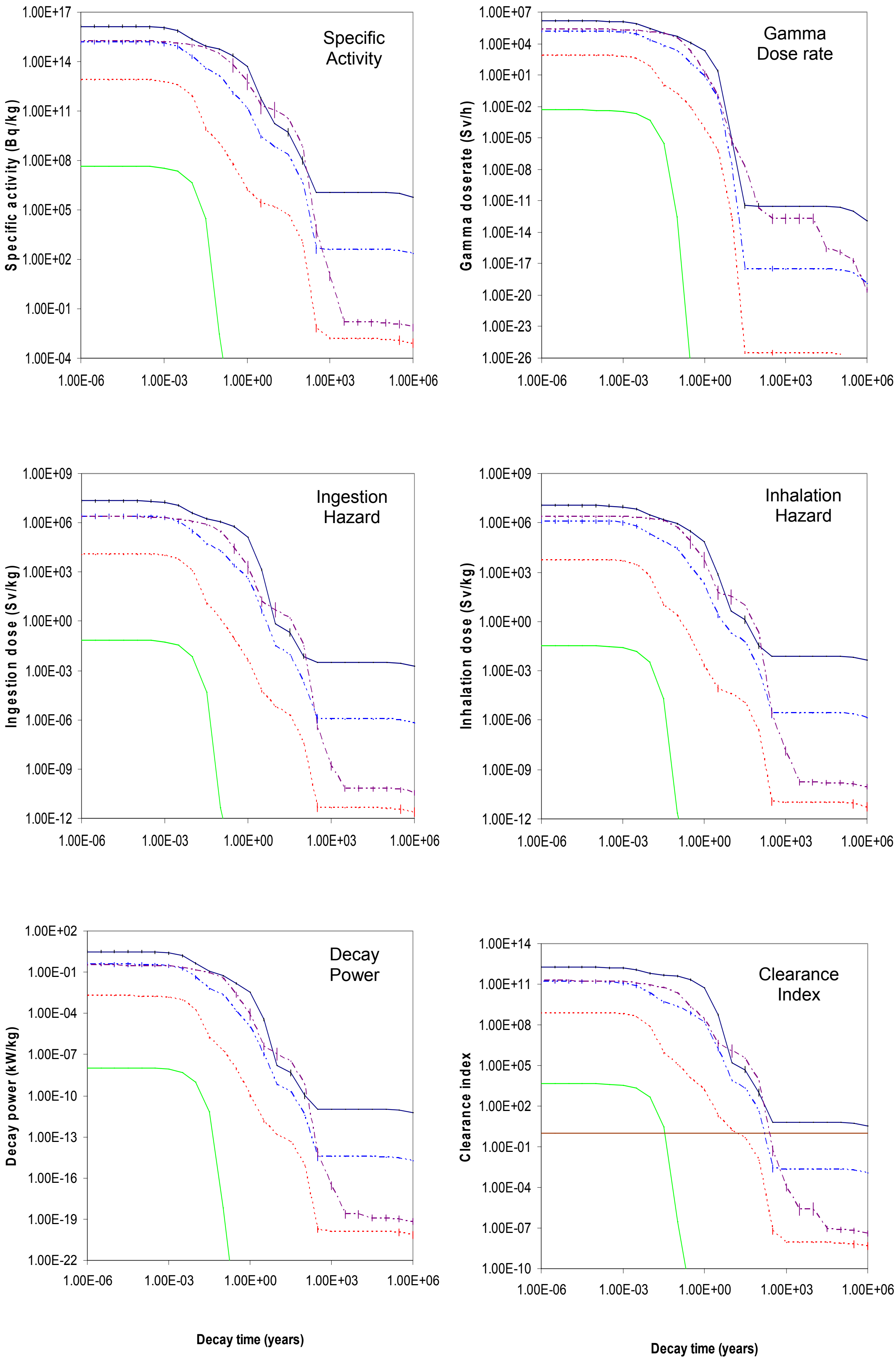
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	As75(n,4n)As72						80.8	98.4
As76	1.093 d	As75(n,γ)As76	100.0	100.0	100.0	98.8	99.5	99.7	99.8
Br82	1.472 d	**&**As75(n,γ)As76(β^-)Se76(n,γ)*Se77*(n,γ)_ Se78(n,γ)*Se79*(n,γ)Se80(n,γ)*Se81*(β^-)_ Br81(n,γ)*Br82*	84.5	76.7	71.4				
		&As75(n,γ)As76(n,γ)As77(β^-)Se77(n,γ)_ Se78(n,γ)*Se79*(n,γ)Se80(n,γ)*Se81*(β^-)_ Br81(n,γ)*Br82*	0.1	8.0	1.3				
As77	1.618 d	As75(n,γ)As76(n,γ)As77	100.0	100.0	100.0	10.5	6.4	9.2	17.1
		&As75(n,γ)As76(β^-)Se76(n,γ)*Se77*(n,p)As77				89.1	93.3	90.7	82.9
Ge71	11.43 d	As75(n,2n)As74(β^-)Se74(n,α)Ge71				41.2	0.5	0.3	0.7
		As75(n,α)Ga72(β^-)Ge72(n,2n)Ge71				35.9	0.7	0.2	0.2
		&As75(n,2n)As74(β^+)Ge74(n,2n)*Ge73*_ (n,2n)Ge72(n,2n)Ge71				16.0			
		As75(n,3n)As73(β^+)Ge73(n,3n)Ge71					73.4	55.6	4.3
		As75(n,t)Ge73(n,3n)Ge71					6.6	13.7	2.2
		As75(n,nt)Ge72(n,2n)Ge71					0.4	4.6	3.8
		As75(n,2n)As74(β^+)Ge74(n,4n)Ge71						6.5	3.3
		As75(n,d)Ge74(n,4n)Ge71						4.4	2.8
		As75(n,2nt)Ge71						0.8	53.8
		As75(n,5n)As71(β^+)Ge71							23.3
As74	17.78 d	As75(n,2n)As74				98.7	99.4	99.5	99.7
As73	80.301 d	As75(n,2n)As74(β^-)Se74(n,d)As73				46.9	2.0	0.6	0.7
		&As75(n,2n)As74(β^-)Se74(n,2n)*Se73*(β^+)As73				40.6	2.1	0.6	
		As75(n,2n)As74(β^-)Se74(n,2n)Se73m(β^+)As73				7.0	0.3		
		As75(n,2n)As74(n,2n)As73				5.3			
		As75(n,3n)As73					95.3	98.6	98.5
Se75	119.64 d	As75(n,γ)As76(β^-)Se76(n,2n)Se75				60.4	78.7	76.3	76.4
		As75(n,2n)As74(β^-)Se74(n,γ)Se75				39.4	21.2	23.7	23.6
Zn65	244.15 d	As75(n,2n)As74(β^-)Se74(n,nα)Ge70_ (n,nα)Zn66(n,2n)Zn65				57.9	0.9		
		As75(n,nα)Ga71(n,2n)Ga70(β^-)Ge70_ (n,nα)Zn66(n,2n)Zn65				17.1	1.3		
		As75(n,2n)As74(β^-)Se74(n,α)Ge71(β^+)Ga71_ (n,2n)Ga70(β^-)Ge70(n,nα)Zn66(n,2n)Zn65				4.6			
		As75(n,α)Ga72(β^-)Ge72(n,2n)Ge71(β^+)Ga71_ (n,2n)Ga70(β^-)Ge70(n,nα)Zn66(n,2n)Zn65				4.2			
		As75(n,nα)Ga71(n,nα)Cu67(β^-)Zn67(n,3n)Zn65					13.1	0.2	
		As75(n,2nα)Ga70(β^-)Ge70(n,2nα)Zn65					12.3	57.9	6.0
		As75(n,nα)Ga71(n,2n)Ga70(β^-)Ge70_ (n,2nα)Zn65					7.8	0.6	
		As75(n,2n)As74(β^-)Se74(n,nα)Ge70_ (n,2nα)Zn65					5.8	0.4	
		As75(n,nα)Ga71(n,3n)Ga69(n,3n)Ga67_ (β^+)Zn67(n,3n)Zn65					3.2		
		As75(n,nt)Ge72(n,3n)Ge70(n,2nα)Zn65					0.5	3.7	0.7
		As75(n,3n)As73(β^+)Ge73(n,4n)Ge70_ (n,2nα)Zn65						7.5	0.8
		As75(n,3n)As73(β^+)Ge73(n,3n)Ge71(β^+)_ Ga71(n,nα)Cu67(β^-)Zn67(n,3n)Zn65						4.5	
		As75(n,3nα)Ga69(n,2nt)Zn65							22.1
		As75(n,4n)As72(β^+)Ge72(n,4nα)Zn65							9.9
		As75(n,nt)Ge72(n,4nα)Zn65							9.4
		As75(n,4nα)Ga68(β^+)Zn68(n,4n)Zn65							5.9
Co60	5.271 y	**&**As75(n,2n)As74(β^-)Se74(n,nα)Ge70_ (n,nα)Zn66(n,nα)Ni62(n,2n)Ni61(n,d)*Co60*				13.5			
		&As75(n,2n)As74(β^-)Se74(n,nα)Ge70_ (n,nα)Zn66(n,2n)Zn65(n,nα)Ni61(n,d)*Co60*				11.4			
	►	**&**As75(n,2n)As74(β^-)Se74(n,nα)Ge70_ (n,nα)Zn66(n,α)Ni63(β^-)Cu63(n,α)*Co60*				6.7			

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**As75(n,nα)Ga71(n,3n)Ga69(n,nα)_ Cu65(n,2nα)*Co60*					9.5	0.2	
		&As75(n,2nα)Ga70(β^-)Ge70(n,2nα)_ Zn65(β^+)Cu65(n,2nα)*Co60*					3.3	35.9	0.2
		&As75(n,2nα)Ga70(β^-)Ge70(n,n2α)_ Ni62(n,t)*Co60*					0.6	4.8	
		&As75(n,2nα)Ga70(β^-)Ge70(n,dα)Cu65_ (n,2nα)*Co60*					0.1	5.3	
		&As75(n,3n)As73(β^+)Ge73(n,nα)*Zn69*_ (β^-)Ga69(n,nα)Cu65(n,2nα)*Co60*						6.5	
		&As75(n,2nα)Ga70(β^-)Ge70(n,2nα)_ Zn65(n,dα)*Co60*						5.0	
		&As75(n,3nα)Ga69(n,2n2α)*Co60*							28.8
		Other pathways involving (n,nα), (n,α), β^-				68.4	86.5	42.3	71.0
Kr85	10.752 y	Very long pathways of (n,γ), β^-	100.0	100.0	100.0				
H3	12.33 y	As75(n,γ)As76(n,X)H1(n,γ)H2(n,γ)H3	93.4	95.2	99.3				
		As75(n,X)H3				94.1	91.7	91.6	92.3
		As75(n,2n)As74(n,X)H3				4.3	0.2		
		As75(n,3n)As73(β^+)Ge73(n,X)H3					3.9	3.6	1.3
		As75(n,2n)As74(β^+)Ge74(n,X)H3					1.2	0.8	0.6
Ni63	100.6 y	As75(n,2n)As74(β^-)Se74(n,nα)Ge70_ (n,nα)Zn66(n,α)Ni63				36.6	0.1		
		As75(n,2n)As74(β^-)Se74(n,nα)Ge70_ (n,α)Zn67(n,nα)Ni63				11.2			
		As75(n,nα)Ga71(n,2n)Ga70(β^-)Ge70_ (n,nα)Zn66(n,α)Ni63				10.9	0.1		
		As75(n,nα)Ga71(n,nα)Cu67(β^-)Zn67(n,nα)Ni63				5.8	23.9	0.3	
		As75(n,3n)As73(β^+)Ge73(n,2nα)Zn68_ (n,2nα)Ni63					5.2	19.2	0.4
		As75(n,nα)Ga71(n,3n)Ga69(n,3n)Ga67_ (β^+)Zn67(n,nα)Ni63					4.9	0.1	
		As75(n,3n)As73(n,2nα)Ga68(β^+)Zn68_ (n,2nα)Ni63					0.8	5.9	
		As75(n,t)Ge73(n,2nα)Zn68(n,2nα)Ni63					0.5	5.3	0.2
		As75(n,2nα)Ga70(β^-)Ge70(n,2nα)Zn65_ (β^+)Cu65(n,t)Ni63					0.3	6.0	0.2
		As75(n,2nα)Ga70(β^-)Ge70(n,t)Ga68(β^+)_ Zn68(n,2nα)Ni63					0.2	12.6	0.3
		As75(n,3n)As73(β^+)Ge73(n,3n)Ge71(β^+)_ Ga71(n,nα)Cu67(β^-)Zn67(n,nα)Ni63						6.9	
		As75(n,3nα)Ga69(n,tα)Ni63						0.1	27.1
		As75(n,4n)As72(β^+)Ge72(n,2n2α)Ni63							8.3
		As75(n,nt)Ge72(n,2n2α)Ni63							7.9
		As75(n,4nα)Ga68(β^+)Zn68(n,2nα)Ni63							6.7
		Many other similar pathways				35.5	64.0	43.6	48.9
Ni59	7.6 10^4 y	As75(n,2n)As74(β^-)Se74(n,nα)Ge70_ (n,nα)Zn66(n,2n)Zn65(n,2n)Zn64(n,nα)_ Ni60(n,2n)Ni59				13.5			
		As75(n,2n)As74(β^-)Se74(n,nα)Ge70_ (n,nα)Zn66(n,nα)Ni62(n,2n)Ni61(n,2n)_ Ni60(n,2n)Ni59				11.2			
		As75(n,2n)As74(β^-)Se74(n,nα)Ge70_ (n,nα)Zn66(n,2n)Zn65(n,nα)Ni61(n,2n)_ Ni60(n,2n)Ni59				10.1			
		As75(n,nα)Ga71(n,2n)Ga70(β^-)Ge70_ (n,nα)Zn66(n,2n)Zn65(n,2n)Zn64(n,nα)_ Ni60(n,2n)Ni59				4.8			
	►	As75(n,nα)Ga71(n,2n)Ga70(β^-)Ge70_ (n,nα)Zn66(n,2n)Zn65(n,2n)Zn64(n,nα)_ Ni60(n,2n)Ni59				4.2			

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	As75(n,nα)Ga71(n,2n)Ga70(β^-)Ge70_ (n,nα)Zn66(n,2n)Zn65(n,nα)Ni61(n,2n)_ Ni60(n,2n)Ni59				3.0			
		As75(n,nα)Ga71(n,2n)Ga70(β^-)Ge70_ (n,nα)Zn66(n,nα)Ni62(n,2n)Ni61(n,2n)_ Ni60(n,2n)Ni59				3.5			
		As75(n,nα)Ga71(n,2n)Ga70(β^-)Ge70_ (n,nα)Zn66(n,2n)Zn65(n,nα)Ni61(n,2n)_ Ni60(n,2n)Ni59				3.1			
		As75(n,nα)Ga71(n,3n)Ga69(n,2nα)Cu64_ (β^-)Zn64(n,2nα)Ni59					3.7	1.4	
		As75(n,2nα)Ga70(β^-)Ge70(n,3nα)Zn64_ (n,2nα)Ni59						14.3	3.7
		As75(n,3nα)Ga69(n,2nα)Cu64(β^-)Zn64_ (n,2nα)Ni59						5.7	2.0
		As75(n,2nα)Ga70(β^-)Ge70(n,2nα)Zn65_ (n,3nα)Ni59						4.8	1.1
		As75(n,3nα)Ga69(n,3nα)Cu63(n,2nt)Ni59							8.2
		As75(n,3nα)Ga69(n,2nt)Zn65(n,3nα)Ni59							4.0
		Other pathways involving (n,nα), (n,α), β^-				46.6	96.3	73.8	81.0
Kr81	2.1 10^5 y	**&**As75(n,γ)As76(β^-)Se76(n,γ)*Se77*(n,γ)_ Se78(n,γ)Se79m(β^-)Br79(n,γ)*Br80*(β^-)_ Kr80(n,γ)*Kr81*	99.8	89.8	98.1				
		&As75(n,γ)As76(n,γ)As77(β^-)Se77(n,γ)_ Se78(n,γ)Se79m(β^-)Br79(n,γ)*Br80*(β^-)_ Kr80(n,γ)*Kr81*		9.2	1.5				
Se79	1.1 10^6 y	**&**As75(n,γ)As76(β^-)Se76(n,γ)*Se77*(n,γ)_ Se78(n,γ)*Se79*	99.9	93.2	98.9	99.5	99.6	99.8	99.8
		&As75(n,γ)As76(n,γ)As77(β^-)Se77(n,γ)_ Se78(n,γ)*Se79*	0.1	6.3	1.0	0.1			
Fe60	1.5 10^6 y	As75(n,2n)As74(β^-)Se74(n,nα)Ge70_ (n,nα)Zn66(n,α)Ni63(n,α)Fe60				35.3			
		As75(n,2n)As74(β^-)Se74(n,nα)Ge70_ (n,α)Zn67(n,nα)Ni63(n,α)Fe60				10.8			
		As75(n,nα)Ga71(n,2n)Ga70(β^-)Ge70_ (n,nα)Zn66(n,α)Ni63(n,α)Fe60				10.6			
		As75(n,nα)Ga71(n,nα)Cu67(β^-)Zn67_ (n,nα)Ni63(n,α)Fe60				7.1	0.7		
		As75(n,3n)As73(β^+)Ge73(n,2nα)Zn68_ (n,nα)Ni64(n,nα)Fe60					15.3	3.4	
		As75(n,nα)Ga71(n,3n)Ga69(n,2nα)Cu64_ (β^+)Ni64(n,nα)Fe60					11.7	3.8	
		As75(n,3n)As73(n,nα)Ga69(n,2nα)Cu64_ (β^+)Ni64(n,nα)Fe60					5.1	1.4	
		As75(n,3nα)Ga69(n,2nα)Cu64(β^+)Ni64_ (n,nα)Fe60						15.7	14.7
		As75(n,4nα)Ga68(β^+)Zn68(n,n2α)Fe60							6.2
		As75(n,2nt)Ge71(β^+)Ga71(n,4nα)Cu64_ (β^+)Ni64(n,nα)Fe60							6.1
		Many other similar pathways				36.2	67.2	75.7	73.0
Mn53	3.7 10^6 y	As75(n,2nα)Ga70(β^-)Ge70(n,2nα)Zn65_ (n,2nα)Ni60(n,2nα)Fe55(n,t)Mn53						6.6	
		As75(n,2nα)Ga70(β^-)Ge70(n,2nα)Zn65_ (n,2nα)Ni60(n,3n)Ni58(n,dα)Mn53						2.6	
		As75(n,2nα)Ga70(β^-)Ge70(n,2nα)Zn65_ (n,2nα)Ni60(n,dα)Mn55(n,3n)Mn53						1.6	
		As75(n,2nα)Ga70(β^-)Ge70(n,2nα)Zn65_ (n,2nα)Ni60(n,t)Co58(n,2nα)Mn53						1.3	
	►	As75(n,2nt)Ge71(β^+)Ga71(n,3nα)Cu65_ (n,3nα)Co59(n,3nα)Mn53							2.2

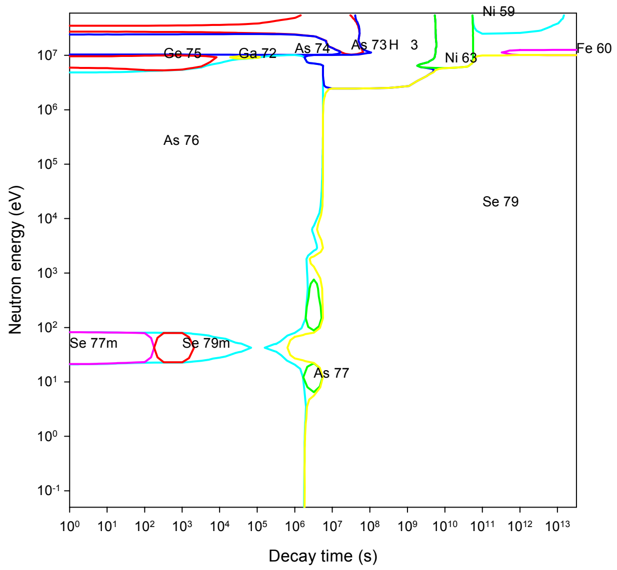
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	As75(n,3nα)Ga69(n,3nα)Cu63(n,nα)_ Co59(n,3nα)Mn53							1.5
		As75(n,3nα)Ga69(n,3n2α)Co59(n,3nα)Mn53							1.4
		Many other similar pathways				100.0	100.0	87.9	94.9

Arsenic activation characteristics

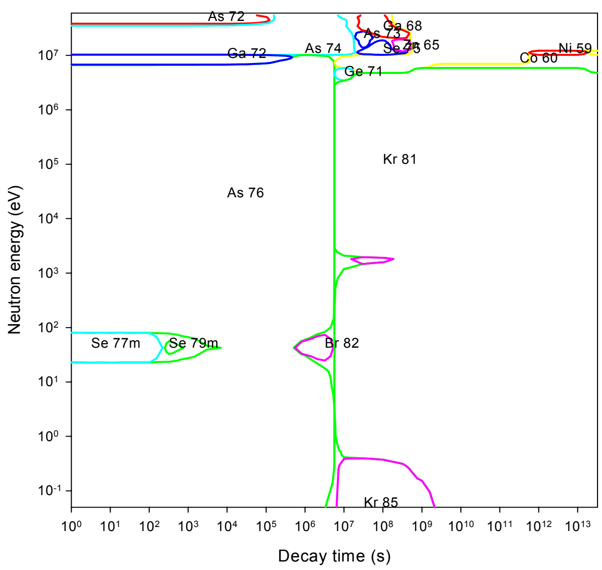


Arsenic importance diagrams & transmutation

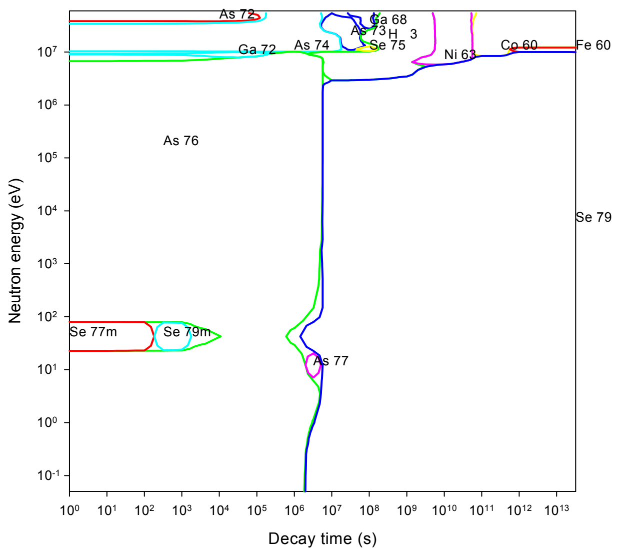
Activity



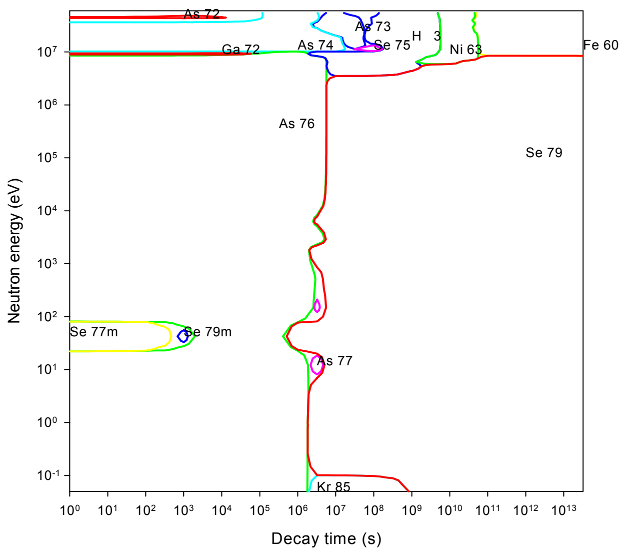
Dose rate



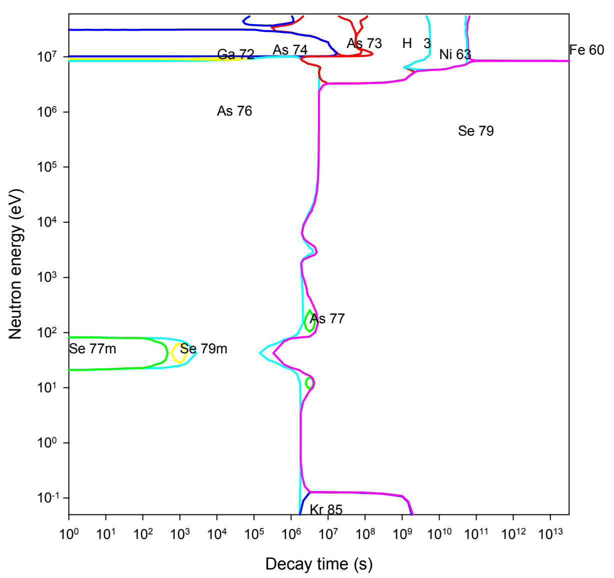
Heat output



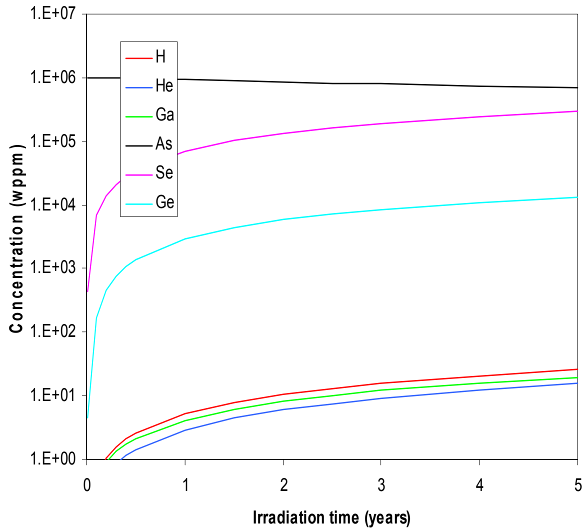
Ingestion dose



Inhalation dose



First wall transmutation



Selenium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	34		
Crustal abundance / wppm	$5.0\ 10^{-2}$	Se74	0.89
Melting point / K	494	Se76	9.37
Boiling point / K	958.1	Se77	7.63
Density / kgm^{-3}	4790	Se78	23.77
Thermal conductivity / $Wm^{-1}K^{-1}$	2.04	Se80	49.61
Electrical resistivity /Ωm	$1.0\ 10^{-2}$	Se82	8.73 ($T_{1/2} = 1.21\ 10^{20}$ y)
Coefficient of thermal expansion / K^{-1}	$3.69\ 10^{-5}$		
Crystal structure	Hexagonal		
Number of stable isotopes	5 (6)		
Mean atomic weight	78.96		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.89E15	1.05E15	2.17E14	2.24E13	2.84E9	2.65E9	kW kg^{-1}	1.40E-1	1.16E-1	2.26E-2	1.45E-3	2.52E-8	2.36E-8
Se77m	25.59						Br82	27.66	33.47	30.79			
Se79m	23.41	16.60					Se81	21.70	23.38				
Se81	16.23	26.08					As76	19.82	23.93	12.13			
Se75	9.81	17.69	83.52	99.79			Se77m	8.94					
Se81m	6.49	10.99					Se75	8.58	10.39	52.13	99.96		
As76	6.19	11.14	5.31				Se79m	4.84	2.30				
Br82	4.60	8.29	7.18				As80	1.56					
Br82m	4.28	4.24					Se81m	1.44	1.63				
Kr83m	0.90	1.58					As78	1.26	1.47				
As74	0.39	0.70	2.94				As74	0.86	1.05	4.67			
Se79				0.01	99.10	99.69	Br80	0.62	0.69				
H3				0.01	0.41		Se79					99.50	99.92

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	8.89E4	8.47E4	2.08E4	9.47E2	2.96E-6	1.19E-6	Sv kg^{-1}	1.36E6	8.46E5	5.13E5	5.97E4	1.15E1	8.15E0
Br82	68.55	71.97	52.49				Se75	35.48	56.95	92.00	97.29		
As76	13.19	13.82	5.55				As76	13.78	22.07	3.60			
Se75	8.83	9.28	36.91	99.99			Br82	3.45	5.54	1.64			
Se77m	2.49						As74	0.71	1.14	1.62			
As78	1.83	1.85					Se81	0.61	0.87				
As74	1.35	1.42	5.01				Se81m	0.47	0.72				
As80	0.93						As77	0.16	0.27	0.10			
Kr81					58.91	100.0	As78	0.06	0.10				
Kr85					51.08*		Se79				0.01	70.64	93.91

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.03E6	5.38E5	3.30E5	8.42E4	1.37E2	3.55E1		3.87E11	3.22E11	1.99E11	2.23E10	1.60E4	1.47E4
Se75	23.31	44.80	71.56	34.46			Se75	47.83	57.59	91.24	100.0		
As76	8.37	16.06	2.59				Br82	22.44	27.01	7.84			
Kr85	5.68	10.92	17.82	65.43	68.13		Se77m	12.47					
Br82	5.30	10.18	2.98				Se81	5.65	6.05				
As74	1.50	2.88	4.08				As76	3.01	3.62	0.58			
Se81m	0.60	1.09					Se79m	2.53	1.20				
Se81	0.44	0.76					As78	1.59	1.85				
As77	0.21	0.41	0.15				As80	0.99					
Kr81			0.01	0.03	17.89	49.50	As74	0.19	0.22	0.32			
Se79			0.01	0.02	13.97	50.49	Se79					97.86	99.57

Selenium

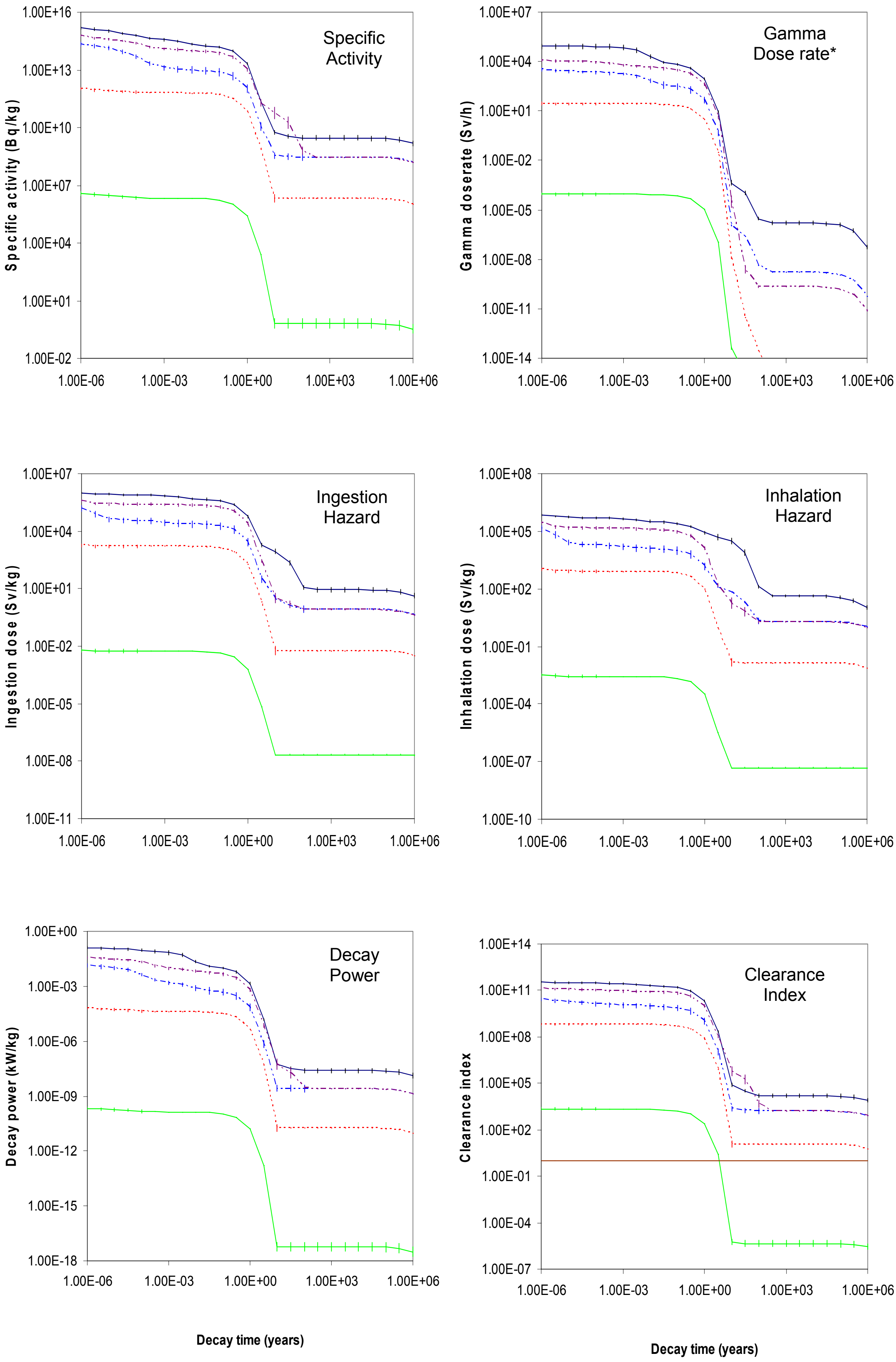
Pathway analysis

Nuclide	T½	Pathway	210	181	151	42	30	21	6
Se77m	17.36 s	Se76(n,γ)Se77m	63.0	100.0	100.0				
		Se74(n,γ)Se75(n,γ)Se76(n,γ)Se77m	29.4						
		Se74(n,γ)Se75(β^{+})As75(n,γ)As76(β^{-})_ Se76(n,γ)Se77m	7.6						
		Se78(n,2n)Se77m				79.2	60.5	34.3	22.6
		Se77(n,n′)Se77m				11.5	9.5	7.9	5.1
		&Se80(n,2n)*Se79*(n,2n)Se78(n,2n)Se77m				2.8	0.4		
		Se78(n,2n)Se77(n,n′)Se77m				1.6	0.4	0.2	
		Se80(n,3n)Se78(n,2n)Se77m					14.0	6.7	1.6
		&Se80(n,2n)*Se79*(n,3n)Se77m					9.5	4.5	1.0
		Se80(n,d)As79(β^{-})Se79m(IT)Se79(n,3n)Se77m					1.2	1.5	
		Se80(n,4n)Se77m						38.9	64.3
Se83m	1.168 m	Se82(n,γ)Se83m	100.0	100.0	100.0	99.9	99.3	99.4	99.7
Se81	18.45 m	**&**Se80(n,γ)*Se81*	99.8	100.0	100.0	0.3	0.2	0.2	0.2
		&Se82(n,2n)*Se81*				99.7	92.2	81.3	74.5
		Se82(n,d)As81(β^{-})Se81					7.6	18.5	25.3
Ga68	1.128 h	Se74(n,nα)Ge70(n,2n)Ge69(β^{+})Ga69(n,2n)Ga68				49.7	4.9	0.1	
		Se74(n,nα)Ge70(n,d)Ga69(n,2n)Ga68				13.3	2.7		
		Se74(n,nα)Ge70(n,3n)Ge68(β^{+})Ga68					18.0	2.3	0.2
		Se74(n,nα)Ge70(n,t)Ga68					14.2	5.2	0.6
		Se74(n,α)Ge71(β^{+})Ga71(n,2n)Ga70(β^{-})_ Ge70(n,2n)Ge69(β^{+})Ga69(n,2n)Ga68					6.0		
		Se74(n,2nα)Ge69(β^{+})Ga69(n,2n)Ga68					3.9	7.1	0.4
		Se76(n,2nα)Ge71(β^{+})Ga71(n,4n)Ga68						14.8	3.1
		Se76(n,3nα)Ge70(n,t)Ga68						1.0	4.7
		Se74(n,3nα)Ge68(β^{+})Ga68						0.9	9.4
		Se74(n,tα)Ga68						0.2	10.9
		Se77(n,3nα)Ge71(β^{+})Ga71(n,4n)Ga68						0.2	4.0
		Other pathways				37.0	50.3	68.2	66.7
Kr83m	1.83 h	**&**Se80(n,γ)*Se81*(β^{-})Br81(n,γ)*Br82*(β^{-})_ Kr82(n,γ)Kr83m	71.5	29.7	0.2				
		Se82(n,γ)Se83m(β^{-})Br83(β^{-})Kr83m	23.1	47.5	86.7	25.7	25.6	26.2	26.0
		Se82(n,γ)Se83(β^{-})Br83(β^{-})Kr83m	3.4	7.1	12.9	74.3	74.4	73.8	74.0
		&Se80(n,γ)*Se81*(β^{-})Br81(n,γ)Br82m(β^{-})_ Kr82(n,γ)Kr83m	1.6	0.7					
		&Se80(n,γ)*Se81*(β^{-})Br81(n,γ)*Br82*(n,γ)_ Br83(β^{-})Kr83m	0.2	15.0					
As76	1.093 d	Se74(n,γ)Se75(β^{+})As75(n,γ)As76	100.0	100.0	100.0				
		Se76(n,p)As76				66.2	9.7	3.0	1.2
		Se77(n,d)As76				13.9	52.4	21.1	14.1
		Se77(n,2n)Se76(n,p)As76				9.5	0.7	0.1	
		&Se78(n,2n)*Se77*(n,d)As76				7.2	14.7	3.0	1.3
		Se78(n,t)As76					10.4	52.8	48.0
		Se80(n,3n)Se78(n,t)As76					2.4	10.3	3.4
		&Se80(n,4n)*Se77*(n,d)As76						3.6	3.7
		Se80(n,2nt)As76							18.6
Kr79	1.46 d	**&**Se82(n,2n)*Se81*(β^{-})Br81(n,2n)*Br80*(β^{-})_ Kr80(n,2n)*Kr79*				93.2	85.5	74.7	67.7
		&Se82(n,d)As81(β^{-})*Se81*(β^{-})Br81(n,2n)_ Br80(β^{-})Kr80(n,2n)*Kr79*					4.0	10.3	13.8
Br82	1.472 d	**&**Se80(n,γ)*Se81*(β^{-})Br81(n,γ)*Br82*	94.0	100.0	89.0	0.2			
		&Se82(n,2n)*Se81*(β^{-})Br81(n,γ)*Br82*				94.4	78.9	65.5	58.8
		&Se82(n,γ)Se83(β^{-})Br83(β^{-})*Kr83*(n,d)*Br82*				0.2	7.1	10.5	8.1
		&Se82(n,d)As81(β^{-})*Se81*(β^{-})Br81(n,γ)*Br82*					6.5	15.6	20.3
		&Se82(n,γ)Se83m(β^{-})Br83(β^{-})Kr83m_ (IT)Kr83(n,d)*Br82*					2.4	3.7	2.9

Nuclide	T½	Pathway	210	181	151	42	30	21	6
As74	17.78 d	Se76(n,2n)Se75(β^+)As75(n,2n)As74				78.6	37.0	3.9	1.2
		Se74(n,p)As74				7.1	1.6	0.5	0.2
		Se77(n,2n)Se76(n,2n)Se75(β^+)As75(n,2n)As74				5.2	1.1		
		Se76(n,d)As75(n,2n)As74				2.0	9.4	1.7	0.7
		Se77(n,3n)Se75(β^+)As75(n,2n)As74					18.2	4.0	0.8
		Se76(n,t)As74					11.1	55.7	28.3
		Se78(n,3n)Se76(n,2n)Se75(β^+)As75(n,2n)As74					3.8	0.4	
		Se78(n,3n)Se76(n,t)As74					2.5	13.2	2.4
		Se77(n,nt)As74					0.4	4.0	25.4
		Se78(n,4n)Se75(β^+)As75(n,2n)As74						1.9	3.3
		&Se80(n,4n)*Se77*(n,nt)As74						0.6	6.6
		Se78(n,2nt)As74							11.8
		Se80(n,5n)Se76(n,t)As74							4.1
Se75	119.64 d	Se74(n,γ)Se75	100.0	100.0	100.0				
		Se76(n,2n)Se75				85.3	50.1	30.2	18.3
		Se77(n,2n)Se76(n,2n)Se75				11.2	3.1	1.0	0.4
		&Se78(n,2n)*Se77*(n,2n)Se76(n,2n)Se75				2.6	0.3		
		Se77(n,3n)Se75					24.8	30.8	11.9
		Se78(n,3n)Se76(n,2n)Se75					10.3	6.5	1.4
		&Se78(n,2n)*Se77*(n,3n)Se75					6.3	4.0	1.0
		Se78(n,4n)Se75						14.4	51.3
		&Se80(n,4n)*Se77*(n,3n)Se75						4.8	2.7
		Se80(n,3n)Se78(n,4n)Se75						2.5	3.3
		Se80(n,5n)Se76(n,2n)Se75							2.4
Co60	5.271 y	**&**Se74(n,nα)Ge70(n,nα)Zn66(n,nα)Ni62_ (n,2n)Ni61(n,d)*Co60*				21.3	0.5		
		&Se74(n,nα)Ge70(n,nα)Zn66(n,2n)Zn65_ (n,nα)Ni61(n,d)*Co60*				16.4	0.3		
		&Se74(n,nα)Ge70(n,2nα)Zn65(β^+)Cu65_ (n,2nα)*Co60*				10.5	6.3		
		&Se74(n,nα)Ge70(n,nα)Zn66(n,α)Ni63_ (β^-)Cu63(n,α)*Co60*				10.5			
		&Se74(n,nα)Ge70(n,nα)Zn66(n,2n)Zn65_ (n,2n)Zn64(n,d)Cu63(n,α)*Co60*				6.4			
		&Se74(n,nα)Ge70(n,α)Zn67(n,nα)Ni63_ (β^-)Cu63(n,α)*Co60*				3.3			
		&Se74(n,nα)Ge70(n,nα)Zn66(n,2n)Zn65_ (n,2n)Zn64(n,nα)Ni60(n,p)*Co60*				2.7			
		&Se74(n,nα)Ge70(n,nα)Zn66(n,nα)Ni62_ (n,2n)Ni61(n,2n)Ni60(n,p)*Co60*				2.5			
		&Se74(n,nα)Ge70(n,nα)Zn66(n,2n)Zn65_ (n,nα)Ni61(n,2n)Ni60(n,p)*Co60*				2.1			
		&Se74(n,nα)Ge70(n,nα)Zn66(n,2nα)_ Ni61(n,d)*Co60*					3.4		
		&Se74(n,nα)Ge70(n,nα)Zn66(n,3n)Zn64_ (n,pα)*Co60*					2.7		
		&Se74(n,2nα)Ge69(β^+)Ga69(n,nα)Cu65_ (n,2nα)*Co60*					2.6	6.0	
		&Se74(n,nα)Ge70(n,nα)Zn66(n,nα)Ni62_ (n,t)*Co60*					2.4		
		&Se74(n,nα)Ge70(n,2nα)Zn65(n,nα)_ Ni61(n,d)*Co60*					2.3		
		&Se74(n,n2α)Zn66(n,2nα)Ni61(n,d)*Co60*					2.2	1.1	
		&Se76(n,2nα)Ge71(β^+)Ga71(n,3nα)_ Cu65(n,2nα)*Co60*						4.9	0.9
		&Se74(n,2n2α)Zn65(β^+)Cu65(n,2nα)*Co60*						0.1	3.5
		&Se74(n,2nα)Ge69(β^+)Ga69(n,2n2α)*Co60*							2.8
		Other pathways				24.3	77.3	87.9	92.8
Kr85	10.752 y	**&**Se82(n,γ)Se83m(β^-)Br83(β^-)*Kr83*(n,γ)_ Kr84(n,γ)*Kr85*	50.3	63.6	86.9	24.5	25.4	26.1	26.0
	►	**&**Se80(n,γ)*Se81*(β^-)Br81(n,γ)Br82m(β^-)_ Kr82(n,γ)*Kr83*(n,γ)Kr84(n,γ)*Kr85*	32.4	9.0					

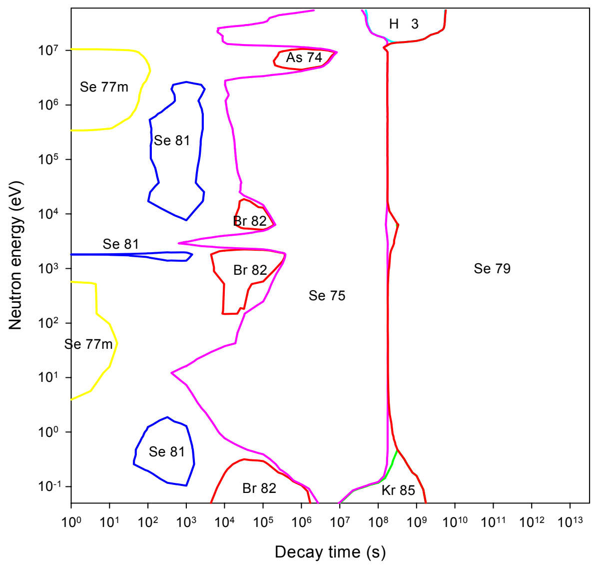
Nuclide	T½	Pathway	210	181	151	42	30	21	6
	◄	&Se80(n,γ)*Se81*(β^-)Br81(n,γ)*Br82*(β^-)_ Kr82(n,γ)*Kr83*(n,γ)Kr84(n,γ)*Kr85*	9.4	2.6					
		&Se80(n,γ)*Se81*(β^-)Br81(n,γ)*Br82*(n,γ)_ Br83(β^-)*Kr83*(n,γ)Kr84(n,γ)*Kr85*		15.0					
		&Se82(n,γ)Se83(β^-)Br83(β^-)*Kr83*(n,γ)_ Kr84(n,γ)*Kr85*				75.2	74.0	73.5	73.8
H3	12.33 y	Se74(n,γ)Se75(n,X)H1(n,γ)H2(n,γ)H3	93.0	95.6	99.4				
		Se77(n,X)H3				57.0	13.8	10.5	8.8
		&Se80(n,2n)*Se79*(n,X)H3				17.2	3.1	1.3	0.7
		&Se78(n,2n)*Se77*(n,X)H3				14.9	1.9	0.7	0.3
		Se76(n,2n)Se75(β^+)As75(n,X)H3				3.9	0.8	0.3	0.2
		Se76(n,2n)Se75(n,X)H3				1.3	0.2		
		Se80(n,X)H3					41.8	42.0	43.9
		Se78(n,X)H3					17.3	20.3	21.2
		Se76(n,X)H3					7.6	8.4	8.3
		Se82(n,X)H3					5.0	6.5	7.3
		Se80(n,3n)Se78(n,X)H3					2.0	2.0	0.8
Kr81	2.1 10^5 y	&Se78(n,γ)Se79m(β^-)Br79(n,γ)*Br80*(β^-)_ Kr80(n,γ)*Kr81*	81.8	75.9	99.3				
		&Se77(n,γ)Se78(n,γ)Se79m(β^-)Br79(n,γ)_ *Br80*(β^-)Kr80(n,γ)*Kr81*	10.8	1.0	0.3				
		&Se76(n,γ)*Se77*(n,γ)Se78(n,γ)Se79m(β^-)_ Br79(n,γ)*Br80*(β^-)Kr80(n,γ)*Kr81*	7.3						
		&Se82(n,2n)*Se81*(β^-)Br81(n,2n)*Br80*(β^-)_ Kr80(n,γ)*Kr81*				42.8	5.0	1.7	1.9
		&Se82(n,2n)*Se81*(β^-)Br81(n,γ)*Br82*(β^-)_ Kr82(n,2n)*Kr81*				33.7	4.2	1.0	1.2
		&Se82(n,γ)*Se83*(β^-)Br83(β^-)*Kr83*(n,2n)_ Kr82(n,2n)*Kr81*				17.1	2.3	0.5	0.6
		&Se82(n,γ)Se83m(β^-)Br83(β^-)*Kr83*_ (n,2n)Kr82(n,2n)*Kr81*				5.6	0.8	0.2	0.2
		&Se82(n,γ)Se83(β^-)Br83(β^-)*Kr83*(n,3n)*Kr81*					64.0	69.8	69.2
		&Se82(n,γ)Se83m(β^-)Br83(β^-)*Kr83*(n,3n)*Kr81*					21.9	24.7	24.4
Se79	1.1 10^6 y	&Se78(n,γ)*Se79*	71.9	97.6	99.0				
		&Se77(n,γ)Se78(n,γ)*Se79*	14.7	2.3	0.9				
		&Se76(n,γ)*Se77*(n,γ)Se78(n,γ)*Se79*	13.1	0.1					
		&Se80(n,2n)*Se79*				99.6	86.7	63.0	53.9
		&Se80(n,d)As79(β^-)*Se79*					11.2	21.4	26.4
		&Se82(n,4n)*Se79*						13.8	14.9
		Se82(n,nt)As79(β^-)Se79m(IT)Se79						0.3	3.7

Selenium activation characteristics

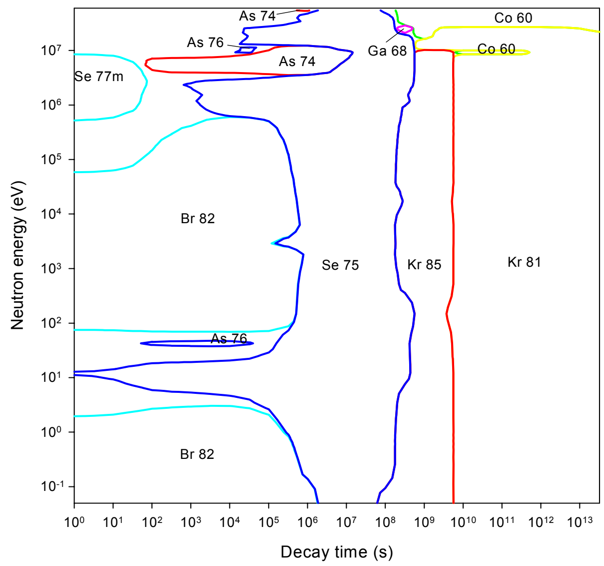


Selenium importance diagrams & transmutation

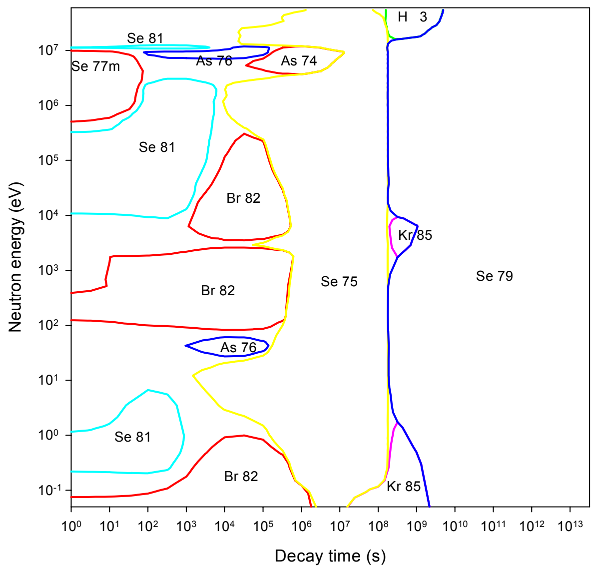
Activity



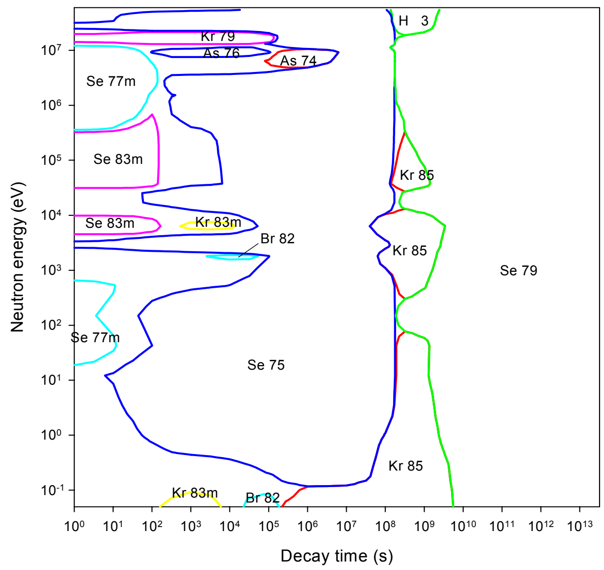
Dose rate



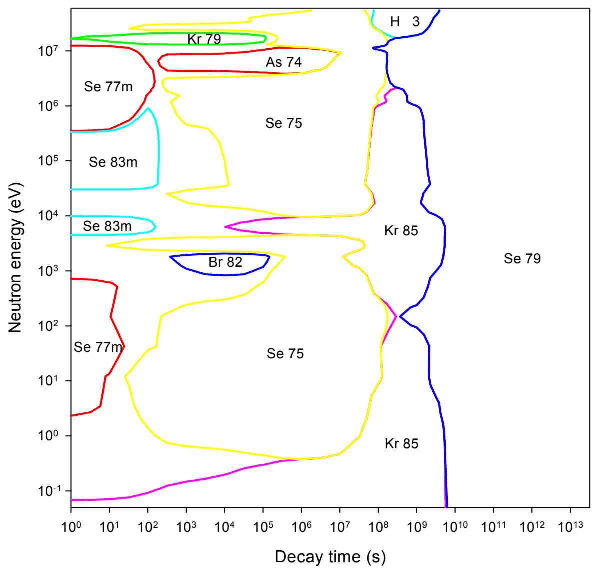
Heat output



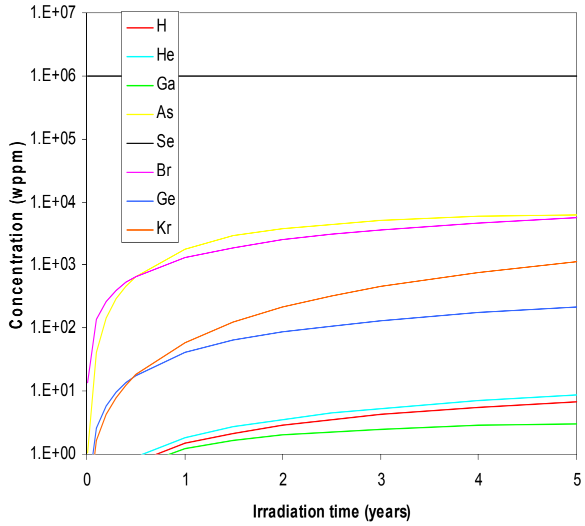
Ingestion dose



Inhalation dose



First wall transmutation



Bromine

General properties

		Isotopes	Isotopic abundances / %
Atomic number	35		
Crustal abundance / wppm	2.4	Br79	50.69
Melting point / K	266.0	Br81	49.31
Boiling point / K	332.0		
Density / kgm^{-3}	3120		
Thermal conductivity / $Wm^{-1}K^{-1}$	$1.22\ 10^{-1}$		
Electrical resistivity /Ωm	-		
Coefficient of thermal expansion / K^{-1}	-		
Crystal structure	orthorhombic		
Number of stable isotopes	2		
Mean atomic weight	79.904		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	2.53E16	1.99E16	1.01E15	3.11E11	3.18E10	2.25E10	kW kg^{-1}	3.77E0	3.50E0	4.37E-1	9.99E-6	8.06E-8	4.67E-8
Br80	33.76	36.96					Br82	64.39	69.34	99.71			
Br82	21.52	27.40	97.37				Br80	29.10	26.95				
Br82m	20.01	14.01					Br78	1.98	1.21				
Br80m	8.48	10.66					Br82m	1.68	0.99				
Kr83m	7.58	9.35					Kr81m	1.15					
Kr81m	5.65						Br80m	0.78	0.83				
Br79m	0.92						Kr83m	0.34	0.35				
Kr79	0.57	0.72	2.54				Kr85				93.84	16.66	
Kr85			0.02	81.75	1.35		Kr81				10.00	79.01	97.98
Kr81				10.00	98.08	99.53	H3				5.74	0.07	
H3				5.74	0.21		Se75				2.62		
Se75				2.62			Se79				0.03	1.24	2.02

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	3.97E6	3.91E6	6.74E5	4.73E-1	4.58E-3	3.14E-3	Sv kg^{-1}	7.37E7	7.09E7	1.11E7	2.81E5	2.41E3	1.39E3
Br82	94.38	95.76	99.81				Kr79	78.53	81.48	92.70			
Br80	3.73	3.25					Kr83m	8.35	8.39				
Br78	1.23	0.71					Br78	4.01	2.37				
Kr81m	0.23						Br82	3.99	4.15	4.78			
Se75				72.67			Br82m	3.30	1.89				
Kr85				25.40*	4.31*		Kr85	0.40	0.41	2.69	99.30	19.64	
Kr81				0.95	95.69	100.0	Br80	0.35	0.32				
Rb84				0.82			Br80m	0.32	0.32				
							Kr81				0.68	80.34	99.98
							Se79					0.01	0.02

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	5.39E7	5.10E7	1.63E7	9.72E6	8.49E4	4.93E4		7.43E12	6.86E12	9.86E11	2.27E7	2.65E5	1.73E5
Kr79	56.35	59.48	32.85				Br82	73.42	79.47	99.30			
Kr85	19.08	20.17	62.96	99.29	19.23		Br80	17.19	16.00				
Br82	6.37	6.73	3.77				Br78	3.47	2.14				
Kr83m	5.70	5.83					Kr81m	2.64					
Br80m	0.30	0.31					Kr85				62.07	9.00	
Br80	0.14	0.13					Se75				35.99		
Kr81	0.12	0.13	0.41	0.70	80.77	100.0	Kr81				1.05	90.50	99.66

Bromine

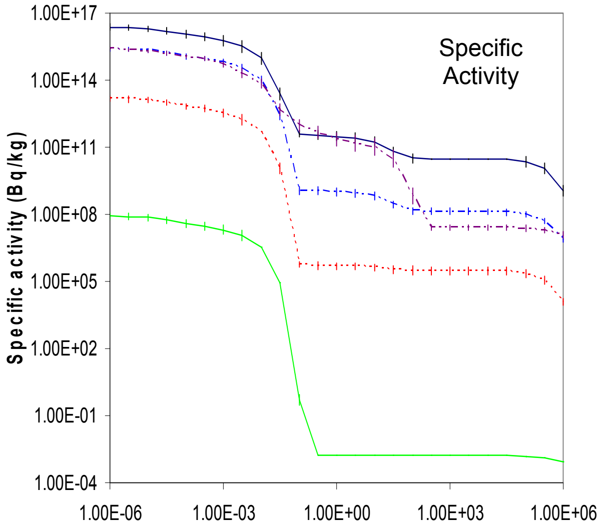
Pathway analysis

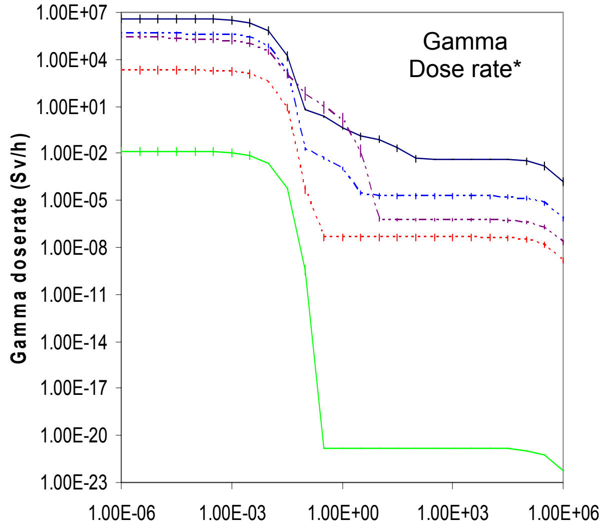
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Br79m	4.864 s	Br79(n,n′)Br79m				97.5	17.8	12.9	20.7
		&Br81(n,2n)*Br80*(β^-)Kr80(n,d)Br79m				1.3	2.8	1.0	
		Br81(n,3n)Br79m					77.2	84.5	77.0
Br78	6.46 m	Br79(n,2n)Br78				98.8	90.8	70.4	41.6
		&Br81(n,2n)*Br80*(β^-)Kr80(n,2n)*Kr79*_ (β^+)Br79(n,2n)Br78				1.0	1.9		
		&Br81(n,3n)*Br79*(n,2n)Br78					8.4	6.5	0.9
		Br81(n,4n)Br78						20.2	55.9
Br80	17.6 m	**&**Br79(n,γ)*Br80*	100.0	100.0	100.0				
		&Br81(n,2n)*Br80*				100.0	100.0	100.0	100.0
Ga68	1.128 h	**&**Br79(n,α)As76(β^-)Se76(n,α)*Ge73*_ (n,nα)*Zn69*(β^-)Ga69(n,2n)Ga68				15.7			
		&Br79(n,α)As76(β^-)Se76(n,nα)Ge72_ (n,α)*Zn69*(β^-)Ga69(n,2n)Ga68				9.6			
		&Br79(n,nα)As75(n,α)Ga72(β^-)Ge72_ (n,α)*Zn69*(β^-)Ga69(n,2n)Ga68				6.4			
		Br79(n,nα)As75(n,2n)As74(β^-)Se74(n,nα)_ Ge70(n,2n)Ge69(β^+)Ga69(n,2n)Ga68				5.8			
		&Br79(n,α)As76(β^-)Se76(n,α)*Ge73*_ (n,2n)Ge72(n,α)*Zn69*(β^-)Ga69(n,2n)Ga68				4.6			
		Br79(n,nα)As75(n,nα)Ga71(n,3n)Ga69_ (n,2n)Ga68					7.8		
		Br79(n,nα)As75(n,3n)As73(n,2nα)Ga68					4.9	1.5	
		Br79(n,nα)As75(n,2nα)Ga70(β^-)Ge70_ (n,t)Ga68					1.9	4.4	
		Br79(n,2nα)As74(β^+)Ge74(n,4n)Ge71_ (β^+)Ga71(n,4n)Ga68						5.4	0.9
		Br79(n,nt)Se76(n,2nα)Ge71(β^+)Ga71_ (n,4n)Ga68						5.3	1.4
		Br79(n,2nt)Se75(β^+)As75(n,4nα)Ga68							3.9
		Other pathways				57.9	85.4	83.4	93.8
Kr83m	1.83 h	**&**Br81(n,γ)*Br82*(β^-)Kr82(n,γ)Kr83m	74.1	97.7	97.0	94.5	95.7	96.4	97.0
		&Br79(n,γ)*Br80*(β^-)Kr80(n,γ)*Kr81*(n,γ)_ Kr82(n,γ)Kr83m	24.0						
		Br81(n,γ)Br82m(β^-)Kr82(n,γ)Kr83m	1.7	2.2	2.2	1.1	1.1	1.1	1.1
		&Br81(n,γ)*Br82*(β^-)Kr82(n,γ)Kr83(n,n')Kr83m				2.3	1.3	1.1	0.7
Br80m	4.41 h	Br79(n,γ)Br80m	100.0	100.0	100.0				
		Br81(n,2n)Br80m				98.6	98.9	99.2	99.6
Br76	16.2 h	**&**Br81(n,2n)*Br80*(β^-)Kr80(n,2n)*Kr79*_ (n,2n)Kr78(n,d)*Br77*(n,2n)*Br76*				23.2			
		&Br81(n,2n)*Br80*(β^-)Kr80(n,2n)*Kr79*_ (n,2n)Kr78(n,2n)Kr77(β^+)Br77(n,2n)*Br76*				10.5			
		&Br81(n,2n)*Br80*(β^-)Kr80(n,3n)Kr78(n,t)*Br76*					44.6	1.5	
		&Br81(n,2n)*Br80*(β^-)Kr80(n,3n)Kr78_ (n,3n)Kr76(β^+)Br76					23.4	0.2	
		&Br79(n,3n)*Br77*(n,2n)*Br76*					22.3		
		&Br81(n,3n)*Br79*(n,3n)*Br77*(n,2n)*Br76*					1.3		
		&Br79(n,4n)*Br76*						90.7	97.7
		&Br81(n,3n)*Br79*(n,4n)*Br76*						7.6	1.3
As76	1.093 d	Br79(n,α)As76				96.3	30.4	9.1	25.0
		&Br79(n,2n)Br78(β^+)Se78(n,2n)*Se77*(n,d)As76				1.2	2.4	0.2	
		&Br79(n,3n)*Br77*(β^+)Se77(n,d)As76					45.8	20.6	5.7
		&Br79(n,t)*Se77*(n,d)As76					5.5	6.5	3.4
		Br79(n,2n)Br78(β^+)Se78(n,t)As76					3.4	9.2	5.9
		Br79(n,d)Se78(n,t)As76					1.0	4.6	3.5
	►	Br81(n,2nα)As76					0.7	39.6	32.4

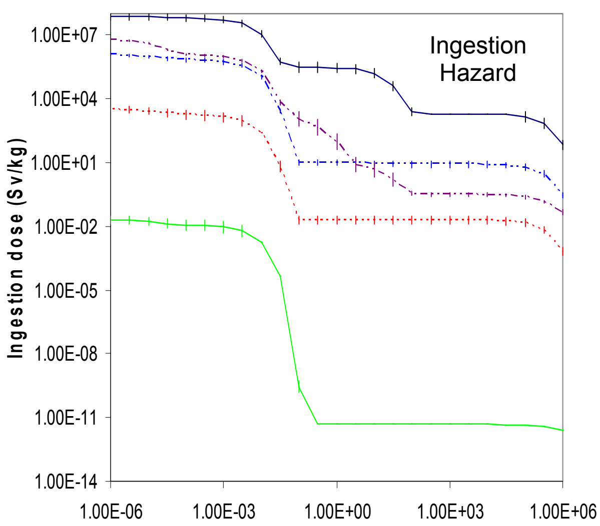
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	Br81(n,4n)Br78(β^+)Se78(n,t)As76						2.6	8.0
		Br81(n,nt)Se78(n,t)As76						0.9	3.9
		&Br81(n,5n)*Br77*(β^+)Se77(n,d)As76							3.1
Kr79	1.460 d	&Br81(n,2n)*Br80*(β^-)Kr80(n,2n)*Kr79*				96.0	93.9	93.9	93.6
Br82	1.472 d	&Br81(n,γ)*Br82*	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Br77	2.377 d	&Br81(n,2n)*Br80*(β^-)Kr80(n,2n)*Kr79*_ (n,2n)Kr78(n,d)*Br77*				52.3			
		&Br81(n,2n)*Br80*(β^-)Kr80(n,2n)*Kr79*_ (n,2n)Kr78(n,2n)Kr77(β^+)Br77				31.9			
		&Br79(n,3n)*Br77*					92.2	92.3	62.5
		&Br81(n,3n)*Br79*(n,3n)*Br77*					7.8	7.7	
		&Br81(n,5n)*Br77*							33.8
As74	17.78 d	Br79(n,nα)As75(n,2n)As74				45.5	47.7	2.1	0.9
		Br79(n,α)As76(β^-)Se76(n,2n)Se75(β^+)_ As75(n,2n)As74				28.9	0.4		
		&Br79(n,2n)Br78(β^+)Se78(n,α)*Ge75*(β^-)_ As75(n,2n)As74				16.7	0.2		
		&Br79(n,2n)Br78(β^+)Se78(n,2n)*Se77*_ (n,2n)Se76(n,2n)Se75(β^+)As75(n,2n)As74				4.3			
		&Br79(n,3n)*Br77*(β^+)Se77(n,3n)Se75_ (β^+)As75(n,2n)As74					19.4	0.3	
		Br79(n,2nα)As74					9.9	71.1	41.2
		&Br81(n,3n)*Br79*(n,2nα)As74					0.9	4.4	1.4
		&Br79(n,3n)*Br77*(β^+)Se77(n,nt)As74					0.8	2.9	8.6
		Br79(n,nt)Se76(n,t)As74						5.5	8.8
		&Br79(n,4n)*Br76*(β^+)Se76(n,t)As74						1.2	6.6
		&Br79(n,t)*Se77*(n,nt)As74						1.0	5.2
		&Br81(n,5n)*Br77*(β^+)Se77(n,nt)As74							4.7
		Br79(n,2nt)Se75(β^+)As75(n,2n)As74							3.3
		Br81(n,4nα)As74							3.2
Rb86	18.64 d	&Br81(n,γ)*Br82*(β^-)Kr82(n,γ)*Kr83*(n,γ)_ Kr84(n,γ)*Kr85m*(β^-)Rb85(n,γ)*Rb86*	86.7	47.4	92.6	79.5			
		&Br79(n,γ)*Br80*(β^-)Kr80(n,γ)*Kr81*(n,γ)_ Kr82(n,γ)*Kr83*(n,γ)Kr84(n,γ)Kr85m(β^-)_ Rb85(n,γ)*Rb86*	6.9						
		&Br81(n,γ)*Br82*(β^-)Kr82(n,γ)*Kr83*(n,γ)_ Kr84(n,γ)*Kr85*(β^-)Rb85(n,γ)*Rb86*	3.0	1.5	2.5	19.2			
		&Br81(n,γ)Br82m(β^-)Kr82(n,γ)*Kr83*(n,γ)_ Kr84(n,γ)Kr85m(β^-)Rb85(n,γ)*Rb86*	1.9	0.9	2.0	1.2			
		&Br81(n,γ)*Br82*(n,γ)Br83(β^-)*Kr83*(n,γ)_ Kr84(n,γ)Kr85m(β^-)Rb85(n,γ)*Rb86*	0.3	47.2	2.1	0.1			
		&Br81(n,γ)*Br82*(n,γ)Br83(β^-)*Kr83*(n,γ)_ Kr84(n,γ)*Kr85*(β^-)Rb85(n,γ)*Rb86*		2.1					
Se75	119.64 d	Br79(n,α)As76(β^-)Se76(n,2n)Se75				73.5	1.2	0.3	0.2
		&Br79(n,2n)Br78(β^+)Se78(n,2n)*Se77*_ (n,2n)Se76(n,2n)Se75				22.2			
		&Br79(n,3n)*Br77*(β^+)Se77(n,3n)Se75					65.2	51.0	3.5
		&Br79(n,t)*Se77*(n,3n)Se75					7.8	16.0	2.0
		Br79(n,2n)Br78(β^+)Se78(n,3n)Se76(n,2n)Se75					5.1	1.0	
		&Br79(n,3n)*Br77*(β^+)Se77(n,2n)Se76_ (n,2n)Se75					4.1	0.9	
		Br79(n,nt)Se76(n,2n)Se75					0.5	6.8	4.9
		Br79(n,2n)Br78(β^+)Se78(n,4n)Se75						4.2	4.6
		&Br79(n,4n)*Br76*(β^+)Se76(n,2n)Se75						1.5	3.7
		Br79(n,2nt)Se75						0.4	47.2
		Br79(n,5n)Br75(β^+)Se75							13.6
Co60	5.271 y ►	Br79(n,nα)As75(n,2n)As74(β^-)Se74_ (n,nα)Ge70(n,nα)Zn66(n,nα)Ni62(n,2n)_ Ni61(n,d)Co60				2.9			

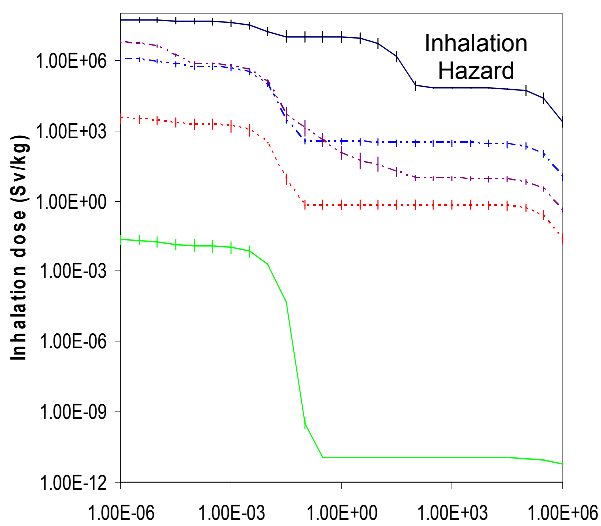
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Br79(n,nα)As75(n,2n)As74(β^-)Se74_ (n,nα)Ge70(n,nα)Zn66(n,2n)Zn65(n,nα)_ Ni61(n,d)Co60				2.6			
		Br79(n,nα)As75(n,2n)As74(β^-)Se74(n,nα)_ Ge70(n,nα)Zn66(n,α)Ni63(β^-)Cu63(n,α)Co60				2.6			
		&Br79(n,nα)As75(n,nα)Ga71(n,3n)Ga69_ (n,nα)Cu65(n,2nα)*Co60*					4.5		
		&Br79(n,nα)As75(n,3n)As73(n,nα)Ga69_ (n,nα)Cu65(n,2nα)*Co60*					2.3		
		Br79(n,nα)As75(n,2nα)Ga70(β^-)Ge70_ (n,2nα)Zn65(β^+)Cu65(n,2nα)Co60					1.2	2.9	
		Br79(n,2nα)As74(β^-)Se74(n,nα)Ge70_ (n,2nα)Zn65(β^+)Cu65(n,2nα)Co60					0.3	1.4	
		&Br79(n,nt)Se76(n,2nα)Ge71(β^+)Ga71_ (n,3nα)Cu65(n,2nα)*Co60*						1.7	0.2
		Br79(n,2nα)As74(β^-)Se74(n,2nα)Ge69_ (β^+)Ga69(n,nα)Cu65(n,2nα)Co60						1.6	
		&Br79(n,3nα)As73(β^+)Ge73(n,4nα)_ Zn66(n,tα)*Co60*							5.9
		&Br79(n,2nt)Se75(β^+)As75(n,3nα)Ga69_ (n,2n2α)*Co60*							3.1
		&Br79(n,3nα)As73(β^+)Ge73(n,2nt)Ga69_ (n,2n2α)*Co60*							2.7
		Br79(n,3nα)As73(β^+)Ge73(n,5n)Ge69_ (β^+)Ga69(n,2n2α)Co60							1.7
		&Br81(n,3nα)As75(n,3nα)Ga69(n,2n2α)*Co60*							1.5
		Other pathways				91.9	91.7	92.4	84.9
Kr85	10.752 y	**&**Br81(n,γ)*Br82*(β^-)Kr82(n,γ)*Kr83*(n,γ)_ Kr84(n,γ)*Kr85*	89.7	50.5	95.6	98.1	98.2	98.1	97.5
		&Br79(n,γ)*Br80*(β^-)Kr80(n,γ)*Kr81*(n,γ)_ Kr82(n,γ)*Kr83*(n,γ)Kr84(n,γ)*Kr85*	7.8						
		&Br81(n,γ)Br82m(β^-)Kr82(n,γ)*Kr83*(n,γ)_ Kr84(n,γ)*Kr85*	2.0	1.2	2.1	1.1	1.1	1.0	0.8
		&Br81(n,γ)*Br82*(n,γ)Br83(β^-)*Kr83*(n,γ)_ Kr84(n,γ)*Kr85*	0.3	48.3	2.2	0.4	0.4	0.4	
H3	12.33 y	**&**Br79(n,γ)*Br80*(β^-)Kr80(n,γ)*Kr81*(n,X)_ H1(n,γ)H2(n,γ)H3	91.0	85.0	45.9				
		Br79(n,X)H1(n,γ)H2(n,γ)H3	4.2	11.8	53.6				
		Br79(n,X)H3				71.4	50.1	48.3	47.6
		Br81(n,X)H3				27.7	42.0	43.2	44.6
		&Br81(n,3n)*Br79*(n,X)H3					2.4	2.2	0.5
Kr81	2.1 10^5 y	**&**Br79(n,γ)*Br80*(β^-)Kr80(n,γ)*Kr81*	100.0	100.0	100.0				
		&Br81(n,2n)*Br80*(β^-)Kr80(n,γ)*Kr81*				55.6	53.5	57.0	57.3
		&Br81(n,γ)*Br82*(β^-)Kr82(n,2n)*Kr81*				43.7	45.7	42.4	42.1
		&Br81(n,γ)Br82m(β^-)Kr82(n,2n)*Kr81*				0.5	0.4	0.4	
Se79	1.1 10^6 y	**&**Br79(n,γ)*Br80*(β^-)Kr80(n,γ)*Kr81*(n,α)_ Se78(n,γ)*Se79*	93.6	20.1	0.2				
		&Br79(n,p)*Se79*	6.4	79.8	96.0	77.1	48.8	17.5	9.3
		&Br81(n,2n)*Br80*(β^+)Se80(n,2n)*Se79*				19.1	3.1	0.4	
		&Br81(n,d)Se80(n,2n)*Se79*				2.7	6.0	1.9	0.9
		&Br81(n,t)*Se79*				0.2	37.6	77.1	86.9
		&Br81(n,3n)*Br79*(n,p)*Se79*					2.3	0.7	
		Br81(n,h)As79(β^-)Se79m(IT)Se79					0.3	1.2	1.6

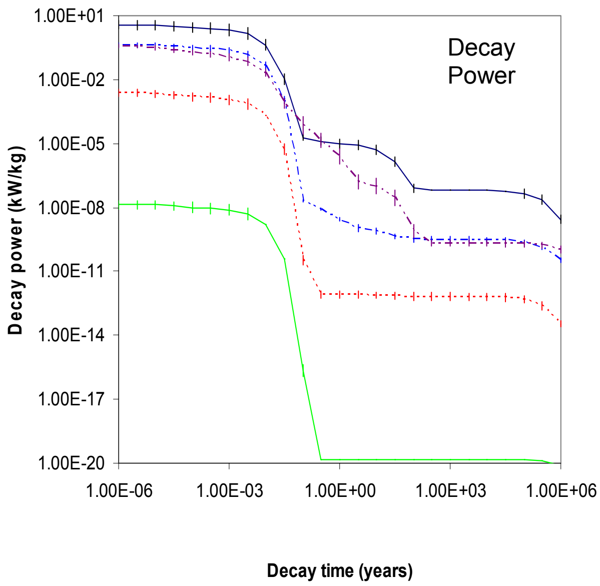
Bromine activation characteristics

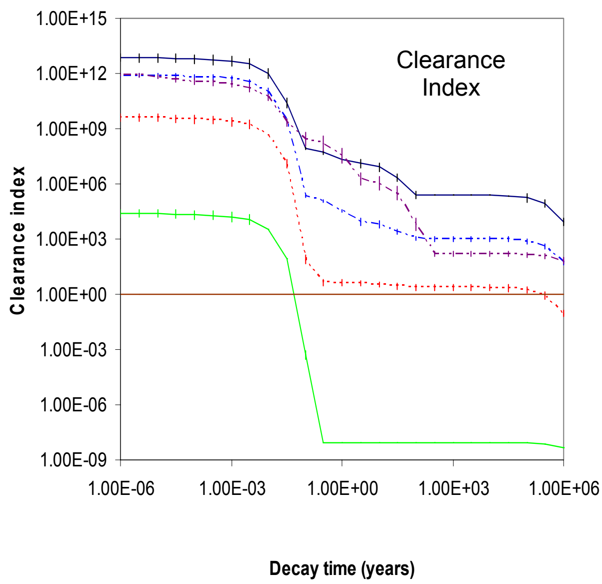






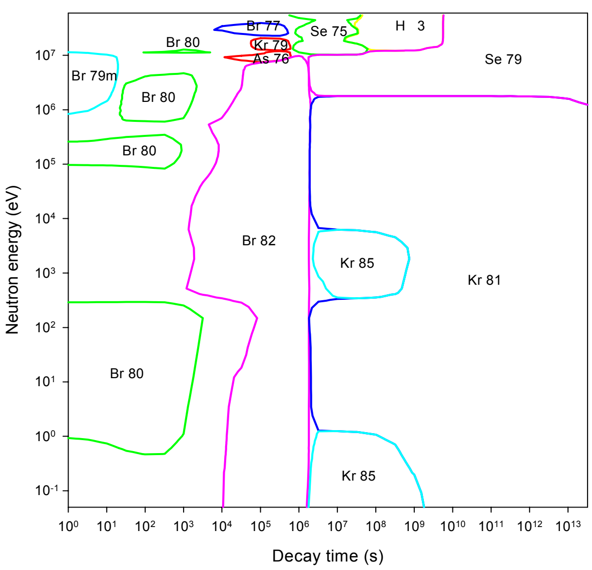




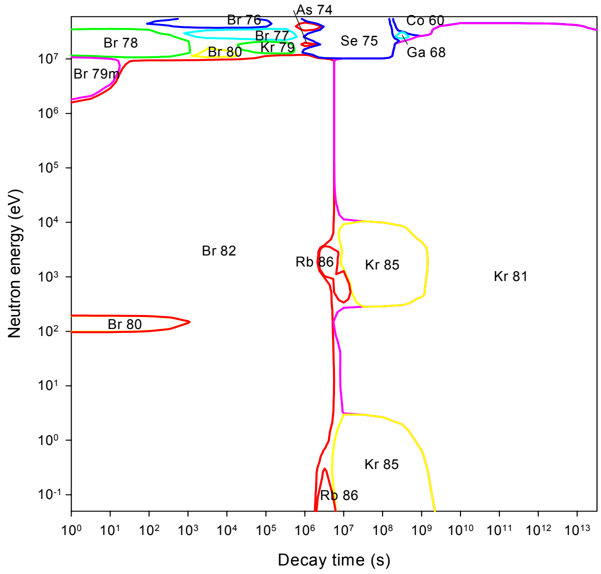


Bromine importance diagrams & transmutation

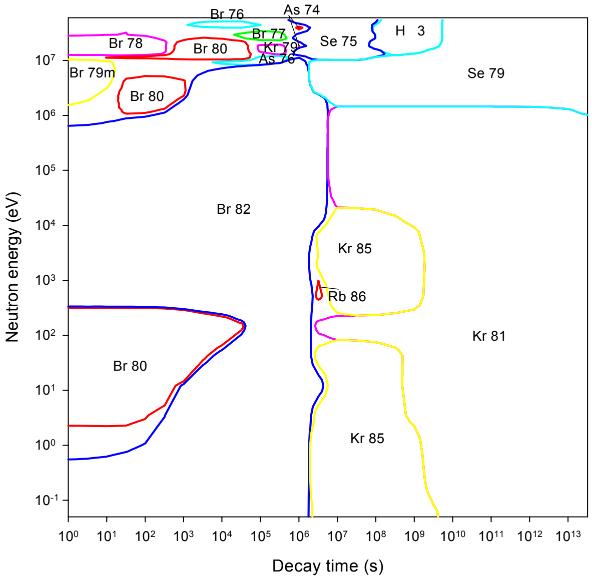
Activity



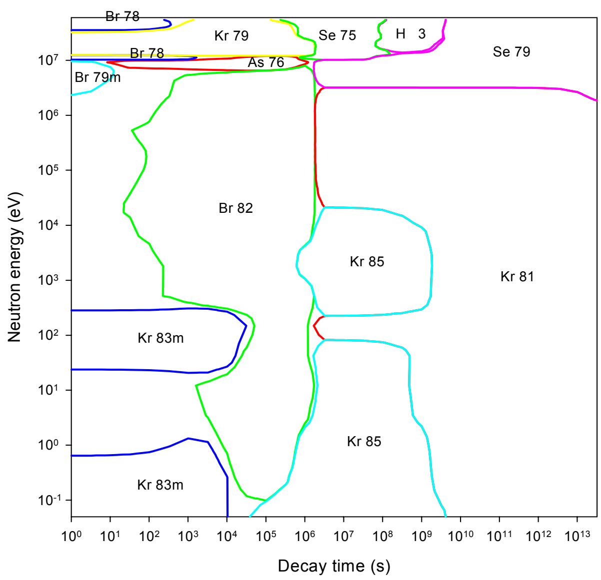
Dose rate



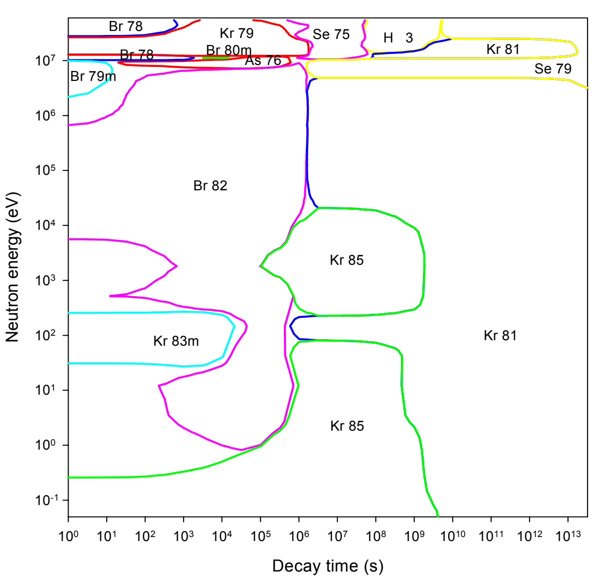
Heat output



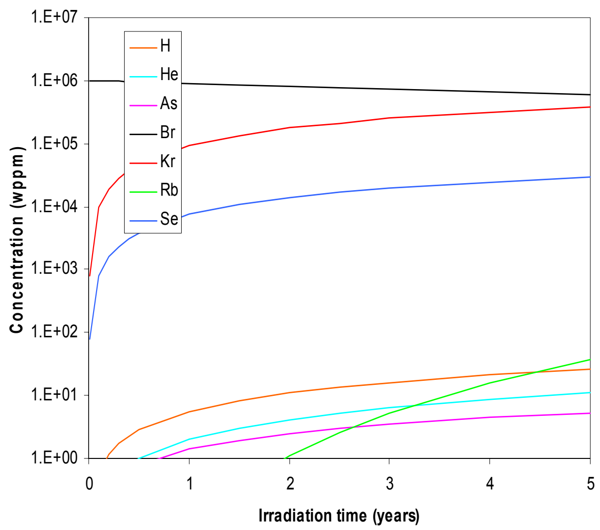
Ingestion dose



Inhalation dose



First wall transmutation



Krypton

General properties

		Isotopes	Isotopic abundances / %
Atomic number	36	Kr78	0.35 ($T_{1/2}$ = 1.10 10^{20} y)
Crustal abundance / wppm	1.0 10^{-5}	Kr80	2.25
Melting point / K	116.6	Kr82	11.60
Boiling point / K	120.8	Kr83	11.50
Density / kgm^{-3}	3.749	Kr84	57.00
Thermal conductivity / $Wm^{-1}K^{-1}$	9.49 10^{-3}	Kr86	17.30
Electrical resistivity /Ωm	-		
Coefficient of thermal expansion / K^{-1}	-		
Crystal structure	FCC		
Number of stable isotopes	5 (6)		
Mean atomic weight	83.80		

Activation properties

Act	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Bq kg^{-1}	2.52E15	2.32E15	1.79E14	1.22E14	2.12E11	4.19E9
Kr83m	53.67	56.50				
Kr85m	30.11	32.33				
Kr85	5.16	5.61	72.81	99.97	97.25	
Kr81m	5.10					
Rb86	1.32	1.43	16.27			
Kr79	1.24	1.35	3.10			
Br80	0.73	0.68				
Rb84	0.51	0.56	6.79			
Rb84m	0.24	0.21				
Br80m	0.18	0.19				
Br82	0.12	0.13	0.32			
Br77	0.09	0.10	0.47			
Br83	0.08	0.09				
Kr81					2.74	99.94

Heat	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
kW kg^{-1}	8.82E-2	7.98E-2	1.09E-2	4.51E-3	7.63E-6	8.58E-9
Kr85m	56.82	61.89				
Kr83m	10.30	11.00				
Kr85	5.45	6.02	44.11	99.94	99.84	
Rb86	4.54	5.01	32.09			
Kr81m	4.46					
Br84	3.02	2.98				
Br80	2.69	2.55				
Rb84	2.45	2.70	18.42	0.02		
Br84m	2.21	1.33				
Br82	1.64	1.80	2.38			
Kr79	1.61	1.77	2.30			
Br86	1.11					
Kr87	0.87	0.91				
Kr81					0.15	99.74

Dose	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv h^{-1}	2.75E4	2.30E4	4.40E3	6.63E1	1.08E-1	5.74E-4
Kr85m	34.04	40.11				
Br84	11.31	12.05				
Br84m	9.70	6.31				
Br82	8.23	9.82	9.25			
Kr79	5.62	6.70	6.22			
Br86	4.49	0.10				
Rb86	3.36	4.02	18.43			
Kr81m	2.90					
Kr87	1.92	2.19				
Rb84	1.80	12.90	62.80	2.61		
Rb86m	1.69	0.05				
Rb84m	1.28	1.28				
Br80	1.18	1.21				
Br78	0.77	0.52				
Kr85	0.21	0.26*	1.37*	95.38*	99.17*	
Se75			0.09	0.89		
Kr81					0.82	100.0

Ing	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	2.06E8	2.05E8	1.45E8	1.34E8	2.27E5	2.60E2
Kr85	69.44	69.73	98.40	100.0	99.84	
Kr85m	22.09	21.89				
Kr79	6.09	6.10	1.52			
Kr83m	2.10	2.04				
Kr87	0.12	0.11				
Rb86	0.04	0.04	0.05			
Rb84	0.01	0.01	0.02			
Sr85					0.15	100.0

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	4.98E9	4.98E9	4.95E9	4.64E9	7.86E6	9.21E3
Kr85	96.36	99.37	99.98	100.0	99.84	
Kr85m	0.45	0.45				
Kr79	0.13	0.13	0.02			
Rb86					0.16	100.0

Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
	2.34E11	2.01E11	2.12E10	6.81E9	1.15E7	3.22E4
Kr85m	58.96	67.94				
Kr81m	7.53					
Rb84	5.07	5.93	51.92	0.09		
Br84	4.47	4.66				
Br84m	4.04	2.57				
Kr83m	3.85	4.35				
Kr79	3.52	4.11	6.86			
Kr85	3.08	3.60	34.03	99.63	99.61	
Br86	1.74					
Br82	1.38	1.61	2.73			
Br80	1.17	1.18				
Rb84m	0.99	0.97				
Rb86m	0.97					
Br77	0.33	0.38	1.27			
Rb86	0.14	0.16	1.36			
Kr81					0.38	99.96

Krypton

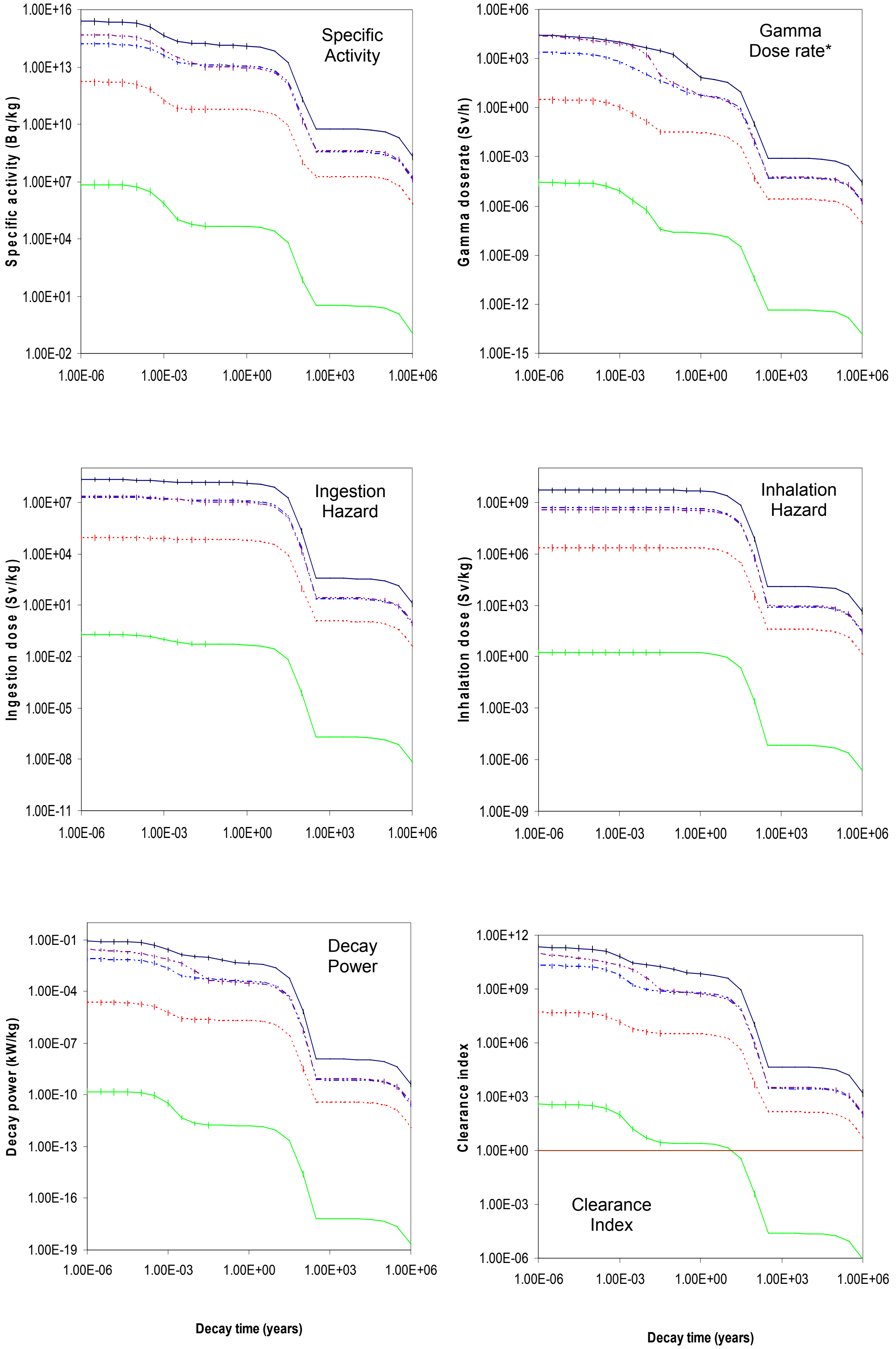
Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Br78	6.46 m	**&**Kr80(n,2n)*Kr79*(β^+)Br79(n,2n)Br78				82.9	35.2	2.0	0.5
		Kr78(n,p)Br78				9.5	3.3	0.6	0.2
		&Kr80(n,d)*Br79*(n,2n)Br78				4.6	13.1	1.2	0.4
		Kr80(n,t)Br78					11.6	42.8	15.5
		&Kr82(n,3n)Kr80(n,2n)*Kr79*(β^+)Br79_ (n,2n)Br78					6.2	0.5	
		Kr82(n,3n)Kr80(n,t)Br78					4.0	20.1	2.6
		Kr84(n,3n)Kr82(n,3n)Kr80(n,t)Br78					0.9	5.1	0.2
		Kr84(n,4n)Kr81(n,nt)Br78						0.9	19.5
		Kr84(n,nt)Br81(n,4n)Br78						0.4	9.9
		Kr82(n,2nt)Br78							8.5
		Kr84(n,5n)Kr80(n,t)Br78							7.3
Kr87	1.272 h	Kr86(n,γ)Kr87	100.0	100.0	100.0	99.7	99.0	99.1	99.5
Kr83m	1.83 h	Kr82(n,γ)Kr83m	92.9	99.4	100.0				
		&Kr80(n,γ)*Kr81*(n,γ)Kr82(n,γ)Kr83m	7.1	0.6					
		Kr84(n,2n)Kr83m				84.4	39.2	20.6	13.7
		Kr83(n,n′)Kr83m				6.4	6.4	5.3	3.9
		Kr84(n,2n)Kr83(n,n′)Kr83m				4.7	2.6	1.0	
		Kr83(n,p)Br83(β^-)Kr83m				1.0	2.0	1.5	
		Kr84(n,d)Br83(β^-)Kr83m				0.3	42.2	59.3	58.6
		Kr86(n,4n)Kr83m						5.5	6.1
		Kr86(n,nt)Br83(β^-)Kr83m						1.2	14.2
Kr85m	4.48 h	Kr84(n,γ)Kr85m	75.2	99.9	99.3	0.2	0.2		
		Kr83(n,γ)Kr84(n,γ)Kr85m	15.2		0.7				
		&Kr82(n,γ)*Kr83*(n,γ)Kr84(n,γ)Kr85m	9.6						
		Kr86(n,2n)Kr85m				97.0	62.5	38.3	29.6
		Kr86(n,2n)Kr85(n,n′)Kr85m				1.8	1.3	0.5	
		Kr86(n,2n)Kr85(n,p)Br85(β^-)Kr85m				0.5	1.0		
		Kr86(n,d)Br85(β^-)Kr85m					35.9	61.5	71.1
Kr79	1.460 d	**&**Kr78(n,γ)*Kr79*	100.0	100.0	100.0				
		&Kr80(n,2n)*Kr79*				91.9	44.2	21.6	6.5
		&Kr82(n,2n)*Kr81*(n,2n)Kr80(n,2n)*Kr79*				5.3	0.9		
		&Kr82(n,3n)Kr80(n,2n)*Kr79*					14.3	9.4	1.0
		&Kr82(n,2n)*Kr81*(n,3n)*Kr79*					12.9	7.7	0.8
		&Kr83(n,3n)Kr81(n,3n)*Kr79*					9.8	12.4	0.8
		&Kr84(n,4n)*Kr81*(n,3n)*Kr79*						13.0	6.8
		&Kr82(n,4n)*Kr79*						10.8	44.0
		&Kr84(n,3n)Kr82(n,4n)*Kr79*						4.9	6.6
		&Kr83(n,5n)*Kr79*							14.4
Br82	1.472 d	**&**Kr78(n,γ)*Kr79*(β^+)Br79(n,γ)*Br80*(β^+)_ Se80(n,γ)*Se81*(β^-)Br81(n,γ)*Br82*	34.9	0.2	4.6				
		&Kr80(n,γ)Kr81m(β^+)Br81(n,γ)*Br82*	28.3	55.4	50.6				
		&Kr80(n,γ)*Kr81*(β^+)Br81(n,γ)*Br82*	19.0	42.2	42.3				
		&Kr82(n,p)*Br82*				65.2	15.9	5.1	1.5
		&Kr83(n,2n)Kr82(n,p)*Br82*				11.5	1.3		
		&Kr83(n,d)*Br82*				8.6	41.6	20.2	14.2
		&Kr84(n,2n)*Kr83*(n,d)*Br82*				7.7	18.2	3.7	1.2
		&Kr84(n,2n)*Kr83*(n,2n)Kr82(n,p)*Br82*				5.3	0.2		
		&Kr84(n,t)*Br82*					11.5	63.0	64.4
		Kr84(n,3n)Kr82(n,p)Br82					7.1	2.4	
		Kr86(n,2nt)Br82							3.8
Rb86	18.64 d	**&**Kr84(n,γ)Kr85m(β^-)Rb85(n,γ)*Rb86*	78.4	96.2	95.8				
		&Kr83(n,γ)Kr84(n,γ)Kr85m(β^-)Rb85_ (n,γ)*Rb86*	13.5		0.3				
		&Kr82(n,γ)*Kr83*(n,γ)Kr84(n,γ)Kr85m_ (β^-)Rb85(n,γ)*Rb86*	4.5						
	►	**&**Kr84(n,γ)Kr85(β^-)Rb85(n,γ)*Rb86*	3.0	3.8	3.8				

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Kr83(n,γ)Kr84(n,γ)*Kr85*(β^-)Rb85(n,γ)Rb86	0.8						
		&Kr86(n,γ)Kr87(β^-)Rb87(n,2n)*Rb86*				78.6	82.8	71.8	58.3
		&Kr86(n,2n)Kr85m(β^-)Rb85(n,γ)*Rb86*				12.7	6.4	7.8	9.5
		&Kr86(n,2n)*Kr85*(β^-)Rb85(n,γ)*Rb86*				8.2	6.6	7.3	8.7
		&Kr86(n,d)*Br85*(β^-)Kr85m(β^-)Rb85(n,γ)*Rb86*						12.7	22.9
Rb84	33.5 d	&Kr86(n,2n)Kr85m(β^-)Rb85(n,2n)*Rb84*				60.7	38.3	28.1	23.1
		&Kr86(n,2n)*Kr85*(β^-)Rb85(n,2n)*Rb84*				38.2	38.7	25.4	20.2
		&Kr86(n,2n)Kr85(n,n′)Kr85m(β^-)Rb85_ (n,2n)*Rb84*				0.6	0.4	0.1	
		&Kr86(n,d)Br85(β^-)Kr85m(β^-)Rb85_ (n,2n)*Rb84*					20.9	43.9	54.0
		&Kr86(n,d)Br85(β^-)Kr85m(IT)Kr85(β^-)_ Rb85(n,2n)*Rb84*					0.8	1.7	1.0
		&Kr86(n,2n)Kr85(n,p)Br85(β^-)Kr85m_ (β^-)Rb85(n,2n)*Rb84*					0.4		
Rb83	86.2 d	&Kr86(n,2n)Kr85m(β^-)Rb85(n,2n)*Rb84*_ (n,2n)Rb83				46.1			
		&Kr86(n,2n)*Kr85*(β^-)Rb85(n,2n)*Rb84*_ (n,2n)*Rb83*				19.1			
		&Kr86(n,2n)Kr85m(β^-)Rb85(n,2n)*Rb84*_ (β^-)Sr84(n,2n)*Sr83*(β^+)Rb83				15.9			
		&Kr86(n,2n)*Kr85*(β^-)Rb85(n,2n)*Rb84*_ (β^-)Sr84(n,2n)*Sr83*(β^+)Rb83				6.2			
		Kr86(n,2n)Kr85m(β^-)Rb85(n,3n)Rb83					38.7	28.3	23.2
		&Kr86(n,2n)*Kr85*(β^-)Rb85(n,3n)Rb83					37.7	24.8	19.7
		Kr86(n,d)Br85(β^-)Kr85m(β^-)Rb85(n,3n)Rb83					21.1	44.3	54.4
Se75	119.64 d	Kr78(n,α)Se75	100.0	100.0	99.8	69.9	5.3	2.7	6.4
		&Kr78(n,d)*Br77*(β^+)Se77(n,2n)Se76(n,2n)Se75				12.8	1.0		
		Kr78(n,2n)Kr77(β^+)Br77(β^+)Se77(n,2n)_ Se76(n,2n)Se75				8.5	0.8		
		Kr80(n,nα)Se76(n,2n)Se75				2.6	13.9	1.2	0.3
		&Kr78(n,d)*Br77*(β^+)Se77(n,3n)Se75					15.8	2.2	0.2
		Kr78(n,2n)Kr77(β^+)Br77(β^+)Se77(n,3n)Se75					13.3	1.7	0.2
		Kr78(n,h)Se76(n,2n)Se75					4.3	0.6	
		Kr80(n,2nα)Se75					1.1	32.2	7.7
		Kr82(n,3n)Kr80(n,2nα)Se75					0.4	13.7	1.2
		&Kr82(n,2nα)*Se77*(n,3n)Se75						5.2	0.6
		Kr78(n,nt)Br75(β^+)Se75						1.3	8.2
		Kr84(n,4n)Kr81(n,3nα)Se75							11.1
		Kr84(n,3nα)Se78(n,4n)Se75							5.2
Kr85	10.752 y	&Kr84(n,γ)*Kr85*	79.5	99.9	99.6	0.2	0.2		0.1
		&Kr83(n,γ)Kr84(n,γ)*Kr85*	14.7		0.4				
		&Kr82(n,γ)*Kr83*(n,γ)Kr84(n,γ)*Kr85*	5.7						
		&Kr86(n,2n)*Kr85*				99.7	97.2	93.2	90.3
		Kr86(n,d)Br85(β^-)Kr85m(IT)Kr85					2.0	6.2	9.3
H3	12.33 y	&Kr78(n,γ)*Kr79*(n,X)H1(n,γ)H2(n,γ)H3	93.3	94.6	98.7				
		Kr83(n,X)H3				56.2	20.4	15.0	13.0
		&Kr84(n,2n)*Kr83*(n,X)H3				26.9	4.8	1.5	
		&Kr82(n,2n)*Kr81*(n,X)H3				9.2	1.3		
		Kr84(n,X)H3					42.4	47.8	49.9
		Kr86(n,X)H3					10.7	13.2	14.4
		Kr82(n,X)H3					9.2	10.1	10.3
Kr81	2.1 10^5 y	&Kr80(n,γ)*Kr81*	99.6	100.0	100.0				
		&Kr82(n,2n)*Kr81*				88.6	43.0	19.9	10.0
		&Kr83(n,2n)Kr82(n,2n)*Kr81*				8.4	1.9		
		&Kr84(n,2n)*Kr83*(n,2n)Kr82(n,2n)*Kr81*				2.6	0.2		
		&Kr83(n,3n)*Kr81*					34.8	33.4	9.0
		&Kr84(n,3n)Kr82(n,2n)*Kr81*					10.0	5.0	
		&Kr84(n,2n)*Kr83*(n,3n)*Kr81*					7.9	3.0	
		Kr84(n,d)Br83(β^-)Kr83m(IT)Kr83(n,3n)Kr81					0.9	1.2	
		&Kr84(n,4n)*Kr81*						33.6	76.4

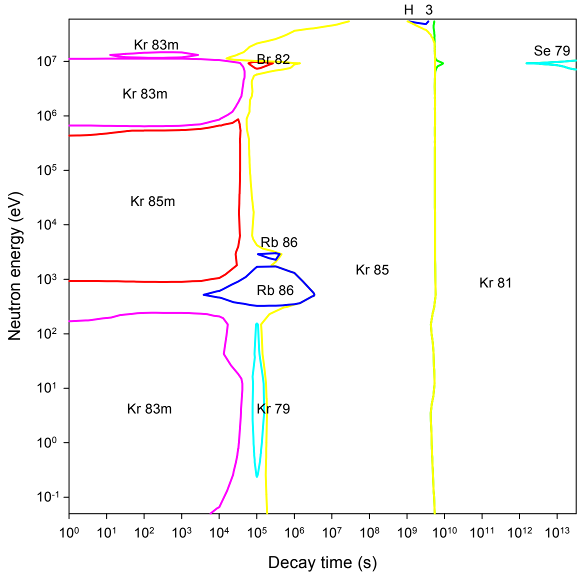
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Se79	1.1 10^6 y	**&**Kr80(n,γ)*Kr81*(n,γ)Kr82(n,α)*Se79*	80.2	99.9	99.8				
		&Kr78(n,γ)*Kr79*(n,α)Se76(n,γ)*Se77*(n,γ)_ Se78(n,γ)*Se79*	19.4						
		&Kr82(n,α)*Se79*				79.1	23.8	6.6	9.2
		&Kr83(n,2n)Kr82(n,α)*Se79*				7.4	1.0		0.1
		&Kr83(n,α)Se80(n,2n)*Se79*				4.7	0.4		
		&Kr80(n,2n)*Kr79*(β^+)Br79(n,p)*Se79*				3.4	0.5		
		&Kr84(n,2n)*Kr83*(n,2n)Kr82(n,α)*Se79*				2.3	0.1		
		&Kr84(n,2n)*Kr83*(n,α)Se80(n,2n)*Se79*				1.2			
		&Kr83(n,nα)*Se79*				0.6	47.8	22.6	12.0
		&Kr84(n,2n)*Kr83*(n,nα)*Se79*				0.2	10.9	2.0	0.7
		&Kr84(n,3n)Kr82(n,α)Se79					5.6	1.5	0.7
		&Kr84(n,nα)Se80(n,2n)Se79					4.0	1.4	0.5
		&Kr84(n,2nα)*Se79*					0.2	56.3	63.2
		&Kr84(n,nt)Br81(n,t)Se79							3.5

Krypton activation characteristics

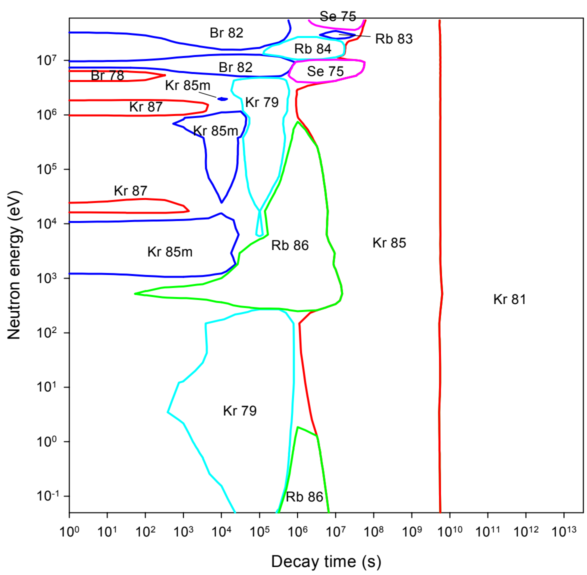


Krypton importance diagrams & transmutation

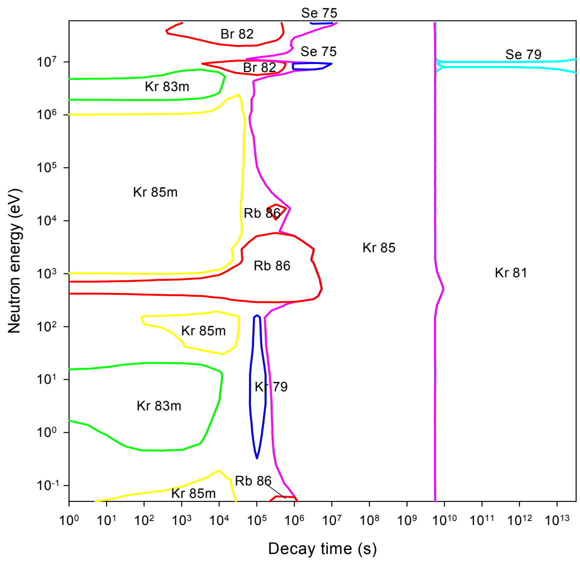
Activity



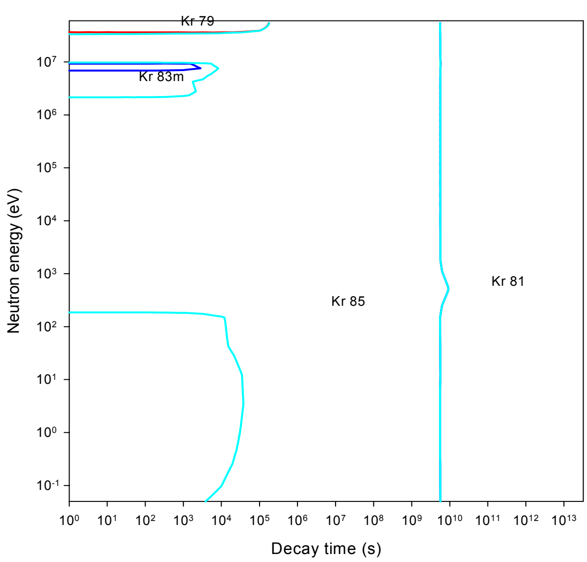
Dose rate



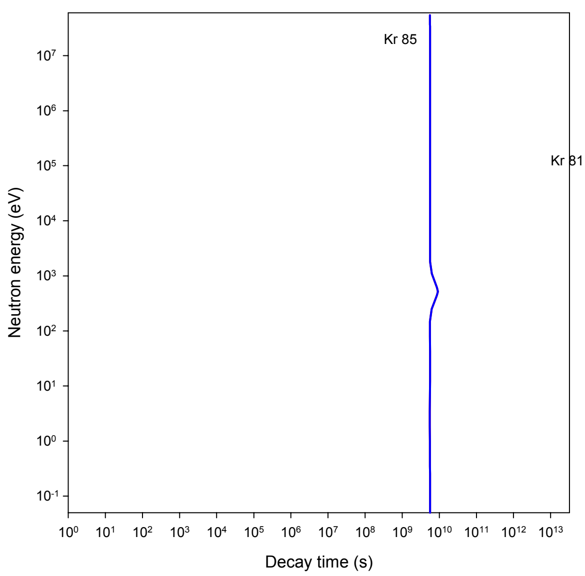
Heat output



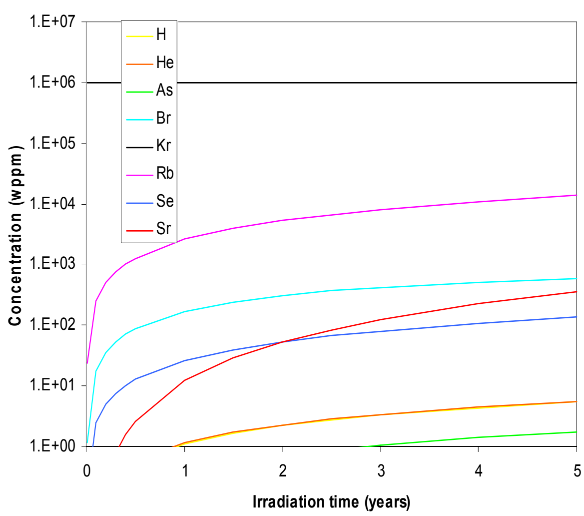
Ingestion dose



Inhalation dose



First wall transmutation



Graphs for H, He are indistinguishable

Rubidium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	37		
Crustal abundance / wppm	90	Rb85	72.17
Melting point / K	312.5	Rb87	27.83 ($T_{½}$ = 4.75 10^{10} y)
Boiling point / K	961		
Density / kgm^{-3}	1532		
Thermal conductivity / $Wm^{-1}K^{-1}$	58.2		
Electrical resistivity /Ωm	1.25 10^{-7}		
Coefficient of thermal expansion / K^{-1}	9.0 10^{-5}		
Crystal structure	BCC		
Number of stable isotopes	1 (2)		
Mean atomic weight	85.4678		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	3.52E15	3.11E15	2.32E15	5.56E12	7.50E9	1.46E6	kW kg^{-1}	4.79E-1	4.32E-1	3.05E-1	2.83E-4	2.76E-7	1.26E-11
Rb86	54.94	62.08	72.57	0.04			Rb86	48.49	53.74	66.51	0.10		
Rb84	18.28	20.66	25.65	6.04			Rb84	22.19	24.59	32.33	19.58		
Rb86m	9.38	0.29					Rb88	16.18	14.61				
Rb84m	8.22	7.77					Rb86m	6.14	0.18				
Rb88	5.04	4.64					Rb84m	4.48	4.15				
Sr87m	1.63	1.81					Sr87m	0.74	0.80				
Sr85	1.01	1.15	1.48	13.00			Sr85	0.63	0.70	0.95	21.53		
Kr85m	0.55	0.61					Kr85m	0.26	0.29				
Kr85	0.13	0.15	0.20	79.66	99.75		Kr85	0.03	0.04	0.05	57.63	99.98	
H3				0.07	0.22		Rb83	0.01	0.01	0.01	1.04		
Rb87					0.01	59.71	Rb87						90.41
Kr81					0.01	40.20	Kr81						9.50

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	3.01E5	2.55E5	1.85E5	1.57E2	3.82E-3	2.06E-7	Sv kg^{-1}	1.39E7	1.39E7	1.16E7	4.87E6	8.23E3	3.76E-2
Rb84	48.04	54.66	72.56	48.15			Rb86	38.90	39.01	40.70			
Rb86	17.67	20.84	25.13	0.04			Kr85	37.34	37.44	44.72	99.97	100.0	
Rb88	12.71	12.22					Rb84	12.94	12.98	14.38	0.01		
Rb86m	12.22	0.39					Sr85	0.14	0.14	0.16			
Rb84m	5.49	5.41					Rb88	0.11	0.09				
Sr85	1.24	1.46	1.94	48.13			Rb84m	0.10	0.08				
Br82	1.08	1.28	0.31				Br82	0.01	0.01				
Sr87m	0.95	1.09					Rb83			0.01			
Rb83	0.02	0.02	0.03	2.34			Kr81						96.52
Kr85				1.28*	99.99*		Rb87						3.46
Kr81						100.0							

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.83E8	1.83E8	1.81E8	1.68E8	2.84E5	1.29E0		1.11E12	8.83E11	5.95E11	1.29E9	4.17E5	8.75E2
Kr85	98.24	98.25	98.79	100.0	100.0		Rb84	52.66	66.21	91.12	23.62		
Rb86	0.98	0.98	0.86				Rb86m	16.53	0.57				
Rb84	0.35	0.35	0.32				Rb88	14.54	14.89				
Kr85m	0.32	0.31					Rb84m	10.02	10.54				
Sr85	0.01	0.01	0.01				Sr85	3.22	4.05	5.79	55.59		
Kr81						99.96	Rb86	1.74	2.18	2.83			
Rb87						0.03	Br82	0.42	0.53	0.14			
							Sr87m	0.05	0.06				
							Rb83	0.03	0.03				
							Kr85		0.02	0.04	19.03	99.73	
							Rb87					0.20	99.48
							Kr81						0.51

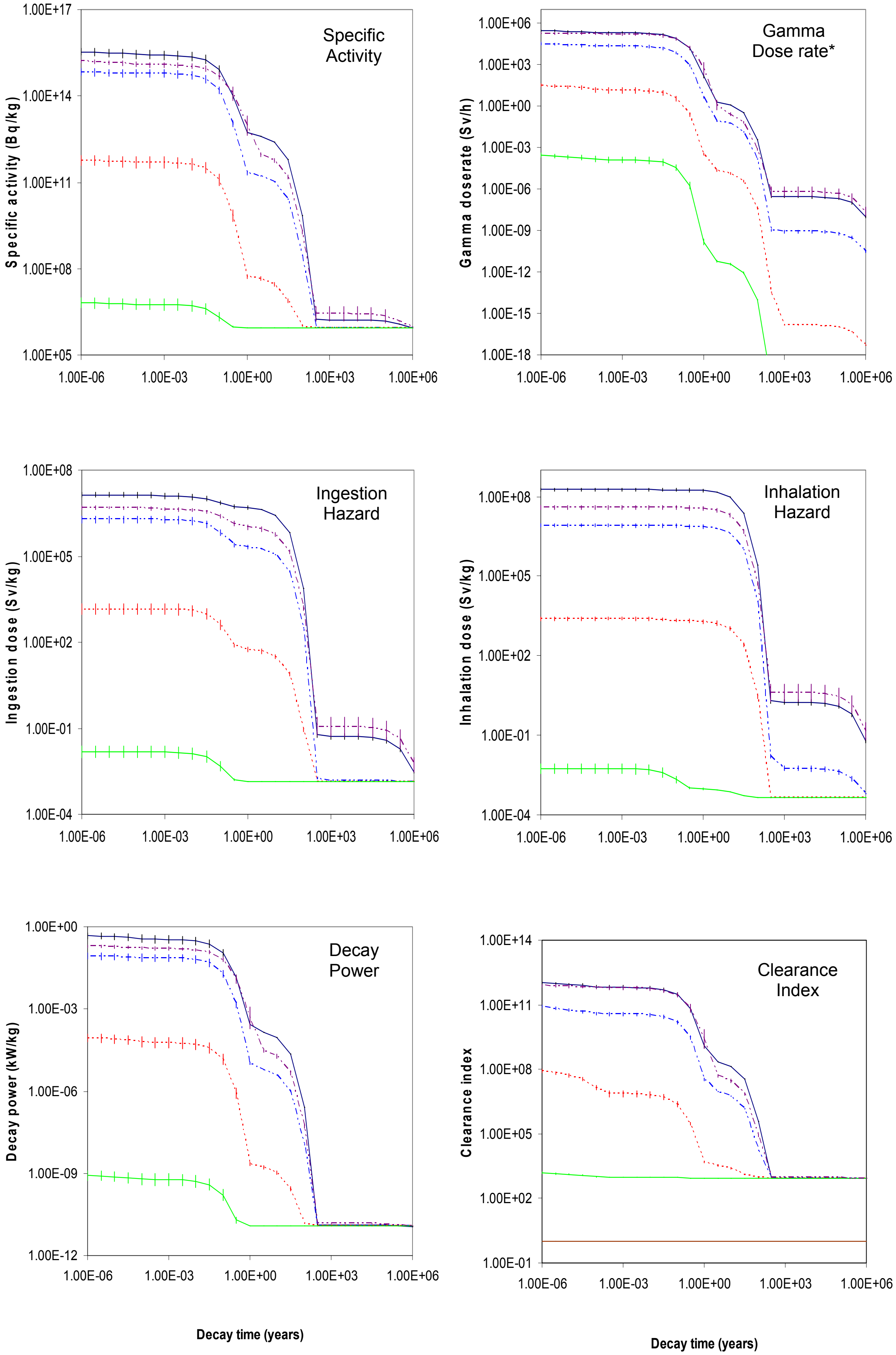
Rubidium

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Rb82m	6.472 h	&Rb85(n,2n)*Rb84*(n,2n)Rb83(n,2n)Rb82m				55.5			
		&Rb85(n,2n)*Rb84*(β^-)Sr84(n,2n)*Sr83*_ (β^+)Rb83(n,2n)Rb82m				38.2	0.1		
		&Rb85(n,2n)*Rb84*(β^-)Sr84(n,d)Rb83_ (n,2n)Rb82m				5.3			
		Rb85(n,3n)Rb83(n,2n)Rb82m					71.1	2.6	
		&Rb85(n,2n)*Rb84*(n,3n)Rb82m					21.9		
		Rb87(n,3n)Rb85(n,3n)Rb83(n,2n)Rb82m					2.5		
		&Rb85(n,2n)*Rb84*(β^-)Sr84(n,t)Rb82m					1.9		
		Rb85(n,4n)Rb82m						90.9	97.9
		Rb87(n,3n)Rb85(n,4n)Rb82m						3.7	
Br82	1.472 d	&Rb85(n,α)*Br82*				99.9	53.4	22.1	31.5
		&Rb85(n,3n)Rb83(β^+)*Kr83*(n,d)*Br82*					34.8	36.0	7.6
		&Rb85(n,2n)*Rb84*(β^+)Kr84(n,t)*Br82*					2.2	11.5	9.4
		&Rb85(n,t)*Kr83*(n,d)*Br82*					1.6	6.5	5.3
		&Rb85(n,d)Kr84(n,t)*Br82*					0.3	4.2	4.9
		&Rb87(n,2nα)*Br82*						11.1	18.7
		&Rb87(n,4n)*Rb84*(β^+)Kr84(n,t)*Br82*						1.4	5.5
Y90	2.671 d	&Rb87(n,γ)Rb88(β^-)Sr88(n,γ)Sr89(β^-)_ Y89(n,γ)*Y90*	96.7	99.8	99.0	97.1	94.4	94.5	95.6
		&Rb85(n,γ)*Rb86*(β^-)Sr86(n,γ)*Sr87*(n,γ)_ Sr88(n,γ)Sr89(β^-)Y89(n,γ)Y90	2.9						
		Rb87(n,γ)Rb88(β^-)Sr88(n,γ)Sr89(n,γ)_ Sr90(β^-)Y90	0.2	0.2	0.9	0.7	0.9	0.9	0.8
Rb86	18.64 d	&Rb85(n,γ)*Rb86*	100.0	100.0	99.9				
		&Rb87(n,2n)*Rb86*				98.7	98.7	98.9	99.3
Rb84	33.50 d	&Rb85(n,2n)*Rb84*				98.9	95.4	84.0	61.6
		&Rb87(n,3n)Rb85(n,2n)*Rb84*					3.5	3.4	
		&Rb87(n,4n)*Rb84*						11.1	36.4
Sr89	50.57 d	Rb87(n,γ)Rb88(β^-)Sr88(n,γ)Sr89	94.3	100.0	99.9	99.8	99.7	99.8	99.9
		&Rb85(n,γ)*Rb86*(β^-)Sr86(n,γ)*Sr87*(n,γ)_ Sr88(n,γ)Sr89	5.6						
Sr85	64.849 d	&Rb87(n,2n)*Rb86*(β^-)Sr86(n,2n)*Sr85*				99.6	99.7	99.6	99.7
Rb83	86.20 d	&Rb85(n,2n)*Rb84*(n,2n)Rb83				55.7	0.1		
		&Rb85(n,2n)*Rb84*(β^-)Sr84(n,2n)*Sr83*(β^+)Rb83				35.6			
		&Rb85(n,2n)*Rb84*(β^-)Sr84(n,d)Rb83				5.3			
		Rb85(n,3n)Rb83					95.4	95.8	76.9
		Rb87(n,3n)Rb85(n,3n)Rb83					3.3	3.7	
		Rb87(n,5n)Rb83							19.8
Kr85	10.752 y	&Rb85(n,γ)*Rb86*(β^-)Sr86(n,γ)*Sr87*(n,α)_ Kr84(n,γ)*Kr85*	100.0		100.0				
		&Rb85(n,p)*Kr85*				98.6	81.7	42.8	22.0
		Rb87(n,d)Kr86(n,2n)Kr85				0.8	3.7	1.8	
		&Rb87(n,t)*Kr85*					12.3	53.8	69.6
		Rb87(n,3n)Rb85(n,p)Kr85					1.5	0.9	
H3	12.33 y	&Rb85(n,γ)*Rb86*(n,X)H1(n,γ)H2(n,γ)H3	93.5	95.3	99.4				
		Rb85(n,X)H3				80.5	69.7	67.7	67.5
		&Rb85(n,2n)*Rb84*(n,X)H3				13.3	0.4		
		Rb87(n,X)H3				3.8	21.0	22.9	24.0
		&Rb85(n,3n)Rb83(β^+)*Kr83*(n,X)H3					3.1	0.8	
		&Rb85(n,2n)*Rb84*(β^+)Kr84(n,X)H3					1.5		
		Rb87(n,3n)Rb85(n,X)H3					1.3	1.4	
		&Rb87(n,2n)*Rb86*(β^-)Sr86(n,X)H3						1.0	
Nb93m	16.126 y ►	&Rb87(n,γ)Rb88(β^-)Sr88(n,γ)Sr89(β^-)_ *Y89*(n,γ)*Y90*(n,γ)*Y91*(β^-)Zr91(n,γ)Zr92_ (n,γ)Zr93(β^-)Nb93m	65.0						

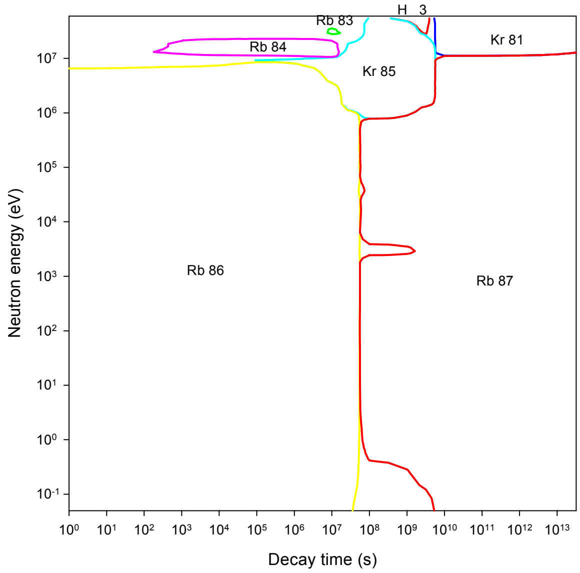
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Rb87(n,γ)Rb88(β^-)Sr88(n,γ)Sr89(β^-)_ *Y89*(n,γ)*Y90*(n,γ)*Y91*(n,γ)Y92(β^-)Zr92_ (n,γ)Zr93(β^-)Nb93m	23.3						
		&Rb87(n,γ)Rb88(β^-)Sr88(n,γ)Sr89(β^-)_ *Y89*(n,γ)*Y90*(β^-)Zr90(n,γ)Zr91(n,γ)Zr92_ (n,γ)Zr93(β^-)Nb93m	8.8						
		Other long pathways involving (n,γ) and β^-	2.9						
Sr90	28.79 y	Rb87(n,γ)Rb88(β^-)Sr88(n,γ)Sr89(n,γ)Sr90	96.9	100.0	100.0	99.8	99.5	99.6	99.7
		&Rb85(n,γ)*Rb86*(β^-)Sr86(n,γ)*Sr87*(n,γ)_ Sr88(n,γ)Sr89(n,γ)Sr90	3.0						
Kr81	2.1 10^5 y	&Rb85(n,α)*Br82*(β^-)Kr82(n,2n)*Kr81*				67.1	1.9	0.2	
		&Rb85(n,2n)*Rb84*(β^+)Kr84(n,2n)*Kr83*_ (n,2n)Kr82(n,2n)*Kr81*				22.1			
		&Rb85(n,2n)*Rb84*(β^-)Sr84(n,α)*Kr81*				5.7			
		&Rb85(n,2n)*Rb84*(n,2n)Rb83(β^+)*Kr83*_ (n,2n)Kr82(n,2n)*Kr81*				1.7			
		&Rb85(n,3n)Rb83(β^+)*Kr83*(n,3n)*Kr81*					71.1	56.6	1.7
		&Rb85(n,t)*Kr83*(n,3n)*Kr81*					33.7	11.0	0.9
		&Rb85(n,3n)Rb83(n,3n)*Rb81*(β^+)Kr81					6.6	6.9	0.2
		&Rb85(n,3n)Rb83(n,t)*Kr81*					1.8	3.3	0.2
		&Rb85(n,2n)*Rb84*(β^+)Kr84(n,4n)*Kr81*						6.0	2.9
		&Rb85(n,2nt)*Kr81*						0.3	29.1
		&Rb85(n,5n)*Rb81*(β^+)Kr81							52.3
Rb87	4.8 10^{10} y	&Rb85(n,γ)*Rb86*(n,γ)Rb87	0.1						
		Nuclide present in starting material	99.9	100.0	100.0	100.0	100.0	100.0	100.0

Rubidium activation characteristics

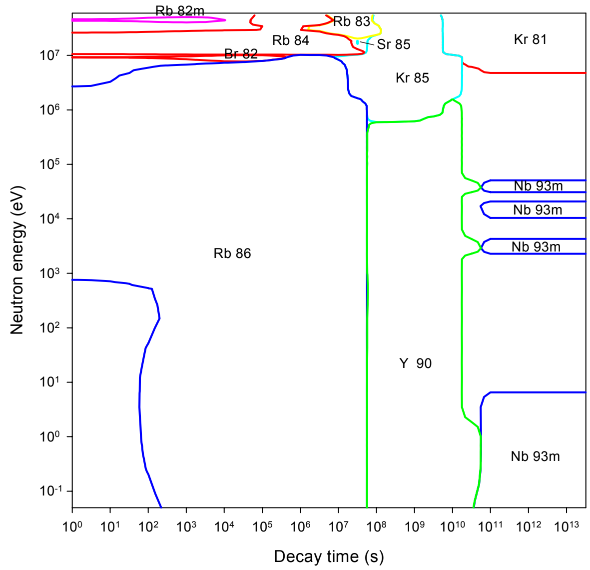


Rubidium importance diagrams & transmutation

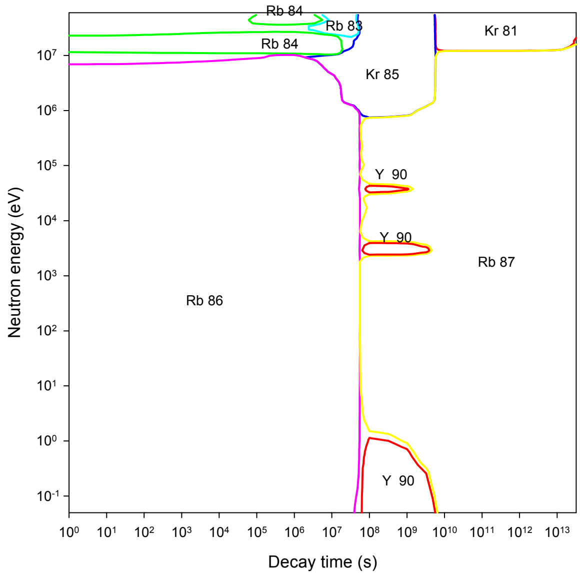
Activity



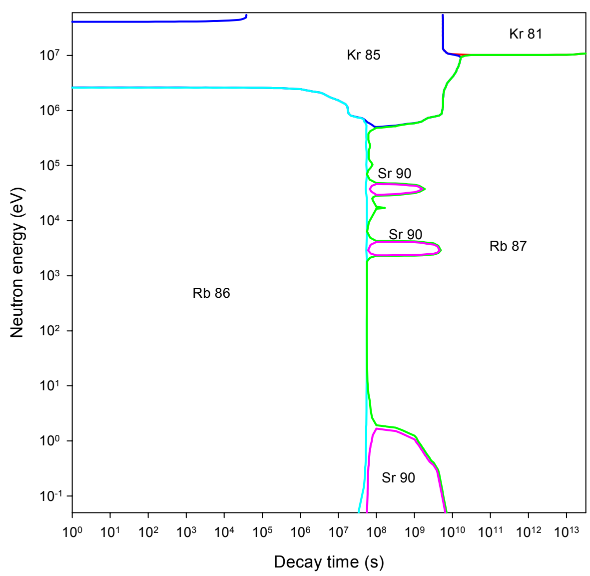
Dose rate



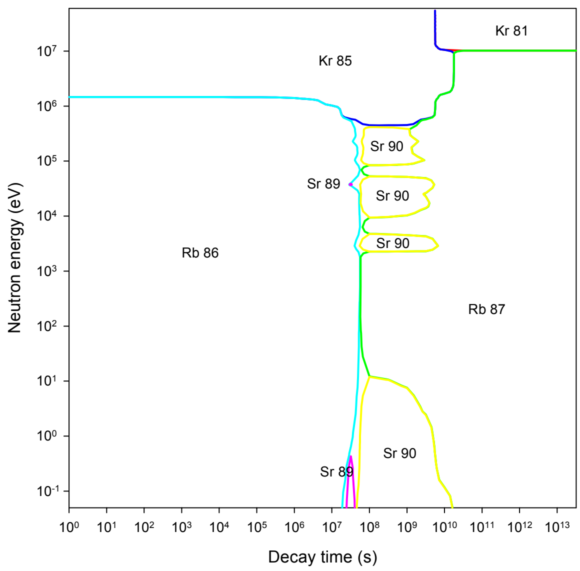
Heat output



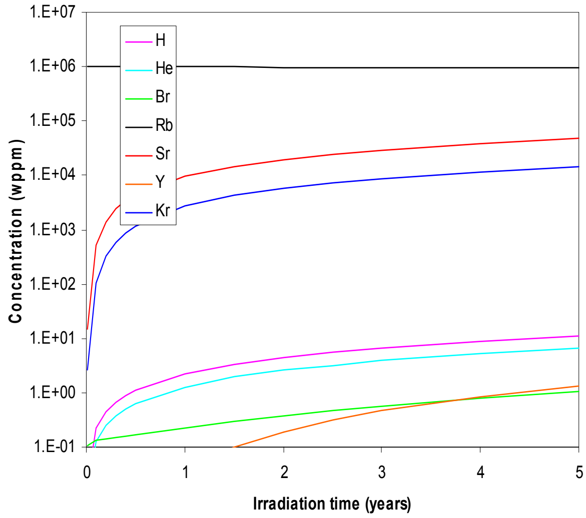
Ingestion dose



Inhalation dose



First wall transmutation



Strontium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	38		
Crustal abundance / wppm	370	Sr84	0.56
Melting point / K	1050	Sr86	9.86
Boiling point / K	1655	Sr87	7.00
Density / kgm^{-3}	2540	Sr88	82.58
Thermal conductivity / Wm^{-1}K^{-1}	35.3		
Electrical resistivity /Ωm	2.30 10^{-7}		
Coefficient of thermal expansion / K^{-1}	2.25 10^{-5}		
Crystal structure	FCC		
Number of stable isotopes	4		
Mean atomic weight	87.62		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	5.09E14	4.95E14	1.32E14	2.94E12	1.00E9	1.26E6
Sr87m	62.97	63.28				
Sr85	18.56	19.06	68.83	64.79		
Sr85m	6.41	6.23				
Sr89	4.79	4.92	17.57	5.55		
Rb86	1.96	2.01	6.60			
Rb88	1.87	1.57				
Rb83	0.58	0.60	2.22	5.47		
Rb84	0.55	0.57	1.98	0.05		
Kr83m	0.50	0.51	1.67	4.10		
Kr85	0.11	0.11	0.44	18.72	92.69	
Y88	0.07	0.08	0.29	1.27		
Y90	0.02	0.02	0.03	0.01	3.54	
Sr90				0.01	3.54	
Kr81					0.17	99.98
H3					0.04	

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Kw kg^{-1}	3.84E-2	3.69E-2	1.18E-2	2.27E-4	4.06E-8	2.59E-12
Sr87m	51.57	52.56				
Sr85	20.76	21.62	64.79	70.91		
Rb88	10.84	9.20				
Sr89	5.94	6.18	18.34	6.74		
Rb86	3.12	3.25	8.84			
Sr85m	3.11	3.07				
Rb84	1.21	1.26	3.66	0.10		
Sr83	1.07	1.12	0.53			
Rb83	0.62	0.65	2.00	5.73		
Y88	0.45	0.47	1.44	7.17		
Rb86m	0.44	0.01				
Kr85	0.05	0.05	0.18	8.94	84.46	
Y90	0.04	0.04	0.05	0.02	13.09	
Sr90					2.43	
Kr81						99.91

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	3.06E4	2.95E4	1.09E4	2.45E2	5.10E-4	4.14E-7
Sr87m	51.06	51.82				
Sr85	31.90	33.08	85.99	80.28		
Rb88	6.68	5.64				
Sr85m	2.26	2.22				
Rb84	2.06	2.14	5.36	0.13		
Sr83	1.61	1.67	0.69			
Y88	1.11	1.15	3.05	12.97		
Rb83	0.96	1.00	2.67	6.51		
Rb86	0.89	0.92	2.18			
Kr85				0.10*	99.86*	
Kr81					0.13	100.0

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	8.89E5	8.87E5	8.01E5	6.07E5	1.02E3	7.84E-2
Kr85	72.62	72.73	80.48	99.63	99.88	
Sr85	7.95	5.95	6.34	0.17		
Sr89	7.13	7.14	7.52	0.06		
Rb86	3.14	3.15	3.04			
Sr87m	1.08	1.06				
Rb84	0.89	0.89	0.91			
Rb83	0.63	0.64	0.69	0.05		
Sr83	0.15	0.15	0.02			
Y88	0.05	0.05	0.06			
Y90	0.03	0.03	0.01			
Sr90					0.09	
Kr81					0.01	100.0

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	2.26E7	2.26E7	2.26E7	2.09E7	3.54E4	2.78E0
Kr85	98.54	98.55	98.78	99.98	99.97	
Sr89	0.85	0.85	0.81			
Sr85	0.33	0.33	0.32			
Rb86	0.04	0.04	0.03			
Sr87m	0.02	0.02				
Rb84	0.01	0.01	0.01			
Sr90					0.01	
Kr81					0.01	100.0

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	1.16E11	1.13E11	9.62E10	2.12E9	8.73E4	9.89E0
Sr85	81.10	83.51	94.37	89.84		
Rb88	7.45	6.25				
Sr87m	2.75	2.77				
Rb84	2.21	2.27	2.48	0.06		
Sr83	1.84	1.89	0.34			
Rb83	1.28	1.32	1.52	3.79		
Y88	0.93	0.96	1.10	4.79		
Sr85m	0.28	0.27				
Rb86	0.08	0.08	0.09			
Kr85	0.02	0.02	0.03	1.44	59.20	
Sr90				0.01	40.74	
Kr 81					0.01	98.31

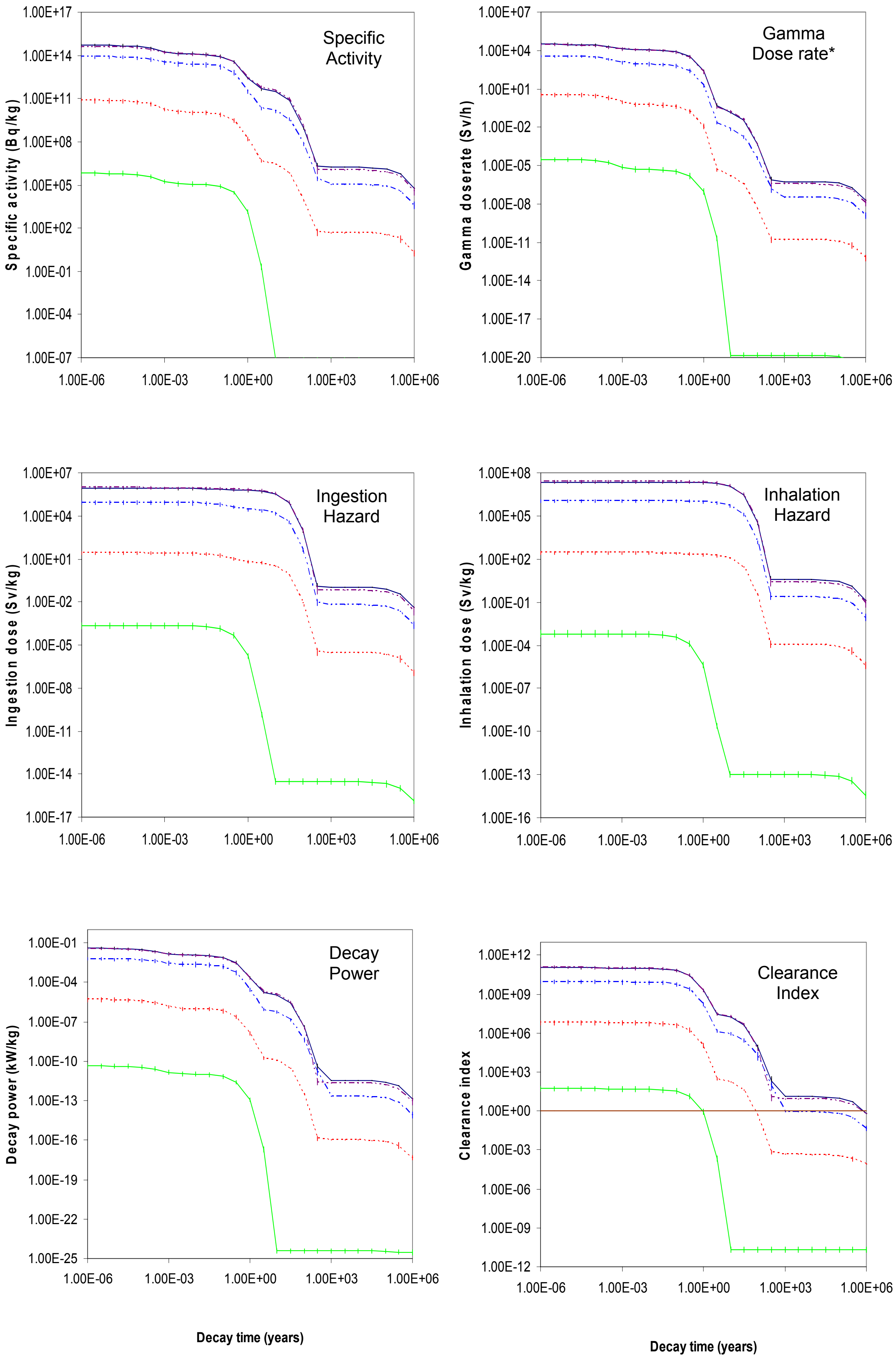
Strontium

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Sr87m	2.803 h	Sr86(n,γ)Sr87m	100.0	100.0	100.0				
		Sr88(n,2n)Sr87m				92.6	94.5	94.0	94.3
		Sr88(n,2n)Sr87(n,n')Sr87m				3.5	2.4	1.7	
		Sr87(n,n')Sr87m				2.5	2.0	3.4	4.0
Y90	2.671 d	&Sr88(n,γ)Sr89(β^-)Y89(n,γ)*Y90*	96.9	99.7	99.1	98.2	96.8	97.1	97.4
		Sr87(n,γ)Sr88(n,γ)Sr89(β^-)Y89(n,γ)Y90	2.8						
		Sr88(n,γ)Sr89(n,γ)Sr90(β^-)Y90	0.1	0.1	0.8	0.7	0.9	0.9	0.8
Rb86	18.64 d	&Sr84(n,γ)*Sr85*(β^+)Rb85(n,γ)*Rb86*	88.9	88.6	89.4				
		&Sr84(n,γ)Sr85m(β^+)Rb85(n,γ)*Rb86*	11.1	11.4	10.6				
		&Sr86(n,p)*Rb86*				62.4	10.5	3.6	
		&Sr88(n,2n)*Sr87*(n,d)*Rb86*				8.5	30.4	5.5	
		&Sr87(n,2n)Sr86(n,p)*Rb86*				8.1	0.9		
		&Sr88(n,2n)*Sr87*(n,2n)Sr86(n,p)*Rb86*				7.5	0.5		
		&Sr87(n,d)*Rb86*				4.6	21.1	10.2	7.0
		&Sr87(n,p)Rb87(n,2n)*Rb86*				2.3	0.3		
		&Sr88(n,2n)*Sr87*(n,p)Rb87(n,2n)*Rb86*				2.1	0.1		
		&Sr88(n,d)Rb87(n,2n)*Rb86*				1.9	17.3	5.5	
		&Sr88(n,2n)Sr87m(β^+)Rb87(n,2n)*Rb86*				1.6			
		&Sr88(n,t)*Rb86*					11.9	70.3	85.1
		&Sr88(n,3n)Sr86(n,p)*Rb86*					5.6	3.3	
Rb84	33.50 d	&Sr86(n,2n)*Sr85*(β^+)Rb85(n,2n)*Rb84*				83.0	40.4	4.0	1.1
		&Sr87(n,2n)Sr86(n,2n)*Sr85*(β^+)Rb85_ (n,2n)*Rb84*				4.6	1.5		
		&Sr84(n,p)*Rb84*				2.8	0.8	0.3	
		&Sr86(n,2n)Sr85m(β^+)Rb85(n,2n)*Rb84*				2.8	0.7		
		&Sr88(n,2n)*Sr87*(n,2n)Sr86(n,2n)*Sr85*_ (β^+)Rb85(n,2n)*Rb84*				1.0	0.2		
		&Sr86(n,d)Rb85(n,2n)*Rb84*				0.9	6.7	1.5	0.6
		&Sr87(n,3n)*Sr85*(β^+)Rb85(n,2n)*Rb84*					12.0	4.7	0.6
		&Sr88(n,3n)Sr86(n,2n)*Sr85*(β^+)Rb85_ (n,2n)*Rb84*					9.4	1.5	
		&Sr88(n,2n)Sr87(n,3n)Sr85(β^+)Rb85_ (n,2n)*Rb84*					6.1	1.0	
		&Sr86(n,t)*Rb84*					4.2	35.2	21.5
		&Sr88(n,3n)Sr86(n,t)*Rb84*					2.2	31.8	6.7
		&Sr88(n,d)Rb87(n,4n)*Rb84*						3.3	6.2
		&Sr88(n,4n)Sr85(β^+)Rb85(n,2n)*Rb84*						2.6	12.5
		&Sr87(n,nt)*Rb84*						1.3	16.3
		&Sr88(n,2n)Sr87(n,nt)*Rb84*						0.6	4.8
		&Sr88(n,nt)Rb85(n,2n)*Rb84*						0.4	4.5
		&Sr88(n,2nt)*Rb84*							16.3
Sr89	50.57 d	Sr88(n,γ)Sr89	95.1	99.9	99.9	99.5	99.1	99.3	99.7
		Sr87(n,γ)Sr88(n,γ)Sr89	4.7		0.1				
		&Sr86(n,γ)*Sr87*(n,γ)Sr88(n,γ)Sr89	0.2						
Sr85	64.849 d	&Sr84(n,γ)*Sr85*	100.0	100.0	100.0				
		&Sr86(n,2n)*Sr85*				80.2	41.5	21.6	6.3
		&Sr87(n,2n)Sr86(n,2n)*Sr85*				10.0	3.4	0.7	
		&Sr88(n,2n)*Sr87*(n,2n)Sr86(n,2n)*Sr85*				9.0	2.2		
		&Sr88(n,3n)Sr86(n,2n)*Sr85*					21.2	18.9	1.9
		&Sr88(n,2n)*Sr87*(n,3n)*Sr85*					17.2	14.1	1.1
		&Sr87(n,3n)*Sr85*					12.6	25.8	4.0
		&Sr88(n,4n)*Sr85*						15.7	83.5
Kr85	10.752 y	&Sr84(n,γ)*Sr85*(n,α)Kr82(n,γ)*Kr83*(n,γ)_ Kr84(n,γ)*Kr85*	90.2	99.9					
		&Sr87(n,α)Kr84(n,γ)*Kr85*	9.6		99.4				
		&Sr86(n,γ)*Sr87*(n,α)Kr84(n,γ)*Kr85*	0.2		0.4				
	►	&Sr88(n,α)*Kr85*				94.8	98.1	93.9	88.5

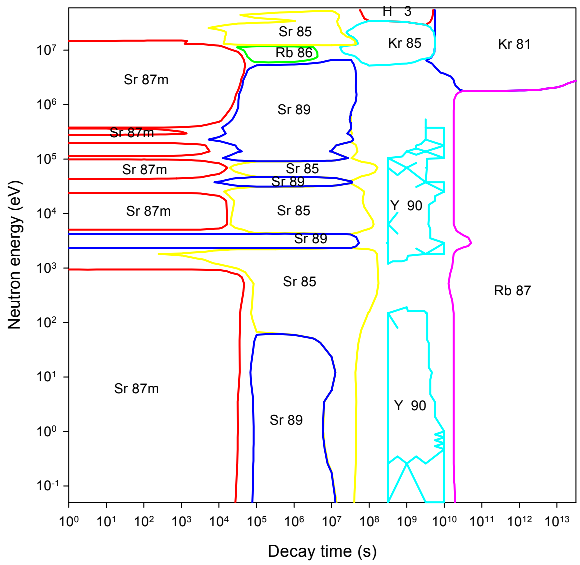
Nuclide	T$_{1/2}$	Pathway	210	186	151	42	30	21	6
	◄	&Sr86(n,2n)*Sr85*(β^+)Rb85(n,p)*Kr85*				4.6			
		Sr88(n,d)Rb87(n,t)Kr85					0.2	2.6	5.1
		Sr87(n,h)Kr85						0.6	1.2
H3	12.33 y	&Sr84(n,γ)*Sr85*(n,X)H1(n,γ)H2(n,γ)H3	93.6	95.4	99.3				
		Sr87(n,X)H3				38.1	8.5	7.4	7.2
		&Sr88(n,2n)*Sr87*(n,X)H3				36.3	6.3	1.8	1.1
		Sr86(n,2n)Sr85(β^+)Rb85(n,X)H3				12.3	0.8		
		Sr86(n,2n)Sr85(n,X)H3				1.4			
		Sr88(n,X)H3					69.1	74.3	73.9
		Sr86(n,X)H3					8.8	7.8	8.4
		Sr88(n,3n)Sr86(n,X)H3					2.4	3.6	1.4
		Sr88(n,4n)Sr85(β^+)Rb85(n,X)H3							1.9
Nb93m	16.126 y	&Sr88(n,γ)Sr89(β^-)Y89(n,γ)*Y90*(n,γ)_ *Y91*(β^-)Zr91(n,γ)Zr92(n,γ)Zr93(β^-)Nb93m	67.5		8.5				
		&Sr88(n,γ)Sr89(β^-)Y89(n,γ)*Y90*(n,γ)_ *Y91*(n,γ)Y92(β^-)Zr92(n,γ)Zr93(β^-)Nb93m	20.1		1.5				
		&Sr88(n,γ)Sr89(β^-)Y89(n,γ)*Y90*(β^-)Zr90_ (n,γ)Zr91(n,γ)Zr92(n,γ)Zr93(β^-)Nb93m	10.3		78.9				
		&Sr88(n,γ)Sr89(n,γ)Sr90(n,γ)Sr91(β^-)_ *Y91*(β^-)Zr91(n,γ)Zr92(n,γ)Zr93(β^-)Nb93m	0.6		8.7				
		&Sr88(n,γ)Sr89(n,γ)Sr90(n,γ)Sr91(β^-)_ *Y91*(n,γ)Y92(β^-)Zr92(n,γ)Zr93(β^-)Nb93m	0.1		1.5				
Sr90	28.79 y	Sr88(n,γ)Sr89(n,γ)Sr90	97.1	100.0	99.9	99.6	99.1	99.3	99.6
		Sr87(n,γ)Sr88(n,γ)Sr89(n,γ)Sr90	2.8						
Kr81	2.1 10^5 y	&Sr84(n,α)*Kr81*				76.9	7.8	1.2	1.3
		&Sr84(n,2n)*Sr83*(β^+)Rb83(β^+)*Kr83*(n,2n)_ Kr82(n,2n)*Kr81*				9.9	0.2		
		&Sr86(n,nα)Kr82(n,2n)*Kr81*				0.1	7.8	1.1	0.1
		&Sr84(n,2n)*Sr83*(β^+)Rb83(β^+)*Kr83*(n,3n)*Kr81*					11.9	1.1	
		&Sr86(n,α)*Kr83*(n,3n)*Kr81*					8.2	0.9	0.1
		&Sr86(n,2n)Sr85(β^+)Rb85(n,3n)Rb83_ (β^+)*Kr83*(n,3n)Kr81					5.6	0.2	
		&Sr86(n,2nα)*Kr81*					0.1	37.9	11.8
		&Sr88(n,3n)Sr86(n,2nα)*Kr81*						17.4	1.8
		&Sr84(n,nt)*Rb81*(β^+)Kr81						1.6	9.2
		&Sr87(n,3nα)*Kr81*							10.3
		&Sr88(n,4n)Sr85(β^+)Rb85(n,5n)*Rb81*(β^+)Kr81							8.0
		&Sr88(n,5n)Sr84(n,nt)*Rb81*(β^+)Kr81							6.4
Zr93	1.5 10^6 y	&Sr88(n,γ)Sr89(β^-)Y89(n,γ)*Y90*(n,γ)*Y91*_ (β^-)Zr91(n,γ)Zr92(n,γ)Zr93	68.7	80.5	7.7	1.5	1.7	2.0	
		&Sr88(n,γ)Sr89(β^-)Y89(n,γ)*Y90*(n,γ)*Y91*_ (n,γ)Y92(β^-)Zr92(n,γ)Zr93	16.7	3.6	1.1	0.6	0.4	0.1	
		&Sr88(n,γ)Sr89(β^-)Y89(n,γ)*Y90*(β^-)Zr90_ (n,γ)Zr91(n,γ)Zr92(n,γ)Zr93	12.1	14.6	81.5	71.7	70.9	69.8	
		&Sr87(n,γ)Sr88(n,γ)Sr89(β^-)Y89(n,γ)_ Y90(n,γ)*Y91*(β^-)Zr91(n,γ)Zr92(n,γ)Zr93	0.9						
		&Sr88(n,γ)Sr89(n,γ)Sr90(n,γ)Sr91(β^-)_ *Y91*(β^-)Zr91(n,γ)Zr92(n,γ)Zr93	0.5	1.0	7.8	19.7	18.7	19.5	
		&Sr88(n,γ)Sr89(n,γ)Sr90(n,γ)Sr91(β^-)_ *Y91*(n,γ)Y92(β^-)Zr92(n,γ)Zr93			1.0	5.7	5.3	5.2	
Rb87	4.8 10^{10} y	Sr86(n,γ)Sr87m(β^+)Rb87	99.7	100.0	100.0				
		Sr87(n,p)Rb87				28.8	1.9	1.0	0.6
		&Sr88(n,2n)*Sr87*(n,p)Rb87				27.0	1.3	0.3	
		Sr88(n,d)Rb87				23.9	95.8	98.1	99.0
		Sr88(n,2n)Sr87m(β^+)Rb87				19.2	0.5	0.2	0.1

Strontium activation characteristics

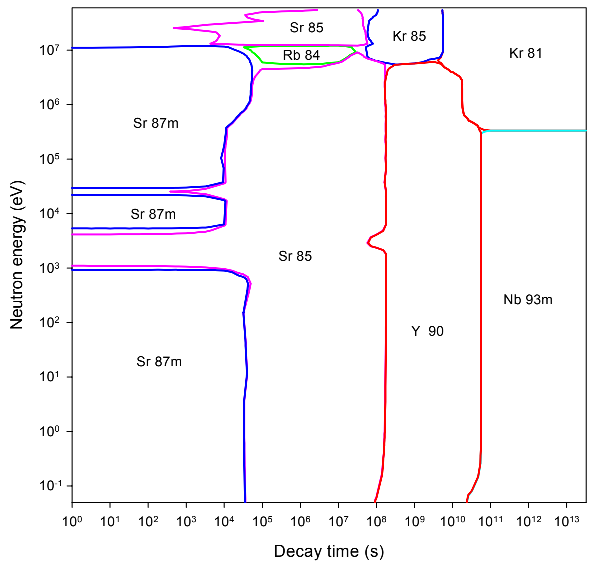


Strontium importance diagrams & transmutation

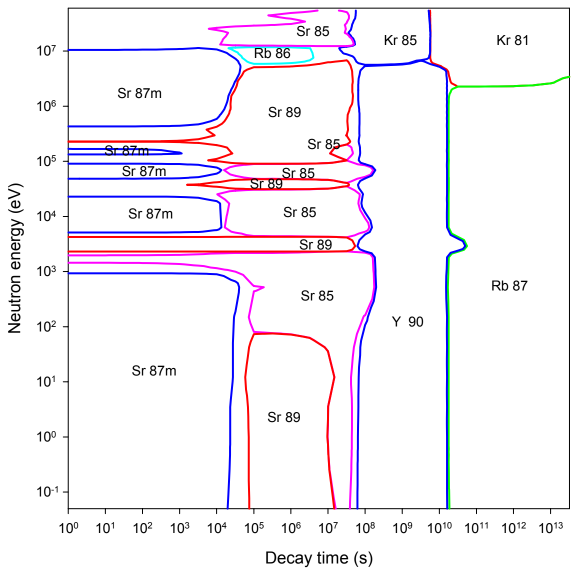
Activity



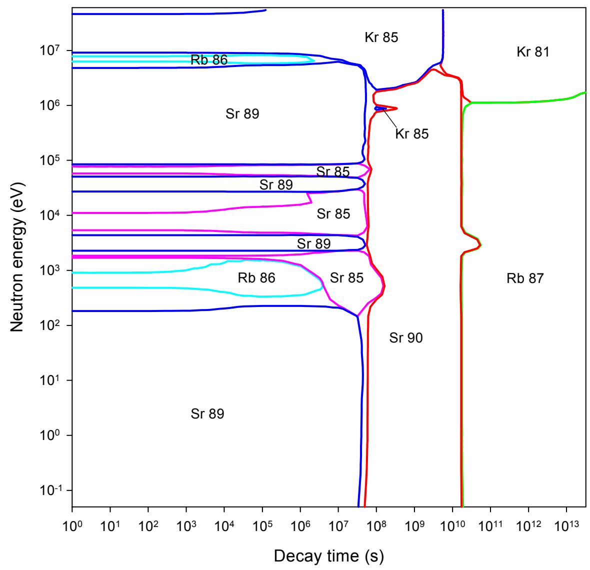
Dose rate



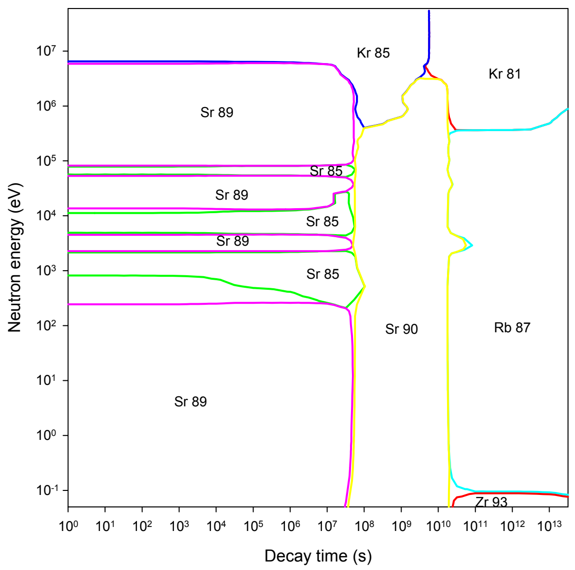
Heat output



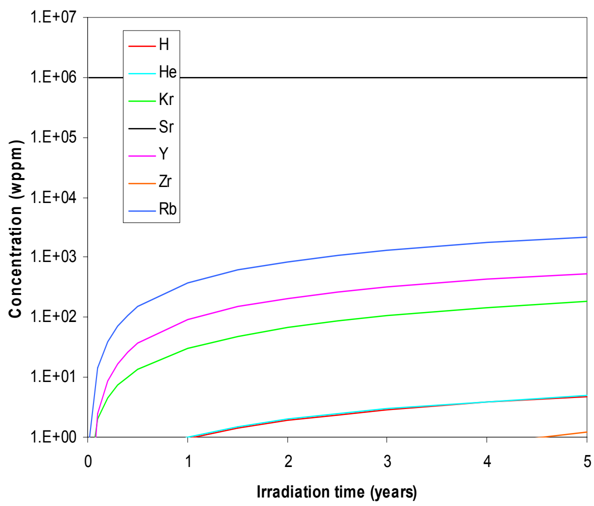
Ingestion dose



Inhalation dose



First wall transmutation



Graphs for H, He curves are indistinguishable

Yttrium

General properties

Property	Value	Isotopes	Isotopic abundances / %
Atomic number	39	Y89	100.0
Crustal abundance / wppm	33		
Melting point / K	1799		
Boiling point / K	3609		
Density / kgm^{-3}	4469		
Thermal conductivity / $Wm^{-1}K^{-1}$	17.2		
Electrical resistivity /Ωm	$5.70\ 10^{-7}$		
Coefficient of thermal expansion / K^{-1}	$1.06\ 10^{-5}$		
Crystal structure	HCP		
Number of stable isotopes	1		
Mean atomic weight	88.90585		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.92E15	1.03E15	8.80E14	7.43E13	9.19E7	1.66E1
Y89m	46.20	0.24	0.13			
Y88	41.42	77.26	88.31	99.80		
Y90	10.12	18.86	8.56		34.73	
Sr89	1.06	1.98	2.21	0.18		
Sr90					34.72	
H3					19.32	
Kr85					11.24	
Zr93						41.06
Nb93m						40.03
Rb87						13.06
Kr81						5.83

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	5.08E-1	3.77E-1	3.51E-1	3.21E-2	6.06E-9	8.45E-17
Y88	67.82	91.29	96.01	99.96		
Y89m	25.44	0.09	0.04			
Y90	5.72	7.70	3.22		78.77	
Sr89	0.37	0.50	0.52	0.04		
Sr90					14.67	
Kr85					6.28	
H3					0.26	
Nb93m						39.05
Rb87						33.67
Zr93						24.90
Kr81						2.34

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	8.83E5	6.66E5	6.49E5	6.18E4	4.09E-5	7.44E-13
Y88	75.26	99.77	99.91	100.0		
Y89m	24.25	0.09	0.04			
Zr90m	0.35					
Sr87m	0.02	0.02				
Y90m		0.02				
Kr85					99.96*	
Y90					0.03*	
Nb93m						60.48
Kr81						39.50

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.78E6	1.64E6	1.29E6	1.03E5	1.23E1	7.18E-8
Y88	58.06	63.09	78.54	93.15		
Y90	29.47	31.99	15.83		0.69	
Sr89	2.98	3.24	3.93	0.34		
Rb86	0.82	0.90	1.00			
Kr85	0.40	0.43	0.22	6.49	92.06	
Sr90					7.23	
Kr81						83.87
Zr93						10.47
Rb87						4.54
Nb93m						1.11

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	4.29E6	4.21E6	3.94E6	5.59E5	3.98E2	2.32E-6
Y88	81.74	83.16	86.80	58.30		
Y90	6.81	6.92	2.87		0.01	
Kr85	5.77	5.87	6.27	41.49	98.70	
Sr89	3.77	3.84	3.90	0.19		
Sr90					1.28	
Kr81						92.08
Zr93						7.36
Nb93m						0.51
Rb87						0.04

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	2.97E12	2.16E12	2.10E12	2.00E11	3.27E4	3.53E-3
Y88	27.37	99.73	99.90	100.0		
Y89m	27.15	0.10	0.05			
Sr90					97.60	
Kr85					1.75	
Y90					0.09	
Rb87						61.57
Zr93						19.35
Nb93m						18.87
Kr81						0.21

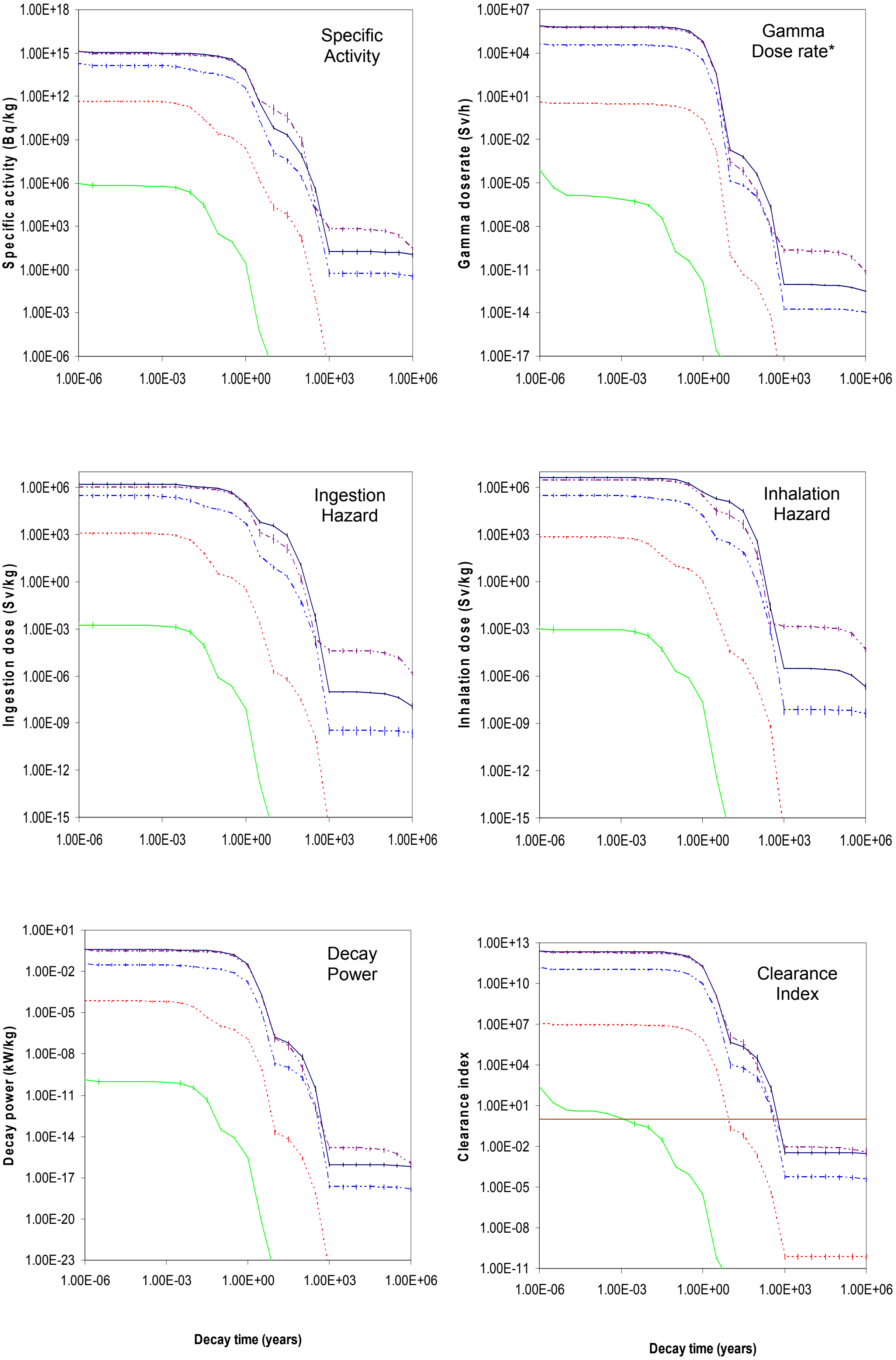
Yttrium

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Y89m	15.663 s	&Y89(n,γ)Y90(n,γ)*Y91*(β^-)Zr91(n,α)_ Sr88(n,γ)Sr89(β^-)Y89m	78.8						
		Y89(n,γ)Y90(β^-)Zr90(n,γ)Zr91(n,α)Sr88_ (n,γ)Sr89(β^-)Y89m	21.1						
		Y89(n,n′)Y89m				99.6	99.5	99.7	99.8
Y90m	3.19 h	Y89(n,γ)Y90m	100.0	100.0	100.0	99.1	98.9	99.2	99.5
Y86	14.74 h	&Y89(n,2n)Y88(n,2n)*Y87*(n,2n)*Y86*				86.6			
		&Y89(n,2n)Y88(n,2n)Y87m(n,2n)*Y86*				13.4			
		&Y89(n,2n)Y88(n,3n)*Y86*					97.0	30.6	
		&Y89(n,3n)*Y87*(n,2n)*Y86*					2.2		
		&Y89(n,4n)*Y86*						69.4	100.0
Y90	2.671 d	&Y89(n,γ)*Y90*	99.9	99.9	100.0	100.0	100.0	100.0	100.0
Rb86	18.64 d	&Y89(n,α)*Rb86*				96.7	61.3	25.4	48.3
		&Y89(n,2n)Y88(β^+)Sr88(n,2n)*Sr87*(n,d)*Rb86*				0.6	3.0	0.4	
		&Y89(n,3n)*Y87m*(β^+)Sr87(n,d)*Rb86*					15.9	31.2	11.2
		&Y89(n,3n)Y87(β^+)Sr87(n,d)*Rb86*					7.1	10.0	3.3
		&Y89(n,t)*Sr87*(n,d)*Rb86*					3.0	10.4	9.0
		&Y89(n,2n)Y88(β^+)Sr88(n,t)*Rb86*					2.8	13.1	13.9
		&Y89(n,2n)Y88(β^+)Sr88(n,d)Rb87(n,2n)*Rb86*					1.8	0.5	0.1
		&Y89(n,d)Sr88(n,t)*Rb86*					0.5	5.6	7.3
		&Y89(n,nt)Sr86(n,p)*Rb86*						0.4	2.0
		&Y89(n,4n)*Y86*(β^+)Sr86(n,p)*Rb86*							2.8
Sr89	50.57 d	&Y89(n,γ)Y90(n,γ)*Y91*(β^-)Zr91(n,α)_ Sr88(n,γ)Sr89	78.8	78.3	4.3				
		Y89(n,γ)Y90(β^-)Zr90(n,γ)Zr91(n,α)Sr88_ (n,γ)Sr89	21.1	21.6	92.4				
		Y89(n,p)Sr89				98.9	99.2	99.4	99.5
Y91	58.51 d	&Y89(n,γ)*Y90*(n,γ)*Y91*	99.7	99.9	100.0	65.7	81.0	87.7	95.1
		&Y89(n,γ)*Y90*(β^-)Zr90(n,γ)Zr91(n,p)*Y91*				24.4	8.2	4.9	1.8
		&Y89(n,p)Sr89(n,γ)Sr90(n,γ)Sr91(β^-)*Y91*				2.2	1.2	0.9	0.5
Y88	106.63 d	Y89(n,2n)Y88				99.7	99.8	99.8	99.9
Kr85	10.752 y	&Y89(n,2n)Y88(β^+)Sr88(n,α)*Kr85*				93.1	81.3	48.9	34.6
		&Y89(n,d)Sr88(n,α)*Kr85*				6.1	15.6	22.1	19.7
		Y89(n,nα)Rb85(n,p)Kr85					1.2	3.7	2.1
		&Y89(n,pα)*Kr85*					0.2	5.8	7.5
		&Y89(n,3n)*Y87*(β^+)Sr87(n,h)*Kr85*					0.1	7.1	6.7
		&Y89(n,t)Sr87(n,h)*Kr85*						1.5	3.7
		&Y89(n,h)Rb87(n,t)*Kr85*						1.2	4.6
		&Y89(n,2nt)*Sr85*(β^+)Rb85(n,p)*Kr85*							5.9
		Y89(n,5n)Y85m(β^+)Sr85(β^+)Rb85(n,p)Kr85							3.2
H3	12.33 y	Y89(n,X)H3				78.9	95.3	93.5	92.3
		Y89(n,2n)Y88(n,X)H3				19.5	0.9		
		Y89(n,2n)Y88(β^+)Sr88(n,X)H3				1.6	1.2		
Nb93m	16.126 y	&Y89(n,γ)*Y90*(n,γ)*Y91*(β^-)Zr91(n,γ)Zr92_ (n,γ)Zr93(β^-)Nb93m	70.8	81.2	8.2	2.1	2.2		
		&Y89(n,γ)*Y90*(n,γ)*Y91*(n,γ)Y92(β^-)Zr92_ (n,γ)Zr93(β^-)Nb93m	16.3	3.5	1.1	0.4	0.7		
		&Y89(n,γ)*Y90*(β^-)Zr90(n,γ)Zr91(n,γ)_ Zr92(n,γ)Zr93(β^-)Nb93m	12.9	15.2	90.7	96.4	94.7		
Sr90	28.79 y	&89(n,γ)Y90(n,γ)*Y91*(β^-)Zr91(n,α)Sr88_ (n,γ)Sr89(n,γ)Sr90	55.9	2.0	6.0				
		&89(n,γ)Y90(n,γ)*Y91*(β^-)Zr91(n,γ)Zr92_ (n,γ)Zr93(n,α)Sr90	22.9	79.2	1.2				
	►	&89(n,γ)*Y90*(β^-)Zr90(n,γ)Zr91(n,α)Sr88_ (n,γ)Sr89(n,γ)Sr90	11.8	0.4	78.4				

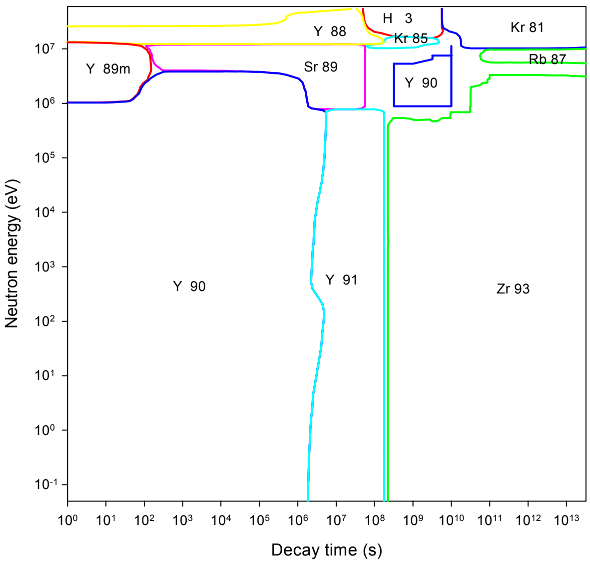
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&89(n,γ)Y90(n,γ)*Y91*(n,γ)Y92(β$^-$)Zr92_ (n,γ)Zr93(n,α)Sr90	5.3	3.3	0.1				
		Y89(n,γ)*Y90*(β$^-$)Zr90(n,γ)Zr91(n,γ)Zr92_ (n,γ)Zr93(n,α)Sr90	4.1	14.8	14.0				
		Y89(n,p)Sr89(n,γ)Sr90				95.8	97.7	98.1	96.4
		&Y89(n,γ)*Y90*(n,p)Sr90				3.8	3.0	3.0	3.2
Kr81	2.1 10^5 y	&Y89(n,α)*Rb86*(β$^-$)Sr86(n,α)*Kr83*(n,2n)_ Kr82(n,2n)*Kr81*				28.7			
		&Y89(n,2n)Y88(n,α)Rb85(n,α)*Br82*(β$^-$)_ Kr82(n,2n)*Kr81*				9.2			
		&Y89(n,α)*Rb86*(β$^-$)Sr86(n,2n)*Sr85*_ (n,2n)Sr84(n,α)*Kr81*				7.5			
		&Y89(n,α)*Rb86*(β$^-$)Sr86(n,2n)*Sr85*(n,α)_ Kr82(n,2n)*Kr81*				6.0			
		Y89(n,α)Rb86(β$^-$)Sr86(n,2n)Sr85(β$^+$)_ Rb85(n,α)Br82(β$^-$)Kr82(n,2n)Kr81				3.0			
		&Y89(n,α)*Rb86*(β$^-$)Sr86(n,nα)Kr82(n,2n)*Kr81*				2.1	0.4		
		&Y89(n,nα)Rb85(n,3n)Rb83(β$^+$)*Kr83*_ (n,3n)*Kr81*					24.7	5.6	
		&Y89(n,3n)*Y87*(β$^+$)Sr87(n,nα)*Kr83*(n,3n)*Kr81*					20.3	5.9	
		&89(n,2nα)*Rb84*(β$^+$)Kr84(n,4n)*Kr81*						22.2	11.0
		&Y89(n,nt)Sr86(n,2nα)*Kr81*						8.1	7.2
		&Y89(n,4n)*Y86*(β$^+$)Sr86(n,2nα)*Kr81*						1.5	10.5
		&Y89(n,3n)*Y87*(β$^+$)Sr87(n,3nα)*Kr81*							10.0
		&Y89(n,3nα)Rb83(β$^+$)*Kr83*(n,3n)*Kr81*							7.2
		&Y89(n,t)Sr87(n,3nα)*Kr81*							5.3
		&Y89(n,2nt)*Sr85*(β$^+$)Rb85(n,5n)*Rb81*(β$^+$)Kr81							4.5
		Long pathways involving (n,2n), (n,α), β$^+$				43.5	54.6	56.7	44.3
Se79	1.1 10^6 y	&Y89(n,α)*Rb86*(β$^-$)Sr86(n,α)*Kr83*(n,2n)_ Kr82(n,α)*Se79*				22.8			
		&Y89(n,α)*Rb86*(β$^-$)Sr86(n,α)*Kr83*(n,α)_ Se80(n,2n)*Se79*				14.7			
		&Y89(n,2n)Y88(n,α)Rb85(n,α)*Br82*(β$^-$)_ Kr82(n,α)*Se79*				7.3			
		&Y89(n,α)*Rb86*(β$^-$)Sr86(n,2n)*Sr85*(n,α)_ Kr82(n,α)*Se79*				4.7			
		&Y89(n,α)*Rb86*(β$^-$)Sr86(n,α)*Kr83*(n,nα)*Se79*				3.9	1.0		
		&Y89(n,nα)Rb85(n,3n)Rb83(β$^+$)*Kr83*_ (n,nα)*Se79*					30.1	5.0	
		&Y89(n,3n)*Y87*(β$^+$)Sr87(n,nα)*Kr83*(n,nα)*Se79*					24.7	5.5	0.1
		&Y89(n,2nα)*Rb84*(β$^+$)Kr84(n,2nα)*Se79*						50.8	25.1
		&Y89(n,3nα)Rb83(β$^+$)*Kr83*(n,nα)*Se79*							25.3
		Long pathways involving (n,2n), (n,α), β$^+$				46.6	44.2	38.7	49.5
Zr93	1.5 10^6 y	&Y89(n,γ)*Y90*(n,γ)*Y91*(β$^-$)Zr91(n,γ)Zr92_ (n,γ)Zr93	71.9	79.6	6.9	1.4	1.9	2.2	3.0
		&Y89(n,γ)*Y90*(β$^-$)Zr90(n,γ)Zr91(n,γ)_ Zr92(n,γ)Zr93	15.6	17.8	92.4	97.6	95.5	95.0	93.4
		&Y89(n,γ)*Y90*(n,γ)*Y91*(n,γ)Y92(β$^-$)Zr92_ (n,γ)Zr93	12.5	2.5	0.7	0.1	0.3	0.3	0.5
Rb87	4.8 10^{10} y	&Y89(n,γ)*Y90*(n,α)Rb87	99.9	99.9	100.0				
		Y89(n,2n)Y88(β$^+$)Sr88(n,d)Rb87				33.9	71.1	36.1	24.7
		Y89(n,2n)Y88(β$^+$)Sr88(n,2n)Sr87m(β$^+$)Rb87				27.2	0.4		
		&Y89(n,2n)Y88(β$^+$)Sr88(n,2n)*Sr87*(n,p)Rb87				23.8	0.5		
		&Y89(n,2n)Y88(n,2n)*Y87*(β$^+$)Sr87(n,p)Rb87				7.7	0.1		
		Y89(n,d)Sr88(n,d)Rb87				2.2	13.7	16.4	14.1
		Y89(n,d)Sr88(n,2n)Sr87m(β$^+$)Rb87				1.8			
		&Y89(n,d)Sr88(n,2n)*Sr87*(n,p)Rb87				1.7	0.1		
		&Y89(n,3n)*Y87*(β$^+$)Sr87(n,p)Rb87					7.0	8.7	2.0
		Y89(n,h)Rb87					4.5	34.3	56.1
		&Y89(n,t)*Sr87*(n,p)Rb87					0.9	2.2	1.2
		Y89(n,t)Sr87m(β$^+$)Rb87					0.6	1.3	1.3

Yttrium activation characteristics

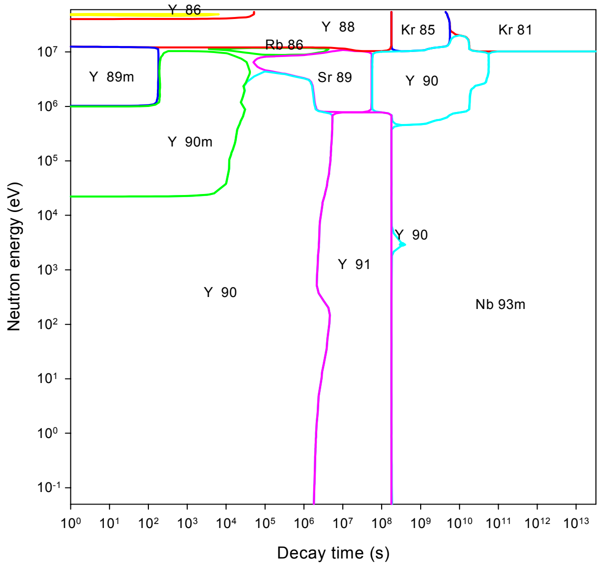


Yttrium importance diagrams & transmutation

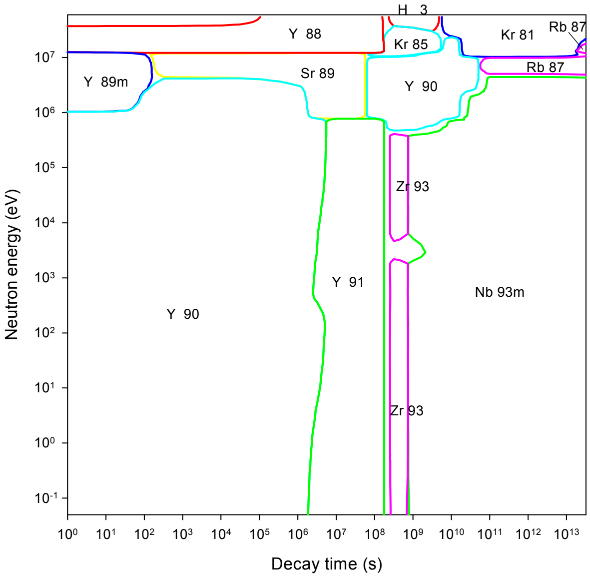
Activity



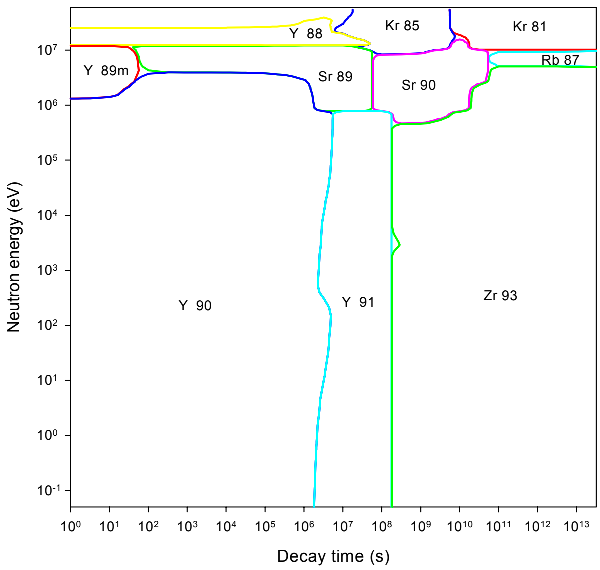
Dose rate



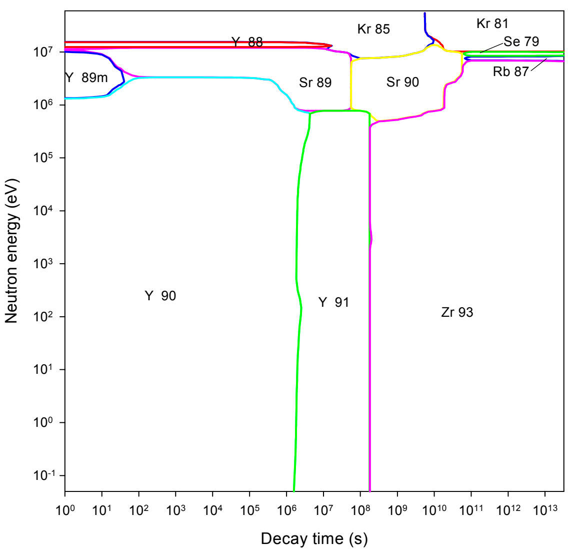
Heat output



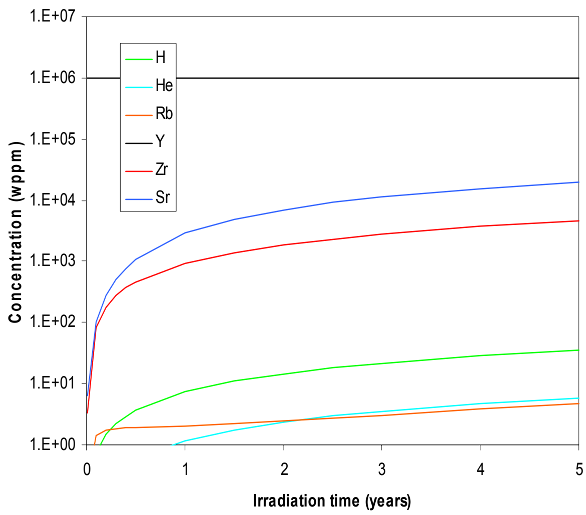
Ingestion dose



Inhalation dose



First wall transmutation



Zirconium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	40		
Crustal abundance / wppm	165	Zr90	51.45
Melting point / K	2128	Zr91	11.22
Boiling point / K	4682	Zr92	17.15
Density / kgm^{-3}	6506	Zr94	17.38 ($T_{½}$ = 6.00 10^{15} y)
Thermal conductivity / $Wm^{-1}K^{-1}$	22.7	Zr96	2.80 ($T_{½}$ = 3.90 10^{19} y)
Electrical resistivity /Ωm	4.21 10^{-7}		
Coefficient of thermal expansion / K^{-1}	5.70 10^{-6}		
Crystal structure	HCP		
Number of stable isotopes	3 (5)		
Mean atomic weight	91.224		

Activation properties

Act	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Bq kg^{-1}	1.44E15	8.69E14	4.03E14	4.45E12	2.41E9	1.18E9
Zr90m	36.81					
Y89m	20.34	31.83	31.67			
Zr89	19.21	31.87	31.71			
Zr95	4.37	7.26	15.07	27.22		
Nb95	4.23	7.03	15.19	58.71		
Zr89m	2.95	2.05				
Nb97	2.76	4.59	0.26			
Zr97	2.76	4.57	0.26			
Nb97m	2.63	4.35	0.25			
Y90	1.78	2.96	2.51		23.15	
Y88	0.38	0.63	1.33	11.57		
Y91	0.31	0.51	1.07	1.33		
H3				0.30	2.18	
Sr90				0.13	23.14	
Zr93				0.01	25.94	50.60
Nb93m					25.09	49.34

Heat	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
kW kg^{-1}	3.04E-1	1.02E-1	4.69E-2	7.36E-4	1.06E-7	4.81E-9
Zr90m	64.86					
Y89m	14.04	39.66	39.62			
Zr89	5.06	15.15	15.13			
Zr95	2.83	8.49	17.69	22.50		
Nb95	2.60	7.80	16.92	46.04		
Nb97	2.38	7.13	0.41			
Zr97	1.81	5.40	0.31			
Zr89m	1.50	1.88				
Nb97m	1.48	4.43	0.25			
Y90	1.26	3.79	3.23	0.12	78.43	
Y88	0.78	2.34	4.96	30.29		
Y91	0.14	4.32	0.89	0.78		
Sr90				0.02	14.61	
Nb93m					2.81	60.03
Nb94					2.27	1.57
Zr93					1.80	38.28

Dose	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv h^{-1}	5.40E5	1.27E5	6.37E4	1.11E3	4.10E-3	1.45E-4
Zr90m	75.09					
Y89m	13.06	52.37	48.10			
Zr89	2.61	11.11	10.20			
Nb95	2.04	8.71	17.38	42.55		
Zr95	2.02	8.62	16.52	18.90		
Nb97m	1.21	5.13	0.27			
Nb97	1.17	4.97	0.26			
Zr89m	1.07	1.91				
Y88	0.84	3.61	7.02	38.54		
Zr97	0.30	1.30	0.06			
Nb94					98.89	74.75
Nb93m					1.08	25.21

Ing	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	5.49E5	5.45E5	2.67E5	3.73E3	1.80E1	7.29E-1
Zr89	39.90	40.14	37.83			
Zr97	15.28	15.32	0.83			
Y90	12.69	12.77	10.26		8.38	
Zr95	10.93	11.00	21.61	30.81		
Nb95	6.46	6.50	13.31	40.58		
Y91	1.96	1.98	3.88	3.82		
Y88	1.30	1.31	2.62	17.92		
Sr89	0.82	0.83	1.62	0.81		
Nb97	0.49	0.49	0.02			
Nb96	0.41	0.41	0.06			
Sr90	0.03	0.03	0.06	4.53	86.95	
Zr93				0.01	3.83	90.30
Nb93m					0.41	9.60

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y	Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	8.24E5	8.22E5	6.44E5	1.68E4	1.09E2	1.60E1		1.79E12	5.20E11	2.88E11	5.22E9	7.70E5	1.21E5
Zr95	45.24	45.34	55.65	42.47			Zr90m	69.14					
Zr89	18.52	18.55	10.92				Y89m	14.94	48.37	40.35			
Nb95	13.37	13.40	17.12	27.95			Zr89	4.08	14.02	11.69			
Y91	4.86	4.87	5.96	3.14			Zr95	3.53	12.14	21.11	23.19		
Y90	4.70	4.70	2.36	0.05	0.76		Nb95	3.42	11.76	21.29	50.02		
Zr97	4.46	4.45	0.15				Nb97m	1.51	5.19	0.25			
Y88	2.94	2.95	3.67	13.46			Zr89m	1.49	2.14				
Sr89	1.67	1.68	2.04	0.55			Y88	0.83	2.86	5.05	26.63		
Nb97	0.21	0.21					Nb96	0.28	0.98	0.13			
Nb96	0.16	0.16	0.01				Zr97	0.22	0.76	0.03			
Sr90	0.12	0.12	0.15	5.75	81.81		Nb97	0.22	0.76	0.03			
Nb95m	0.07	0.07	0.09	0.06			Y90m	0.22	0.75				
Y90m	0.07	0.07					Sr90				0.11	72.47	
Zr93				0.09	14.33	93.33	Nb94					11.30	2.24
Nb93m					0.99	6.55	Zr93					8.12	49.33
Nb94						0.08	Nb93m					7.85	48.10

Zirconium

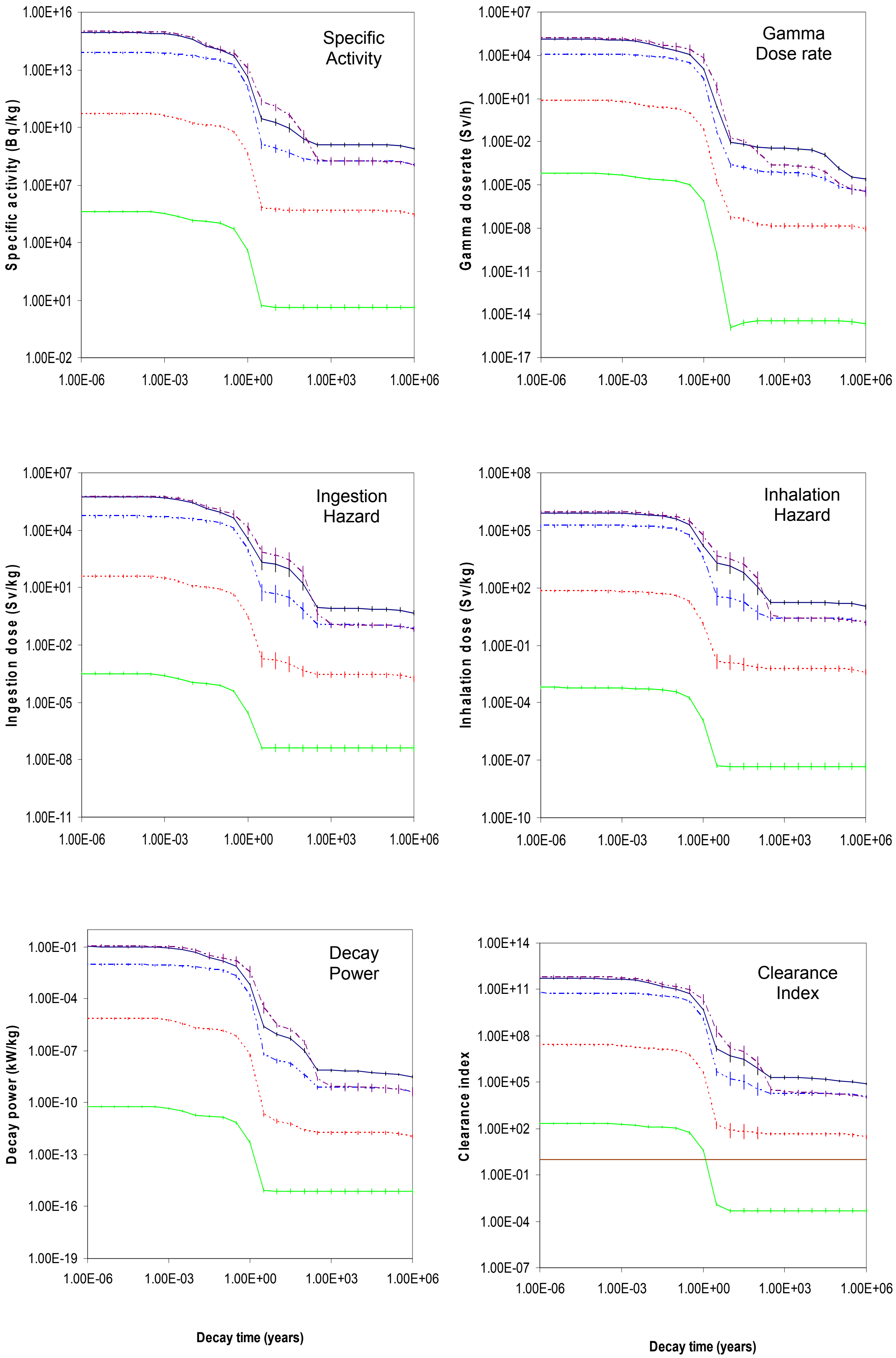
Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Zr90m	0.809 s	Zr90(n,n′)Zr90m				68.7	28.8	29.5	23.0
		Zr91(n,2n)Zr90m				20.3	22.0	16.2	13.6
		Zr92(n,2n)Zr91(n,2n)Zr90m				6.7	2.2	1.0	
		Zr91(n,2n)Zr90(n,n′)Zr90m				1.2	0.2		
		Zr92(n,3n)Zr90m					37.3	43.3	23.1
		Zr94(n,3n)Zr92(n,3n)Zr90m					5.8	2.6	
		Zr94(n,4n)Zr91(n,2n)Zr90m						2.2	
		Zr94(n,5n)Zr90m							34.3
Y89m	15.663 s	Zr91(n,α)Sr88(n,γ)Sr89(β$^-$)Y89m	99.4	99.0	98.4				
		Zr92(n,α)Sr89(β$^-$)Y89m	0.4	0.9	1.0				
		&Zr90(n,2n)*Zr89*(β$^+$)Y89m				87.2	73.5	48.6	41.3
		Zr90(n,d)Y89m				3.4	11.2	14.7	15.3
		&Zr91(n,2n)*Zr90*(n,2n)*Zr89*(β$^+$)Y89m				3.2	1.3		
		&Zr91(n,3n)*Zr89*(β$^+$)Y89m					7.7	15.7	8.4
		&Zr92(n,3n)*Zr90*(n,2n)*Zr89*(β$^+$)Y89m					3.0	0.9	
		Zr91(n,t)Y89m					0.8	3.7	3.9
		&Zr92(n,4n)*Zr89*(β$^+$)Y89m						8.2	16.8
		Zr94(n,4n)Zr91(n,3n)Zr89(β$^+$)Y89m						1.7	
		Zr92(n,nt)Y89m						1.2	7.9
Zr97	16.744 h	Zr96(n,γ)Zr97	100.0	100.0	100.0	99.9	99.4	99.5	99.7
Y90	2.671 d	&Zr91(n,α)Sr88(n,γ)Sr89(β$^-$)Y89(n,γ)*Y90*	93.0	3.5	42.7				
		Zr92(n,γ)Zr93(n,α)Sr90(β$^-$)Y90	5.9	96.1	55.5				
		Zr92(n,α)Sr89(β$^-$)Y89(n,γ)Y90	0.8		0.9				
		&Zr90(n,p)*Y90*				90.6	50.6	29.1	15.3
		&Zr91(n,d)*Y90*				3.6	29.8	34.1	20.3
		&Zr91(n,2n)*Zr90*(n,p)*Y90*				3.6	1.0		
		&Zr92(n,2n)Zr91(n,d)*Y90*				1.2	2.8	1.4	
		&Zr92(n,t)*Y90*					10.2	37.0	36.2
		&Zr94(n,3n)Zr92(n,t)*Y90*					1.5	2.1	
		&Zr94(n,4n)Zr91(n,d)*Y90*						3.0	
		&Zr94(n,2nt)*Y90*							22.1
Zr89	3.267 d	&Zr90(n,2n)*Zr89*				94.8	83.5	61.1	57.7
		&Zr91(n,2n)*Zr90*(n,2n)*Zr89*				4.1	1.6		
		&Zr91(n,3n)*Zr89*					8.7	19.8	11.8
		&Zr92(n,3n)*Zr90*(n,2n)*Zr89*					3.3	1.7	
		&Zr92(n,4n)*Zr89*						10.2	23.6
		Zr94(n,4n)Zr91(n,3n)Zr89						2.4	
Nb95	34.991 d	&Zr94(n,γ)Zr95(β$^-$)*Nb95*	99.9	100.0	100.0	0.3	0.5	0.3	0.2
		&Zr96(n,2n)Zr95(β$^-$)*Nb95*				99.0	89.9	81.7	76.6
		&Zr96(n,d)Y95(β$^-$)Zr95(β$^-$)*Nb95*					8.3	17.0	22.7
Y91	58.51 d	&Zr91(n,α)Sr88(n,γ)Sr89(β$^-$)Y89(n,γ)_ Y90(n,γ)*Y91*	68.5	0.3	0.5				
		&Zr92(n,γ)Zr93(n,α)Sr90(n,γ)Sr91(β$^-$)*Y91*	23.6	85.9	96.9				
		&Zr92(n,γ)Zr93(n,α)Sr90(β$^-$)Y90(n,γ)*Y91*	4.4	11.2	0.8				
		&Zr92(n,γ)Zr93(β$^-$)Nb93m(n,γ)*Nb94*_ (n,α)*Y91*	1.6	1.3	0.3				
		&Zr91(n,p)*Y91*				58.4	15.1	9.1	2.4
		&Zr92(n,2n)Zr91(n,p)*Y91*				18.4	1.5		
		&Zr94(n,α)Sr91(β$^-$)*Y91*				13.8	2.0	0.7	
		&Zr92(n,d)*Y91*				8.3	67.4	63.8	42.2
		&Zr94(n,2n)Zr93(n,t)*Y91*				0.1	0.9	2.0	
		&Zr94(n,3n)Zr92(n,d)*Y91*					10.0	3.6	
		&Zr94(n,nt)*Y91*					1.4	14.2	46.3
Zr95	64.032 d	Zr94(n,γ)Zr95	99.9	100.0	100.0	0.3	0.5		
		Zr96(n,2n)Zr95				99.6	90.5	82.1	76.7
		Zr96(n,d)Y95(β$^-$)Zr95					8.4	17.1	22.8
Y88	106.63 d►	&Zr90(n,2n)*Zr89*(β$^+$)*Y89*(n,2n)Y88				86.5	35.7	1.7	

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Zr90(n,d)*Y89*(n,2n)Y88				8.8	8.1	0.6	
		Zr90(n,3n)Zr88(β^+)Y88					37.8	60.6	35.9
		Zr90(n,t)Y88					7.9	27.7	30.8
		&Zr91(n,3n)*Zr89*(β^+)Y89m(IT)Y89(n,2n)Y88					3.7	0.6	
		Zr91(n,4n)Zr88(β^+)Y88						1.4	8.6
		Zr91(n,nt)Y88						0.6	6.9
		Zr92(n,5n)Zr88(β^+)Y88							5.8
		Zr92(n,2nt)Y88							3.1
Kr85	10.752 y	**&**Zr90(n,2n)*Zr89*(β^+)*Y89*(n,2n)Y88(β^+)_ Sr88(n,α)*Kr85*				73.5	14.3	0.6	0.3
		&Zr90(n,d)*Y89*(n,2n)Y88(β^+)Sr88(n,α)*Kr85*				7.7	3.9	0.2	0.1
		&Zr91(n,α)Sr88(n,α)*Kr85*				5.5	0.8	0.2	0.4
		&Zr90(n,2n)*Zr89*(β^+)*Y89*(n,d)Sr88(n,α)*Kr85*				4.3	2.9	0.3	0.2
		&Zr92(n,nα)Sr88(n,α)*Kr85*				1.2	5.0	1.0	0.7
		&Zr90(n,3n)Zr88(β^+)Y88(β^+)Sr88(n,α)*Kr85*					47.7	55.5	24.0
		&Zr90(n,t)Y88(β^+)Sr88(n,α)*Kr85*					11.4	29.1	23.6
		&Zr91(n,4n)Zr88(β^+)Y88(β^+)Sr88(n,α)*Kr85*						1.2	5.8
		&Zr91(n,nt)Y88(β^+)Sr88(n,α)*Kr85*						0.6	5.3
		&Zr90(n,nt)*Y87*(β^+)Sr87(n,h)*Kr85*							6.8
H3	12.33 y	Zr91(n,X)H3				52.5	14.3	11.5	11.7
		Zr90(n,X)H3				22.7	43.6	49.2	45.8
		Zr92(n,2n)Zr91(n,X)H3				8.8	0.7		
		Zr92(n,X)H3				5.6	14.1	13.9	15.5
		Zr94(n,2n)Zr93(n,X)H3				4.8	0.5		
		Zr94(n,X)H3				1.7	12.5	13.2	15.2
		Zr96(n,X)H3					1.7	1.9	2.3
		&Zr90(n,d)*Y89*(n,X)H3					1.3		
		Zr94(n,3n)Zr92(n,X)H3					1.1		
		&Zr92(n,3n)*Zr90*(n,X)H3					1.0	0.6	
Nb93m	16.126 y	Zr92(n,γ)Zr93(β^-)Nb93m	98.7	99.7	99.8				
		Zr91(n,γ)Zr92(n,γ)Zr93(β^-)Nb93m	1.3	0.3	0.2				
		&Zr96(n,2n)Zr95(β^-)*Nb95*(n,2n) *Nb94*(n,2n)Nb93m				41.9	0.2		
		&Zr96(n,2n)Zr95(β^-)*Nb95*(β^-)Mo95_ (n,2n)Mo94(n,d)Nb93m				33.1	3.8	0.9	0.5
		&Zr96(n,2n)Zr95(β^-)*Nb95*(β^-)Mo95(n,t)Nb93m				10.2	56.0	74.3	71.7
		Zr94(n,2n)Zr93(β^-)Nb93m				6.1	0.4	0.2	0.2
		&Zr96(n,2n)Zr95(β^-)Nb95(β^-)Mo95(n,d)_ *Nb94*(n,2n)Nb93m				3.5	0.9	0.3	0.1
		Zr96(n,2n)Zr95(β^-)Nb95(β^-)Mo95(n,2n)_ Mo94(n,2n)Mo93(n,p)Nb93m				1.7			
		&Zr96(n,2n)Zr95(β^-)Nb95(n,2n)*Nb94*_ (n,2n)Nb93(n,n′)Nb93m				1.2			
		&Zr96(n,2n)Zr95(β^-)*Nb95*(n,3n)Nb93m					25.9	5.4	3.5
		&Zr96(n,d)Y95(β^-)Zr95(β^-)*Nb95*(β^-)_ Mo95(n,t)Nb93m					5.1	15.5	21.3
		Zr96(n,d)Y95(β^-)Zr95(β^-)Nb95(n,3n)Nb93m					2.4	1.1	1.0
		&Zr96(n,2n)Zr95(β^-)Nb95(β^-)Mo95_ (n,3n)*Mo93*(n,p)Nb93m					1.9	0.3	
Sr90	28.79 y	Zr92(n,γ)Zr93(n,α)Sr90	96.3	99.7	99.1				
		Zr91(n,α)Sr88(n,γ)Sr89(n,γ)Sr90	2.4		0.7				
		Zr91(n,γ)Zr92(n,γ)Zr93(n,α)Sr90	1.3	0.3	0.2				
		Zr94(n,2n)Zr93(n,α)Sr90				64.0	0.5		
		Zr94(n,nα)Sr90				35.4	95.4	84.0	67.2
		Zr92(n,h)Sr90					1.7	11.0	12.3
		Zr96(n,3n)Zr94(n,nα)Sr90					1.1		
		Zr96(n,3nα)Sr90						2.2	17.8
Mo93	4000 y	**&**Zr96(n,2n)Zr95(β^-)*Nb95*(β^-)Mo95_ (n,2n)Mo94(n,2n)*Mo93*				99.4	0.7	0.4	0.3
		&Zr96(n,2n)Zr95(β^-)*Nb95*(β^-)Mo95(n,3n)*Mo93*					89.9	81.9	76.2
		&Zr96(n,d)Y95(β^-)Zr95(β^-)*Nb95*(β^-)_ Mo95(n,3n)*Mo93*					8.2	17.1	22.5

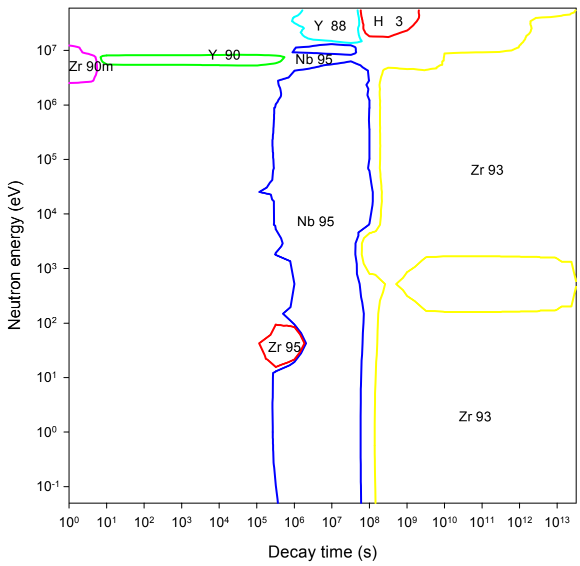
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Nb94	2.0 10^4 y	&Zr92(n,γ)Zr93(β⁻)Nb93m(n,γ)*Nb94*	91.4	92.0	92.3				
		&Zr92(n,γ)Zr93(β⁻)*Nb93*(n,γ)*Nb94*	7.6	7.8	7.5				
		&Zr91(n,γ)Zr92(n,γ)Zr93(β⁻)Nb93m(n,γ)_ *Nb94*	1.0						
		&Zr96(n,2n)Zr95(β⁻)*Nb95*(n,2n)*Nb94*				84.9	15.4	10.4	9.8
		&Zr96(n,2n)Zr95(β⁻)*Nb95*(β⁻)Mo95(n,d)*Nb94*				10.5	74.2	71.1	68.4
		&Zr96(n,2n)Zr95(β⁻)Nb95(β⁻)Mo95_ (n,2n)Mo94(n,p)*Nb94*				3.6	0.6	0.2	
		&Zr96(n,d)Y95(β⁻)Zr95(β⁻)*Nb95*(β⁻)_ Mo95(n,d)*Nb94*					6.8	14.7	20.2
		&Zr96(n,d)Y95(β⁻)Zr95(β⁻)Nb95(n,2n)*Nb94*					1.4	2.2	2.4
Tc99	2.1 10^5 y	&Zr96(n,γ)Zr97(β⁻)*Nb97*(β⁻)Mo97(n,γ)_ Mo98(n,γ)Mo99(β⁻)*Tc99*	4.9	4.5	5.0	99.6	99.5	99.5	99.6
		&Zr94(n,γ)Zr95(β⁻)*Nb95*(β⁻)Mo95(n,γ)_ Mo96(n,γ)Mo97(n,γ)Mo98(n,γ)Mo99(β⁻)_ *Tc99*	0.8	7.4	0.1				
		Other pathways involving (n,γ) and β⁻	94.3	88.1	94.9	0.4	0.5	0.5	0.4
Kr81	2.1 10^5 y	&Zr90(n,α)*Sr87*(n,2n)Sr86(n,α)*Kr83*_ (n,2n)Kr82(n,2n)*Kr81*				23.6			
		&Zr90(n,α)*Sr87*(n,α)Kr84(n,2n)*Kr83*_ (n,2n)Kr82(n,2n)*Kr81*				16.7			
		&Zr90(n,α)*Sr87*(n,2n)Sr86(n,2n)*Sr85*_ (n,2n)Sr84(n,α)*Kr81*				7.4			
		&Zr90(n,α)*Sr87*(n,2n)Sr86(n,2n)*Sr85*_ (n,α)Kr82(n,2n)*Kr81*				5.7			
		&Zr90(n,α)*Sr87*(n,nα)*Kr83*(n,3n)*Kr81*					11.8	0.3	
		&Zr90(n,nα)Sr86(n,α)*Kr83*(n,3n)*Kr81*					7.8	0.3	
		&Zr90(n,nα)Sr86(n,nα)Kr82(n,2n)*Kr81*					7.5	0.3	
		&Zr90(n,nα)Sr86(n,2nα)*Kr81*					0.2	18.6	0.9
		&Zr90(n,3n)Zr88(β⁺)Y88(β⁺)Sr88(n,3n)_ Sr86(n,2nα)*Kr81*						8.8	
		&Zr90(n,nt)*Y87*(β⁺)Sr87(n,3nα)*Kr81*							16.0
		&Zr90(n,3nα)Sr84(n,nt)*Rb81*(β⁺)Kr81							15.3
		&Zr90(n,4n)Zr87(β⁺)*Y87*(β⁺)Sr87(n,3nα)*Kr81*							10.2
		Other pathways involving (n,2n), (n,α), β⁺				46.6	72.7	71.7	57.6
Zr93	1.5 10^6 y	Zr92(n,γ)Zr93	98.0	99.6	99.7				
		Zr91(n,γ)Zr92(n,γ)Zr93	2.0	0.4	0.3				
		Zr94(n,2n)Zr93				99.7	82.2	57.6	58.1
		&Zr94(n,d)*Y93*(β⁻)Zr93					14.0	18.2	24.5
		Zr96(n,4n)Zr93					2.0	23.0	13.0
		Zr96(n,3n)Zr94(n,2n)Zr93					1.0		
		&Zr96(n,nt)*Y93*(β⁻)Zr93							3.7

Zirconium activation characteristics

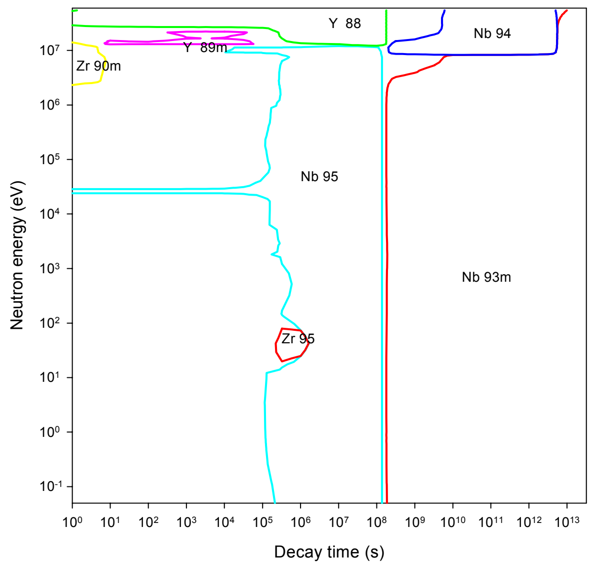


Zirconium importance diagrams & transmutation

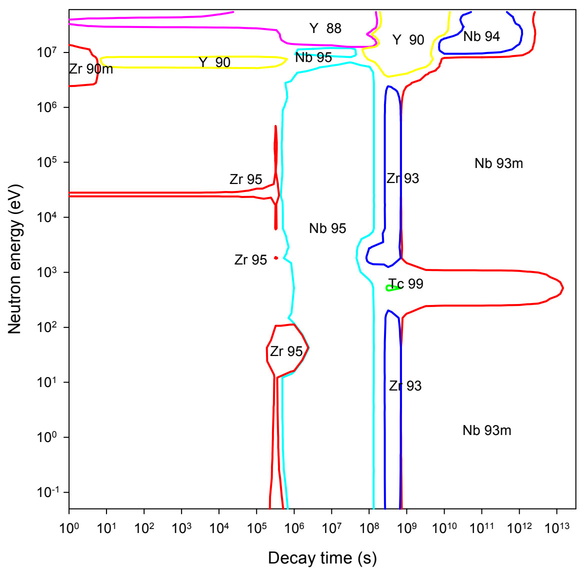
Activity



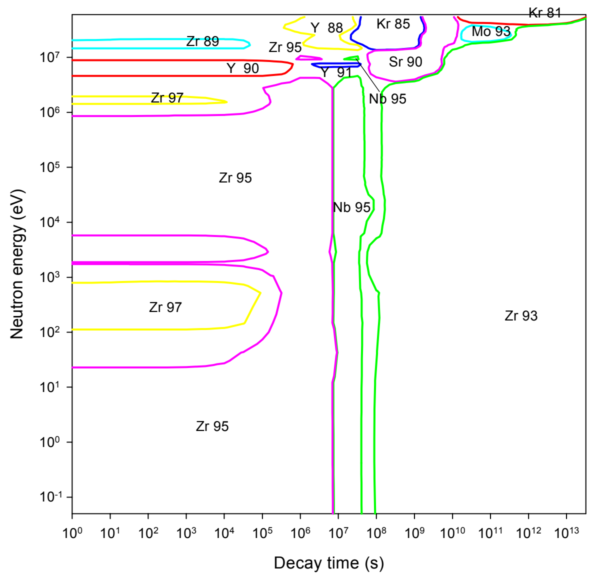
Dose rate



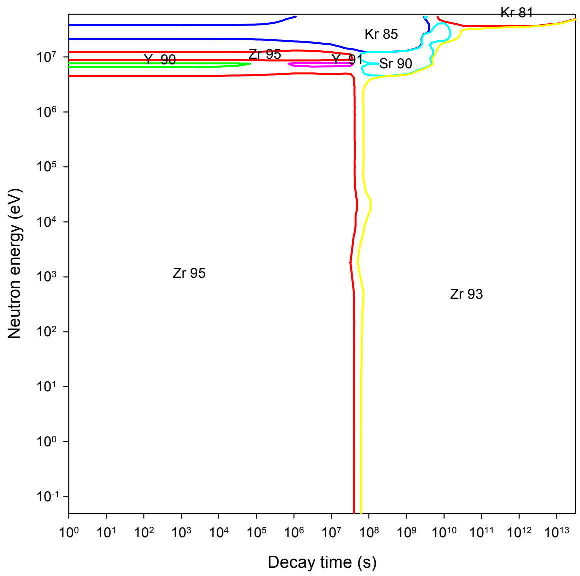
Heat output



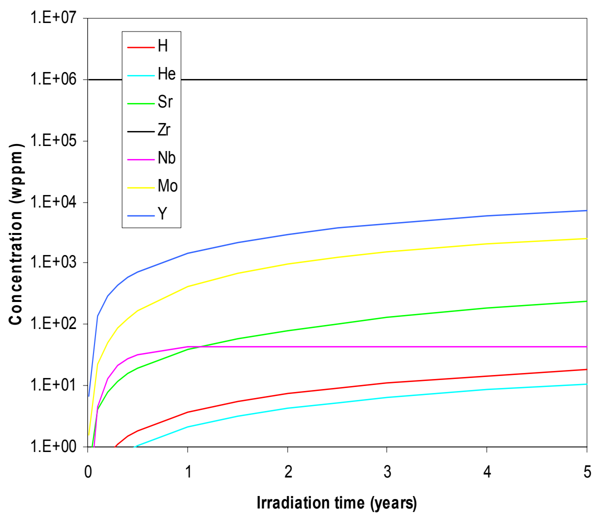
Ingestion dose



Inhalation dose



First wall transmutation



Niobium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	41	Nb93	100.0
Crustal abundance / wppm	20		
Melting point / K	2750		
Boiling point / K	5017		
Density / kgm^{-3}	8570		
Thermal conductivity / $Wm^{-1}K^{-1}$	53.7		
Electrical resistivity /Ωm	$1.25\ 10^{-7}$		
Coefficient of thermal expansion / K^{-1}	$7.3\ 10^{-6}$		
Crystal structure	BCC		
Number of stable isotopes	1		
Mean atomic weight	92.90638		

Activation properties

Act	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Bq kg^{-1}	3.45E15	2.54E15	1.19E15	6.46E13	1.37E12	1.33E10
Nb94m	59.47	45.10				
Nb95	23.53	31.94	63.63	0.90		
Nb92m	12.58	17.08	28.45			
Nb93m	1.91	2.60	5.56	98.10	65.79	0.69
Nb95m	0.96	1.31	1.39			
Nb96	0.79	1.07	0.17			
Nb94	0.01	0.01	0.03	0.64	30.57	98.08
Nb91				0.08	3.59	

Heat	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
kW kg^{-1}	2.05E-1	1.98E-1	1.54E-1	5.13E-4	1.21E-4	3.66E-6
Nb95	51.19	53.11	63.73	14.87		
Nb92m	33.05	34.28	34.40			
Nb94m	7.57	4.39				
Nb96	5.75	5.95	0.56			
Y90	0.87	0.90	0.46			
Nb95m	0.64	0.67	0.42			
Nb93m	0.15	0.16	0.21	61.28	3.67	0.01
Nb94	0.05	0.05	0.07	22.82	96.18	99.53

Dose	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv h^{-1}	2.77E5	2.75E5	2.23E5	2.80E2	1.65E2	5.17E0
Nb95	52.26	52.78	60.65	37.48		
Nb92m	39.89	40.20	38.63			
Nb96	5.96	5.99	0.54			
Nb94m	1.01	0.57				
Nb94	0.05	0.06	0.07	58.90	99.93	99.53
Y88	0.02	0.02	0.02	2.10		
Nb93m				1.30	0.03	

Ing	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	8.67E5	8.49E5	6.78E5	8.74E3	8.23E2	2.24E1
Nb95	54.27	55.46	64.68	3.90		
Nb92m	30.02	30.68	29.91			
Y90	3.72	3.80	1.88			
Nb96	3.47	3.53	0.32			
Nb95m	2.15	2.20	1.36			
Nb93m	0.91	0.93	1.17	87.04	13.12	0.04
Nb94		0.08	0.10	8.15	86.34	99.15

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	2.00E6	1.97E6	1.74E6	1.36E5	2.23E4	6.46E2
Nb95	72.95	74.03	78.38	0.77		
Nb92m	12.79	12.97	11.48			
Nb93m	5.95	6.04	6.85	83.75	7.25	0.02
Nb95m	1.46	1.48	0.83			
Nb94	1.02	1.04	1.18	15.08	91.79	99.21
Nb96	0.90	0.91	0.07			
Y90	0.89	0.90	0.40			

Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
	1.37E12	1.35E12	1.11E12	1.11E10	4.27E9	1.31E8
Nb95	59.34	60.12	68.00	5.27		
Nb92m	31.73	32.14	30.40			
Nb96	5.00	5.05	0.45			
Nb94m	2.38	1.34				
Nb93m	0.48	0.49	0.59	56.88	2.10	
Nb94	0.30	0.31	0.37	37.63	97.87	99.91
Nb95m	0.22	0.22	0.13			

Niobium

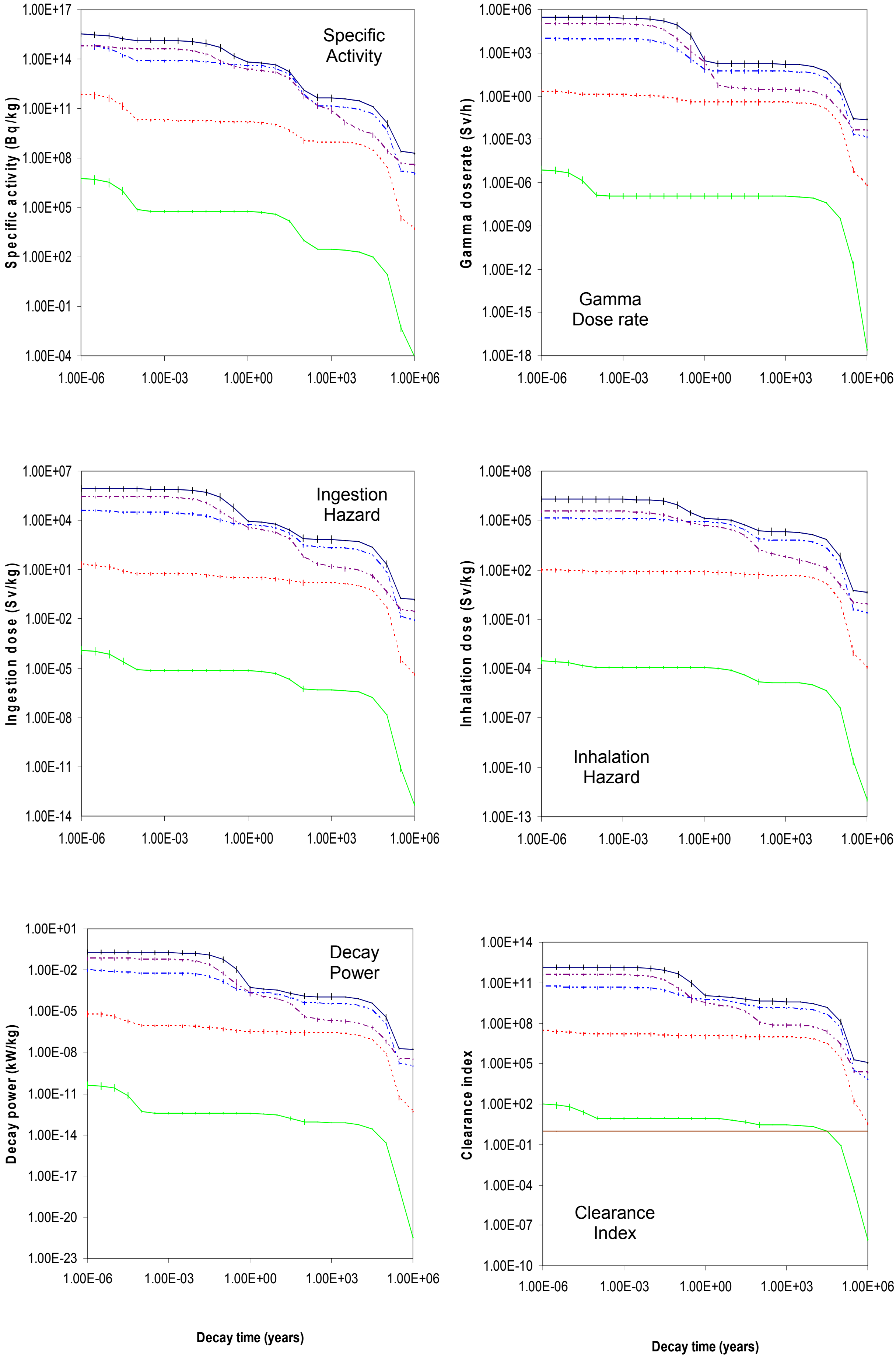
Pathway analysis

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Zr90m	0.809 s	Nb93(n,α)Y90m(β^-)Zr90m	100.0	100.0	100.0				
		Nb93(n,2n)Nb92m(β^+)Zr92(n,2n)Zr91_ (n,2n)Zr90m				52.0	0.5		
		&Nb93(n,2n)Nb92(n,2n)*Nb91*(n,d)Zr90m				20.2	0.9		
		&Nb93(n,α)*Y90*(β^-)Zr90(n,n′)Zr90m				9.5			
		Nb93(n,d)Zr92(n,2n)Zr91(n,2n)Zr90m				3.6	0.5		
		Nb93(n,2n)Nb92(n,d)Zr91(n,2n)Zr90m				2.6	0.4		
		Nb93(n,2n)Nb92(n,t)Zr90m				1.5	8.5	5.2	
		Nb93(n,t)Zr91(n,2n)Zr90m				0.4	6.5	5.1	
		&Nb93(n,3n)*Nb91*(n,d)Zr90m					41.2	10.5	
		Nb93(n,2n)Nb92m(β^+)Zr92(n,3n)Zr90m					16.2	5.7	
		Nb93(n,d)Zr92(n,3n)Zr90m					15.6	7.1	
		Nb93(n,nt)Zr90m					3.2	59.6	90.2
Nb94m	6.26 m	Nb93(n,γ)Nb94m	100.0	100.0	100.0	94.0	96.5	97.3	98.1
		Nb93(n,γ)Nb94(n,n′)Nb94m				1.7	1.0	0.8	0.6
		Nb93(n,n′)Nb93m(n,γ)Nb94m				0.7	0.2	0.2	0.1
Y90m	3.19 h	Nb93(n,α)Y90m	100.0	100.0	100.0	98.3	58.4	34.2	68.9
		Nb93(n,t)Zr91(n,d)Y90m					14.5	21.2	9.0
		Nb93(n,2n)Nb92m(β^+)Zr92(n,t)Y90m					6.0	14.4	6.4
		Nb93(n,d)Zr92(n,t)Y90m					5.8	18.0	9.4
		&Nb93(n,3n)*Nb91*(n,2p)Y90m					2.7	0.7	0.1
Nb90	14.6 h	**&**Nb93(n,2n)Nb92(n,2n)*Nb91*(n,2n)*Nb90*				93.7	1.7		
		&Nb93(n,2n)Nb92(n,2n)Nb91m(n,2n)*Nb90*				1.5			
		&Nb93(n,3n)*Nb91*(n,2n)*Nb90*					79.8	17.0	1.9
		&Nb93(n,2n)Nb92(n,3n)*Nb90*					15.8	9.1	1.4
		&Nb93(n,4n)*Nb90*						74.2	96.3
Nb96	23.35 h	**&**Nb93(n,γ)*Nb94*(n,γ)*Nb95*(n,γ)Nb96	99.8	99.8	99.4	95.3	95.7	95.9	96.2
		&Nb93(n,γ)*Nb94*(n,γ)Nb95m(n,γ)Nb96			0.2	2.2	2.6	2.9	3.1
Y90	2.671 d	**&**Nb93(n,α)*Y90*	100.0	100.0	100.0	99.9	55.9	33.0	66.7
		&Nb93(n,t)Zr91(n,d)*Y90*					12.6	19.7	9.2
		&Nb93(n,2n)Nb92m(β^+)Zr92(n,t)*Y90*					6.4	12.7	2.6
		&Nb93(n,d)Zr92(n,t)*Y90*					6.2	15.8	8.7
		&Nb93(n,nt)*Zr90*(n,p)*Y90*					0.2	4.1	1.9
		&Nb93(n,4n)*Nb90*(β^+)Zr90(n,p)*Y90*						4.8	1.9
Nb92m	10.15 d	Nb93(n,2n)Nb92m				94.0	95.1	96.5	97.7
		Nb93(n,2n)Nb92(n,n′)Nb92m				4.8	4.5	3.3	
		Nb93(n,n′)Nb93m(n,2n)Nb92m				1.1	0.4		
Nb95	34.991 d	**&**Nb93(n,γ)*Nb94*(n,γ)*Nb95*	100.0	100.0	100.0	98.9	99.0	99.2	99.6
		Nb93(n,p)Zr93(n,γ)Zr94(n,γ)Zr95(β^-)Nb95				0.3	0.1		
Nb91m	60.90 d	Nb93(n,2n)Nb92(n,2n)Nb91m				96.4	5.2	2.5	
		Nb93(n,2n)Nb92(n,2n)Nb91(n,n')Nb91m				2.3			
		Nb93(n,3n)Nb91m					91.7	95.2	96.7
		Nb93(n,3n)Nb91(n,n')Nb91m					2.3	1.7	
Y88	106.63 d	**&**Nb93(n,nα)*Y89*(n,2n)Y88				50.5	20.8	1.1	0.6
		&Nb93(n,2n)Nb92(n,2n)*Nb91*(n,α)Y88				17.4	0.3		
		&Nb93(n,2n)Nb92(n,α)*Y89*(n,2n)Y88				10.4			
		Nb93(n,2n)Nb92(n,nα)Y88				6.8	15.2	1.6	0.6
		&Nb93(n,α)*Y90*(β^-)Zr90(n,2n)*Zr89*(β^+)_ *Y89*(n,2n)Y88				6.4			
		Nb93(n,2n)Nb92m(β^+)Zr92(n,α)Sr89(β^-)_ Y89(n,2n)Y88				3.0			
		&Nb93(n,3n)*Nb91*(n,α)Y88					16.0	1.3	2.1
		Nb93(n,2nα)Y88					14.7	48.6	32.6
		&Nb93(n,3n)*Nb91*(n,t)*Zr89*(β^+)Y89m_ (IT)Y89(n,2n)Y88					8.6	1.0	
	►	**&**Nb93(n,nt)*Zr90*(n,3n)Zr88(β^+)Y88					0.4	11.0	7.7

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	**&**Nb93(n,4n)*Nb90*(β^+)Zr90(n,3n)Zr88(β^+)Y88						10.4	7.1
		&Nb93(n,nt)*Zr90*(n,t)Y88						5.3	7.0
		&Nb93(n,4n)*Nb90*(β^+)Zr90(n,t)Y88						5.1	6.5
		&Nb93(n,3n)*Nb91*(n,nt)Zr88(β^+)Y88						2.6	12.1
		Nb93(n,t)Zr91(n,4n)Zr88(β^+)Y88						1.4	3.9
		Nb93(n,t)Zr91(n,nt)Y88						0.6	3.4
		&Nb93(n,2nt)*Zr89*(β^+)Y89m(IT)Y89(n,2n)Y88							3.4
Kr85	10.752 y	**&**Nb93(n,nα)*Y89*(n,2n)Y88(β^+)Sr88(n,α)*Kr85*				50.8	15.4	0.5	0.2
		&Nb93(n,2n)Nb92m(β^+)Zr92(n,nα)Sr88_ (n,α)*Kr85*				9.2	3.1	0.2	
		&Nb93(n,2n)Nb92(n,2n)*Nb91*(n,α)Y88_ (β^+)Sr88(n,α)*Kr85*				8.9			
		&Nb93(n,2n)Nb92(n,nα)Y88(β^+)Sr88_ (n,α)*Kr85*				6.9	11.6	0.8	0.2
		&Nb93(n,2n)Nb92(n,α)*Y89*(n,2n)Y88_ (β^+)Sr88(n,α)*Kr85*				5.5			
		&Nb93(n,2nα)Y88(β^+)Sr88(n,α)*Kr85*					32.1	70.4	40.6
		&Nb93(n,3n)*Nb91*(n,α)Y88(β^+)Sr88(n,α)*Kr85*					11.8	0.5	0.8
		&Nb93(n,nt)*Zr90*(n,3n)Zr88(β^+)Y88(β^+)_ Sr88(n,α)Kr85					0.2	4.6	2.7
		&Nb93(n,3nα)*Y87*(β^+)Sr87(n,h)*Kr85*							10.8
H3	12.33 y	**&**Nb93(n,γ)*Nb94(n,X)*H1(n,γ)H2(n,γ)H3	92.3	96.2	61.4				
		Nb93(n,X)H1(n,γ)H2(n,γ)H3	2.3		38.0				
		Nb93(n,X)H3				61.8	81.3	87.5	90.4
		Nb93(n,2n)Nb92(n,X)H3				37.1	7.0	2.5	1.2
		&Nb93(n,3n)*Nb91*(n,X)H3					6.3	3.7	1.2
Nb93m	16.126 y	**&**Nb93(n,γ)*Nb94*(n,γ)*Nb95*(β^-)Mo95_ (n,α)Zr92(n,γ)Zr93(β^-)Nb93m	59.5	1.1					
		&Nb93(n,γ)*Nb94*(n,α)*Y91*(β^-)Zr91(n,γ)_ Zr92(n,γ)Zr93(β^-)Nb93m	30.0						
		&Nb93(n,γ)*Nb94*(n,α)*Y91*(n,γ)Y92(β^-)_ Zr92(n,γ)Zr93(β^-)Nb93m	8.6						
		Nb93(n,p)Zr93(β^-)Nb93m	1.0						
		&Nb93(n,γ)*Nb94*(n,γ)*Nb95*(β^-)Mo95_ (n,γ)Mo96(n,α)Zr93(β^-)Nb93m	0.7	97.2					
		&Nb93(n,γ)*Nb94*(n,γ)Nb95(n,γ)Nb96(β^-)_ Mo96(n,α)Zr93(β^-)Nb93m		1.2					
		Nb93(n,n′)Nb93m			100.0	100.0	100.0	100.0	100.0
Nb91	680.0 y	**&**Nb93(n,2n)Nb92(n,2n)*Nb91*				98.5	1.7	0.8	
		&Nb93(n,2n)Nb92m(n,2n)*Nb91*				0.9			
		&Nb93(n,3n)*Nb91*					97.5	98.7	98.9
Nb94	2.0 10^4 y	**&**Nb93(n,γ)*Nb94*	100.0	100.0	100.0	99.6	99.8	99.9	99.9
		&Nb93(n,n′)Nb93m(n,γ)*Nb94*				0.3			
Kr81	2.1 10^5 y	**&**Nb93(n,nα)*Y89*(n,α)*Rb86*(β^-)Sr86_ (n,α)*Kr83*(n,2n)Kr82(n,2n)*Kr81*				12.1			
		&Nb93(n,nα)Y89(n,2n)Y88(n,α)Rb85_ (n,α)*Br82*(β^-)Kr82(n,2n)*Kr81*				4.7			
		&Nb93(n,3n)Nb91(n,nα)*Y87*(β^+)Sr87_ (n,nα)*Kr83*(n,3n)*Kr81*					14.8	0.3	
		&Nb93(n,2nα)Y88(β^+)Sr88(n,3n)Sr86_ (n,2nα)*Kr81*						17.5	0.2
		&Nb93(n,3n)Nb91(n,2nα)*Y86*(β^+)Sr86_ (n,2nα)*Kr81*						8.2	0.1
		&Nb93(n,2nα)Y88(β^+)Sr88(n,2nα)*Kr83*_ (n,3n)*Kr81*						5.1	
		&Nb93(n,2nα)Y88(n,2nα)Rb83(β^+)*Kr83*_ (n,3n)*Kr81*						4.0	
		&Nb93(n,2nα)Y88(n,3n)*Y86*(β^+)Sr86_ (n,2nα)*Kr81*						3.1	
		&Nb93(n,3nα)*Y87*(β^+)Sr87(n,3nα)*Kr81*							28.3
		Other pathways involving (n,2n), (n,α), β^+				83.2	85.2	61.8	71.4

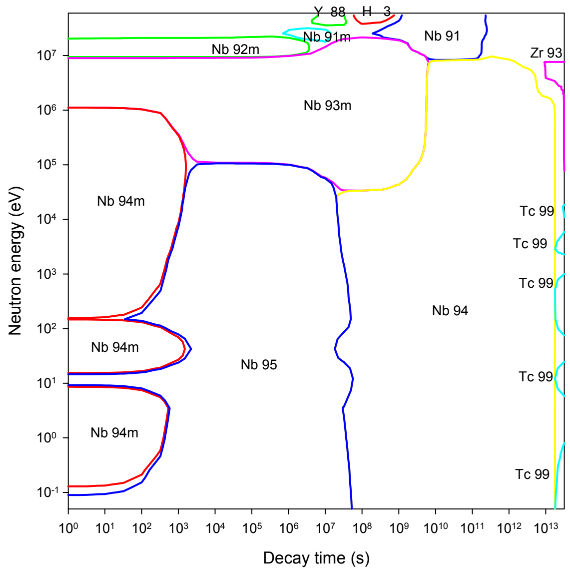
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Tc99	2.1 10^5 y	**&**Nb93(n,γ)*Nb94*(n,γ)*Nb95*(β^-)Mo95(n,γ)_ Mo96(n,γ)Mo97(n,γ)Mo98(n,γ)Mo99(β^-)_ *Tc99*	90.3	98.2	84.9				
		&Nb93(n,γ)*Nb94*(n,γ)*Nb95*(n,γ)Nb96(β^-)_ Mo96(n,γ)Mo97(n,γ)Mo98(n,γ)Mo99(β^-)_ *Tc99*	8.3	1.4	14.4				
		&Nb93(n,γ)*Nb94*(n,γ)Nb95(n,γ)Nb96(n,γ)_ *Nb97*(β^-)Mo97(n,γ)Mo98(n,γ)Mo99(β^-)*Tc99*	0.8						
Zr93	1.5 10^6 y	**&**Nb93(n,γ)*Nb94*(n,γ)*Nb95*(β^-)Mo95_ (n,α)Zr92(n,γ)Zr93	60.1		62.0				
		&Nb93(n,γ)*Nb94*(n,α)*Y91*(β^-)Zr91(n,γ)_ Zr92(n,γ)Zr93	31.4		1.7				
		&Nb93(n,γ)*Nb94*(n,α)*Y91*(n,γ)Y92(β^-)_ Zr92(n,γ)Zr93	7.0						
		&Nb93(n,γ)*Nb94*(n,γ)*Nb95*(β^-)Mo95_ (n,γ)Mo96(n,α)Zr93	0.7	97.3					
		Nb93(n,p)Zr93	0.4		35.7	99.5	99.7	99.8	99.9
		&Nb93(n,γ)*Nb94*(n,γ)Nb95(n,γ)Nb96(β^-)_ Mo96(n,α)Zr93		1.0					
Nb92	3.5 10^7 y	Nb93(n,2n)Nb92				99.7	99.9	99.9	99.9
		Nb93(n,n′)Nb93m(n,2n)Nb92				0.3			

Niobium activation characteristics

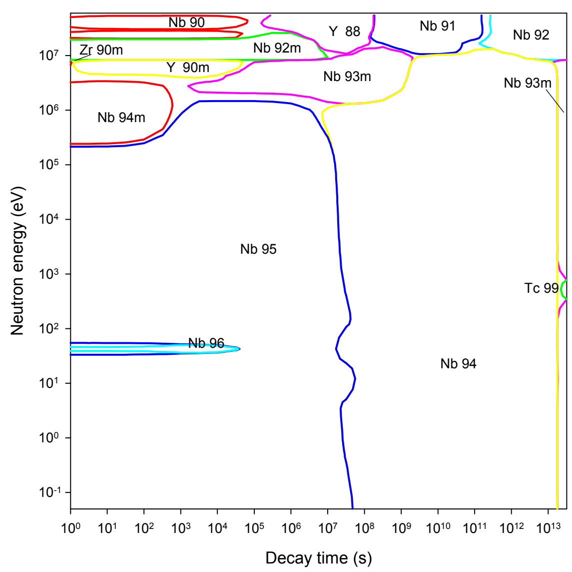


Niobium importance diagrams & transmutation

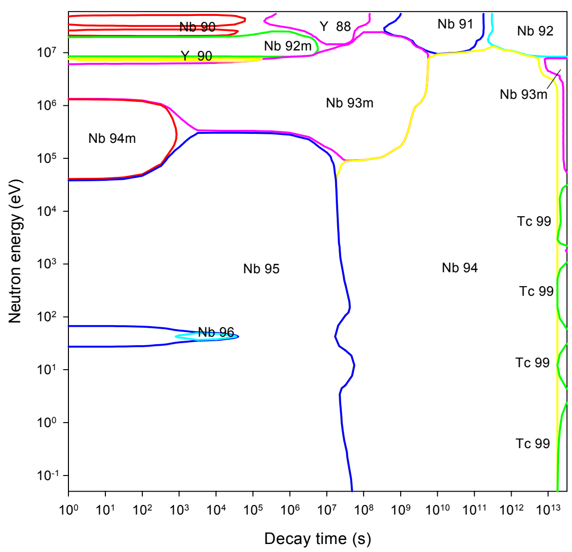
Activity



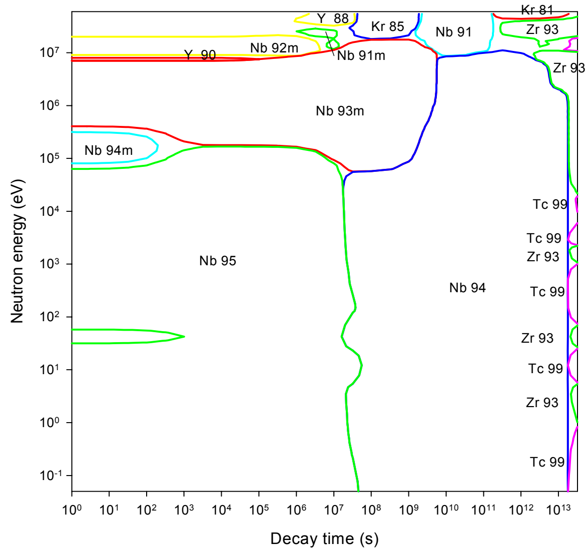
Dose rate



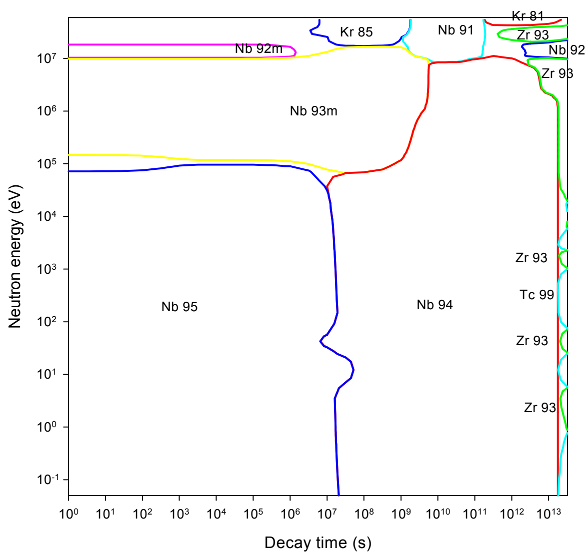
Heat output



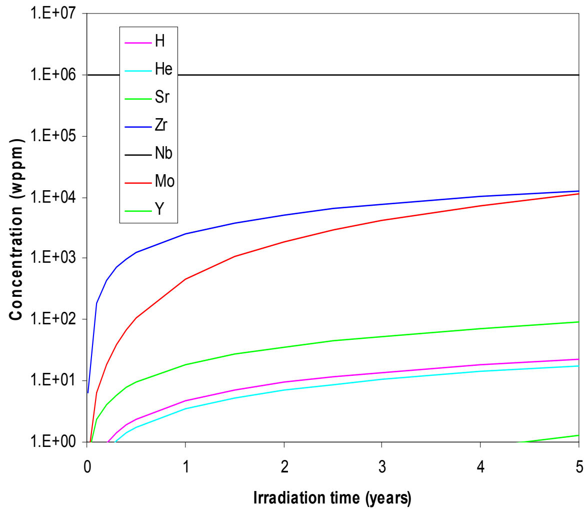
Ingestion dose



Inhalation dose



First wall transmutation



Molybdenum

General properties

		Isotopes	Isotopic abundances / %
Atomic number	42	Mo92	14.84 ($T_{½}$ = 1.90 10^{20} y)
Crustal abundance / wppm	1.2	Mo94	9.25
Melting point / K	2896	Mo95	15.92
Boiling point / K	4912	Mo96	16.68
Density / kgm^{-3}	10220	Mo97	9.55
Thermal conductivity / $Wm^{-1}K^{-1}$	138	Mo98	24.13 ($T_{½}$ = 1.00 10^{14} y)
Electrical resistivity /Ωm	5.2 10^{-8}	Mo100	9.63 ($T_{½}$ = 9.90 10^{18} y)
Coefficient of thermal expansion / K^{-1}	4.8 10^{-6}		
Crystal structure	BCC		
Number of stable isotopes	4 (7)		
Mean atomic weight	95.94		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.64E15	1.34E15	4.89E14	1.50E12	9.30E11	5.00E9	kW kg^{-1}	1.88E-1	1.18E-1	2.88E-2	2.77E-5	3.29E-6	7.63E-8
Mo99	34.10	41.67	45.65				Tc100	30.84					
Mo101	30.44	6.47					Mo99	25.90	41.21	67.28			
Zr95	6.80	0.09	0.24	1.60			Mo101	18.73	23.25				
Mo91	6.79	1.31					Tc101	7.75	12.02				
Mo93	1.35		0.03		19.16		Tc99m	6.05	9.64	17.08			
Tc99m	1.24	37.22	44.23				Mo91	4.59	5.81				
Tc101	1.22	8.09					Nb92m	1.68	2.67	8.55			
Tc100	0.42						Nb96	1.00	1.59	0.48			
Nb91m	0.26	1.52	4.01	21.29			Nb95	0.48	0.77	3.00	26.45		
Y89m	0.19	0.24	0.30				Nb91m	0.22	0.36	1.43	24.38		
Nb93m	0.09		0.04	15.90	17.05	0.03	Zr95	0.09	0.14	0.57	11.95		
Nb92m	0.07	1.50	3.22				Y88		0.04	0.18	21.76		
Nb91	0.03	0.04	0.13	43.04	62.96		Nb91				6.91	52.55	
Nb95		0.52	1.36	3.75			Nb93m				4.28	23.85	0.02
Nb96		0.32	0.06				Mo93				1.65	13.71	
Y88			0.02	0.92			Nb94				0.83	6.98	9.43
Tc99				0.45	0.73	99.24	Tc99				0.33	2.85	89.08

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	9.26E4	7.55E4	1.42E4	2.98E1	7.81E-1	1.17E-2	Sv kg^{-1}	1.51E6	3.97E5	1.69E5	9.18E2	6.15E2	3.23E0
Mo101	46.67	44.58					Mo99	22.24	84.75	79.30			
Mo99	18.62	22.80	48.26				Nb91m	0.85	3.25	7.32	21.98		
Tc101	6.05	7.22					Nb92m	0.80	3.05	5.59			
Nb92m	5.58	6.84	28.34				Tc99m	0.72	2.77	2.81			
Tc100	4.81						Nb96	0.31	1.20	0.21			
Mo91	4.57	4.45					Mo101	0.30	0.90				
Nb96	2.86	3.49	1.38				Nb95	0.27	1.03	2.29	3.56		
Tc99m	2.32		6.53				Zr89	0.16	0.64	0.69			
Nb90	2.04	2.49	0.20				Tc101	0.14	0.52				
Nb95	1.36	1.67	8.42	33.94			Nb90	0.12	0.46	0.01			
Y89m	0.85	1.02	2.51				Zr95	0.07	0.30	0.68	2.50		
Zr95	0.23	0.28	1.46	13.94			Mo93	0.03	0.14	0.33	61.20	89.86	
Nb91m	0.18			9.16			Zr97	0.03	0.12				
Y88		0.14	0.72	38.71			Ru103	0.02	0.11	0.25	0.07		
Nb91				1.45	50.36		Y88	0.01	0.04	0.08	1.97		
Nb94				1.09	41.74	87.01	Nb91			0.02	4.51	6.09	
Mo93					6.59		Nb93m				3.12	3.09	0.01
Tc98					0.15	10.12	Tc99				0.47	0.71	98.25
Nb92					0.04	2.86	Nb94				0.15	0.22	1.35

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.67E6	6.62E5	3.07E5	4.71E3	3.22E3	6.61E1		2.58E11	1.87E11	5.27E10	2.02E8	5.65E7	5.23E6
Tc100	60.36						Mo99	21.71	30.00	42.31			
Mo99	33.17	83.82	72.06				Tc100	21.34					
Nb91m	2.81	7.11	14.73	15.63			Tc101	16.65	22.40				
Nb95	0.75	1.91	3.92	2.15			Mo91	9.66	10.61				
Nb92m	0.71	1.80	3.02				Nb92m	7.82	10.81	29.84			
Tc99m	0.59	1.51	1.41				Mo101	4.32					
Zr95	0.44	1.12	2.33	3.03			Nb96	4.22	5.83	1.53			
Nb96	0.17	0.43	0.06				Nb90	2.46	3.39	0.18			
Mo101	0.17	0.34					Nb95	2.27	3.77	12.67	27.79		
Nb91	0.15	0.39	0.86	56.32	74.41		Tc 99m	1.94	2.68	4.10			
Ru103	0.11	0.28		0.06			Tc99m	1.93	2.68	4.09			
Zr89	0.10	0.26	0.26				Mo91m	1.59					
Tc101	0.08	0.19					Y89m	1.16	1.57	2.57			
Nb90	0.06	0.15					Nb98m	0.75	0.96				
Mo91	0.05	0.10					Zr90m	0.71					
Nb95m	0.04	0.11	0.12				Zr95	0.48	0.67	2.30	11.99		
Y88	0.03	0.08	0.17	1.29			Mo93m	0.45	0.62				
Mo93	0.02	0.06	0.13	8.84	12.70		Nb91m	0.37	0.52	1.77	7.55		
Nb93m	0.02		0.14	9.13	8.84		Zr89	0.33	0.46	0.75			
Tc99			0.02	1.89	2.76	97.64	Ru103	0.24	0.33	1.10	0.49		
Nb94			0.01	0.86	1.25	1.91	Zr89m	0.22	0.13				
Tc98						0.24	Y88		0.18	0.63	18.63		
							Nb93m			0.04	11.85	28.06	
							Mo93			0.03	8.97	31.54	
							Nb91			0.01	4.21	13.63	
							Nb94			0.01	4.09	14.60	4.93
							Tc99			0.01	3.39	12.15	94.93
							Tc98						0.09
							Nb92						0.02

Molybdenum

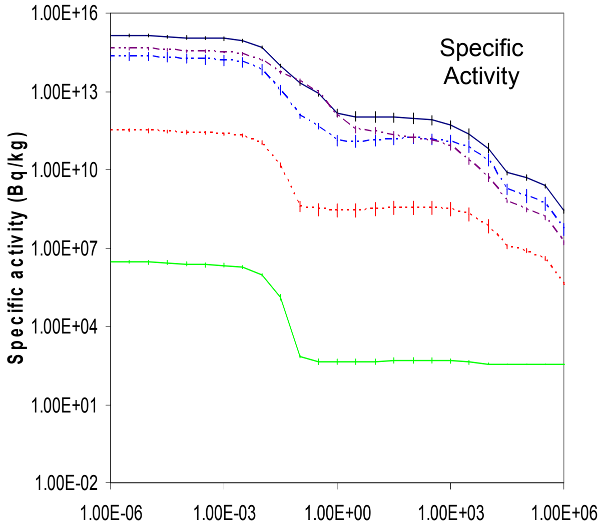
Pathway analysis

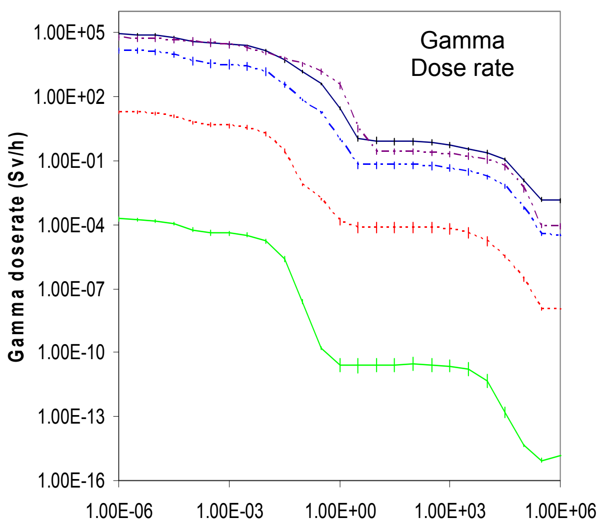
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Tc100	15.8 s	&Mo98(n,γ)Mo99(β^{-})*Tc99*(n,γ)Tc100	97.6	94.7	99.0	0.3	0.5	0.3	0.3
		&Mo97(n,γ)Mo98(n,γ)Mo99(β^{-})*Tc99*_ (n,γ)Tc100	2.4	1.9	0.9				
		&Mo96(n,γ)Mo97(n,γ)Mo98(n,γ)Mo99_ (β^{-})*Tc99*(n,γ)Tc100		2.7					
		Mo95(n,γ)Mo96(n,γ)Mo97(n,γ)Mo98_ (n,γ)Mo99(β^{-})Tc99m(IT)Tc99(n,γ)Tc100		0.5					
		&Mo100(n,2n)Mo99(β^{-})*Tc99*(n,γ)Tc100				98.5	58.2	45.5	39.0
		Mo100(n,γ)Mo101(β^{-})Tc101(β^{-})Ru101_ (n,2n)Ru100(n,p)Tc100				0.4	0.6	0.3	0.1
		Mo100(n,γ)Mo101(β^{-})Tc101(β^{-})Ru101_ (n,d)Tc100				0.3	32.1	40.8	44.9
		&Mo100(n,d)Nb99(β^{-})Mo99(β^{-})*Tc99*_ (n,γ)Tc100					6.6	10.8	13.5
		Mo100(n,d)Nb99m(β^{-})Mo99(β^{-})*Tc99*_ (n,γ)Tc100					1.2	1.7	1.9
Mo101	14.61 m	Mo100(n,γ)Mo101	100.0	100.0	100.0	99.9	99.5	99.6	99.8
Nb90	14.6 h	&Mo92(n,d)*Nb91*(n,2n)*Nb90*				71.4	28.1	1.6	1.3
		&Mo92(n,2n)*Mo91*(β^{+})Nb91(n,2n)*Nb90*				23.5	23.5	1.4	1.1
		&Mo92(n,t)*Nb90*					36.2	66.8	52.2
		Mo92(n,3n)Mo90(β^{+})Nb90					4.1	16.1	10.8
		&Mo94(n,3n)Mo92(n,t)*Nb90*					2.2	3.3	1.0
		&Mo95(n,4n)Mo92(n,t)*Nb90*						2.8	1.8
		&Mo94(n,2nt)*Nb90*							8.2
		&Mo96(n,4n)*Mo93*(n,nt)*Nb90*							2.3
Mo99	2.748 d	Mo98(n,γ)Mo99	96.0	91.9	98.1	0.3	0.8	0.6	
		Mo97(n,γ)Mo98(n,γ)Mo99	3.9	2.7	1.8				
		Mo96(n,γ)Mo97(n,γ)Mo98(n,γ)Mo99		4.3					
		Mo95(n,γ)Mo96(n,γ)Mo97(n,γ)Mo98(n,γ)Mo99		1.2					
		Mo100(n,2n)Mo99				99.3	86.8	77.5	70.5
		Mo100(n,d)Nb99(β^{-})Mo99					10.4	19.5	25.8
		Mo100(n,d)Nb99m(β^{-})Mo99					2.0	3.0	3.7
Nb92m	10.15 d	Mo92(n,p)Nb92m				89.0	13.5	4.5	1.7
		&Mo94(n,2n)*Mo93*(n,d)Nb92m				3.1	3.5	0.7	0.3
		Mo94(n,t)Nb92m					30.2	44.4	19.9
		&Mo95(n,3n)*Mo93*(n,d)Nb92m					16.0	3.5	1.0
		Mo96(n,3n)Mo94(n,t)Nb92m					7.4	6.5	1.2
		&Mo95(n,d)*Nb94*(n,3n)Nb92m					5.9	1.3	0.5
		Mo95(n,2n)Mo94(n,t)Nb92m					3.8	3.5	1.0
		Mo95(n,nt)Nb92m					1.5	14.2	33.5
		Mo96(n,2nt)Nb92m							18.9
Nb95	34.991 d	&Mo92(n,γ)Mo93(β^{+})Nb93m(n,γ)*Nb94*_ (n,γ)*Nb95*	80.9	79.7	79.7				
		&Mo92(n,γ)Mo93(β^{+})*Nb93*(n,γ)*Nb94*_ (n,γ)*Nb95*	13.0	12.8	12.7				
		&Mo98(n,α)Zr95(β^{-})*Nb95*				14.3	2.9	1.3	1.9
		&Mo97(n,α)Zr94(n,γ)Zr95(β^{-})*Nb95*	0.2	0.5	1.1				
		&Mo95(n,p)*Nb95*				61.4	22.0	12.4	5.1
		&Mo96(n,2n)Mo95(n,p)*Nb95*				14.2	1.5		0.1
		&Mo96(n,d)*Nb95*				6.5	45.6	37.1	25.6
		&Mo97(n,t)*Nb95*				0.1	7.7	19.5	15.6
		&Mo98(n,3n)Mo96(n,d)*Nb95*					10.1	3.7	1.2
		&Mo98(n,nt)*Nb95*					0.9	10.9	40.7
		Mo100(n,2nα)Zr95(β^{-})Nb95					0.6	3.2	1.7
Ru103	39.26 d ►	Mo100(n,γ)Mo101(β^{-})Tc101(β^{-})Ru101_ (n,γ)Ru102(n,γ)Ru103	96.6	99.7	99.9	99.8	99.6	99.6	99.8

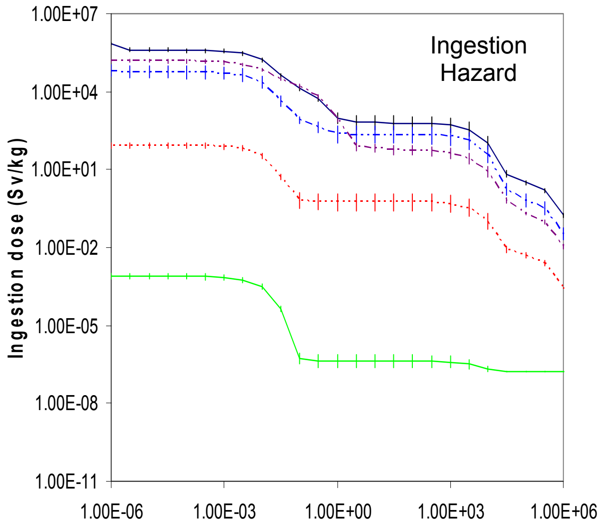
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Mo98(n,γ)Mo99(β$^-$)*Tc99*(n,γ)Tc100(β$^-$)_ Ru100(n,γ)Ru101(n,γ)Ru102(n,γ)Ru103	3.4	0.3					
Nb91m	60.90 d	Mo92(n,d)Nb91m				81.4	52.7	39.3	20.3
		Mo92(n,2n)Mo91m(β$^+$)Nb91m				10.4	24.4	14.6	7.5
		Mo92(n,d)Nb91(n,n′)Nb91m				4.1	1.7	0.8	
		Mo95(n,3n)Mo93(n,t)Nb91m					6.1	5.9	1.2
		Mo94(n,3n)Mo92(n,d)Nb91m					3.2	1.9	
		Mo94(n,nt)Nb91m						11.3	23.5
		Mo96(n,4n)Mo93(n,t)Nb91m						4.6	1.6
		Mo95(n,2nt)Nb91m							20.0
		Mo98(n,5n)Mo94(n,nt)Nb91m							2.9
Y88	106.63 d	&Mo92(n,α)*Zr89*(β$^+$)*Y89*(n,2n)Y88				43.8	2.7	0.4	1.9
		&Mo92(n,d)*Nb91*(n,α)Y88				33.2	3.1	0.4	0.8
		&Mo92(n,2n)Mo91(β$^+$)*Nb91*(n,α)Y88				11.0	2.8	0.3	0.7
		&Mo92(n,2n)*Mo91*(β$^+$)Nb91(n,α)Y88				6.5			
		Mo92(n,nα)Zr88(β$^+$)Y88				1.9	57.9	25.4	17.6
		Mo92(n,pα)Y88					7.5	4.0	1.1
		Mo94(n,3n)Mo92(n,nα)Zr88(β$^+$)Y88					3.1	1.1	0.3
		&Mo92(n,t)*Nb90*(β$^+$)Zr90(n,3n)Zr88(β$^+$)Y88					2.4	21.1	3.5
		&Mo92(n,h)*Zr90*(n,3n)Zr88(β$^+$)Y88					1.2	3.4	0.6
		&Mo92(n,t)*Nb90*(β$^+$)Zr90(n,t)Y88					0.5	10.4	3.2
		Mo92(n,3n)Mo90(β$^+$)Nb90(β$^+$)Zr90_ (n,3n)Zr88(β$^+$)Y88					0.3	5.0	0.7
		&Mo92(n,d)*Nb91*(n,nt)Zr88(β$^+$)Y88						0.8	5.0
		Mo94(n,3nα)Zr88(β$^+$)Y88							9.5
		&Mo95(n,2nt)*Nb91*(n,nt)Zr88(β$^+$)Y88							3.7
Kr85	10.752 y	&Mo92(n,α)Zr89(β$^+$)Y89m(IT)*Y89*_ (n,2n)Y88(β$^+$)Sr88(n,α)*Kr85*				41.5			
		&Mo92(n,d)*Nb91*(n,α)Y88(β$^+$)Sr88(n,α)*Kr85*				32.0	1.5	0.2	0.4
		&Mo92(n,2n)Mo91(β$^+$)Nb91(n,α)Y88_ (β$^+$)Sr88(n,α)*Kr85*				10.1	1.2	0.2	0.3
		&Mo92(n,nα)Zr88(β$^+$)Y88(β$^+$)Sr88(n,α)*Kr85*				4.7	74.2	42.0	23.2
		&Mo92(n,α)*Zr89*(β$^+$)Y89m(IT)Y89(n,d)_ Sr88(n,α)*Kr85*				3.0	0.2	0.1	0.5
		&Mo92(n,pα)Y88(β$^+$)Sr88(n,α)*Kr85*					10.9	7.5	1.6
		Mo92(n,t)Nb90(β$^+$)Zr90(n,t)Y88(β$^+$)Sr88_ (n,α)Kr85					0.2	5.0	1.3
		Mo92(n,2nα)Zr87(β$^+$)Y87m(IT)Y87(β$^+$)_ Sr87(n,h)Kr85						1.7	3.4
		&Mo94(n,3nα)Zr88(β$^+$)Y88(β$^+$)Sr88(n,α)*Kr85*							12.2
		&Mo94(n,tα)Y88(β$^+$)Sr88(n,α)*Kr85*							3.3
		Other pathways involving (n,2n), (n,α), β$^+$				8.7	11.8	43.3	53.8
H3	12.33 y	&Mo92(n,γ)*Mo93*(n,X)H1(n,γ)H2(n,γ)H3	94.5	95.9	96.8				
		Mo92(n,γ)Mo93m(n,X)H1(n,γ)H2(n,γ)H3	0.1	0.4	2.7				
		Mo95(n,X)H3				41.8	20.1	17.6	16.0
		Mo97(n,X)H3				17.7	11.5	10.2	9.8
		Mo98(n,X)H3				10.1	21.0	20.4	21.3
		Mo98(n,2n)Mo97(n,X)H3				5.4	0.9	0.5	0.3
		Mo96(n,2n)Mo95(n,X)H3				5.1	0.7		0.2
		Mo94(n,X)H3				2.2	8.2	8.4	8.3
		Mo92(n,p)Nb92(n,X)H3				2.2			
		Mo96(n,X)H3				1.1	12.7	13.9	14.6
		Mo100(n,X)H3				0.4	6.9	7.9	8.5
		Mo92(n,X)H3					6.2	9.0	10.5
Nb93m	16.126 y	&Mo92(n,γ)*Mo93*(β$^+$)Nb93m	100.0	100.0	100.0				
		Mo94(n,d)Nb93m				65.9	50.8	26.3	19.4
		Mo95(n,2n)Mo94(n,d)Nb93m				12.5	3.4	1.1	0.5
		Mo94(n,2n)Mo93(n,p)Nb93m				7.3	0.3		
		&Mo94(n,p)*Nb94*(n,2n)Nb93m				4.1	0.1		
		Mo95(n,t)Nb93m				2.3	29.7	51.6	39.9
		Mo96(n,3n)Mo94(n,d)Nb93m					6.6	2.0	0.6
	►	Mo96(n,nt)Nb93m					0.5	7.1	22.4

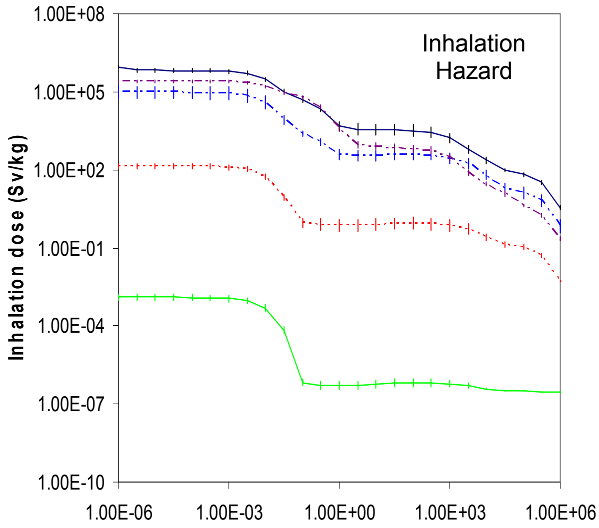
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Mo98(n,4n)Mo95(n,t)Nb93m						3.2	1.2
		Mo97(n,2nt)Nb93m							6.8
Nb91	680.0 y	&Mo92(n,d)*Nb91*				73.2	47.3	40.0	22.7
		&Mo92(n,2n)*Mo91*(β^+)Nb91				24.2	42.6	32.1	18.9
		Mo92(n,2n)Mo91m(β^+)Nb91				1.5	2.6	1.9	1.1
		&Mo94(n,nt)*Nb91*						10.3	19.2
		&Mo94(n,4n)*Mo91*(β^+)Nb91						1.1	5.7
		Mo95(n,2nt)Nb91							16.6
		&Mo95(n,5n)*Mo91*(β^+)Nb91							3.3
Mo93	4000 y	&Mo92(n,γ)*Mo93*	100.0	100.0	100.0	0.6	0.1		
		&Mo94(n,2n)*Mo93*				83.0	15.8	8.1	7.1
		&Mo95(n,2n)Mo94(n,2n)*Mo93*				15.1	1.0		0.2
		&Mo95(n,3n)*Mo93*					73.6	45.7	26.8
		&Mo96(n,4n)*Mo93*						35.6	35.9
		Mo98(n,4n)Mo95(n,3n)Mo93						2.5	0.7
		Mo98(n,3n)Mo96(n,4n)Mo93						1.7	0.8
		&Mo97(n,5n)*Mo93*							19.2
		&Mo98(n,6n)*Mo93*							3.6
Nb94	2.0 10^4 y	&Mo92(n,γ)Mo93(β^+)Nb93m(n,γ)*Nb94*	83.0	82.9	82.9				
		&Mo92(n,γ)Mo93(β^+)*Nb93*(n,γ)*Nb94*	16.8	16.8	16.4				
		&Mo92(n,γ)Mo93m(β^+)Nb93(n,γ)*Nb94*	0.1	0.3	0.4				
		&Mo94(n,p)*Nb94*				63.8	13.8	6.3	1.9
		&Mo95(n,d)*Nb94*				20.2	60.6	36.2	23.3
		&Mo95(n,2n)Mo94(n,p)*Nb94*				11.6	0.9		
		&Mo96(n,t)*Nb94*					13.8	40.9	28.2
		&Mo97(n,nt)*Nb94*					0.8	6.2	16.8
		&Mo98(n,2nt)*Nb94*							23.5
Tc99	2.1 10^5 y	&Mo98(n,γ)Mo99(β^-)*Tc99*	97.6	94.8	99.0	0.3	0.7	0.6	0.5
		&Mo97(n,γ)Mo98(n,γ)Mo99(β^-)*Tc99*	2.4	1.9	0.9				
		&Mo96(n,γ)Mo97(n,γ)Mo98(n,γ)Mo99(β^-)*Tc99*		2.7					
		&Mo100(n,2n)Mo99(β^-)*Tc99*				99.5	87.1	77.8	71.2
		&Mo100(n,d)Nb99(β^-)Mo99(β^-)*Tc99*					9.8	18.4	24.5
		&Mo100(n,d)Nb99m(β^-)Mo99(β^-)*Tc99*					1.8	2.8	3.4
Tc98	4.2 10^6 y	&Mo100(n,2n)Mo99(β^-)*Tc99*(n,2n)Tc98				99.5	87.2	77.8	71.0
		&Mo100(n,d)Nb99(β^-)Mo99(β^-)*Tc99*_ (n,2n)Tc98					9.8	18.4	24.5
		&Mo100(n,d)Nb99m(β^-)Mo99(β^-)*Tc99*_ (n,2n)Tc98					1.8	2.8	3.4
Nb92	3.5 10^7 y	Mo92(β^+)Nb92	100.0	100.0	100.0				
		Mo92(n,p)Nb92				94.8	17.9	5.2	1.7
		Mo94(n,2n)Mo93(n,d)Nb92				1.7	2.1		
		Mo94(n,t)Nb92					38.4	50.9	19.0
		&Mo95(n,3n)*Mo93*(n,d)Nb92					10.3	1.6	0.3
		&Mo95(n,d)*Nb94*(n,3n)Nb92					7.9	1.4	0.4
		Mo96(n,3n)Mo94(n,t)Nb92					4.8	3.8	0.6
		Mo95(n,nt)Nb92					2.0	21.9	41.4
		Mo96(n,2nt)Nb92							24.5

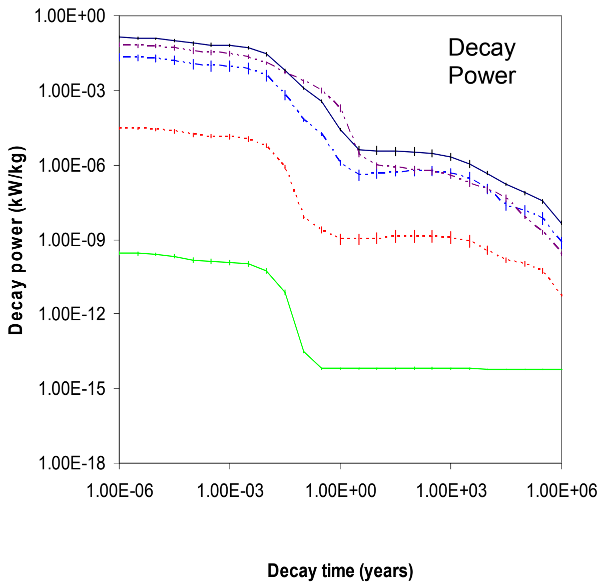
Molybdenum activation characteristics

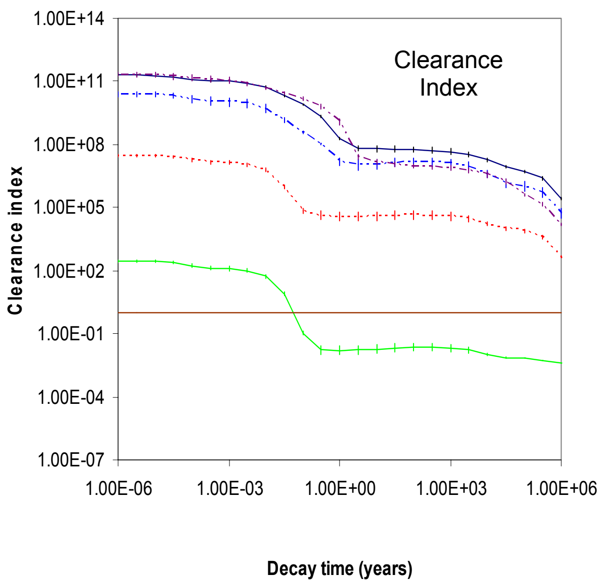






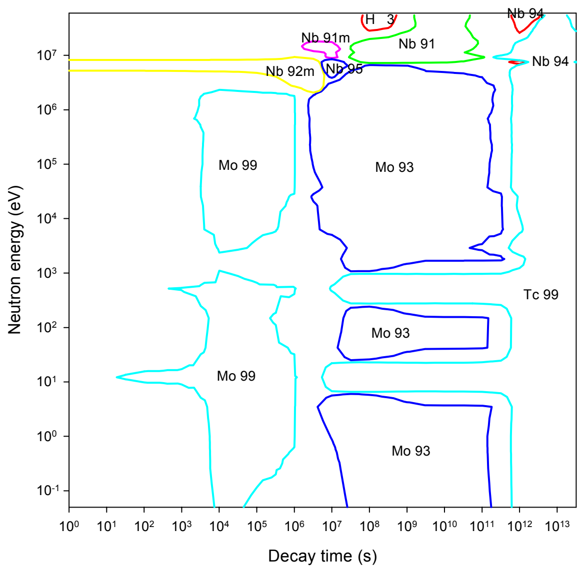




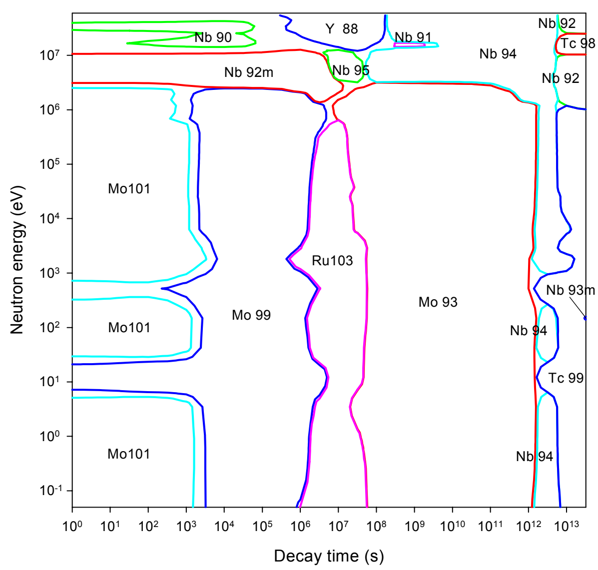


Molybdenum importance diagrams & transmutation

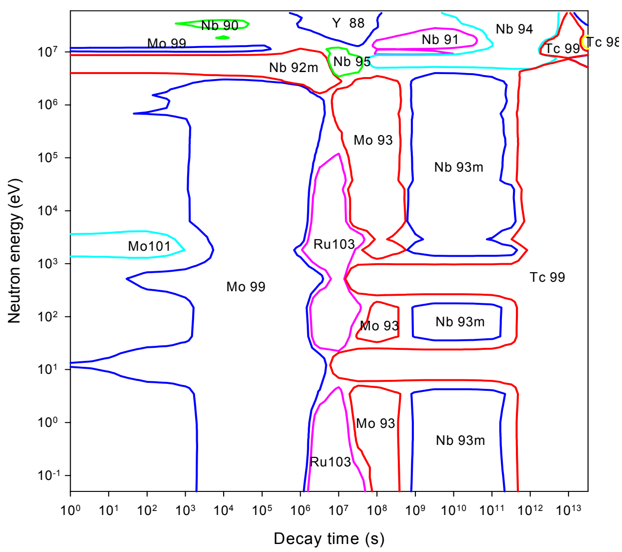
Activity



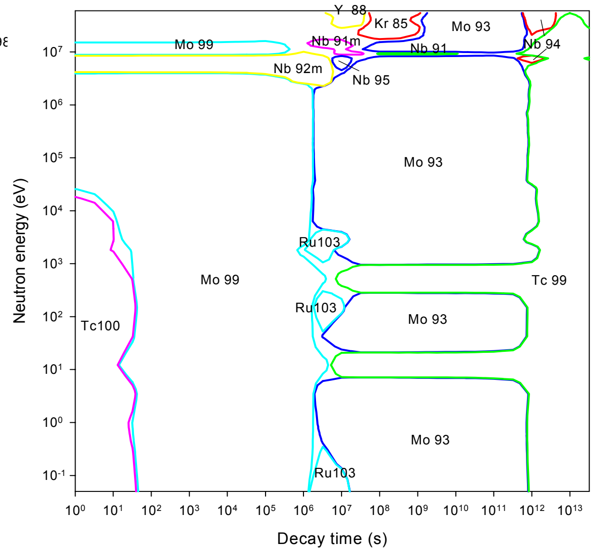
Dose rate



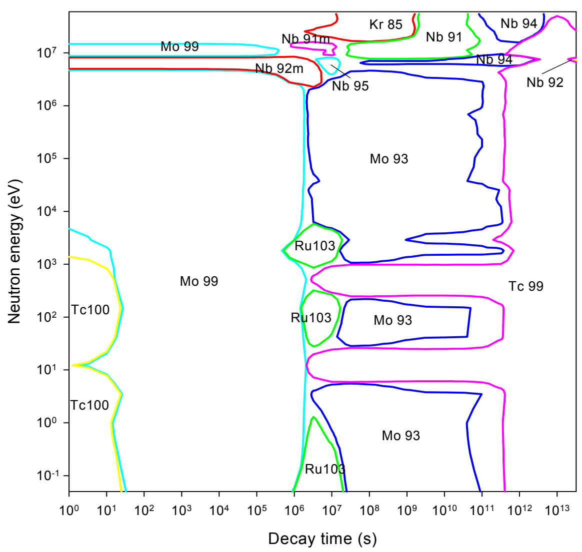
Heat output



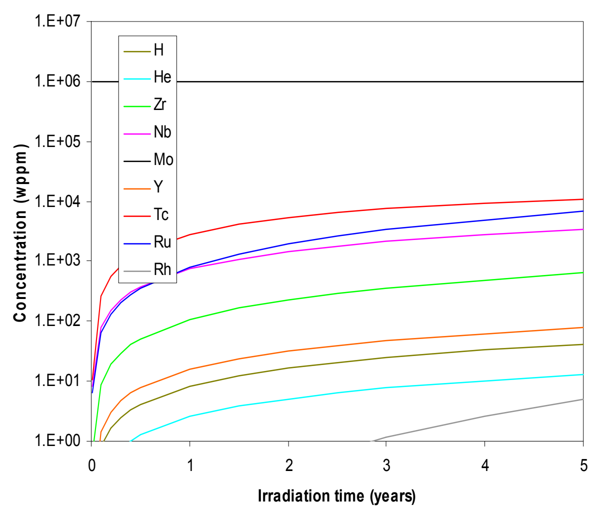
Ingestion dose



Inhalation dose



First wall transmutation



Ruthenium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	44	Ru96	5.54 ($T_{½}$ = 6.70 10^{16} y)
Crustal abundance / wppm	1.0 10^{-3}	Ru98	1.87
Melting point / K	2607	Ru99	12.76
Boiling point / K	4423	Ru100	12.60
Density / kgm^{-3}	12410	Ru101	17.06
Thermal conductivity / $Wm^{-1}K^{-1}$	117	Ru102	31.55
Electrical resistivity /Ωm	7.6 10^{-8}	Ru104	18.62
Coefficient of thermal expansion / K^{-1}	6.4 10^{-6}		
Crystal structure	HCP		
Number of stable isotopes	6 (7)		
Mean atomic weight	101.07		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	2.39E15	2.15E15	1.24E15	4.91E12	3.61E9	3.49E8
Rh103m	25.17	28.03	44.24	18.76		
Ru103	24.58	27.42	44.49	18.97		
Ru105	12.72	14.00				
Rh105	12.70	14.17	5.03			
Rh104	9.24	0.45				
Ru97	5.50	6.13	4.44			
Rh105m	3.61	3.98				
Tc95	1.43	1.60	0.14	0.03		
Ru95	1.01	1.09				
Tc99m	0.87	0.96				
Tc96	0.51	0.57				
Rh102m	0.14	0.15		20.29		
Rh102	0.12	0.11		39.79		
Tc97m				0.81		
H3				0.14	0.73	
Mo93				0.03	45.82	
Nb93m					40.09	
Tc99					7.76	58.11
Tc97					3.49	35.23
Nb91					1.34	
Tc98					0.63	6.48

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	1.90E-1	1.50E-1	6.22E-2	8.71E-4	2.24E-8	8.70E-9
Ru105	29.59	36.93				
Ru103	27.94	35.35	80.00	9.64		
Rh104	18.60	1.04				
Rh105	5.92	7.49	3.71			
Ru97	2.81	3.55	3.59			
Ru95	2.71	3.30				
Tc96	2.59	3.28	4.41			
Tc95	2.32	2.94	0.38	0.02		
Rh103m	1.90	2.40	5.30	0.63		
Tc100	1.72					
Rh105m	0.92	1.16				
Tc102m	0.53	0.29				
Rh102	0.44	0.55	1.34	76.71		
Tc104	0.25	0.26				
Rh102m	0.18	0.23	0.57	12.22		
Nb93m					32.06	
Tc98					25.23	63.81
Mo93					18.74	
Tc99					17.16	31.91
Nb94					4.20	0.33
Tc97					1.56	3.92

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	1.38E5	1.35E5	6.12E4	1.17E3	9.53E-3	7.52E-3
Ru103	40.72	41.52	85.99	7.57		
Ru105	35.39	35.60				
Tc96	5.65	5.76	7.08			
Ru95	5.20	5.11				
Tc95	4.62	4.71	0.55	0.02		
Rh105	2.32	2.37	1.07			
Ru97	2.15	2.19	2.02			
Tc102m	0.97	0.43				
Rh102	0.89	0.90	2.00	83.39		
Rh102m	0.24	0.24		8.42		
Tc98					79.44	99.00
Nb94					13.92	0.55
Mo93					4.38	

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.07E6	8.20E5	4.57E5	7.03E3	5.55E0	1.84E-1
Ru103	39.97	52.39	88.05	9.67		
Rh102m	30.44	0.49	0.87	17.02		
Rh105	10.47	13.73	5.04			
Ru105	7.36	9.52				
Ru97	1.84	2.41	1.80			
Tc96	1.25	1.64	1.64			
Rh102	0.59	0.77	1.39	72.29		
Tc95	0.57	0.75	0.07			
Mo93				0.07	92.46	
Tc99					3.23	70.69
Nb93m					3.13	
Tc98					0.82	24.64
Tc97					0.15	4.55

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	2.38E6	2.16E6	1.76E6	4.34E4	1.17E1	3.88E0		7.56E11	7.23E11	5.75E11	5.64E9	6.71E5	2.49E5
Ru103	74.06	81.83	93.87	6.43			Ru103	77.80	81.40	95.91	16.51		
Rh105	4.46	4.93	1.23				Ru105	4.02	4.15				
Ru105	2.30	2.50					Ru95	4.02	4.05				
Rh102	1.75	1.93	2.36	76.44			Tc95	3.49	3.65	0.24	0.02		
Rh102m	1.00	1.10	1.33	16.28			Rh104	3.32	0.15				
Ru97	0.60	0.67	0.34				Ru97	1.74	1.82	0.95			
Tc96	0.36	0.39	0.27				Tc96	1.62	1.69	1.18			
Tc95	0.15	0.17	0.01				Rh102	0.69	0.72		73.69		
Tc95m	0.14	0.16	0.19	0.12			Rh105	0.40	0.42				
Tc97m	0.11	0.12	0.14	0.37			Rh102m	0.22	0.23	0.28	8.83		
Mo93					32.53		Tc99					41.78	81.62
Tc99					31.16	67.93	Mo93					24.65	
Nb93m					22.27		Nb93m					21.57	
Tc98					8.85	26.23	Nb94					5.02	0.42
Tc97					1.94	5.70	Tc97					1.88	4.94
Nb91					1.70		Tc98						13.01
Nb94					1.41	0.13							

Ruthenium

Pathway analysis

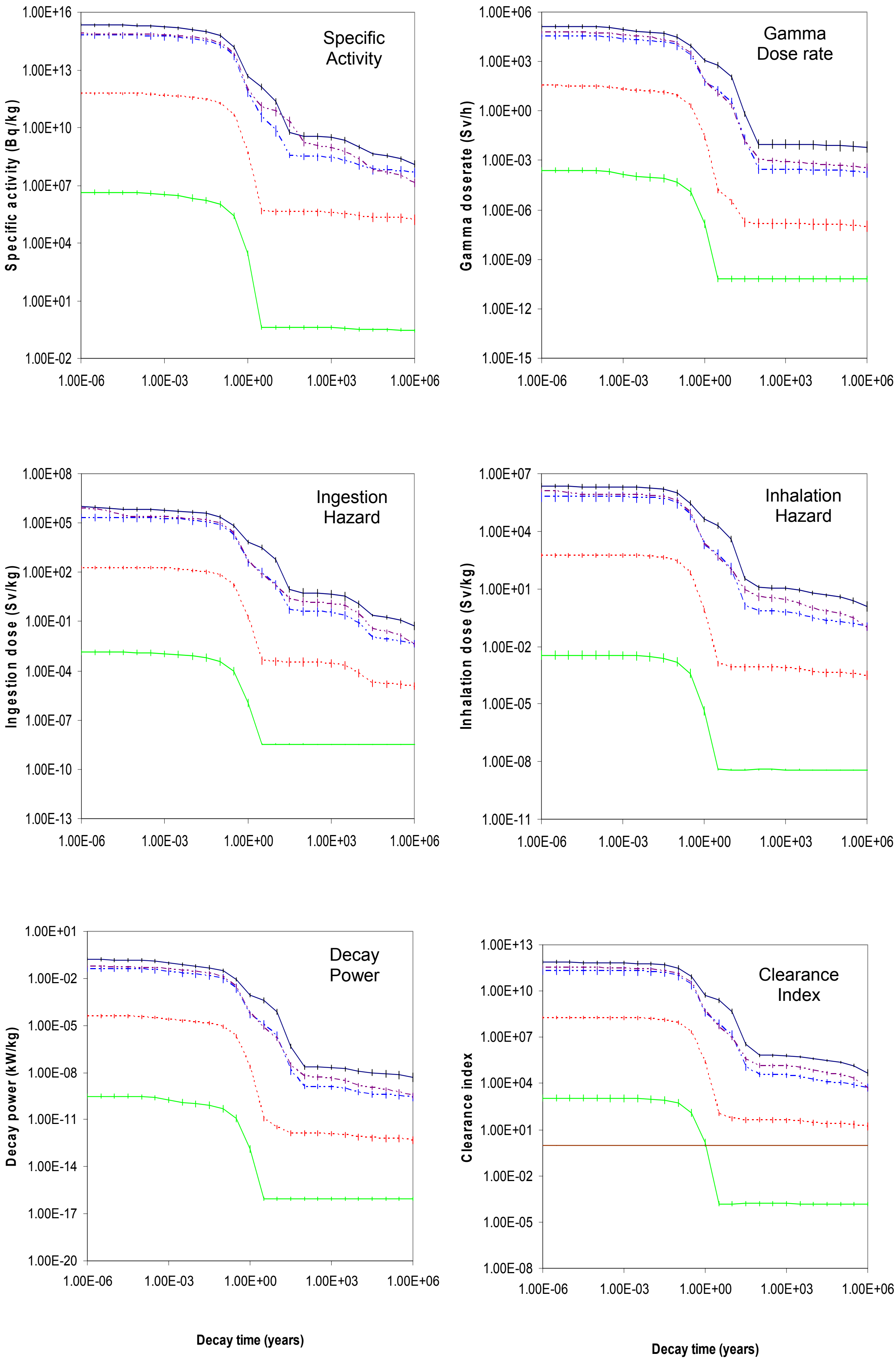
Nuclide	$T_{1/2}$	Pathway	210	186	151	42	30	21	6
Tc100	15.8 s	**&**Ru96(n,γ)Ru97(β^+)Tc97(n,γ)Tc98_(n,γ)*Tc99*(n,γ)Tc100	100.0	99.9	99.9				
		Ru100(n,p)Tc100				60.2	19.4	8.0	3.8
		Ru101(n,2n)Ru100(n,p)Tc100				17.9	1.8	0.5	
		Ru101(n,d)Tc100				7.5	49.0	30.8	25.0
		Ru104(n,2n)Ru103(β^-)Rh103m(IT)_Rh103(n,α)Tc100				6.8			
		Ru102(n,2n)Ru101(n,2n)Ru100(n,p)Tc100				4.0			
		Ru102(n,2n)Ru101(n,d)Tc100				3.3	6.0	2.4	
		Ru102(n,t)Tc100					11.7	49.1	50.3
		Ru102(n,3n)Ru100(n,p)Tc100					7.7	1.6	
		Ru104(n,4n)Ru101(n,d)Tc100						3.2	
		Ru104(n,2nt)Tc100						0.2	15.0
Rh106	30.0 s	**&**Ru104(n,γ)Ru105(β^-)*Rh105*(n,γ)Rh106	99.7	96.6	87.7	25.3	5.7	7.4	10.6
		&Ru102(n,γ)Ru103(n,γ)Ru104(n,γ)_Ru105(β^-)Rh105(n,γ)Rh106	0.2	0.2					
		Ru104(n,γ)Ru105(n,γ)Ru106(β^-)Rh106		3.0	12.3	15.4	12.4	16.5	26.7
		&Ru104(n,γ)Ru105(β^-)*Rh105*(β^-)_Pd105(n,γ)Pd106(n,p)Rh106				59.3	81.9	76.1	62.7
Rh104	42.3 s	**&**Ru102(n,γ)Ru103(β^-)*Rh103*(n,γ)*Rh104*	91.6	80.8	95.3		0.2	0.1	
		&Ru101(n,γ)Ru102(n,γ)Ru103(β^-)_*Rh103*(n,γ)*Rh104*	7.4	19.0	3.3				
		&Ru100(n,γ)Ru101(n,γ)Ru102(n,γ)_Ru103(β^-)Rh103m(IT)Rh103(n,γ)*Rh104*	0.7						
		&Ru104(n,2n)Ru103(β^-)*Rh103*(n,γ)*Rh104*				97.4	61.0	49.9	40.4
		&Ru104(n,γ)Ru105(β^-)*Rh105*(β^-)_Pd105(n,d)*Rh104*				0.3	28.1	34.6	38.6
		&Ru104(n,d)Tc103(β^-)Ru103(β^-)_Rh103m(IT)Rh103(n,γ)*Rh104*					6.5	11.3	13.2
Tc102m	4.35 m	Ru102(n,p)Tc102m				99.2	82.3	42.7	21.3
		Ru104(n,t)Tc102m					9.0	55.0	78.0
Ru97	2.90 d	Ru96(n,γ)Ru97	100.0	100.0	100.0	0.1			
		Ru99(n,2n)Ru98(n,2n)Ru97				55.3	3.8	1.3	0.6
		Ru98(n,2n)Ru97				38.3	7.1	4.1	2.9
		Ru100(n,2n)Ru99(n,2n)Ru98(n,2n)Ru97				5.7			
		Ru99(n,3n)Ru97					63.4	43.0	20.8
		Ru101(n,3n)Ru99(n,3n)Ru97					11.2	3.7	0.5
		Ru100(n,3n)Ru98(n,2n)Ru97					6.0	2.3	0.7
		Ru100(n,2n)Ru99(n,3n)Ru97					4.4	1.8	0.6
		Ru100(n,4n)Ru97						24.0	24.9
		Ru102(n,4n)Ru99(n,3n)Ru97						7.8	2.1
		Ru102(n,3n)Ru100(n,4n)Ru97						4.8	2.1
		Ru101(n,5n)Ru97							29.7
Tc96	4.28 d	Ru96(β^+)Tc96	100.0	100.0	100.0				
		&Ru96(n,p)*Tc96*				51.8	13.9	4.8	1.5
		&Ru98(n,2n)Ru97(β^+)Tc97(n,2n)*Tc96*				26.7	3.5	0.6	0.1
		&Ru99(n,2n)Ru98(n,2n)Ru97(β^+)Tc97_(n,2n)*Tc96*				19.0	0.8		
		&Ru99(n,3n)Ru97(β^+)Tc97(n,2n)*Tc96*					31.6	11.1	1.1
		&Ru99(n,d)Tc98(n,3n)*Tc96*					9.8	2.3	0.5
		&Ru98(n,t)*Tc96*					6.9	13.8	4.4
		&Ru100(n,3n)Ru98(n,t)*Tc96*					5.5	7.7	1.0
		&Ru99(n,2n)Ru98(n,t)*Tc96*					3.5	4.4	0.9
		&Ru99(n,nt)*Tc96*					1.0	17.3	40.2
		&Ru101(n,4n)Ru98(n,t)*Tc96*						8.0	1.6
		&Ru100(n,2nt)*Tc96*							17.0
Ru103	39.26 d▶	Ru102(n,γ)Ru103	90.8	77.4	93.6	0.2	0.4	0.3	

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Ru101(n,γ)Ru102(n,γ)Ru103	8.2	22.5	6.3				
		Ru100(n,γ)Ru101(n,γ)Ru102(n,γ)Ru103	0.8	0.1					
		Ru104(n,2n)Ru103				99.4	88.6	80.1	74.3
		Ru104(n,d)Tc103(β^-)Ru103					9.5	18.4	24.5
Tc97m	90.2 d	Ru96(n,γ)Ru97(β^+)Tc97m	99.9	100.0	99.8				
		Ru99(n,2n)Ru98(n,d)Tc97m				29.5	6.3	1.7	0.7
		Ru98(n,d)Tc97m				21.9	12.7	5.7	3.5
		Ru98(n,2n)Ru97(β^+)Tc97(n,n′)Tc97m				16.4	0.8	0.2	
		Ru99(n,2n)Ru98(n,2n)Ru97(β^+)Tc97_ (n,n′)Tc97m				11.2			
		Ru99(n,d)Tc98(n,2n)Tc97m				3.7	1.7	0.8	0.4
		Ru100(n,2n)Ru99(n,2n)Ru98(n,d)Tc97m				2.8	0.2		
		Ru98(n,p)Tc98(n,2n)Tc97m				2.7	0.1		
		Ru99(n,t)Tc97m				1.4	33.4	46.2	26.8
		Ru100(n,3n)Ru98(n,d)Tc97m					10.0	3.0	0.7
		Ru99(n,3n)Ru97(β^+)Tc97(n,n')Tc97m					7.4	2.5	0.5
		Ru101(n,3n)Ru99(n,t)Tc97m					5.5	3.7	1.0
		Ru100(n,d)Tc99(n,3n)Tc97m					3.3	1.1	0.4
		Ru100(n,nt)Tc97m					0.3	7.2	23.8
		Ru102(n,4n)Ru99(n,t)Tc97m						7.7	2.4
		Ru101(n,4n)Ru98(n,d)Tc97m						3.1	1.2
		Ru101(n,2nt)Tc97m						0.3	16.8
		Ru102(n,5n)Ru98(n,d)Tc97m							2.7
Y88	106.63 d	**&**Ru96(n,nα)Mo92(n,α)*Zr89*(β^+)Y89m_ (IT)Y89(n,2n)Y88				35.9	1.1		0.1
		&Ru96(n,nα)Mo92(n,d)*Nb91*(n,α)Y88				27.1	1.1		
		Ru96(n,nα)Mo92(n,2n)Mo91(β^+)Nb91_ (n,α)Y88				8.5	1.0		
		&Ru96(n,α)Mo93(n,nα)*Zr89*(β^+)Y89m_ (IT)Y89(n,2n)Y88				4.7	0.4		
		Ru96(n,nα)Mo92(n,nα)Zr88(β^+)Y88				2.9	41.4	4.4	2.1
		Ru96(n,nα)Mo92(n,pα)Y88					5.8	0.7	0.1
		Ru96(n,t)Tc94(β^+)Mo94(n,3n)Mo92_ (n,nα)Zr88(β^+)Y88					5.6	1.9	
		Ru96(n,nt)Tc93(β^+)Mo93(n,2nα)Zr88_ (β^+)Y88						8.1	4.8
		Other pathways involving (n,2n), (n,α), β^+				20.9	43.6	84.9	93.0
Ag110m	249.78 d	**&**Ru104(n,γ)Ru105(β^-)*Rh105*(n,γ)_ Rh106(β^-)Pd106(n,γ)*Pd107*(n,γ)Pd108_ (n,γ)*Pd109*(β^-)*Ag109*(n,γ)Ag110m	42.3	0.3					
		&Ru104(n,γ)Ru105(β^-)*Rh105*(n,γ)_ Rh106m(β^-)Pd106(n,γ)*Pd107*(n,γ)_ Pd108(n,γ)*Pd109*(β^-)*Ag109*(n,γ)Ag110m	35.6						
		&Ru104(n,γ)Ru105(β^-)*Rh105*(β^-)_ Pd105(n,γ)Pd106(n,γ)*Pd107*(n,γ)Pd108_ (n,γ)*Pd109*(β^-)*Ag109*(n,γ)Ag110m	21.5	83.5	99.2				
		&Ru102(n,γ)Ru103(β^-)*Rh103*(n,γ)*Rh104*(β^-)_ Pd104(n,γ)Pd105(n,γ)Pd106(n,γ)*Pd107*(n,γ)_ Pd108(n,γ)*Pd109*(β^-)*Ag109*(n,γ)Ag110m		13.4					
Ru106	1.020 y	Ru104(n,γ)Ru105(n,γ)Ru106	99.7	99.7	100.0	99.9	99.6	99.7	99.8
		Ru102(n,γ)Ru103(n,γ)Ru104(n,γ)_ Ru105(n,γ)Ru106	0.3	0.2					
Rh102	2.902 y	**&**Ru104(n,2n)Ru103(β^-)*Rh103*(n,2n)*Rh102*				99.5	89.5	80.7	74.5
		&Ru104(n,d)Tc103(β^-)Ru103(β^-)_ *Rh103*(n,2n)Rh102					9.2	17.7	23.5
Kr85	10.752 y	**&**Ru96(n,nα)Mo92(n,d)*Nb91*(n,α)Y88_ (β^+)Sr88(n,α)*Kr85*				24.5	0.7		
		Ru96(n,nα)Mo92(n,2n)Mo91(β^+)Nb91_ (n,α)Y88(β^+)Sr88(n,α)Kr85				7.1			
	►	**&**Ru96(n,nα)Mo92(n,nα)Zr88(β^+)Y88_ (β^+)Sr88(n,α)*Kr85*				4.6	49.9	4.9	1.8

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Ru96(n,nα)Mo92(n,pα)Y88(β$^+$)Sr88_ (n,α)*Kr85*					8.2	0.9	0.1
		&Ru96(n,dα)*Nb91*(n,α)Y88(β$^+$)Sr88_ (n,α)Kr85					3.1	1.9	0.6
		&Ru96(n,n2α)Zr88(β$^+$)Y88(β$^+$)Sr88_ (n,α)*Kr85*						11.0	9.2
		Other pathways involving (n,2n), (n,α), β$^+$				63.8	38.1	81.3	88.3
H3	12.33 y	Ru96(n,γ)Ru97(n,X)H1(n,γ)H2(n,γ)H3	93.2	94.5	98.4				
		Ru101(n,X)H3				33.4	22.3	19.0	17.8
		Ru99(n,X)H3				30.2	17.3	14.4	13.0
		Ru104(n,2n)Ru103(β$^-$)Rh103m(IT)_ Rh103(n,X)H3				15.5			0.3
		Ru102(n,2n)Ru101(n,X)H3				7.6	1.4	0.8	0.5
		Ru100(n,2n)Ru99(n,X)H3				3.2	0.6		0.2
		Ru96(n,X)H3				1.0	5.0	5.0	4.7
		Ru100(n,X)H3				0.3	8.8	10.0	10.6
		Ru102(n,X)H3				0.2	20.3	24.0	26.2
		Ru104(n,X)H3					10.5	13.2	14.9
Nb93m	16.126 y	&Ru96(n,α)*Mo93*(β$^+$)Nb93m	100.0	100.0	100.0	8.3	0.1	0.2	0.5
		Ru96(n,α)Mo93(n,p)Nb93m				31.9	0.3	0.2	0.3
		Ru96(n,2n)Ru95(β$^+$)Tc95(β$^+$)Mo95_ (n,2n)Mo94(n,d)Nb93m				14.6		0.1	
		Ru98(n,2n)Ru97(β$^+$)Tc97(n,nα)Nb93m				11.8	1.6	0.3	
		Ru96(n,d)Tc95(β$^+$)Mo95(n,2n)Mo94_ (n,d)Nb93m				6.5	0.7	0.1	
		Ru99(n,2n)Ru98(n,2n)Ru97(β$^+$)Tc97_ (n,nα)Nb93m				5.9	0.3		
		Ru96(n,2n)Ru95(β$^+$)Tc95(β$^+$)Mo95(n,t)_ Nb93m				4.2	10.2	10.1	3.6
		Ru96(n,d)Tc95(β$^+$)Mo95(n,t)Nb93m				1.9	9.4	8.2	2.9
		Ru96(n,t)Tc94(β$^+$)Mo94(n,d)Nb93m					19.8	18.4	4.2
		Ru99(n,3n)Ru97(β$^+$)Tc97(n,nα)Nb93m					14.1	2.8	0.6
		Ru96(n,3n)Ru94(β$^+$)Tc94m(β$^+$)Mo94_ (n,d)Nb93m					13.5	7.0	1.7
		Ru99(n,2nα)Mo94(n,d)Nb93m					2.2	4.6	1.2
		Ru100(n,2nα)Mo95(n,t)Nb93m					0.2	3.4	1.0
		&Ru99(n,nt)*Tc96*(β$^+$)Mo96(n,nt)Nb93m						0.7	5.6
		Ru99(n,tα)Nb93m						0.2	12.7
		Ru99(n,2nt)Tc95(β$^+$)Mo95(n,t)Nb93m							6.4
		Other pathways from high mass Ru isotopes				14.9	27.6	43.7	59.3
Nb91	680.0 y	&Ru96(n,nα)Mo92(n,d)*Nb91*				65.1	18.6	1.0	1.5
		&Ru96(n,nα)Mo92(n,2n)*Mo91*(β$^+$)Nb91				21.7	16.8	0.8	1.2
		&Ru96(n,α)Mo93(n,2n)Mo92(n,d)*Nb91*				7.0			
		&Ru96(n,dα)*Nb91*					34.2	37.8	16.5
		&Ru96(n,2nα)*Mo91*(β$^+$)Nb91					2.6	25.8	13.1
		&Ru96(n,t)Tc94(β$^+$)Mo94(n,nt)*Nb91*						5.2	3.8
		&Ru96(n,nt)*Tc93*(β$^+$)Mo93(n,t)*Nb91*						3.1	4.4
Mo93	4000 y	&Ru96(n,α)*Mo93*	100.0	100.0	100.0	92.3	12.9	11.2	15.8
		Ru96(n,2n)Ru95(β$^+$)Tc95(β$^+$)Mo95_ (n,2n)Mo94(n,2n)Mo93				4.4	0.2		
		&Ru96(n,2n)Ru95(β$^+$)Tc95(β$^+$)Mo95_ (n,3n)*Mo93*					24.3	3.2	0.3
		&Ru96(n,d)Tc95(β$^+$)Mo95(n,3n)*Mo93*					22.4	2.8	0.2
		&Ru99(n,nα)Mo95(n,3n)*Mo93*					6.4	0.8	
		&Ru96(n,t)Tc94(β$^+$)Mo94(n,2n)*Mo93*					5.9	2.3	0.2
		&Ru98(n,2nα)*Mo93*					2.9	8.1	1.2
		&Ru96(n,nt)*Tc93*(β$^+$)Mo93					0.6	39.0	40.6
		&Ru99(n,3nα)*Mo93*						5.5	14.6
Nb94	2.0 10^4 y	&Ru96(n,γ)Ru97(β$^+$)Tc97(n,α)*Nb94*	96.5	99.9	94.7				
	►	&Ru96(n,α)Mo93(β$^+$)Nb93m(n,γ)*Nb94*	2.6		4.1				

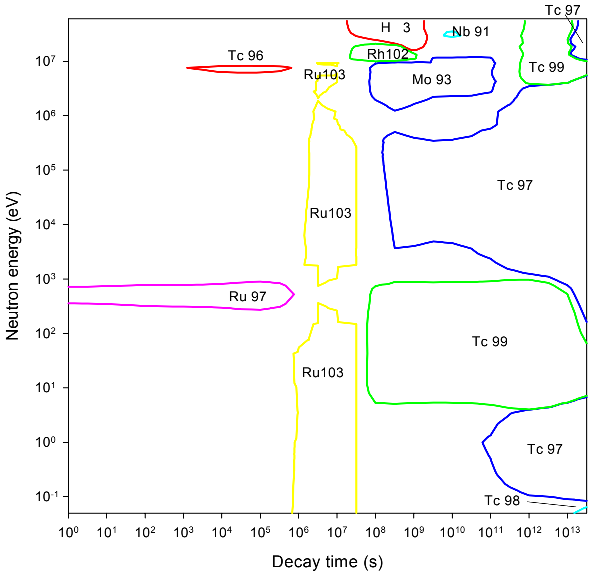
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Ru96(n,2n)Ru95(β$^+$)Tc95(β$^+$)Mo95_ (n,d)*Nb94*				26.7	23.1	8.6	2.6
		&Ru98(n,2n)Ru97(β$^+$)Tc97(n,α)*Nb94*				23.1	0.5		0.1
		&Ru96(n,d)Tc95(β$^+$)Mo95(n,d)*Nb94*				11.8	21.4	7.0	2.2
		&Ru99(n,2n)Ru98(n,2n)Ru97(β$^+$)Tc97_ (n,α)*Nb94*				11.3			
		Ru96(n,2n)Ru95(β$^+$)Tc95(β$^+$)Mo95_ (n,2n)Mo94(n,p)Nb94				5.8	0.2		
		&Ru96(n,d)Tc95(β$^+$)Mo95(n,2n)Mo94_ (n,p)*Nb94*				4.5	0.1		
		&Ru99(n,nα)Mo95(n,d)*Nb94*				0.5	6.1	2.2	0.8
		&Ru99(n,d)Tc98(n,nα)*Nb94*				0.5	5.2	1.7	0.7
		&Ru96(n,t)Tc94(β$^+$)Mo94(n,p)*Nb94*					6.0	5.4	0.7
		&Ru99(n,3n)Ru97(β$^+$)Tc97(n,α)*Nb94*					5.2	1.7	1.0
		&Ru96(n,3n)Ru94(β$^+$)Tc94m(β$^+$)Mo94_ (n,p)*Nb94*					4.1	2.1	0.2
		&Ru99(n,dα)*Nb94*						8.0	6.8
		&Ru100(n,tα)*Nb94*							13.1
		&Ru99(n,2nt)Tc95(β$^+$)Mo95(n,d)*Nb94*							4.8
		Pathways from high mass Ru isotopes	0.9	0.1	1.2	15.8	28.1	63.3	67.0
Tc99	2.1 10^5 y	**&**Ru96(n,γ)Ru97(β$^+$)Tc97(n,γ)Tc98_ (n,γ)*Tc99*	100.0	100.0	99.9				
		&Ru99(n,p)*Tc99*				64.0	18.9	8.9	3.0
		&Ru102(n,α)Mo99(β$^-$)*Tc99*				20.3	6.1	1.8	1.9
		&Ru100(n,2n)Ru99(n,p)*Tc99*				6.6	0.7	0.1	
		&Ru100(n,d)*Tc99*				6.4	40.0	25.6	15.5
		&Ru101(n,t)*Tc99*				0.2	17.9	35.9	23.7
		&Ru102(n,3n)Ru100(n,d)*Tc99*					7.9	2.6	0.7
		&Ru102(n,nt)*Tc99*					0.9	13.1	47.2
		&Ru104(n,2nα)Mo99(β$^-$)*Tc99*					0.3	4.2	2.2
Tc97	2.6 10^6 y	Ru96(n,γ)Ru97(β$^+$)Tc97	100.0	100.0	100.0	0.1			
		Ru98(n,2n)Ru97(β$^+$)Tc97				53.0	7.1	3.5	2.0
		Ru99(n,2n)Ru98(n,2n)Ru97(β$^+$)Tc97				38.7	1.9	0.6	0.2
		Ru99(n,3n)Ru97(β$^+$)Tc97					63.3	37.2	14.5
		&Ru99(n,t)*Tc97*					7.5	16.0	9.5
		Ru101(n,3n)Ru99(n,3n)Ru97(β$^+$)Tc97					5.6	1.6	0.3
		Ru100(n,4n)Ru97(β$^+$)Tc97						20.7	17.3
		&Ru100(n,nt)*Tc97*						2.5	11.9
		&Ru101(n,2nt)*Tc97*						0.1	8.6
		Ru101(n,5n)Ru97(β$^+$)Tc97							20.7
Tc98	4.2 10^6 y	Ru96(n,γ)Ru97(β$^+$)Tc97(n,γ)Tc98	100.0	100.0	100.0				
		Ru99(n,d)Tc98				34.3	63.9	32.3	16.9
		Ru98(n,p)Tc98				24.5	4.1	1.7	
		Ru99(n,2n)Ru98(n,p)Tc98				17.9	1.1	0.3	
		&Ru99(n,p)*Tc99*(n,2n)Tc98				11.8	0.6	0.2	
		&Ru102(n,α)Mo99(β$^-$)*Tc99*(n,2n)Tc98				3.8			
		Ru100(n,2n)Ru99(n,d)Tc98				3.6	2.2	0.7	
		Ru100(n,t)Tc98					11.4	36.8	17.9
		Ru101(n,3n)Ru99(n,d)Tc98					5.6	1.4	
		Ru102(n,3n)Ru100(n,t)Tc98					2.3	3.7	
		Ru101(n,nt)Tc98					1.2	12.1	28.7
		Ru102(n,4n)Ru99(n,d)Tc98						2.9	
		Ru102(n,2nt)Tc98						0.3	27.7

Ruthenium activation characteristics

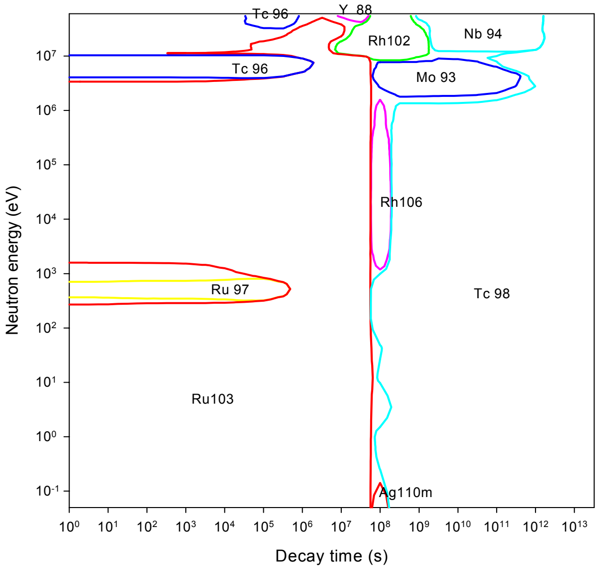


Ruthenium importance diagrams & transmutation

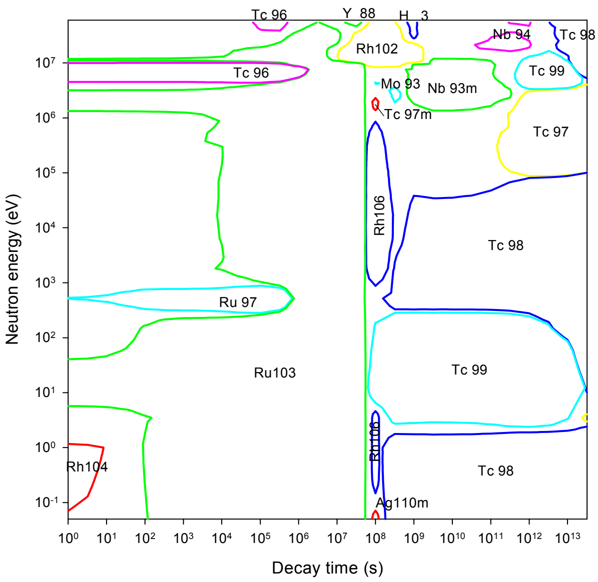
Activity



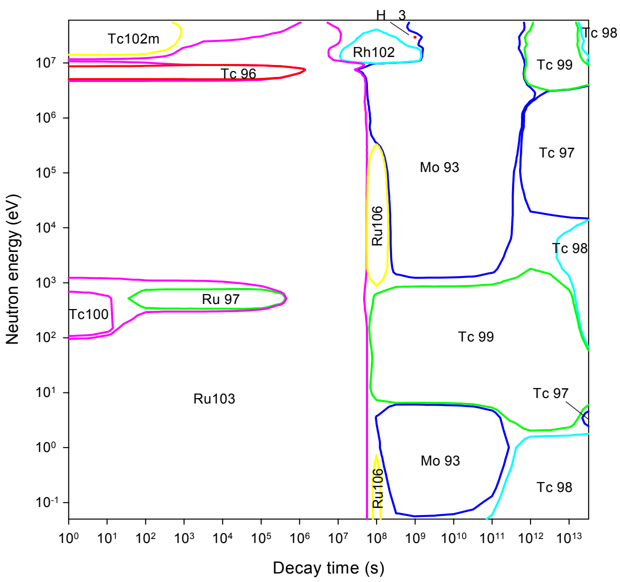
Dose rate



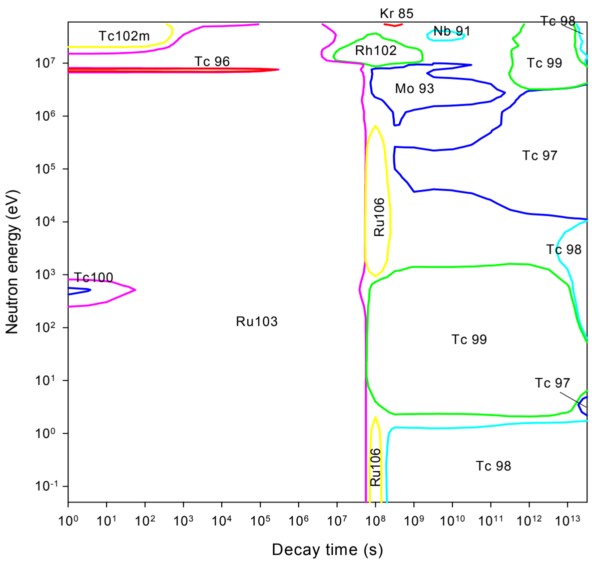
Heat output



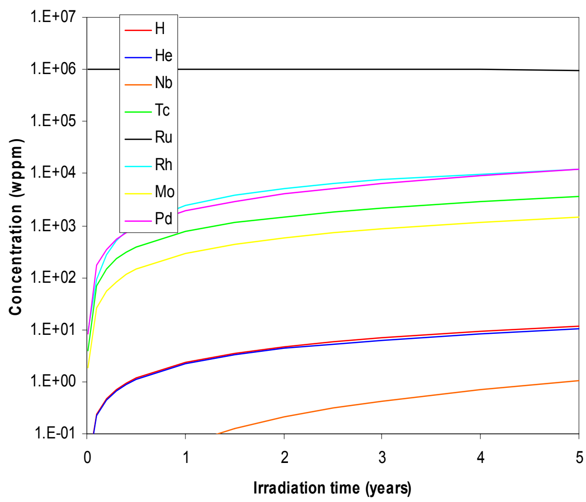
Ingestion dose



Inhalation dose



First wall transmutation



Graphs for H, He curves are indistinguishable

Rhodium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	45		
Crustal abundance / wppm	$1.0\ 10^{-3}$	Rh103	100.0
Melting point / K	2237		
Boiling point / K	3968		
Density / kgm^{-3}	12410		
Thermal conductivity / $Wm^{-1}K^{-1}$	150		
Electrical resistivity /Ωm	$4.51\ 10^{-8}$		
Coefficient of thermal expansion / K^{-1}	$8.20\ 10^{-6}$		
Crystal structure	FCC		
Number of stable isotopes	1		
Mean atomic weight	102.9055		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.43E16	3.05E15	1.15E15	2.17E14	3.58E8	4.93E6	kW kg^{-1}	1.90E0	1.89E-1	9.40E-2	5.97E-2	4.55E-10	6.09E-11
Rh104	78.29	16.37					Rh104	93.65	42.16				
Rh103m	9.73	43.60	32.56	0.01			Rh102	3.51	35.49	71.10	89.07		
Rh104m	6.00	12.14					Rh102m	1.14	11.59	23.00	10.85		
Pd103	2.88	13.50	30.72				Rh104m	0.94	4.13				
Rh102m	1.43	6.72	17.53	27.93			Rh103m	0.43	4.23	2.40			
Rh102	1.37	6.42	16.94	71.62			Ru103	0.10	1.05	1.98			
Ru103	0.15	0.72	1.79	0.01			Pd103	0.07	0.71	1.24			
Rh101		0.03	0.08	0.37			H3					70.55	
H3				0.04	98.11		Tc99					17.68	95.68
Tc99					1.64	86.27	Ag108m					10.82	
Pd107					0.18	13.59	Tc98					0.36	2.68

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	1.47E5	1.22E5	1.19E5	8.31E4	6.84E-5	2.17E-6	Sv kg^{-1}	9.09E5	8.66E5	8.37E5	4.78E5	1.90E-2	2.76E-3
Rh102	66.17	79.86	81.53	92.83			Rh102	56.07	58.82	60.75	84.66		
Rh104	17.57	0.94					Rh102m	27.06	28.38	29.03	15.24		
Rh102m	13.67	16.50	16.68	7.15			Pd103	8.61	9.02	8.05			
Ru103	1.41	1.71	1.64				Ru103	1.77	1.86	1.81			
Rh104m	0.47	0.24					Rh104	1.60	0.07				
Ru105	0.31	0.37					Rh103m	0.58	0.58	0.17			
Ag108m					96.65		H3					77.70	
Tc98					3.22	99.98	Tc99					19.83	98.62

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	5.09E6	5.06E6	4.99E6	3.08E6	1.75E-1	5.60E-2		1.86E12	6.22E11	5.40E11	3.62E11	9.72E3	4.27E3
Rh102	65.40	65.88	66.61	85.87			Rh104	68.15	9.11				
Rh102m	28.56	28.77	28.80	13.99			Rh102	22.36	66.99	77.08	91.54		
Pd103	3.63	3.66	3.19				Rh102m	5.49	16.46	18.75	8.38		
Ru103	1.30	1.31	1.24				Rh104m	2.55	3.30				
Rh104	0.24	0.01					Ru103	1.18	3.55	3.84			
Rh101	0.10	0.10	0.10	0.14			Pd103	0.02	0.06	0.06			
Rh103m	0.07	0.07	0.02				Rh103m		0.02				
H3					52.06		Tc99					60.56	99.76
Tc99					43.59	98.76	H3					36.16	
Ag108m					3.93		Ag108m					3.15	
Tc98					0.17	0.53	Tc98					0.09	0.22

Rhodium

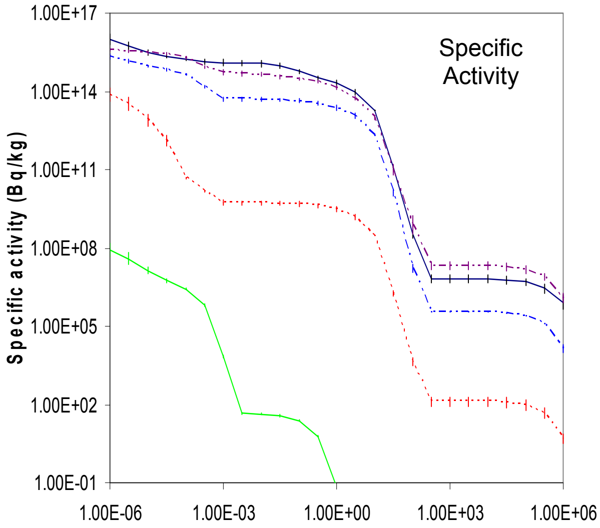
Pathway analysis

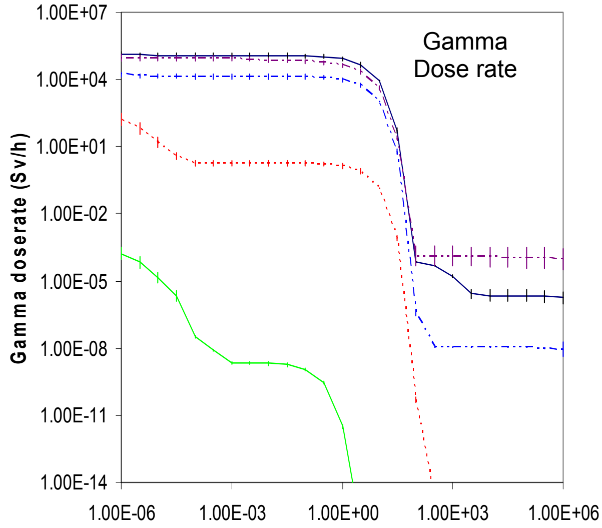
Nuclide	T½	Pathway	210	186	151	42	30	21	6
Rh106	30.0 s	&Rh103(n,γ)*Rh104*(β^+)Ru104(n,γ)_ Ru105(β^-)*Rh105*(n,γ)Rh106	100.0	97.3	90.5	0.2		0.1	0.3
		&Rh103(n,γ)*Rh104*(β^+)Ru104(n,γ)_ Ru105(n,γ)Ru106(β^-)Rh106		2.7	9.5		0.4	0.5	1.1
		&Rh103(n,γ)*Rh104*(β^-)Pd104(n,γ)_ Pd105(n,γ)Pd106(n,p)Rh106				97.5	97.3	97.3	96.8
Rh104	42.3 s	&Rh103(n,γ)*Rh104*	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Rh104m	4.34 m	Rh103(n,γ)Rh104m	100.0	100.0	100.0	99.1	97.4	98.2	98.9
		Rh103(n,γ)Rh104(β^-)Pd104(n,p)Rh104m				0.3	0.4	0.3	0.2
Rh103m	56.114 m	&Rh103(n,γ)*Rh104*(β^-)Pd104(n,γ)Pd105_ (n,α)Ru102(n,γ)Ru103(β^-)Rh103m	94.6	91.5					
		&Rh103(n,γ)*Rh104*(β^-)Pd104(n,α)Ru101_ (n,γ)Ru102(n,γ)Ru103(β^-)Rh103m	5.0	8.4					
		Rh103(n,n′)Rh103m			100.0	90.9	78.8	79.1	82.5
		Rh103(n,p)Ru103(β^-)Rh103m				8.3	20.4	20.3	17.1
Rh106m	2.20 h	&Rh103(n,γ)*Rh104*(β^+)Ru104(n,γ)_ Ru105(β^-)*Rh105*(n,γ)Rh106m	100.0	100.0	100.0	0.9	0.4	0.6	0.9
		&Rh103(n,γ)*Rh104*(β^-)Pd104(n,γ)_ Pd105(n,γ)Pd106(n,p)Rh106m				96.3	97.1	97.1	96.8
		&Rh103(n,γ)*Rh104*(β^-)Pd104(n,γ)_ Pd105(n,p)*Rh105*(n,γ)Rh106m				0.8			
		Rh103(n,γ)Rh104(β^+)Ru104(n,γ)Ru105(β^-)_ Rh105(β^-)Pd105(n,γ)Pd106(n,p)Rh106m				0.1			
Ru105	4.44 h	&Rh103(n,γ)*Rh104*(β^+)Ru104(n,γ)Ru105	100.	100.0	100.0	96.1	97.1	98.0	98.9
		Rh103(n,p)Ru103(n,γ)Ru104(n,γ)Ru105				1.6	1.3	0.9	0.5
Rh100	20.8 h	&Rh103(n,2n)Rh102(n,2n)*Rh101*(n,2n)*Rh100*				75.8			
		&Rh103(n,2n)Rh102m(n,2n)*Rh101*_ (n,2n)*Rh100*				11.8			
		&Rh103(n,2n)Rh102(n,3n)*Rh100*					38.1		
		&Rh103(n,3n)*Rh101*(n,2n)*Rh100*					34.5		
		&Rh103(n,2n)Rh102m(n,3n)*Rh100*					13.5		
		Rh103(n,2n)Rh102m(β^-)Pd102(n,3n)_ Pd100(β^+)Rh100					7.1		
		&Rh103(n,4n)*Rh100*						98.2	100.0
Rh105	1.473 d	&Rh103(n,γ)*Rh104*(β^+)Ru104(n,γ)_ Ru105(β^-)*Rh105*	100.0	100.0	97.9	55.5	76.1	81.1	89.1
		&Rh103(n,γ)*Rh104*(β^-)Pd104(n,γ)_ Pd105(n,p)*Rh105*				41.4	21.2	17.3	10.5
		&Rh103(n,p)Ru103(n,γ)Ru104(n,γ)_ Ru105(β^-)*Rh105*				1.0	1.1	0.8	0.4
Rh101m	4.34 d	&Rh103(n,2n)*Rh102*(n,2n)Rh101m				69.6	0.9		
		Rh103(n,2n)Rh102m(n,2n)Rh101m				15.2	0.3		
		Rh103(n,2n)Rh102m(β^-)Pd102(n,2n)_ Pd101(β^+)Rh101m				12.0			
		Rh103(n,3n)Rh101m					97.1	98.1	98.5
Ru103	39.26 d	&Rh103(n,γ)*Rh104*(β^-)Pd104(n,γ)_ Pd105(n,α)Ru102(n,γ)Ru103	94.6	91.5	85.5				
		&Rh103(n,γ)*Rh104*(β^-)Pd104(n,α)_ Ru101(n,γ)Ru102(n,γ)Ru103	5.0	8.5	14.2				
		Rh103(n,p)Ru103				98.5	98.9	99.1	99.2
Ag110m	249.78 d	&Rh103(n,γ)*Rh104*(β^-)Pd104(n,γ)_ Pd105(n,γ)Pd106(n,γ)*Pd107*(n,γ)Pd108_ (n,γ)*Pd109*(β^-)*Ag109*(n,γ)Ag110m	98.9	99.8	99.5				
Ru106	1.02 y ►	&Rh103(n,γ)*Rh104*(β^+)Ru104(n,γ)_ Ru105(n,γ)Ru106	100.0	100.0	100.0	97.9	97.3	98.1	99.0

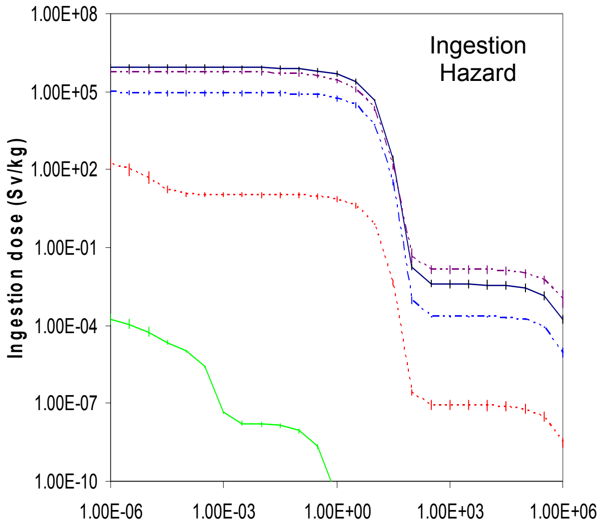
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Rh103(n,p)Ru103(n,γ)Ru104(n,γ)_ Ru105(n,γ)Ru106				1.6	1.3	0.9	0.5
Rh102	2.902 y	**&**Rh103(n,2n)*Rh102*				99.6	99.6	99.8	94.0
Rh101	3.30 y	**&**Rh103(n,2n)*Rh102*(n,2n)*Rh101*				84.5	0.4		
		&Rh103(n,2n)Rh102m(n,2n)*Rh101*				12.4	0.1		
		&Rh103(n,3n)*Rh101*					98.8	99.2	99.3
H3	12.33 y	Rh103(n,X)H3				82.4	92.1	91.6	91.0
		&Rh103(n,2n)*Rh102*(n,X)H3				14.8	1.2	0.6	
		Rh103(n,2n)Rh102m(n,X)H3				2.3	0.5		
		Rh103(n,3n)Rh101m(β^+)Ru101(n,X)H3					2.9	2.1	1.0
		Rh103(n,5n)Rh99m(β^+)Ru99(n,X)H3							1.1
Ag108m	418.0 y	**&**Rh103(n,γ)*Rh104*(β^-)Pd104(n,γ)_ Pd105(n,γ)Pd106(n,γ)*Pd107*(β^-)Ag107_ (n,γ)Ag108m	98.9	99.9	99.6				
Mo93	4000 y	**&**Rh103(n,α)Tc100(β^-)Ru100(n,2n)_ Ru99(n,2n)Ru98(n,nα)Mo94(n,2n)*Mo93*				18.7			
		&Rh103(n,α)Tc100(β^-)Ru100(n,2n)Ru99_ (n,nα)Mo95(n,2n)Mo94(n,2n)*Mo93*				13.6			
		&Rh103(n,2n)Rh102m(β^-)Pd102(n,nα)_ Ru98(n,nα)Mo94(n,2n)*Mo93*				10.7			
		&Rh103(n,nα)*Tc99*(n,nα)Nb95(β^-)_ Mo95(n,2n)Mo94(n,2n)Mo93				9.8			
		Rh103(n,3n)Rh101m(β^+)Ru101(n,3n)_ Ru99(n,nα)Mo95(n,3n)Mo93					12.6		
		&Rh103(n,nα)*Tc99*(n,nα)Nb95(β^-)_ Mo95(n,3n)*Mo93*					9.1		
		Rh103(n,3n)Rh101m(β^+)Ru101(n,nα)_ Mo97(n,3n)Mo95(n,3n)Mo93					8.9		
		Rh103(n,nα)Tc99(n,3n)Tc97(n,3n)_ Tc95(β^+)Mo95(n,3n)Mo93					7.0		
		&Rh103(n,3n)Rh101m(β^+)Ru101(n,4n)_ Ru98(n,2nα)*Mo93*					0.1	11.0	0.1
		&Rh103(n,4n)Rh100(β^+)*Ru100*(n,3n)_ Ru98(n,2nα)*Mo93*						13.0	
		&Rh103(n,4n)Rh100(β^+)*Ru100*(n,2nα)_ Mo95(n,3n)*Mo93*						6.5	
		&Rh103(n,2nt)Ru99(n,3nα)*Mo93*						0.1	10.0
		&Rh103(n,5n)Rh99m(β^+)Ru99(n,3nα)*Mo93*							18.5
		&Rh103(n,3nα)Tc97(n,2nt)*Mo93*							9.1
		&Rh103(n,4nα)*Tc96*(β^+)Mo96(n,4n)*Mo93*							7.8
		&Rh103(n,3nα)Tc97(n,5n)*Tc93*(β^+)Mo93							7.2
		&Rh103(n,4n)Rh100(β^+)*Ru100*(n,4nα)*Mo93*							7.1
		Other pathways involving (n,2n), (n,α), β^+				65.9	62.3	69.4	40.2
Nb94	2.0 10^4 y	**&**Rh103(n,2n)*Rh102*(n,nα)Tc98(n,nα)*Nb94*				27.5	2.2		
		&Rh103(n,nα)*Tc99*(n,2n)Tc98(n,nα)*Nb94*				21.5	5.1	0.1	
		&Rh103(n,2n)Rh102m(n,nα)Tc98(n,nα)*Nb94*				8.4	1.3		
		&Rh103(n,2n)Rh102(n,α)*Tc99*(n,2n)_ Tc98(n,nα)*Nb94*				6.8			
		&Rh103(n,2n)Rh102(n,nα)Tc98(n,2n)_ *Tc97*(n,α)*Nb94*				6.5			
		&Rh103(n,nα)*Tc99*(n,2nα)*Nb94*					36.7	22.6	2.5
		&Rh103(n,2nα)Tc98(n,nα)*Nb94*					27.9	26.4	3.0
		&Rh103(n,3nα)Tc97(n,α)*Nb94*						0.7	4.3
		&Rh103(n,2n2α)*Nb94*							31.7
		&Rh103(n,4nα)*Tc96*(β^+)Mo96(n,t)*Nb94*							16.4
		&Rh103(n,4n)*Rh100*(β^+)Ru100(n,tα)*Nb94*							6.5
Tc99	2.1 10^5 y	**&**Rh103(n,γ)*Rh104*(β^-)Pd104(n,α)_ Ru101(n,α)Mo98(n,γ)Mo99(β^-)*Tc99*	97.2	100.0	99.8				
		&Rh103(n,α)Tc100(β^-)Ru100(n,γ)_ Ru101(n,α)Mo98(n,γ)Mo99(β^-)*Tc99*	2.8		0.2				
	►	**&**Rh103(n,nα)*Tc99*				50.2	89.6	64.7	53.9

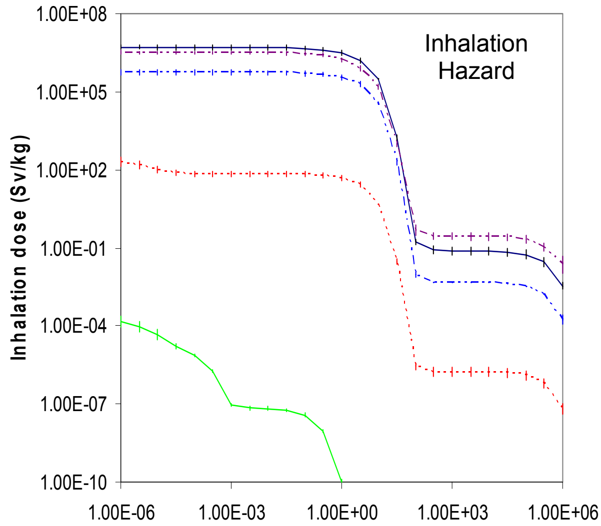
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	&Rh103(n,2n)Rh102(n,α)*Tc99*				28.8	0.1		0.1
		&Rh103(n,2n)Rh102m(n,α)*Tc99*				6.8			
		&Rh103(n,2n)Rh102m(β^+)Ru102(n,α)_ Mo99(β^-)*Tc99*				6.6	0.2		
		&Rh103(n,2n)Rh102(β^+)Ru102(n,α)_ Mo99(β^-)*Tc99*				6.0			
		&Rh103(n,3n)Rh101m(β^+)Ru101(n,t)*Tc99*					5.6	12.6	6.5
		&Rh103(n,t)Ru101(n,t)*Tc99*					0.4	4.1	4.2
		&Rh103(n,4n)*Rh100*(β^+)Ru100(n,d)*Tc99*						10.4	9.1
		&Rh103(n,nt)Ru100(n,d)*Tc99*						1.4	5.0
		&Rh103(n,d)Ru102(n,nt)*Tc99*						0.6	4.0
		&Rh103(n,2n)Rh102m(β^+)Ru102(n,nt)*Tc99*							2.0
Tc97	2.6 10^6 y	&Rh103(n,2n)Rh102(n,nα)Tc98(n,2n)*Tc97*				26.1	0.1		
		&Rh103(n,nα)Tc99(n,2n)Tc98(n,2n)*Tc97*				17.2	0.3		
		&Rh103(n,2n)Rh102(n,2n)*Rh101*(n,nα)*Tc97*				10.5			
		Rh103(n,α)Tc100(β^-)Ru100(n,2n)Ru99_ (n,2n)Ru98(n,2n)Ru97(β^+)Tc97				8.5			
		&Rh103(n,2n)Rh102m(n,nα)Tc98(n,2n)*Tc97*				8.1			
		&Rh103(n,2n)Rh102(n,α)*Tc99*(n,2n)_ Tc98(n,2n)*Tc97*				6.5			
		&Rh103(n,nα)Tc99(n,3n)*Tc97*					33.4	3.3	0.3
		Rh103(n,3n)Rh101m(β^+)Ru101(n,3n)_ Ru99(n,3n)Ru97(β^+)Tc97					25.1		
		&Rh103(n,3n)*Rh101*(n,nα)*Tc97*					10.5	0.6	
		&Rh103(n,3nα)*Tc97*						20.6	52.9
		Rh103(n,4n)Rh100(β^+)Ru100(n,4n)_ Ru97(β^+)Tc97						14.9	2.8
		Rh103(n,nt)Ru100(n,4n)Ru97(β^+)Tc97						5.5	4.1
		&Rh103(n,4n)*Rh100*(β^+)Ru100(n,nt)*Tc97*						4.2	4.8
		Rh103(n,5n)Rh99m(β^+)Ru99(n,3n)_ Ru97(β^+)Tc97							4.2
Tc98	4.2 10^6 y	&Rh103(n,2n)*Rh102*(n,nα)Tc98				35.0	6.8		0.2
		&Rh103(n,nα)*Tc99*(n,2n)Tc98				29.2	16.2	0.8	0.7
		&Rh103(n,2n)*Rh102*(n,α)*Tc99*(n,2n)Tc98				12.2			
		Rh103(n,2n)Rh102m(n,nα)Tc98				8.9	3.1		0.1
		&Rh103(n,2n)Rh102(n,2n)*Rh101*(n,α)Tc98				4.7			
		&Rh103(n,2n)Rh102m(n,α)*Tc99*(n,2n)Tc98				3.4			
		Rh103(n,2nα)Tc98					58.8	81.1	63.5
		Rh103(n,3n)Rh101m(β^+)Ru101(n,3n)_ Ru99(n,d)Tc98					4.6		
		Rh103(n,3n)Rh101m(β^+)Ru101(n,nt)Tc98					1.4	2.5	5.8
		Rh103(n,t)Ru101(n,nt)Tc98					0.1	0.8	3.8
		&Rh103(n,4n)*Rh100*(β^+)Ru100(n,t)Tc98						9.9	7.7
		Rh103(n,nt)Ru100(n,t)Tc98						1.4	4.3
		Rh103(n,5n)Rh99m(β^+)Ru99(n,d)Tc98							4.9
Pd107	6.5 10^6 y	&Rh103(n,γ)*Rh104*(β^-)Pd104(n,γ)_ Pd105(n,γ)Pd106(n,γ)*Pd107*	99.1	99.9	99.6	99.2	97.8	98.2	98.4
		Rh103(n,γ)Rh104(β^+)Ru104(n,γ)Ru105(β^-)_ Rh105(β^-)Pd105(n,γ)Pd106(n,γ)Pd107					0.2	0.2	0.2

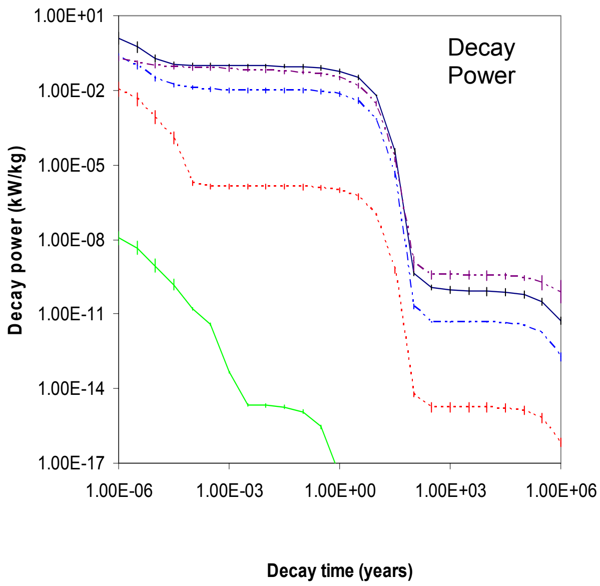
Rhodium activation characteristics

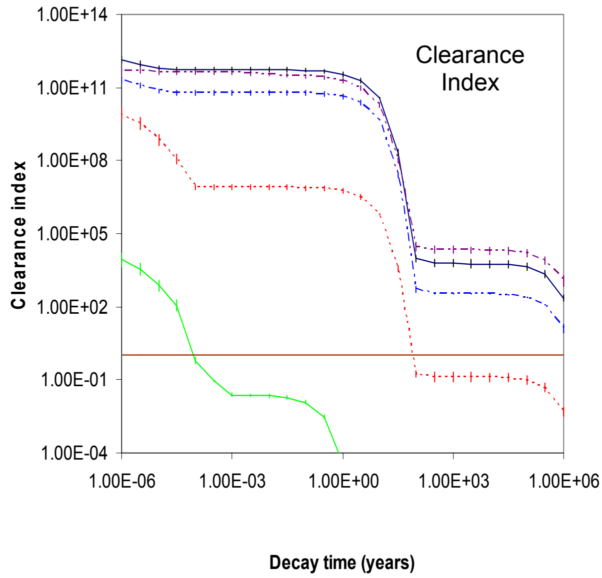






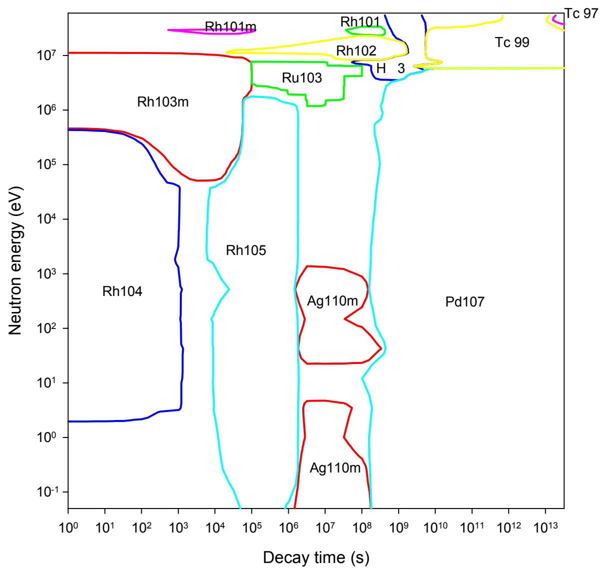




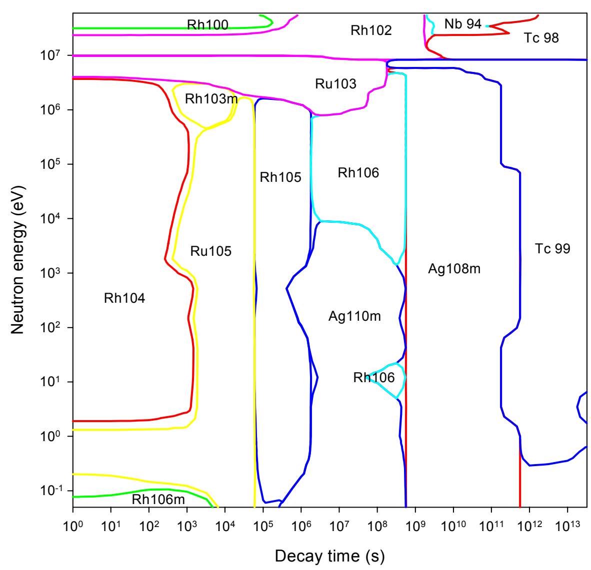


Rhodium importance diagrams & transmutation

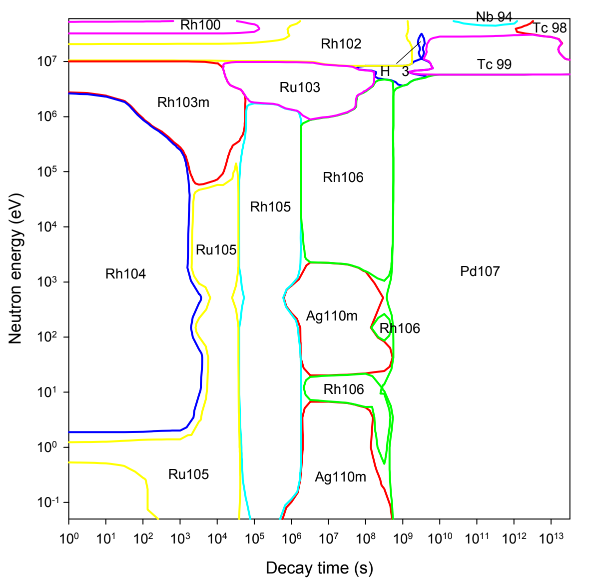
Activity



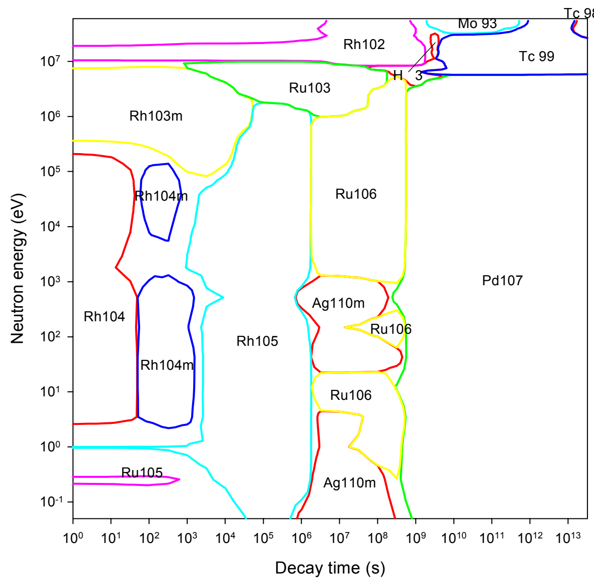
Dose rate



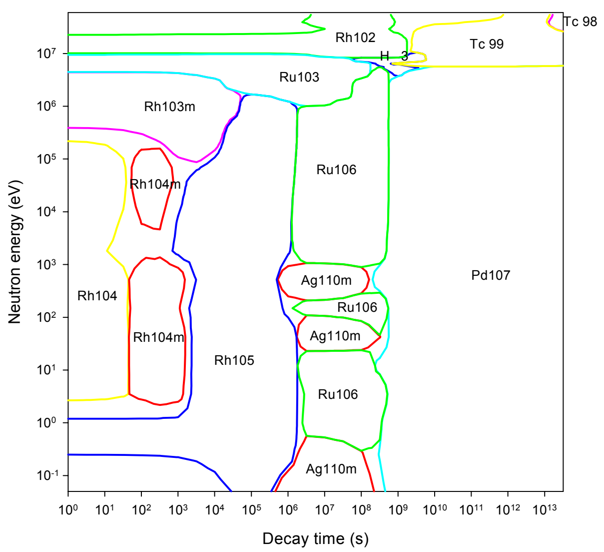
Heat output



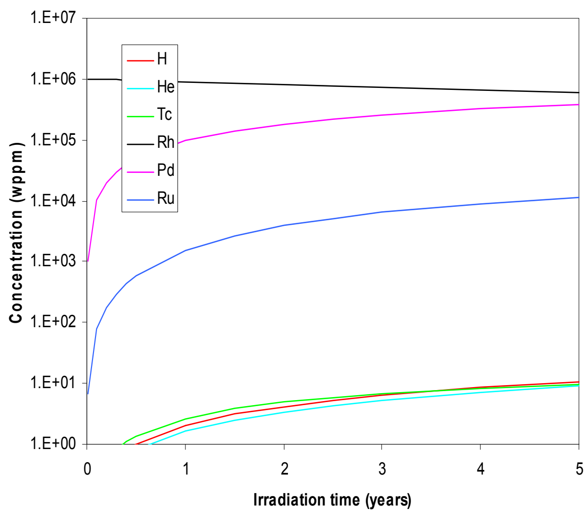
Ingestion dose



Inhalation dose



First wall transmutation



Palladium

General properties

Property	Value	Isotopes	Isotopic abundances / %
Atomic number	46	Pd102	1.02
Crustal abundance / wppm	$1.5\ 10^{-2}$	Pd104	11.14
Melting point / K	1828	Pd105	22.33
Boiling point / K	3236	Pd106	27.33
Density / kgm^{-3}	12020	Pd108	26.46
Thermal conductivity / $Wm^{-1}K^{-1}$	71.8	Pd110	11.72 ($T_{½}$ = $6.00\ 10^{17}$ y)
Electrical resistivity /Ωm	$1.08\ 10^{-7}$		
Coefficient of thermal expansion / K^{-1}	$1.18\ 10^{-5}$		
Crystal structure	FCC		
Number of stable isotopes	5 (6)		
Mean atomic weight	106.42		

Activation properties

Act	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Bq kg^{-1}	1.22E16	7.96E15	6.40E14	8.29E13	8.32E10	2.96E8
Ag110	31.77	0.02	0.22	0.63		
Ag109m	29.79	44.81	12.22	25.35		
Pd109	28.95	44.33	6.57			
Ag111	1.34	2.07	18.44			
Rh103m	1.22	1.88	19.56			
Pd103	1.17	1.80	19.32			
Ag111m	1.00	0.93				
Pd109m	0.98	0.69				
Ag110m	0.97	1.34	16.55	46.84		
Cd109	0.29	0.45	5.64	25.35		
Ag108	0.25	0.08			7.95	
Rh101	0.05		0.05	0.31		
Rh102m			0.20	0.46		
Rh102			0.14	0.88		
Ag108m			0.01	0.10	91.44	
Pd107					0.35	100.0

Heat	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
kW kg^{-1}	1.11E0	3.33E-1	6.12E-2	1.84E-2	2.07E-5	4.42E-10
Ag110	68.06	0.11	0.45	0.55		
Pd109	18.49	61.42	3.97			
Ag109m	4.57	14.94	1.78	1.58		
Ag110m	4.37	14.60	78.60	95.68		
Pd111	0.99	2.90				
Rh104	0.90	0.17				
Ag111	0.89	3.00	11.66			
Pd109m	0.32	0.49				
Ag108	0.28	0.20			2.31	
Rh103m	0.08	0.27	1.22			
Pd103	0.04	0.14	0.66			
Rh102		0.09	0.51	1.35		
Rh102m			0.22	0.22		
Ag108m			0.08	0.12	96.76	
Rh101			0.02	0.07		
Pd107						99.95

Dose	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv h^{-1}	1.23E5	8.40E4	7.78E4	2.85E4	2.71E1	4.75E-8
Ag110m	67.34	91.90	98.25	98.44		
Ag110	24.80*		0.01*	0.01*		
Rh106m	1.43	1.90				
Pd107m	0.85					
Pd111	0.78	0.93				
Pd111m	0.76	1.03				
Ag111	0.48	0.65	0.50			
Rh102	0.40	0.54	0.58	1.28		
Pd101	0.39	0.53				
Rh102m		0.15	0.16	1.33		
Ag108m		0.03	0.04	0.11	99.89	
Tc98						99.59

Ing	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	2.59E6	2.58E6	5.77E5	1.54E5	1.79E2	1.10E-2
Pd109	75.20	75.25				
Ag110m	11.55	11.61	51.44	70.58		
Ag111	8.27	8.31	0.50			
Cd109	2.80	2.81		27.28		
Pd103	1.05	1.05	0.01			
Rh102	0.09	0.09	0.58	1.23		
Rh102m	0.06	0.06	0.16	0.30		
Cd113m	0.02	0.02		0.36	2.40	
Ag108m			0.04	0.13	97.59	
Rh101				0.09		
Pd107						99.91
Tc99						0.08

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	3.30E6	3.29E6	1.87E6	6.59E5	2.83E3	1.75E-1
Pd109	39.82	39.76	0.83			
Ag110m	38.97	39.08	67.84	70.73		
Cd109	8.93	8.95	15.62	25.84		
Ag111	8.52	8.54	10.70			
Pd103	1.96	1.96	2.96			
Rh102	0.47	0.47	0.83	1.89		
Rh102m	0.28	0.28	0.48	0.41		
Ru103	0.12	0.12	0.21			
Ag108m	0.10	0.10	0.17	0.50	99.27	
Cd113m	0.08	0.08	0.15	0.40	0.72	
Rh101	0.05	0.05	0.09	0.21		
Pd107						99.89
Tc99						0.10

Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
	1.87E12	1.25E12	1.10E12	4.12E11	1.25E8	2.84E2
Ag110m	57.20	85.39	95.91	94.30		
Ag110	31.05			0.01		
Ag109m	3.68	5.37	0.13	0.09		
Pd109	1.89	2.81				
Pd109m	0.76	0.52				
Pd107m	0.68					
Pd111	0.54	0.71				
Rh106m	0.35	0.51				
Pd111m	0.26	0.38				
Rh102	0.10	0.15	0.17	0.37		
Ag111	0.08	0.13	0.10			
Ag108m			0.01	0.03	99.56	
Pd107						94.93

Palladium

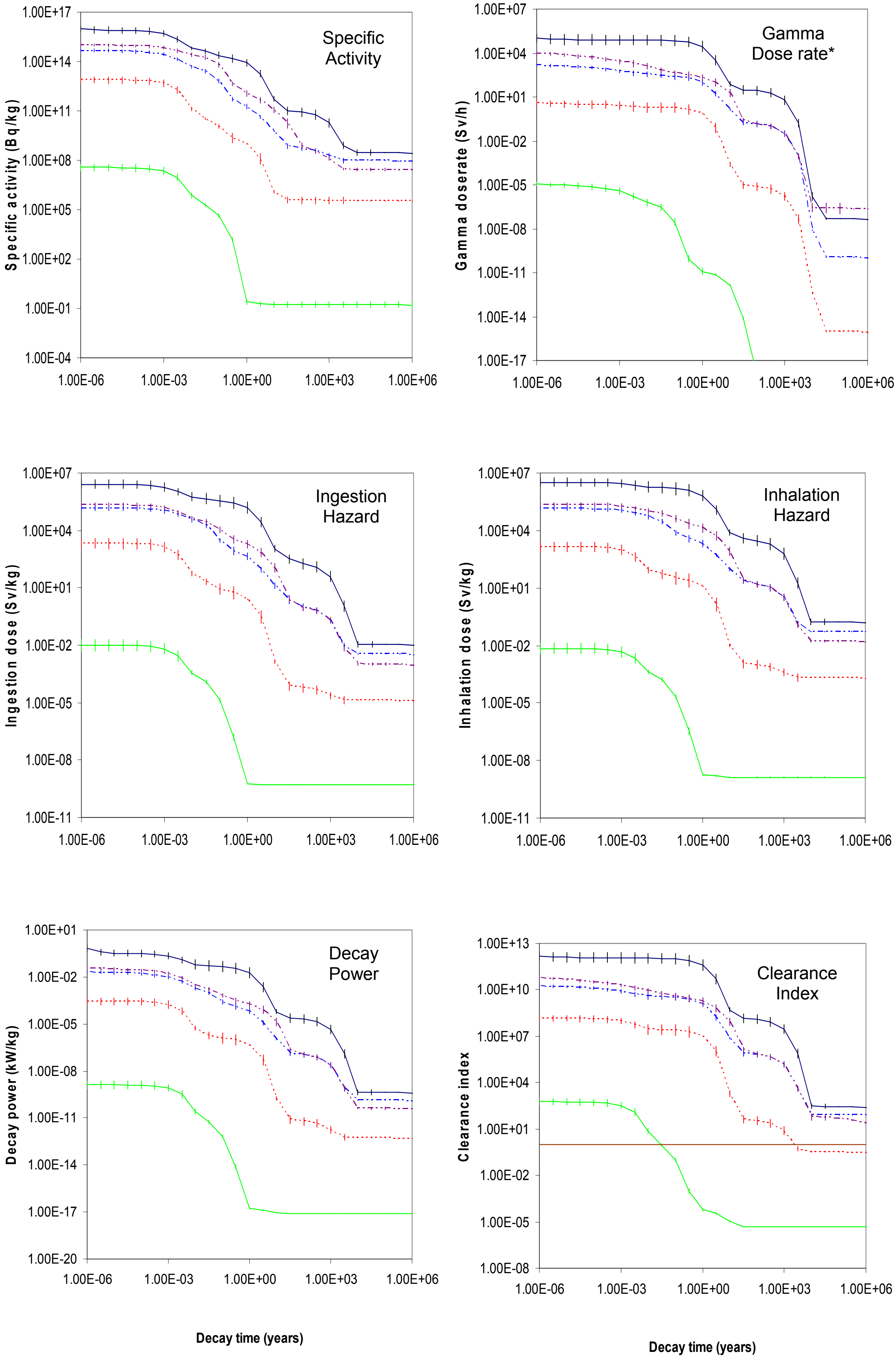
Pathway analysis

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Ag110	24.56 s	&Pd108(n,γ)*Pd109*(β^-)*Ag109*(n,γ)*Ag110*	99.9	99.8	99.8				
		&Pd110(n,2n)*Pd109*(β^-)*Ag109*(n,γ)*Ag110*				98.6	76.5	61.9	47.4
		&Pd110(n,γ)*Pd111*(β^-)*Ag111*(n,2n)*Ag110*				0.5	0.3	0.3	0.3
		&Pd110(n,γ)*Pd111*(β^-)*Ag111*(β^-)_ Cd111(n,d)*Ag110*					7.7	16.9	27.1
		&Pd110(n,d)Rh109(β^-)Pd109(β^-)_ Ag109(n,γ)*Ag110*					7.2	14.0	16.1
		&Pd110(n,γ)Pd111m(β^-)*Ag111*(β^-)_ Cd111(n,d)Ag110					1.8	2.8	4.2
Pd111m	5.50 h	Pd110(n,γ)Pd111m	99.8	100.0	100.0	99.9	99.5	99.6	99.8
Pd109	13.701 h	&Pd108(n,γ)*Pd109*	100.0	99.9	99.7				
		Pd106(n,γ)Pd107(n,γ)Pd108(n,γ)Pd109			0.3				
		&Pd110(n,2n)*Pd109*				100.0	90.9	81.2	74.3
		Pd110(n,d)Rh109(β^-)Pd109					9.1	18.8	25.7
Rh100	20.8 h	&Pd102(n,2n)Pd101(β^+)Rh101m(IT)_ Rh101(n,2n)*Rh100*				52.5			
		&Pd102(n,d)*Rh101*(n,2n)*Rh100*				16.8			
		Pd104(n,2n)Pd103(β^+)Rh103m(IT)Rh103_ (n,2n)Rh102(n,2n)Rh101(n,2n)Rh100				4.5			
		&Pd102(n,2n)Pd101(β^+)Rh101m(n,2n)*Rh100*				3.6			
		Pd104(n,3n)Pd102(n,3n)Pd100(β^+)Rh100					36.3	8.5	1.1
		Pd102(n,3n)Pd100(β^+)Rh100					30.2	9.6	3.3
		&Pd104(n,3n)Pd102(n,t)*Rh100*					6.6	7.4	1.2
		Pd106(n,3n)Pd104(n,3n)Pd102(n,3n)_ Pd100(β^+)Rh100					6.5	1.1	
		&Pd102(n,t)*Rh100*					5.6	8.0	3.4
		&Pd105(n,3n)Pd103(β^+)Rh103m(IT)_ Rh103(n,4n)*Rh100*						11.7	3.2
		Pd105(n,4n)Pd102(n,3n)Pd100(β^+)Rh100						10.2	2.6
		&Pd106(n,4n)Pd103(β^+)Rh103m(IT)_ Rh103(n,4n)*Rh100*						9.6	5.4
		&Pd105(n,4n)Pd102(n,t)*Rh100*						9.0	2.7
		&Pd104(n,2n)Pd103(β^+)Rh103m(IT)_ Rh103(n,4n)*Rh100*						3.5	1.4
		Pd104(n,5n)Pd100(β^+)Rh100							23.5
		&Pd104(n,2nt)*Rh100*							17.8
Ag111	7.45 d	&Pd108(n,γ)*Pd109*(β^-)*Ag109*(n,γ)_ Ag110m(n,γ)*Ag111*	55.0						
		&Pd110(n,γ)*Pd111*(β^-)*Ag111*	43.2	95.8	95.9	88.4	88.0	86.9	87.7
		&Pd110(n,γ)Pd111m(β^-)*Ag111*	1.8	4.0	4.0	11.6	12.0	12.2	11.8
Pd103	16.98 d	Pd102(n,γ)Pd103	99.8	100.0	100.0				
		Pd104(n,2n)Pd103				65.3	18.9	12.0	11.9
		Pd105(n,2n)Pd104(n,2n)Pd103				29.9	2.9	1.1	0.7
		Pd106(n,2n)Pd105(n,2n)Pd104(n,2n)Pd103				4.0	0.1		
		Pd105(n,3n)Pd103					61.8	39.6	26.5
		Pd106(n,3n)Pd104(n,2n)Pd103					6.5	2.8	1.1
		Pd106(n,2n)Pd105(n,3n)Pd103					5.7	2.1	0.9
		Pd106(n,4n)Pd103						32.4	45.0
		Pd108(n,4n)Pd105(n,3n)Pd103						3.9	1.3
		Pd108(n,3n)Pd106(n,4n)Pd103						2.4	1.4
		Pd108(n,6n)Pd103							2.3
		Pd108(n,5n)Pd104(n,2n)Pd103							1.6
Ag110m	249.78 d	&Pd108(n,γ)*Pd109*(β^-)*Ag109*(n,γ)Ag110m	99.9	99.9	99.9				
		&Pd110(n,2n)*Pd109*(β^-)*Ag109*(n,γ)Ag110m				98.6	69.0	50.4	35.2
	►	&Pd110(n,γ)*Pd111*(β^-)*Ag111*(β^-)_ Cd111(n,d)Ag110m					19.0	31.2	44.6

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Pd110(n,d)Rh109(β^-)Pd109(β^-)_ Ag109m(IT)Ag109(n,γ)Ag110m					6.6	11.5	12.0
		&Pd110(n,γ)Pd111m(β^-)*Ag111*(β^-)_ Cd111(n,d)Ag110m					2.7	4.4	6.0
Rh102	2.902 y	&Pd104(n,2n)Pd103(β^+)*Rh103*(n,2n)*Rh102*				79.5	12.1	1.8	0.4
		&Pd105(n,2n)Pd104(n,2n)Pd103(β^+)_ *Rh103*(n,2n)*Rh102*				12.8	0.6		
		&Pd102(n,p)*Rh102*				4.2	3.8	1.1	0.3
		&Pd104(n,d)*Rh103*(n,2n)*Rh102*				0.7	3.2	0.8	0.2
		&Pd105(n,3n)Pd103(β^+)Rh103m(IT)_ Rh103(n,2n)*Rh102*					39.6	6.1	0.8
		&Pd104(n,t)*Rh102*					20.6	47.7	19.4
		&Pd106(n,3n)Pd104(n,t)*Rh102*					4.2	6.6	1.0
		&Pd105(n,nt)*Rh102*					1.5	17.8	45.9
		&Pd106(n,4n)Pd103(β^+)Rh103m(IT)_ Rh103(n,2n)*Rh102*						5.0	1.4
		&Pd106(n,2nt)*Rh102*						0.1	20.3
H3	12.33 y	Pd104(n,γ)Pd105(n,X)H1(n,γ)H2(n,γ)H3	92.8	94.9					
		Pd105(n,X)H3				59.0	32.1	26.0	23.6
		Pd104(n,2n)Pd103(β^+)Rh103m(IT)_ Rh103(n,X)H3				13.5	0.9	0.3	0.2
		Pd106(n,2n)Pd105(n,X)H3				8.2	1.5	0.7	0.4
		&Pd108(n,2n)*Pd107*(n,X)H3				6.6	1.1	0.6	0.3
		&Pd110(n,2n)*Pd109*(β^-)*Ag109*(n,X)H3				4.6	0.7	0.4	0.1
		Pd104(n,X)H3				0.3	8.4	9.2	9.5
		Pd106(n,X)H3				0.2	18.9	21.5	23.0
		Pd108(n,X)H3				0.1	17.3	20.3	22.0
		Pd110(n,X)H3					7.2	8.7	9.5
		Pd105(n,3n)Pd103(β^+)Rh103m(IT)_ Rh103(n,X)H3					3.0	1.1	0.4
Cd113m	14.1 y	&Pd108(n,γ)*Pd109*(β^-)*Ag109*(n,γ)_ Ag110(β^-)Cd110(n,γ)*Cd111*(n,γ)Cd112_ (n,γ)Cd113m	78.8	24.9					
		&Pd110(n,γ)*Pd111*(β^-)*Ag111*(β^-)_ Cd111(n,γ)Cd112(n,γ)Cd113m	10.0	68.3	93.6	84.4	83.6	83.9	84.7
		&Pd108(n,γ)*Pd109*(β^-)*Ag109*(n,γ)_ Ag110m(n,γ)*Ag111*(β^-)Cd111(n,γ)_ Cd112(n,γ)Cd113m	4.3						
		&Pd108(n,γ)*Pd109*(β^-)*Ag109*(n,γ)_ Ag110m(β^-)Cd110(n,γ)*Cd111*(n,γ)_ Cd112(n,γ)Cd113m	1.4	0.6					
		&Pd110(n,γ)Pd111m(β^-)*Ag111*(β^-)_ Cd111(n,γ)Cd112(n,γ)Cd113m	0.3	2.9	2.8	8.2	11.8	11.8	11.4
		&Pd110(n,γ)*Pd111*(β^-)*Ag111*(n,γ)_ Ag112(β^-)Cd112(n,γ)Cd113m		1.1	1.1	2.2	1.1	1.1	1.1
Ag108m	418.0 y	&Pd106(n,γ)*Pd107*(β^-)Ag107(n,γ)Ag108m	82.7	65.9	96.6				
		&Pd105(n,γ)Pd106(n,γ)*Pd107*(β^-)_ Ag107(n,γ)Ag108m	17.3	33.9	3.5				
		&Pd110(n,2n)*Pd109*(β^-)*Ag109*(n,2n)Ag108m				99.7	90.9	81.1	74.3
		Pd110(n,d)Rh109(β^-)Pd109(β^-)_ Ag109m(IT)Ag109(n,2n)Ag108m					8.6	18.5	25.3
Mo93	4000 y	&Pd102(n,nα)Ru98(n,nα)Mo94(n,2n)*Mo93*				54.4	1.3		
		&Pd102(n,α)Ru99(n,2n)Ru98(n,nα)_ Mo94(n,2n)*Mo93*				13.2			
		&Pd102(n,nα)Ru98(n,α)Mo95(n,2n)_ Mo94(n,2n)*Mo93*				10.4			
		&Pd102(n,α)Ru99(n,nα)Mo95(n,2n)_ Mo94(n,2n)*Mo93*				9.6			
		&Pd102(n,nα)Ru98(n,2nα)*Mo93*					14.8	3.5	0.5
		&Pd104(n,3n)Pd102(n,nα)Ru98(n,2nα)*Mo93*					6.4	1.2	
		&Pd104(n,2nα)Ru99(n,3nα)*Mo93*						5.2	1.8
	►	&Pd105(n,3nα)Ru99(n,3nα)*Mo93*						0.8	6.7

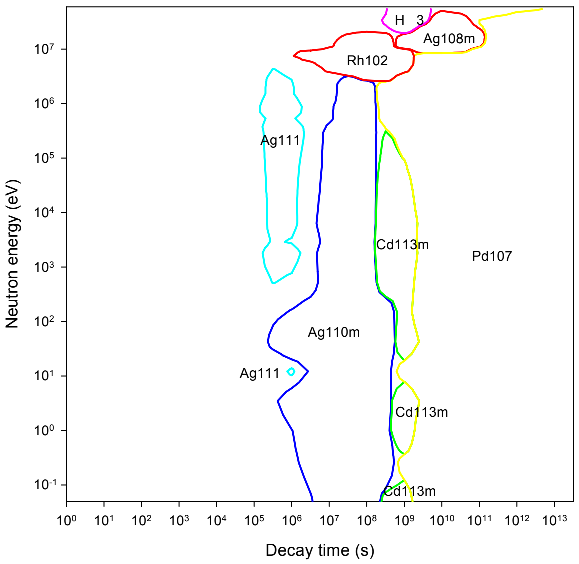
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Other pathways involving (n,2n), (n,α), β^+				12.4	77.5	89.3	91.0
Nb94	2.0 10^4 y	**&**Pd102(n,nα)Ru98(n,2n)Ru97(β^+)_ Tc97(n,α)*Nb94*				56.1	0.7		
		&Pd102(n,α)Ru99(n,2n)Ru98(n,2n)_ Ru97(β^+)Tc97(n,α)*Nb94*				13.8			
		Pd105(n,3n)Pd103(β^+)Rh103m(IT)_ Rh103(n,2nα)Tc98(n,nα)Nb94					5.4	1.8	
		Pd105(n,3n)Pd103(β^+)Rh103m(IT)_ Rh103(n,nα)Tc99(n,2nα)Nb94					5.3	1.2	
		&Pd102(n,2nα)Ru97(β^+)Tc97(n,α)*Nb94*					3.1	2.2	0.4
		&Pd104(n,5n)Pd100(β^+)Rh100(β^+)_ Ru100(n,tα)*Nb94*							3.7
		Other pathways involving (n,2n), (n,α), β^+				30.1	85.5	93.8	95.9
Tc99	2.1 10^5 y	**&**Pd102(n,α)Ru99(n,α)Mo96(n,γ)_ Mo97(n,γ)Mo98(n,γ)Mo99(β^-)*Tc99*	91.8	96.5	81.0				
		&Pd104(n,α)Ru101(n,α)Mo98(n,γ)_ Mo99(β^-)*Tc99*	0.2	2.6	18.1				
		&Pd104(n,2n)Pd103(β^+)*Rh103*(n,nα)*Tc99*				45.0	13.9	3.2	0.8
		&Pd104(n,2n)Pd103(β^+)Rh103m(IT)_ Rh103(n,2n)*Rh102*(n,α)*Tc99*				18.2			
		&Pd105(n,2n)Pd104(n,2n)Pd103(β^+)_ *Rh103*(n,nα)*Tc99*				6.7	0.6		
		&Pd105(n,α)Ru102(n,α)Mo99(β^-)*Tc99*				2.5			
		&Pd105(n,3n)Pd103(β^+)Rh103m(IT)_ Rh103(n,nα)*Tc99*					45.4	10.4	1.7
		&Pd104(n,4n)Pd101(β^+)Rh101m(β^+)_ Ru101(n,t)*Tc99*						13.2	7.0
		&Pd106(n,4n)Pd103(β^+)Rh103m(IT)_ Rh103(n,nα)*Tc99*						8.5	2.7
		&Pd105(n,tα)*Tc99*							15.4
		&Pd105(n,5n)Pd101(β^+)Rh101m(β^+)_ Ru101(n,t)*Tc99*							10.4
Tc98	4.2 10^6 y	**&**Pd104(n,2n)Pd103(β^+)*Rh103*(n,2n)_ *Rh102*(n,nα)Tc98				18.5	0.6		
		&Pd102(n,2n)Pd101(β^+)*Rh101*(n,α)Tc98				16.2	0.1		
		&Pd104(n,2n)Pd103(β^+)*Rh103*(n,nα)_ *Tc99*(n,2n)Tc98				14.1	1.1		
		Pd102(n,nα)Ru98(n,p)Tc98				5.8	1.3		
		&Pd104(n,2n)Pd103(β^+)*Rh103*(n,2n)_ Rh102m(n,nα)Tc98				5.7	0.4		
		Pd102(n,α)Ru99(n,d)Tc98				5.5	0.7		
		Pd105(n,3n)Pd103(β^+)Rh103m(IT)_ Rh103(n,2nα)Tc98					25.7	18.2	1.9
		Pd104(n,2n)Pd103(β^+)Rh103m(IT)_ Rh103(n,2nα)Tc98					7.9	5.5	0.9
		Pd105(n,2nα)Ru100(n,t)Tc98					1.3	6.3	1.3
		Pd105(n,t)Rh103m(IT)Rh103(n,2nα)Tc98					1.1	4.2	0.8
		Pd106(n,4n)Pd103(β^+)Rh103m(IT)_ Rh103(n,2nα)Tc98						14.9	3.3
		Pd104(n,4n)Pd101(β^+)Rh101m(β^+)_ Ru101(n,nt)Tc98						3.7	7.4
		Pd104(n,nt)Rh101m(β^+)Ru101(n,nt)Tc98						0.5	5.6
		Pd105(n,5n)Pd101(β^+)Rh101m(β^+)_ Ru101(n,nt)Tc98							11.1
		Pd105(n,2nt)Rh101m(β^+)Ru101(n,nt)Tc98							5.4
Pd107	6.5 10^6 y	**&**Pd106(n,γ)*Pd107*	76.1	57.6	93.4				
		&Pd105(n,γ)Pd106(n,γ)*Pd107*	23.9	42.3	6.5				
		&Pd108(n,2n)*Pd107*				99.6	80.4	38.8	41.0
		Pd108(n,d)Rh107(β^-)Pd107					13.4	13.7	20.6
		&Pd110(n,4n)*Pd107*						44.7	27.7
		Pd110(n,nt)Rh107(β^-)Pd107							9.2

Palladium activation characteristics

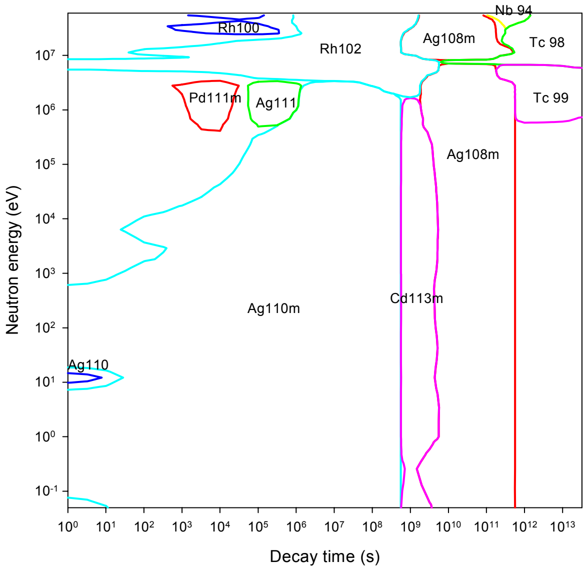


Palladium importance diagrams & transmutation

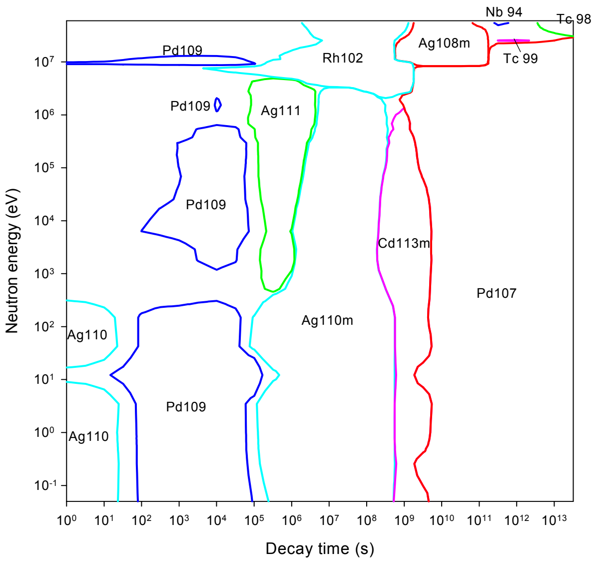
Activity



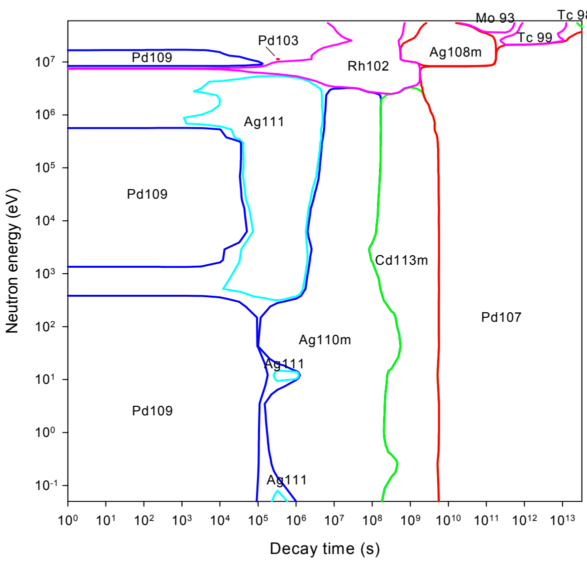
Dose rate



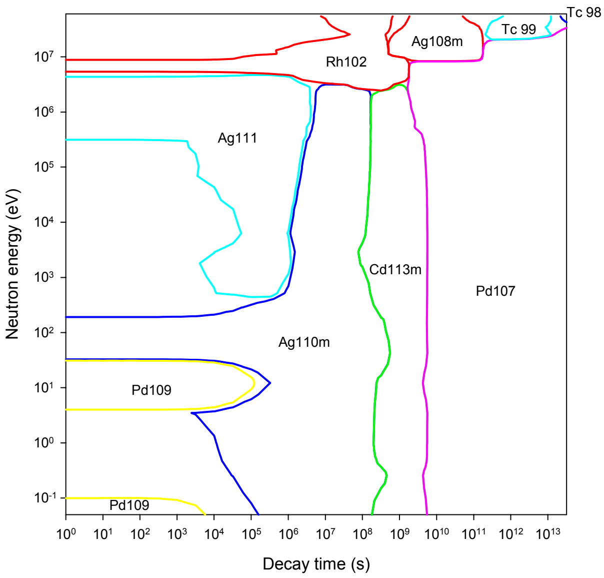
Heat output



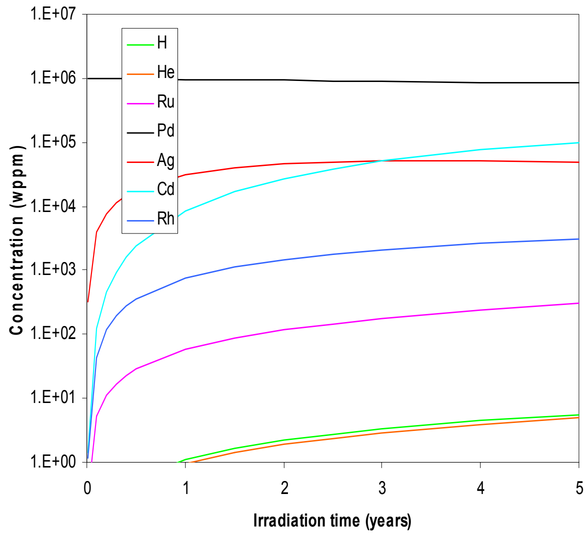
Ingestion dose



Inhalation dose



First wall transmutation



Silver

General properties

		Isotopes	Isotopic abundances / %
Atomic number	47		
Crustal abundance / wppm	7.5 10^{-2}	Ag107	51.839
Melting point / K	1235	Ag109	48.161
Boiling point / K	2435		
Density / kgm^{-3}	10500		
Thermal conductivity / Wm^{-1}K^{-1}	429		
Electrical resistivity /Ωm	1.59 10^{-5}		
Coefficient of thermal expansion / K^{-1}	1.89 10^{-5}		
Crystal structure	FCC		
Number of stable isotopes	2		
Mean atomic weight	107.8682		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Bq kg^{-1}	1.18E16	3.34E15	1.44E15	6.96E14	4.43E11	1.08E7
Ag108	48.89	33.26		0.01	7.97	
Ag110	33.77	0.07	0.13	0.10		
Ag109m	6.55	19.75	38.40	46.24		
Cd109	4.70	16.67	38.32	46.24		
Ag107m	3.94	4.34				
Ag106	1.62	4.92				
Ag106m	1.30	4.60	7.88			
Cd107	1.21	4.26				
Ag110m	1.18	4.19	9.60	7.30		
Ag111	0.94	3.33	5.49			
Pd109	0.86	3.05	0.08			
Cd111m	0.38	1.26				
Ag108m		0.01	0.03	0.07	91.65	
Pd107						100.0

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
kW kg^{-1}	1.49E0	3.06E-1	1.28E-1	2.89E-2	1.11E-4	1.61E-11
Ag110	51.97	0.15	0.28	0.46		
Ag108	34.20	36.58		0.01	3.21	
Ag106m	4.55	22.26	39.28			
Ag110m	4.26	20.82	49.05	79.83		
Ag106	2.48	10.41				
Ag109m	0.72	3.00	6.02	15.51		
Ag107m	0.46	0.96				
Ag111	0.45	2.20	3.73			
Pd109	0.39	1.93	0.05			
Cd111m	0.19	0.86				
Cd109	0.12	0.60	1.44	3.71		
Ag108m	0.01	0.04	0.09	0.43	96.74	
Pd107						99.99

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv h^{-1}	2.91E5	2.31E5	1.76E5	3.64E4	1.42E2	9.74E-12
Ag106m	36.75	44.75	43.58			
Ag110m	35.44	43.16	56.12	99.44		
Ag110	10.20	0.01	0.01	0.01		
Ag106	8.70	9.10				
Ag108	8.17*	2.17*			0.11	2.21
Cd111m	0.31	0.35				
Ag108m	0.06	0.07	0.09	0.45	99.88	
Tc98						97.77

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv kg^{-1}	1.97E6	1.96E6	1.78E6	7.92E5	9.66E2	3.99E-4
Cd109	56.60	56.74	62.34	81.34		
Ag110m	19.95	20.00	21.87	17.98		
Ag106m	11.71	11.73	9.61			
Ag111	7.36	7.38	5.81			
Pd109	2.86	2.86	0.04			
Cd113m	0.22	0.22	0.24	0.52	3.31	
Ag108m	0.06	0.06	0.06	0.13	96.68	
Pd107						99.99

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv kg^{-1}	6.65E6	6.65E6	6.45E6	3.26E6	1.52E4	6.36E-3
Cd109	67.79	67.83	69.53	80.09		
Ag110m	25.29	25.30	25.81	18.74		
Ag111	2.85	2.85	2.09			
Ag106m	2.53	2.54	1.94			
Pd109	0.57	0.56	0.01			
Cd113m	0.31	0.31	0.32	0.61	1.01	
Ag108m	0.26	0.26	0.27	0.54	98.99	
Cd107	0.17	0.17				
Cd111m	0.10	0.09				
Pd107						99.95
Tc99						0.01

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
	3.60E12	2.64E12	2.27E12	8.37E11	6.69E8	9.83E0
Ag110m	38.95	53.10	61.13	60.72		
Ag110	16.56	0.01	0.01	0.01		
Cd109	15.47	21.09	24.39	38.44		
Ag106m	11.85	16.15	13.93			
Ag108	11.74	3.50			0.44	
Ag106	4.08	4.78				
Ag109m	0.40	0.47	0.46	0.72		
Cd111m	0.37	0.46				
Ag107m	0.27	0.11				
Ag111	0.03	0.04	0.04			
Ag108m		0.03	0.03	0.09	99.55	
Pd107						99.75

Silver

Pathway analysis

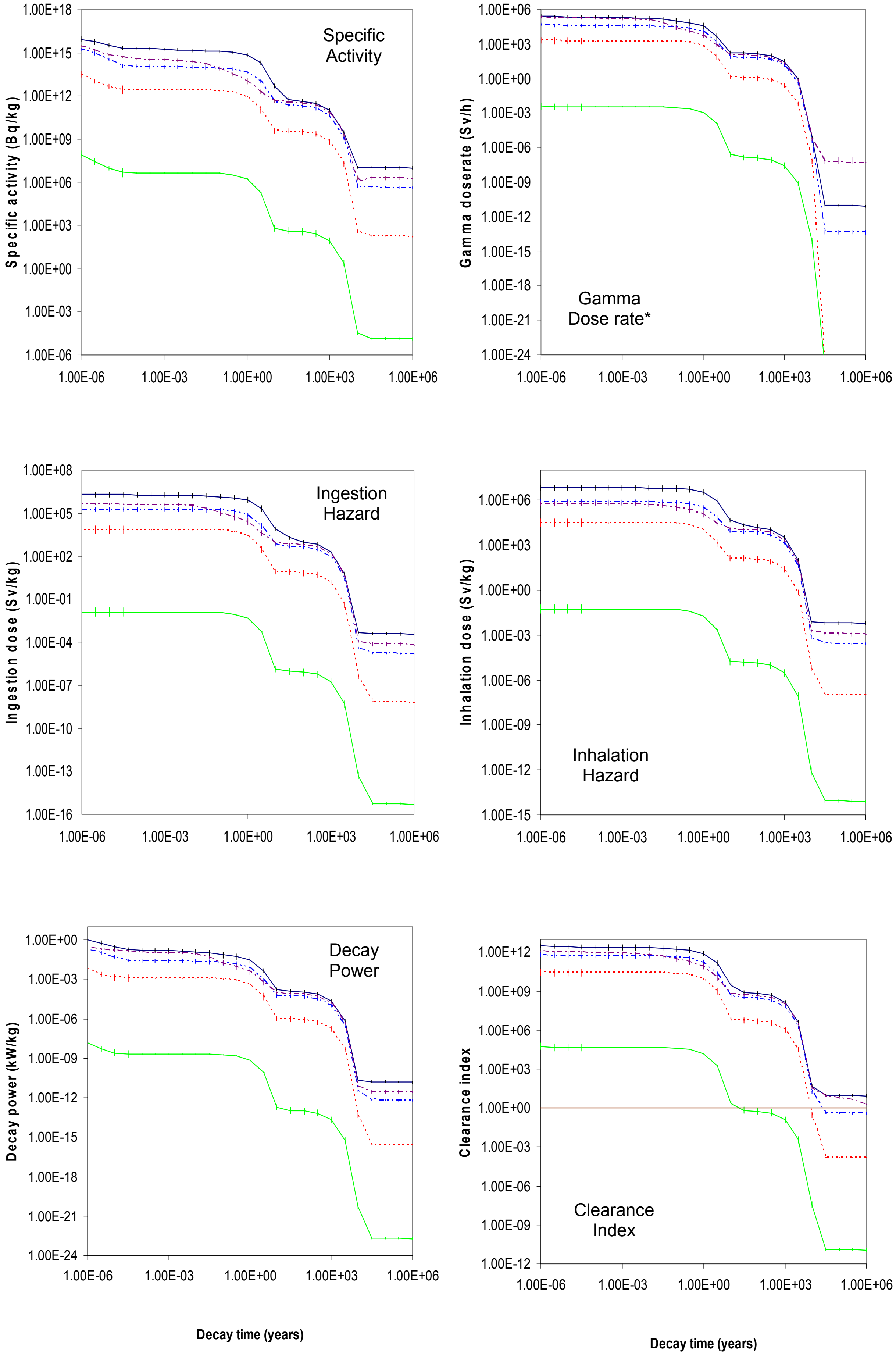
Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ag110	24.56 s	&Ag109(n,γ)*Ag110*	56.0	85.4	99.7	99.3	96.9	97.9	98.8
		&Ag107(n,γ)Ag108(β^-)Cd108(n,γ)_ Cd109(β^+)*Ag109*(n,γ)*Ag110*	16.4	3.5					
		&Ag107(n,γ)Ag108(β^+)Pd108(n,γ)_ *Pd109*(β^-)*Ag109*(n,γ)*Ag110*	14.2	0.5					
		&Ag107(n,γ)Ag108m(n,γ)*Ag109*(n,γ)_ *Ag110*	13.4	10.6					
Ag109m	39.6 s	Ag107(n,γ)Ag108(β^-)Cd108(n,γ)_ Cd109(β^+)Ag109m	46.7	44.7	95.5				
		&Ag107(n,γ)Ag108(β^+)Pd108(n,γ)_ *Pd109*(β^-)Ag109m	39.3	5.8	1.6				
		Ag107(n,γ)Ag108m(n,γ)Ag109m	14.0	49.1	2.5				
		Ag109(n,n′)Ag109m				93.2	85.4	84.9	87.2
		&Ag109(n,p)*Pd109*(β^-)Ag109m				6.5	14.6	15.1	6.0
Ag107m	44.3 s	Ag107(n,n′)Ag107m				53.7	19.6	23.6	30.2
		Ag109(n,2n)Ag108m(n,2n)Ag107m				23.2	1.9	1.3	
		Ag109(n,2n)Ag108(β^-)Cd108(n,2n)_ Cd107(β^+)Ag107m				20.4	1.2	0.7	
		Ag109(n,2n)Ag108(β^-)Cd108(n,d)Ag107m				0.3	0.3		
		Ag109(n,3n)Ag107m					73.8	72.1	66.6
		Ag109(n,3n)Ag107(n,n′)Ag107m					0.5		
Ag108	2.4 m	Ag107(n,γ)Ag108	100.0	100.0	100.0		0.2		
		&Ag109(n,2n)*Ag108*				98.1	97.8	98.3	99.1
		Ag109(n,2n)Ag108m(n,n′)Ag108				0.9	1.2		
In116m	54.6 m	&Ag109(n,γ)*Ag110*(β^-)Cd110(n,γ)_ *Cd111*(n,γ)Cd112(n,γ)*Cd113*(n,γ)_ Cd114(n,γ)Cd115(β^-)*In115*(n,γ)*In116m*	65.7	70.5	67.8				
		&Ag109(n,γ)*Ag110*(β^-)Cd110(n,γ)*Cd111*_ (n,γ)Cd112(n,γ)*Cd113*(n,γ)Cd114(n,γ)_ Cd115m(β^-)*In115*(n,γ)*In116m*	4.3	4.1	1.5				
		&Ag109(n,γ)Ag110m(n,γ)*Ag111*(β^-)_ Cd111(n,γ)Cd112(n,γ)*Cd113*(n,γ)_ Cd114(n,γ)Cd115(β^-)*In115*(n,γ)*In116m*	3.9		4.6				
		&Ag109(n,γ)Ag110m(β^-)Cd110(n,γ)_ *Cd111*(n,γ)Cd112(n,γ)*Cd113*(n,γ)_ Cd114(n,γ)Cd115(β^-)*In115*(n,γ)*In116m*	1.2	1.6	1.4				
		&Ag109(n,γ)Ag110m(n,γ)*Ag111*(β^-)_ Cd111(n,γ)Cd112(n,γ)*Cd113*(n,γ)Cd114_ (n,γ)Cd115m(β^-)*In115*(n,γ)*In116m*	0.5		0.6				
		Other pathways involving (n,γ), β^-	24.4	23.8	24.1				
Pd109	13.701 h	&Ag107(n,γ)Ag108(β^+)Pd108(n,γ)_ *Pd109*	100.0	99.8	99.4				
		Ag107(n,γ)Ag108m(β^+)Pd108(n,γ)Pd109			0.1				
		&Ag109(n,p)*Pd109*				100.0	100.0	100.0	100.0
Ag111	7.45 d	&Ag109(n,γ)Ag110m(n,γ)*Ag111*	77.0	50.7	97.1	95.2	89.1	91.6	94.2
		&Ag107(n,γ)Ag108(β^-)Cd108(n,γ)_ Cd109(β^+)*Ag109*(n,γ)Ag110m(n,γ)*Ag111*	8.8						
		&Ag107(n,γ)Ag108m(n,γ)*Ag109*(n,γ)_ Ag110m(n,γ)*Ag111*	8.6	0.9					
		&Ag107(n,γ)Ag108(β^+)Pd108(n,γ)_ *Pd109*(β^-)*Ag109*(n,γ)Ag110m(n,γ)*Ag111*	7.8						
		&Ag109(n,γ)*Ag110*(β^+)Pd110(n,γ)_ *Pd111*(β^-)*Ag111*	1.8	45.9	1.4	1.2	1.7	1.6	1.7
	▶	&Ag109(n,γ)Ag110(β^+)Pd110(n,γ)_ Pd111m(β^-)*Ag111*		2.2		0.3	0.4	0.3	0.3

Nuclide	$T_{1/2}$	Pathway	210	186	151	42	30	21	6
	◄	**&**Ag109(n,γ)Ag110(β^-)Cd110(n,γ)_ *Cd111*(n,p)*Ag111*				1.0	1.8	1.2	0.4
Ag106m	8.46 d	Ag107(n,2n)Ag106m				97.8	79.2	36.9	36.5
		&Ag109(n,2n)Ag108m(n,2n)*Ag107*_ (n,2n)Ag106m				1.2			
		&Ag109(n,3n)*Ag107*(n,2n)Ag106m					10.9	2.4	
		Ag109(n,2n)Ag108m(n,3n)Ag106m					9.4	2.4	
		Ag109(n,4n)Ag106m						57.2	61.0
Ag105	41.3 d	**&**Ag107(n,2n)Ag106m(n,2n)*Ag105*				68.7			
		Ag107(n,2n)Ag106(β^-)Cd106(n,2n)_ Cd105(β^+)Ag105				23.0			
		&Ag107(n,2n)Ag106(β^-)Cd106(n,d)*Ag105*				6.5			
		&Ag107(n,3n)*Ag105*					87.4	90.4	42.9
		&Ag109(n,3n)*Ag107*(n,3n)*Ag105*					11.8	6.6	
		Ag109(n,2n)Ag108m(n,4n)Ag105m(IT)Ag105						1.8	
		&Ag109(n,5n)*Ag105*							53.3
Ag110m	249.78 d	Ag109(n,γ)Ag110m	73.7	96.8	99.8	99.5	98.9	97.9	98.7
		&Ag107(n,γ)Ag108(β^-)Cd108(n,γ)_ Cd109(β^+)*Ag109*(n,γ)Ag110m	9.2						
		&Ag107(n,γ)Ag108m(n,γ)*Ag109*(n,γ)_ Ag110m	8.8	2.5					
		&Ag107(n,γ)Ag108(β^+)Pd108(n,γ)_ *Pd109*(β^-)*Ag109*(n,γ)Ag110m	8.3						
Cd109	1.267 y	Ag107(n,γ)Ag108(β^-)Cd108(n,γ)Cd109	100.0	100.0	100.0				
		Ag109(n,2n)Ag108(β^-)Cd108(n,γ)Cd109				61.7	49.7	58.4	69.0
		&Ag109(n,γ)*Ag110*(β^-)Cd110(n,2n)Cd109				26.2	33.8	28.1	21.0
		Ag109(n,γ)Ag110m(β^-)Cd110(n,2n)Cd109				11.6	15.1	12.5	9.4
		Ag109(n,2n)Ag108m(n,n′)Ag108(β^-)_ Cd108(n,γ)Cd109				0.2	0.2	0.2	0.1
Rh102	2.902 y	**&**Ag107(n,nα)*Rh103*(n,2n)*Rh102*				43.8	16.6	0.8	0.4
		&Ag107(n,α)Rh104m(IT)Rh104(β^-)_ Pd104(n,2n)Pd103(β^+)Rh103m(IT)_ Rh103(n,2n)*Rh102*				15.8			
		&Ag107(n,α)Rh104(β^-)Pd104(n,2n)Pd103_ (β^+)Rh103m(IT)Rh103(n,2n)Rh102				14.2			
		&Ag107(n,2n)Ag106(β^+)Pd106(n,α)Ru103_ (β^-)Rh103m(IT)Rh103(n,2n)*Rh102*				6.5			
		&Ag107(n,2n)Ag106m(β^+)Pd106(n,α)_ Ru103(β^-)Rh103m(IT)Rh103(n,2n)Rh102				5.5			
		&Ag107(n,2nα)*Rh102*					45.6	74.8	37.7
		&Ag107(n,4n)*Ag104*(β^+)Pd104(n,t)*Rh102*						6.1	4.5
		&Ag109(n,4nα)*Rh102*							18.0
		&Ag109(n,5n)*Ag105*(β^+)Pd105(n,nt)*Rh102*							6.4
H3	12.33 y	Ag107(n,γ)Ag108m(n,X)H1(n,γ)H2(n,γ)H3	94.0	95.5	99.5				
		Ag107(n,X)H3				80.5	50.7	47.7	47.1
		Ag109(n,X)H3				12.2	38.6	42.3	43.2
		Ag109(n,2n)Ag108m(n,X)H3				6.3	1.8	0.9	
		&Ag109(n,3n)*Ag107*(n,X)H3					3.6	1.6	
Cd113m	14.10 y	**&**Ag109(n,γ)*Ag110*(β^-)Cd110(n,γ)_ *Cd111*(n,γ)Cd112(n,γ)Cd113m	89.4	96.9	87.5	59.0	57.7	56.7	56.6
		&Ag109(n,γ)Ag110m(n,γ)*Ag111*(β^-)_ Cd111(n,γ)Cd112(n,γ)Cd113m	7.6		9.9	18.7	20.9	22.6	23.3
		&Ag109(n,γ)Ag110m(β^-)Cd110(n,γ)_ *Cd111*(n,γ)Cd112(n,γ)Cd113m	1.8	2.9	2.2	19.0	18.5	18.2	18.2
		Ag107(n,γ)Ag108(β^-)Cd108(n,γ)Cd109_ (n,γ)Cd110(n,γ)Cd111(n,γ)Cd112(n,γ)_ Cd113m	0.6						
		&Ag109(n,γ)Ag110m(n,γ)*Ag111*(n,γ)_ Ag112(β^-)Cd112(n,γ)Cd113m				0.6	0.4	0.4	0.4
Ag108m	418.0 y	Ag107(n,γ)Ag108m	100.0	100.0	100.0				
		Ag109(n,2n)Ag108m				99.7	99.7	99.7	99.9

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Mo93	4000 y	Ag107(n,nα)Rh103m(IT)Rh103(n,α)_ Tc100(β^-)Ru100(n,2n)Ru99(n,2n)Ru98_ (n,nα)Mo94(n,2n)Mo93				5.7			
		Ag107(n,nα)Rh103m(IT)Rh103(n,α)_ Tc100(β^-)Ru100(n,2n)Ru99(n,nα)_ Mo95(n,2n)Mo94(n,2n)Mo93				4.1			
		Ag107(n,α)Rh104m(IT)Rh104(β^-)_ Pd104(n,nα)Ru100(n,2n)Ru99(n,2n)_ Ru98(n,nα)Mo94(n,2n)Mo93				4.1			
		Ag107(n,α)Rh104(β^-)Pd104(n,nα)_ Ru100(n,2n)Ru99(n,2n)Ru98(n,nα)_ Mo94(n,2n)Mo93				3.7			
		Ag107(n,nα)Rh103m(IT)Rh103(n,2n)_ Rh102m(β^-)Pd102(n,nα)Ru98(n,nα)_ Mo94(n,2n)Mo93				3.5			
		Ag107(n,3n)Ag105m(IT)Ag105(β^+)Pd105_ (n,2nα)Ru100(n,3n)Ru98(n,2nα)Mo93					4.2		
		&Ag107(n,3nα)Rh101m(β^+)Ru101_ (n,4n)Ru98(n,2nα)*Mo93*						3.6	1.0
		&Ag107(n,4nα)Rh100m(IT)Rh100(β^+)_ Ru100(n,4nα)*Mo93*							3.8
		Other pathways involving (n,2n), (n,α), β^+				78.9	95.8	96.4	95.2
Nb94	2.0 10^4 y	**&**Ag107(n,nα)Rh103m(IT)Rh103_ (n,2n)*Rh102*(n,nα)Tc98(n,nα)*Nb94*				14.6	0.6		
		&Ag107(n,nα)Rh103m(IT)Rh103_ (n,nα)Tc99(n,2n)Tc98(n,nα)*Nb94*				9.0	1.2		
		&Ag107(n,nα)Rh103m(IT)Rh103_ (n,2n)Rh102m(n,nα)Tc98(n,nα)*Nb94*				5.0	0.4		
		&Ag107(n,nα)Rh103(n,2n)Rh102_ (n,nα)Tc98(n,nα)*Nb94*				3.2			
		&Ag107(n,nα)Rh103m(IT)Rh103_ (n,nα)Tc99(n,2nα)*Nb94*					11.4	1.5	
		&Ag107(n,nα)Rh103m(IT)Rh103_ (n,2nα)Tc98(n,nα)*Nb94*					10.6	2.2	
		&Ag107(n,2nα)Rh102(n,nα)Tc98(n,nα)*Nb94*					4.6	1.0	
		&Ag107(n,n2α)Tc99(n,2nα)*Nb94*						3.6	0.4
		&Ag107(n,2nt)Pd103(β^+)Rh103m(IT)_ Rh103(n,2n2α)*Nb94*							6.5
		Ag107(n,5n)Ag103(β^+)Pd103(β^+)_ Rh103m(IT)Rh103(n,2n2α)Nb94							4.4
		&Ag107(n,4nα)Rh100m(IT)Rh100(β^+)_ Ru100(n,tα)*Nb94*							3.9
		&Ag107(n,3nα)Rh101m(β^+)Ru101(n,ntα)*Nb94*							3.1
		Other pathways involving (n,2n), (n,α), β^+				68.2	71.2	91.7	81.7
Tc99	2.1 10^5 y	**&**Ag107(n,nα)*Rh103*(n,nα)*Tc99*				22.2	31.4	6.6	0.9
		&Ag107(n,α)*Rh104*(β^-)Pd104(n,2n)_ Pd103(β^+)*Rh103*(n,nα)*Tc99*				17.0			
		&Ag107(n,nα)Rh103m(IT)Rh103_ (n,2n)Rh102(n,α)*Tc99*				9.2			
		&Ag107(n,nα)Rh103(n,nα)*Tc99*				4.9	3.9	0.6	
		&Ag107(n,2n)Ag106(β^+)Pd106(n,α)_ Ru103(β^-)*Rh103*(n,nα)*Tc99*				3.1			
		&Ag107(n,2n)Ag106(β^+)Pd106(n,2n)_ Pd105(n,2n)Pd104(n,2n)Pd103(β^+)_ *Rh103*(n,nα)*Tc99*				1.8			
		&Ag107(n,n2α)*Tc99*						10.4	7.4
		&Ag107(n,2nα)Rh102m(β^+)Ru102(n,nt)*Tc99*						6.1	3.2
		&Ag107(n,3nα)Rh101m(β^+)Ru101(n,t)*Tc99*						5.8	18.1
	►	**&**Ag107(n,2nt)Pd103(β^+)Rh103m(IT)_ Rh103(n,nα)*Tc99*						0.2	7.2

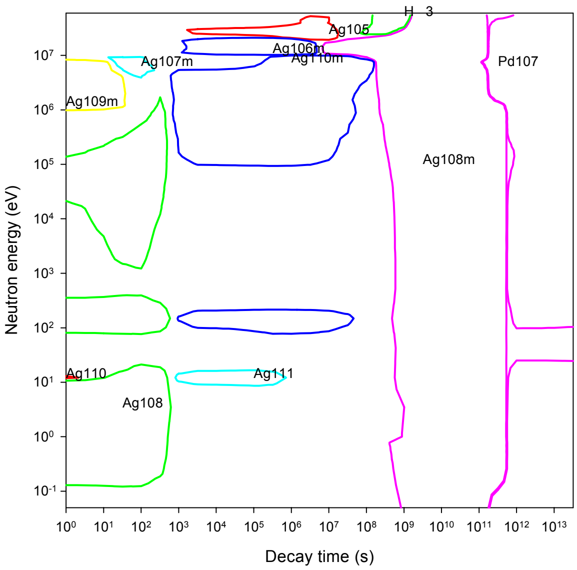
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	**&**Ag107(n,5n)Ag103(β^+)Pd103(β^+)_ Rh103m(IT)Rh103(n,nα)*Tc99*							7.3
		Other pathways involving (n,2n), (n,α), β^+				41.8	64.7	70.3	55.9
Tc98	4.2 10^6 y	**&**Ag107(n,nα)*Rh103*(n,2n)*Rh102*(n,nα)Tc98				20.2	1.8		
		&Ag107(n,nα)*Rh103*(n,nα)*Tc99*(n,2n)Tc98				15.5	4.1		
		&Ag107(n,α)*Rh104*(β^-)Pd104(n,2n)_ Pd103(β^+)*Rh103*(n,2n)*Rh102*(n,nα)Tc98				9.8			
		&Ag107(n,α)*Rh104*(β^-)Pd104(n,2n)_ Pd103(β^+)*Rh103*(n,nα)*Tc99*(n,2n)Tc98				6.6			
		&Ag107(n,nα)*Rh103*(n,2n)Rh102m_ (n,nα)Tc98				6.2	1.0		
		&Ag107(n,nα)Rh103m(IT)Rh103_ (n,2n)Rh102(n,α)*Tc99*(n,2n)Tc98				4.1			
		&Ag107(n,nα)*Rh103*(n,2nα)Tc98					22.6	14.2	1.0
		Ag107(n,2nα)Rh102(n,nα)Tc98					8.1	5.6	0.4
		Ag107(n,2nα)Rh102m(n,nα)Tc98					4.2	3.4	0.2
		Ag107(n,3nα)Rh101m(β^+)Ru101(n,nt)Tc98						1.8	16.2
		Ag107(n,2nt)Pd103(β^+)Rh103m(IT)_ Rh103(n,2nα)Tc98						0.5	7.1
		Ag107(n,2n2α)Tc98							18.6
		Ag107(n,5n)Ag103(β^+)Pd103(β^+)_ Rh103m(IT)Rh103(n,2nα)Tc98							7.2
		Other pathways involving (n,2n), (n,α), β^+				37.6	58.2	74.5	49.3
Pd107	6.5 10^6 y	Ag107(n,γ)Ag108(β^-)Cd108(n,γ)Cd109_ (n,α)Pd106(n,γ)Pd107	95.0	14.5	91.0				
		Ag109(n,γ)Ag110m(n,α)Rh107(β^-)Pd107	0.5	83.5	4.5				
		&Ag107(n,p)*Pd107*				84.7	44.9	18.0	10.0
		&Ag109(n,2n)*Ag108*(β^+)Pd108(n,2n)*Pd107*				6.4			
		&Ag109(n,d)Pd108(n,2n)*Pd107*				3.4	3.8	1.6	
		&Ag109(n,2n)Ag108m(n,d)*Pd107*				2.9	3.6	0.9	
		&Ag109(n,t)*Pd107*				0.5	43.0	76.1	85.7
		&Ag109(n,3n)*Ag107*(n,p)Pd107					1.7		
		Ag109(n,h)Rh107(β^-)Pd107					0.2	1.2	1.6
Cd108	4.1 10^{17} y	Ag107(n,γ)Ag108(β^-)Cd108	100.0	100.0	100.0		0.2	0.1	
		Ag109(n,2n)Ag108(β^-)Cd108				99.3	97.8	98.4	99.1
		Ag109(n,2n)Ag108m(n,n′)Ag108(β^-)Cd108				0.5	0.6	0.4	0.2

Silver activation characteristics

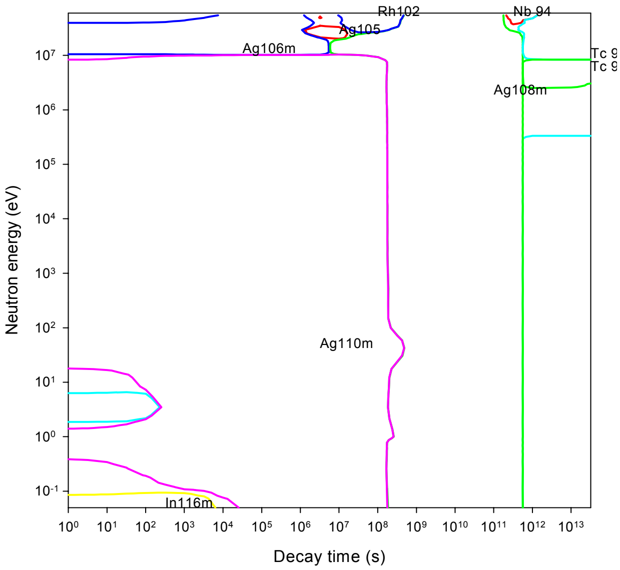


Silver importance diagrams & transmutation

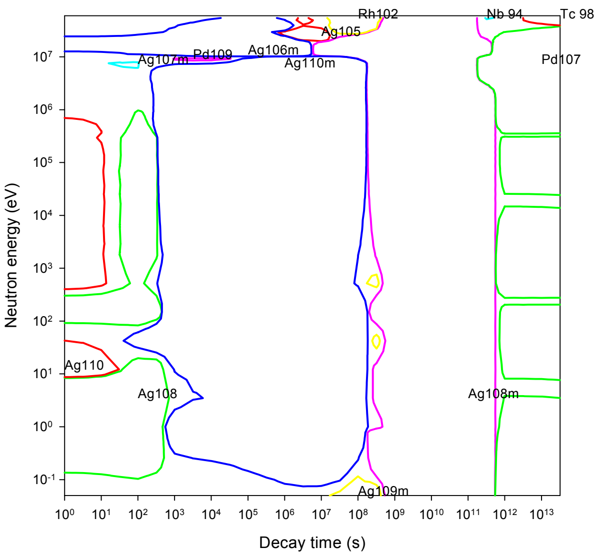
Activity



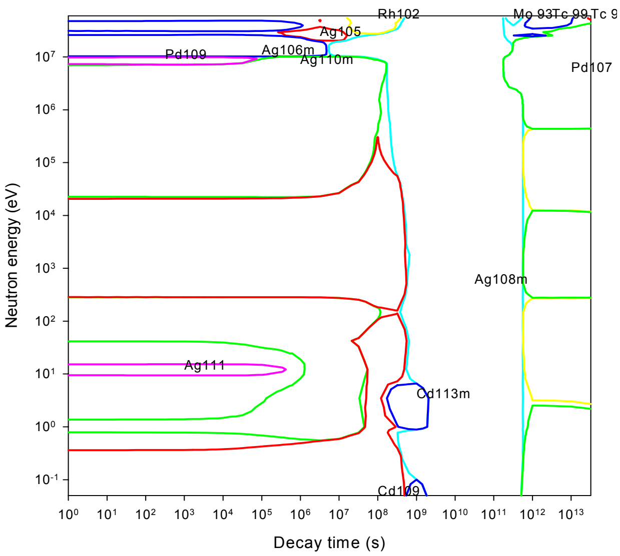
Dose rate



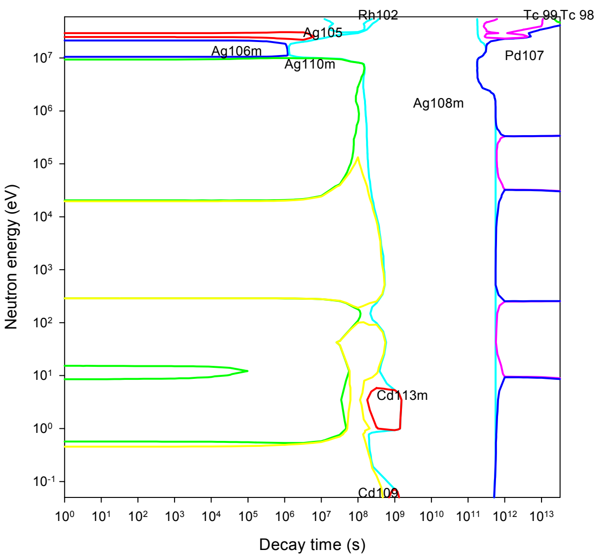
Heat output



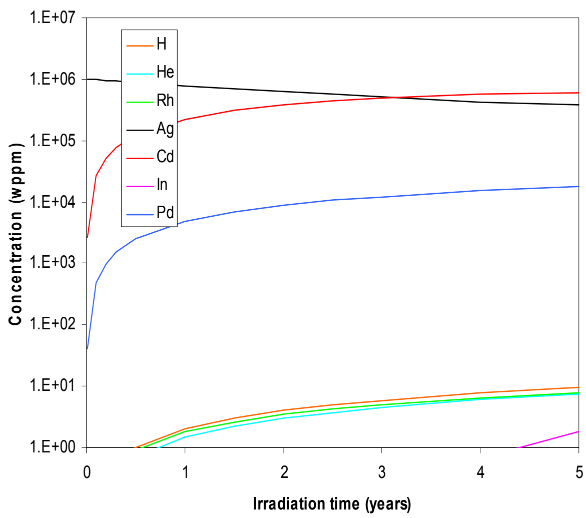
Ingestion dose



Inhalation dose



First wall transmutation



Cadmium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	48	Cd106	1.25 ($T_{½}$ = 6.60 10^{18} y)
Crustal abundance / wppm	0.15	Cd108	0.89 ($T_{½}$ = 4.10 10^{17} y)
Melting point / K	594.2	Cd110	12.49
Boiling point / K	1040	Cd111	12.80
Density / kgm^{-3}	8650	Cd112	24.13
Thermal conductivity / $Wm^{-1}K^{-1}$	96.8	Cd113	12.22 ($T_{½}$ = 7.70 10^{15} y)
Electrical resistivity /Ωm	6.83 10^{-8}	Cd114	28.73 ($T_{½}$ = 6.00 10^{17} y)
Coefficient of thermal expansion / K^{-1}	3.08 10^{-5}	Cd116	7.49 ($T_{½}$ = 3.40 10^{19} y)
Crystal structure	HCP		
Number of stable isotopes	3 (8)		
Mean atomic weight	112.411		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Bq kg^{-1}	4.51E15	3.77E15	1.19E15	1.18E14	2.87E11	3.45E5
In115m	25.87	30.99	34.21			
Cd115	25.72	30.77	31.34	0.55		
In116m	16.33	18.31				
In116n	8.74					
In116	4.42					
Cd115m	4.20	5.03	15.07			
Cd111m	3.66	4.07				
Ag109m	1.56	1.84	5.72	33.54		
Cd109	1.51	1.81	5.72	33.54		
Ag110	1.35			0.59		
Cd113m	0.86	1.03	3.27	31.45	99.43	
Ag107m	0.68	0.79				
In114	0.67	0.57	1.69	0.11		
Cd107	0.66	0.79				
In117	0.62	0.75				
Cd117	0.62	0.73				
In114m	0.48	0.58	1.75	0.11		
Pd107						99.99

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
kW kg^{-1}	6.17E-1	5.26E-1	7.82E-2	2.20E-3	8.90E-6	5.14E-13
In116m	53.64	58.89				
Cd115	15.40	18.05	39.00			
In115m	10.18	11.95	27.98			
In116	7.06					
Cd115m	3.13	3.67	23.38	3.01		
Ag110	1.92		0.01	0.08		
Cd111m	1.67	1.82				
In116n	1.66					
Cd117	1.10	1.26				
Cd117m	0.82	0.94				
In114	0.60	0.50	3.19	0.75		
Cd113m	0.18	0.22	1.48	50.20	95.45	
Ag109m	0.15	0.18	1.21	25.08		
Ag110m	0.14	0.16	1.10	14.40		
Cd109			0.29	6.01		
Ag108m				0.02	4.40	
Pd107						99.90
Tc99						0.06

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv h^{-1}	6.41E5	6.04E5	2.52E4	5.20E2	5.33E-1	1.29E-11
In116m	85.22	84.66				
Cd115	6.25	6.63	51.24			
In115m	3.61*	3.84*	32.14*			
Cd117m	1.35	1.40				
Cd117	1.27	1.32				
Cd115m	0.26*	0.28*	6.48*	1.13*		
Ag110m	0.21	0.23	5.47	97.12		
Ag106m	0.10	0.10	1.90			
Ag105	0.07	0.07	1.69	0.18		
Ag108m				0.11	99.63	
Tc98						99.91

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv kg^{-1}	3.63E6	3.61E6	2.28E6	9.37E5	6.57E3	1.30E-5
Cd115	44.82	44.96	22.87			
Cd113m	24.73	24.83	39.30	91.05	99.95	
Cd115m	17.25	17.33	25.92	0.22		
Cd109	3.77	3.79	5.97	8.44		
In115m	2.77	2.78	1.53			
In114m	2.48	2.49	3.75	0.06		
In116m	1.30	1.22				
Cd111m	0.50	0.46				
Pd107						98.41
In115						1.29
Tc99						0.12

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y	Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	8.04E6	8.02E6	6.88E6	4.42E6	3.15E4	2.06E-4		2.29E12	2.10E12	1.44E11	4.81E10	7.74E6	3.44E-1
Cd113m	53.33	53.45	62.27	92.41	99.83		In116m	80.47	82.29				
Cd115m	18.15	18.19	20.03	0.11			Cd115	5.06	5.53	1.24			
Cd115	15.88	15.90	5.95				Cd109	2.98	3.26	47.32	82.31		
Cd109	6.89	6.90	8.00	7.25			Cd111m	2.12	2.15				
In114m	2.54	2.54	2.82	0.02			Cd117	1.38	1.47				
In115m	0.85	0.85	0.34				In116n	1.32					
In116m	0.41	0.38					Cd117m	1.25	1.35				
Cd111m	0.30	0.28					In116	1.22					
Ag110m	0.28	0.28	0.33	0.18			Ag110m	0.83	0.91	13.24	14.51		
Ag111	0.08	0.08	0.07				In115m	0.50	0.55	2.82			
Sn117m	0.07	0.07	0.07				Ag105	0.23	0.25	3.56	0.02		
Ag105	0.05	0.05	0.06				Ag106m	0.11	0.12	1.35			
Ag108m					0.17		In114m	0.09	0.10	1.45	0.02		
Pd107						98.80	Cd115m	0.08	0.09	1.25			
In115						0.99	Ag109m		0.06	0.86	1.55		
Tc99						0.15	Cd113m		0.03	0.50	1.42	68.34	
							Ag108m					31.52	
							Pd107						90.98
							Tc99						7.22
							In115						1.52
							Cd113						0.25

Cadmium

Pathway analysis

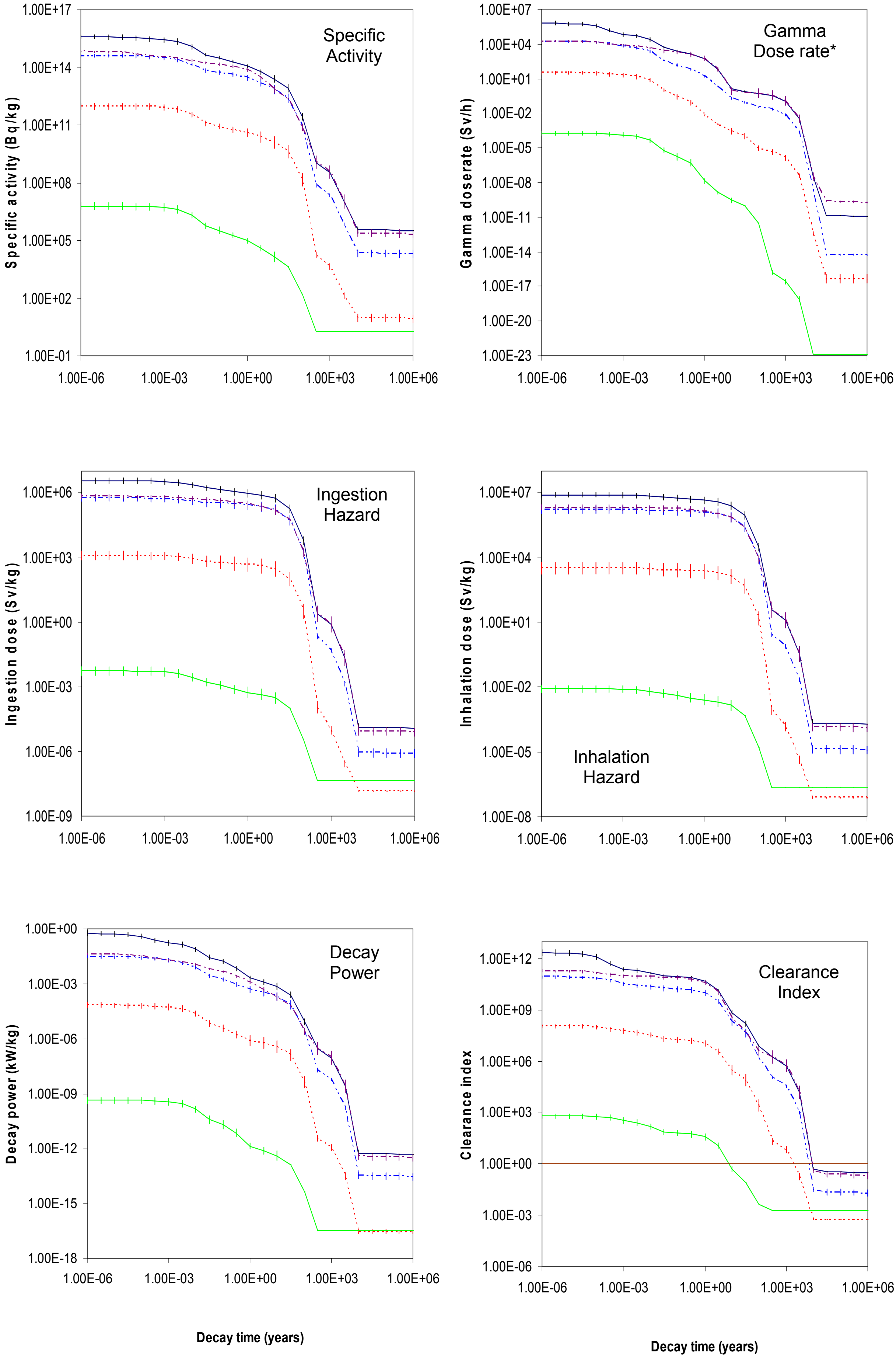
Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ag109m	39.6 s	Cd108(n,γ)Cd109(β^+)Ag109m	91.7	99.9	99.6				
		&Cd106(n,γ)Cd107(β^+)*Ag107*(n,γ)_ Ag108m(n,γ)Ag109m	1.9						
		Cd110(n,2n)Cd109(β^+)Ag109m				79.7	24.2	12.2	8.6
		Cd111(n,2n)Cd110(n,2n)Cd109(β^+)Ag109m				14.0	1.3		
		&Cd112(n,2n)*Cd111*(n,2n)Cd110(n,2n)_ Cd109(β^+)Ag109m				2.2			
		Cd110(n,d)Ag109m				0.2	3.9	3.7	3.5
		Cd111(n,3n)Cd109(β^+)Ag109m					45.8	22.9	10.8
		Cd112(n,3n)Cd110(n,2n)Cd109(β^+)Ag109m					4.9		
		Cd111(n,t)Ag109m					1.3	3.9	4.0
		Cd112(n,4n)Cd109(β^+)Ag109m						35.4	29.0
		Cd112(n,nt)Ag109m						1.0	7.5
		Cd113(n,5n)Cd109(β^+)Ag109m							17.2
Cd111m	48.54 m	Cd110(n,γ)Cd111m	99.5	100.0	100.0				
		Cd112(n,2n)Cd111m				76.7	37.7	20.1	22.6
		Cd113(n,2n)Cd112(n,2n)Cd111m				9.5	1.3		
		Cd111(n,n′)Cd111m				7.7	5.1	3.7	4.0
		Cd112(n,2n)Cd111(n,n′)Cd111m				1.7	0.2		
		Cd114(n,2n)Cd113(n,2n)Cd112(n,2n)Cd111m				1.2			
		Cd114(n,2n)Cd113m(n,2n)Cd112(n,2n)_ Cd111m				1.0			
		Cd113(n,3n)Cd111m					37.4	18.7	14.2
		Cd114(n,3n)Cd112(n,2n)Cd111m					7.6		
		Cd114(n,2n)Cd113m(n,3n)Cd111m					3.9		
		Cd114(n,2n)Cd113(n,3n)Cd111m					2.1		
		Cd114(n,4n)Cd111m						47.5	50.3
		Cd116(n,6n)Cd111m							2.7
In116m	54.60 m	&Cd114(n,γ)Cd115(β^-)*In115*(n,γ)*In116m*	57.6	75.3	84.9				
		&Cd113(n,γ)Cd114(n,γ)Cd115m(β^-)_ In115(n,γ)*In116m*	14.3	1.5	0.2				
		&Cd114(n,γ)Cd115m(β^-)In115(n,γ)*In116m*	7.8	9.8	11.6				
		&Cd113(n,γ)Cd114(n,γ)Cd115(β^-)_ *In115*(n,γ)*In116m*	6.4	12.4	1.9				
		&Cd112(n,γ)*Cd113*(n,γ)Cd114(n,γ)_ Cd115(β^-)*In115*(n,γ)*In116m*	4.2						
		&Cd116(n,2n)Cd115m(β^-)In115(n,γ)*In116m*				49.1	47.8	37.3	28.4
		&Cd116(n,2n)Cd115(β^-)*In115*(n,γ)*In116m*				47.3	28.7	23.7	21.2
		&Cd116(n,γ)Cd117m(β^-)In117(β^-)_ Sn117(n,d)*In*116*m*					5.3	8.3	10.0
		&Cd116(n,γ)Cd117(β^-)In117m(β^-)_ Sn117(n,d)*In116m*					3.4	5.2	6.2
		&Cd116(n,γ)Cd117(β^-)*In117*(β^-)_ Sn117(n,d)*In116m*					2.6	3.8	6.2
		&Cd116(n,d)Ag115(β^-)Cd115(β^-)_ In115m(IT)In115(n,γ)*In116m*					1.7	8.0	10.7
		&Cd116(n,d)Ag115m(β^-)Cd115(β^-)_ In115m(IT)In115(n,γ)*In116m*					1.4	5.6	7.3
Cd115	2.228 d	Cd114(n,γ)Cd115	82.8	80.2	95.7	0.3	0.4	0.3	0.3
		Cd113(n,γ)Cd114(n,γ)Cd115	9.2	19.7	4.2				
		Cd116(n,2n)Cd115				99.4	79.5	60.7	51.4
		Cd112(n,γ)Cd113(n,γ)Cd114(n,γ)Cd115	6.6		0.1				
		Cd111(n,γ)Cd112(n,γ)Cd113(n,γ)_ Cd114(n,γ)Cd115	1.4						
		&Cd116(n,d)*Ag115*(β^-)Cd115					10.2	24.0	30.5
		Cd116(n,d)Ag115m(β^-)Cd115					8.4	14.4	17.5

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ag106m	8.46 d	**&**Cd108(n,2n)Cd107(β^+)*Ag107*(n,2n)Ag106m				53.8	7.5	0.4	0.1
		Cd106(n,p)Ag106m				36.5	10.2	1.4	0.6
		Cd110(n,3n)Cd108(n,t)Ag106m					13.3	11.8	1.7
		Cd108(n,t)Ag106m					7.2	8.2	3.3
		Cd110(n,3n)Cd108(n,2n)Cd107(β^+)_ Ag107m(IT)Ag107(n,2n)Ag106m					6.9	0.3	
		Cd111(n,3n)Cd109(β^+)Ag109m(IT)_ Ag109(n,2n)Ag108m(n,3n)Ag106m					5.5	0.2	
		Cd112(n,4n)Cd109(β^+)Ag109m(IT)_ Ag109(n,4n)Ag106m						16.4	6.7
		Cd111(n,3n)Cd109(β^+)Ag109m(IT)_ Ag109(n,4n)Ag106m						10.6	2.5
		Cd111(n,4n)Cd108(n,t)Ag106m						8.0	2.2
		Cd110(n,2n)Cd109(β^+)Ag109m(IT)_ Ag109(n,4n)Ag106m						5.7	2.0
		Cd110(n,2nt)Ag106m							26.9
		Other pathways				9.7	49.4	37.0	54.0
Cd115m	44.60 d	Cd114(n,γ)Cd115m	89.8	80.6	95.7	0.2	0.3		
		Cd112(n,γ)Cd113(n,γ)Cd114(n,γ)Cd115m	6.9		0.1				
		Cd111(n,γ)Cd112(n,γ)Cd113(n,γ)_ Cd114(n,γ)Cd115m	1.5						
		Cd112(n,γ)Cd113m(n,γ)Cd114(n,γ)_ Cd115m	1.1						
		Cd113(n,γ)Cd114(n,γ)Cd115m	0.4	19.4	4.0				
		Cd110(n,γ)Cd111(n,γ)Cd112(n,γ)_ Cd113(n,γ)Cd114(n,γ)Cd115m	0.3						
		Cd116(n,2n)Cd115m				99.6	98.5	96.7	95.7
Ag110m	249.78 d	Cd108(n,γ)Cd109(β^+)Ag109m(IT)_ Ag109(n,γ)Ag110m	93.2	99.9	99.9				
		Cd110(n,p)Ag110m				72.7	28.0	11.9	4.6
		Cd111(n,2n)Cd110(n,p)Ag110m				14.7	1.7	0.4	0.1
		Cd111(n,d)Ag110m				6.4	40.5	24.7	14.6
		&Cd112(n,2n)*Cd111*(n,2n)Cd110(n,p)_ Ag110m				2.6			
		&Cd112(n,2n)*Cd111*(n,d)Ag110m				2.2	4.6	1.6	0.6
		Cd112(n,t)Ag110m					7.7	40.7	34.9
		Cd112(n,3n)Cd110(n,p)Ag110m					6.5	1.7	0.2
		&Cd113(n,3n)*Cd111*(n,d)Ag110m					5.1	1.3	0.4
		Cd114(n,3n)Cd112(n,t)Ag110m					1.3	3.3	1.2
		Cd113(n,nt)Ag110m					0.5	4.8	18.9
		&Cd114(n,4n)*Cd111*(n,d)Ag110m						3.9	1.3
		Cd114(n,2nt)Ag110m						0.2	17.2
Cd109	1.267 y	Cd108(n,γ)Cd109	96.6	100.0	99.6				
		Cd110(n,2n)Cd109				82.8	27.3	14.5	11.4
		Cd111(n,2n)Cd110(n,2n)Cd109				14.5	1.4	0.5	0.2
		Cd111(n,3n)Cd109					51.6	27.2	14.3
		&Cd113(n,3n)*Cd111*(n,3n)Cd109					5.6	1.3	0.2
		Cd112(n,3n)Cd110(n,2n)Cd109					5.5	1.8	0.5
		&Cd112(n,2n)*Cd111*(n,3n)Cd109					5.2	1.6	0.5
		Cd112(n,4n)Cd109						42.1	38.4
		Cd113(n,5n)Cd109							22.7
Cd113m	14.1 y	Cd112(n,γ)Cd113m	67.4	69.0	95.9	0.1	0.2		
		Cd111(n,γ)Cd112(n,γ)Cd113m	25.4	30.6	4.0				
		Cd110(n,γ)Cd111(n,γ)Cd112(n,γ)Cd113m	7.1	0.4					
		Cd114(n,2n)Cd113m				89.0	81.8	50.0	60.5
		Cd113(n,n′)Cd113m				9.4	14.2	10.4	12.4
		Cd116(n,4n)Cd113m					0.3	37.6	24.9
Ag108m	418.0 y	**&**Cd106(n,γ)Cd107(β^+)*Ag107*(n,γ)Ag108m	99.9	99.9	99.9				
		&Cd110(n,2n)Cd109(β^+)*Ag109*(n,2n)Ag108m				88.1	13.6	1.7	0.4
		&Cd111(n,2n)Cd110(n,2n)Cd109(β^+)_ *Ag109*(n,2n)Ag108m				6.1			
		Cd108(n,p)Ag108m				2.3	3.7	1.0	0.3
	►	**&**Cd110(n,d)*Ag109*(n,2n)Ag108m				0.5	5.2	1.2	0.4

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Cd111(n,3n)Cd109(β^+)Ag109m(IT)_ Ag109(n,2n)Ag108m					25.9	3.1	0.5
		Cd110(n,t)Ag108m					21.3	56.8	29.4
		Cd111(n,3n)Cd109(n,d)Ag108m					5.3	0.9	0.2
		Cd110(n,3n)Cd108(n,p)Ag108m					3.5	0.7	
		Cd112(n,3n)Cd110(n,t)Ag108m					3.1	5.1	1.0
		Cd111(n,nt)Ag108m					1.1	9.8	29.1
		Cd112(n,4n)Cd109(β^+)Ag109m(IT)_ Ag109(n,2n)Ag108m						4.8	1.4
		Cd112(n,2nt)Ag108m						0.1	22.1
Mo93	4000 y	**&**Cd106(n,nα)Pd102(n,nα)Ru98(n,nα)_ Mo94(n,2n)*Mo93*				57.1	1.2		
		Cd106(n,nα)Pd102(n,α)Ru99(n,2n)_ Ru98(n,nα)Mo94(n,2n)Mo93				11.0			
		Cd106(n,nα)Pd102(n,nα)Ru98(n,α)_ Mo95(n,2n)Mo94(n,2n)Mo93				8.6			
		Cd106(n,nα)Pd102(n,α)Ru99(n,nα)_ Mo95(n,2n)Mo94(n,2n)Mo93				8.0			
		&Cd106(n,nα)Pd102(n,nα)Ru98(n,2nα)*Mo93*					19.1	0.7	
		&Cd106(n,n2α)Ru98(n,2nα)*Mo93*					0.6	6.2	0.2
		Cd106(n,2nα)Pd101(β^+)Rh101m(β^+)_ Ru101(n,4n)Ru98(n,2nα)Mo93						19.1	0.1
		Cd106(n,2nα)Pd101(β^+)Rh101m(β^+)_ Ru101(n,2nα)Mo96(n,4n)Mo93						9.3	
		Cd106(n,3nα)Pd100(β^+)Rh100(β^+)_ Ru100(n,4nα)Mo93							6.5
		&Cd106(n,tα)*Rh100*(β^+)Ru100(n,4nα)*Mo93*							3.6
		Other pathways involving (n,2n), (n,α), β^+				15.3	79.1	64.7	89.6
Nb94	2.0 10^4 y	Cd106(n,nα)Pd102(n,nα)Ru98(n,2n)_ Ru97(β^+)Tc97(n,α)Nb94				12.9	0.3		
		&Cd106(n,nα)Pd102(n,2nα)Ru97(β^+)_ Tc97(n,α)*Nb94*					4.1	0.4	
		Cd106(n,2nα)Pd101(β^+)Rh101m(β^+)_ Ru101(n,t)Tc99(n,2nα)Nb94					1.1	6.5	0.1
		Cd106(n,2nα)Pd101(β^+)Rh101m(β^+)_ Ru101(n,2nα)Mo96(n,t)Nb94					0.9	8.2	0.2
		&Cd106(n,3nα)Pd100(β^+)Rh100(β^+)_ Ru100(n,tα)*Nb94*							8.9
		&Cd106(n,tα)*Rh100*(β^+)Ru100(n,tα)*Nb94*							4.5
		Cd106(n,nt)Ag103(β^+)Pd103(β^+)_ Rh103m(IT)Rh103(n,2n2α)Nb94							3.6
		Other pathways involving (n,2n), (n,α), β^+				87.1	93.6	84.9	82.7
Tc99	2.1 10^5 y	**&**Cd106(n,α)Pd103(β^+)*Rh103*(n,nα)*Tc99*				53.5	9.5	0.9	1.9
		&Cd106(n,α)Pd103(β^+)*Rh103*(n,2n)_ *Rh102*(n,α)*Tc99*				20.8			
		&Cd106(n,2nα)Pd101(β^+)Rh101m(β^+)_ Ru101(n,t)*Tc99*					8.2	39.1	5.4
		Cd106(n,nα)Pd102(n,3n)Pd100(β^+)_ Rh100(β^+)Ru100(n,d)Tc99					5.0	0.4	
		&Cd108(n,2nα)Pd103(β^+)Rh103m(IT)_ Rh103(n,nα)*Tc99*					1.8	2.9	0.3
		Cd106(n,nt)Ag103(β^+)Pd103(β^+)_ Rh103m(IT)Rh103(n,nα)Tc99					0.3	4.7	5.7
		&Cd106(n,dα)Rh101m(β^+)Ru101(n,t)*Tc99*						3.4	1.0
		&Cd106(n,3nα)Pd100(β^+)Rh100(β^+)_ Ru100(n,d)*Tc99*						1.1	8.1
		&Cd106(n,tα)*Rh100*(β^+)Ru100(n,d)*Tc99*							3.8
		Other pathways involving (n,2n), (n,α), β^+				25.7	75.2	47.5	73.8
Tc98	4.2 10^6 y ►	**&**Cd106(n,α)Pd103(β^+)*Rh103*(n,2n)_ Rh102(n,nα)Tc98				29.5	0.4		

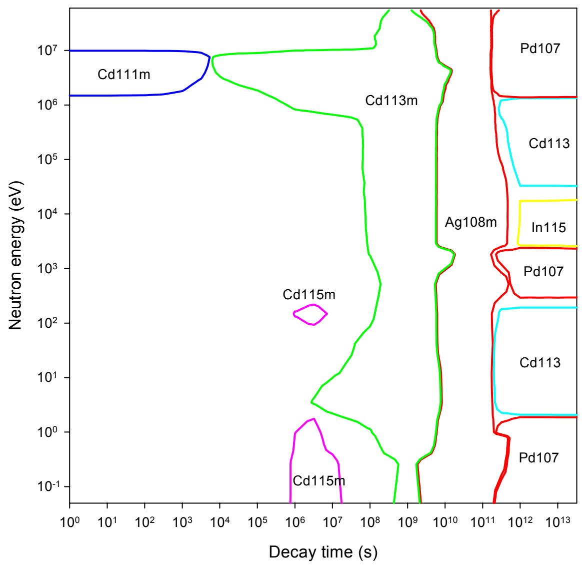
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Cd106(n,α)Pd103(β^+)*Rh103*(n,nα)_ Tc99(n,2n)Tc98				19.4	0.7		
		&Cd106(n,α)Pd103(β^+)*Rh103*(n,2n)_ Rh102m(n,nα)Tc98				9.2	0.2		
		Cd106(n,nα)Pd102(n,2n)Pd101(β^+)_ Rh101m(IT)Rh101(n,α)Tc98				5.2	0.2		
		&Cd106(n,nα)Pd102(n,p)*Rh102*(n,nα)Tc98				0.6	0.4		
		Cd106(n,nα)Pd102(n,2n)Pd101(β^+)_ Rh101(n,α)Tc98				0.2			
		Cd106(n,2nα)Pd101(β^+)Rh101m(β^+)_ Ru101(n,3n)Ru99(n,d)Tc98					5.5	1.1	
		Cd106(n,nα)Pd102(n,3n)Pd100(β^+)_ Rh100(β^+)Ru100(n,t)Tc98					5.4	0.7	
		Cd106(n,α)Pd103(β^+)Rh103m(IT)_ Rh103(n,2nα)Tc98					5.0	2.1	2.0
		Cd106(n,nα)Pd102(n,pα)Tc98					5.0	0.2	
		Cd106(n,2nα)Pd101(β^+)Rh101m(β^+)_ Ru101(n,nt)Tc98					1.7	14.6	5.1
		Cd108(n,2nα)Pd103(β^+)Rh103m(IT)_ Rh103(n,2nα)Tc98					1.0	6.9	0.4
		Cd106(n,nt)Ag103(β^+)Pd103(β^+)_ Rh103m(IT)Rh103(n,2nα)Tc98					0.2	14.0	7.9
		Cd106(n,3nα)Pd100(β^+)Rh100(β^+)_ Ru100(n,t)Tc98						1.7	7.4
		Other pathways involving (n,2n), (n,α), β^+				35.9	74.3	58.7	77.2
Pd107	6.5 10^6 y	**&**Cd108(n,γ)Cd109(n,α)Pd106(n,γ)*Pd107*	99.2	99.2	99.8				
		&Cd110(n,α)*Pd107*				75.6	30.3	9.9	8.9
		&Cd111(n,2n)Cd110(n,α)*Pd107*				9.4	1.1	0.2	
		&Cd111(n,α)Pd108(n,2n)*Pd107*				6.2	0.3		
		&Cd111(n,nα)*Pd107*				2.4	45.0	23.9	11.9
		&Cd112(n,3n)Cd110(n,α)*Pd107*					4.4	0.9	0.2
		&Cd112(n,2nα)*Pd107*					1.6	37.5	23.7
		&Cd112(n,4n)Cd109(β^+)Ag109m(IT)_ Ag109(n,t)*Pd107*						3.7	2.0
		&Cd113(n,3nα)*Pd107*						1.4	21.6
		&Cd114(n,4nα)*Pd107*							12.9
In115	4.4 10^{14} y	Cd114(n,γ)Cd115(β^-)In115m(IT)In115	75.6	75.8	86.0	0.1	0.2	0.2	0.2
		Cd114(n,γ)Cd115m(β^-)In115	10.3	9.9	11.7	0.1	0.1	0.1	0.1
		Cd113(n,γ)Cd114(n,γ)Cd115(β^-)_ In115m(IT)In115	8.4	12.7	1.9				
		Cd112(n,γ)Cd113(n,γ)Cd114(n,γ)_ Cd115(β^-)In115m(IT)In115	5.7						
		Cd113(n,γ)Cd114(n,γ)Cd115m(β^-)In115		1.6	0.3				
		Cd116(n,2n)Cd115m(β^-)In115				49.7	55.6	47.3	41.9
		Cd116(n,2n)Cd115(β^-)In115m(IT)In115				49.7	34.7	31.3	29.5
		Cd116(n,d)Ag115(β^-)Cd115(β^-)_ In115m(IT)In115					4.2	10.5	14.9
		Cd116(n,d)Ag115m(β^-)Cd115(β^-)_ In115m(IT)In115					3.4	7.4	10.1
Cd113	7.7 10^{15} y	Cd112(n,γ)Cd113	67.5	0.4	6.5				
		Cd111(n,γ)Cd112(n,γ)Cd113	25.4	0.2	0.3				
		Cd110(n,γ)Cd111(n,γ)Cd112(n,γ)Cd113	7.1						
		Cd114(n,2n)Cd113				20.5	5.1	3.4	2.2
		&Cd114(n,d)*Ag113*(β^-)Cd113					1.4	2.1	2.0
		Cd116(n,4n)Cd113						2.3	0.9
		Nuclide also present in starting material		99.4	93.2	79.5	93.5	92.2	94.9
Cd114	6.0 10^{17} y	Cd112(n,γ)Cd113(n,γ)Cd114	1.8		0.1				
		Cd113(n,γ)Cd114		19.7	4.2				
		Cd116(n,3n)Cd114					4.5	1.7	0.8
		Nuclide also present in starting material	98.2	80.3	95.7	100.0	95.5	98.3	99.2

Cadmium activation characteristics

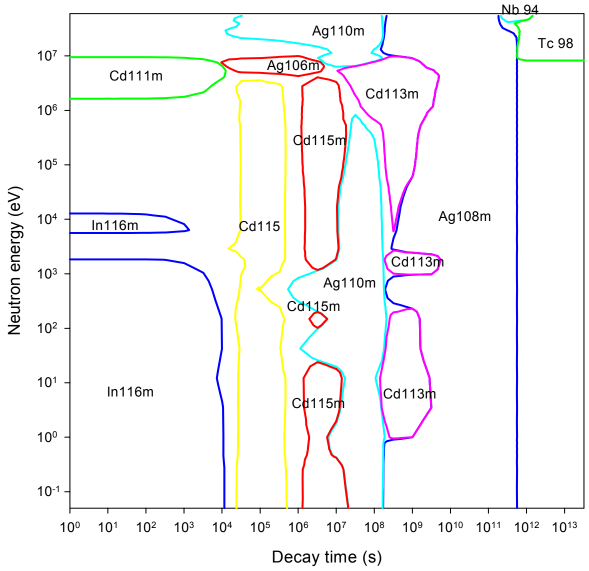


Cadmium importance diagrams & transmutation

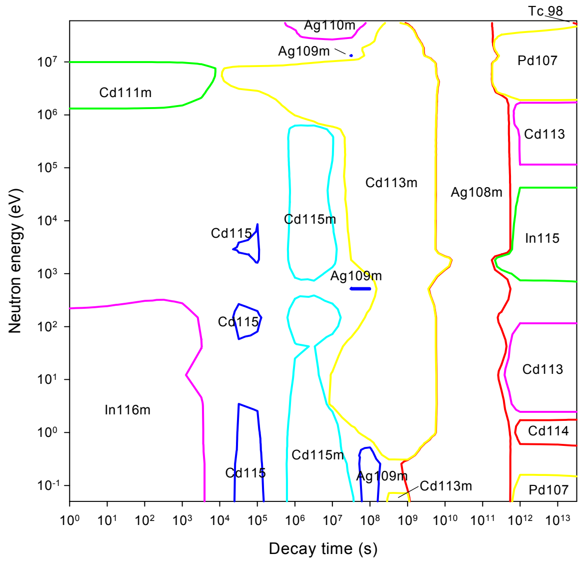
Activity



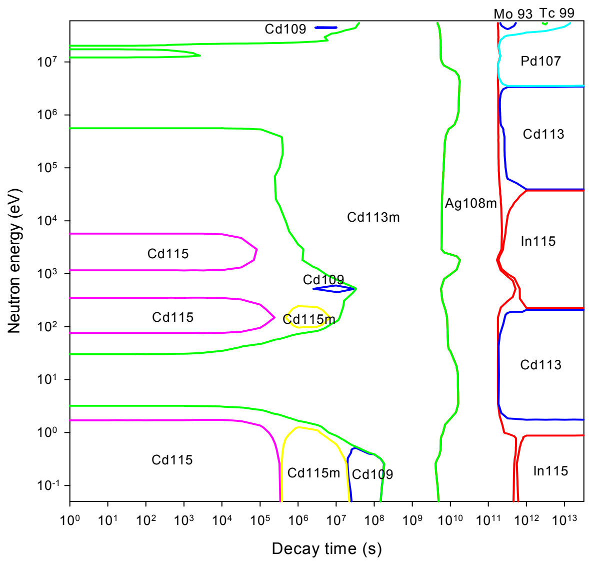
Dose rate



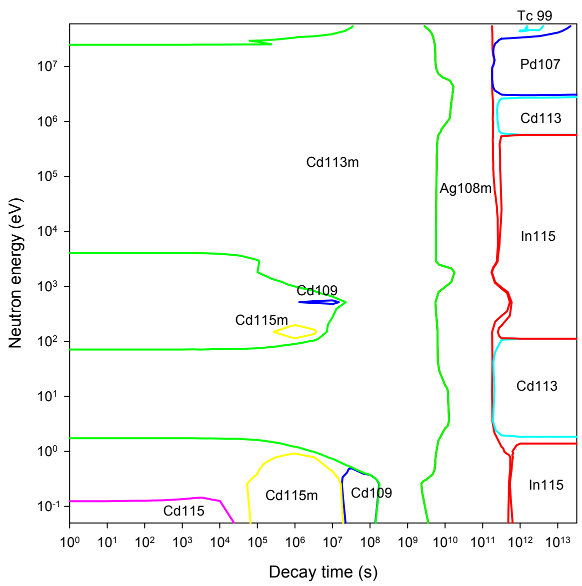
Heat output



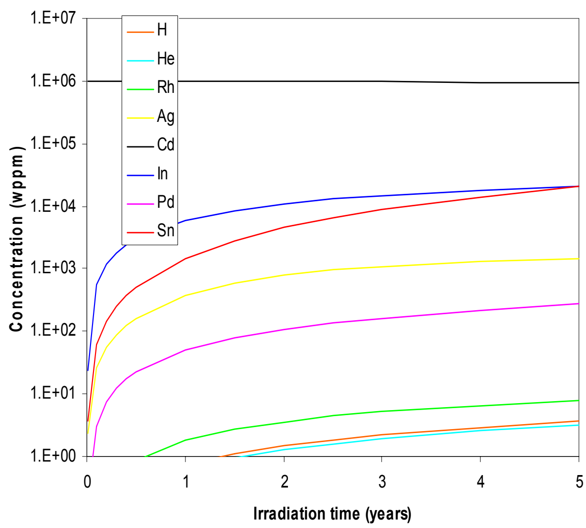
Ingestion dose



Inhalation dose



First wall transmutation



Indium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	49	In113	4.29
Crustal abundance / wppm	0.25	In115	95.71 ($T_{½}$ = 4.41 10^{14} y)
Melting point / K	429.8		
Boiling point / K	2345		
Density / kgm^{-3}	7310		
Thermal conductivity / $Wm^{-1}K^{-1}$	81.6		
Electrical resistivity /Ωm	8.37 10^{-8}		
Coefficient of thermal expansion / K^{-1}	3.21 10^{-5}		
Crystal structure	FCT		
Number of stable isotopes	1 (2)		
Mean atomic weight	114.818		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.65E16	8.99E15	9.38E14	1.18E13	1.72E9	6.62E1
In116m	50.60	86.94				
In116n	27.09					
In116	13.72					
In115m	6.19	1.12	0.14			
In114	4.02	4.78	42.40	22.46		
In114m	2.62	4.82	43.94	23.28		
Sn117m	0.50	0.93	7.41			
In113m	0.19	0.35	2.88	26.05		
Sn113	0.16	0.30	2.88	26.04		
Cd113m				1.87	98.77	
In115						88.55
Pd107						11.45

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	4.48E0	3.60E0	7.02E-2	6.48E-4	5.07E-8	1.44E-15
In116m	83.82	97.65				
In116	11.04					
In116n	2.59					
In114	1.83	1.48	70.29	50.64		
In114m	0.35	0.44	21.65	15.59		
In115m	0.12	0.15				
Sn117m	0.09	0.11	4.97			
In113m	0.04	0.05	2.42	29.72		
Sn113			0.18	2.24		
Cd113m				1.01	99.90	
In115						99.21
Pd107						0.78

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	6.19E6	5.79E6	5.89E3	1.38E2	7.71E-5	1.77E-13
In116m	99.73	99.83				
In114m	0.07	0.07	74.26	20.64		
In113m	0.01	0.01	15.20	71.94		
In114			4.27*	1.18*		
Sn117m			4.24			
Ag110m			0.34	5.25		
Ag108m					84.31	
Cd113m					15.60*	
Tc98						99.99

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	5.46E6	4.92E6	1.78E6	1.88E4	3.91E1	1.88E-6
Sn113m	55.17	51.38				
In114m	32.59	36.14	95.02	59.96		
In116m	9.80	10.17				
Sn117m	1.09	1.20	2.77			
Sn113	0.37	0.41	1.11	11.94		
In115m	0.16	0.17				
Cd113m	0.09	0.10	0.30	27.10	100.0	
Cd115m	0.07	0.08	0.22	0.07		
In113m	0.01	0.01	0.04	0.45		
In115						99.98

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	9.38E6	8.61E6	4.12E6	5.84E4	1.87E2	2.29E-5
Sn113m	49.35	45.02				
In114m	42.99	46.88	93.14	43.68		
In116m	4.00	4.08				
Sn117m	2.14	2.33	4.05			
Sn113	0.79	0.86	1.77	14.19		
Cd113m	0.27	0.29	0.62	41.63	99.99	
Cd115m	0.10	0.11	0.22	0.05		
In115m	0.06	0.06				
Cd115	0.04	0.05	0.03			
In113m	0.01	0.01	0.01	0.11		
Cd109				0.05		
In115						99.98

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	2.17E13	1.97E13	1.14E11	3.70E9	3.19E4	5.86E-2
In116m	96.24	99.33				
In116n	1.58					
In116	1.47					
In114	0.25	0.18	29.04	5.95		
In114m	0.19	0.22	36.11	7.40		
Sn117m	0.06	0.07	10.51			
Sn113	0.12		23.72	82.89		
Ag110m			0.23	2.69		
In113m			0.23	0.82		
Cd113m				0.11	98.72	
In115						99.99

Indium

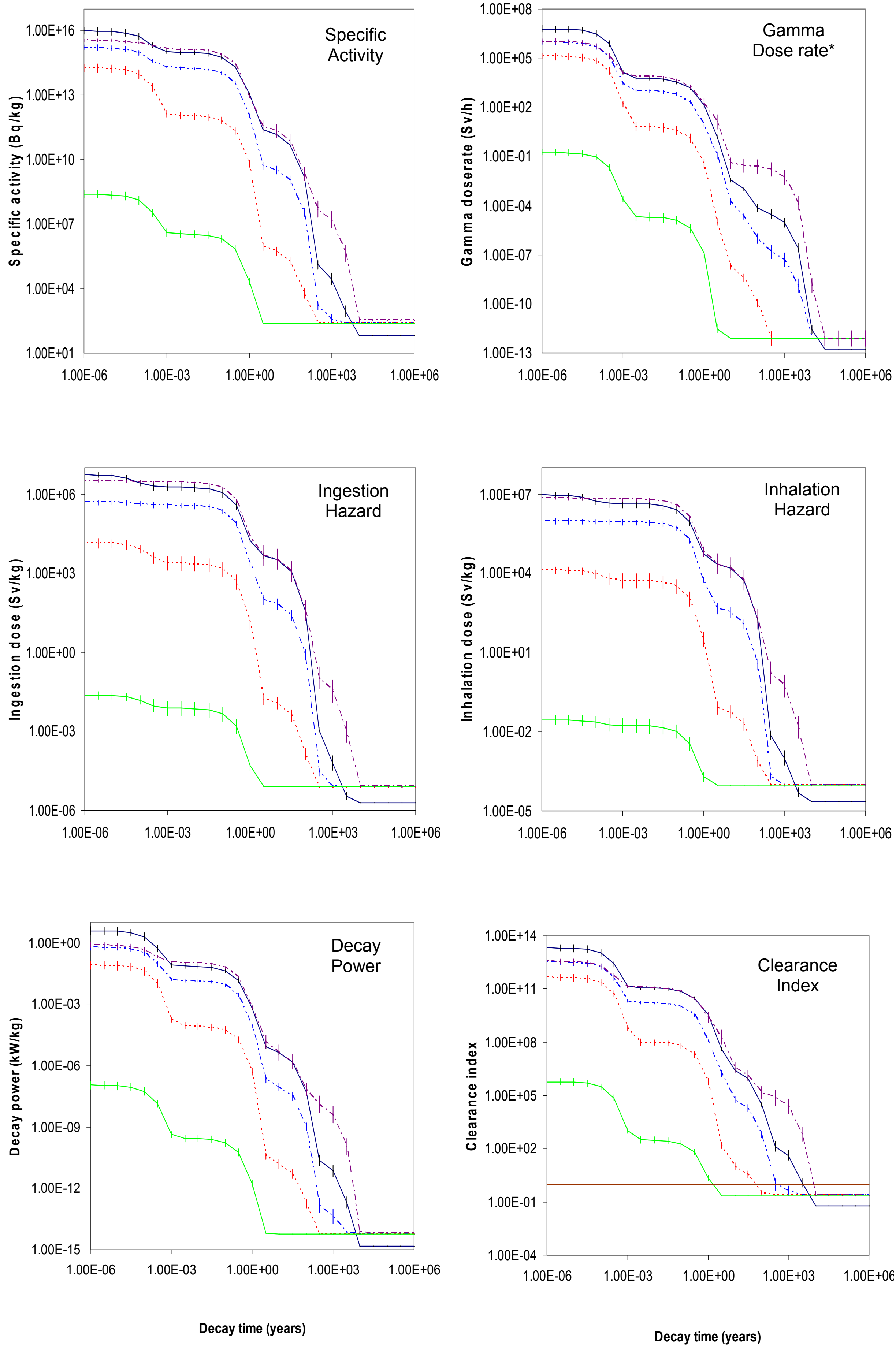
Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
In114	1.198 m	&In113(n,γ)*In114*	100.0	100.0	100.0				
		&In115(n,2n)*In114*				99.4	99.2	99.4	99.6
Sn109	18.0 m	&In115(n,4n)*In112*(β^-)Sn112(n,4n)Sn109						87.5	93.6
		In113(n,2n)In112m(IT)In112(β^-)_ Sn112(n,4n)Sn109						1.7	1.7
		In115(n,2n)In114(β^-)Sn114(n,3n)_ Sn112(n,4n)Sn109						1.4	
Sn113m	20.9 m	In115(n,2n)In114(β^-)Sn114(n,2n)Sn113m				99.2	98.5	97.6	98.6
		In115(n,2n)In114m(IT)In114(β^-)_ Sn114(n,2n)Sn113(n,n')Sn113m				0.1			
		In115(n,n')In115m(β^-)Sn115(n,3n)Sn113m					0.6	1.5	
In116m	54.6 m	&In113(n,γ)In114m(n,γ)*In115*(n,γ)_ *In116m*	99.3						
		&In115(n,γ)*In116m*	0.7	100.0	100.0	100.0	100.0	100.0	100.0
In113m	1.658 h	&In115(n,2n)*In114*(β^-)Sn114(n,2n)_ *Sn113*(β^+)In113m				97.4	27.9	16.8	14.3
		In113(n,n′)In113m				0.8	0.6	1.0	1.6
		In115(n,2n)In114m(n,2n)In113m				0.5			
		&In115(n,2n)*In114*(β^-)Sn114(n,d)In113m				0.2	2.1	2.8	3.4
		In115(n,3n)In113m					66.6	76.6	78.9
		In115(n,3n)In113(n,n')In113m					2.0	1.9	1.1
In115m	4.486 h	In113(n,γ)In114m(n,γ)In115m	97.7	99.9	90.2				
		In113(n,γ)In114m(β^+)Cd114(n,γ)_ Cd115(β^-)In115m	1.8		7.7				
		&In113(n,γ)*In114*(β^+)Cd114(n,γ)_ Cd115(β^-)In115m	0.5		1.8				
		In115(n,n′)In115m				91.5	83.2	82.2	84.2
		In115(n,p)Cd115(β^-)In115m				8.5	16.4	17.5	15.7
Sn121	1.128 d	&In115(n,γ)*In116m*(β^-)Sn116(n,γ)_ *Sn117*(n,γ)Sn118(n,γ)*Sn119*(n,γ)Sn120_ (n,γ)Sn121	77.4	77.3	84.0				
		&In115(n,γ)In116(β^-)Sn116(n,γ)_ *Sn117*(n,γ)Sn118(n,γ)*Sn119*(n,γ)_ Sn120(n,γ)Sn121	21.2	21.2	15.4				
Sn117m	13.6 d	&In115(n,γ)*In116m*(β^-)Sn116(n,γ)_ Sn117m	78.5	78.5	84.4	82.5	83.8	84.6	85.4
		In115(n,γ)In116(β^-)Sn116(n,γ)Sn117m	21.4	21.5	15.6	15.0	14.7	14.4	14.1
		&In115(n,γ)*In116m*(β^-)Sn116(n,γ)_ Sn117(n,n′)Sn117m				1.3	0.6	0.4	0.3
		In115(n,γ)In116(β^-)Sn116(n,γ)Sn117_ (n,n′)Sn117m				0.2	0.1		
In114m	50.0 d	In113(n,γ)In114m	100.0	100.0	100.0				
		In115(n,2n)In114m				99.5	99.3	99.4	99.7
Ag110m	249.78 d	In113(n,γ)In114m(n,α)Ag111(β^-)_ Cd111(n,α)Pd108(n,γ)Pd109(β^-)_ Ag109m(IT)Ag109(n,γ)Ag110m	35.0	35.8					
		In113(n,α)Ag110m				73.5	14.4	1.1	1.4
		&In115(n,2n)*In114*(β^-)Sn114(n,2n)_ *Sn113*(β^+)*In113*(n,α)Ag110m				19.7			
		&In115(n,3n)*In113*(n,α)Ag110m					40.3	1.7	0.8
		In115(n,3n)In113(n,3n)In111(β^+)_ Cd111(n,d)Ag110m					10.7	0.9	0.1
		In115(n,2nα)Ag110m					10.5	76.3	49.5
		&In113(n,3n)*In111*(β^+)Cd111(n,d)Ag110m					8.7	1.2	0.4
	►	&In115(n,4n)*In112*(β^+)Cd112(n,t)Ag110m						10.6	10.3

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	In115(n,nt)Cd112(n,t)Ag110m						1.0	6.4
		In115(n,5n)In111(β$^+$)Cd111(n,d)Ag110m							14.6
Sn119m	293.0 d	&In115(n,γ)*In116m*(β$^-$)Sn116(n,γ)_ *Sn117*(n,γ)Sn118(n,γ)Sn119m	78.3	78.3	84.4	79.1	76.6	77.3	78.7
		&In115(n,γ)In116(β$^-$)Sn116(n,γ)_ *Sn117*(n,γ)Sn118(n,γ)Sn119m	21.4	21.4	15.5	14.4	13.4	13.1	13.0
		&In115(n,γ)*In116m*(β$^-$)Sn116(n,γ)_ Sn117m(n,γ)Sn118(n,γ)Sn119m	0.1	0.2		4.1	7.4	7.3	6.6
		In115(n,γ)In116(β$^-$)Sn116(n,γ)_ Sn117m(n,γ)Sn118(n,γ)Sn119m				0.8	1.3	1.2	1.1
Cd113m	14.1 y	&In113(n,γ)*In114*(β$^-$)Sn114(n,γ)Sn115_ (n,α)Cd112(n,γ)Cd113m	61.8	0.2	93.2				
		In113(n,γ)In114m(n,γ)In115m(β$^-$)_ Sn115(n,α)Cd11(n,γ)Cd113m	27.2	0.2	3.6				
		&In113(n,γ)In114m(n,α)*Ag111*(β$^-$)_ Cd111(n,γ)Cd112(n,γ)Cd113m	10.8	97.6	3.0				
		&In113(n,γ)In114m(n,α)*Ag111*(n,γ)_ Ag112(β$^-$)Cd112(n,γ)Cd113m		1.7					
		In115(n,2n)In114m(β$^+$)Cd114(n,2n)Cd113m				59.5			
		In113(n,p)Cd113m				14.0	3.7		
		&In115(n,2n)*In114*(β$^+$)Cd114(n,2n)Cd113m				10.1			
		In115(n,d)Cd114(n,2n)Cd113m				9.5	9.4		
		In115(n,2n)In114m(n,d)Cd113m				1.7	0.9		
		In115(n,t)Cd113m				1.4	76.3	95.0	97.7
		In115(n,3n)In113(n,p)Cd113m					6.1		
Sn121m	55.0 y	&In115(n,γ)*In116m*(β$^-$)Sn116(n,γ)_ *Sn117*(n,γ)Sn118(n,γ)*Sn119*(n,γ)Sn120_ (n,γ)Sn121m	77.3	77.2	84.0				
		&In115(n,γ)In116(β$^-$)Sn116(n,γ)*Sn117*_ (n,γ)Sn118(n,γ)*Sn119*(n,γ)Sn120(n,γ)_ Sn121m	21.1	21.1	15.4				
Ag108m	418.0 y	&In113(n,2n)*In112*(β$^-$)Sn112(n,α)_ Cd109(β$^+$)*Ag109*(n,2n)Ag108m				37.9			
		&In113(n,nα)*Ag109*(n,2n)Ag108m				16.6	10.3	0.6	
		&In113(n,2n)*In112*(β$^+$)Cd112(n,α)_ *Pd109*(β$^-$)*Ag109*(n,2n)Ag108m				7.0			
		&In113(n,α)Ag110m(n,2n)*Ag109*_ (n,2n)Ag108m				6.5			
		In115(n,3n)In113(n,2nα)Ag108m					18.3	28.1	1.5
		In113(n,2nα)Ag108m					11.5	30.9	4.4
		&In115(n,3n)In113(n,nα)*Ag109*(n,2n)_ Ag108m					11.0	0.3	
		In113(n,3n)In111(β$^+$)Cd111(n,3n)Cd109_ (β$^+$)Ag109m(IT)Ag109(n,2n)Ag108m					7.9	0.3	
		In115(n,4nα)Ag108m							49.1
		&In115(n,5n)*In111*(β$^+$)Cd111(n,nt)Ag108m							20.1
		In113(n,α)Ag110(β$^-$)Cd110(n,2n)Cd109_ (β$^+$)Ag109m(IT)Ag109(n,2n)Ag108m							10.6
		Other similar long pathways				32.0	41.0	39.8	14.3
Mo93	4000 y	Pathways involving (n,α), (n,nα), (n,2n),β$^-$,β$^+$				100.0	100.0	100.0	100.0
Nb94	2.0 10^4 y	Pathways involving (n,α), (n,nα), (n,2n),β$^-$,β$^+$				100.0	100.0	100.0	100.0
Tc98	4.2 10^6 y	Pathways involving (n,α), (n,nα), (n,2n),β$^-$,β$^+$				100.0	100.0	100.0	100.0
Pd107	6.5 10^6 y	&In113(n,α)*Ag110*(β$^-$)Cd110(n,α)*Pd107*				18.4			
		&In113(n,2n)*In112*(β$^+$)Cd112(n,2n)_ *Cd111*(n,2n)Cd110(n,α)*Pd107*				12.4			
		&In113(n,2n)*In112*(β$^+$)Cd112(n,2n)_ *Cd111*(n,α)Pd108(n,2n)*Pd107*				8.2			
		&In113(n,α)Ag110m(β$^-$)Cd110(n,α)*Pd107*				7.7			
	►	&In113(n,2n)*In112*(β$^+$)Cd112(n,2n)_ *Cd111*(n,nα)*Pd107*				6.6			

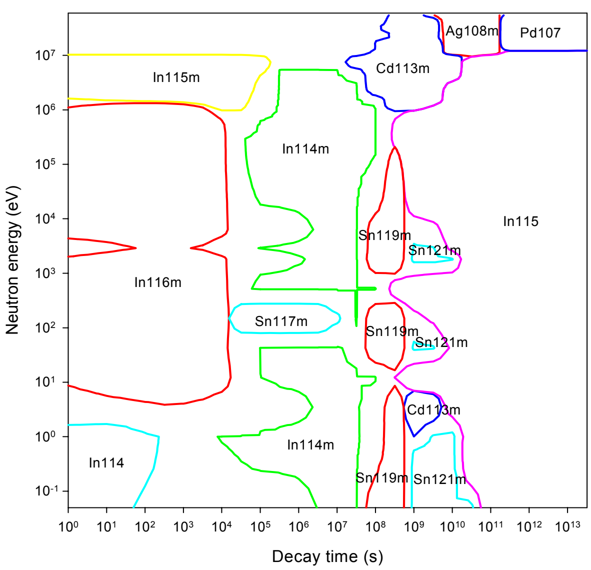
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&In113(n,2n)*In112*(β⁻)Sn112(n,2n)Sn111_ (β⁺)In111(β⁺)*Cd111*(n,2n)Cd110(n,α)*Pd107*				5.5			
		&In113(n,2n)*In112*(β⁻)Sn112(n,2n)_ Sn111(β⁺)In111(β⁺)*Cd111*(n,nα)*Pd107*				4.5			
		&In115(n,2n)*In114*(β⁻)Sn114(n,α)_ *Cd111*(n,2n)Cd110(n,α)*Pd107*				4.1			
		&In113(n,2n)*In112*(β⁻)Sn112(n,2n)Sn111_ (β⁺)In111(β⁺)*Cd111*(n,α)Pd108(n,2n)*Pd107*				4.0			
		In113(n,α)Ag110m(n,α)Rh107(β⁻)Pd107				1.9			
		&In115(n,nα)*Ag111*(β⁻)Cd111(n,nα)*Pd107*				0.1	15.2	4.8	0.8
		&In115(n,3n)In113(n,3n)*In111*(β⁺)_ Cd111(n,nα)*Pd107*					35.0	3.6	0.1
		&In113(n,3n)*In111*(β⁺)Cd111(n,nα)*Pd107*					30.4	6.1	0.6
		&In115(n,4n)*In112*(β⁺)Cd112(n,2nα)*Pd107*						47.1	11.9
		&In115(n,nt)Cd112(n,2nα)*Pd107*						4.4	7.4
		&In115(n,3nα)*Ag109*(n,t)*Pd107*						1.0	11.7
		&In115(n,t)Cd113m(n,3nα)*Pd107*						0.7	6.5
		&In115(n,t)Cd113(n,3nα)*Pd107*						0.4	4.4
		&In115(n,5n)In111(β⁺)Cd111(n,nα)*Pd107*							21.7
		Other similar pathways				26.6	19.4	31.9	34.9
In115	4.4 10^{14} y	&In113(n,γ)In114m(n,γ)*In115*	98.3						
		In113(n,γ)In114m(β⁺)Cd114(n,γ)_ Cd115(β⁻)In115m(IT)In115	0.8						
		In113(n,γ)In114m(β⁺)Cd114(n,γ)_ Cd115m(β⁻)In115	0.1						
		Nuclide also present in starting material	0.8	100.0	100.0	100.0	100.0	100.0	100.0

Indium activation characteristics

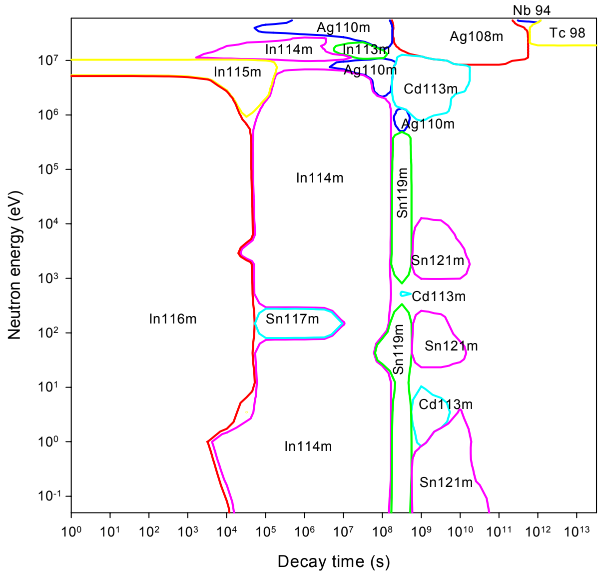


Indium importance diagrams & transmutation

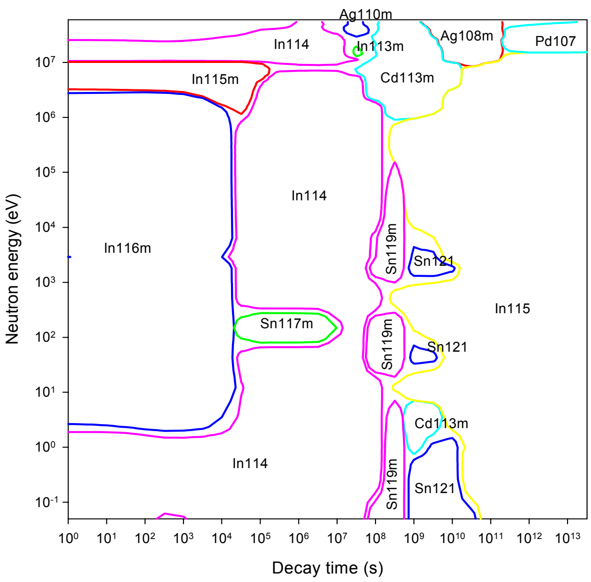
Activity



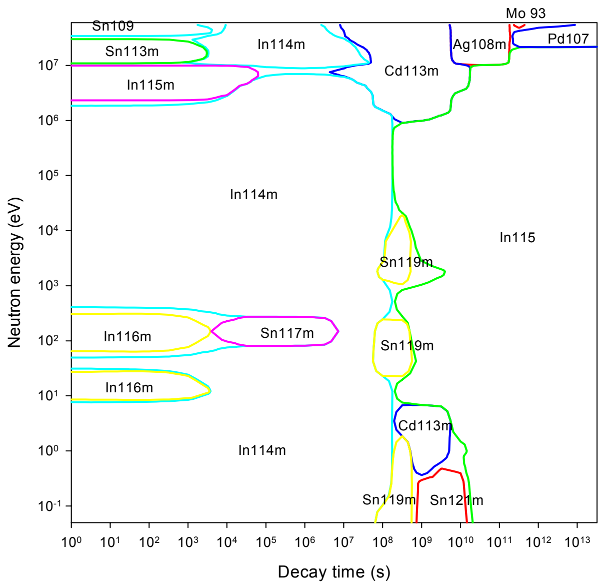
Dose rate



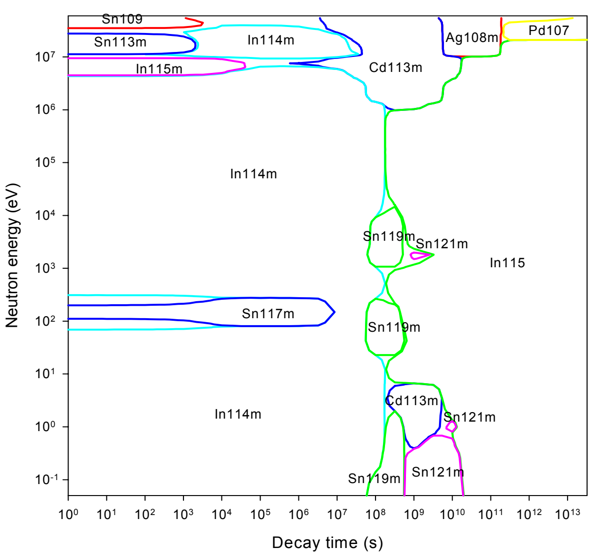
Heat output



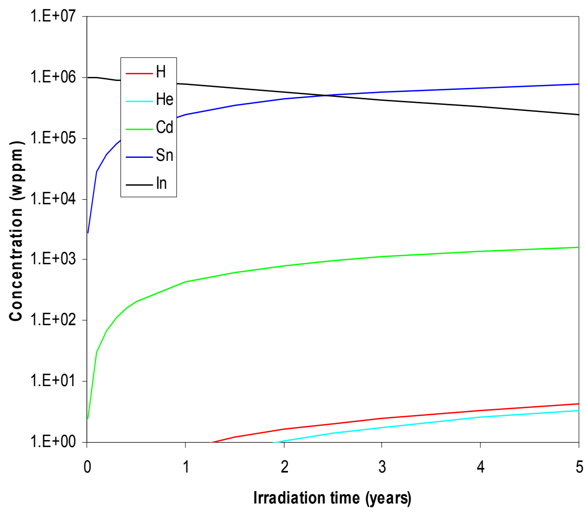
Ingestion dose



Inhalation dose



First wall transmutation



Tin

General properties

		Isotopes	Isotopic abundances / %
Atomic number	50		
Crustal abundance / wppm	2.3	Sn112	0.97
Melting point / K	505.1	Sn114	0.66
Boiling point / K	2875	Sn115	0.34
Density / kgm^{-3}	5750	Sn116	14.54
Thermal conductivity / $Wm^{-1}K^{-1}$	66.6	Sn117	7.68
Electrical resistivity /Ωm	$1.10\ 10^{-7}$	Sn118	24.22
Coefficient of thermal expansion / K^{-1}	$2.2\ 10^{-5}$	Sn119	8.59
Crystal structure	Cubic	Sn120	32.58
Number of stable isotopes	9 (10)	Sn122	4.63
Mean atomic weight	118.710	Sn124	5.79 ($T_{½} = 1.00\ 10^{17}$ y)

Activation properties

Act	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Bq kg^{-1}	9.95E14	9.45E14	6.47E14	1.52E14	8.51E11	7.74E4
Sn119m	20.18	21.25	30.79	55.66		
Sn117m	18.05	19.00	23.06			
Sn121	12.94	13.49	2.27	0.85	43.68	
Sn125m	6.51	4.67				
Sb122	5.52	5.80	3.32			
Sn123	5.08	5.35	7.66	4.68		
In113m	5.06	5.33	7.59	3.66		
Sn113	5.04	5.31	7.59	3.65		
Sb125	4.70	4.95	7.22	23.98		
Sn123m	3.05	4.67				
Sb124	2.35	2.48	3.47	0.23		
In114	2.17	1.24	1.66	0.04		
Sn113m	1.75	1.55				
In114m	1.17	1.23	1.72	0.04		
Te125m	1.07	1.13	1.65	5.69		
Sb126m	0.35	0.31				35.59
Sb126n	0.32					23.82
Sn121m			0.26	1.09	56.29	
Sb126			0.24			4.98
Sn126						35.59

Heat	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
kW kg^{-1}	7.00E-2	6.27E-2	3.75E-2	5.72E-3	9.98E-6	1.25E-11
Sn125m	17.10	13.03				
Sn117m	12.87	14.38	19.97			
Sb122	12.63	14.11	9.24			
Sb124	11.97	13.38	21.46	2.18		
Sn123	6.12	6.84	11.23	10.56		
Sb125	5.75	6.43	10.74	54.83		
In113m	4.51	5.04	8.22	6.09		
Sn123m	4.29	4.38				
Sn119m	4.11	4.60	7.63	21.23		
In114	3.82	2.33	3.55	0.15		
Sn121	3.36	3.75	0.72	0.41	68.80	
Sb126m	1.78	1.65				77.75
In116m	1.42	1.48				
Sb126	1.37	1.53	2.10			15.40
Sn111	1.04	1.05				
Sn125	0.65	0.73	0.94			
In114m	0.61	0.68	1.09			
Te125m			0.64	3.40		
Sn121m			0.02	0.18	31.11	
Sn126						6.31

Dose	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv h^{-1}	3.48E4	3.21E4	2.18E4	3.49E3	9.48E-3	1.20E-5
Sb124	35.79	38.77	54.78	5.32		
Sb122	13.25	14.34	8.28			
Sb125	11.43	12.38	18.20	88.70		
Sn125m	8.75	6.46				
In116m	4.74	4.80				
In113m	4.60	4.98	7.15	5.06		
Sb126m	3.54	3.20			0.13	79.89
Sb126	3.47	3.76	4.52		0.03	20.05
In118m	2.29	1.10				
Sn111	2.07	2.02				
Sb120m	2.05	2.22	2.11			
Sn117m	1.73	1.87	2.29			
In120m	1.40					
Sn121m					94.58	
Ag108m					5.23	

Ing	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	6.20E7	4.28E7	5.37E5	9.93E4	2.74E2	1.74E-4
Sn125m	95.27	94.01				
Sn113m	3.67	4.46				
Sn117m	0.20	0.29	19.73			
Sn123	0.17	0.24	19.40	15.07		
Sb122	0.15	0.21	6.81			
Sn119m	0.11	0.15	12.62	28.98		
Sb124	0.09	0.13	10.47	0.88		
Sb125	0.08	0.12	9.58	40.38		
In114m	0.07	0.11	8.50	0.30		
Sn113	0.05	0.08	6.68	4.09		
Sn121	0.04	0.06	0.63	29.00	31.17	
Te125m	0.01	0.02	1.73			
Sn125	0.01	0.01	1.12	7.57		
Sb126		0.01	0.70			5.32
Cd113m			0.17	0.88	2.46	
Sn121m			0.11	0.63	66.37	
Sn126						74.50
Sn124						19.50
Sb126m						0.57

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.03E8	7.18E7	2.31E6	7.51E5	2.27E3	9.09E-4		6.61E11	6.44E11	5.86E11	3.73E11	8.27E6	5.79E1
Sn125m	94.21	92.45					Sb125	70.85	72.78	79.77	97.72		
Sb125	0.54	0.78	24.33	58.25			Sn113	7.59	7.80	8.38	1.49		
Sn119m	0.42	0.61	19.00	24.79			Sn117m	4.68	4.81	4.38			
Sn117m	0.41	0.60	15.52				Sn125m	4.26	2.98				
Sn123	0.39	0.57	17.42	7.68			Sb124	3.54	3.64	3.83	0.09		
Sb124	0.19	0.28	8.38	0.40			Sb126m	0.87	0.75				77.97
Sn113	0.13	0.18	5.75	2.00			Sn123m	0.86	0.81				
In114m	0.10	0.15	4.48	0.09			Sb122	0.83	0.85	0.36			
Sb122	0.05	0.08	1.02				In116m	0.83	0.80				
Te125m	0.04	0.06	1.95	4.83			Sb126	0.81	0.83	0.74			18.50
Sn121	0.02	0.04	0.14		3.76		Sn126	0.81					3.17
Te123m	0.01	0.01	0.54	0.20			Sn119m	0.58	0.60	0.65	0.43		
Sn121m		0.01	0.32	0.99	94.82		Sn111	0.52	0.48				
Sn125		0.01	0.26				Sn123	0.44	0.46	0.49	0.11		
Sb126			0.21			1.35	In118m	0.43	0.19				
Cd113m			0.19	0.55	1.14		Sb120m	0.41	0.42	0.30			
Te121m			0.08				Sn121	0.22	0.22	0.02		51.65	
Sn126						84.84	In113m			0.08	0.01		
Sn124						13.74	In111			0.04			
Sb126m						0.06	Sn121m					48.25	

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Pathway analysis

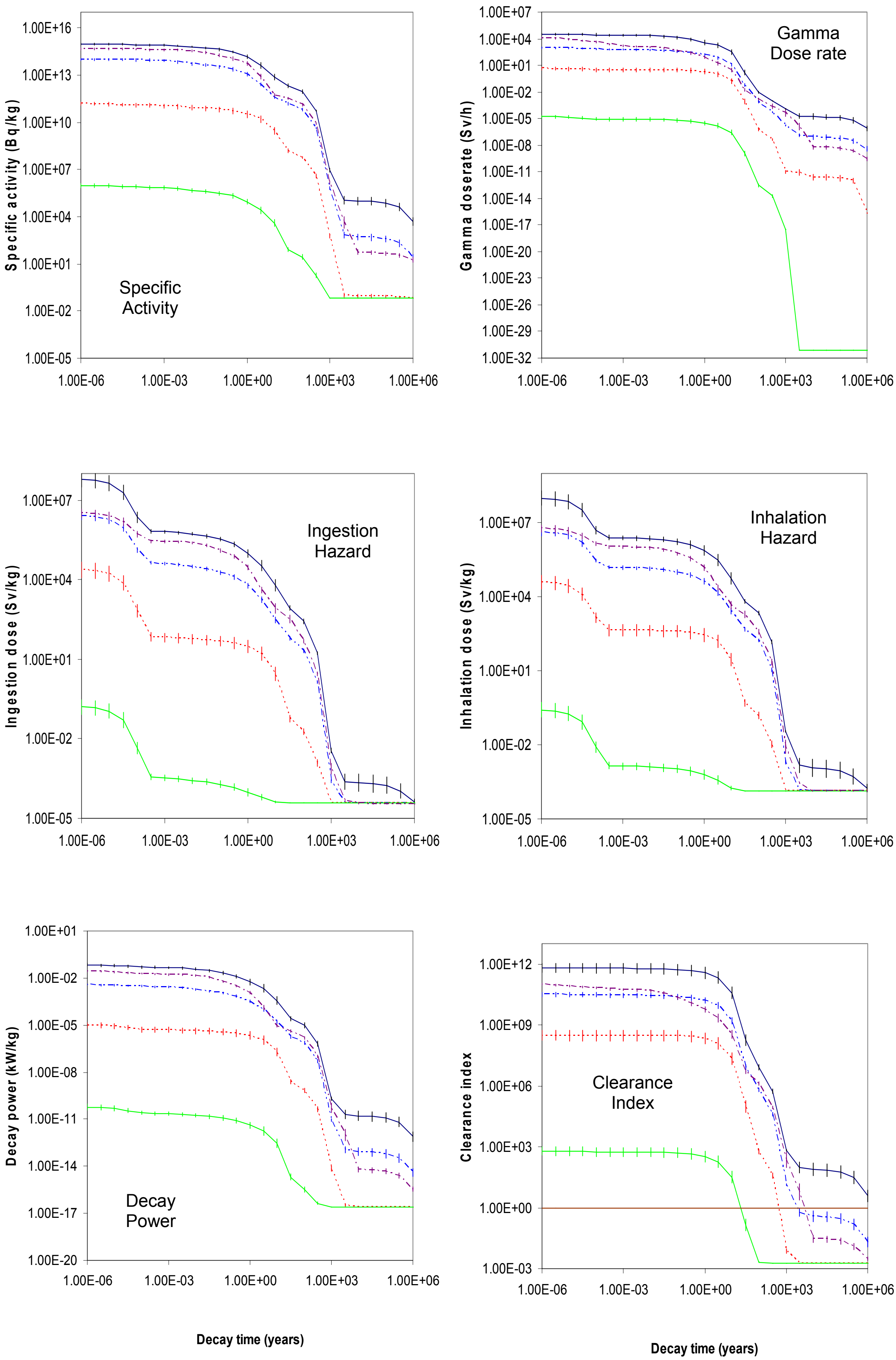
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Sn125m	9.52 m	Sn124(n,γ)Sn125m	100.0	100.0	100.0	99.9	99.7	99.8	99.9
Sb126m	19.1 m	&Sn124(n,γ)Sn125m(β^-)Sb125(n,γ)_ *Sb126m*	93.0	95.7	93.4	39.1	40.5	43.6	45.4
		&Sn124(n,γ)Sn125(β^-)Sb125(n,γ)*Sb126m*	3.2	3.6	3.3	59.6	57.9	55.0	53.3
Sn113m	20.9 m	Sn112(n,γ)Sn113m	100.0	100.0	100.0				
		Sn114(n,2n)Sn113m				56.5	7.7	1.8	0.7
		Sn116(n,2n)Sn115(n,2n)Sn114(n,2n)Sn113m				33.8	0.9		
		Sn115(n,2n)Sn114(n,2n)Sn113m				6.7	0.4		
		Sn116(n,2n)Sn115(n,3n)Sn113m					26.9	6.1	0.9
		Sn116(n,3n)Sn114(n,2n)Sn113m					21.4	4.7	0.6
		Sn117(n,3n)Sn115(n,3n)Sn113m					20.5	6.0	0.5
		Sn115(n,3n)Sn113m					5.8	2.8	0.6
		Sn116(n,4n)Sn113m						43.9	44.8
		Sn118(n,4n)Sn115(n,3n)Sn113m						11.6	2.8
		Sn118(n,3n)Sn116(n,4n)Sn113m						8.6	3.0
		Sn117(n,5n)Sn113m							19.1
		Sn120(n,5n)Sn116(n,4n)Sn113m							7.3
In116m	54.6 m	&Sn112(n,γ)*Sn113*(β^+)In113m(IT)_ In113(n,γ)In114m(n,γ)*In115*(n,γ)*In116m*	89.4	87.1	91.1				
		&Sn112(n,γ)Sn113m(β^+)In113(n,γ)_ In114m(n,γ)*In115*(n,γ)*In116m*	2.6	2.8	3.3				
		&Sn116(n,p)*In116m*				82.6	31.9	11.9	4.1
		&Sn117(n,2n)Sn116(n,p)*In116m*				10.4	1.2	0.3	
		&Sn118(n,2n)*Sn117*(n,2n)Sn116(n,p)*In116m*				3.4			
		&Sn117(n,d)*In116m*				1.9	30.1	19.3	11.1
		&Sn118(n,2n)*Sn117*(n,d)*In116m*				1.4	8.8	2.8	0.9
		&Sn118(n,3n)Sn116(n,p)*In116m*					7.7	2.2	0.2
		&Sn118(n,t)*In116m*					7.2	41.4	42.4
		&Sn119(n,3n)*Sn117*(n,d)*In116m*					5.5	1.5	0.3
		&Sn120(n,3n)Sn118(n,t)*In116m*					1.7	5.4	2.1
		&Sn119(n,nt)*In116m*					0.4	3.5	14.4
		&Sn120(n,4n)*Sn117*(n,d)*In116m*						6.6	2.3
		&Sn120(n,2nt)*In116m*							16.4
In113m	1.658 h	&Sn112(n,γ)*Sn113*(β^+)In113m	100.0	100.0	100.0				
		&Sn114(n,2n)*Sn113*(β^+)In113m				60.4	8.5	2.0	0.8
		&Sn116(n,2n)Sn115(n,2n)Sn114(n,2n)_ *Sn113*(β^+)In113m				30.2	0.8		
		&Sn115(n,2n)Sn114(n,2n)*Sn113*(β^+)In113m				6.6	0.3		
		&Sn116(n,2n)Sn115(n,3n)*Sn113*(β^+)In113m					25.0	5.3	0.7
		&Sn116(n,3n)Sn114(n,2n)*Sn113*(β^+)In113m					21.7	4.8	0.6
		&Sn117(n,3n)Sn115(n,3n)*Sn113*(β^+)In113m					19.1	5.3	0.4
		&Sn115(n,3n)*Sn113*(β^+)In113m					6.0	2.7	0.6
		&Sn116(n,4n)*Sn113*(β^+)In113m						44.5	43.5
		&Sn118(n,4n)Sn115(n,3n)*Sn113*(β^+)In113m						10.1	2.6
		&Sn118(n,3n)Sn116(n,4n)*Sn113*(β^+)In113m						7.9	2.6
		&Sn117(n,5n)*Sn113*(β^+)In113m							18.9
		&Sn120(n,5n)Sn116(n,4n)*Sn113*(β^+)In113m							6.5
Sn121	1.128 d	Sn120(n,γ)Sn121	97.0	93.7	99.1	1.4	4.1	1.1	1.2
		Sn119(n,γ)Sn120(n,γ)Sn121	2.9	6.3	0.8				
		&Sn122(n,2n)*Sn121*				96.9	49.7	12.4	11.3
		Sn122(n,d)In121(β^-)Sn121					16.6	15.8	24.5
		Sn124(n,3n)Sn122(n,2n)Sn121					11.5	1.1	
		Sn122(n,d)In121m(β^-)Sn121					4.9	3.3	4.6
		&Sn124(n,4n)*Sn121*					4.5	60.3	25.7
		Sn124(n,nt)In121(β^-)Sn121					0.1	1.7	27.3
		Sn124(n,nt)In121m(β^-)Sn121							3.6
Sb122	2.70 d▶	&Sn120(n,γ)Sn121(β^-)Sb121(n,γ)*Sb122*	98.0	95.2	98.8				

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Sn119(n,γ)Sn120(n,γ)Sn121(β^-)_ Sb121(n,γ)*Sb122*	1.5	4.7	0.4				
		&Sn124(n,2n)Sn123(β^-)Sb123(n,2n)*Sb122*				66.7	76.5	67.8	62.1
		&Sn124(n,2n)Sn123m(β^-)Sb123(n,2n)*Sb122*				31.3	16.8	13.7	11.7
		&Sn124(n,d)In123(β^-)Sn123m(β^-)_ Sb123(n,2n)*Sb122*					2.4	7.4	20.6
		&Sn124(n,d)In123m(β^-)Sn123m(β^-)_ Sb123(n,2n)*Sb122*					0.6	1.4	3.4
Sn117m	13.60 d	Sn116(n,γ)Sn117m	98.2	99.6	99.9				
		Sn115(n,γ)Sn116(n,γ)Sn117m	1.8		0.1				
		Sn118(n,2n)Sn117m				80.2	47.4	24.0	24.1
		Sn119(n,2n)Sn118(n,2n)Sn117m				7.3	1.2	0.4	
		Sn117(n,n′)Sn117m				4.9	2.3	1.7	1.5
		&Sn120(n,2n)*Sn119*(n,2n)Sn118(n,2n)_ Sn117m				2.7			
		Sn118(n,2n)Sn117(n,n′)Sn117m				1.8	0.2		
		Sn119(n,3n)Sn117m					26.5	13.4	9.0
		Sn120(n,3n)Sn118(n,2n)Sn117m					11.5	3.3	
		&Sn120(n,2n)*Sn119*(n,3n)Sn117m					6.2	1.9	
		Sn120(n,4n)Sn117m						50.2	56.6
		Sn122(n,6n)Sn117m							1.1
Sb124	60.20 d	&Sn122(n,γ)Sn123m(β^-)Sb123(n,γ)*Sb124*	99.1	61.0	98.6				
		Sn122(n,γ)Sn123(β^-)Sb123(n,γ)Sb124	0.6	0.4	1.4				
		&Sn120(n,γ)Sn121(β^-)Sb121(n,γ)_ *Sb122*(n,γ)Sb123(n,γ)Sb124	0.3	37.6					
		Sn119(n,γ)Sn120(n,γ)Sn121(β^-)Sb121_ (n,γ)Sb122(n,γ)Sb123(n,γ)Sb124		0.9					
		&Sn124(n,2n)Sn123(β^-)Sb123(n,γ)_ *Sb124*				51.9	67.4	60.6	55.2
		&Sn124(n,2n)Sn123m(β^-)Sb123(n,γ)_ *Sb124*				24.8	14.9	12.4	10.4
		&Sn124(n,γ)Sn125(β^-)Sb125(n,2n)_ *Sb124*				13.8	7.1	4.9	4.6
		&Sn124(n,γ)Sn125m(β^-)Sb125(n,2n)_ *Sb124*				9.1	4.3	4.0	3.9
		&Sn124(n,d)In123(β^-)Sn123m(β^-)_ Sb123(n,γ)*Sb124*					4.0	11.9	17.5
		&Sn124(n,d)In123m(β^-)Sn123m(β^-)_ Sb123(n,γ)*Sb124*					0.9	2.2	2.9
Sn113	115.09 d	&Sn112(n,γ)*Sn113*	100.0	100.0	100.0				
		&Sn114(n,2n)*Sn113*				60.9	9.0	2.1	0.9
		&Sn116(n,2n)Sn115(n,2n)Sn114(n,2n)*Sn113*				30.5	0.8		
		&Sn115(n,2n)Sn114(n,2n)*Sn113*				6.6	0.3		
		&Sn116(n,2n)Sn115(n,3n)*Sn113*					26.2	5.6	0.8
		&Sn116(n,3n)Sn114(n,2n)*Sn113*					22.7	5.1	0.7
		&Sn117(n,3n)Sn115(n,3n)*Sn113*					19.8	5.5	0.5
		&Sn115(n,3n)*Sn113*					6.2	2.8	0.6
		&Sn116(n,4n)*Sn113*						46.6	45.8
		&Sn118(n,4n)Sn115(n,3n)*Sn113*						10.7	2.7
		&Sn118(n,3n)Sn116(n,4n)*Sn113*						8.3	2.8
		&Sn117(n,5n)*Sn113*							19.8
		&Sn120(n,5n)Sn116(n,4n)*Sn113*							6.8
Sn123	129.2 d	Sn122(n,γ)Sn123	99.9	99.9	100.0		0.2		
		Sn124(n,2n)Sn123				99.9	99.0	98.1	97.3
Ag110m	249.78 d	Sn112(n,α)Cd109(β^+)Ag109m(IT)_ Ag109(n,γ)Ag110m	100.0	100.0	100.0	0.2			
		&Sn114(n,2n)*Sn113*(β^+)In113m(IT)_ In113(n,α)Ag110m				44.8	2.7	0.2	
		Sn112(n,2n)Sn111(β^+)In111(β^+)Cd111_ (n,2n)Cd110(n,p)Ag110m				20.9	0.6		
	►	Sn112(n,2n)Sn111(β^+)In111(β^+)Cd111_ (n,d)Ag110m				17.4	28.0	5.9	1.4

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Sn112(n,d)*In111*(β^+)Cd111(n,d)Ag110m				0.8	13.1	3.7	1.1
		Sn112(n,3n)Sn110(β^+)In110m(β^+)_ Cd110(n,p)Ag110m					12.8	6.3	0.6
		Sn116(n,nα)Cd112(n,t)Ag110m					1.1	4.8	1.9
		&Sn116(n,d)*In115*(n,2nα)Ag110m					0.3	7.6	1.7
		&Sn116(n,2nα)*Cd111*(n,d)Ag110m					0.2	6.3	2.2
		Sn118(n,3nα)Cd112(n,t)Ag110m						0.1	6.0
		Sn116(n,tα)Ag110m							6.0
		Other pathways involving (n,2n), (n,α), β^+				15.9	41.2	65.1	79.1
Sn119m	293.0 d	Sn118(n,γ)Sn119m	98.6	99.5	98.8				
		Sn117(n,γ)Sn118(n,γ)Sn119m	1.4	0.4	1.2				
		Sn116(n,γ)Sn117(n,γ)Sn118(n,γ)Sn119m		0.1					
		Sn120(n,2n)Sn119m				91.5	84.0	57.0	58.3
		Sn119(n,n′)Sn119m				5.0	10.3	9.0	9.1
		Sn120(n,2n)Sn119(n,n′)Sn119m				1.9			
		Sn122(n,4n)Sn119m					0.2	27.1	17.2
		Sn124(n,6n)Sn119m							10.7
Sb125	2.759 y	Sn124(n,γ)Sn125m(β^-)Sb125	95.7	96.3	96.2	39.6	41.1	44.3	46.1
		Sn124(n,γ)Sn125(β^-)Sb125	3.7	3.7	3.8	60.4	58.8	55.5	53.7
		Sn122(n,γ)Sn123m(β^-)Sb123(n,γ)_ Sb124(n,γ)Sb125	0.6						
H3	12.33 y	**&**Sn120(n,γ)Sn121(β^-)Sb121(n,γ)_ *Sb122*(n,X)H1(n,γ)H2(n,γ)H3	84.5	94.0	18.6				
		&Sn112(n,γ)*Sn113*(n,X)H1(n,γ)H2(n,γ)H3	7.0	0.5	76.9				
		Sn117(n,X)H3				27.8	12.4	9.5	8.4
		Sn119(n,X)H3				20.1	13.1	10.2	9.2
		&Sn118(n,2n)*Sn117*(n,X)H3				10.7	1.9	0.8	0.3
		Sn116(n,2n)Sn115(n,X)H3				8.9	1.4	0.5	0.3
		&Sn120(n,2n)*Sn119*(n,X)H3				7.6	1.4	0.6	0.4
		Sn124(n,2n)Sn123(β^-)Sb123(n,X)H3				6.6	0.3	0.1	
		&Sn122(n,2n)*Sn121*(β^-)Sb121(n,X)H3				5.2			
		Sn116(n,X)H3				0.1	12.6	12.9	13.1
		Sn120(n,X)H3					21.0	25.0	27.1
		Sn118(n,X)H3					18.2	20.0	21.0
Cd113m	14.1 y	Sn115(n,α)Cd112(n,γ)Cd113m	97.8	49.7	96.6				
		&Sn112(n,γ)*Sn113*(n,α)Cd110(n,γ)_ *Cd111*(n,γ)Cd112(n,γ)Cd113m	1.0	48.4					
		Sn114(n,γ)Sn115(n,α)Cd112(n,γ)Cd113m	0.8	1.2	1.4				
		Sn116(n,α)Cd113m				84.2	51.2	17.9	12.3
		Sn117(n,2n)Sn116(n,α)Cd113m				5.8	1.1	0.2	0.1
		Sn117(n,α)Cd114(n,2n)Cd113m				3.6	0.3		
		Sn117(n,nα)Cd113m				3.0			
		Sn117(n,nα)Cd113m				0.4	26.4	19.1	8.7
		Sn118(n,3n)Sn116(n,α)Cd113m					6.8	1.8	0.4
		&Sn118(n,2n)*Sn117*(n,nα)Cd113m					4.1	1.6	0.4
		Sn118(n,2nα)Cd113m					0.5	38.1	30.9
		&Sn120(n,4n)*Sn117*(n,nα)Cd113m						3.5	1.0
		Sn119(n,3nα)Cd113m						0.6	18.7
		Sn120(n,4nα)Cd113m							12.6
Sn121m	55.0 y	Sn120(n,γ)Sn121m	98.3	95.9	99.6	0.7	3.0		
		Sn119(n,γ)Sn120(n,γ)Sn121m	1.7	4.1	0.4				
		Sn122(n,2n)Sn121m				98.9	67.1	7.2	12.0
		Sn124(n,4n)Sn121m					13.9	90.9	82.6
		Sn124(n,3n)Sn122(n,2n)Sn121m					8.5		
		Sn124(n,2n)Sn123(n,3n)Sn121m					4.4		
		Sn122(n,d)In121(β^-)Sn121m					1.9		
Ag108m	418.0 y	Sn112(n,α)Cd109(β^+)Ag109m(IT)_ Ag109(n,2n)Ag108m				88.4	12.7	0.6	0.4
	►	Sn112(n,3n)Sn110(β^+)In110m(β^+)_ Cd110(n,t)Ag108m					12.8	19.4	2.2

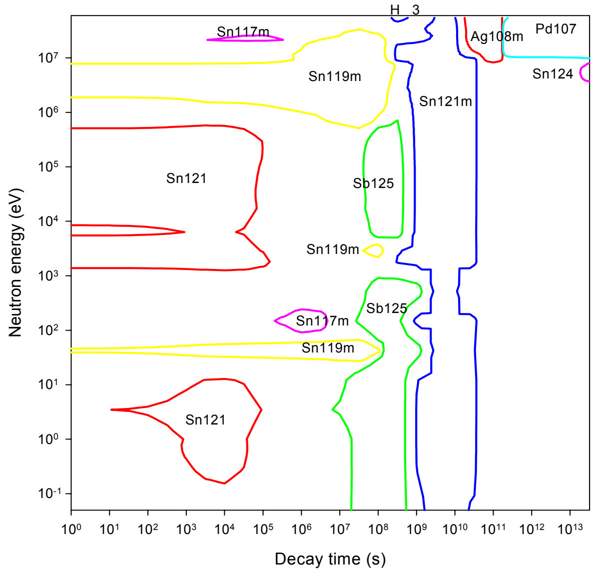
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	Sn112(n,d)In111(β^+)Cd111(n,3n)Cd109_ (β^+)Ag109m(IT)Ag109(n,2n)Ag108m					5.3		
		Sn112(n,pα)Ag108m					4.2	1.5	0.3
		Sn112(n,t)In110(β^+)Cd110(n,t)Ag108m					1.2	6.5	1.0
		Sn112(n,t)In110m(β^+)Cd110(n,t)Ag108m					1.1	6.0	1.0
		&Sn116(n,4n)*Sn113*(β^+)In113m(IT)_ In113(n,2nα)Ag108m						17.7	5.9
		Sn116(n,3nα)Cd110(n,t)Ag108m						0.2	4.9
		Other pathways involving (n,2n), (n,α), β^+				11.6	62.7	48.1	84.3
Mo93	4000 y	Pathways involving (n,α), (n,nα), (n,2n), β^-,β^+				100.0	100.0	100.0	100.0
Nb94	2.0 10^4 y	Pathways involving (n,α), (n,nα), (n,2n), β^-,β^+				100.0	100.0	100.0	100.0
Tc98	4.2 10^6 y	Pathways involving (n,α), (n,nα), (n,2n), β^-,β^+				100.0	100.0	100.0	100.0
Pd107	6.5 10^6 y	**&**Sn112(n,α)Cd109(n,α)Pd106(n,γ)*Pd107*	99.9	99.3	100.0				
		Sn112(n,2n)Sn111(β^+)In111(β^+)Cd111_ (n,2n)Cd110(n,α)Pd107				24.0	0.2		
		Sn112(n,2n)Sn111(β^+)In111(β^+)Cd111_ (n,α)Pd108(n,2n)Pd107				18.5			
		&Sn112(n,2n)Sn111(β^+)In111(β^+)_ Cd111(n,nα)*Pd107*				17.3	36.9	2.1	
		&Sn112(n,d)*In111*(β^+)Cd111(n,2n)_ Cd110(n,α)*Pd107*				2.0	0.2		
		&Sn112(n,d)*In111*(β^+)Cd111(n,nα)*Pd107*				0.7	17.3	4.2	
		&Sn112(n,3n)Sn110(β^+)In110m(β^+)_ Cd110(n,α)*Pd107*					16.5	1.9	
		&Sn116(n,nα)Cd112(n,2nα)*Pd107*					0.2	5.9	
		&Sn116(n,2nα)*Cd111*(n,nα)Pd107m_ (IT)*Pd107*					0.1	7.4	
		&Sn117(n,2nα)Cd112(n,2nα)*Pd107*						4.2	
		&Sn116(n,2n2α)*Pd107*							5.9
		Sn118(n,3nα)Cd112(n,2nα)Pd107m_ (IT)Pd107							2.9
		Pathways involving (n,2n), (n,α), β^+	0.1	0.7		37.5	28.6	74.3	91.2
Sn124	1.0 10^{17} y	Nuclide present in starting material	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Tin activation characteristics

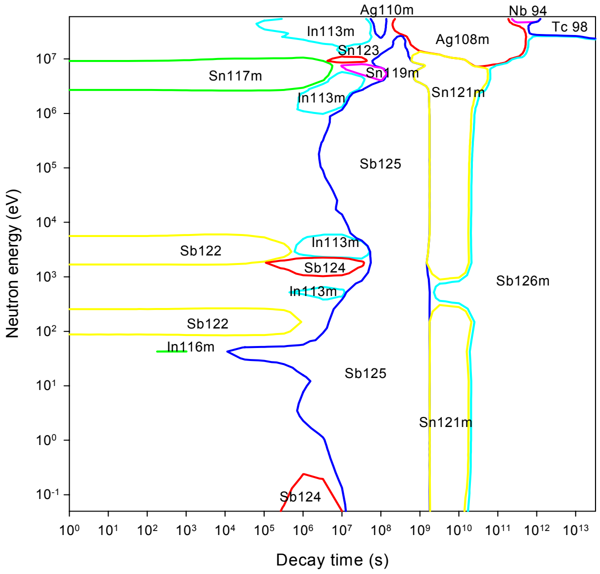


Tin importance diagrams & transmutation

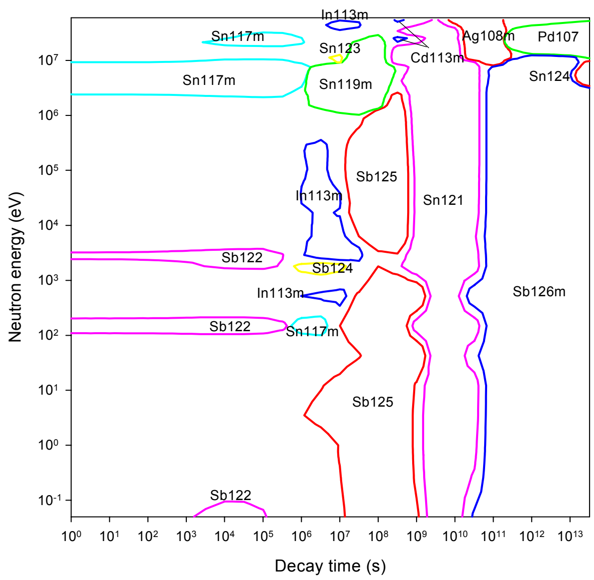
Activity



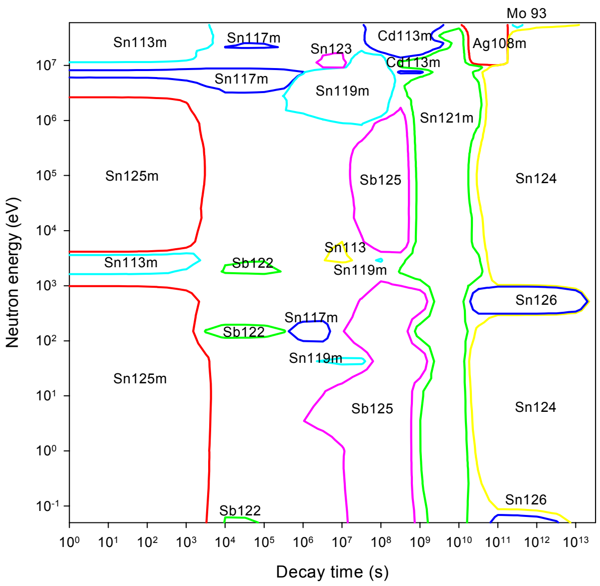
Dose rate



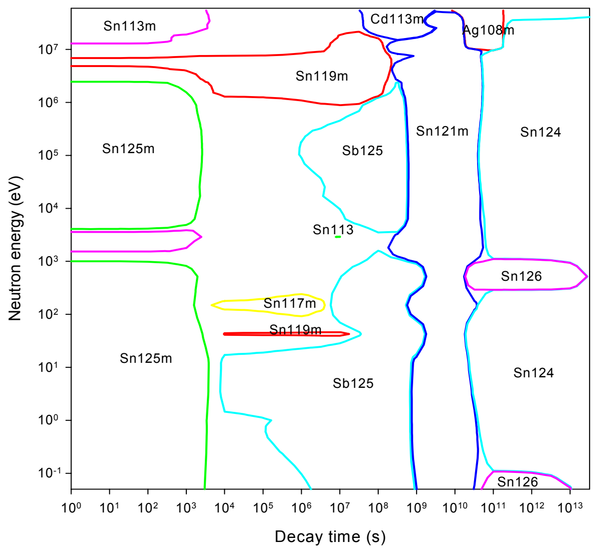
Heat output



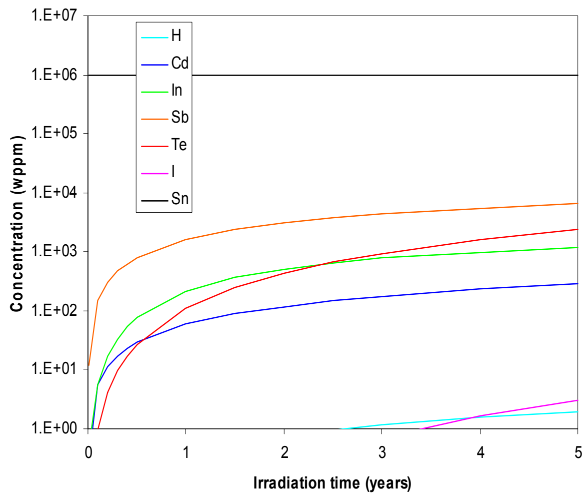
Ingestion dose



Inhalation dose



First wall transmutation



Antimony

General properties

		Isotopes	Isotopic abundances / %
Atomic number	51		
Crustal abundance / wppm	0.2	Sb121	57.21
Melting point / K	903.8	Sb123	42.79
Boiling point / K	1860		
Density / kgm^{-3}	6691		
Thermal conductivity / $Wm^{-1}K^{-1}$	24.3		
Electrical resistivity /Ωm	$3.90\ 10^{-7}$		
Coefficient of thermal expansion / K^{-1}	$1.1\ 10^{-5}$		
Crystal structure	Rhombohedral		
Number of stable isotopes	2		
Mean atomic weight	121.76		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.10E16	1.06E16	6.47E15	2.56E14	9.85E10	7.99E1	kW kg^{-1}	2.25E0	2.23E0	1.56E0	2.96E-2	1.15E-6	1.23E-14
Sb122	52.51	54.32	34.97				Sb124	51.63	52.06	71.22	58.52		
Sb124	29.47	30.51	48.05	18.92			Sb122	41.45	41.76	23.35			
Te123m	5.99	6.20	9.98	31.00			Sb120m	2.08	2.09	1.92			
Sb122m	4.13	1.79					Sb120	1.40	1.12				
Sb120	2.32	1.91					Te123m	1.15	1.16	1.62	10.47		
Te121	1.54	1.60	2.46	7.13			Te121	0.71	0.72	0.96	5.81		
Sb120m	1.05	1.09	1.16				Sb122m	0.53	0.22				
Te121m	0.85	0.88	1.42	7.04			Sb125	0.35	0.36	0.51	20.83		
Sb125	0.84	0.87	1.42	27.98			Sb124m	0.25	0.08				
Te125m	0.22	0.23	0.38	6.65			Te121m	0.20	0.20	0.28	2.90		
Sn121	0.08	0.08	0.02	0.06	43.66		Sb126m	0.11	0.10				77.41
Sn119m	0.06	0.06	0.10	1.09			Sb126	0.08	0.09	0.10			15.33
Sb126m	0.06	0.05				33.90	Te125m	0.03	0.03	0.04	1.30		
Sb126n	0.06						Sn121	0.01	0.01		0.01	68.86	
Sb126	0.03	0.04	0.05			4.75	Sn126	0.08	0.09	0.10			15.33
Sn121m				0.08	56.26		Sn121m					31.13	
Sn126						33.90	Sb126n						0.54
I129						4.75	I129						0.43
Te123						0.03							

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	2.34E6	2.33E6	1.92E6	3.42E4	1.01E-3	1.18E-8	Sv kg^{-1}	1.94E7	1.94E7	1.30E7	3.76E5	3.10E1	5.55E-7
Sb124	73.62	73.93	86.13	75.17			Sb122	50.57	50.55	29.53			
Sb122	20.57	20.64	9.83				Sb124	41.73	41.75	59.66	32.16		
Sb120m	3.18	3.19	2.50				Te123m	4.75	4.75	6.94	29.52		
Sb120	0.91	0.73					Te121m	1.10	1.10	1.62	11.01		
Te121	0.73	0.73	0.83	5.36			Sb125	0.52	0.52	0.77	20.93		
Sb125	0.33	0.33	0.40	17.67			Te121	0.38	0.38	0.53	2.09		
Sb124m	0.26	0.08					Te125m	0.11	0.11	0.16	3.94		
Sb126	0.10	0.10	0.10			20.06	Sn121	0.01	0.01		0.01	31.96	
Sb126m	0.10	0.09				79.88	Sn121m				0.02	68.04	
Te123m	0.09	0.09	0.10	0.71			I129						75.18
Te121m	0.08	0.08	0.10	1.09			Sn126						22.92
Sn121m					100.0		Te123						0.02

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y	Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	3.96E7	3.96E7	3.44E7	1.87E6	2.59E2	9.09E-7		6.02E12	5.95E12	5.20E12	8.58E11	9.57E5	4.36E-1
Sb124	70.43	70.45	77.65	22.27			I129						86.98
Sb122	16.06	16.05	7.23				Sb124	53.87	54.50	59.75	5.64		
Te123m	8.49	8.50	9.56	21.64			Sb125	15.28	15.46	17.63	83.39		
Sb125	2.79	2.79	3.20	45.95			Te123m	10.95	11.08	12.41	9.24		
Te121m	1.34	1.34	1.52	5.49			Sb122	9.60	9.71	4.35			
Te125m	0.26	0.26	0.30	3.82			Sb120m	4.70	4.75	3.50			
Te121	0.18	0.18	0.19	0.40			Te121	1.66	1.68	1.80	1.25		
Sn121	0.01	0.01			3.82		Te121m	0.35	0.36	0.40	0.48		
Sn121m				0.05	96.18		Sb126m	0.19	0.16				10.17
Sn126						83.42	Sb126	0.18	0.18	0.17			2.41
I129						15.03	Sn121					51.66	
Te123						0.01	Sn121m					48.26	
							Sn126						0.41

Antimony

Pathway analysis

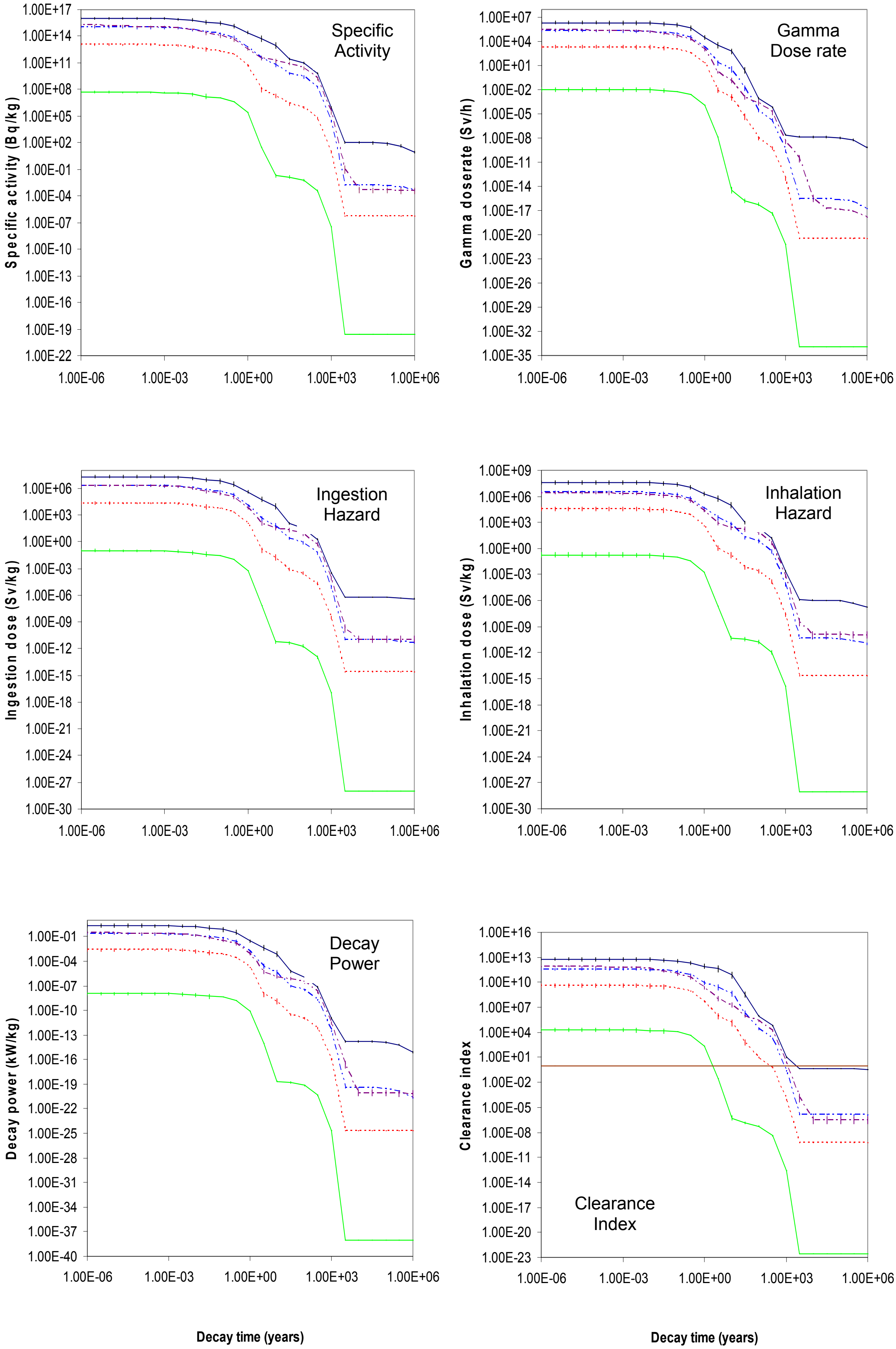
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Sn113m	20.9 m	**&**Sb121(n,α)In118m(β$^-$)Sn118(n,2n)_ *Sn117*(n,2n)Sn116(n,2n)Sn115(n,2n)_ Sn114(n,2n)Sn113m				14.0			
		&Sb121(n,α)In118(β$^-$)Sn118(n,2n)_ *Sn117*(n,2n)Sn116(n,2n)Sn115(n,2n)_ Sn114(n,2n)Sn113m				12.9			
		Sb121(n,nα)In117(β$^-$)Sn117(n,2n)Sn116_ (n,2n)Sn115(n,2n)Sn114(n,2n)Sn113m				10.4			
		&Sb121(n,3n)Sb119(β$^+$)Sn119(n,3n)_ *Sn117*(n,3n)Sn115(n,3n)Sn113m					62.4	1.3	
		Sb121(n,nα)In117(β$^-$)Sn117(n,3n)_ Sn115(n,3n)Sn113m					13.0	1.0	
		Sb121(n,3n)Sb119(β$^+$)Sn119(n,4n)_ Sn116(n,4n)Sn113m						19.7	1.0
		Sb121(n,4n)Sb118(β$^+$)Sn118(n,4n)_ Sn115(n,3n)Sn113m						16.3	0.6
		Sb121(n,4n)Sb118(β$^+$)Sn118(n,3n)_ Sn116(n,4n)Sn113m						12.1	0.6
		&Sb121(n,2nα)*In116m*(β$^-$)Sn116(n,4n)_ Sn113m						8.0	2.2
		Sb121(n,4n)Sb118m(β$^+$)Sn118(n,4n)_ Sn115(n,3n)Sn113m						7.0	0.5
		Sb121(n,4n)Sb118m(β$^+$)Sn118(n,3n)_ Sn116(n,4n)Sn113m						5.2	0.5
		Sb121(n,5n)Sb117(β$^+$)Sn117(n,5n)Sn113m							54.0
		&Sb121(n,2nt)*Sn117*(n,5n)Sn113m							8.1
		Other pathways involving (n,2n), (n,α), β$^+$				62.7	24.6	29.4	32.5
In113m	1.658 h	**&**Sb121(n,nα)In117(β$^-$)Sn117(n,2n)_ Sn116(n,2n)Sn115(n,2n)Sn114(n,2n)_ *Sn113*(β$^+$)In113m				11.1			
		&Sb121(n,3n)Sb119(β$^+$)Sn119(n,3n)_ *Sn117*(n,3n)Sn115(n,3n)*Sn113*(β$^+$)In113m					23.4	0.2	
		&Sb121(n,nα)In117(β$^-$)Sn117(n,3n)_ Sn115(n,3n)*Sn113*(β$^+$)In113m					13.3		
		&Sb121(n,3n)Sb119(β$^+$)Sn119(n,4n)_ Sn116(n,4n)*Sn113*(β$^+$)In113m						19.2	0.9
		&Sb121(n,4n)Sb118(β$^+$)Sn118(n,4n)_ Sn115(n,3n)*Sn113*(β$^+$)In113m						15.1	0.5
		&Sb121(n,4n)Sb118(β$^+$)Sn118(n,3n)_ Sn116(n,4n)*Sn113*(β$^+$)In113m						11.8	0.5
		&Sb121(n,2nα)*In116m*(β$^-$)Sn116(n,4n)_ *Sn113*(β$^+$)In113m						8.5	
		&Sb121(n,4n)Sb118m(β$^+$)Sn118(n,4n)_ Sn115(n,3n)*Sn113*(β$^+$)In113m						6.4	0.4
		&Sb121(n,4n)Sb118m(β$^+$)Sn118(n,3n)_ Sn116(n,4n)*Sn113*(β$^+$)In113m						5.0	0.4
		&Sb121(n,5n)Sb117(β$^+$)Sn117(n,5n)_ *Sn113*(β$^+$)In113m							52.9
		&Sb121(n,2nt)*Sn117*(n,5n)*Sn113*(β$^+$)In113m							7.9
		Other pathways involving (n,2n), (n,α), β$^+$				88.9	63.3	33.8	36.5
Sn121	1.128 d	**&**Sb121(n,γ)*Sb122*(β$^-$)Te122(n,γ)_ Te123m(n,α)Sn120(n,γ)Sn121	83.8	83.5	42.3				
		&Sb121(n,γ)*Sb122*(β$^-$)Te122(n,γ)_ *Te123*(n,α)Sn120(n,γ)Sn121	6.7	7.3	32.4				
	►	**&**Sb123(n,γ)Sb124(β$^-$)Te124(n,α)*Sn121*	1.8		24.8				

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Sb121(n,γ)*Sb122*(β^-)Te122(n,γ)_ *Te123*(n,γ)Te124(n,α)Sn121	0.2						
		&Sb121(n,p)*Sn121*				40.8	31.2	8.0	2.6
		&Sb123(n,2n)*Sb122*(β^+)Sn122(n,2n)*Sn121*				30.5	0.6		
		&Sb123(n,2n)Sb122m(IT)Sb122(β^+)_ Sn122(n,2n)*Sn121*				14.4	1.2		
		&Sb123(n,d)Sn122(n,2n)*Sn121*				5.8	7.8	2.0	
		Sb121(n,2n)Sb120(β^+)Sn120(n,γ)Sn121				3.4	0.5		
		Sb121(n,2n)Sb120m(β^+)Sn120(n,γ)Sn121				1.6	0.4		
		&Sb123(n,t)*Sn121*				0.9	49.0	82.2	90.4
		&Sb123(n,3n)Sb121(n,p)*Sn121*					4.0		
		Sb123(n,d)Sn122(n,d)In121(β^-)Sn121					2.3	2.2	
		Sb123(n,h)In121(β^-)Sn121					0.1	2.0	2.4
Sb119	1.596 d	Sb121(n,2n)Sb120m(n,2n)Sb119				57.5			
		&Sb123(n,2n)Sb122(β^-)*Te122*(n,2n)_ Te121m(n,2n)Te120(n,2n)Te119(β^+)Sb119				19.0			
		&Sb123(n,2n)*Sb122*(β^-)Te122(n,2n)_ Te121m(n,2n)Te120(n,2n)Te119m(β^+)Sb119				17.1			
		&Sb123(n,2n)Sb122(β^-)Te122(n,2n)_ *Te121*(n,2n)Te120(n,2n)Te119(β^+)Sb119				2.7			
		&Sb123(n,2n)Sb122(β^-)Te122(n,2n)*Te121*_ (n,2n)Te120(n,2n)Te119m(β^+)Sb119				2.4			
		Sb121(n,3n)Sb119					87.5	91.5	38.9
		Sb123(n,3n)Sb121(n,3n)Sb119					11.9	6.7	
		Sb123(n,5n)Sb119							58.2
Sb122	2.70 d	&Sb121(n,γ)*Sb122*	100.0	100.0	100.0	0.2	0.4		
		&Sb123(n,2n)*Sb122*				99.8	99.6	100.0	100.0
Sb120m	5.76 d	Sb121(n,2n)Sb120m				98.1	87.7	51.5	58.1
		Sb123(n,2n)Sb122(β^-)Te122(n,2n)_ Te121(β^+)Sb121(n,2n)Sb120m				0.6			
		Sb123(n,3n)Sb121(n,2n)Sb120m					11.9	3.7	
		Sb123(n,4n)Sb120m						44.2	39.6
Te121	19.16 d	&Sb123(n,2n)*Sb122*(β^-)Te122(n,2n)*Te121*				99.6	99.3	98.9	98.8
Sb124	60.20 d	&Sb123(n,γ)*Sb124*	99.8	98.7	100.0	99.7	99.6	99.6	94.6
		Sb121(n,γ)Sb122(n,γ)Sb123(n,γ)Sb124	0.1	1.2					
Te123m	119.5 d	&Sb121(n,γ)*Sb122*(β^-)Te122(n,γ)Te123m	99.9	100.0	100.0		0.1	0.1	0.1
		&Sb123(n,2n)*Sb122*(β^-)Te122(n,γ)Te123m				47.9	32.2	35.1	33.1
		&Sb123(n,γ)*Sb124*(β^-)Te124(n,2n)Te123m				42.8	56.8	54.5	56.6
		&Sb123(n,γ)*Sb124m*(β^-)Te124(n,2n)Te123m				7.0	9.6	9.1	9.4
Sn123	129.2 d	&Sb121(n,γ)*Sb122*(β^+)Sn122(n,γ)Sn123	99.9	100.0	100.0				
		Sb123(n,p)Sn123				99.8	99.8	99.8	99.8
		Sb123(n,2n)Sb122(β^+)Sn122(n,γ)Sn123				0.1			
Te121m	154.0 d	&Sb123(n,2n)*Sb122*(β^-)Te122(n,2n)Te121m				99.7	99.3	98.8	98.8
		Sb121(n,γ)Sb122(β^-)Te122(n,2n)Te121m				0.2	0.4		
Ag110m	249.78 d	Pathways involving (n,α), (n,nα), (n,2n), β^-,β^+				100.0	100.0	100.0	100.0
Sn119m	293.0 d	&Sb121(n,γ)*Sb122*(β^-)Te122(n,α)Sn119m	99.9	99.9	100.0				
		Sb121(n,2n)Sb120(β^+)Sn120(n,2n)Sn119m				65.6	14.4	3.0	1.1
		Sb121(n,2n)Sb120m(β^+)Sn120(n,2n)Sn119m				31.1	11.4	2.4	
		Sb121(n,d)Sn120(n,2n)Sn119m				0.7	4.5	1.8	
		Sb121(n,t)Sn119m					32.6	66.1	66.5
		Sb121(n,3n)Sb119(β^+)Sn119(n,n′)Sn119m					25.1	6.7	1.4
		Sb123(n,3n)Sb121(n,t)Sn119m					3.5	3.8	1.5
		Sb123(n,4n)Sb120(β^+)Sn120(n,2n)Sn119m						5.3	1.5
		Sb123(n,d)Sn122(n,4n)Sn119m						3.9	1.2
		Sb123(n,2nt)Sn119m						0.7	19.6
Sb125	2.759 y	&Sb123(n,γ)*Sb124*(n,γ)Sb125	99.9	98.9	100.0	99.6	99.5	99.5	99.7
		Sb121(n,γ)Sb122(n,γ)Sb123(n,γ)Sb124_ (n,γ)Sb125		1.0					
H3	12.33 y	&Sb121(n,γ)*Sb122*(n,X)H1(n,γ)H2(n,γ)H3	93.3	94.5	99.3				
		Sb121(n,X)H3				70.6	54.8	53.6	52.6
	►	Sb123(n,X)H3				27.9	35.9	37.2	37.6

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Sb123(n,3n)Sb121(n,X)H3					3.7	2.0	
		Sb121(n,3n)Sb119(β^+)Sn119(n,X)H3					3.0	2.1	
		Sb121(n,5n)Sb117(β^+)Sn117(n,X)H3							1.3
		Sb123(n,5n)Sb119(β^+)Sn119(n,X)H3							1.3
Cd113m	14.1 y	**&**Sb121(n,α)In118m(β^-)Sn118(n,2n)_ Sn117(n,2n)Sn116(n,α)Cd113m				11.0			
		&Sb121(n,α)In118(β^-)Sn118(n,2n)_ *Sn117*(n,2n)Sn116(n,α)Cd113m				10.1			
		&Sb121(n,2n)Sb120(β^+)Sn120(n,2n)_ *Sn119*(n,2n)Sn118(n,2n)*Sn117*(n,2n)_ Sn116(n,α)Cd113m				7.7			
		&Sb121(n,α)In118m(β^-)Sn118(n,2n)_ *Sn117*(n,α)Cd114(n,2n)Cd113m				6.8			
		Sb121(n,nα)In117(β^-)Sn117(n,2n)_ Sn116(n,α)Cd113m				6.4	0.3		
		&Sb121(n,α)In118(β^-)Sn118(n,2n)_ *Sn117*(n,α)Cd114(n,2n)Cd113m				6.4			
		Sb121(n,nα)In117(β^-)Sn117(n,nα)Cd113m				0.7	12.3	2.2	0.3
		&Sb121(n,3n)Sb119(β^+)Sn119(n,3n)_ *Sn117*(n,nα)Cd113m					60.6	3.0	
		Sb121(n,4n)Sb118(β^+)Sn118(n,2nα)Cd113m						37.3	6.5
		Sb121(n,4n)Sb118m(β^+)Sn118(n,2nα)_ Cd113m						15.9	5.2
		Sb121(n,3n)Sb119(β^+)Sn119(n,3nα)Cd113m						3.3	14.7
		&Sb121(n,3nα)*In115*(n,t)Cd113m						0.7	6.2
		Sb123(n,5n)Sb119(β^+)Sn119(n,3nα)Cd113m							22.1
		Sb121(n,5n)Sb117(β^+)Sn117(n,nα)Cd113m							12.0
		Other pathways involving (n,2n), (n,α), β^+				50.9	26.8	37.6	33.0
Sn121m	55.0 y	**&**Sb121(n,γ)*Sb122*(β^-)Te122(n,γ)_ Te123m(n,α)Sn120(n,γ)Sn121m	62.3	84.1	61.8				
		&Sb123(n,γ)*Sb124*(β^-)Te124(n,α)Sn121m	24.7						
		&Sb121(n,γ)*Sb122*(β^-)Te122(n,γ)_ *Te123*(n,α)Sn120(n,γ)Sn121m	5.0	7.1	36.1				
		Sb121(n,γ)Sb122(β^-)Te122(n,γ)_ Te123(n,γ)Te124(n,α)Sn121m	1.6						
		&Sb121(n,γ)*Sb122*(β^-)Te122(n,α)_ Sn119(n,γ)Sn120(n,γ)Sn121m	0.2	0.8	1.9				
		Sb121(n,p)Sn121m				60.8	37.3	11.2	5.4
		&Sb123(n,2n)*Sb122*(β^+)Sn122(n,2n)Sn121m				31.9			
		Sb123(n,d)Sn122(n,2n)Sn121m				4.1	2.6		
		Sb121(n,2n)Sb120(β^+)Sn120(n,γ)Sn121m				1.1			
		Sb123(n,t)Sn121m				1.0	56.3	87.2	93.8
		Sb123(n,3n)Sb121(n,p)Sn121m					2.6		
Ag108m	418.0 y	Pathways involving (n,2n), (n,α), β^-				100.0	100.0	100.0	100.0
Mo93	4000 y	Pathways involving (n,α), (n,nα), (n,2n), β^-,β^+				100.0	100.0	100.0	100.0
Nb94	$2.0\ 10^4$ y	Pathways involving (n,α), (n,nα), (n,2n), β^-,β^+				100.0	100.0	100.0	100.0
Sn126	$2.3\ 10^5$ y	**&**Sb121(n,γ)*Sb122*(β^+)Sn122(n,γ)_ Sn123(n,γ)Sn124(n,γ)Sn125(n,γ)Sn126	95.9	89.7	96.9				
		&Sb123(n,γ)*Sb124*(n,p)Sn124(n,γ)_ Sn125(n,γ)Sn126	1.1	7.3		14.9	8.3	7.6	6.7
		Sb123(n,p)Sn123(n,γ)Sn124(n,γ)Sn125_ (n,γ)Sn126				50.5	31.7	30.3	30.9
		&Sb123(n,γ)*Sb124*(n,γ)Sb125(n,p)_ Sn125(n,γ)Sn126				21.9	42.6	43.3	42.7
		&Sb123(n,γ)*Sb124*(n,γ)Sb125(n,γ)_ *Sb126*(n,p)Sn126				7.7	9.3	10.7	11.6
Tc98	$4.2\ 10^6$ y	Pathways involving (n,α), (n,nα), (n,2n), β^-,β^+				100.0	100.0	100.0	100.0
Pd107	$6.5\ 10^6$ y	Pathways involving (n,α), (n,nα), (n,2n), β^-,β^+				100.0	100.0	100.0	100.0
I129	$1.6\ 10^7$ y ►	**&**Sb123(n,γ)*Sb124*(β^-)Te124(n,γ)_ *Te125*(n,γ)Te126(n,γ)Te127m(n,γ)_ Te128(n,γ)*Te129*(β^-)I129	42.2	1.2	14.8				

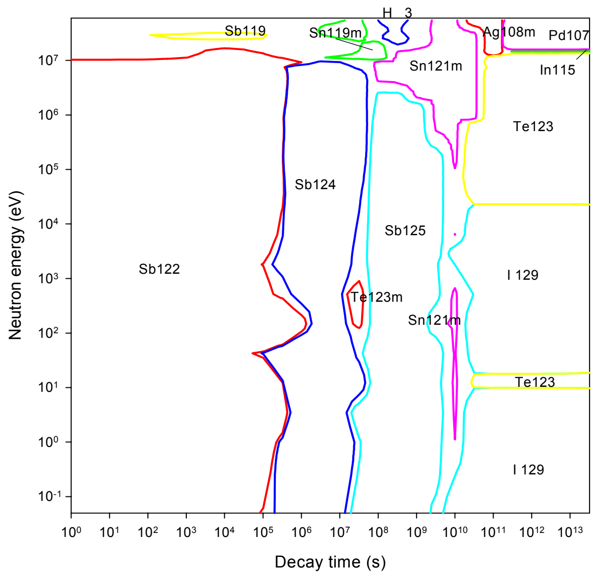
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Sb123(n,γ)*Sb124*(β^-)Te124(n,γ)_ *Te125*(n,γ)Te126(n,γ)*Te127*(n,γ)_ Te128(n,γ)*Te129*(β^-)I129	16.3		0.2				
		&Sb123(n,γ)*Sb124*(n,γ)Sb125(β^-)_ *Te125*(n,γ)Te126(n,γ)Te127m(n,γ)_ Te128(n,γ)*Te129*(β^-)I129	4.8	1.4	4.8				
		&Sb123(n,γ)*Sb124*(n,γ)Sb125(n,γ)_ *Sb126m*(β^-)Te126(n,γ)Te127m(n,γ)_ Te128(n,γ)*Te129*(β^-)I129	4.4	0.7	1.0				
		&Sb123(n,γ)*Sb124*(n,γ)Sb125(n,γ)_ *Sb126*(β^-)Te126(n,γ)Te127m(n,γ)_ Te128(n,γ)*Te129*(β^-)I129	4.1	2.6	5.1				
		&Sb123(n,γ)*Sb124*(n,γ)Sb125(β^-)_ *Te125*(n,γ)Te126(n,γ)*Te127*(n,γ)Te128_ (n,γ)*Te129*(β^-)I129	2.1						
		&Sb123(n,γ)*Sb124*(n,γ)Sb125(n,γ)_ *Sb126*(β^-)Te126(n,γ)*Te127*(n,γ)Te128_ (n,γ)*Te129*(β^-)I129	1.6						
		&Sb123(n,γ)*Sb124*(n,γ)Sb125(n,γ)_ *Sb126*(n,γ)Sb127(β^-)Te127m(n,γ)_ Te128(n,γ)*Te129*(β^-)I129	1.0	21.6	1.2				
		&Sb123(n,γ)*Sb124*(n,γ)Sb125(n,γ)_ *Sb126*(n,γ)Sb127(n,γ)Sb128(n,γ)Sb29_ (β^-)*Te129*(β^-)I129		10.2	0.1				
		&Sb123(n,γ)*Sb124*(n,γ)Sb125(n,γ)_ *Sb126*(n,γ)Sb127(n,γ)Sb128(β^-)Te128_ (n,γ)*Te129*(β^-)I129		4.0	0.1				
		Other pathways	23.5	58.3	72.7				
In115	$4.4\ 10^{14}$ y	&Sb121(n,2n)Sb120(β^+)Sn120(n,2n)_ *Sn119*(n,α)Cd116(n,2n)Cd115(β^-)_ In115m(IT)In115				18.0			
		&Sb121(n,2n)Sb120(β^+)Sn120(n,2n)_ Sn119(n,α)Cd116(n,2n)Cd115m(β^-)In115				16.3			
		&Sb121(n,2n)Sb120(β^+)Sn120(n,2n)_ *Sn119*(n,2n)Sn118(n,α)Cd115(β^-)_ In115m(IT)In115				7.9			
		Sb121(n,3n)Sb119(β^+)Sn119(n,nα)_ Cd115(β^-)In115m(IT)In115					45.2	11.8	0.3
		Sb121(n,3n)Sb119(β^+)Sn119(n,nα)_ Cd115m(β^-)In115					30.7	5.7	0.1
		&Sb121(n,3nα)*In115*						23.0	64.5
		&Sb121(n,4n)Sb118(β^+)Sn118(n,nt)*In115*						6.5	3.9
		&Sb121(n,5n)Sb117(β^+)Sn117(n,t)*In115*							8.3
		Other pathways involving (n,2n), (n,α), β^+				57.8	24.1	53.0	22.9
Te123	$9.2\ 10^{16}$ y	&Sb121(n,γ)*Sb122*(β^-)Te122(n,γ)*Te123*	100.0	99.9	100.0		0.1	0.1	0.2
		&Sb123(n,2n)*Sb122*(β^-)Te122(n,γ)*Te123*				59.7	49.9	52.3	57.5
		&Sb123(n,γ)*Sb124*(β^-)Te124(n,2n)*Te123*				33.9	42.1	40.1	37.3
		&Sb123(n,γ)*Sb124m*(β^-)Te124(n,2n)*Te123*				5.8	7.4	7.2	6.2
Sn124	$1.0\ 10^{17}$ y	&Sb121(n,γ)*Sb122*(β^+)Sn122(n,γ)_ Sn123(n,γ)Sn124	99.3	94.3	100.0				
		&Sb123(n,γ)*Sb124*(n,p)Sn124	0.7	5.6		22.8	20.7	19.9	17.9
		Sb123(n,p)Sn123(n,γ)Sn124				77.1	79.0	79.8	81.8

Antimony activation characteristics

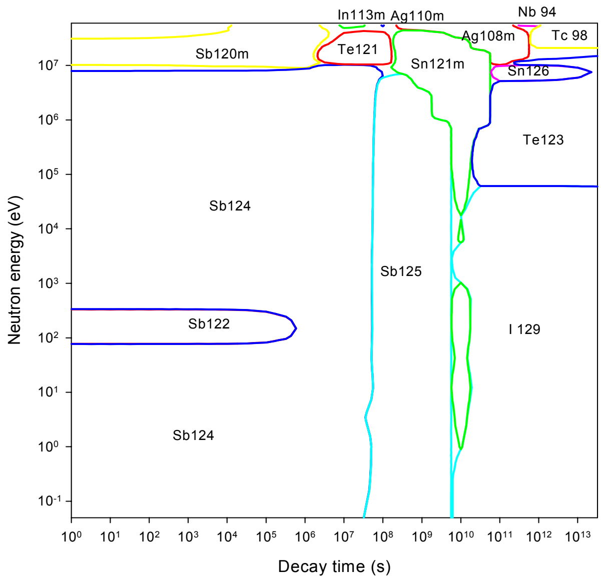


Antimony importance diagrams & transmutation

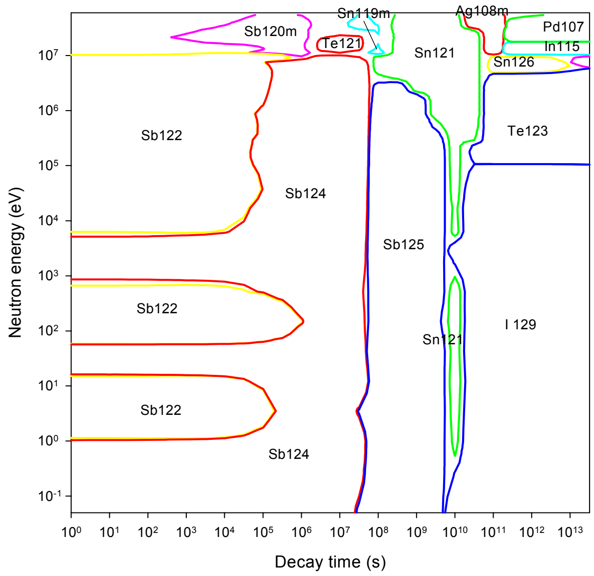
Activity



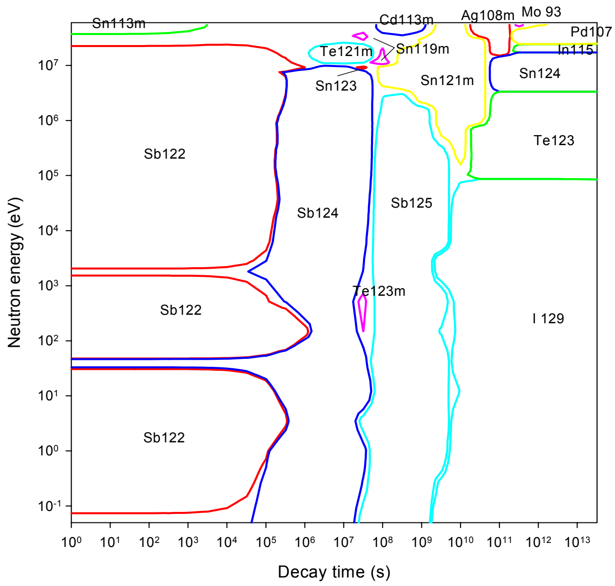
Dose rate



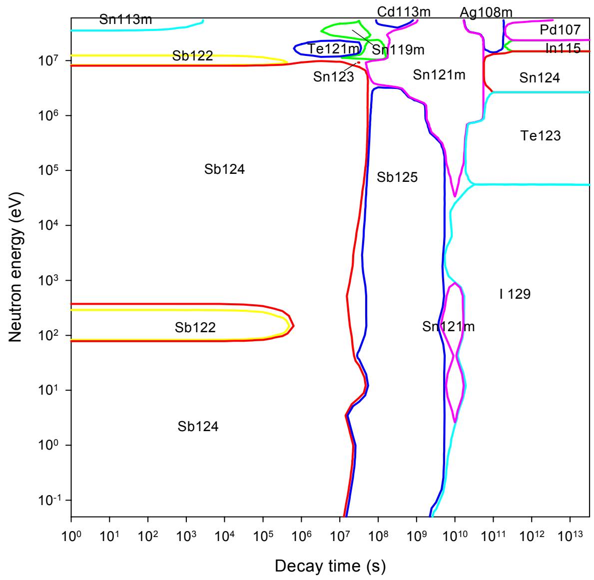
Heat output



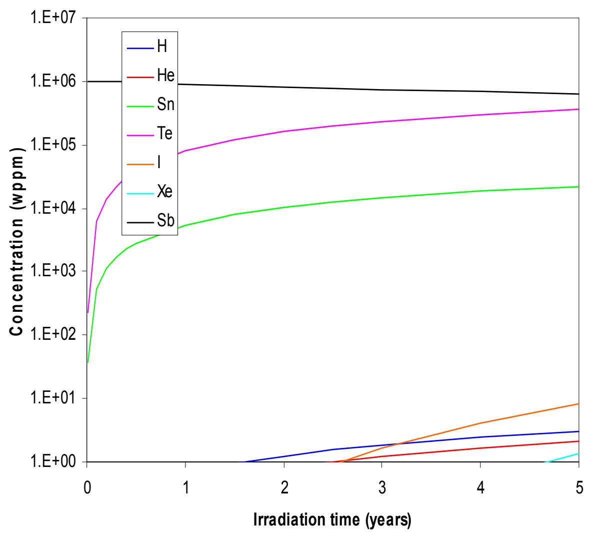
Ingestion dose



Inhalation dose



First wall transmutation



Tellurium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	52		
Crustal abundance / wppm	1.0 10^{-3}	Te120	0.09
Melting point / K	722.7	Te122	2.55
Boiling point / K	1261	Te123	0.89 ($T_{½}$ = 9.92 10^{16} y)
Density / kgm^{-3}	6240	Te124	4.74
Thermal conductivity / $Wm^{-1}K^{-1}$	2.35	Te125	7.07
Electrical resistivity /Ωm	4.36 10^{-3}	Te126	18.84
Coefficient of thermal expansion / K^{-1}	16.75 10^{-6}	Te128	31.74 ($T_{½}$ = 2.20 10^{24} y)
Crystal structure	Hexagonal	Te130	34.08 ($T_{½}$ = 7.90 10^{23} y)
Number of stable isotopes	5 (8)		
Mean atomic weight	127.60		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	2.45E15	2.36E15	1.15E15	5.92E13	1.57E9	1.07E8	kW kg^{-1}	1.81E-1	1.72E-1	5.12E-2	1.83E-3	1.85E-8	1.50E-9
Te127	27.46	28.33	18.56	36.03			I128	26.05	23.76				
Te129	17.96	18.02	13.37	0.15			Te129	23.49	24.00	29.12	0.47		
I128	14.59	13.07					I130	15.08	15.87	0.40			
Te129m	10.73	11.12	21.20	0.24			Te127	13.61	14.30	15.31	42.69		
Te127m	9.07	9.40	18.88	36.79			Te129m	6.97	7.36	22.94	0.37		
Te125m	7.25	7.52	14.78	3.75			Te131	2.32	2.13				
Te123m	3.36	3.49	7.02	16.73			Te125m	2.20	2.32	7.48	2.72		
I130	2.89	2.99	0.05				Te127m	1.84	1.94	6.37	17.82		
I130m	1.88	1.30					Te123m	1.77	1.87	6.15	21.08		
I131	1.03	1.07	1.64				I131	1.28	1.35	3.39			
Te131	0.91	0.82					I130m	1.26	0.89				
I126	0.67	0.70	1.18				I126	0.84	0.89	2.46			
Te121	0.65	0.67	1.29	2.89			Te121	0.82	0.87	2.73	8.78		
Te121m	0.36	0.37	0.75	2.86			Sb122	0.71	0.75	0.99			
Xe127	0.31	0.33	0.62	0.01			Te121m	0.23	0.24	0.80	4.39		
Sn121m				0.01	52.09		Sb125			0.06	1.22		
Sn121					40.43		Sn121					63.24	
I129					6.87	99.98	Sn121m					28.59	
H3					0.61		I129					8.10	99.83

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	5.79E4	5.62E4	9.03E3	2.92E2	2.57E-5	9.53E-6	Sv kg^{-1}	1.60E7	1.59E7	1.40E7	8.54E4	1.23E1	1.18E1
I130	58.01	59.66	2.75				Xe127	67.41	67.65	71.52	12.01		
I128	9.84	8.77					Xe129m	8.50	8.53	7.27			
Te129	8.58	8.56	19.22	0.34			Te129m	4.94	4.96	5.21	0.49		
Te131	3.23	2.90					I131	3.48	3.49	2.96			
Te129m	3.15	3.25	18.75	0.34			Te127m	3.20	3.21	3.56	58.62		
Te121	2.78	2.87	16.72	59.85			I126	2.99	3.00	2.80			
Te131m	2.39	2.46	2.02				Te125m	0.97	0.97	1.05	2.26		
I126	2.36	2.44	12.47				I130	0.89	0.89	0.01			
I131	2.28	2.35	10.94				Te123m	0.72	0.73	0.81	16.23		
I130m	1.78	1.23					Te127	0.72	0.72	0.26	4.24		
Sb122	1.17	1.20	2.94				Te129	0.17	0.17	0.07	0.01		
Te127	0.96*	0.98*	1.95*	6.04*			Te121m	0.13	0.13	0.14	4.55		
Sb124	0.44	0.46	2.71	1.31			I128	0.10	0.09				
Te123m	0.43	0.44	2.67	10.18			Sb122	0.09	0.09	0.04			
Te121m	0.31	0.32	1.98	12.04			Te121			0.05	0.86		
Sb126m	0.28	0.24			10.75	21.48	Te131m			0.01			
Xe127	0.25	0.26	1.51	0.05			Sb125				0.34		
Sb126			0.80		2.70	5.40	Cs134				0.29		
Sb125			0.32	7.66			I129				0.01	96.29	100.0
Cs134				1.66			Sn121m					2.52	
Sn121m					56.98		Sn121					1.19	
I129					27.20	73.11							
Ba133					1.80								

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	5.26E7	5.25E7	4.84E7	3.33E5	7.71E0	3.87E0
Xe127	83.28	83.42	84.39	12.54		
Te127m	4.14	4.15	4.39	64.06		
Te129m	3.95	3.95	3.98	0.33		
Xe129m	2.97	2.97	2.42			
Xe131m	1.70	1.70	1.58			
Te125m	1.42	1.42	1.47	2.80		
Te123m	0.80	0.80	0.85	15.16		
I131	0.36	0.36	0.29			
I126	0.31	0.31	0.27			
Te127	0.18	0.18	0.06	0.90		
Te121m	0.10	0.10	0.10	2.89		
I130	0.09	0.09				
Te129	0.03	0.03	0.01			
Sb122	0.02	0.02	0.01			
I128	0.01					
Te121		0.01	0.01	0.21		
Sb125			0.01	0.94		
Sb124			0.01	0.02		
I129					50.35	100.0
Sn121m					47.72	
Sn121					1.89	

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	2.36E11	2.24E11	1.50E11	1.63E10	1.08E7	1.07E7
Te123m	34.96	36.68	53.75	60.88		
I128	24.46	22.18				
Te129m	11.15	11.70	16.24	0.09		
Te127m	9.43	9.89	14.46	13.39		
Te121	3.96	4.15	5.82	6.19		
I130	3.00	3.14	0.04			
I130m	2.72	1.90				
Te129	1.87	1.90	1.02	0.01		
Sb125	1.42	1.49	2.22	15.99		
I131	1.07	1.13	1.26			
Xe127	0.93	0.98	1.37	0.01		
Te121m	0.84	0.89	1.30	2.36		
I126	0.70	0.73	0.90			
Sb122	0.34	0.36	0.21			
Te127	0.29	0.30	0.14	0.13		
Sb124	0.20	0.21	0.30	0.04		
Cs134			0.12	0.81		
Te125m			0.11	0.01		
I129				0.07	99.87	100.0
Sn121					0.07	
Sn121m					0.06	

Tellurium

Pathway analysis

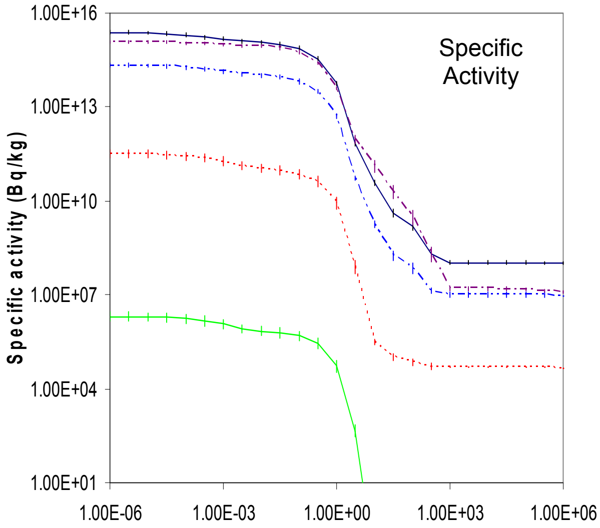
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Ba137m	2.552 m	&Te130(n,γ)*Te131*(β$^-$)I131(β$^-$)_ *Xe131*(n,γ)Xe132(n,γ)*Xe133*(β$^-$)_ Cs133(n,γ)*Cs134*(n,γ)*Cs135*(n,γ)_ *Cs136*(β$^-$)Ba136(n,γ)Ba137m	73.5	0.3	58.6				
		&Te130(n,γ)*Te131*(β$^-$)I131(β$^-$)_ *Xe131*(n,γ)Xe132(n,γ)*Xe133*(β$^-$)_ Cs133(n,γ)*Cs134*(n,γ)*Cs135*(n,γ)_ *Cs136*(n,γ)Cs137(β$^-$)Ba137m	11.6	82.1	15.9				
		&Te130(n,γ)Te131m(β$^-$)I131(β$^-$)_ *Xe131*(n,γ)Xe132(n,γ)*Xe133*(β$^-$)_ Cs133(n,γ)*Cs134*(n,γ)*Cs135*(n,γ)_ *Cs136*(β$^-$)Ba136(n,γ)Ba137m	9.1		7.2				
		&Te130(n,γ)Te131m(β$^-$)I131(β$^-$)_ *Xe131*(n,γ)Xe132(n,γ)*Xe133*(β$^-$)_ Cs133(n,γ)*Cs134*(n,γ)*Cs135*(n,γ)_ *Cs136*(n,γ)Cs137(β$^-$)Ba137m	1.4	10.1	2.0				
		&Te130(n,γ)Te131m(β$^-$)I131(β$^-$)*Xe131*(n,γ)_ Xe132(n,γ)*Xe133*(β$^-$)Cs133(n,γ)*Cs134*(β$^-$)_ Ba134(n,γ)*Ba135*(n,γ)*Ba136*(n,γ)Ba137m			1.3				
Sb126m	19.1 m	&Te120(n,γ)*Te121*(β$^+$)Sb121(n,γ)_ *Sb122*(n,γ)Sb123(n,γ)*Sb124*(n,γ)_ Sb125(n,γ)*Sb126m*	95.7	97.6	92.8				
		&Te126(n,p)*Sb126m*				83.8	46.7	12.6	2.9
		&Te130(n,2n)*Te129*(β$^-$)I129(n,α)*Sb126m*				10.5	0.4		
		&Te130(n,2n)Te129m(β$^-$)I129(n,α)*Sb126m*				3.2	0.2		
		&Te128(n,2n)Te127m(n,d)*Sb126m*				0.2	1.0		
		&Te128(n,t)*Sb126m*					27.7	79.0	71.2
		&Te128(n,3n)Te126(n,p)*Sb126m*					15.4	1.2	
		&Te130(n,3n)Te128(n,t)*Sb126m*					5.6	3.0	1.4
		&Te130(n,3n)Te128(n,3n)Te126(n,p)*Sb126m*					1.7		
		&Te130(n,2nt)*Sb126m*							22.8
I128	24.99 m	&Te126(n,γ)*Te127*(β$^-$)I127(n,γ)I128	98.3	82.9	98.5				
		&Te125(n,γ)Te126(n,γ)*Te127*(β$^-$)I127_ (n,γ)I128	1.5	16.8	1.1				
		&Te130(n,2n)*Te129*(β$^-$)I129(n,2n)I128				76.6	64.8	56.8	52.0
		Te130(n,2n)Te129m(β$^-$)I129(n,2n)I128				22.9	24.8	22.6	21.2
		Te130(n,d)Sb129(β$^-$)Te129(β$^-$)I129(n,2n)I128					6.8	13.6	18.2
		Te130(n,d)Sb129(β$^-$)Te129m(β$^-$)I129_ (n,2n)I128					0.5	1.0	1.3
		Te130(n,d)Sb129m(β$^-$)Te129m(β$^-$)I129_ (n,2n)I128					0.4	0.8	1.1
		&Te130(n,4n)*Te127*(β$^-$)I127(n,γ)I128						1.0	0.4
Te129	1.16 h	&Te128(n,γ)*Te129*	99.5	100.0	100.0				
		&Te130(n,2n)*Te129*				99.5	88.9	76.8	69.4
		Te130(n,d)Sb129(β$^-$)Te129					9.8	19.3	25.5
Te127	9.35 h	&Te126(n,γ)*Te127*	96.7	78.7	97.9		0.1		
		&Te125(n,γ)Te126(n,γ)*Te127*	2.9	21.1	2.2				
		&Te128(n,2n)*Te127*				99.2	68.4	19.8	27.5
		&Te130(n,3n)Te128(n,2n)*Te127*					13.8		
		&Te128(n,d)Sb127(β$^-$)*Te127*					9.2	5.3	10.9
		&Te130(n,4n)*Te127*					4.2	70.4	44.0
		&Te130(n,3n)Te128(n,d)Sb127(β$^-$)*Te127*					2.0		
		Te130(n,nt)Sb127(β$^-$)Te127					0.1		11.8
I130	12.36 h	&Te128(n,γ)*Te129*(β$^-$)I129(n,γ)*I130*	96.3	97.0	91.1				
		&Te128(n,γ)Te129m(β$^-$)I129(n,γ) *I130*	2.7	2.7	2.6				
	►	&Te130(n,2n)*Te129*(β$^-$)I129(n,γ)*I130*				74.1	46.7	34.6	28.5

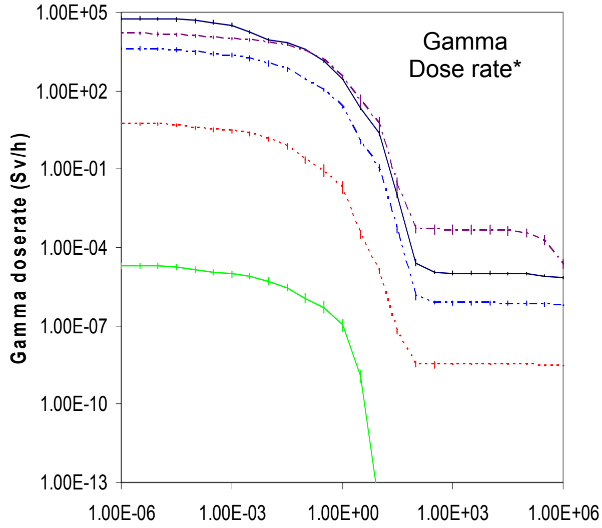
Nuclide	$T_{1/2}$	Pathway	210	186	151	42	30	21	6
	◄	&Te130(n,2n)Te129m(β^-)I129(n,γ)*I130*				22.5	18.1	13.9	11.7
		&Te130(n,γ)*Te131*(β^-)I131(β^-)*Xe131*_ (n,d)*I130*					15.7	23.3	28.9
		&Te130(n,γ)Te131m(β^-)I131(β^-)_ Xe131(n,d)*I130*					8.5	12.5	12.6
		&Te130(n,d)*Sb129*(β^-)*Te129*(β^-)I129(n,γ)*I130*					5.1	8.8	10.6
Sn121	1.128 d	Te122(n,γ)Te123(n,α)Sn120(n,γ)Sn121	70.3	10.6	5.4				
		Te123(n,α)Sn120(n,γ)Sn121	21.7	87.0	80.2				
		Te122(n,γ)Te123(n,α)Sn120(n,γ)Sn121	5.6	1.0	4.0				
		&Te124(n,α)*Sn121*	2.2	0.8	8.4	48.8	9.9	2.7	3.5
		&Te125(n,2n)Te124(n,α)*Sn121*				18.2	0.9	0.2	0.1
		&Te125(n,α)Sn122(n,2n)*Sn121*				7.8	0.2		
		&Te126(n,2n)*Te125*(n,2n)Te124(n,α)Sn121				6.1			
		&Te122(n,2n)*Te121*(β^+)Sb121(n,p)*Sn121*				6.0	0.7		
		&Te125(n,nα)*Sn121*				3.4	49.7	18.1	9.2
		&Te126(n,2n)*Te125*(n,nα)*Sn121*				2.2	9.0	2.0	0.5
		&Te126(n,3n)Te124(n,α)*Sn121*					6.6	0.8	0.4
		&Te126(n,2nα)*Sn121*					2.2	35.6	22.4
		&Te128(n,3n)Te126(n,2nα)*Sn121*					0.6	4.2	1.1
		&Te128(n,nα)Sn124(n,4n)*Sn121*					0.3	5.7	0.9
		&Te128(n,4n)*Te125*(n,nα)*Sn121*						8.4	1.5
		&Te126(n,nt)Sb123(n,t)*Sn121*						0.6	5.6
		&Te128(n,4nα)*Sn121*							17.1
I131	8.023 d	&Te130(n,γ)*Te131*(β^-)I131	88.7	88.7	88.7	65.5	65.6	64.7	70.2
		Te130(n,γ)Te131m(β^-)I131	11.3	11.3	11.3	34.4	34.0	34.1	29.6
Xe131m	11.93 d	&Te130(n,γ)*Te131*(β^-)I131(β^-)Xe131m	50.1	85.7	85.0	23.8	28.4	33.9	43.8
		&Te128(n,γ)*Te129*(β^-)I129(n,γ)*I130*_ (β^-)Xe130(n,γ)Xe131m	37.8		0.7				
		Te130(n,γ)Te131m(β^-)I131(β^-)Xe131m	6.4	11.3	11.2	12.5	14.7	17.6	18.5
		Te128(n,γ)Te129(β^-)I129(n,γ)I130m_ (β^-)Xe130(n,γ)Xe131m	3.9						
		&Te130(n,γ)*Te131*(β^-)I131(β^-)Xe131_ (n,n′)Xe131m				36.9	36.5	31.3	25.9
		Te130(n,γ)Te131m(β^-)I131(β^-)Xe131_ (n,n′)Xe131m				22.5	19.0	16.3	10.9
Te121	19.16 d	&Te120(n,γ)*Te121*	99.8	99.9	99.9				
		&Te122(n,2n)*Te121*				87.5	32.6	13.3	5.9
		&Te123(n,2n)Te122(n,2n)*Te121*				7.0	0.7	0.1	
		&Te125(n,3n)*Te123*(n,3n)*Te121*					20.0	3.4	0.3
		&Te123(n,3n)*Te121*					17.6	7.3	2.1
		&Te124(n,3n)Te122(n,2n)*Te121*					8.7	2.4	0.4
		&Te124(n,2n)*Te123*(n,3n)*Te121*					6.5	1.4	0.2
		&Te124(n,4n)*Te121*						32.1	17.2
		&Te126(n,4n)*Te123*(n,3n)*Te121*						11.4	1.6
		&Te126(n,3n)Te124(n,4n)*Te121*						10.8	2.1
		&Te128(n,5n)Te124(n,4n)*Te121*						0.1	9.0
		&Te125(n,5n)*Te121*							33.0
		&Te128(n,4n)*Te125*(n,5n)*Te121*							5.5
Te129m	33.6 d	Te128(n,γ)Te129m	99.4	100.0	100.0				
		Te130(n,2n)Te129m				99.2	95.7	92.0	89.2
		&Te130(n,d)*Sb129*(β^-)Te129m							5.6
		Te130(n,d)Sb129m(β^-)Te129m							4.5
Xe127	36.4 d	&Te130(n,2n)*Te129*(β^-)I129(n,2n)I128_ (β^-)Xe128(n,2n)*Xe127*				77.0	59.8	51.5	15.4
		&Te130(n,2n)Te129m(β^-)I129(n,2n)_ I128(β^-)Xe128(n,2n)*Xe127*				22.7	22.7	20.3	6.2
		&Te130(n,d)Sb129(β^-)*Te129*(β^-)I129_ (n,2n)I128(β^-)Xe128(n,2n)*Xe127*					7.0	13.6	5.9
	►	&Te130(n,γ)Te131(β^-)I131(β^-)Xe131_ (n,3n)*Xe129*(n,3n)*Xe127*					4.1	1.4	0.2

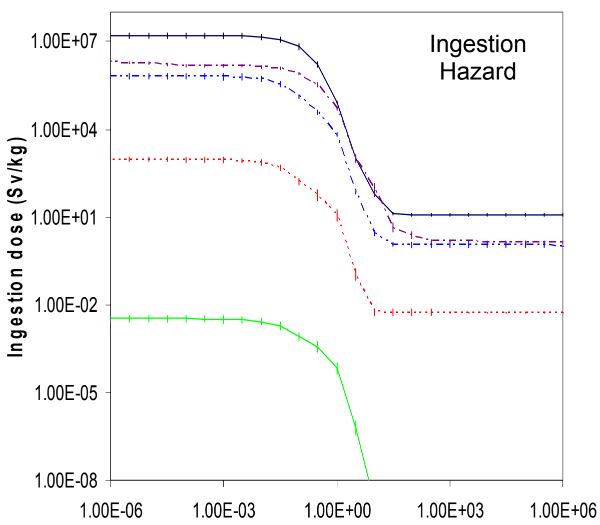
Nuclide	$T_{1/2}$	Pathway	210	186	151	42	30	21	6
	◄	&Te130(n,γ)Te131m(β^-)I131(β^-)_ Xe131(n,3n)*Xe129*(n,3n)*Xe127*					2.5	0.8	
		&Te130(n,γ)*Te131*(β^-)I131(β^-)Xe131_ (n,5n)*Xe127*							47.4
		&Te130(n,γ)Te131m(β^-)I131(β^-)*Xe131*_ (n,5n)*Xe127*							20.2
Te125m	57.4 d	Te124(n,γ)Te125m	78.7	83.9	98.3				
		Te123(n,γ)Te124(n,γ)Te125m	15.0	15.8	1.5				
		&Te122(n,γ)*Te123*(n,γ)Te124(n,γ)Te125m	4.9	0.2					
		Te126(n,2n)Te125m				89.1	63.5	14.5	16.1
		Te125(n,n′)Te125m				4.8	7.0	2.2	2.5
		Te128(n,3n)Te126(n,2n)Te125m					20.5	1.8	0.9
		Te128(n,4n)Te125m					0.6	70.9	40.1
		Te130(n,3n)Te128(n,4n)Te125m					0.1	4.6	1.3
		Te126(n,4n)Te123m						51.1	
		Te125(n,3n)Te123m						16.6	
		&Te128(n,4n)*Te125*(n,3n)Te123m						8.0	
		Te124(n,2n)Te123m						7.1	
		Te128(n,3n)Te126(n,4n)Te123m						6.0	
		Te130(n,6n)Te125m							28.1
Te127m	109.0 d	Te126(n,γ)Te127m	96.7	79.2	98.0		0.1		
		Te125(n,γ)Te126(n,γ)Te127m	2.9	20.6	2.0				
		Te128(n,2n)Te127m				99.4	76.0	19.8	32.8
		Te130(n,3n)Te128(n,2n)Te127m					15.0		
		Te130(n,4n)Te127m					4.8	76.6	58.3
		Te128(n,d)Sb127(β^-)Te127m					2.2		
Te123m	119.5 d	Te122(n,γ)Te123m	99.6	100.0	100.0				
		Te124(n,2n)Te123m				64.6	17.8	7.1	6.9
		Te125(n,2n)Te124(n,2n)Te123m				22.3	1.6	0.4	0.3
		&Te126(n,2n)*Te125*(n,2n)Te124(n,2n)Te123m				7.0			
		Te123(n,n′)Te123m				2.2	0.9	0.5	0.5
		Te125(n,3n)Te123m					50.1	16.6	10.8
		Te126(n,3n)Te124(n,2n)Te123m					11.5	2.4	0.9
		&Te126(n,2n)*Te125*(n,3n)Te123m					1.6	1.8	0.7
		Te126(n,4n)Te123m						51.1	44.1
		&Te128(n,4n)*Te125*(n,3n)Te123m						8.0	1.9
		Te128(n,3n)Te126(n,4n)Te123m						6.0	2.4
		Te130(n,5n)Te126(n,4n)Te123m						0.3	6.3
		Te128(n,6n)Te123m							14.5
		Te128(n,5n)Te124(n,2n)Te123m							3.7
Cs134	2.065 y	&Te130(n,γ)*Te131*(β^-)I131(β^-)*Xe131*_ (n,γ)Xe132(n,γ)*Xe133*(β^-)Cs133(n,γ)_ *Cs134*	87.0	82.7	84.8	55.3	51.1	49.8	50.1
		&Te130(n,γ)Te131m(β^-)I131(β^-)_ Xe131(n,γ)Xe132(n,γ)*Xe133*(β^-)Cs133_ (n,γ)*Cs134*	11.0	10.8	11.2	31.2	29.2	28.7	23.7
		&Te128(n,γ)*Te129*(β^-)I129(n,γ)*I130*_ (β^-)Xe130(n,γ)*Xe131*(n,γ)Xe132(n,γ)_ *Xe133*(β^-)Cs133(n,γ)*Cs134*	1.0						
		&Te130(n,γ)*Te131*(β^-)I131(n,γ)*I132*(β^-)_ Xe132(n,γ)*Xe133*(β^-)Cs133(n,γ)*Cs134*		0.1	0.6	3.0	6.0	6.9	9.7
		&Te130(n,γ)Te131m(β^-)I131(n,γ)*I132*_ (β^-)Xe132(n,γ)*Xe133*(β^-)Cs133(n,γ)*Cs134*				1.5	3.0	3.4	3.9
Sb125	2.759 y	&Te120(n,γ)*Te121*(β^+)Sb121(n,γ)_ *Sb122*(n,γ)Sb123(n,γ)*Sb124*(n,γ)Sb125	97.0	98.6	94.2				
		Te120(n,γ)Te121(β^+)Sb121(n,γ)Sb122_ (β^+)Sn122(n,γ)Sn123m(β^-)Sb123(n,γ)_ Sb124(n,γ)Sb125	1.4		3.5				
		Te125(n,p)Sb125				36.7	4.5	2.1	0.6
		Te128(n,α)Sn125m(β^-)Sb125				17.2	3.7	1.0	1.2
		Te128(n,α)Sn125(β^-)Sb125				16.0	3.6	0.9	0.8
	►	&Te126(n,2n)*Te125*(n,p)Sb125				15.4	0.4	0.1	

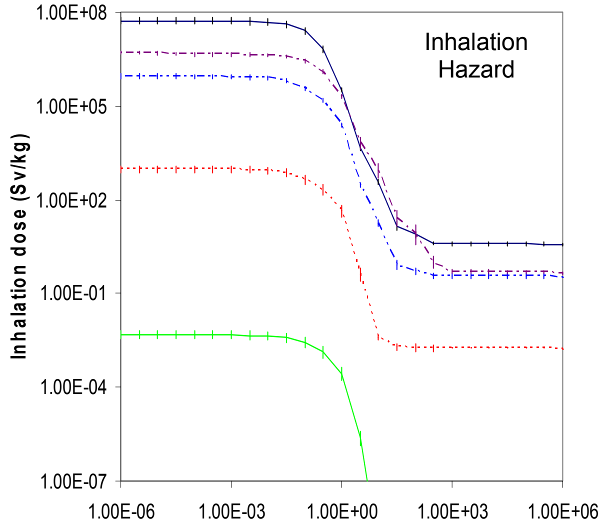
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	Te126(n,d)Sb125				12.5	67.5	64.6	31.0
		Te128(n,3n)Te126(n,d)Sb125					13.8	5.0	1.1
		Te128(n,nt)Sb125					1.5	13.8	52.5
		Te130(n,2nα)Sn125(β^-)Sb125					0.1	3.4	1.6
		Te130(n,2nα)Sn125m(β^-)Sb125						4.0	2.7
		Te130(n,5n)Te126(n,d)Sb125						0.3	3.0
		Te130(n,3nt)Sb125							2.6
H3	12.33 y	Te120(n,γ)Te121m(n,X)H1(n,γ)H2(n,γ)H3	82.8	62.9					
		&Te120(n,γ)*Te121*(β^+)Sb121(n,γ)_ *Sb122*(n,X)H1(n,γ)H2(n,γ)H3	5.7	26.7					
		&Te120(n,γ)*Te121*(n,X)H1(n,γ)H2(n,γ)H3	5.0	3.9					
		Te125(n,X)H3				31.6	11.7	9.2	8.4
		Te130(n,X)H3				22.2	29.3	26.8	26.4
		&Te126(n,2n)*Te125*(n,X)H3				11.0	1.1	0.6	0.2
		&Te128(n,2n)*Te127*(β^-)I127(n,X)H3				10.5	1.3	0.7	0.3
		&Te130(n,2n)*Te129*(β^-)I129(n,X)H3				7.5	1.1	0.6	0.4
		Te123(n,X)H3				5.3	1.6	1.2	1.1
		&Te124(n,2n)*Te123*(n,X)H3				4.0	0.2		
		Te128(n,X)H3				0.3	21.1	23.8	25.9
		Te126(n,X)H3				0.2	14.3	15.9	17.1
		Te122(n,X)H3				0.2	2.3	2.4	2.5
		Te124(n,X)H3				0.1	4.0	4.3	4.5
Cs137	30.041 y	&Te130(n,γ)*Te131*(β^-)I131(β^-)*Xe131*_ (n,γ)Xe132(n,γ)*Xe133*(β^-)Cs133(n,γ)_ *Cs134*(n,γ)*Cs135*(n,γ)*Cs136*(n,γ)Cs137	84.2	82.2	84.2				
		&Te130(n,γ)Te131m(β^-)I131(β^-)*Xe131*_ (n,γ)Xe132(n,γ)*Xe133*(β^-)Cs133(n,γ)_ *Cs134*(n,γ)*Cs135*(n,γ)*Cs136*(n,γ)Cs137	10.5	10.5	11.0				
		&Te130(n,γ)*Te131*(β^-)I131(β^-)*Xe131*_ (n,γ)Xe132(n,γ)*Xe133*(n,γ)Xe134(n,γ)_ *Xe135*(n,γ)Xe136(n,γ)Xe137(β^-)Cs137	3.0						
Sn121m	55.0 y	Te122(n,γ)Te123m(n,α)Sn120(n,γ)Sn121m	37.9	7.1	5.6				
		Te124(n,α)Sn121m	31.1			51.4	9.6	2.7	4.7
		Te123(n,α)Sn120(n,γ)Sn121m	20.3	92.1	90.2				
		Te123(n,γ)Te124(n,α)Sn121m	5.7						
		&Te122(n,γ)*Te123*(n,α)Sn120(n,γ)Sn121m	3.5	0.7	4.1				
		Te125(n,nα)Sn121m				10.2	69.0	29.2	14.3
		Te125(n,2n)Te124(n,α)Sn121m				10.0	0.5		
		Te125(n,α)Sn122(n,2n)Sn121m				9.3			
		&Te122(n,2n)*Te121*(β^+)Sb121(n,p)Sn121m				7.6	0.3		
		&Te126(n,2n)*Te125*(n,nα)Sn121m				3.6	6.5	1.7	0.6
		&Te126(n,2n)*Te125*(n,2n)Te124(n,α)Sn121m				2.3			
		&Te126(n,2n)*Te125*(n,α)Sn122(n,2n)Sn121m				2.0			
		Te126(n,3n)Te124(n,α)Sn121m					3.5	0.5	0.3
		Te126(n,2nα)Sn121m					2.6	44.0	38.5
		Te128(n,3n)Te126(n,2nα)Sn121m					0.4	2.9	1.2
		Te128(n,nα)Sn124(n,4n)Sn121m					0.2	3.9	0.7
		&Te128(n,4n)*Te125*(n,nα)Sn121m						7.5	1.3
		Te130(n,5n)Te126(n,2nα)Sn121m						0.2	3.1
		Te128(n,4nα)Sn121m							21.7
Sn126	2.3 10^5 y	Te128(n,γ)Te129m(n,α)Sn126	94.1	95.1	94.6				
		&Te128(n,γ)*Te129*(n,α)Sn126	5.6	4.9	5.4				
		Te130(n,2n)Te129m(n,α)Sn126				64.6			
		Te130(n,nα)Sn126				35.2	99.4	91.1	84.7
		Te128(n,h)Sn126					0.4	8.4	14.7
I129	1.6 10^7 y	&Te128(n,γ)*Te129*(β^-)I129	96.9	97.3	97.3				
		Te128(n,γ)Te129m(β^-)I129	2.7	2.7	2.7				
		&Te130(n,2n)*Te129*(β^-)I129				77.0	65.4	57.8	52.8
		Te130(n,2n)Te129m(β^-)I129				23.0	25.1	23.0	21.5
		&Te130(n,d)*Sb129*(β^-)*Te129*(β^-)I129					7.8	15.8	21.3

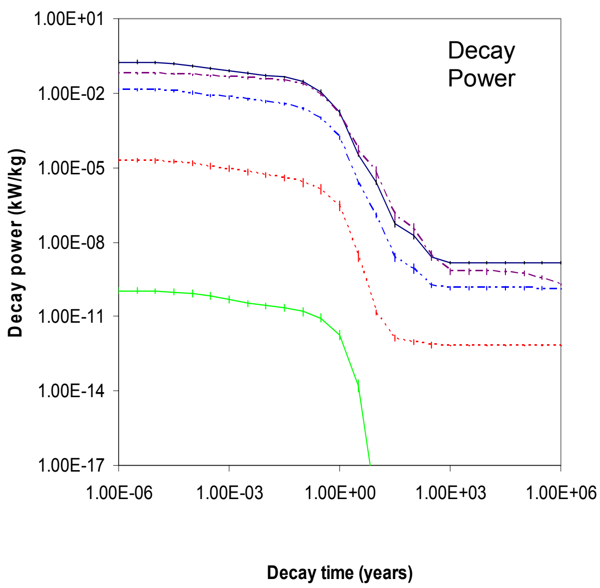
Tellurium activation characteristics

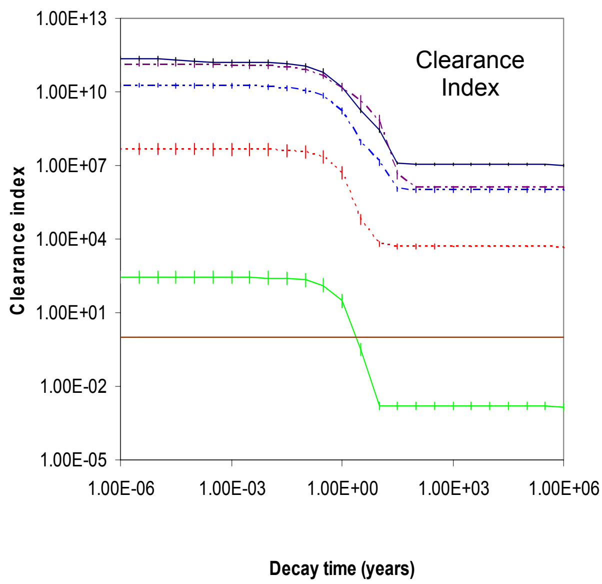






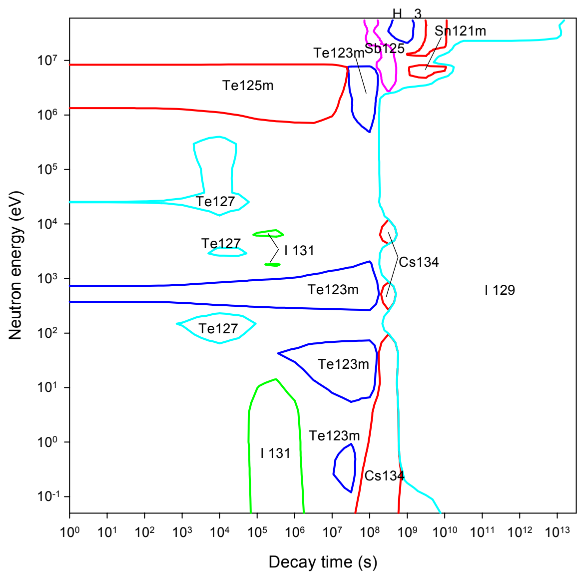




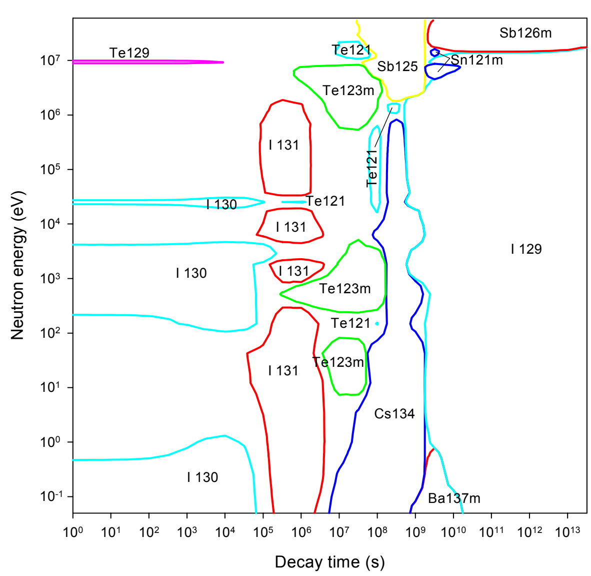


Tellurium importance diagrams & transmutation

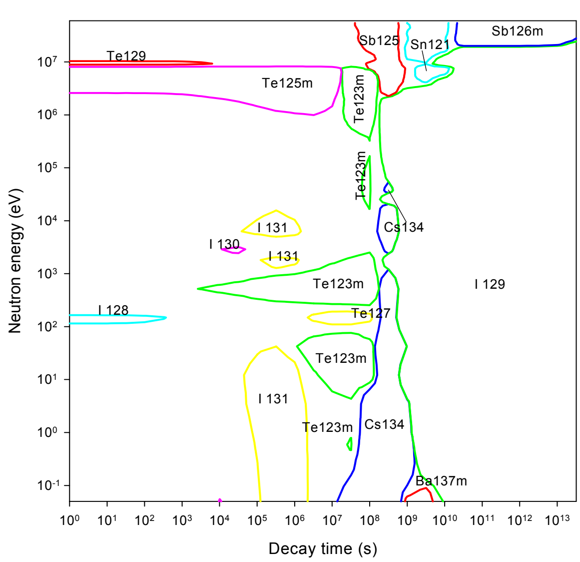
Activity



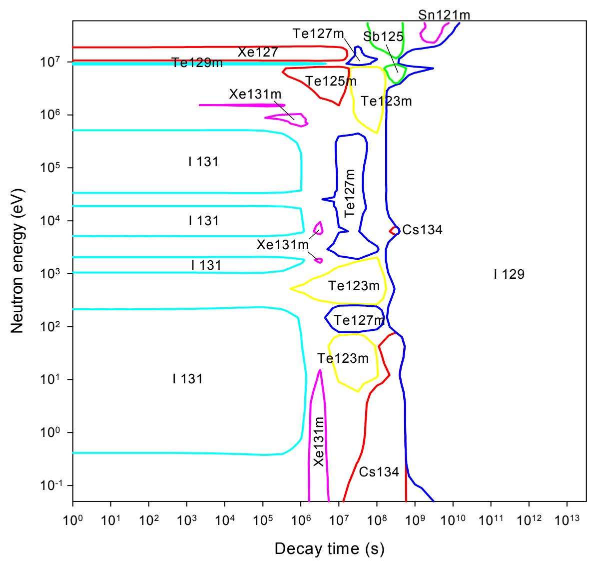
Dose rate



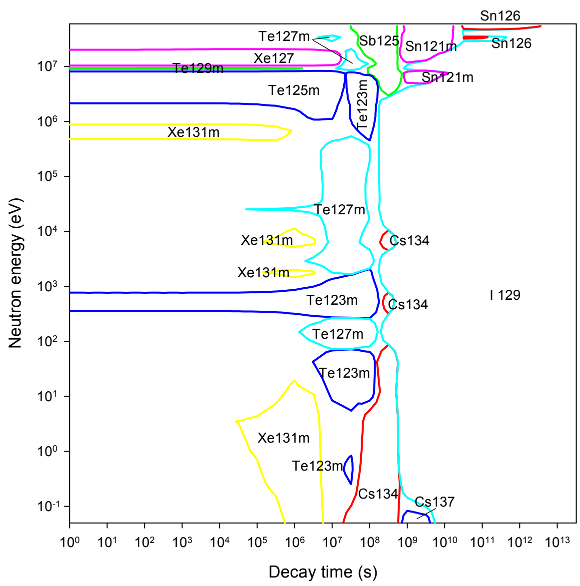
Heat output



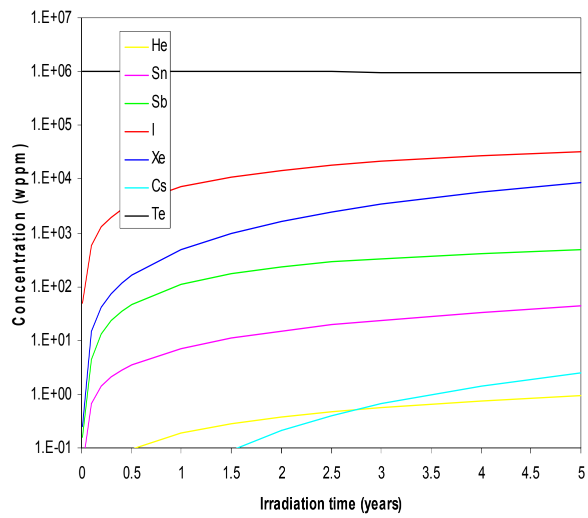
Ingestion dose



Inhalation dose



First wall transmutation



Iodine

General properties

		Isotopes	Isotopic abundances / %
Atomic number	53	I127	100.0
Crustal abundance / wppm	0.45		
Melting point / K	386.9		
Boiling point / K	457.6		
Density / kgm^{-3}	4930		
Thermal conductivity / $Wm^{-1}K^{-1}$	0.449		
Electrical resistivity /Ωm	$1.37\ 10^{7}$		
Coefficient of thermal expansion / K^{-1}	$9.3\ 10^{-5}$		
Crystal structure	Orthorhombic		
Number of stable isotopes	1		
Mean atomic weight	126.90447		

Activation properties

Act	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Bq kg^{-1}	1.18E16	1.03E16	1.09E15	5.50E12	3.26E7	1.57E6
I128	87.97	87.25				
Xe127	5.08	5.83	51.15	10.38		
I126	4.31	4.95	38.29			
Xe127m	0.92	0.05				
Xe129m	0.59	0.68	4.77			
Te127	0.55	0.63	2.12	42.13		
Te127m	0.21	0.24	2.16	43.02		
Te125m	0.09	0.10	0.93	2.48		
I125	0.03	0.03	0.29	0.84		
H3				0.14	91.93	
I129					4.83	99.99
Sn121m					1.82	
Sn121					1.41	

Heat	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
kW kg^{-1}	1.46E0	1.27E0	7.05E-2	1.61E-4	6.18E-11	2.19E-11
I128	93.81	93.29				
I126	3.23	3.71	55.08			
Xe127	2.04	2.34	39.41	17.63		
Xe129m	0.18	0.20	2.76			
Te127	0.16	0.19	1.21	52.83		
Te127m	0.03	0.03	0.50	22.05		
Sb124	0.02	0.03	0.48	3.28		
Te125m	0.02	0.02	0.32	1.91		
Sb125			0.01	1.79		
H3					44.41	
I129					35.53	99.88
Sn121					13.77	
Sn121m					6.23	

Dose	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv h^{-1}	2.12E5	1.90E5	4.40E4	2.29E1	1.44E-7	1.22E-7
I128	74.90	72.21				
I126	19.15	21.36	75.99			
Xe127	5.05	5.63	22.72	44.79		
Sb124	0.25	0.27	1.14	34.14		
Te127	0.02	0.03	0.04	8.04*		
Sb126m	0.01	0.01			19.23	16.71
Sb126			0.01		4.83	4.20
Sb125			0.01	12.13		
I129					67.64	79.08
Sn121m					7.28	

Ing	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	9.16E8	9.16E8	8.40E8	8.06E5	1.75E-1	1.73E-1
Xe127	91.49	91.51	93.12	99.16		
Xe129m	6.58	6.58	5.40			
I126	1.61	1.61	1.44			
I128	0.05	0.05				
Te127m	0.01	0.01	0.01	0.68		
I125	0.01	0.01	0.01	0.09		
Te127				0.05		
Te125m				0.02		
I129					99.09	100.0
H3					0.72	

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	3.49E9	3.49E9	3.24E9	3.28E6	6.74E-2	5.65E-2
Xe127	97.82	97.82	98.25	99.24		
Xe129m	1.99	1.99	1.61			
I126	0.14	0.14	0.13			
Te127m	0.01	0.01	0.01	0.71		
I128	0.01	0.01				
Te125m				0.02		
I125				0.01		
Te127				0.01		
Sb125				0.01		
I129					84.29	100.0
H3					11.58	
Sn121m					3.97	

Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
	1.93E12	1.68E12	2.09E11	7.58E8	1.58E5	1.57E5
I128	86.79	86.01				
Xe127	8.88	10.18	76.29	21.53		
I126	2.64	3.03	19.99			
Xe129m	0.26	0.30	1.78			
Te127m	0.13	0.14	1.13	31.22		
Sb124	0.05	0.06	0.46	1.95		
Sb125	0.02	0.03	0.21	44.17		
Te127			0.01	0.31		
Te125m			0.01	0.02		
I129				0.02	99.80	100.0
H3				0.01	0.19	

Iodine

Pathway analysis

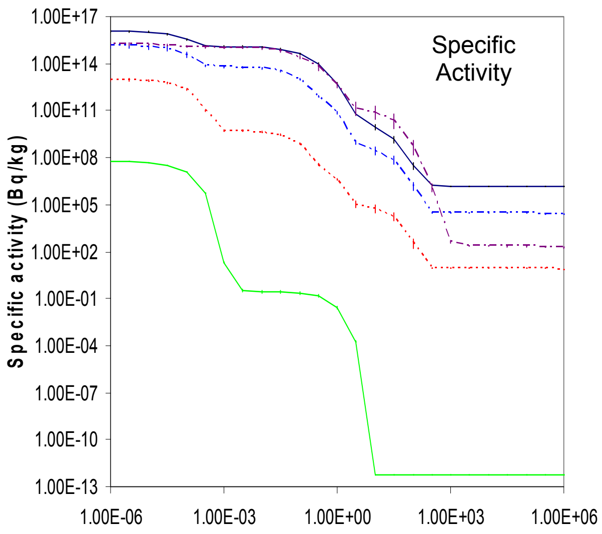
Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ba137m	2.552 m	&I127(n,γ)I128(β$^-$)Xe128(n,γ)*Xe129*_ (n,γ)Xe130(n,γ)*Xe131*(n,γ)Xe132(n,γ)_ *Xe133*(β$^-$)Cs133(n,γ)*Cs134*(n,γ)*Cs135*_ (n,γ)*Cs136*(β$^-$)Ba136(n,γ)Ba137m	80.1	0.3					
		&I127(n,γ)I128(β$^-$)Xe128(n,γ)*Xe129*_ (n,γ)Xe130(n,γ)*Xe131*(n,γ)Xe132(n,γ)_ *Xe133*(β$^-$)Cs133(n,γ)*Cs134*(n,γ)*Cs135*_ (n,γ)*Cs136*(n,γ)Cs137(β$^-$)Ba137m	12.7	93.3					
Sb126m	19.1 m	&I127(n,γ)I128(n,α)Sb125(n,γ)*Sb126m*	100.0	99.8	95.3				
		&I127(n,α)*Sb124*(n,γ)Sb125(n,γ)*Sb126m*		0.2					
		&I127(n,2n)I126(β$^+$)Te126(n,p)*Sb126m*				97.0	73.6	57.1	27.0
		&I127(n,d)Te126(n,p)*Sb126m*				0.7	23.1	34.4	27.2
		&I127(n,p)Te127m(n,d)*Sb126m*					1.1	1.9	
		&I127(n,2p)*Sb126m*						4.8	36.8
I128	24.99 m	I127(n,γ)I128	100.0	100.0	100.0	99.3	98.8	99.1	99.5
Te129	1.16 h	&I127(n,γ)I128(β$^+$)Te128(n,γ)*Te129*	100.0	100.0	100.0	99.5	99.1	99.3	99.7
Te127	9.35 h	&I127(n,γ)I128(β$^-$)Xe128(n,γ)*Xe129*_ (n,α)Te126(n,γ)*Te127*	93.2	99.8	99.6				
		&I127(n,γ)I128(β$^-$)Xe128(n,α)Te125_ (n,γ)Te126(n,γ)*Te127*			0.1				
		&I127(n,p)*Te127*				97.0	99.4	99.6	99.7
		&I127(n,2n)I126(β$^+$)Te126(n,γ)*Te127*				1.7			
I130	12.36 h	&I127(n,γ)I128(β$^+$)Te128(n,γ)*Te129*_ (β$^-$)I129(n,γ)*I130*	94.5	96.6	96.3	78.7	75.4	76.7	78.1
		&I127(n,γ)I128(n,γ)I129(n,γ)*I130*	2.9	0.7	0.9				
		&I127(n,γ)I128(β$^+$)Te128(n,γ)Te129m_ (β$^-$)I129(n,γ)*I130*	2.6	2.7	2.6	15.2	14.6	14.8	15.1
		&I127(n,γ)I128(β$^-$)Xe128(n,γ)*Xe129*_ (n,p)I129(n,γ)*I130*				0.5	2.4	1.9	1.0
		I127(n,γ)I128(β$^-$)Xe128(n,γ)*Xe129*(n,γ)_ Xe130(n,p)*I130*				0.2	1.8	1.2	0.3
Sn121	1.128 d	&I127(n,2n)I126(β$^+$)Te126(n,2n)*Te125*_ (n,2n)Te124(n,α)*Sn121*				23.2			
		&I127(n,2n)I126(β$^+$)Te126(n,nα)_ Sn122(n,2n)*Sn121*				13.1	0.6	0.2	
		&I127(n,2n)I126(β$^-$)Xe126(n,2n)*Xe125*_ (β$^+$)I125(β$^+$)Te125(n,2n)Te124(n,α)*Sn121*				10.6			
		&I127(n,2n)I126(β$^+$)Te126(n,2n)*Te125*_ (n,α)Sn122(n,2n)*Sn121*				9.8			
		&I127(n,2n)I126(β$^-$)Xe126(n,2n)_ *Xe125*(β$^+$)I125(β$^+$)Te125(n,nα)*Sn121*				8.4			
		&I127(n,α)*Sb124*(β$^-$)Te124(n,α)Sn121				8.3			
		&I127(n,2n)I126(β$^-$)Xe126(n,2n)*Xe125*_ (β$^+$)I125(β$^+$)Te125(n,α)Sn122(n,2n)*Sn121*				4.5			
		&I127(n,3n)I125(β$^+$)Te125(n,nα)*Sn121*					88.8	44.7	15.3
		&127(n,nα)Sb123(n,t)*Sn121*					1.3	9.6	14.7
		&127(n,t)*Te125*(n,t)Sb123(n,t)*Sn121*					1.0	4.5	5.3
		&127(n,2n)I126(β$^+$)Te126(n,2nα)*Sn121*					0.3	9.3	6.3
		&127(n,d)Te126(n,2nα)*Sn121*					0.1	5.6	5.1
		&127(n,4n)I124(β$^+$)Te124(n,α)*Sn121*						9.6	13.6
		&127(n,nt)Te124(n,α)*Sn121*						0.4	4.1
		&127(n,5n)I123(β$^+$)Te123(n,h)*Sn121*							9.7
		&127(n,tα)*Sn121*							4.9
I124	4.176 d ▶	&I127(n,2n)I126(β$^-$)Xe126(n,2n)*Xe125*_ (β$^+$)I125(n,2n)I124				96.8			

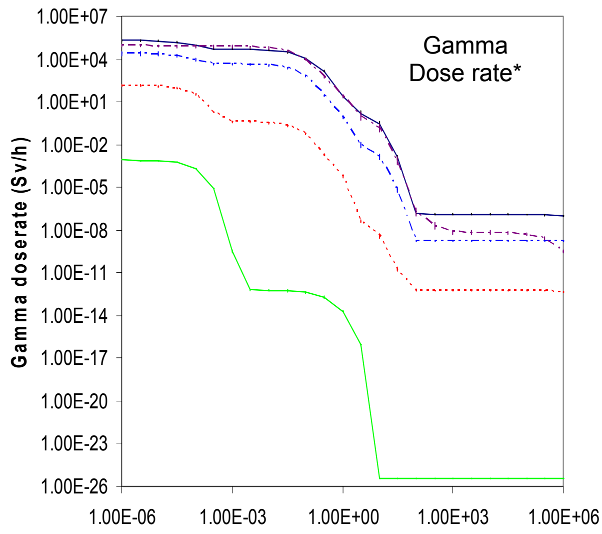
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	I127(n,2n)I126(n,2n)I125(n,2n)I124				2.5			
		I127(n,2n)I126(β⁻)Xe126(n,d)I125(n,2n)I124				0.5			
		I127(n,3n)I125(n,2n)I124					74.1		
		I127(n,2n)I126(n,3n)I124					13.2		
		I127(n,2n)I126(β⁻)Xe126(n,t)I124					10.1		
		I127(n,4n)I124						99.1	99.3
Xe129m	8.88 d	I127(n,γ)I128(β⁻)Xe128(n,γ)Xe129m	100.0	100.0	100.0	97.5	97.8	98.4	98.9
		I127(n,γ)I128(β⁻)Xe128(n,γ)Xe129_ (n,n′)Xe129m				1.3	1.3	0.9	0.6
Xe131m	11.93 d	**&**I127(n,γ)I128(β⁻)Xe128(n,γ)*Xe129*_ (n,γ)Xe130(n,γ)Xe131m	97.2	96.9	96.3	87.4	90.6	90.5	88.7
		&I127(n,γ)I128(β⁺)Te128(n,γ)Te129_ (β⁻)I129(n,γ)*I130*(β⁻)Xe130(n,γ)Xe131m	0.4	0.9	0.8	2.1	1.2	1.4	2.0
		I127(n,γ)I128(β⁻)Xe128(n,γ)Xe129m_ (n,γ)Xe130(n,γ)Xe131m	0.1	0.2	0.1	0.8	0.7	0.7	0.7
		&I127(n,γ)I128(β⁻)Xe128(n,γ)*Xe129*_ (n,γ)Xe130(n,γ)Xe131(n,n′)Xe131m				0.6	0.4	0.3	0.1
		I127(n,γ)I128(β⁺)Te128(n,γ)Te129m_ (β⁻)I129(n,γ)I130(β⁻)Xe130(n,γ)Xe131m				0.6	0.3	0.4	0.5
I126	12.98 d	I127(n,2n)I126				99.3	99.2	99.3	99.5
Cs136	13.03 d	**&**I127(n,γ)I128(β⁻)Xe128(n,γ)*Xe129*(n,γ)_ Xe130(n,γ)*Xe131*(n,γ)Xe132(n,γ)*Xe133*_ (β⁻)Cs133(n,γ)*Cs134*(n,γ)*Cs135*(n,γ)*Cs136*	94.2	93.7	95.6				
Te121	19.16 d	**&**I127(n,2n)I126(β⁻)Xe126(n,nα)_ Te122(n,2n)*Te121*				14.2	0.1		
		&I127(n,2n)I126(β⁻)Xe126(n,α)*Te123*_ (n,2n)Te122(n,2n)*Te121*				13.9			
		&I127(n,nα)Sb123(n,2n)*Sb122*(β⁻)_ Te122(n,2n)*Te121*				9.4	0.1		
		&I127(n,α)Sb124(β⁻)Te124(n,2n)_ *Te123*(n,2n)Te122(n,2n)*Te121*				7.2			
		&I127(n,3n)I125(β⁺)Te125(n,3n)*Te123*_ (n,3n)*Te121*					68.3	2.5	
		&I127(n,3n)I125(β⁺)Te125(n,3n)_ Te123m(n,3n)*Te121*					11.6	0.4	
		&I127(n,3n)I125(n,3n)I123(β⁺)Te123_ (n,3n)*Te121*					7.6	0.5	
		&I127(n,4n)I124(β⁺)Te124(n,4n)*Te121*						73.8	25.3
		&I127(n,nt)Te124(n,4n)*Te121*						3.0	8.3
		&I127(n,3n)I125(β⁺)Te125(n,5n)*Te121*							22.9
		&I127(n,5n)I123(β⁺)Te123(n,3n)*Te121*							22.7
		&I127(n,t)*Te125*(n,5n)*Te121*							9.4
		Other pathways involving (n,2n), (n,α), β⁺				55.3	12.3	19.8	11.4
Te129m	33.60 d	I127(n,γ)I128(β⁺)Te128(n,γ)Te129m	100.0	100.0	100.0	99.5	99.1	99.3	99.6
I125	59.407 d	**&**I127(n,2n)I126(β⁻)Xe126(n,2n)*Xe125*_ (β⁺)I125				96.8			
		I127(n,2n)I126(n,2n)I125				2.5			
		I127(n,3n)I125					98.3	98.8	98.4
Sb124	60.20 d	**&**I127(n,γ)I128(β⁻)Xe128(n,α)*Te125*_ (n,α)Sn122(n,γ)Sn123m(β⁻)Sb123(n,γ)_ *Sb124*	98.9						
		&127(n,α)*Sb124*		100.0		97.4	33.0	18.8	46.2
		&I127(n,3n)I125(β⁺)Te125(n,d)*Sb124*					59.9	48.2	19.8
		&I127(n,2n)I126(β⁺)Te126(n,t)*Sb124*					1.4	8.3	10.4
		&I127(n,t)*Te125*(n,d)*Sb124*					0.7	6.0	8.1
		&I127(n,d)Te126(n,t)*Sb124*					0.4	5.0	8.4
		&I127(n,4n)I124(β⁺)Te124(n,p)*Sb124*						10.2	4.0
Te127m	109.0 d	I127(n,γ)I128(β⁻)Xe128(n,γ)Xe129_ (n,α)Te126(n,γ)Te127m	94.0	94.1	93.1				
		I127(n,p)Te127m				98.1	99.4	99.6	99.7
		I127(n,2n)I126(β⁺)Te126(n,γ)Te127m				1.5			

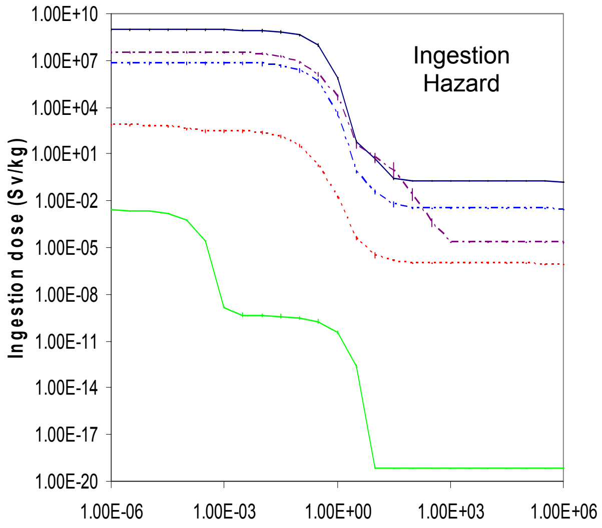
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Ag110m	249.78 d	Pathways involving (n,α), (n,nα), (n,2n), β^-,β^+				100.0	100.0	100.0	100.0
Cs134	2.065 y	**&**I127(n,γ)I128(β^-)Xe128(n,γ)*Xe129*_ (n,γ)Xe130(n,γ)*Xe131*(n,γ)Xe132(n,γ)_ *Xe133*(β^-)Cs133(n,γ)*Cs134*	98.2	97.7	98.0				
Sb125	2.759 y	I127(n,γ)I128(n,α)Sb125	100.0	99.6	100.0				
		&I127(n,α)*Sb124*(n,γ)Sb125		0.4					
		I127(n,2n)I126(β^+)Te126(n,d)Sb125				43.3	45.3	32.9	24.8
		&I127(n,2n)I126(β^+)Te126(n,2n)*Te125*_ (n,p)Sb125				31.1			
		&I127(n,2n)I126(β^-)Xe126(n,2n)*Xe125*_ (β^+)I125(β^+)Te125(n,p)Sb125				19.9			
		I127(n,2n)I126(β^+)Te126(n,2n)Te125m_ (n,p)Sb125				2.7			
		I127(n,2n)I126(n,2n)I125(β^+)Te125_ (n,p)Sb125				1.4			
		I127(n,d)Te126(n,d)Sb125				0.3	14.4	20.1	20.0
		I127(n,3n)I125(β^+)Te125(n,p)Sb125					33.8	10.6	2.7
		I127(n,h)Sb125					4.9	34.3	50.9
		&I127(n,t)*Te125*(n,p)Sb125					0.5	1.1	
H3	12.33 y	I127(n,X)H1(n,γ)H2(n,γ)H3	93.3	94.7					
		I127(n,X)H3				94.2	88.2	89.1	88.9
		I127(n,2n)I126(n,X)H3				3.9	0.1		
		I127(n,3n)I125(β^+)Te125(n,X)H3					7.5	4.0	1.5
		I127(n,2n)I126(β^+)Te126(n,X)H3					0.8	0.7	
		I127(n,2n)I126(β^-)Xe126(n,X)H3					0.8	0.6	
		I127(n,4n)I124(β^+)Te124(n,X)H3						2.7	1.8
		I127(n,5n)I123(β^+)Te123(n,X)H3							3.1
Cs137	30.041 y	**&**I127(n,γ)I128(β^-)Xe128(n,γ)*Xe129*_ (n,γ)Xe130(n,γ)*Xe131*(n,γ)Xe132(n,γ)_ *Xe133*(β^-)Cs133(n,γ)*Cs134*(n,γ)*Cs135*_ (n,γ)*Cs136*(n,γ)Cs137	90.1	93.6	93.3				
		&I127(n,γ)I128(β^-)Xe128(n,γ)*Xe129*_ (n,γ)Xe130(n,γ)*Xe131*(n,γ)Xe132(n,γ)_ *Xe133*(n,γ)*Xe134*(n,γ)*Xe135*(n,γ)Xe136_ (n,γ)Xe137(β^-)Cs137	3.9						
Sn121m	55.0 y	**&**I127(n,2n)I126(β^+)Te126(n,2n)*Te125*_ (n,nα)Sn121m				24.0			
		&I127(n,2n)I126(β^-)Xe126(n,2n)*Xe125*_ (β^+)I125(β^+)Te125(n,nα)Sn121m				15.3			
		&I127(n,2n)I126(β^+)Te126(n,2n)*Te125*_ (n,2n)Te124(n,α)Sn121m				11.2			
		&I127(n,2n)I126(β^+)Te126(n,2n)*Te125*_ (n,α)Sn122(n,2n)Sn121m				10.3			
		&I127(n,α)*Sb124*(β^-)Te124(n,α)Sn121m				8.0			
		&I127(n,2n)I126(β^-)Xe126(n,2n)*Xe125*_ (β^+)I125(β^+)Te125(n,2n)Te124(n,α)Sn121m				5.1			
		&I127(n,2n)I126(β^-)Xe126(n,2n)*Xe125*_ (β^+)I125(β^+)Te125(n,α)Sn122(n,2n)Sn121m				4.7			
		I127(n,3n)I125(β^+)Te125(n,nα)Sn121m					93.2	59.1	21.5
		&I127(n,t)*Te125*(n,nα)Sn121m					1.6	7.5	8.9
		I127(n,nα)Sb123(n,t)Sn121m					1.0	5.0	6.5
		I127(n,2n)I126(β^+)Te126(n,2nα)Sn121m					0.3	9.3	10.3
		I127(n,d)Te126(n,2nα)Sn121m					0.1	5.7	8.4
		I127(n,4n)I124(β^+)Te124(n,α)Sn121m						7.7	15.6
		I127(n,tα)Sn121m							11.2
		I127(n,nt)Te124(n,α)Sn121m							5.1
		I127(n,5n)I123(β^+)Te123(n,h)Sn121m							4.5
Sn126	2.3 10^5 y	I127(n,γ)I128(β^+)Te128(n,γ)Te129m_ (n,α)Sn126	94.3	94.7	94.5				
	►	**&**I127(n,γ)I128(β^+)Te128(n,γ)*Te129*_ (n,α)Sn126	5.7	5.3	5.5				

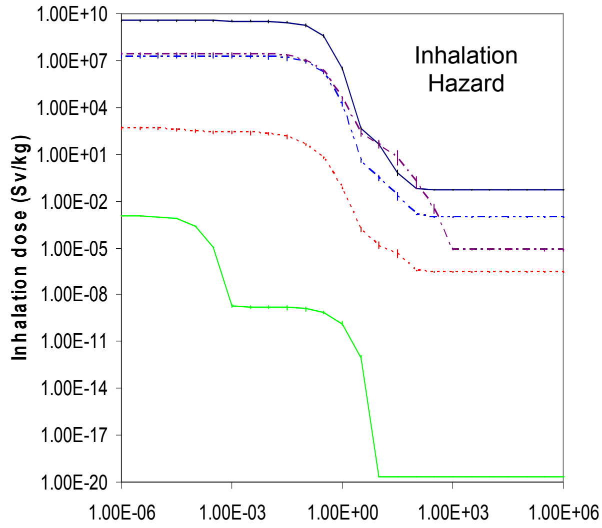
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**I127(n,2n)I126(β^+)Te126(n,p)*Sb126*_(n,p)Sn126				98.7	58.0	6.0	
		&I127(n,d)Te126(n,p)*Sb126*(n,p)Sn126				0.7	19.4	3.7	
		I127(n,γ)I128(β^+)Te128(n,h)Sn126					11.3	54.3	54.3
		I127(n,p)Te127m(n,2p)Sn126					2.7	32.1	62.3
		I127(n,p)Te127m(n,p)Sb127(n,d)Sn126					2.6	0.5	
		&I127(n,p)*Te127m*(n,d)Sb126(n,p)Sn126					1.5		
Cs135	2.3 10^6 y	**&**I127(n,γ)I128(β^-)Xe128(n,γ)*Xe129*_(n,γ)Xe130(n,γ)*Xe131*(n,γ)Xe132(n,γ)_*Xe133*(β^-)Cs133(n,γ)*Cs134*(n,γ)*Cs135*	97.9	97.5	97.7				
Pd107	6.5 10^6 y	Pathways involving (n,α), (n,nα), (n,2n), β^-,β^+				100.0	100.0	100.0	100.0
I129	1.6 10^7 y	**&**I127(n,γ)I128(β^+)Te128(n,γ)*Te129*_(β^-)I129	94.5	96.7	96.3	83.4	81.4	82.1	83.1
		I127(n,γ)I128(n,γ)I129	2.9	0.6	1.0				
		I127(n,γ)I128(β^+)Te128(n,γ)Te129m_(β^-)I129	2.6	2.7	2.6	15.6	15.3	15.4	15.6
		&I127(n,γ)I128(β^-)Xe128(n,γ)*Xe129*_(n,p)I129				0.6	2.6	1.9	1.0
Xe124	2.0 10^{14} y	**&**I127(n,2n)I126(β^-)Xe126(n,2n)*Xe125*_(n,2n)Xe124				99.9			
		I127(n,2n)I126(β^-)Xe126(n,3n)Xe124					99.8	99.9	99.1

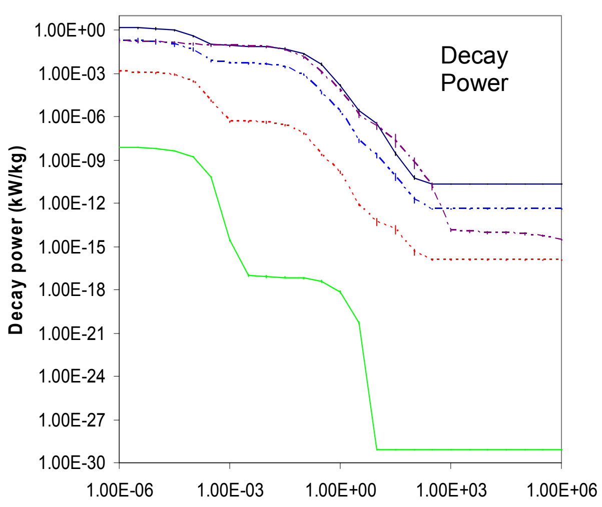
Iodine activation characteristics

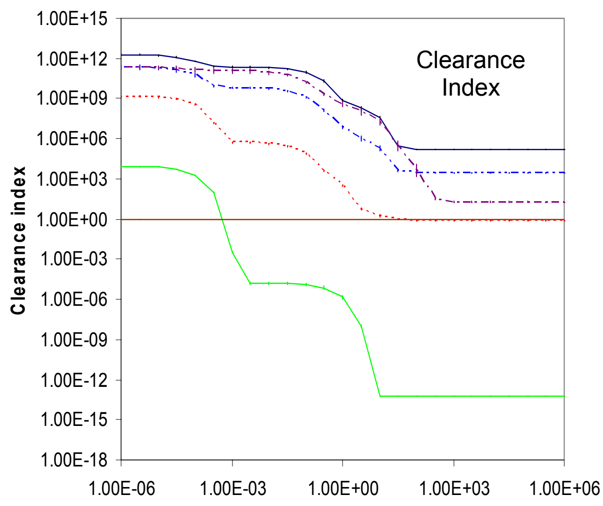










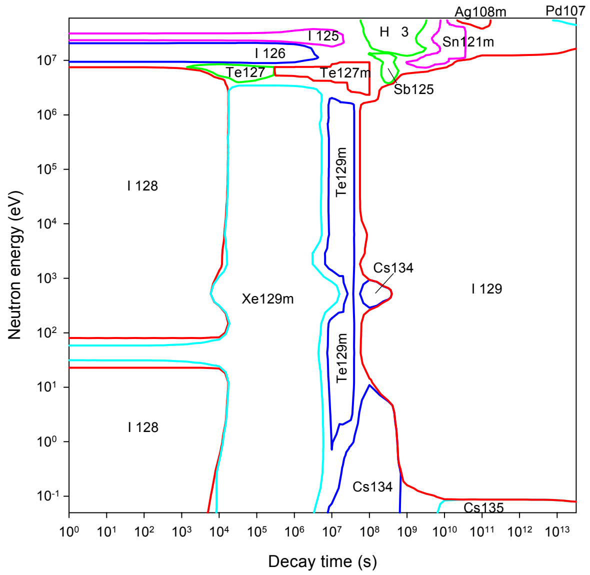


Decay time (years)

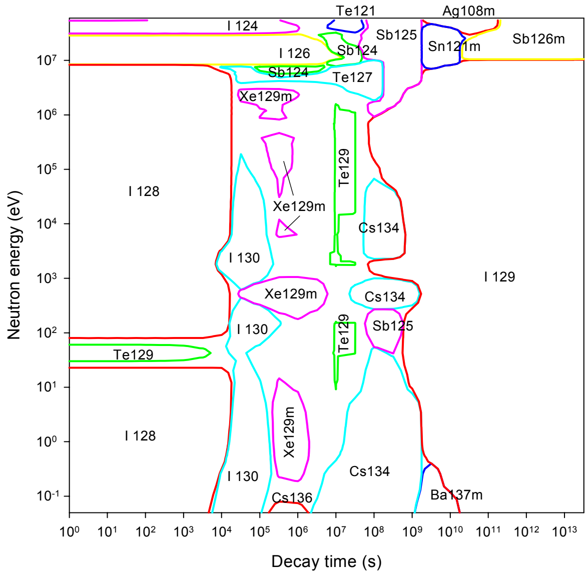
Decay time (years)

Iodine importance diagrams & transmutation

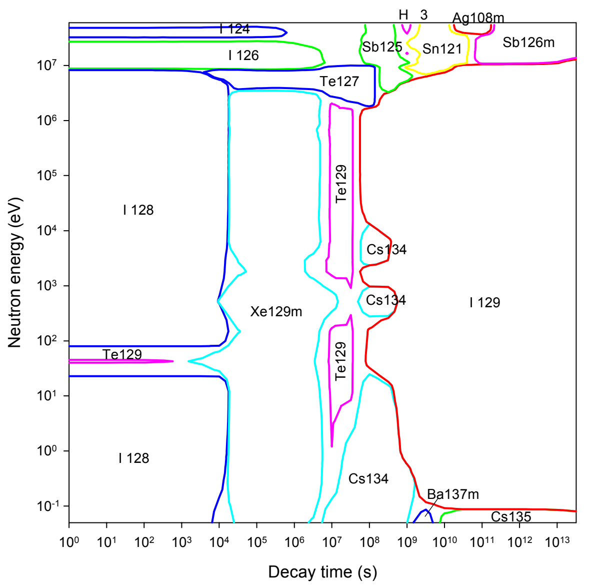
Activity



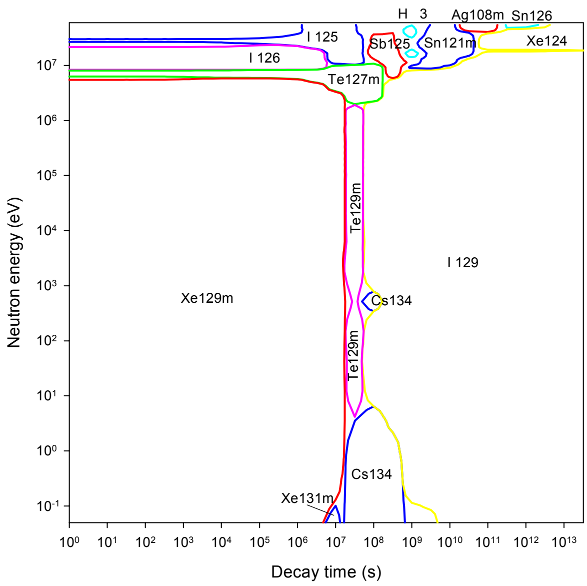
Dose rate



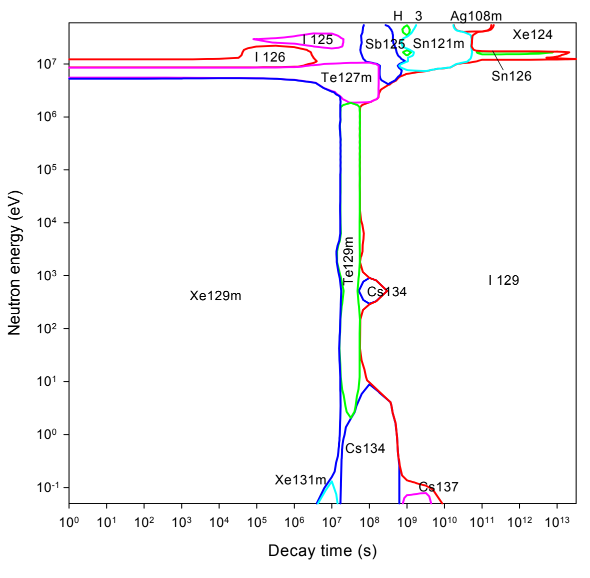
Heat output



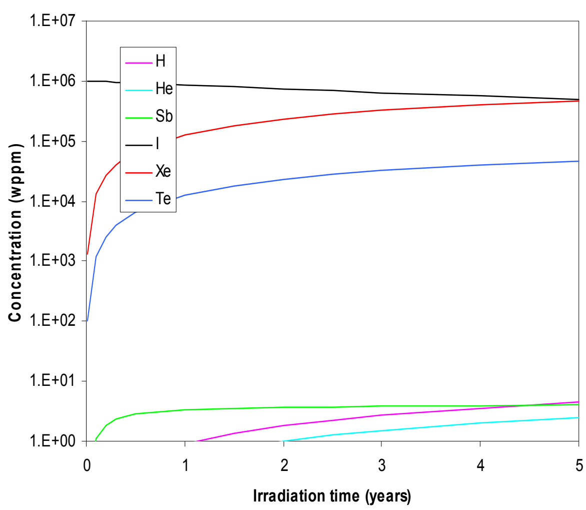
Ingestion dose



Inhalation dose



First wall transmutation



Xenon

General properties

		Isotopes	Isotopic abundances / %
Atomic number	54		
Crustal abundance / wppm	$3.0\ 10^{-5}$	Xe124	0.095 ($T_{½} = 2.00\ 10^{14}$ y)
Melting point / K	161.4	Xe126	0.089
Boiling point / K	165	Xe128	1.91
Density / kgm^{-3}	5.887	Xe129	26.4
Thermal conductivity / $Wm^{-1}K^{-1}$	$5.69\ 10^{-3}$	Xe130	4.071
Electrical resistivity /Ωm	-	Xe131	21.232
Coefficient of thermal expansion / K^{-1}	-	Xe132	26.909
Crystal structure	FCC	Xe134	10.436 ($T_{½} = 1.10\ 10^{16}$ y)
Number of stable isotopes	6 (9)	Xe136	8.857 ($T_{½} = 2.10\ 10^{20}$ y)
Mean atomic weight	131.293		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.18E15	1.15E15	7.28E14	5.85E13	2.46E10	1.42E8	kW kg^{-1}	8.08E-2	7.72E-2	5.12E-2	1.60E-2	1.64E-6	2.03E-9
Xe131m	29.12	29.78	38.23				Cs134	27.71	29.00	43.57	99.84		
Xe133	23.58	24.12	25.61				Cs136	14.54	15.21	18.89			
Xe129m	10.56	10.80	12.89				Xe135	12.10	12.61	0.03			
Xe135	9.17	9.34	0.02				Xe131m	11.08	11.59	14.14			
Cs134	6.88	7.04	11.13	99.30			Xe133	9.92	10.38	10.47			
Xe133m	5.66	5.79	2.89				Xe129m	5.76	6.02	6.83			
Xe135m	3.89	3.13					Xe135m	4.73	3.90				
Xe127	2.98	3.05	4.51	0.06			Xe133m	3.07	3.20	1.52			
Cs136	2.71	2.78	3.63				I128	3.01	2.72				
I128	1.55	1.37					Xe127	2.17	2.27	3.19	0.01		
Cs134m	1.33	1.33					Xe134m	2.10					
Xe134m	0.46						Cs132	0.83	0.87	0.89			
Cs137			0.02	0.21	50.85		Ba137m			0.03	0.08	76.29	
Ba137m			0.02	0.20	48.00		Cs137				0.02	23.04	
Cs135					0.59	99.82	Cs135					0.13	99.82

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	5.82E4	5.48E4	4.50E4	2.07E4	1.61E0	1.63E-8	Sv kg^{-1}	6.10E8	6.09E8	4.30E8	1.15E6	3.88E2	3.11E-1
Cs134	49.58	52.70	63.86	99.90			Xe131m	36.67	36.69	42.03			
Cs136	30.85	32.78	32.83				Xe133	26.04	26.05	24.69			
Xe135m	5.85	4.90					Xe129m	17.80	17.81	18.97			
Xe134m	4.34						Xe127	8.08	8.09	10.68	4.07		
Xe135	3.60	3.81	0.01				Xe133m	7.24	7.24	3.23			
Cs132	1.56	1.65	1.37				Xe135	3.73	3.72	0.01			
Xe127	1.07	1.14	1.29				Cs134	0.25	0.25	0.36	95.58		
I132	0.75	0.78					Cs136	0.02	0.02	0.02			
I130	0.58	0.62	0.01				I126	0.01	0.01	0.01			
Ba137m		0.03	0.04	0.08	99.71		Cs137				0.14	41.97	
I129						98.01	Cs135					0.08	91.04
Sb126m						1.59	I129					0.01	8.96

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	8.34E8	8.34E8	6.49E8	1.36E6	6.33E2	1.23E0		9.65E11	9.47E11	8.76E11	5.82E11	1.32E8	2.67E4
Xe131m	39.40	40.01	41.54				Cs134	84.24	85.76	92.43	99.77		
Xe127	24.05	24.05	28.80	14.06			Cs136	3.32	3.38	3.01			
Xe133	15.70	15.70	13.49				Xe135	3.12	3.16	0.01			
Xe129m	14.96	14.96	14.44				Xe135m	2.07	1.66				
Xe133m	3.61	3.61	1.46				Xe133	1.70	1.73	1.25			
Xe135	1.43	1.42					Xe131m	1.23	1.25	1.10			
Cs134	0.20	0.20	0.25	85.41			Xe134m	1.07					
Cs136	0.01	0.01	0.01				Xe127	1.04	1.06	1.07			
Cs137				0.35	77.19		Xe129m	0.92	0.94	0.77			
Ba137m				0.10	22.42		Cs137	0.13	0.13	0.14	0.21	94.69	
Ba133				0.06	0.19		Cs132	0.06	0.06	0.04			
Cs135					0.20	99.25	Ba137m		0.01	0.01	0.01	5.26	
I129						0.74	I129					0.02	94.71
							Cs135						5.29

Xenon

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Xe134m	0.29 s	&Xe132(n,γ)*Xe133*(n,γ)Xe134m	51.0	17.2	92.6				
		&Xe131(n,γ)Xe132(n,γ)*Xe133*(n,γ)_ Xe134m	42.4	0.2	2.9				
		&Xe129(n,γ)Xe130(n,γ)*Xe131*(n,γ)_ Xe132(n,γ)*Xe133*(n,γ)Xe134m	2.5						
		Xe132(n,γ)Xe133m(n,γ)Xe134m	2.4	81.6	4.3				
		Xe131(n,γ)Xe132(n,γ)Xe133m(n,γ)_ Xe134m	2.0	0.8	0.1				
		&Xe130(n,γ)*Xe131*(n,γ)Xe132(n,γ)_ *Xe133*(n,γ)Xe134m	1.4						
		Xe134(n,n′)Xe134m				99.4	6.5	11.7	14.7
		Xe136(n,3n)Xe134m					92.0	87.0	84.0
Ba137m	2.552 m	Xe136(n,γ)Xe137(β^-)Cs137(β^-)Ba137m	99.1	99.2	99.9	98.9	99.1	99.3	99.7
		Xe134(n,γ)Xe135(n,γ)Xe136(n,γ)_ Xe137(β^-)Cs137(β^-)Ba137m	0.7						
Xe135m	15.29 m	Xe134(n,γ)Xe135m	99.6	100.0	100.0		0.3	0.2	0.2
		Xe132(n,γ)Xe133(n,γ)Xe134(n,γ)Xe135m	0.2						
		Xe131(n,γ)Xe132(n,γ)Xe133(n,γ)_ Xe134(n,γ)Xe135m	0.1						
		Xe136(n,2n)Xe135m				99.9	84.8	65.7	53.2
		Xe136(n,d)I135(β^-)Xe135m					14.9	34.1	46.6
Sb126m	19.10 m	&Xe124(n,γ)*Xe125*(β^+)I125(n,γ)I126_ (n,α)Sb123(n,γ)Sb124(n,γ)Sb125(n,γ)_ *Sb126m*	83.7	23.7					
		&Xe124(n,α)Te121(β^+)Sb121(n,γ)_ Sb122(n,γ)Sb123(n,γ)Sb124(n,γ)Sb125_ (n,γ)*Sb126m*	0.2	7.3					
		&Xe126(n,γ)*Xe127*(β^+)I127(n,γ)I128_ (n,α)Sb125(n,γ)*Sb126m*		60.4					
		&Xe129(n,α)Te126(n,p)*Sb126m*				12.6	4.6	1.3	0.9
		&Xe129(n,p)I129(n,α)*Sb126m*				10.1	4.0	0.7	0.3
		&Xe129(n,3n)*Xe127*(β^+)I127(n,d)_ Te126(n,p)*Sb126m*					8.0	1.6	0.1
		Xe129(n,3n)Xe127(β^+)I127(n,2n)I126_ (β^+)Te126(n,p)Sb126m					6.3	0.5	
		&Xe132(n,nα)Te128(n,t)*Sb126m*					5.1	23.0	13.0
		&Xe131(n,nα)Te127m(n,d)*Sb126m*					4.8	3.2	1.1
		&Xe131(n,t)I129(n,α)*Sb126m*					2.6	3.6	5.1
		&Xe129(n,d)I128(β^+)Te128(n,t)*Sb126m*					2.5	12.4	8.5
		&Xe131(n,2nα)Te126(n,p)*Sb126m*					1.2	7.4	1.9
		&Xe131(n,α)Te128(n,t)*Sb126m*					1.0	2.7	5.5
		&Xe129(n,nt)I126(β^+)Te126(n,p)*Sb126m*					0.9	5.4	8.1
		&Xe132(n,nt)I129(n,α)*Sb126m*					0.1	0.7	5.5
		&Xe131(n,nt)I128(β^+)Te128(n,t)*Sb126m*						1.7	7.7
		&Xe134(n,3nα)Te128(n,t)*Sb126m*							6.8
		Other pathways involving (n,2n), (n,α), β^+	16.1	8.6		77.3	58.9	35.8	35.5
Xe135	9.14 h	&Xe134(n,γ)*Xe135*	99.6	100.0	100.0		0.2		
		&Xe136(n,2n)*Xe135*				100.0	66.1	46.7	36.5
		&Xe136(n,d)I135(β^-)*Xe135*					33.9	47.9	56.7
Sn121	1.128 d	&Xe124(n,γ)*Xe125*(n,α)Te122(n,γ)_ Te123m(n,α)Sn120(n,γ)Sn121	72.7	0.2					
	►	&Xe124(n,α)Te121(β^+)Sb121(n,γ)_ *Sb122*(β^-)Te122(n,γ)Te123m(n,α)_ Sn120(n,γ)Sn121	9.5	3.8					

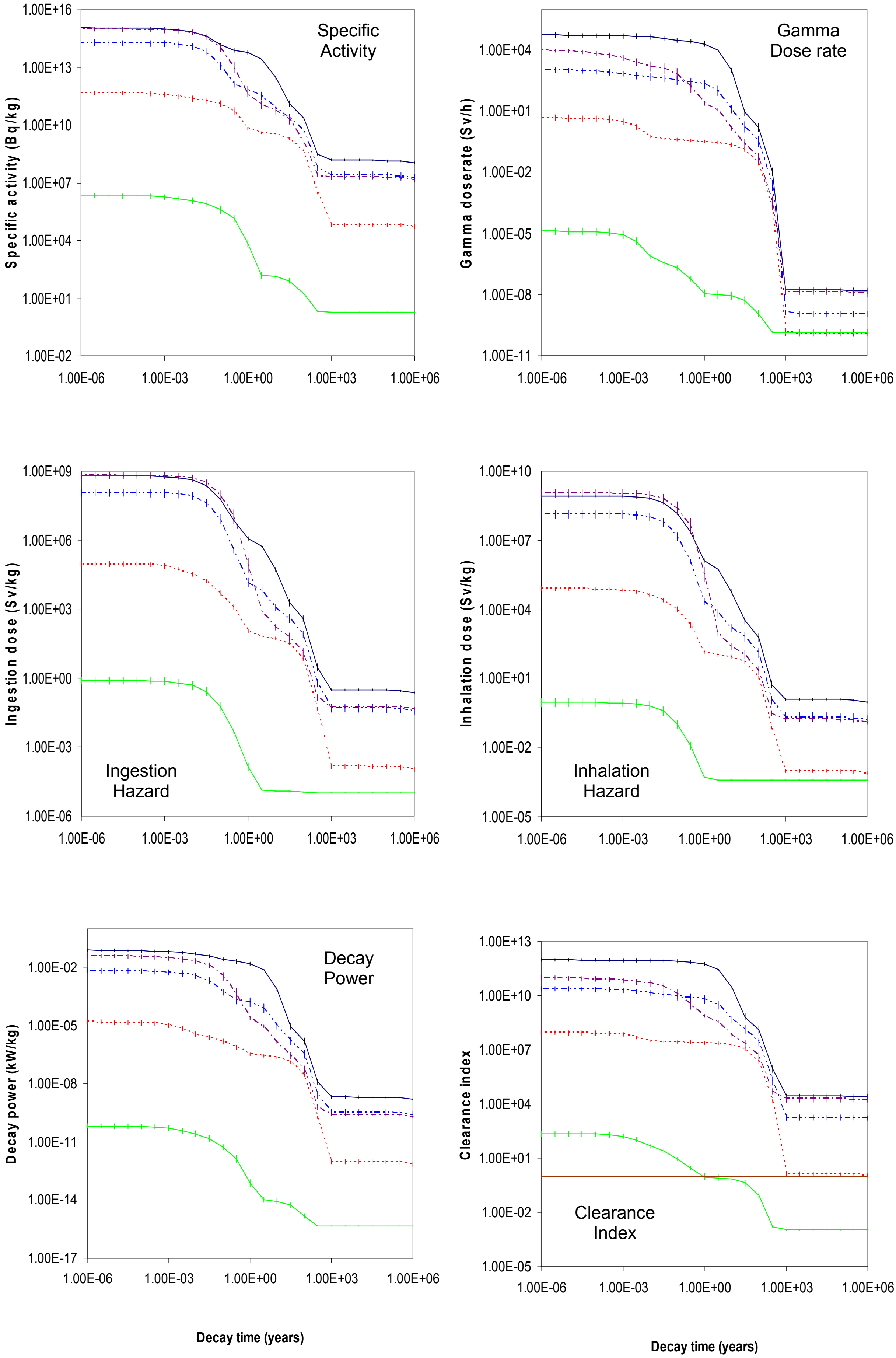
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Xe124(n,γ)Xe125(n,α)Te122(n,γ)_ *Te123*(n,α)Sn120(n,γ)Sn121	5.6						
		&Xe126(n,α)*Te123*(n,α)Sn120(n,γ)Sn121	0.4	55.9					
		Xe126(n,α)Te123m(n,α)Sn120(n,γ)Sn121	0.3	37.0					
		Xe126(n,2n)Xe125(β^{+})I125(β^{+})Te125_ (n,2n)Te124(n,α)Sn121				19.5			
		Xe129(n,3n)Xe127(β^{+})I127(n,3n)I125_ (β^{+})Te125(n,nα)Sn121				14.5	1.4		
		Xe126(n,2n)Xe125(β^{+})I125(β^{+})Te125_ (n,α)Sn122(n,2n)Sn121				8.2			
		&Xe126(n,2n)Xe125(β^{+})I125(β^{+})Te125_ (n,nα)*Sn121*				7.6	0.5	0.1	
		&Xe124(n,p)I124(β^{+})Te124(n,α)*Sn121*				5.7			
		&Xe129(n,nα)*Te125*(n,nα)*Sn121*				0.5	15.8	8.2	1.1
		&Xe128(n,4n)*Xe125*(β^{+})I125(β^{+})Te125_ (n,nα)*Sn121*						9.7	1.9
		&Xe131(n,2nα)Te126(n,2nα)*Sn121*						4.0	1.1
		&Xe129(n,5n)*Xe125*(β^{+})I125(β^{+})Te125_ (n,nα)*Sn121*							32.4
		Other pathways involving (n,2n), (n,α), β^{+}	11.5	3.1		44.0	82.3	78.0	63.5
I124	4.176 d	Xe124(β^{+})I124	100.0	100.0	100.0				
		Xe124(n,p)I124				55.2	7.8	0.1	
		&Xe126(n,2n)*Xe125*(β^{+})I125(n,2n)I124				25.6	0.3		
		&Xe129(n,3n)*Xe127*(β^{+})I127(n,3n)I125_ (n,2n)I124					37.0		
		Xe128(n,3n)Xe126(n,t)I124					12.6	1.1	0.4
		&Xe129(n,3n)*Xe127*(β^{+})I127(n,2n)I126_ (n,3n)I124					6.9		
		Xe129(n,2n)Xe128(n,3n)Xe126(n,t)I124					6.1	0.3	
		Xe126(n,t)I124					3.7	0.4	0.5
		Xe129(n,4n)Xe126(n,t)I124					0.3	12.2	7.8
		&Xe129(n,3n)*Xe127*(β^{+})I127(n,4n)I124						48.3	13.9
		Xe129(n,t)I127(n,4n)I124						8.8	7.3
		&Xe130(n,4n)*Xe127*(β^{+})I127(n,4n)I124						8.4	3.1
		&Xe131(n,5n)*Xe127*(β^{+})I127(n,4n)I124							25.7
		Xe129(n,3nt)I124							3.9
		Xe128(n,2nt)I124							3.7
		Other pathways involving (n,2n), (n,α), β^{+}				19.2	25.3	20.4	33.7
Xe133	5.244 d	&Xe132(n,γ)*Xe133*	53.0	98.8	97.0		0.5		
		&Xe131(n,γ)Xe132(n,γ)*Xe133*	41.7	1.1	3.0				
		&Xe129(n,γ)Xe130(n,γ)*Xe131*(n,γ)_ Xe132(n,γ)*Xe133*	3.6						
		&Xe130(n,γ)*Xe131*(n,γ)Xe132(n,γ)*Xe133*	1.7						
		&Xe134(n,2n)*Xe133*				100.0	45.1	6.2	8.7
		Xe134(n,d)*I133*(β^{-})Xe133					26.9	7.3	15.2
		&Xe136(n,4n)*Xe133*					12.5	84.9	59.4
		&Xe136(n,3n)*Xe134*(n,2n)*Xe133*					7.6		
		&Xe136(n,3n)*Xe134*(n,d)*I133*(β^{-})Xe133					4.2		
		Xe136(n,nt)I133(β^{-})Xe133					0.3	0.8	12.5
Xe129m	8.88 d	Xe128(n,γ)Xe129m	99.2	100.0	100.0				
		Xe131(n,2n)Xe130(n,2n)Xe129m				35.9	1.6	0.6	
		Xe129(n,n′)Xe129m				28.8	9.2	6.7	9.0
		Xe130(n,2n)Xe129m				26.8	4.9	2.9	3.8
		&Xe132(n,2n)*Xe131*(n,2n)Xe130(n,2n)_ Xe129m				6.1			
		Xe131(n,3n)Xe129m					67.7	27.5	25.6
		Xe132(n,3n)Xe130(n,2n)Xe129m					6.1	1.5	
		&Xe132(n,2n)*Xe131*(n,3n)Xe129m					5.7	1.6	
		Xe132(n,4n)Xe129m						52.7	46.0
		Xe134(n,6n)Xe129m							6.5
Xe131m	11.93 d	Xe129(n,γ)Xe130(n,γ)Xe131m	81.3	86.3	32.2				
	►	Xe130(n,γ)Xe131m	17.8	13.7	67.8				

Nuclide	$T_{1/2}$	Pathway	210	186	151	42	30	21	6
	◄	&Xe128(n,γ)Xe129(n,γ)Xe130(n,γ)_ Xe131m	0.8						
		Xe132(n,2n)Xe131m				87.8	75.3	39.0	45.0
		Xe131(n,n′)Xe131m				8.4	15.6	8.7	10.0
		Xe132(n,2n)Xe131(n,n′)Xe131m				1.0			
		Xe134(n,4n)Xe131m					0.3	45.8	25.5
		Xe136(n,6n)Xe131m							14.4
Cs136	13.03 d	&Xe132(n,γ)Xe133(β$^-$)Cs133(n,γ)_ Cs134(n,γ)Cs135(n,γ)Cs136	62.9	90.4					
		&Xe131(n,γ)Xe132(n,γ)Xe133(β$^-$)_ Cs133(n,γ)Cs134(n,γ)Cs135(n,γ)Cs136	33.6	0.3					
		&Xe134(n,γ)Xe135(β$^-$)Cs135(n,γ)Cs136	1.9	8.9	100.0				
		&Xe136(n,γ)Xe137(β$^-$)Cs137(n,2n)Cs136				50.0	56.6	45.2	36.9
		&Xe136(n,2n)Xe135(β$^-$)Cs135(n,γ)Cs136				50.0	28.5	24.9	22.4
		&Xe136(n,d)I135(β$^-$)Xe135(β$^-$)Cs135_ (n,γ)Cs136					14.1	28.9	39.5
Te121	19.16 d	&Xe124(n,α)Te121	100.0	100.0	99.9	18.8	1.4	0.1	
		Xe124(n,2n)Xe123(β$^+$)I123(β$^+$)Te123_ (n,2n)Te122(n,2n)Te121				40.6	0.1		
		&Xe124(n,2n)Xe123(β$^+$)I123(β$^+$)Te123_ (n,3n)Te121				20.3	0.9		
		&Xe124(n,3n)Xe122(β$^+$)I122(β$^+$)Te122_ (n,2n)Te121					9.0	1.2	
		&Xe124(n,d)I123(β$^+$)Te123(n,3n)Te121					3.8	0.3	
		&Xe129(n,4n)Xe126(n,2nα)Te121						17.8	1.4
		&Xe129(n,2nα)Te124(n,4n)Te121						11.6	1.5
		Xe129(n,4n)Xe126(n,3n)Xe124(n,4n)_ Xe121(β$^+$)I121(β$^+$)Te121						4.5	0.6
		Xe124(n,4n)Xe121(β$^+$)I121(β$^+$)Te121						2.7	2.2
		&Xe129(n,5n)Xe125(β$^+$)I125(β$^+$)Te125_ (n,5n)Te121							11.8
		&Xe129(n,2nt)I125(β$^+$)Te125(n,5n)Te121							4.3
		Other pathways involving (n,2n), (n,α), β$^+$			0.1	20.3	84.8	61.8	78.2
Xe127	36.40 d	&Xe126(n,γ)Xe127	94.5	99.9	99.9				
		&Xe124(n,γ)Xe125(β$^+$)I125(n,γ)I126_ (β$^-$)Xe126(n,γ)Xe127	3.9						
		&Xe129(n,2n)Xe128(n,2n)Xe127				75.0	1.3	0.8	0.2
		&Xe128(n,2n)Xe127				21.7	1.4	1.3	0.8
		&Xe129(n,3n)Xe127					80.1	62.0	26.1
		&Xe131(n,3n)Xe129(n,3n)Xe127					11.7	3.4	0.6
		&Xe130(n,4n)Xe127						10.8	5.9
		&Xe132(n,4n)Xe129(n,3n)Xe127						6.9	1.1
		&Xe132(n,3n)Xe130(n,4n)Xe127						5.6	1.3
		&Xe131(n,5n)Xe127							48.2
I125	59.407 d	&Xe124(n,γ)Xe125(β$^+$)I125	100.0	100.0	100.0				
		&Xe126(n,2n)Xe125(β$^+$)I125				57.3	0.6	0.3	
		&Xe129(n,2n)Xe128(n,2n)Xe127(β$^+$)I127_ (n,2n)I126(β$^-$)Xe126(n,2n)Xe125(β$^+$)I125				14.1			
		&Xe128(n,2n)Xe127(β$^+$)I127(n,2n)I126_ (β$^-$)Xe126(n,2n)Xe125(β$^+$)I125				13.1			
		&Xe129(n,3n)Xe127(β$^+$)I127(n,3n)I125					77.5	20.4	1.0
		&Xe131(n,4n)Xe128(n,4n)Xe125(β$^+$)I125						15.3	1.8
		&Xe128(n,4n)Xe125(β$^+$)I125						12.6	3.7
		&Xe129(n,4n)Xe126(n,2n)Xe125(β$^+$)I125						8.4	1.3
		&Xe129(n,2n)Xe128(n,4n)Xe125(β$^+$)I125						7.5	1.4
		Xe129(n,2nt)I125						0.4	6.8
		&Xe129(n,5n)Xe125(β$^+$)I125							58.7
Cs134	2.065 y	&Xe132(n,γ)Xe133(β$^-$)Cs133(n,γ)Cs134	58.8	99.4	98.7				
	►	&Xe131(n,γ)Xe132(n,γ)Xe133(β$^-$)_ Cs133(n,γ)Cs134	38.9	0.4	1.2				

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	&Xe129(n,γ)Xe130(n,γ)*Xe131*(n,γ)_ Xe132(n,γ)*Xe133*(β^-)Cs133(n,γ)*Cs134*	1.2						
		&Xe130(n,γ)*Xe131*(n,γ)Xe132(n,γ)_ *Xe133*(β^-)Cs133(n,γ)*Cs134*	0.7						
		&Xe136(n,2n)*Xe135*(β^-)Cs135(n,2n)*Cs134*				99.6	65.9	44.9	35.4
		Xe136(n,d)I135(β^-)*Xe135*(β^-)Cs135_ (n,2n)*Cs134*					30.6	49.2	58.7
Sb125	2.759 y	&Xe124(n,γ)*Xe125*(β^+)I125(n,γ)I126_ (n,α)Sb123(n,γ)*Sb124*(n,γ)Sb125	99.5	28.7	13.2				
		&Xe124(n,α)Te121(β^+)Sb121(n,γ)_ *Sb122*(n,γ)Sb123(n,γ)*Sb124*(n,γ)Sb125	0.3	8.3	44.9				
		&Xe126(n,γ)*Xe127*(β^+)I127(n,γ)I128_ (n,α)Sb125		61.9	32.1				
		&Xe126(n,2n)*Xe125*(β^+)I125(β^+)Te125_ (n,p)Sb125				47.5	0.3		
		Xe128(n,2n)Xe127(β^+)I127(n,2n)I126_ (β^+)Te126(n,d)Sb125				6.5	0.3		
		&Xe129(n,nα)*Te125*(n,p)Sb125				2.1	6.0	1.8	0.3
		&Xe129(n,3n)*Xe127*(β^+)I127(n,d)_ Te126(n,d)Sb125					7.0	2.7	0.3
		Xe129(n,3n)Xe127(β^+)I127(n,2n)I126_ (β^+)Te126(n,d)Sb125					5.9	0.8	0.1
		&Xe129(n,3n)*Xe127*(β^+)I127(n,h)Sb125					4.0	8.0	1.8
		Xe131(n,t)I129(n,nα)Sb125					3.8	7.9	3.4
		Xe131(n,2nα)Te126(n,d)Sb125					1.1	13.8	5.6
		Xe129(n,nt)I126(β^+)Te126(n,d)Sb125					1.0	10.0	23.1
		Xe132(n,3nα)Te126(n,d)Sb125						0.3	6.3
		&Xe129(n,5n)*Xe125*(β^+)I125(β^+)Te125_ (n,p)Sb125							8.8
		Other pathways involving (n,2n), (n,α), β^+	0.2	1.1	9.8	43.9	70.6	54.7	50.3
Ba133	10.54 y	&Xe136(n,2n)*Xe135*(β^-)Cs135(n,2n)_ *Cs134*(β^-)Ba134(n,2n)*Ba133*				99.5	56.4	37.8	27.8
		&Xe136(n,d)I135(β^-)*Xe135*(β^-)Cs135_ (n,2n)*Cs134*(β^-)Ba134(n,2n)*Ba133*					20.7	32.6	36.0
		&Xe136(n,γ)Xe137(β^-)Cs137(β^-)_ *Ba137*(n,5n)*Ba133*							10.0
H3	12.33 y	&Xe124(n,γ)*Xe125*(β^+)I125(n,γ)I126_ (n,X)H1(n,γ)H2(n,γ)H3	92.1	94.5					
		Xe129(n,X)H3				54.7	33.7	29.4	27.7
		Xe131(n,X)H3				31.0	24.8	22.1	21.1
		&Xe132(n,2n)*Xe131*(n,X)H3				5.3	1.1	0.5	0.3
		Xe132(n,X)H3				0.2	14.7	18.5	20.5
		Xe134(n,X)H3					5.3	6.6	7.3
		Xe136(n,X)H3					4.1	5.1	5.7
		Xe130(n,X)H3					2.6	3.1	3.4
Cs137	30.041 y	Xe136(n,γ)Xe137(β^-)Cs137	99.2	99.2	100.0	100.0	99.8	99.9	99.9
		Xe134(n,γ)Xe135(n,γ)Xe136(n,γ)_ Xe137(β^-)Cs137	0.7						
		Xe132(n,γ)Xe133(β^-)Cs133(n,γ)Cs134_ (n,γ)Cs135(n,γ)Cs136(n,γ)Cs137		0.6					
Sn121m	55.0 y	&Xe124(n,γ)*Xe125*(n,α)Te122(n,γ)_ Te123m(n,α)Sn120(n,γ)Sn121m	52.6	0.2					
		&Xe126(n,γ)*Xe127*(n,α)Te124(n,α)_ Sn121m	28.5						
		&Xe124(n,α)Te121(β^+)Sb121(n,γ)_ *Sb122*(β^-)Te122(n,γ)Te123m(n,α)_ Sn120(n,γ)Sn121m	4.9						
		&Xe124(n,γ)Xe125(n,α)Te122(n,γ)_ *Te123*(n,α)Sn120(n,γ)Sn121m	4.0						
	►	&Xe126(n,α)*Te123*(n,α)Sn120(n,γ)_ Sn121m	0.3	57.0	79.5				

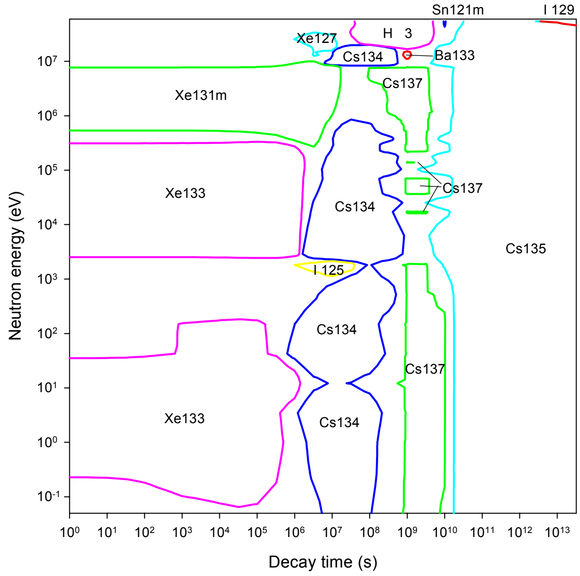
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Xe126(n,α)Te123m(n,α)Sn120(n,γ)_ Sn121m	0.3	39.1	13.8				
		&Xe126(n,2n)*Xe125*(β^+)I125(β^+)Te125_ (n,nα)Sn121m				25.4	1.3	0.4	
		Xe126(n,2n)Xe125(β^+)I125(β^+)Te125_ (n,2n)Te124(n,α)Sn121m				11.3			
		Xe126(n,2n)Xe125(β^+)I125(β^+)Te125_ (n,α)Sn122(n,2n)Sn121m				10.5			
		Xe124(n,p)I124(β^+)Te124(n,α)Sn121m				5.1			
		&Xe129(n,nα)*Te125*(n,nα)Sn121m				1.1	22.0	12.3	1.6
		Xe129(n,3n)Xe127(β^+)I127(n,3n)I125_ (β^+)Te125(n,nα)Sn121m					14.4	1.5	
		&Xe128(n,4n)*Xe125*(β^+)I125(β^+)Te125_ (n,nα)Sn121m						16.2	3.0
		Xe131(n,2nα)Te126(n,2nα)Sn121m						4.7	1.6
		Xe129(n,nt)I126(β^+)Te126(n,2nα)Sn121m						3.4	6.6
		Xe129(n,2nt)I125(β^+)Te125(n,nα)Sn121m						0.5	5.5
		&Xe129(n,5n)*Xe125*(β^+)I125(β^+)Te125_ (n,nα)Sn121m							47.3
		Other pathways involving (n,2n), (n,α), β^+	9.4	3.7	6.7	46.6	62.3	61.0	34.4
Ag108m	418.0 y	Pathways involving (n,α), (n,nα), (n,2n), β^-,β^+				100.0	100.0	100.0	100.0
Cs135	2.3 10^6 y	**&**Xe132(n,γ)Xe133(β^-)Cs133(n,γ)_ Cs134(n,γ)Cs135	62.9	90.7	0.2				
		&Xe131(n,γ)Xe132(n,γ)Xe133(β^-)_ Cs133(n,γ)Cs134(n,γ)Cs135	33.9	0.3					
		&Xe134(n,γ)*Xe135*(β^-)Cs135	2.0	8.9	99.7		0.4	0.1	
		&Xe129(n,γ)Xe130(n,γ)*Xe131*(n,γ)_ Xe132(n,γ)*Xe133*(β^-)Cs133(n,γ)*Cs134*_ (n,γ)*Cs135*	0.5						
		&Xe136(n,2n)*Xe135*(β^-)Cs135				99.6	66.1	45.6	35.7
		&Xe136(n,d)I135(β^-)*Xe135*(β^-)Cs135					33.0	53.8	63.9
I129	1.6 10^7 y	**&**Xe124(n,γ)*Xe125*(β^+)I125(n,γ)I126_ (n,γ)I127(n,γ)I128(β^+)Te128(n,γ)*Te129*_ (β^-)I129	81.5						
		&Xe126(n,γ)*Xe127*(β^+)I127(n,γ)I128_ (β^+)Te128(n,γ)*Te129*(β^-)I129	6.2	97.6	95.3				
		Xe129(n,p)I129				76.9	25.4	9.4	2.7
		&Xe132(n,α)*Te129*(β^-)I129				13.5	9.9	2.0	1.5
		Xe132(n,α)Te129m(β^-)I129				2.6	3.5	0.8	0.6
		Xe131(n,2n)Xe130(n,d)I129				2.6			
		Xe130(n,d)I129				1.7	17.7	12.7	6.4
		Xe131(n,t)I129				0.8	22.2	50.8	38.3
		Xe132(n,3n)Xe130(n,d)I129					11.1	3.4	0.7
		Xe132(n,nt)I129					1.2	9.8	41.8

Xenon activation characteristics

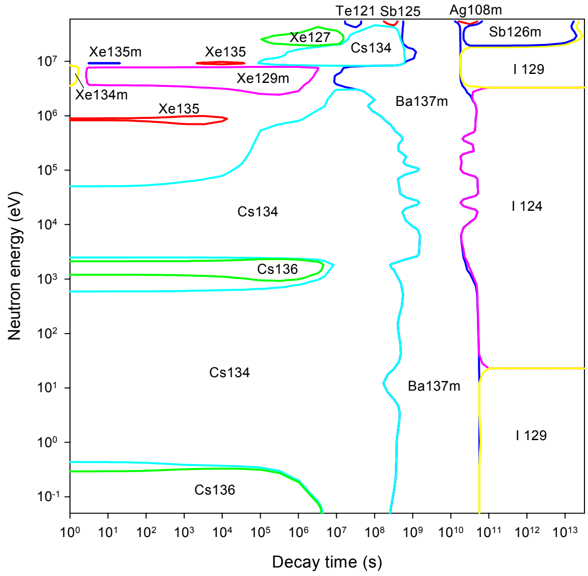


Xenon importance diagrams & transmutation

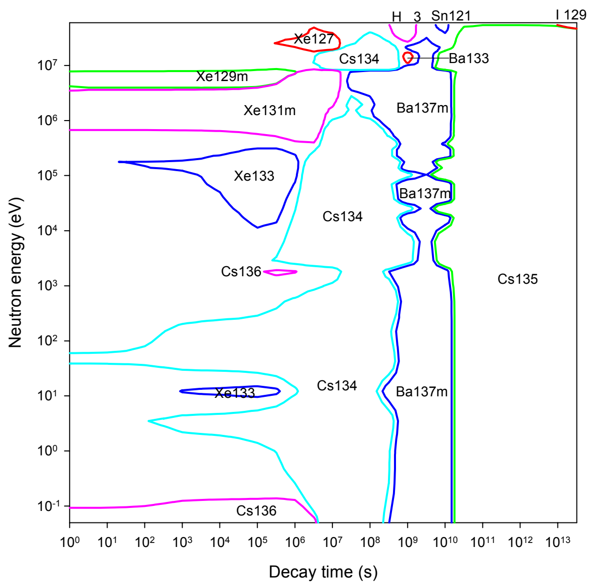
Activity



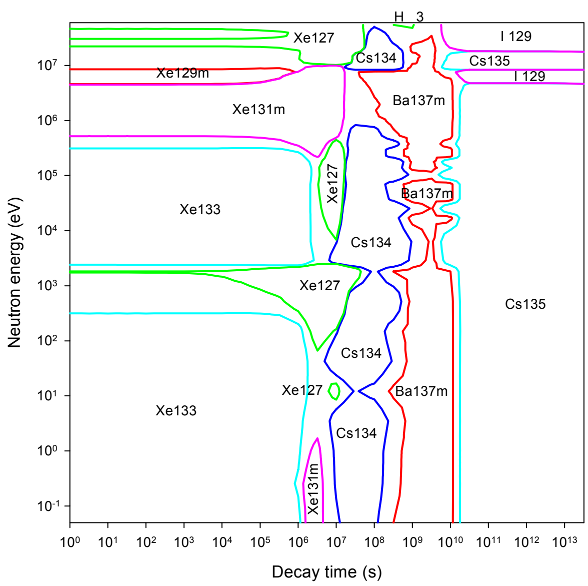
Dose rate



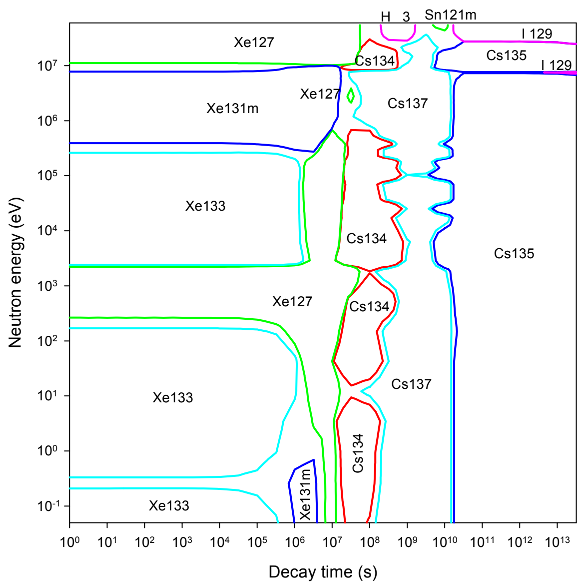
Heat output



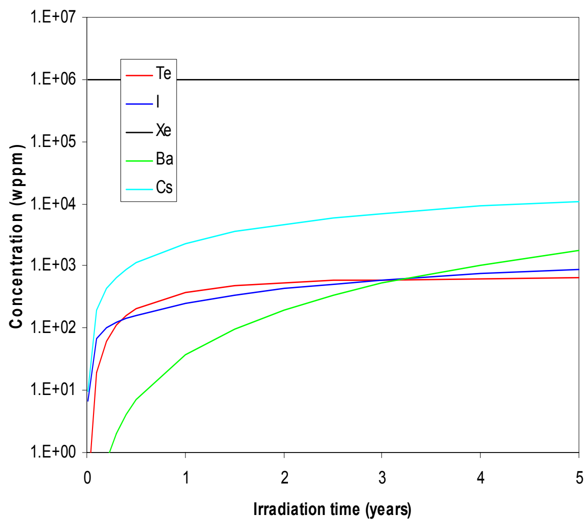
Ingestion dose



Inhalation dose



First wall transmutation



Caesium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	55		
Crustal abundance / wppm	3.0	Cs133	100.0
Melting point / K	301.6		
Boiling point / K	944		
Density / kgm^{-3}	1873		
Thermal conductivity / $Wm^{-1}K^{-1}$	35.9		
Electrical resistivity /Ωm	$2.0\ 10^{-7}$		
Coefficient of thermal expansion / K^{-1}	$9.7\ 10^{-5}$		
Crystal structure	BCC		
Number of stable isotopes	1		
Mean atomic weight	132.90543		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.28E16	1.28E16	1.13E16	7.66E15	5.83E10	1.80E9
Cs134	83.22	83.42	93.89	99.59		
Cs134m	8.02	7.87				
Cs136	3.18	3.18	2.96			
Cs132	2.98	2.98	2.29			
Ba133m	1.16	1.16	0.27			
Ba135m	0.83	0.83	0.11			
Ba133	0.26	0.26	0.30	0.41	80.09	
Cs137					8.48	
Ba137m					8.01	
Cs135					3.19	100.0

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	3.17E0	3.17E0	3.09E0	2.10E0	4.07E-6	2.58E-8
Cs134	92.58	92.66	94.88	99.89		
Cs136	4.70	4.71	3.98			
Cs132	1.40	1.41	0.98			
Cs134m	0.72	0.71				
Ba133m	0.22	0.22	0.05			
Ba135m	0.14	0.14	0.02			
Ba133	0.08	0.08	0.08	0.11	83.59	
Ba137m					12.10	
Cs137					3.65	
Cs135					0.65	100.0

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	4.02E6	4.02E6	3.94E6	2.67E6	2.34E0	1.90E-9
Cs134	92.75	92.78	94.24	99.96		
Cs136	5.60	5.60	4.70			
Cs132	1.48	1.48	1.02			
Ba133	0.03	0.03	0.03	0.04	73.32	
Ba137m					26.68	
I129						99.84

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	2.22E8	2.22E8	2.16E8	1.45E8	2.27E2	3.60E0
Cs134	91.21	91.21	93.53	99.97		
Cs136	0.55	0.55	0.47			
Ba133	0.02	0.02	0.02	0.03	30.89	
Ba137m					39.12	
Cs137					28.35	
Cs135					1.64	99.98
I129						0.02

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	2.36E8	2.36E8	2.30E8	1.53E8	7.32E2	1.55E1
Cs134	90.29	90.29	92.51	99.79		
Cs136	0.48	0.48	0.41			
Ba133	0.14	0.14	0.15	0.21	63.80	
Cs132	0.05	0.05	0.03			
Cs137					26.36	
Cs135					2.18	100.0

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	1.07E14	1.07E14	1.07E14	7.63E13	7.09E7	1.87E4
Cs134	99.53	99.54	99.64	99.98		
Cs136	0.38	0.38	0.31			
Ba133	0.01	0.01	0.01	0.02	26.34	
Cs137					69.75	
Ba137m					3.87	
Cs135					0.03	96.54

Caesium

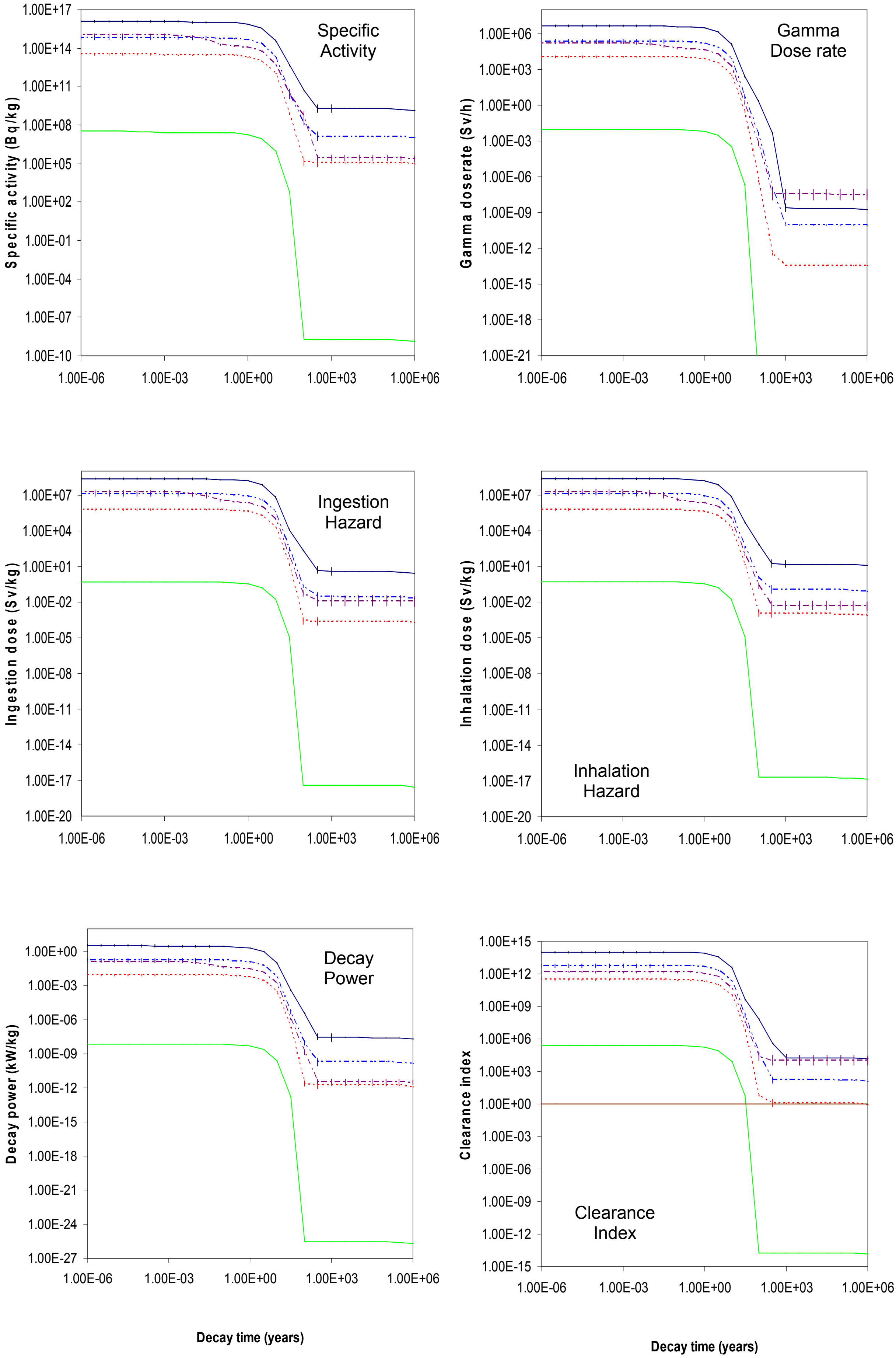
Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ba137m	2.552 m	**&**Cs133(n,γ)*Cs134*(n,γ)*Cs135*(n,γ)_ *Cs136*(β^-)Ba136(n,γ)Ba137m	85.4	0.3	63.3	63.6	79.6	79.9	80.2
		&Cs133(n,γ)*Cs134*(n,γ)*Cs135*(n,γ)_ *Cs136*(n,γ)Cs137(β^-)Ba137m	13.1	99.5	16.8	0.1	0.2	0.2	0.2
		&Cs133(n,γ)*Cs134*(n,γ)*Cs135*(n,γ)_ Cs136m(β^-)Ba136(n,γ)Ba137m	0.6		0.5	2.9	3.6	3.5	3.5
		&Cs133(n,γ)*Cs134*(β^-)Ba134(n,γ)_ *Ba135*(n,γ)*Ba136*(n,γ)Ba137m	0.5		19.0	30.8	10.5	9.9	9.5
Cs130	29.21 m	**&**Cs133(n,2n)Cs132(β^-)Ba132(n,2n)_ *Ba131*(β^+)Cs131(n,2n)Cs130				72.7			
		Cs133(n,2n)Cs132(n,2n)Cs131(n,2n)Cs130				24.9			
		Cs133(n,3n)Cs131(n,2n)Cs130					68.1		
		Cs133(n,2n)Cs132(n,3n)Cs130					30.1		
		&Cs133(n,4n)*Cs130*						100.0	100.0
Sn121	1.128 d	Cs133(n,nα)I129(n,3n)I127(n,3n)I125_ (β^+)Te125(n,nα)Sn121					10.3	0.2	
		&Cs133(n,3n)Cs131(β^+)Xe131(n,2nα)_ Te126(n,2nα)*Sn121*					0.2	7.9	0.4
		&Cs133(n,nα)I129(n,4n)I126(β^+)_ Te126(n,2nα)*Sn121*						4.3	0.2
		&Cs133(n,4n)*Cs130*(β^+)Xe130(n,nα)_ Te126(n,2nα)*Sn121*						2.7	4.5
		&Cs133(n,4nα)I126(β^+)Te126(n,2nα)*Sn121*							5.6
		Cs133(n,5n)Cs129(β^+)Xe129(n,nt)I126_ (β^+)Te126(n,2nα)Sn121							3.5
		Cs133(n,5n)Cs129(β^+)Xe129(n,2nt)_ I125(β^+)Te125(n,nα)Sn121							3.4
		Other pathways involving (n,2n), (n,α), β^+				100.0	89.5	84.9	82.4
Xe133	5.244 d	**&**Cs133(n,γ)*Cs134*(n,α)I131(β^-)*Xe131*_ (n,γ)Xe132(n,γ)*Xe133*	94.4	2.6	27.1				
		&Cs133(n,γ)Cs134(β^-)Ba134(n,γ)_ *Ba135*(n,α)Xe132(n,γ)*Xe133*	4.0	0.5	70.7				
		&Cs133(n,γ)*Cs134*(n,γ)*Cs135*(n,γ)_ *Cs136*(n,α)*I133*(β^-)*Xe133*		96.6					
		&Cs133(n,p)*Xe133*				100.0	100.0	100.0	100.0
Cs132	6.53 d	Cs133(n,2n)Cs132				99.8	99.7	99.8	99.9
Xe129m	8.88 d	Cs133(n,2n)Cs132(β^+)Xe132(n,2n)_ *Xe131*(n,2n)Xe130(n,2n)*Xe129m*				89.6			
		&Cs133(n,α)*I130*(β^-)Xe130(n,2n)Xe129m				8.5			
		Cs133(n,3n)Cs131(β^+)Xe131(n,3n)Xe129m					92.8	38.0	9.0
		&Cs133(n,t)*Xe131*(n,3n)Xe129m					1.4	4.7	3.1
		&Cs133(n,4n)*Cs130*(β^+)Xe130(n,2n)Xe129m						20.6	4.1
		Cs133(n,2n)Cs132(β^+)Xe132(n,4n)Xe129m						18.3	7.1
		Cs133(n,d)Xe132(n,4n)Xe129m						13.7	7.3
		Cs133(n,2nt)Xe129m						0.8	53.3
		Cs133(n,nt)Xe130(n,2n)Xe129m						0.7	3.1
		Cs133(n,5n)Cs129(β^+)Xe129(n,n′)Xe129m							5.9
Cs131	9.69 d	**&**Cs133(n,2n)Cs132(β^-)Ba132(n,2n)_ *Ba131*(β^+)Cs131				63.0			
		Cs133(n,2n)Cs132(n,2n)Cs131				26.6			
		Cs133(n,3n)Cs131					99.7	99.8	99.9
Xe131m	11.93 d	**&**Cs133(n,γ)*Cs134*(n,α)I131(β^-)Xe131m	99.8	99.8	92.6				
		&Cs133(n,γ)*Cs134*(β^-)Ba134(n,α)Xe131m	0.2	0.2	3.0				
		Cs133(n,2n)Cs132(β^+)Xe132(n,2n)Xe131m				96.9	29.5	8.6	
		Cs133(n,d)Xe132(n,2n)Xe131m				1.3	11.7	6.5	
	▶	Cs133(n,3n)Cs131(β^+)Xe131(n,n′)Xe131m					31.4	7.6	

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Cs133(n,t)Xe131m					26.1	75.9	90.4
Cs136	13.03 d	**&**Cs133(n,γ)*Cs134*(n,γ)*Cs135*(n,γ)*Cs136*	99.8	99.8	100.0	99.5	98.3	99.6	99.7
Xe127	36.40 d	**&**Cs133(n,nα)I129(n,2n)I128(β^-)_ Xe128(n,2n)*Xe127*				9.2			
		Cs133(n,2n)Cs132(β^+)Xe132(n,2n)_ Xe131(n,2n)Xe130(n,2n)Xe129(n,2n)_ Xe128(n,2n)Xe127				6.2			
		Cs133(n,2n)Cs132(β^+)Xe132(n,α)_ Te129(β^-)I129(n,2n)I128(β^-)Xe128_ (n,2n)Xe127				5.8			
		Cs133(n,α)*I130*(β^-)Xe130(n,2n)*Xe129*_ (n,2n)Xe128(n,2n)*Xe127*				1.6			
		&Cs133(n,3n)Cs131(β^+)Xe131(n,3n)_ *Xe129*(n,3n)*Xe127*					88.8	0.7	
		&Cs133(n,4n)*Cs130*(β^+)Xe130(n,4n)*Xe127*						81.5	20.6
		&Cs133(n,nt)Xe130(n,4n)*Xe127*						2.8	7.2
		&Cs133(n,3n)Cs131(β^+)Xe131(n,5n)*Xe127*						0.1	25.5
		&Cs133(n,5n)Cs129(β^+)Xe129(n,3n)*Xe127*							26.2
		&Cs133(n,t)*Xe131*(n,5n)*Xe127*							10.6
		Other pathways involving (n,2n), (n,α), β^+				77.2	11.2	14.9	9.9
Cs134	2.065 y	**&**Cs133(n,γ)*Cs134*	100.0	100.0	100.0	99.8	99.7	99.8	99.9
Sb125	2.759 y	Cs133(n,nα)I129(n,nα)Sb125				13.3	80.5	31.6	8.2
		Cs133(n,2n)Cs132(β^+)Xe132(n,α)_ Te129(β^-)I129(n,nα)Sb125				11.6	0.2		
		Cs133(n,2n)Cs132(β^+)Xe132(n,α)_ Te129m(β^-)I129(n,nα)Sb125				3.3	0.2		
		Cs133(n,2n)Cs132(β^+)Xe132(n,nα)_ Te128(n,α)Sn125m(β^-)Sb125				2.5	0.1		
		Cs133(n,2n)Cs132(β^+)Xe132(n,nα) Te128(n,α)Sn125(β^-)Sb125				2.3	0.1		
		Cs133(n,3n)Cs131(β^+)Xe131(n,t)_ I129(n,nα)Sb125					5.7	5.5	
		Cs133(n,3n)Cs131(β^+)Xe131(n,2nα)_ Te126(n,d)Sb125					1.7	9.6	
		Cs133(n,3n)Cs131(β^+)Xe131(n,nα)_ Te127m(n,t)Sb125					1.4	1.4	
		&s133(n,4n)*Cs130*(β^+)Xe130(n,nα)_ Te126(n,d)Sb125						8.9	
		&s133(n,4n)*Cs130*(β^+)Xe130(n,d)_ I129(n,nα)Sb125						7.3	
		Cs133(n,nα)I129(n,4n)I126(β^+)_ Te126(n,d)Sb125						5.2	
		Cs133(n,4nα)I126(β^+)Te126(n,d)Sb125							21.6
		Cs133(n,2nα)I128(β^+)Te128(n,nt)Sb125							6.9
		Cs133(n,n2α)Sb125							4.6
		Cs133(n,3nα)I127(n,h)Sb125							3.1
		Other pathways involving (n,2n), (n,α), β^+				67.0	10.1	30.5	55.6
Ba133	10.54 y	**&**Cs133(n,γ)*Cs134*(β^-)Ba134(n,2n)*Ba133*				84.9	97.3	96.8	96.6
		&Cs133(n,2n)Cs132(β^-)Ba132(n,γ)*Ba133*				15.0	2.6	3.2	2.6
H3	12.33 y	**&**Cs133(n,γ)*Cs134*(n,X)H1(n,γ)H2(n,γ)H3	93.6	94.8	99.5				
		Cs133(n,X)H3				97.5	89.7	89.6	89.0
		Cs133(n,2n)Cs132(n,X)H3				1.5			
		Cs133(n,3n)Cs131(β^+)Xe131(n,X)H3					7.6	4.0	1.5
		Cs133(n,2n)Cs132(β^+)Xe132(n,X)H3					0.9	0.8	
		Cs133(n,4n)Cs130(β^+)Xe130(n,X)H3						1.2	
		Cs133(n,5n)Cs129(β^+)Xe129(n,X)H3							3.7
Cs137	30.041 y	**&**Cs133(n,γ)*Cs134*(n,γ)*Cs135*(n,γ)_ *Cs136*(n,γ)Cs137	99.8	99.8	100.0	96.9	95.9	96.0	96.2
Sn121m	55.0 y ►	Cs133(n,nα)I129(n,3n)I127(n,3n)I125_ (β^+)Te125(n,nα)Sn121m					12.0	0.2	

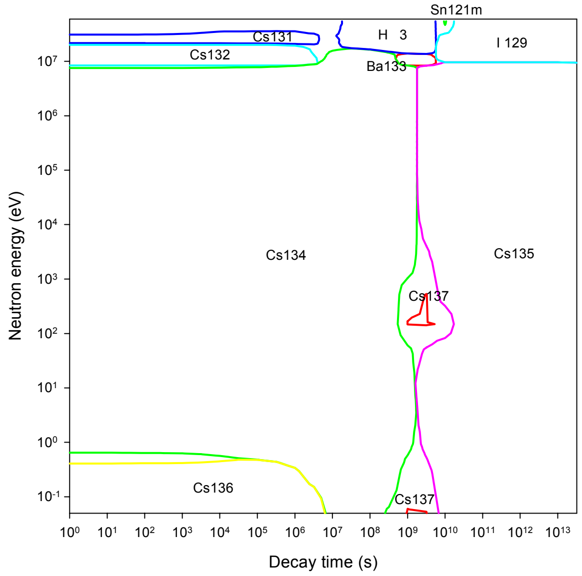
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Cs133(n,3n)Cs131(β^+)Xe131(n,3n)_ Xe129(n,nα)Te125(n,nα)Sn121m					1.7		
		Cs133(n,3n)Cs131(β^+)Xe131(n,2nα)_ Te126(n,2nα)Sn121m					0.3	8.5	0.7
		&s133(n,4n)*Cs130*(β^+)Xe130(n,nα)_ Te126(n,2nα)Sn121m						7.9	0.6
		Cs133(n,nα)I129(n,4n)I126(β^+)Te126_ (n,2nα)Sn121m						4.6	0.3
		&s133(n,4n)Cs130(β^+)Xe130(n,2nα)_ *Te125*(n,nα)Sn121m						4.1	0.3
		Cs133(n,4nα)I126(β^+)Te126(n,2nα)Sn121m							10.4
		Cs133(n,5n)Cs129(β^+)Xe129(n,2nt)_ I125(β^+)Te125(n,nα)Sn121m							4.2
		Other pathways involving (n,2n), (n,α), β^+				100.0	86.0	74.7	83.5
Ag108m	418.0 y	Pathways involving (n,α), (n,nα), (n,2n), β^-,β^+				100.0	100.0	100.0	100.0
Ho166m	1200 y	Threshold for production lies below 0.26eV							
Cs135	2.3 10^6 y	&Cs133(n,γ)*Cs134*(n,γ)*Cs135*	99.9	99.9	100.0	99.9	99.5	99.7	99.8
I129	1.6 10^7 y	&Cs133(n,γ)*Cs134*(n,α)I131(β^-)*Xe131*_ (n,α)Te128(n,γ)*Te129*(β^-)I129	96.1	95.5	94.5				
		&Cs133(n,γ)*Cs134*(n,α)I131(β^-)Xe131_ (n,α)Te128(n,γ)Te129m(β^-)I129	2.5	2.5	2.4				
		&Cs133(n,γ)*Cs134*(β^-)Ba134(n,α)_ *Xe131*(n,α)Te128(n,γ)*Te129*(β^-)I129			0.5				
		&Cs133(n,2n)Cs132(β^+)Xe132(n,α)_ *Te129*(β^-)I129				55.1	0.3		
		Cs133(n,nα)I129				31.2	87.0	60.7	60.3
		Cs133(n,2n)Cs132(β^+)Xe132(n,α)_ Te129m(β^-)I129				10.6	0.3		
		Cs133(n,2n)Cs132(n,α)I129				1.3			
		Cs133(n,3n)Cs131(β^+)Xe131(n,t)I129					8.6	14.6	9.5
		Cs133(n,t)Xe131m(IT)Xe131(n,t)I129					0.1	1.5	3.3
		&Cs133(n,4n)*Cs130*(β^+)Xe130(n,d)I129						19.0	4.9
		Cs133(n,2n)Cs132(β^+)Xe132(n,nt)I129						0.7	4.6
		Cs133(n,nt)Xe130(n,d)I129						0.7	3.7
		Cs133(n,d)Xe132(n,nt)I129						0.5	4.7
		Cs133(n,5n)Cs129(β^+)Xe129(n,p)I129							1.3
La138	1.0 10^{11} y	&Cs133(n,γ)*Cs134*(n,γ)*Cs135*(n,γ)_ *Cs136*(β^-)Ba136(n,γ)*Ba137*(n,γ)Ba138_ (n,γ)Ba139(β^-)La139(n,γ)La140(β^-)_ Ce140(n,γ)Ce141(β^-)Pr141(n,α)La138	91.7						
		&Cs133(n,γ)*Cs134*(n,γ)*Cs135*(n,γ)_ *Cs136*(β^-)Ba136(n,γ)*Ba137*(n,γ)Ba138_ (n,γ)Ba139(β^-)La139(n,γ)La140(n,γ)_ La141(β^-)Ce141(β^-)Pr141(n,α)La138	4.7						

Caesium activation characteristics

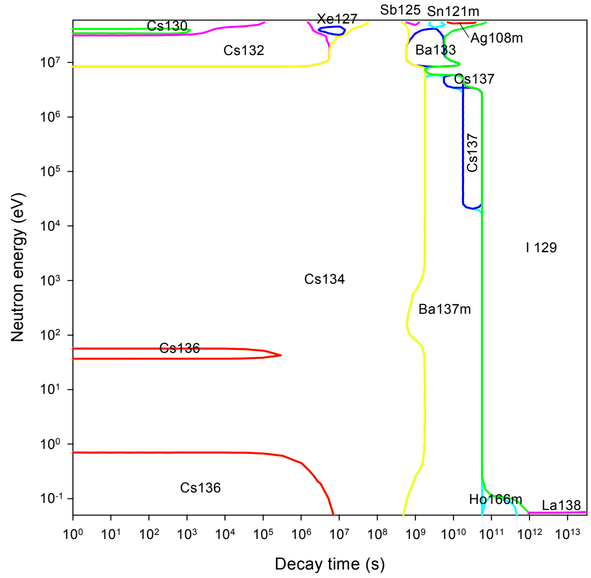


Caesium importance diagrams & transmutation

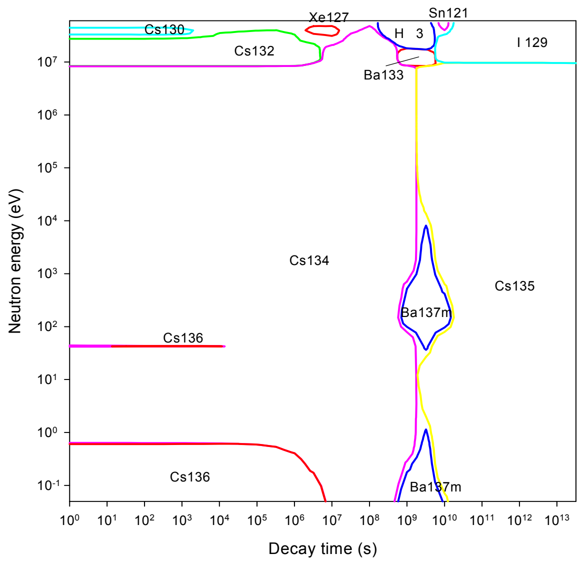
Activity



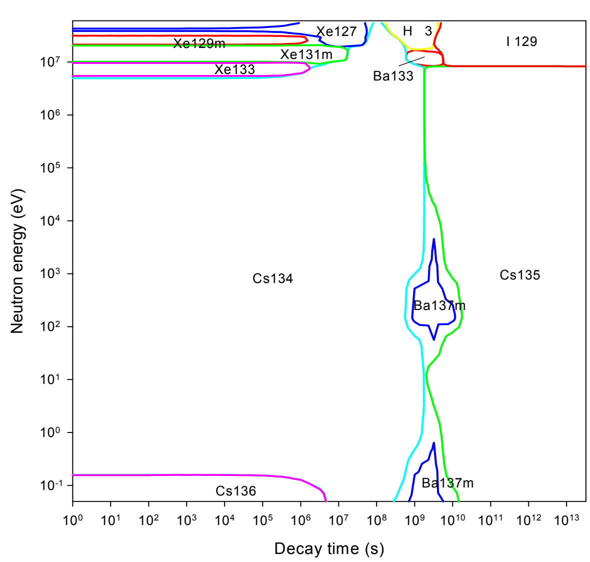
Dose rate



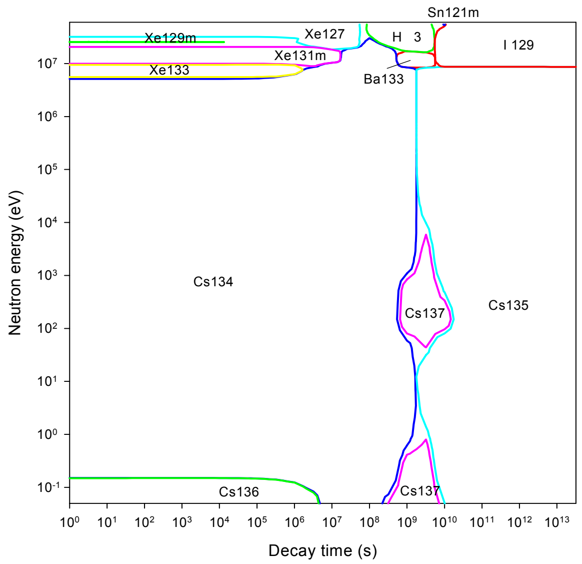
Heat output



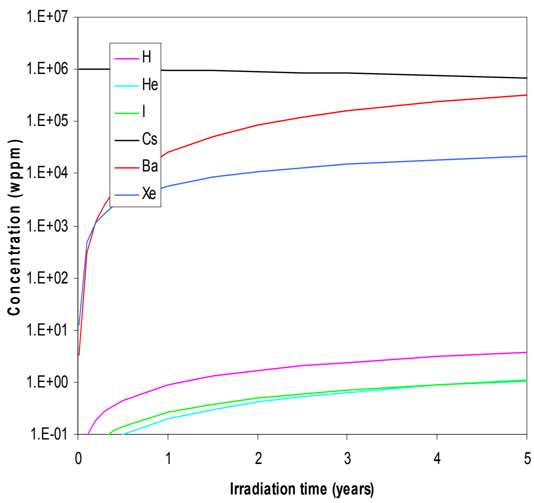
Ingestion dose



Inhalation dose



First wall transmutation



Barium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	56		
Crustal abundance / wppm	425	Ba130	0.106
Melting point / K	1000	Ba132	0.101
Boiling point / K	2170	Ba134	2.417
Density / kgm^{-3}	3500	Ba135	6.592
Thermal conductivity / $Wm^{-1}K^{-1}$	18.4	Ba136	7.854
Electrical resistivity /Ωm	$5.0\ 10^{-7}$	Ba137	11.232
Coefficient of thermal expansion / K^{-1}	$2.06\ 10^{-5}$	Ba138	71.698
Crystal structure	BCC		
Number of stable isotopes	7		
Mean atomic weight	137.327		

Activation properties

Act	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Bq kg^{-1}	6.65E14	2.66E14	4.35E13	7.28E12	2.32E10	1.55E6
Ba137m	67.20	40.27	0.16	0.91	29.11	
Ba135m	15.00	37.41	27.65			
Ba136m	8.61					
Ba133m	1.74	4.35	5.44			
Ba131	1.66	4.16	20.47			
Cs131	1.65	4.12	24.67			
Ba139	1.59	3.79				
Ba133	1.00	2.51	15.35	85.86	40.03	
Ba131m	0.46	0.89				
Cs134	0.19	0.47	2.86	12.23		
Cs136	0.14	0.32				
Xe131m	0.06	0.16	0.78			
Cs137			0.17	0.97	30.84	
Cs135						97.62
La137						2.38

Heat	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
kW kg^{-1}	7.54E-2	2.07E-2	2.52E-3	7.10E-4	1.61E-6	2.18E-11
Ba137m	62.60	54.67	0.29	0.99	44.41	
Ba136m	24.69					
Ba135m	5.66	20.57	20.43			
Ba139	2.12	7.37				
Ba131	1.19	4.33	28.65			
Ba133m	0.71	2.58	4.34			
Cs138	0.70	2.34				
Ba133	0.65	2.35	19.33	64.18	42.18	
Cs134	0.46	1.66	13.59	34.53		
La140	0.32	1.17	2.13			
Cs136	0.31	1.14	7.74			
Cs131	0.07	0.25	2.01			
Cs137			0.09	0.30	13.41	
Cs135						99.12
La137						0.87

Dose	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv h^{-1}	9.33E4	1.76E4	1.68E3	5.50E2	1.25E0	1.37E-8
Ba137m	64.44	81.91	0.54	1.62	72.83	
Ba136m	32.04					
Ba131	0.73	3.86	32.48			
Cs138	0.69	3.35				
Cs134	0.47	2.49	25.96	56.91		
Cs136	0.39	2.05	17.65			
La140	0.38	2.03	4.72			
Ba135m	0.30	1.60	2.03			
Ba133	0.26	1.38	14.48	41.47	27.16	
Ba133m	0.04	0.21	0.45			
Cs132	0.04	0.19	1.38			
La137						84.47
La138						15.45

Ing	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	9.80E6	3.31E6	3.91E5	2.85E4	2.35E2	3.03E-3
Ba137m	86.74	61.48	0.33	4.43	54.54	
Ba129m	3.37	9.69				
Xe131m	2.79	8.23	56.39			
Ba129	2.00	5.77				
Xe135	1.99	5.86	0.07			
Xe133	1.52	4.49	25.24			
Ba135m	0.44	1.29	1.32			
Xe133m	0.36	1.11	2.95			
Cs134	0.24	0.71	6.02	59.42		
Xe129m	0.11	0.33	2.11			
Ba133	0.10	0.30	2.56	32.93	5.92	
Ba133m	0.06	0.19	0.33			
Ba131	0.05	0.15	1.02			
Cs136	0.02	0.06	0.41			
Ba139	0.01	0.04				
Cs137	0.01	0.03	0.24	3.21	39.53	
La140	0.01	0.03	0.06			
Cs131		0.02	0.16			
Cs135						99.75

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	6.57E6	2.47E6	5.51E5	8.39E4	4.53E2	1.33E-2
Ba137m	81.71	52.03	0.15	0.95	17.89	
Xe131m	6.20	16.47	59.75			
Ba129m	3.44	8.88				
Ba129	2.08	5.39				
Xe133	1.87	4.97	14.78			
Xe135	1.56	4.11	0.02			
Ba133	1.02	2.70	12.10	74.53	20.51	
Ba135m	0.55	1.45	0.79			
Cs134	0.38	1.01	4.50	21.23		
Xe127	0.20	0.54	2.26	0.02		
Ba131	0.15	0.39	1.40			
Ba133m	0.08	0.22	0.20			
Cs137	0.04	0.11	0.51	3.27	61.60	
Cs136	0.03	0.07	0.27			
La140	0.01	0.02	0.02			
Ba139	0.01	0.02				
Cs131		0.02	0.09			
Cs135						97.57
La137						2.40

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	4.04E11	9.31E10	1.87E10	1.21E10	7.93E7	2.02E1
Ba137m	65.16	67.76	0.21	0.32	5.01	
Ba136m	27.30					
Cs134	3.09	13.38	66.53	73.30		
Ba135m	2.06	8.92	5.37			
Ba133	0.66	2.87	14.30	20.58	4.69	
Ba139	0.35	1.47				
Ba131	0.27	1.19	4.77			
Ba133m	0.26	1.13	1.15			
Cs137	0.18	0.77	3.86	5.79	90.30	
Cs136	0.16	0.69	2.85			
La140	0.13	0.57	0.63			
Cs138	0.02	0.09				
Cs131			0.06			
Cs135						74.65
I129						20.54
La137						4.78

Barium

Pathway analysis

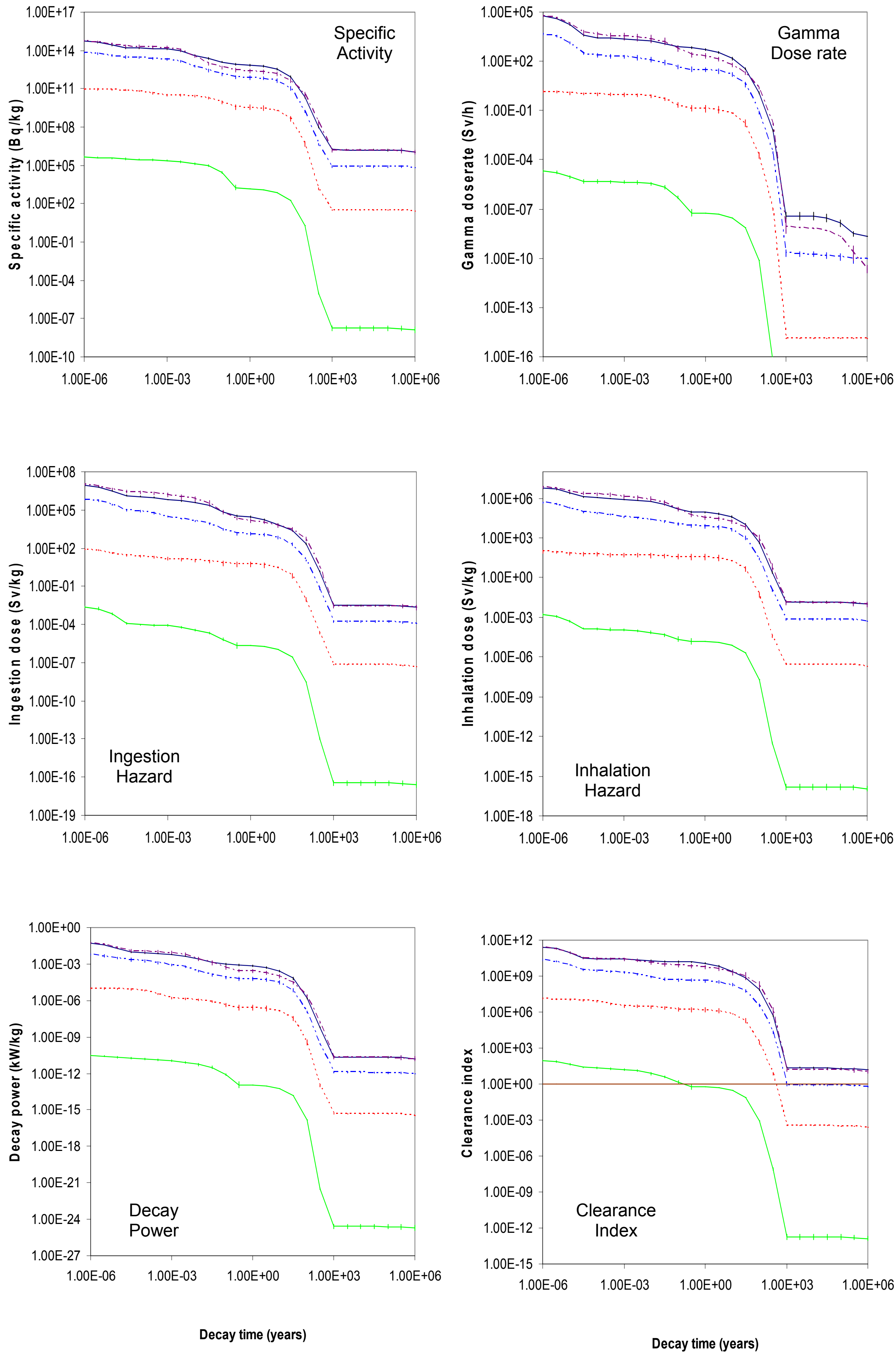
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Ba137m	2.552 m	Ba136(n,γ)Ba137m	81.4	97.0	96.2				
		Ba135(n,γ)Ba136(n,γ)Ba137m	18.1	1.3	3.7				
		Ba134(n,γ)Ba135(n,γ)Ba136(n,γ)Ba137m	0.4						
		Ba138(n,2n)Ba137m				94.5	95.2	90.6	90.4
		Ba137(n,n′)Ba137m				2.0	4.1	4.4	3.8
		Ba138(n,2n)Ba137(n,n′)Ba137m				1.6	0.6		
		Ba138(n,d)Cs137(β^-)Ba137m					1.5	3.4	
Ba139	1.384 h	Ba138(n,γ)Ba139	96.4	99.8	99.9	99.9	99.7	99.7	99.9
		Ba137(n,γ)Ba138(n,γ)Ba139	3.6	0.2	0.1				
Ba135m	1.196 d	Ba134(n,γ)Ba135m	99.8	99.9	100.0				
		Ba136(n,2n)Ba135m				52.0	10.8	3.2	4.8
		&Ba137(n,2n)*Ba136*(n,2n)Ba135m				20.3	1.0		
		&Ba138(n,2n)*Ba137*(n,2n)*Ba136*(n,2n)_ Ba135m				17.1			
		Ba135(n,n′)Ba135m				7.4	2.1	0.7	1.0
		Ba137(n,3n)Ba135m					44.1	8.1	8.8
		&Ba138(n,2n)*Ba137*(n,3n)Ba135m					20.6	2.3	
		&Ba138(n,3n)*Ba136*(n,2n)Ba135m					19.4	2.4	
		Ba138(n,4n)Ba135m						81.4	80.7
La140	1.679 d	Ba138(n,γ)Ba139(β^-)La139(n,γ)La140	98.0	99.9	99.9	99.9	99.7	99.8	99.9
		Ba137(n,γ)Ba138(n,γ)Ba139(β^-)La139_ (n,γ)La140	2.0						
Xe133	5.244 d	&Ba130(n,γ)*Ba131*(β^+)Cs131(β^+)_ Xe131(n,γ)Xe132(n,γ)*Xe133*	96.6	28.3	92.9				
		Ba130(n,γ)*Ba131*(β^+)Cs131(n,γ)Cs132_ (β^+)Xe132(n,γ)*Xe133*	1.2	71.1	3.1				
		&Ba136(n,α)*Xe133*				41.5	8.0	1.6	3.5
		&Ba137(n,2n)*Ba136*(n,α)*Xe133*				15.3	0.8		
		&Ba137(n,α)*Xe134*(n,2n)*Xe133*				11.9			
		&Ba138(n,2n)*Ba137*(n,2n)*Ba136*(n,α)*Xe133*				11.8			
		&Ba138(n,2n)*Ba137*(n,α)*Xe134*(n,2n)*Xe133*				9.2			
		&Ba138(n,2n)*Ba137*(n,nα)*Xe133*				1.9	19.6	5.3	1.6
		&Ba137(n,nα)*Xe133*				1.2	47.0	18.1	9.6
		&Ba138(n,3n)*Ba136*(n,α)*Xe133*					13.4	1.2	1.1
		&Ba138(n,2nα)*Xe133*					2.1	60.3	64.5
		Other pathways involving (n,2n), (n,α), β^+	2.2	0.6	4.0	7.2	9.1	13.5	19.7
Cs131	9.69 d	&Ba130(n,γ)*Ba131*(β^+)Cs131	100.0	100.0	100.0				
		&Ba132(n,2n)*Ba131*(β^+)Cs131				54.0	2.0	0.5	0.1
		&Ba134(n,2n)*Ba133*(n,2n)Ba132(n,2n)_ *Ba131*(β^+)Cs131				34.9			
		&Ba135(n,2n)Ba134(n,2n)*Ba133*(n,2n)_ Ba132(n,2n)*Ba131*(β^+)Cs131				8.4			
		&Ba135(n,3n)*Ba133*(n,3n)*Ba131*(β^+)Cs131					39.4	4.1	0.2
		&Ba134(n,4n)*Ba131*(β^+)Cs131					21.9	6.2	
		&Ba134(n,3n)Ba132(n,2n)*Ba131*(β^+)Cs131					8.2	1.3	0.1
		&Ba135(n,3n)*Ba133*(β^+)Cs133(n,3n)Cs131					7.5	0.8	
		&Ba134(n,2n)*Ba133*(n,3n)*Ba131*(β^+)Cs131					6.3	0.7	
		&Ba137(n,4n)Ba134(n,4n)*Ba131*(β^+)Cs131						12.6	1.3
		&Ba136(n,3n)Ba134(n,4n)*Ba131*(β^+)Cs131						6.5	0.6
		&Ba136(n,4n)*Ba133*(n,3n)*Ba131*(β^+)Cs131						6.5	0.4
		&Ba135(n,4n)Ba132(n,2n)*Ba131*(β^+)Cs131						3.7	0.4
		&Ba138(n,5n)Ba134(n,4n)*Ba131*(β^+)Cs131						0.1	16.4
		&Ba135(n,5n)Ba131(β^+)Cs131							25.0
		&Ba138(n,4n)*Ba135*(n,5n)*Ba131*(β^+)Cs131							12.7
		Ba138(n,5n)Ba134(n,nt)Cs131							5.5
		&Ba138(n,nt)*Cs135*(n,5n)Cs131							4.3

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ba131	11.55 d	&Ba130(n,γ)*Ba131*	100.0	100.0	100.0				
		&Ba132(n,2n)*Ba131*				54.5	2.5	0.7	0.2
		&Ba134(n,2n)*Ba133*(n,2n)Ba132(n,2n)*Ba131*				32.1			
		&Ba135(n,2n)Ba134(n,2n)*Ba133*(n,2n)_ Ba132(n,2n)*Ba131*				5.3			
		&Ba135(n,3n)*Ba133*(n,3n)*Ba131*					50.6	5.1	0.4
		&Ba134(n,3n)Ba132(n,2n)*Ba131*					10.5	1.7	0.2
		&Ba137(n,3n)*Ba135*(n,3n)*Ba133*(n,3n)*Ba131*					8.8	0.1	
		&Ba134(n,2n)*Ba133*(n,3n)*Ba131*					8.0	1.0	
		&Ba136(n,3n)Ba134(n,3n)Ba132(n,2n)*Ba131*					3.2	0.2	
		&Ba134(n,4n)*Ba131*						27.1	8.3
		&Ba137(n,4n)Ba134(n,4n)*Ba131*						15.7	1.7
		&Ba136(n,3n)Ba134(n,4n)*Ba131*						8.2	0.9
		&Ba136(n,4n)*Ba133*(n,3n)*Ba131*						8.1	0.6
		&Ba135(n,4n)Ba132(n,2n)*Ba131*						4.6	0.6
		&Ba135(n,2n)Ba134(n,4n)*Ba131*						3.2	0.5
		&Ba138(n,5n)Ba134(n,4n)*Ba131*						0.2	22.1
		&Ba135(n,5n)*Ba131*							33.2
		&Ba138(n,4n)*Ba135*(n,5n)*Ba131*							17.2
Xe131m	11.93 d	&Ba132(n,γ)*Ba133*(n,α)Xe130(n,γ)_ Xe131m	61.6	78.4	56.5				
		Ba130(n,γ)Ba131(β^+)Cs131(n,γ)Cs132_ (n,α)I129(n,γ)I130(β^-)Xe130(n,γ)Xe131m	20.3						
		Ba134(n,α)Xe131m	1.6	6.3	43.0	13.4	4.2	0.9	1.1
		Ba132(n,γ)Ba133(β^+)Cs133(n,γ)Cs134_ (n,α)I131(β^-)Xe131m	0.4	10.7					
		&Ba134(n,2n)*Ba133*(β^+)Cs133(n,2n)_ Cs132(β^+)Xe132(n,2n)Xe131m				28.5			
		&Ba132(n,2n)*Ba131*(β^+)Cs131(β^+)_ Xe131(n,n′)Xe131m				12.0	0.3		
		Ba135(n,α)Xe132(n,2n)Xe131m				11.1	0.4		
		Ba135(n,2n)Ba134(n,α)Xe131m				9.4	0.8	0.1	
		Ba135(n,nα)Xe131m				2.3	41.9	16.9	6.1
		&Ba137(n,3n)*Ba135*(n,nα)Xe131m					14.0	2.0	0.3
		&Ba138(n,3n)*Ba136*(n,2nα)Xe131m					0.9	7.9	2.4
		Ba136(n,2nα)Xe131m					0.5	10.2	7.0
		&Ba138(n,4n)*Ba135*(n,nα)Xe131m						21.8	3.2
		&Ba138(n,nα)*Xe134*(n,4n)Xe131m						12.6	2.0
		Ba137(n,3nα)Xe131m						0.6	14.9
		Ba138(n,4nα)Xe131m							20.1
		Other pathways involving (n,2n), (n,α), β^+	16.1	4.6	0.5	23.3	37.0	27.0	44.0
Cs136	13.03 d	&Ba132(n,γ)*Ba133*(β^+)Cs133(n,γ)_ *Cs134*(n,γ)*Cs135*(n,γ)*Cs136*	94.7	97.8	90.7				
		&Ba136(n,p)*Cs136*				27.7	4.8	1.4	
		&Ba137(n,p)Cs137(n,2n)*Cs136*				17.1	0.5		
		&Ba138(n,2n)*Ba137*(n,p)Cs137(n,2n)*Cs136*				14.6			
		&Ba137(n,2n)*Ba136*(n,p)*Cs136*				10.7	0.4		
		&Ba138(n,2n)*Ba137*(n,d)*Cs136*				10.1	16.1	5.8	
		&Ba138(n,2n)*Ba137*(n,2n)*Ba136*(n,p)*Cs136*				8.8			
		&Ba137(n,d)*Cs136*				6.1	34.5	18.4	11.7
		&Ba138(n,d)Cs137(n,2n)*Cs136*				4.7	11.0	4.3	1.4
		&Ba138(n,t)*Cs136*					23.5	68.7	83.4
		&Ba138(n,3n)*Ba136*(n,p)*Cs136*					8.6	0.6	
Ce141	32.5 d	Ba138(n,γ)Ba139(β^-)La139(n,γ)La140_ (β^-)Ce140(n,γ)Ce141	97.5	1.0	94.1	99.1	97.6	97.7	97.6
		Ba137(n,γ)Ba138(n,γ)Ba139(β^-)La139_ (n,γ)La140(β^-)Ce140(n,γ)Ce141	1.3						
		Ba138(n,γ)Ba139(β^-)La139(n,γ)La140_ (n,γ)La141(β^-)Ce141	1.2	98.9	5.9	0.8	2.2	2.2	2.3
Xe127	36.40 d	&Ba130(n,α)*Xe127*	100.0	100.0	99.7	13.0	2.3	0.2	
	►	&Ba130(n,2n)Ba129(β^+)Cs129(β^+)_ Xe129(n,2n)Xe128(n,2n)*Xe127*				43.1			

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Ba130(n,2n)Ba129m(β$^+$)Cs129(β$^+$)_ Xe129(n,2n)Xe128(n,2n)*Xe127*				40.8	0.1		
		&Ba130(n,2n)Ba129m(β$^+$)Cs129(β$^+$)_ Xe129(n,3n)*Xe127*					18.5	0.9	
		&Ba130(n,3n)Ba128(β$^+$)Cs128(β$^+$)_ Xe128(n,2n)*Xe127*					7.5	1.0	
		&Ba130(n,2n)Ba129(β$^+$)Cs129(β$^+$)_ Xe129(n,3n)*Xe127*					6.7	0.3	
		&Ba130(n,d)Cs129(β$^+$)Xe129(n,3n)*Xe127*					5.1	0.6	
		&Ba130(n,4n)*Ba127*(β$^+$)Cs127(β$^+$)Xe127						7.9	2.8
		&Ba135(n,4n)Ba132(n,2nα)*Xe127*						6.6	0.4
		&Ba135(n,2nα)Xe130(n,4n)*Xe127*						5.5	0.3
		&Ba138(n,4n)*Ba135*(n,2nα)Xe130(n,4n)*Xe127*						3.4	
		&Ba135(n,5n)*Ba131*(β$^+$)Cs131(β$^+$)_ Xe131(n,5n)*Xe127*							4.9
		&Ba134(n,5n)Ba130(n,4n)*Ba127*(β$^+$)_ Cs127(β$^+$)Xe127							4.5
		Other pathways involving (n,2n), (n,α), β$^+$			0.3	3.1	59.8	73.6	87.1
Cs134	2.065 y	&Ba132(n,γ)*Ba133*(β$^+$)Cs133(n,γ)*Cs134*	93.9	98.1	100.0				
		&Ba130(n,γ)*Ba131*(n,γ)Ba132(n,γ)_ *Ba133*(β$^+$)Cs133(n,γ)*Cs134*	0.1	0.9					
		&Ba138(n,α)*Xe135*(β$^-$)Cs135(n,2n)*Cs134*				38.1	2.5		
		&Ba134(n,p)*Cs134*				23.7	5.2	1.3	0.4
		&Ba135(n,d)*Cs134*				12.2	49.6	22.2	10.6
		&Ba135(n,2n)Ba134(n,p)*Cs134*				10.7	0.6		
		&Ba135(n,p)*Cs135*(n,2n)*Cs134*				7.9	0.3		
		&Ba136(n,2n)*Ba135*(n,d)*Cs134*				2.4	2.6		0.1
		&Ba137(n,3n)*Ba135*(n,d)*Cs134*					10.5	1.4	0.3
		&Ba138(n,3n)*Ba136*(n,t)*Cs134*					7.0	8.4	3.1
		&Ba136(n,t)*Cs134*					6.2	17.3	14.7
		&Ba137(n,nt)*Cs134*					1.3	5.6	19.1
		&Ba138(n,d)Cs137(n,4n)*Cs134*					0.2	15.9	2.6
		&Ba138(n,4n)*Ba135*(n,d)*Cs134*						17.8	3.4
		&Ba138(n,2nt)*Cs134*						0.6	37.7
Ba133	10.54 y	&Ba132(n,γ)*Ba133*	99.6	98.2	100.0				
		&Ba130(n,γ)*Ba131*(n,γ)Ba132(n,γ)*Ba133*	0.3	1.7					
		&Ba134(n,2n)*Ba133*				70.3	10.2	4.6	2.6
		&Ba135(n,2n)Ba134(n,2n)*Ba133*				26.4	1.0		
		&Ba136(n,2n)*Ba135*(n,2n)Ba134(n,2n)*Ba133*				2.8			
		&Ba135(n,3n)*Ba133*					65.0	22.3	8.7
		&Ba137(n,3n)*Ba135*(n,3n)*Ba133*					11.4	1.2	
		&Ba136(n,3n)Ba134(n,2n)*Ba133*					3.4		
		&Ba136(n,2n)*Ba135*(n,3n)*Ba133*					2.8		
		&Ba136(n,4n)*Ba133*						35.1	14.4
		&Ba138(n,3n)*Ba136*(n,4n)*Ba133*						14.3	
		&Ba138(n,4n)*Ba135*(n,3n)*Ba133*						14.2	1.1
		&Ba137(n,5n)*Ba133*							37.3
		&Ba138(n,6n)*Ba133*							22.3
		&Ba138(n,5n)Ba134(n,2n)*Ba133*							3.8
Cs137	30.041 y	&Ba132(n,γ)*Ba133*(β$^+$)Cs133(n,γ)_ *Cs134*(n,γ)*Cs135*(n,γ)*Cs136*(n,γ)Cs137	94.3	97.3	79.6				
		Ba138(n,γ)Ba139(β$^-$)La139(n,γ)La140_ (n,α)Cs137	1.0		20.2				
		&Ba130(n,γ)*Ba131*(β$^+$)Cs131(n,γ)_ Cs132(n,γ)Cs133(n,γ)*Cs134*(n,γ)*Cs135*_ (n,γ)*Cs136*(n,γ)Cs137		1.6					
		Ba137(n,p)Cs137				46.8	4.7	2.3	1.4
		&Ba138(n,2n)*Ba137*(n,p)Cs137				40.3			
		Ba138(n,d)Cs137				12.8	94.0	97.2	98.4
Ho166m	1200 y	Very long pathways of (n,γ), (β$^-$)	100.0						
La137	6.0 10^4 y ►	Ba138(n,γ)Ba139(β$^-$)La139(n,2n)_ La138(n,2n)La137				100.0			

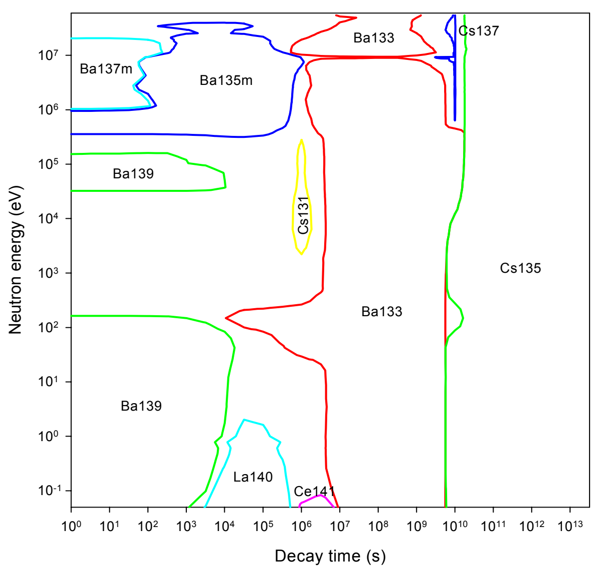
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	Ba138(n,γ)Ba139(β^-)La139(n,3n)La137					98.9	99.2	99.2
Cs135	2.3 10^6 y	**&**Ba132(n,γ)*Ba133*(β^+)Cs133(n,γ)_ *Cs134*(n,γ)*Cs135*	94.2	97.3	99.9				
		&Ba138(n,α)*Xe135*(β^-)Cs135				76.8	27.0	7.3	1.6
		&Ba135(n,p)*Cs135*				16.0	3.4	1.5	
		&Ba136(n,d)*Cs135*				2.6	21.3	21.9	7.9
		&Ba136(n,2n)*Ba135*(n,p)*Cs135*				2.4			
		&Ba137(n,t)*Cs135*				0.2	6.4	22.9	13.2
		&Ba138(n,3n)*Ba136*(n,d)*Cs135*					19.2	8.1	
		&Ba138(n,d)Cs137(n,3n)*Cs135*					15.3	6.3	
		&Ba138(n,nt)*Cs135*					2.1	23.5	70.1
I129	1.6 10^7 y	**&**Ba130(n,γ)*Ba131*(β^+)Cs131(n,γ)_ Cs132(n,α)I129	99.5	99.7	92.3				
		Ba130(n,2n)Ba129(β^+)Cs129(β^+)Xe129_ (n,p)I129				44.2	0.5		
		Ba130(n,2n)Ba129m(β^+)Cs129(β^+)_ Xe129(n,p)I129				41.9	1.3		
		&Ba134(n,2n)*Ba133*(β^+)Cs133(n,nα)I129				2.3	3.2	0.3	
		&Ba135(n,3n)*Ba133*(β^+)Cs133(n,nα)I129					20.2	1.4	
		&Ba135(n,3n)Ba133(n,3n)*Ba131*(β^+)_ Cs131(β^+)Xe131(n,t)I129					4.9	0.4	
		Ba134(n,nα)Xe130(n,d)I129					4.5	1.1	0.2
		Ba134(n,d)Cs133(n,nα)I129					4.5	1.0	0.2
		&Ba137(n,nα)*Xe133*(β^-)Cs133(n,nα)I129					4.2	0.6	
		&Ba135(n,nα)*Xe131*(n,t)I129					3.9	2.6	0.6
		Ba135(n,t)Cs133(n,nα)I129					3.0	2.1	0.5
		Ba135(n,2nα)Xe130(n,d)I129					0.9	3.4	0.7
		&Ba134(n,4n)*Ba131*(β^+)Cs131(β^+)_ Xe131(n,t)I129						24.5	5.3
		Ba135(n,nt)Cs132(β^+)Xe132(n,nt)I129						0.3	3.5
		&Ba135(n,5n)*Ba131*(β^+)Cs131(β^+)_ Xe131(n,t)I129							21.6
		Ba138(n,3nα)Xe132(n,nt)I129							5.4
		Ba138(n,nt)Cs135(n,3nα)I129							4.6
		Other pathways involving (n,2n), (n,α), β^+	0.5	0.3	7.7	11.6	53.1	62.3	57.4
La138	1.0 10^{11} y	Ba138(n,γ)Ba139(β^-)La139(n,γ)La140_ (β^-)Ce140(n,γ)Ce141(β^-)Pr141(n,α)La138	97.0	0.6	88.9				
		Ba138(n,γ)Ba139(β^-)La139(n,γ)La140_ (n,γ)La141(β^-)Ce141(β^-)Pr141(n,α)La138	2.1	99.4	11.0				
		Ba137(n,γ)Ba138(n,γ)Ba139(β^-)La139_ (n,γ)La140(β^-)Ce140(n,γ)Ce141(β^-)_ Pr141(n,α)La138	0.9						
		Ba138(n,γ)Ba139(β^-)La139(n,2n)La138				100.0	99.9	99.9	100.0

Barium activation characteristics

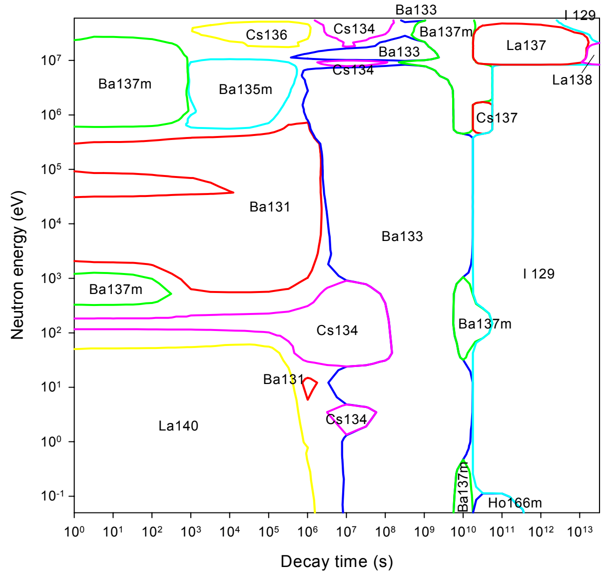


Barium importance diagrams & transmutation

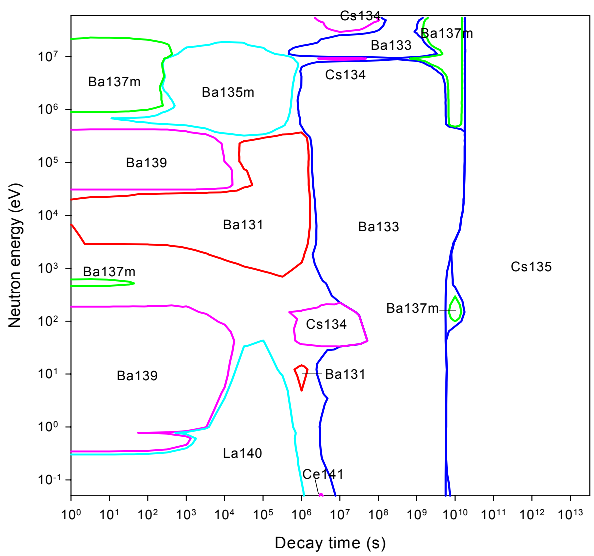
Activity



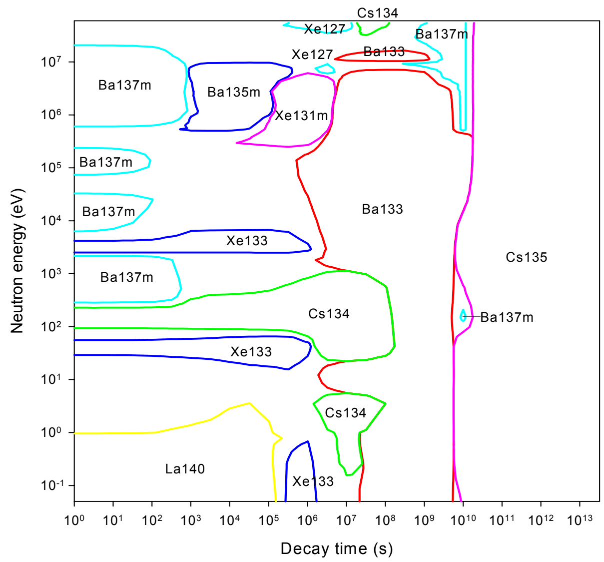
Dose rate



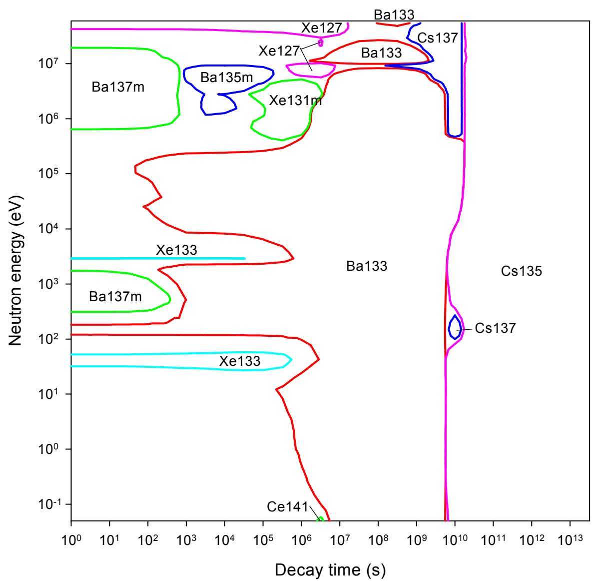
Heat output



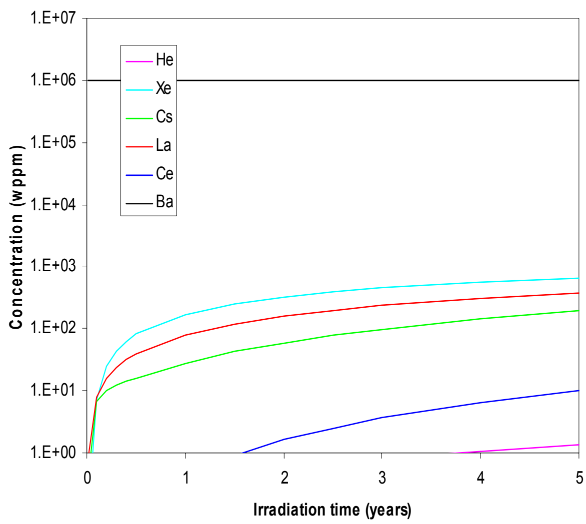
Ingestion dose



Inhalation dose



First wall transmutation



Lanthanum

General properties

		Isotopes	Isotopic abundances / %
Atomic number	57	La138	0.09 ($T_{1/2}$ = 1.02 10^{11} y)
Crustal abundance / wppm	39.0	La139	99.91
Melting point / K	1193		
Boiling point / K	3728		
Density / kgm^{-3}	6145		
Thermal conductivity / $Wm^{-1}K^{-1}$	13.5		
Electrical resistivity /Ωm	5.7 10^{-7}		
Coefficient of thermal expansion / K^{-1}	1.21 10^{-5}		
Crystal structure	Hexagonal		
Number of stable isotopes	1 (2)		
Mean atomic weight	138.9055		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Bq kg^{-1}	1.38E15	1.35E15	3.30E14	6.23E12	9.23E8	2.58E8	kW kg^{-1}	6.01E-1	5.97E-1	1.33E-1	1.92E-4	8.80E-9	1.33E-9
La140	94.83	96.57	87.51				La140	99.11	99.61	98.78			
Ce139	2.84	2.90	11.64	99.79			Ce139m	0.49	0.01				
Ce139m	1.78	0.04					Ce139	0.20	0.20	0.89	99.81		
Ba137m	0.01			0.01	3.58		Ba137m				0.02	39.68	
H3				0.16	4.05		Cs137				0.01	11.98	
La137				0.01	88.57	99.97	H3				0.01	0.39	
Cs137				0.01	3.79		La137					47.88	99.52
Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv h^{-1}	8.73E5	8.68E5	1.93E5	1.67E1	4.62E-3	8.60E-5	Sv kg^{-1}	2.63E6	2.62E6	5.92E5	1.65E3	1.15E0	2.10E-2
La140	99.47	99.90	99.66				La140	99.27	99.36	97.58			
Ce139	0.01	0.01	0.05	97.64			Ce139	0.39	0.39	1.69	98.12		
Cs134				2.10			Cs136	0.14	0.14	0.51			
Ba137m				0.26	94.56		Cs134			0.01	1.17		
La137					5.23	88.56	Cs137				0.27	39.54	
La138					0.21	11.44	La137					5.76	99.41
Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^5 y**
Sv kg^{-1}	1.52E6	1.52E6	4.00E5	1.19E4	8.89E0	2.25E0		1.36E12	1.34E12	3.28E11	6.23E9	3.91E5	6.81E3
La140	94.25	94.34	79.36				La140	95.69	96.93	87.98			
Ce139	4.88	4.89	18.24	99.58			Ce139	2.87	2.91	11.71	99.78		
Ce141	0.47	0.47	1.67	0.03			Ce139m	1.29	0.03				
Cs136	0.23	0.23	0.71				Ba137m	0.01				4.97	
Cs137				0.11	15.36		Cs137				0.06	89.43	
La137				0.06	80.02	99.80	La137					5.50	99.58

Lanthanum

Pathway analysis

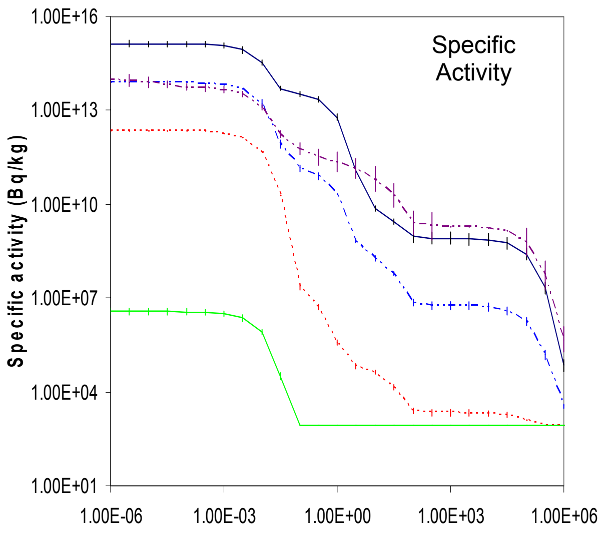
Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ba137m	2.552 m	La139(n,γ)La140(n,α)Cs137(β$^-$)Ba137m	99.3	79.6	99.6				
		La139(n,γ)La140(β$^-$)Ce140(n,α)Ba137m	0.5		0.3				
		&La138(n,α)Cs135(n,γ)*Cs136*(n,γ)Cs137_ (β$^-$)Ba137m		20.3					
		La139(n,2n)La138(n,d)Ba137m				47.1	26.6	6.1	
		La139(n,d)Ba138(n,2n)Ba137m				37.0	19.7	5.0	
		La139(n,2n)La138(n,2n)La137(n,p)Ba137m				6.2			
		La139(n,2n)La138(n,p)Ba138(n,2n)Ba137m				5.7			
		La139(n,t)Ba137m				1.6	45.9	86.4	94.4
		La139(n,3n)La137(n,p)Ba137m					5.3	0.6	
La136	9.87 m	**&**La139(n,2n)La138(n,2n)La137(n,2n)*La136*				96.4	0.6		
		&La139(n,2n)La138(n,3n)*La136*					51.3	2.1	1.2
		&La139(n,3n)La137(n,2n)*La136*					44.3	2.1	1.2
		&La139(n,4n)*La136*						94.2	97.1
La135	19.5 h	**&**La139(n,γ)La140(β$^-$)Ce140(n,2n)*Ce139*_ (n,2n)Ce138(n,2n)Ce137m(n,2n)Ce136_ (n,2n)Ce135(β$^+$)*La135*				70.0			
		&La139(n,γ)La140(β$^-$)Ce140(n,2n)*Ce139*_ (n,2n)Ce138(n,2n)*Ce137*(n,2n)Ce136_ (n,2n)*Ce135*(β$^+$)La135				17.6			
		&La139(n,γ)La140(β$^-$)Ce140(n,2n) *Ce139*(n,2n)Ce138(n,2n)Ce137m(n,2n)Ce13 6(n,d)La135				0.6			
		&La139(n,γ)La140(β$^-$)Ce140(n,2n)*Ce139*(n,2n)_ Ce138(n,2n)*Ce137*(n,2n)Ce136(n,d)La135				0.3			
		La139(n,3n)La137(n,3n)La135					98.4	62.3	
		La139(n,2n)La138(n,4n)La135						35.8	
		La138(n,4n)La135						0.7	
		La139(n,5n)La135							96.6
Ba135m	1.196 d	**&**La139(n,2n)La138(n,2n)La137(n,2n)_ *La136*(β$^+$)Ba136(n,2n)Ba135m				89.4			
		&La139(n,α)*Cs136*(β$^-$)Ba136(n,2n)Ba135m				6.4			
		La139(n,α)Cs136m(β$^-$)Ba136(n,2n)Ba135m				1.1			
La140	1.679 d	La139(n,γ)La140	99.9	99.9	100.0	99.8	99.6	99.7	99.8
Cs136	13.03 d	**&**La138(n,α)Cs135(n,γ)*Cs136*	74.1	99.9	42.3				
		&La139(n,α)*Cs136*	25.7	0.1	57.8	99.1	87.5	40.1	63.3
		&La139(n,t)*Ba137*(n,d)*Cs136*					3.1	18.5	13.2
		La139(n,2n)La138(n,3n)La136(β$^+$)Ba136_ (n,p)Cs136					2.0		
		&La139(n,3n)La137(n,2n)La136(β$^+$)Ba136_ (n,p)*Cs136*					1.8		
		&La139(n,d)Ba138(n,t)*Cs136*					1.7	14.4	14.3
		La139(n,2n)La138(n,h)Cs136					0.2	1.0	
		&La139(n,4n)*La136*(β$^+$)Ba136(n,p)*Cs136*						20.8	2.2
Ce141	32.5 d	La139(n,γ)La140(β$^-$)Ce140(n,γ)Ce141	99.4	2.0	97.0	99.5	98.7	98.7	98.8
		La139(n,γ)La140(n,γ)La141(β$^-$)Ce141	0.5	97.9	3.0	0.4	1.1	1.1	1.2
Xe127	36.40 d	Pathways involving (n,α), (n,nα), (n,2n), β$^-$,β$^+$				100.0	100.0	100.0	100.0
Ce139	137.64 d	**&**La139(n,γ)La140(β$^-$)Ce140(n,γ)Ce141_ (β$^-$)Pr141(n,γ)*Pr142*(β$^-$)Nd142(n,α)*Ce139*	98.1		47.1				
		&La139(n,γ)La140(n,γ)La141(β$^-$)Ce141_ (β$^-$)Pr141(n,γ)*Pr142*(β$^-$)Nd142(n,α)Ce139	1.7	23.8	4.8				
		&La138(β$^-$)Ce138(n,γ)*Ce139*		76.0	47.9				
		&La139(n,γ)La140(β$^-$)Ce140(n,2n)*Ce139*				99.9	99.9	100.0	100.0
Cs134	2.065 y	**&**La138(n,α)Cs135(n,γ)*Cs136*(n,α)*I133*_ (β$^-$)*Xe133*(β$^-$)Cs133(n,γ)*Cs134*	64.8	99.6					

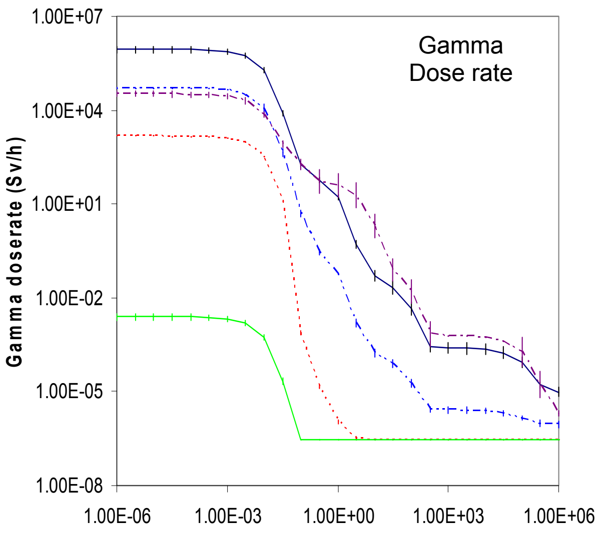
Nuclide	T½	Pathway	210	186	151	42	30	21	6
		&La139(n,α)*Cs136*(n,α)*I133*(β$^-$)*Xe133*_ (β$^-$)Cs133(n,γ)*Cs134*	31.1						
		&La138(n,α)Cs135(n,γ)Cs136(β$^-$)Ba136_ (n,α)Xe133(β$^-$)Cs133(n,γ)*Cs134*	2.0						
		&La139(n,α)Cs136(β$^-$)Ba136(n,α)Xe133_ (β$^-$)Cs133(n,γ)*Cs134*	1.2						
		&La139(n,2n)La138(n,2n)La137(n,α)*Cs134*				41.9	0.1		
		&La139(n,2n)La138(n,α)*Cs135*(n,2n)*Cs134*				34.8			
		&La139(n,2n)La138(n,nα)*Cs134*				13.8	33.0	2.2	1.0
		&La139(n,nα)*Cs135*(n,2n)*Cs134*				7.1	16.0	2.1	0.5
		&La139(n,3n)La137(n,3n)La135(β$^+$)Ba135_ (n,d)*Cs134*					19.4	1.2	
		&La139(n,3n)La137(n,α)*Cs134*					18.6	1.0	0.6
		&La139(n,2nα)*Cs134*							
		&La139(n,4n)*La136*(β$^+$)Ba136(n,t)*Cs134*						24.1	13.2
		&La139(n,nt)*Ba136*(n,t)*Cs134*						0.6	3.6
		&La139(n,t)*Ba137*(n,nt)*Cs134*						0.4	3.3
		&La139(n,5n)La135(β$^+$)Ba135(n,d)*Cs134*							18.6
Pm147	2.623 y	&La139(n,γ)La140(β$^-$)Ce140(n,γ)Ce141_ (β$^-$)Pr141(n,γ)*Pr142*(β$^-$)Nd142(n,γ)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β$^-$)Pm147	88.3	0.1	60.5				
		&La139(n,γ)La140(n,γ)La141(β$^-$)Ce141(β$^-$)_ Pr141(n,γ)*Pr142*(β$^-$)Nd142(n,γ)Nd143(n,γ)_ Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)Nd147(β$^-$)_ Pm147	3.6	47.4	14.9				
		La139(n,γ)La140(β$^-$)Ce140(n,γ)Ce141(n,γ)_ Ce142(n,γ)Ce143(β$^-$)Pr143(β$^-$)Nd143(n,γ)_ Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)Nd147(β$^-$)_ Pm147	2.3		11.1				
		&La139(n,γ)La140(β$^-$)Ce140(n,γ)Ce141(β$^-$)_ Pr141(n,γ)*Pr142*(n,γ)Pr143(β$^-$)Nd143(n,γ)_ Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)Nd147(β$^-$)_ Pm147	0.4						
		La139(n,γ)La140(n,γ)La141(β$^-$)Ce141(n,γ)_ Ce142(n,γ)Ce143(β$^-$)Pr143(β$^-$)Nd143(n,γ)_ Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)Nd147(β$^-$)_ Pm147	0.1						
		La139(n,γ)La140(n,γ)La141(n,γ)La142(β$^-$)_ Ce142(n,γ)Ce143(β$^-$)Pr143(β$^-$)Nd143(n,γ)_ Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)Nd147(β$^-$)_ Pm147		30.5					
		&La139(n,γ)La140(n,γ)La141(β$^-$)Ce141(β$^-$)_ Pr141(n,γ)*Pr142*(n,γ)Pr143(β$^-$)Nd143(n,γ)_ Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)Nd147(β$^-$)_ Pm147		8.5	0.6				
		&La139(n,γ)La140(β$^-$)Ce140(n,γ)Ce141(β$^-$)_ Pr141(n,γ)*Pr142*(n,γ)Pr143(β$^-$)Nd143(n,γ)_ Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)Nd147(β$^-$)_ Pm147			3.0				
Eu154	8.593 y	Very long pathways of (n,γ), β$^-$	100.0	100.0					
Ba133	10.54 y	&La139(n,2n)La138(n,2n)La137(n,2n)*La136*_ (β$^+$)Ba136(n,2n)*Ba135*(n,2n)Ba134(n,2n)*Ba133*				45.2			
		&La139(n,α)*Cs136*(β$^-$)Ba136(n,2n)*Ba135*_ (n,2n)Ba134(n,2n)*Ba133*				26.6			
		&La139(n,2n)La138(n,2n)La137(n,α)_ *Cs134*(β$^-$)Ba134(n,2n)*Ba133*				8.2			
		&La139(n,2n)La138(n,α)*Cs135*(n,2n)_ *Cs134*(β$^-$)Ba134(n,2n)*Ba133*				6.6			
	►	&La139(n,2n)La138(n,nα)*Cs134*(β$^-$)_ Ba134(n,2n)*Ba133*				4.9			

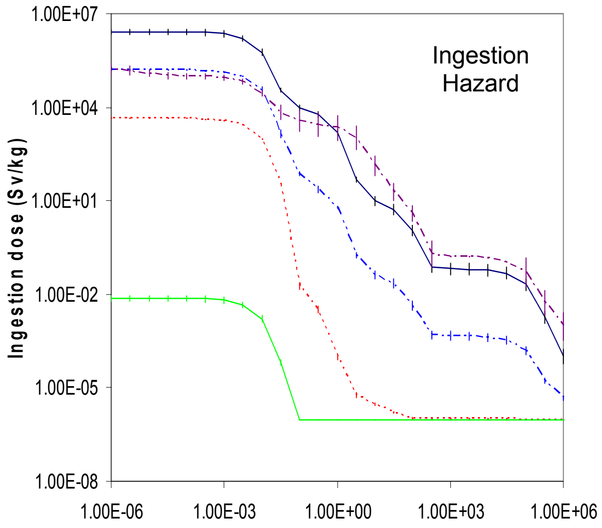
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	&La139(n,α)Cs136m(β^-)Ba136(n,2n)_ *Ba135*(n,2n)Ba134(n,2n)*Ba133*				1.6			
		&La139(n,3n)La137(n,3n)La135(β^+)_ Ba135(n,3n)*Ba133*					91.3	1.9	
		&La139(n,4n)*La136*(β^+)Ba136(n,4n)*Ba133*						86.1	21.5
		&La139(n,α)Cs136(β^-)Ba136(n,2n)*Ba135*_ (n,2n)Ba134(n,2n)*Ba133*						25.6	
		&La139(n,nt)*Ba136*(n,4n)*Ba133*						2.2	5.8
		La139(n,3n)La137(n,5n)La133(β^+)Ba133							25.7
		&La139(n,5n)La135(β^+)Ba135(n,3n)*Ba133*							25.3
		&La139(n,t)*Ba137*(n,5n)*Ba133*							10.8
		&La139(n,3n)La137(n,2nt)*Ba133*							2.4
H3	12.33 y	La138(n,X)H1(n,γ)H2(n,γ)H3	92.7	94.7	99.3				
		La139(n,2n)La138(n,X)H3				60.1	6.8	3.1	1.7
		La139(n,X)H3				38.4	80.8	86.0	87.1
		La139(n,3n)La137(n,X)H3					10.5	4.8	1.9
		La139(n,4n)La136(β^+)Ba136(n,X)H3						2.1	1.1
		La139(n,5n)La135(β^+)Ba135(n,X)H3							4.0
Cs137	30.041 y	La139(n,γ)La140(n,α)Cs137	99.9	79.6	100.0				
		&La138(n,α)Cs135(n,γ)*Cs136*(n,γ)Cs137		20.4					
		&La139(n,2n)La138(n,d)*Ba137*(n,p)Cs137				39.1	0.2		
		&La139(n,d)Ba138(n,2n)*Ba137*(n,p)Cs137				30.3	0.2		
		La139(n,d)Ba138(n,d)Cs137				14.5	72.6	33.8	25.7
		&La139(n,t)*Ba137*(n,p)Cs137				7.2	4.4	3.9	
		&La139(n,2n)La138(n,2n)La137(n,p)_ *Ba137*(n,p)Cs137				3.1			
		&La139(n,2n)La138(n,p)Ba138(n,2n)_ *Ba137*(n,p)Cs137				2.4			
		La139(n,2n)La138(n,p)Ba138(n,d)Cs137				1.5	0.2		
		&La139(n,α)*Cs136*(n,γ)Cs137				1.1			
		La139(n,h)Cs137					21.2	62.0	71.2
Sm151	90.0 y	&La139(n,γ)La140(β^-)Ce140(n,γ)Ce141_ (β^-)Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147(n,γ)Pm148(n,γ)Pm149_ (β^-)Sm149(n,γ)Sm150(n,γ)Sm151	12.1	0.1					
		&La139(n,γ)La140(β^-)Ce140(n,γ)Ce141_ (β^-)Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147(n,γ)Pm148(β^-)Sm148_ (n,γ)Sm149(n,γ)Sm150(n,γ)Sm151	1.1	0.1					
		&La139(n,γ)La140(β^-)Ce140(n,γ)Ce141_ (β^-)Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(n,γ)Nd148(n,γ)Nd149(β^-)Pm149_ (β^-)Sm149(n,γ)Sm150(n,γ)Sm151	0.7	0.1					
		&La139(n,γ)La140(n,γ)La141(β^-)Ce141_ (β^-)Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147(n,γ)Pm148(n,γ)Pm149_ (β^-)Sm149(n,γ)Sm150(n,γ)Sm151	0.6	0.7					
		La139(n,γ)La140(n,γ)La141(n,γ)La142(β^-)_ Ce142(n,γ)Ce143(β^-)Pr143(β^-)Nd143(n,γ)_ Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)Nd147(β^-)_ Pm147(n,γ)Pm148(n,γ)Pm149(β^-)Sm149(n,γ)_ Sm150(n,γ)Sm151		0.6					
		Other very long pathways of (n,γ), β^-	85.5	98.4					
Ho166m	1200 y	Very long pathways of (n,γ), β^-	100.0						
La137	$6.0\ 10^4$ y	La139(n,2n)La138(n,2n)La137				99.3			
		La138(n,2n)La137				0.7			
		La139(n,3n)La137					98.4	98.7	98.7

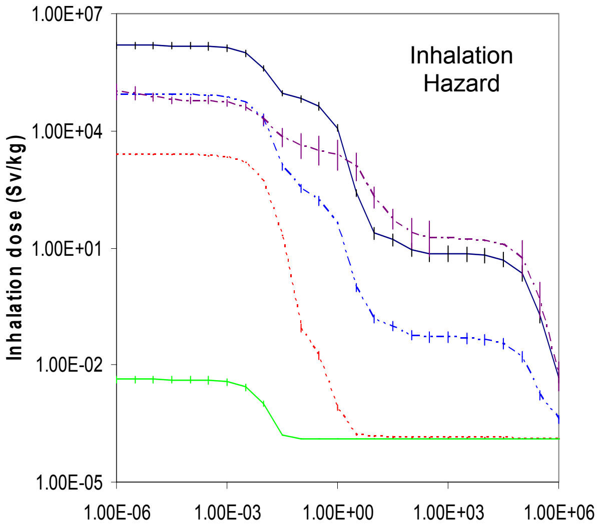
Nuclide	$T_{1/2}$	Pathway	210	186	151	42	30	21	6
Cs135	2.3 10^{6} y	La138(n,α)Cs135	100.0	100.0	100.0	0.5			
		&La139(n,2n)La138(n,α)*Cs135*				83.7	0.8	0.2	0.5
		&La139(n,nα)*Cs135*				12.9	94.8	69.5	68.6
		&La139(n,α)*Cs136*(n,2n)*Cs135*				2.1			
		&La139(n,4n)*La136*(β^+)Ba136(n,d)*Cs135*						25.2	15.2
		&La139(n,t)*Ba137*(n,t)*Cs135*						1.7	4.9
		&La139(n,nt)*Ba136*(n,d)*Cs135*						0.6	4.1
		&La139(n,d)Ba138(n,nt)*Cs135*						0.3	3.4
		&La139(n,5n)La135(β^+)Ba135(n,p)*Cs135*							1.5
La138	1.0 10^{11} y	Nuclide present in starting material	100.0	100.0	100.0				
		La139(n,2n)La138				99.6	98.8	98.1	97.1
Sm147	1.1 10^{11} y	**&**La139(n,γ)La140(β^-)Ce140(n,γ)Ce141_ (β^-)Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147(β^-)Sm147	87.0	0.1	57.1				
		&La139(n,γ)La140(n,γ)La141(β^-)Ce141_ (β^-)Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147(β^-)Sm147	4.0	45.3	15.8				
		La139(n,γ)La140(β^-)Ce140(n,γ)Ce141(n,γ)_ Ce142(n,γ)Ce143(β^-)Pr143(β^-)Nd143(n,γ)_ Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)Nd147_ (β^-)Pm147(β^-)Sm147	2.4		10.6				
		&La139(n,γ)La140(β^-)Ce140(n,γ)Ce141_ (β^-)Pr141(n,γ)*Pr142*(n,γ)Pr143(β^-)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147(β^-)Sm147	0.4		3.1				
		&La139(n,γ)La140(n,γ)La141(β^-)Ce141_ (β^-)Pr141(n,γ)*Pr142*(n,γ)Pr143(β^-)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147(β^-)Sm147	0.1	8.7	0.8				
		La139(n,γ)La140(n,γ)La141(β^-)Ce141(n,γ)_ Ce142(n,γ)Ce143(β^-)Pr143(β^-)Nd143(n,γ)_ Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)Nd147_ (β^-)Pm147(β^-)Sm147	0.1	8.1	2.6				
		La139(n,γ)La140(n,γ)La141(n,γ)La142(β^-)_ Ce142(n,γ)Ce143(β^-)Pr143(β^-)Nd143(n,γ)_ Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)Nd147_ (β^-)Pm147(β^-)Sm147		29.7					

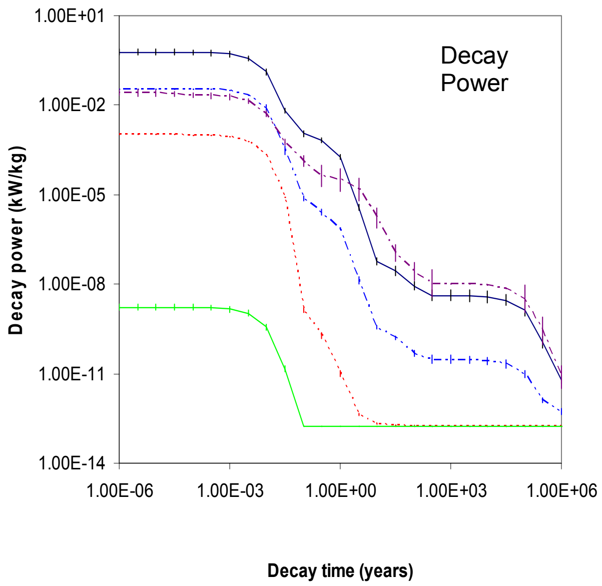
Lanthanum activation characteristics

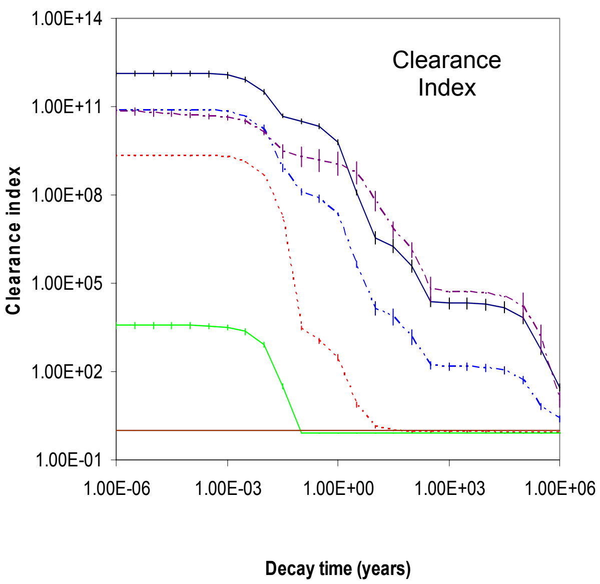






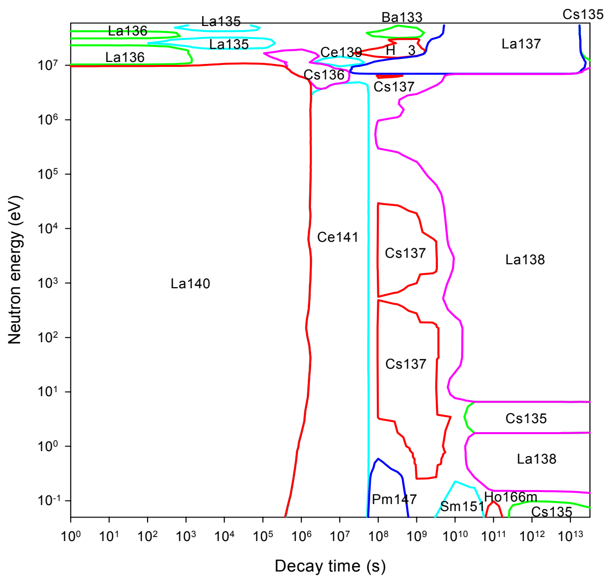




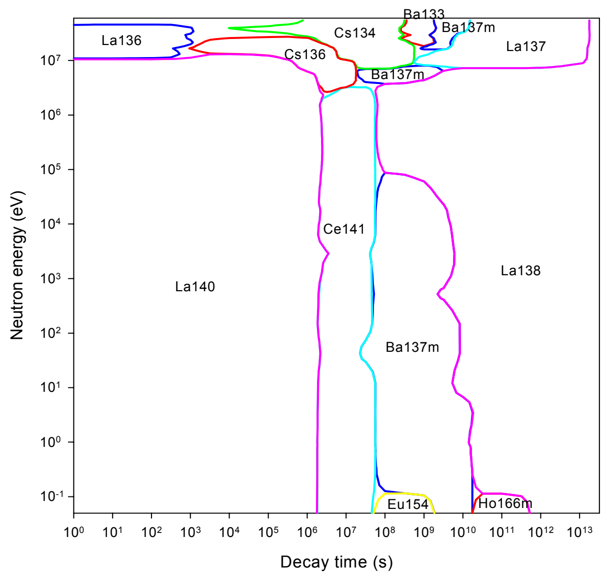


Lanthanum importance diagrams & transmutation

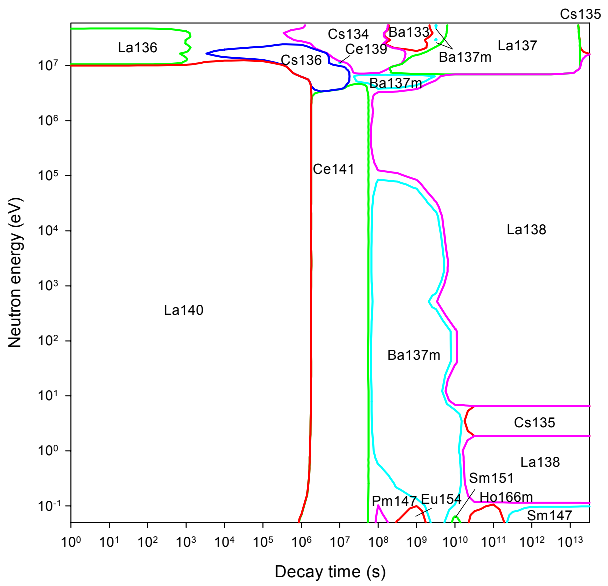
Activity



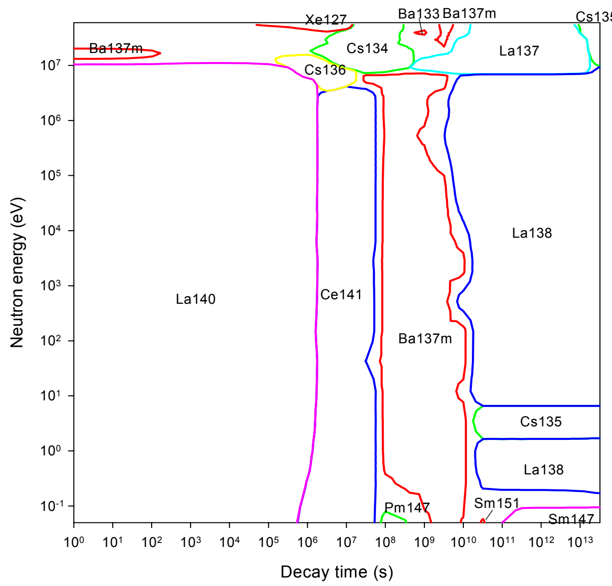
Dose rate



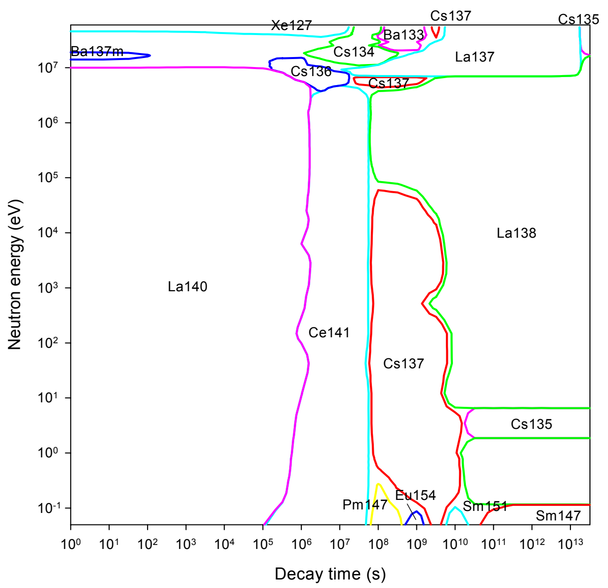
Heat output



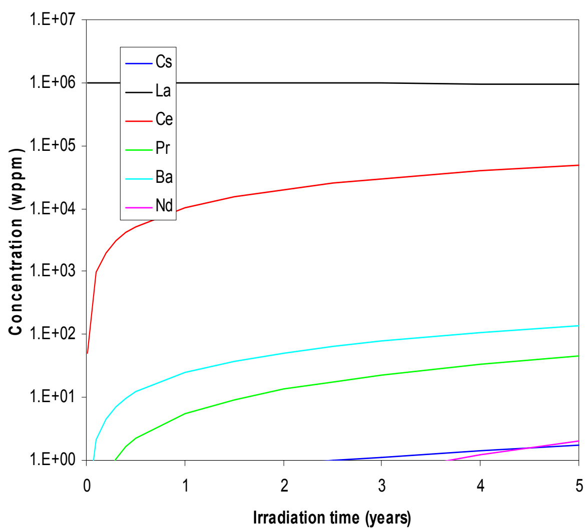
Ingestion dose



Inhalation dose



First wall transmutation



Cerium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	58		
Crustal abundance / wppm	66.5	Ce136	0.185 ($T_{1/2}$ = 7.00 10^{13} y)
Melting point / K	1072	Ce138	0.251
Boiling point / K	3697	Ce140	88.450
Density / kgm^{-3}	6770	Ce142	11.114 ($T_{1/2}$ = 5.00 10^{16} y)
Thermal conductivity / Wm^{-1}K^{-1}	11.4		
Electrical resistivity /Ωm	7.3 10^{-7}		
Coefficient of thermal expansion / K^{-1}	5.2 10^{-6}		
Crystal structure	FCC		
Number of stable isotopes	2 (4)		
Mean atomic weight	140.115		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.46E15	1.03E15	9.09E14	1.19E14	7.42E8	2.31E8	kW kg^{-1}	1.05E-1	5.35E-2	3.34E-2	3.67E-3	4.18E-9	1.19E-9
Ce139	51.34	72.64	80.76	99.94			Ce139m	49.33	1.97				
Ce139m	29.45	0.84					Ce139	21.98	43.20	67.82	99.92		
Ce141	10.97	15.53	16.27	0.06			La140	16.49	32.37	11.47			
La140	2.61	3.68	0.93				Ce141	5.97	11.73	17.36	0.07		
Pr142	1.09	1.53	0.07				Pr142	2.09	4.10	0.26			
Ce137	1.07	1.51	0.08				Ce143	1.67	3.29	0.84			
Ce143	1.07	1.50	0.27				Pr143	0.89	0.60				
Pr143	1.06	1.50	1.54				Ba137m	0.14	0.07			5.38	
Pr142m	0.38	0.42					La137					90.24	99.99
La137					98.85	100.0	Ba133					2.70	
H3					0.35		Cs137					1.62	

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	9.39E4	2.97E4	7.64E3	2.96E2	5.33E-4	6.45E-5	Sv kg^{-1}	4.70E5	4.49E5	3.33E5	3.10E4	1.32E-1	1.87E-2
Ce139m	69.24	4.44					Ce139	41.39	43.27	57.24	99.81		
La140	26.55	83.94	72.21				Ce141	24.16	25.26	31.49	0.15		
Ce139	1.98	6.28	23.93	99.91			La140	16.17	16.88	5.04			
Ce143	0.53	1.68	1.04				Pr142	4.38	4.56	0.26			
Pr142	0.31	0.98	0.16				Pr143	3.93	4.11	5.02			
Ce141	0.21	0.66	2.37	0.03			Ce143	3.63	3.79	0.82			
Ba137m	0.19	0.15			51.82		Ba133				0.01	1.77	
Ba133				0.01	9.87		La137					45.10	99.99
La137					38.27	99.71	Cs137					22.29	

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	2.15E6	2.13E6	2.00E6	2.26E5	6.51E0	2.01E0		1.10E12	7.99E11	7.45E11	1.19E11	4.38E4	6.08E3
Ce139	66.14	66.56	69.67	99.88			Ce139	67.83	93.58	98.62	99.99		
Ce141	28.28	28.45	28.06	0.11			Ce139m	27.80	0.78				
La140	1.95	1.95	0.46				La140	3.45	4.75	1.13			
Pr143	1.72	1.73	1.67				Ce141	0.15	0.20	0.20			
Ce143	0.60	0.60	0.10				Ce143	0.14	0.19	0.03			
Pr142	0.41	0.41	0.02				Ba137m	0.07	0.02			2.86	
Ce137m	0.07	0.07	0.01				Pr142	0.01	0.02				
Ba133				0.01	0.24		Cs137					51.58	
La137					98.01	100.0	La137					44.08	99.99
Cs137					1.35		Ba133					1.42	

Cerium

Pathway analysis

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Ce139m	56.1 s	Ce138(n,γ)Ce139m	100.0	99.9	100.0				
		Ce140(n,2n)Ce139m				98.6	95.7	68.9	78.9
		Ce142(n,3n)Ce140(n,2n)Ce139m				0.3	2.6		
		Ce142(n,4n)Ce139m					1.1	29.8	20.2
Ba137m	2.552 m	Ce140(n,α)Ba137m	96.9		100.0	90.5	80.0	34.9	40.0
		Ce138(n,γ)Ce139(n,α)Ba136(n,γ)Ba137m	2.4						
		&Ce136(n,γ)Ce137(β^+)La137(n,γ)La138_ (n,α)Cs135(n,γ)*Cs136*(n,γ)Cs137(β^-)Ba137m		85.6					
		&Ce136(n,γ)*Ce137m*(β^+)La137(n,γ)La138_ (n,α)Cs135(n,γ)Cs136(n,γ)Cs137(β^-)Ba137m		13.0					
		&Ce140(n,2n)*Ce139*(β^+)La139(n,2n)_ La138(n,d)Ba137m				2.4	1.5		0.1
		Ce142(n,nα)Ba138(n,2n)Ba137m				0.3	1.1	0.5	0.2
		Ce142(n,3n)Ce140(n,α)Ba137m				0.2	2.1		0.2
		&Ce140(n,2n)*Ce139*(β^+)La139(n,t)Ba137m				0.1	6.5	22.3	22.1
		Ce142(n,2nα)Ba137m					1.3	10.8	8.2
		Ce140(n,d)La139(n,t)Ba137m					0.8	7.3	9.5
		Ce140(n,t)La138(n,d)Ba137m					0.8	7.1	9.9
		&Ce142(n,4n)*Ce139*(β^+)La139(n,t)Ba137m						8.1	3.7
		&Ce140(n,4n)*Ce137*(β^+)La137(n,p)Ba137m						3.0	1.2
La136	9.87 m	Ce136(β^+)La136	100.0		100.0				
		&Ce140(n,2n)*Ce139*(β^+)La139(n,2n)_ La138(n,2n)La137(n,2n)*La136*				53.7			
		&Ce140(n,2n)*Ce139*(n,2n)Ce138(n,2n)_ *Ce137*(β^+)La137(n,2n)*La136*				20.7			
		&Ce138(n,2n)*Ce137*(β^+)La137(n,2n)*La136*				18.2	0.6		
		&Ce140(n,3n)Ce138(n,2n)*Ce137*(β^+)_ La137(n,2n)*La136*					15.2	0.5	
		&Ce140(n,2n)*Ce139*(β^+)La139(n,2n)_ La138(n,3n)*La136*					14.3	0.3	
		&Ce140(n,2n)*Ce139*(β^+)La139(n,3n)_ La137(n,2n)*La136*					12.3	0.3	
		&Ce140(n,3n)Ce138(n,t)*La136*					10.7	9.5	5.8
		&Ce140(n,t)La138(n,3n)*La136*					8.4	5.3	4.8
		&Ce140(n,nt)La137(n,2n)*La136*					0.1	0.5	3.5
		&Ce140(n,2n)*Ce139*(β^+)La139(n,4n)*La136*						31.3	13.4
		&Ce140(n,4n)*Ce137*(β^+)La137(n,2n)*La136*						23.0	14.4
		&Ce142(n,4n)*Ce139*(β^+)La139(n,4n)*La136*						11.5	2.2
		&Ce140(n,d)La139(n,4n)*La136*						10.2	5.7
		&Ce140(n,2nt)*La136*							41.9
		Other pathways involving (n,2n), (n,α), β^+				7.4	38.4	7.6	8.3
Pr144	17.28 m	&Ce142(n,γ)Ce143(β^-)Pr143(n,γ)*Pr144*	98.7	100.0	97.1	91.0	85.7	86.5	88.3
		&Ce140(n,γ)Ce141(n,γ)Ce142(n,γ)Ce143_ (β^-)Pr143(n,γ)*Pr144*	0.9						
		&Ce142(n,γ)Ce143(n,γ)Ce144(β^-)*Pr144*	0.7		3.0	9.0	9.2	9.4	9.5
		Ce142(n,γ)Ce143(β^-)Pr143(β^-)Nd143(n,γ)_ Nd144(n,p)Pr144					4.1	3.4	2.0
Ba129m	2.14 h	&Ce136(n,nα)Ba132(n,2n)*Ba131*(n,2n)_ Ba130(n,2n)Ba129m				45.8			
		&Ce136(n,α)*Ba133*(n,2n)Ba132(n,2n)_ *Ba131*(n,2n)Ba130(n,2n)Ba129m				28.1			
		Ce140(n,3n)Ce138(n,3n)Ce136(n,nα)_ Ba132(n,3n)Ba130(n,2n)Ba129m					11.7		
		Ce136(n,nα)Ba132(n,3n)Ba130(n,2n)Ba129m					10.6		
	►	Ce140(n,3n)Ce138(n,nα)Ba134(n,3n)_ Ba132(n,3n)Ba130(n,2n)Ba129m					9.5		

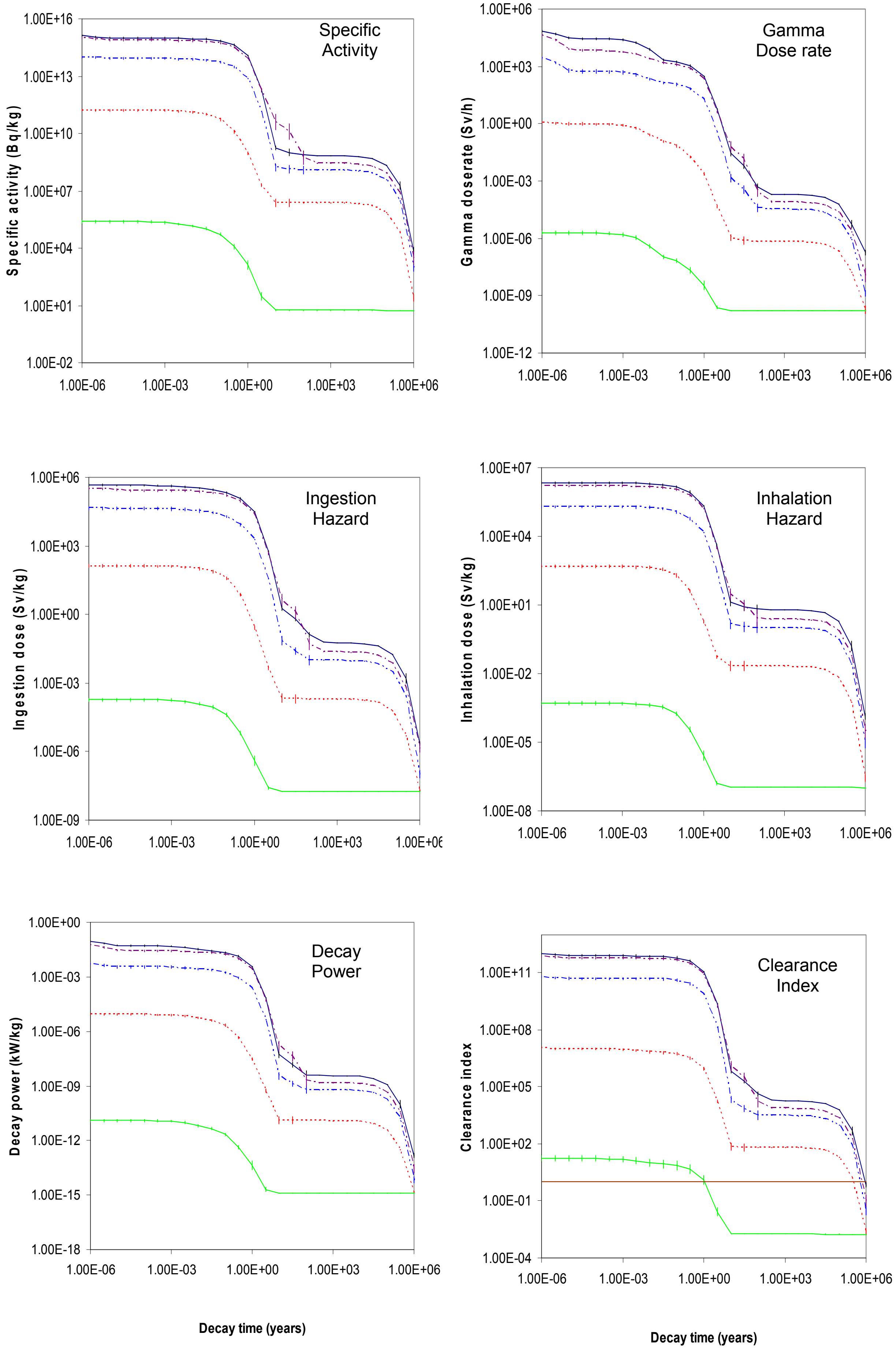
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Ce140(n,nα)Ba136(n,3n)Ba134(n,3n)_ Ba132(n,3n)Ba130(n,2n)Ba129m					4.5		
		&Ce140(n,2nα)*Ba135*(n,4n)Ba132(n,4n)Ba129m						12.2	0.4
		Ce140(n,5n)Ce136(n,5n)Ce132(β^+)La132_ (β^+)Ba132(n,4n)Ba129m							14.7
		Ce140(n,5n)Ce136(n,4n)Ce133m(β^+)_ La133(β^+)Ba133(n,5n)Ba129m							14.0
		Ce140(n,5n)Ce136(n,4nα)Ba129m							8.6
		Ce140(n,5n)Ce136(n,nt)La133(β^+)Ba133_ (n,5n)Ba129m							6.4
		&Ce140(n,4nα)*Ba133*(n,5n)Ba129m							4.2
		Ce140(n,nt)La137(n,5n)La133(β^+)Ba133_ (n,5n)Ba129m							4.2
		Other pathways involving (n,2n), (n,α), β^+				26.1	63.7	87.8	47.5
Ce137	9.0 h	&Ce136(n,γ)*Ce137*	100.0	100.0	100.0				
		&Ce140(n,2n)*Ce139*(n,2n)Ce138(n,2n)*Ce137*				68.7	0.2		
		&Ce138(n,2n)*Ce137*				28.0	1.5		
		&Ce140(n,3n)Ce138(n,2n)*Ce137*					85.0		
		&Ce140(n,2n)*Ce139*(n,3n)*Ce137*					8.9		
		&Ce142(n,3n)Ce140(n,3n)Ce138(n,2n)*Ce137*					1.0		
		&Ce140(n,4n)*Ce137*						93.5	94.7
		&Ce142(n,6n)*Ce137*							3.0
Pr142	19.12 h	&Ce140(n,γ)Ce141(β^-)Pr141(n,γ)*Pr142*	99.4	99.1	99.2	0.4	0.4	0.4	0.4
		&Ce142(n,2n)Ce141(β^-)Pr141(n,γ)*Pr142*				98.2	79.9	69.9	63.2
		&Ce142(n,γ)Ce143(β^-)Pr143(β^-)Nd143(n,d)*Pr142*					8.9	13.6	16.0
		&Ce142(n,d)La141(β^-)Ce141(β^-)Pr141(n,γ)*Pr142*					8.8	14.5	19.0
Ce143	1.379 d	Ce142(n,γ)Ce143	99.1	100.0	100.0	99.9	99.6	99.7	99.8
		Ce140(n,γ)Ce141(n,γ)Ce142(n,γ)Ce143	0.9						
La140	1.679 d	&Ce136(n,γ)*Ce137*(β^+)La137(n,γ)La138_ (n,γ)La139(n,γ)La140	80.0	94.0	0.2				
		&Ce138(n,γ)*Ce139*(β^+)La139(n,γ)La140	20.0	5.9	99.8				
		Ce140(n,p)La140				95.8	91.4	68.7	49.1
		&Ce140(n,2n)*Ce139*(β^+)La139(n,γ)La140				3.4			
		Ce142(n,3n)Ce140(n,p)La140				0.3	2.4		
		Ce142(n,t)La140					5.9	30.0	49.9
Pr143	13.56 d	Ce142(n,γ)Ce143(β^-)Pr143	99.0	100.0	100.0	99.4	99.4	99.5	99.7
		Ce140(n,γ)Ce141(n,γ)Ce142(n,γ)Ce143_ (β^-)Pr143	0.8						
Ce141	32.5 d	Ce140(n,γ)Ce141	100.0	100.0	100.0	0.4	0.5		
		Ce142(n,2n)Ce141				99.4	88.5	81.5	75.9
		Ce142(n,d)La141(β^-)Ce141					9.7	17.0	22.8
Xe127	36.40 d	Pathways involving (n,α), (n,nα), (n,2n), β^-,β^+				100.0	100.0	100.0	100.0
Ce139	137.64 d	&Ce138(n,γ)*Ce139*	100.0	99.9	100.0				
		&Ce140(n,2n)*Ce139*				99.3	94.5	71.8	84.6
		&Ce142(n,3n)Ce140(n,2n)*Ce139*				0.2	2.3		
		&Ce142(n,4n)*Ce139*					1.5	25.9	14.2
Ce144	285.0 d	Ce142(n,γ)Ce143(n,γ)Ce144	99.3	100.0	100.0	99.9	99.6	99.7	99.8
		Ce140(n,γ)Ce141(n,γ)Ce142(n,γ)Ce143_ (n,γ)Ce144	0.7						
Cs134	2.065 y	&Ce136(n,α)*Ba133*(β^+)Cs133(n,γ)*Cs134*	98.5	95.2	94.1				
		&Ce136(n,γ)*Ce137*(β^+)La137(n,α)*Cs134*	1.5	4.8	5.9				
		&Ce140(n,2n)*Ce139*(β^+)La139(n,2n)_ La138(n,2n)La137(n,α)*Cs134*				24.5			
		&Ce140(n,2n)*Ce139*(β^+)La139(n,2n)_ La138(n,α)*Cs135*(n,2n)*Cs134*				20.2			
		&Ce138(n,2n)*Ce137*(β^+)La137(n,α)*Cs134*				13.5	0.2		
		&Ce140(n,2n)*Ce139*(β^+)La139(n,2n)_ La138(n,nα)*Cs134*				12.2	7.6	0.1	
	►	&Ce140(n,2n)*Ce139*(n,2n)Ce138(n,2n)_ *Ce137*(β^+)La137(n,α)*Cs134*				10.9			

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Ce140(n,2n)*Ce139*(β^+)La139(n,nα)_ *Cs135*(n,2n)*Cs134*				6.2	4.2		
		&Ce136(n,2n)Ce135(β^+)La135(β^+)Ba135_ (n,d)*Cs134*				3.7	3.5	0.3	
		&Ce140(n,t)La138(n,nα)*Cs134*					6.7	6.3	5.4
		&Ce140(n,3n)Ce138(n,2n)*Ce137*(β^+)_ La137(n,α)*Cs134*					6.5	0.1	
		&Ce140(n,2n)*Ce139*(β^+)La139(n,3n)_ La137(n,α)*Cs134*					4.8		
		&Ce140(n,2n)*Ce139*(β^+)La139(n,2nα)*Cs134*					4.7	16.1	8.6
		&Ce140(n,nα)*Ba136*(n,t)*Cs134*					4.2	5.7	5.1
		&Ce140(n,d)La139(n,2nα)*Cs134*					0.6	5.6	4.8
		&Ce140(n,2nα)*Ba135*(n,d)*Cs134*					0.5	6.0	5.6
		&Ce140(n,4n)*Ce137*(β^+)La137(n,α)*Cs134*						7.8	10.6
		&Ce142(n,4n)*Ce139*(β^+)La139(n,2nα)*Cs134*						5.9	1.8
		Ce140(n,3n)Ce138(n,4n)Ce135(β^+)La135_ (β^+)Ba135(n,d)Cs134						5.1	1.2
		&Ce140(n,2nt)*La136*(β^+)Ba136(n,t)*Cs134*							12.6
		Other pathways involving (n,2n), (n,α), β^+				8.8	56.5	41.0	44.3
Pm147	2.623 y	Ce142(n,γ)Ce143(β^-)Pr143(β^-)Nd143(n,γ)_ Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)Nd147_ (β^-)Pm147	87.2	95.3	93.7	87.7	71.3	45.2	
		&Ce140(n,γ)Ce141(β^-)Pr141(n,γ)*Pr142*_ (β^-)Nd142(n,γ)Nd143(n,γ)Nd144(n,γ)_ Nd145(n,γ)Nd146(n,γ)Nd147(β^-)Pm147	7.4						
		&Ce142(n,γ)Ce143(β^-)Pr143(n,γ)*Pr144*_ (β^-)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147	5.2	4.6	6.1	11.0	24.1	53.9	
Eu154	8.593 y	Very long pathways of (n,γ), β^-	100.0	100.0	100.0				
Ba133	10.54 y	&Ce136(n,α)*Ba133*	100.0	100.0	100.0	26.3	1.4		
		&Ce136(n,2n)*Ce135*(β^+)La135(β^+)Ba135_ (n,2n)Ba134(n,2n)*Ba133*				69.6			
		&Ce136(n,2n)*Ce135*(β^+)La135(β^+)Ba135_ (n,3n)*Ba133*					9.4	0.2	
		&Ce136(n,3n)Ce134(β^+)La134(β^+)Ba134_ (n,2n)*Ba133*					5.4	0.5	
		&Ce140(n,3n)Ce138(n,2nα)*Ba133*					3.5	11.8	0.7
		&Ce140(n,3n)Ce138(n,3n)Ce136(n,α)*Ba133*					3.2		
		&Ce140(n,3n)Ce138(n,nα)Ba134(n,2n)*Ba133*					3.1	0.1	
		&Ce140(n,2nα)*Ba135*(n,3n)*Ba133*					1.5	5.9	0.4
		&Ce140(n,nα)*Ba136*(n,4n)*Ba133*						11.2	0.5
		Ce140(n,3n)Ce138(n,3n)Ce136(n,4n)_ Ce133m(β^+)La133(β^+)Ba133						5.1	0.2
		Ce136(n,4n)Ce133m(β^+)La133(β^+)Ba133						4.3	1.3
		Ce140(n,3n)Ce138(n,4n)Ce135(β^+)La135_ (β^+)Ba135(n,3n)Ba133						3.4	
		&Ce140(n,4n)*Ce137*(β^+)La137(n,5n)_ La133(β^+)Ba133							29.2
		Ce140(n,5n)Ce136(n,4n)Ce133m(β^+)_ La133(β^+)Ba133							23.2
		Ce140(n,5n)Ce136(n,nt)La133(β^+)Ba133							10.7
		&Ce140(n,4nα)*Ba133*							7.1
		Ce140(n,nt)La137(n,5n)La133(β^+)Ba133							7.0
		Ce140(n,5n)Ce136(n,4n)Ce133(β^+)La133_ (β^+)Ba133							3.6
		Other pathways involving (n,2n), (n,α), β^+				4.1	72.5	57.5	16.1
H3	12.33 y	&Ce136(n,γ)*Ce137*(β^+)La137(n,γ)La138_ (n,X)H1(n,γ)H2(n,γ)H3	91.6	91.6					
		Ce136(n,γ)Ce137m(n,X)H1(n,γ)H2(n,γ)H3	2.7	3.5					
	►	&Ce140(n,2n)*Ce139*(β^+)La139(n,X)H3				29.7	1.2	0.6	

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	&Ce140(n,2n)*Ce139*(β^+)La139(n,2n)_ La138(n,X)H3				28.2			
		Ce142(n,2n)Ce141(β^-)Pr141(n,X)H3				18.5	0.7		
		Ce142(n,X)H3				11.7	12.3	10.6	10.0
		&Ce140(n,2n)*Ce139*(n,X)H3				4.9	1.0		
		Ce140(n,X)H3				4.2	71.7	73.8	75.8
		Ce142(n,2n)Ce141(n,X)H3				1.4			
		Ce140(n,3n)Ce138(n,X)H3					6.2	4.2	1.5
		Ce142(n,3n)Ce140(n,X)H3					1.0		
		Ce140(n,4n)Ce137(β^+)La137(n,X)H3						1.0	
		Ce140(n,5n)Ce136(n,X)H3							2.9
La137	6.0 10^4 y	&Ce136(n,γ)*Ce137*(β^+)La137	99.9	99.9	99.9				
		&Ce140(n,2n)*Ce139*(β^+)La139(n,2n)_ La138(n,2n)La137				59.0	0.3		
		&Ce138(n,2n)*Ce137*(β^+)La137				18.6	1.4		
		&Ce140(n,2n)*Ce139*(n,2n)Ce138(n,2n)_ *Ce137*(β^+)La137				15.8			
		&Ce140(n,3n)Ce138(n,2n)*Ce137*(β^+)La137					43.7	0.7	
		&Ce140(n,2n)*Ce139*(β^+)La139(n,3n)La137					33.3	0.7	
		&Ce140(n,2n)*Ce139*(n,3n)*Ce137*(β^+)La137					7.7		
		Ce140(n,3n)Ce138(n,d)La137					5.4	1.1	
		Ce140(n,d)La139(n,3n)La137					4.6	0.7	
		Ce140(n,nt)La137					0.3	1.8	17.8
		&Ce140(n,4n)*Ce137*(β^+)La137						87.9	74.6
Cs135	2.3 10^6 y	&Ce136(n,γ)*Ce137*(β^+)La137(n,γ)La138_ (n,α)*Cs135*	77.7	98.5	91.9				
		&Ce136(n,α)*Ba133*(β^+)Cs133(n,γ)*Cs134*_ (n,γ)*Cs135*	21.7	1.5	7.3				
		&Ce140(n,2n)*Ce139*(β^+)La139(n,2n)_ La138(n,α)*Cs135*				71.1	0.3		
		&Ce140(n,2n)*Ce139*(β^+)La139(n,nα)*Cs135*				18.2	69.4	27.0	14.5
		&Ce136(n,2n)*Ce135*(β^+)La135(β^+)Ba135_ (n,p)*Cs135*				5.0	0.2		
		&Ce140(n,2n)*Ce139*(β^+)La139(n,α)*Cs136*_ (n,2n)*Cs135*				2.6			
		&Ce140(n,nα)*Ba136*(n,d)*Cs135*					9.9	11.7	8.5
		&Ce140(n,d)La139(n,nα)*Cs135*					9.6	9.7	6.9
		&Ce142(n,4n)*Ce139*(β^+)La139(n,nα)*Cs135*					1.0	9.9	2.4
		&Ce140(n,3n)Ce138(n,t)*La136*(β^+)Ba136_ (n,d)*Cs135*					0.4	2.1	0.8
		&Ce140(n,t)La138(n,α)*Cs135*					0.2	0.9	4.6
		&Ce140(n,4n)*Ce137*(β^+)La137(n,h)*Cs135*						6.1	5.9
		&Ce140(n,dα)*Cs135*						0.2	3.4
		&Ce140(n,2nt)*La136*(β^+)Ba136(n,d)*Cs135*							21.1
		Other pathways involving (n,2n), (n,α), β^+	0.2		0.3	3.1	9.0	32.4	31.9
La138	1.0 10^{11} y	&Ce136(n,γ)*Ce137*(β^+)La137(n,γ)La138	99.9	99.9	99.9				
		&Ce140(n,2n)*Ce139*(β^+)La139(n,2n)La138				99.5	56.6	2.8	
		Ce140(n,t)La138					24.9	82.5	89.8
		Ce140(n,d)La139(n,2n)La138					7.8	3.0	
		Ce140(n,3n)Ce138(n,p)La138					6.0	1.3	
		Ce142(n,2nt)La138							5.2
Sm147	1.1 10^{11} y	Ce142(n,γ)Ce143(β^-)Pr143(β^-)Nd143(n,γ)_ Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)Nd147_ (β^-)Pm147(β^-)Sm147	88.7	95.2	92.5	87.0	70.9		
		&Ce140(n,γ)Ce141(β^-)Pr141(n,γ)*Pr142*(β^-)_ Nd142(n,γ)Nd143(n,γ)Nd144(n,γ)Nd145(n,γ)_ Nd146(n,γ)Nd147(β^-)Pm147(β^-)Sm147	5.7						
		&Ce142(n,γ)Ce143(β^-)Pr143(n,γ)*Pr144*_ (β^-)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147(β^-)Sm147	5.5	4.8	7.3	13.3	29.1		
Ce136	7.0 10^{13} y	Ce140(n,3n)Ce138(n,3n)Ce136					83.4	68.7	1.0
	►	Ce138(n,3n)Ce136					2.7	3.4	0.1

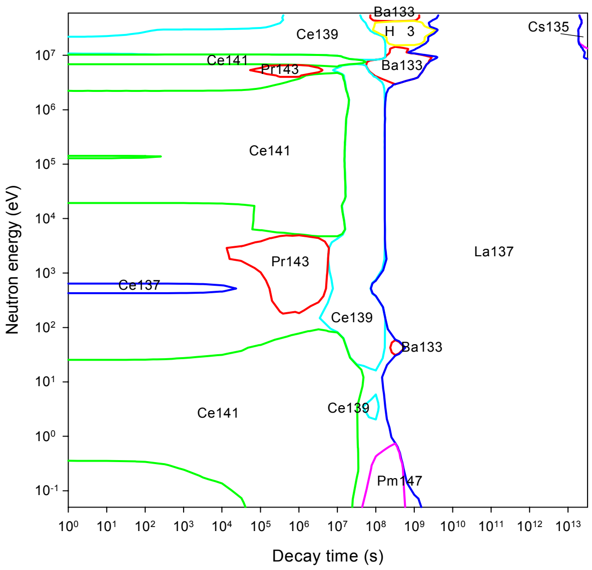
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Ce140(n,2n)*Ce139*(n,4n)Ce136						4.2	0.1
		Ce140(n,5n)Ce136							95.3
		Nuclide present in starting material	100.0	100.0	100.0	100.0	13.9	23.7	3.5

Cerium activation characteristics

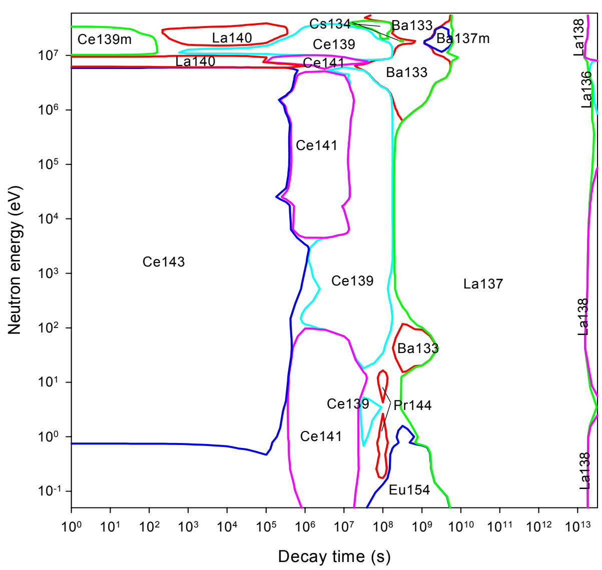


Cerium importance diagrams & transmutation

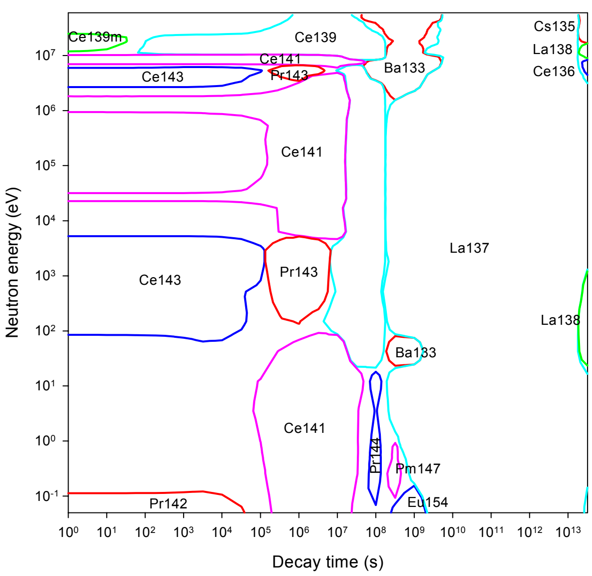
Activity



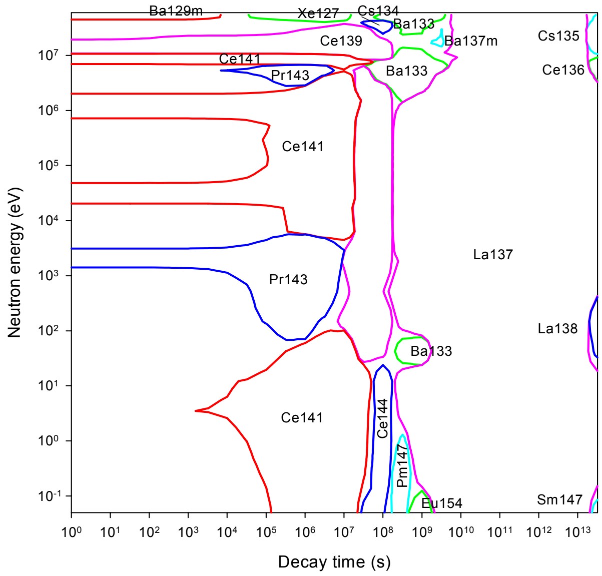
Dose rate



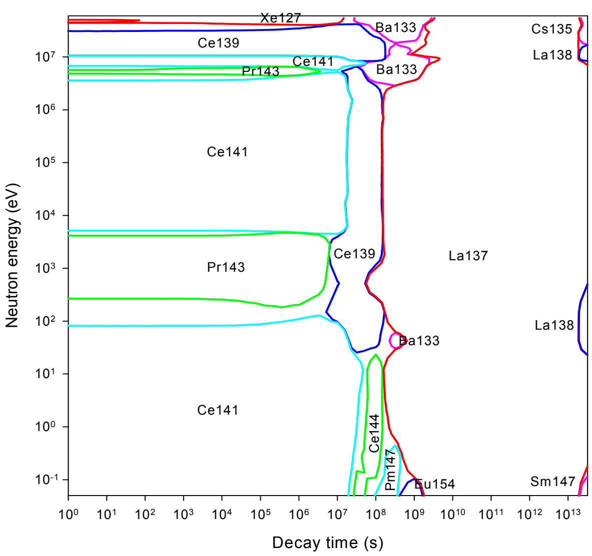
Heat output



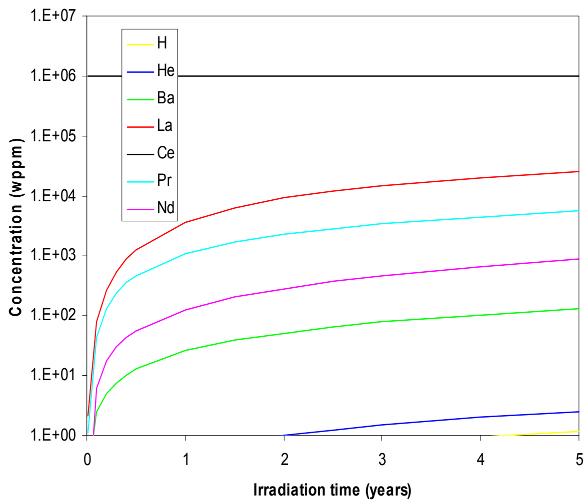
Ingestion dose



Inhalation dose



First wall transmutation



Praseodymium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	59		
Crustal abundance / wppm	9.2	Pr141	100.0
Melting point / K	1204		
Boiling point / K	3783		
Density / kgm^{-3}	6773		
Thermal conductivity / $Wm^{-1}K^{-1}$	12.5		
Electrical resistivity /Ωm	$6.8\ 10^{-7}$		
Coefficient of thermal expansion / K^{-1}	$6.7\ 10^{-6}$		
Crystal structure	HCP		
Number of stable isotopes	1		
Mean atomic weight	140.90765		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	4.39E15	3.58E15	1.36E14	4.27E12	1.33E8	1.04E6	kW kg^{-1}	5.04E-1	4.00E-1	1.56E-2	1.31E-4	1.40E-10	5.38E-12
Pr142	56.84	69.44	76.69				Pr142	68.78	86.56	92.96			
Pr142m	19.79	18.88					Pr140	29.27	12.60				
Pr140	19.27	8.05					Nd141m	0.89	0.03				
Nd141	2.23	2.68					Nd141	0.28	0.34				
Nd141m	0.73	0.03					Ce139	0.16	0.21	5.18	99.90		
Ce139	0.61	0.74	19.21	99.15			Ce141	0.05	0.06	1.34	0.07		
Ce141	0.13	0.16	3.92	0.06			H3				0.02	85.04	
H3			0.03	0.80	97.48		La137					12.18	99.81
La137					2.48	99.99	Ba137m					2.14	

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	1.28E5	7.17E4	2.07E3	9.97E0	4.47E-6	2.88E-7	Sv kg^{-1}	3.28E6	3.26E6	1.47E5	1.10E3	6.66E-3	8.46E-5
Pr140	56.72	34.49					Pr142	98.95	99.18	92.51			
Pr142	35.27	62.74	91.28				Pr142m	0.45	0.35				
Nd141m	4.62	0.24					Ce139	0.21	0.21	4.64	99.71		
Ce139m	1.94	0.07					Pr140	0.15	0.05				
Nd141	0.80	1.39					Ce141	0.13	0.13	2.58	0.15		
La140	0.40	0.71	5.43				La140	0.05	0.05	0.24			
Ce139	0.05	0.09	2.98	99.97			Ba137m	0.03	0.01			8.07	
Ba137m	0.01				80.31		H3				0.13	82.06	
La137					19.33	94.48	Cs137					5.85	
La138					0.36	5.52	La137					4.02	99.84
							Cs135						0.10

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.46E6	1.45E6	1.28E5	8.06E3	6.41E-2	9.08E-3		5.99E11	2.33E11	2.74E10	4.23E9	1.70E3	2.75E1
Pr142	94.18	94.47	44.98				Pr140	82.99	72.83				
Ce139	3.48	3.49	38.92	99.78			Nd141m	4.47	0.34				
Ce141	1.50	1.51	15.87	0.11			Ce139	4.45	11.44	95.36	99.99		
Pr142m	0.42	0.33					Pr142	4.16	10.68	3.81			
Pr140	0.28	0.10					Ce139m	1.99	0.10				
La140	0.06	0.06	0.15				Nd141	1.26	3.17				
Nd141	0.03	0.03					La140	0.13	0.34	0.63			
Pr143	0.01	0.01	0.07				Ce141	0.01	0.03	0.19			
H3			0.01	0.11	52.76		Ba137m	0.01				0.98	
La137					44.88	99.92	H3				0.01	76.33	
Cs137					1.82		Cs137					17.58	
La138					0.01	0.08	La137					5.11	99.83

Praseodymium

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ba137m	2.552 m	**&**Pr141(n,γ)*Pr142*(β^-)Nd142(n,α)Ce139_ (n,α)Ba136(n,γ)Ba137m	81.0						
		&Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,α)Ce140(n,α)Ba137m	11.2						
		&Pr141(n,γ)*Pr142*(β^-)Nd142(n,α)Ce139_ (β^+)La139(n,γ)La140(n,α)Cs137(β^-)_ Ba137m	3.5						
		Pr141(n,α)La138(n,α)Cs135(n,γ)Cs136_ (n,γ)Cs137(β^-)Ba137m	0.1	97.8					
		Pr141(n,2n)Pr140(β^+)Ce140(n,α)Ba137m				95.9	24.3	2.0	2.5
		Pr141(n,d)Ce140(n,α)Ba137m				0.5	3.5	0.7	1.1
		Pr141(n,3n)Pr139(β^+)Ce139(β^+)La139_ (n,t)Ba137m					43.1	80.8	64.0
		Pr141(n,3n)Pr139(β^+)Ce139(β^+)La139_ (n,2n)La138(n,d)Ba137m					11.3		0.8
		Pr141(n,3n)Pr139(β^+)Ce139(β^+)La139_ (n,d)Ba138(n,2n)Ba137m					8.4		0.6
		Pr141(n,3n)Pr139(β^+)Ce139(β^+)La139_ (n,3n)La137(n,p)Ba137m					2.3		
		&Pr141(n,t)*Ce139*(β^+)La139(n,t)Ba137m					0.9	7.2	22.6
		Pr141(n,5n)Pr137(β^+)Ce137(β^+)La137_ (n,p)Ba137m							2.5
Pr140	3.39 m	Pr141(n,2n)Pr140				99.8	99.7	99.8	99.9
Pr144	17.28 m	**&**Pr141(n,γ)*Pr142*(n,γ)Pr143(n,γ)*Pr144*	99.7	98.5	99.3	4.8	3.7	4.6	
		&Pr141(n,γ)*Pr142*(β^+)Ce142(n,γ)Ce143_ (β^-)Pr143(n,γ)*Pr144*	0.3	0.4	0.2	0.3		0.1	0.4
		&Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,γ)Nd144(n,p)*Pr144*				85.0	84.6	84.6	82.4
		&Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,p)Pr143(n,γ)*Pr144*				6.8	4.1	3.8	3.4
Pr138m	2.12 h	**&**Pr141(n,γ)*Pr142*(β^-)Nd142(n,2n)_ *Nd141*(n,2n)Nd140(n,t)Pr138m				99.9			
		&Pr141(n,γ)*Pr142*(β^-)Nd142(n,3n)_ Nd140(n,t)Pr138m					99.7		
		Pr141(n,4n)Pr138m						99.8	99.9
Ba129m	2.14 h	Pathways involving (n,α), (n,nα), (n,2n), β^-,β^+				100.0	100.0	100.0	100.0
Pr139	4.41 h	**&**Pr141(n,γ)*Pr142*(β^-)Nd142(n,2n)*Nd141*_ (n,2n)Nd140(n,2n)Nd139m(β^+)Pr139				42.2			
		&Pr141(n,γ)*Pr142*(β^-)Nd142(n,2n)_ *Nd141*(n,2n)Nd140(n,2n)*Nd139*(β^+)Pr139				41.0			
		&Pr141(n,γ)*Pr142*(β^-)Nd142(n,2n)_ *Nd141*(n,t)Pr139				9.0			
		Pr141(n,3n)Pr139					99.8	99.8	99.9
Ce135	17.70 h	**&**Pr141(n,2n)Pr140(β^+)Ce140(n,2n)_ *Ce139*(n,2n)Ce138(n,2n)*Ce137*(n,2n)_ Ce136(n,2n)*Ce135*				54.2			
		&Pr141(n,2n)Pr140(β^+)Ce140(n,2n)_ Ce139(n,2n)Ce138(n,2n)Ce137m(n,2n)_ Ce136(n,2n)*Ce135*				36.6			
		Pr141(n,2n)Pr140(β^+)Ce140(n,3n)Ce138_ (n,3n)Ce136(n,2n)Ce135					55.8		
		Pr141(n,3n)Pr139(β^+)Ce139(n,2n)Ce138_ (n,3n)Ce136(n,2n)Ce135					12.3		
		&Pr141(n,d)Ce140(n,3n)Ce138(n,3n)_ Ce136(n,2n)*Ce135*					9.7		
	►	**&**Pr141(n,4n)Pr138m(β^+)Ce138(n,4n)*Ce135*						49.8	43.0

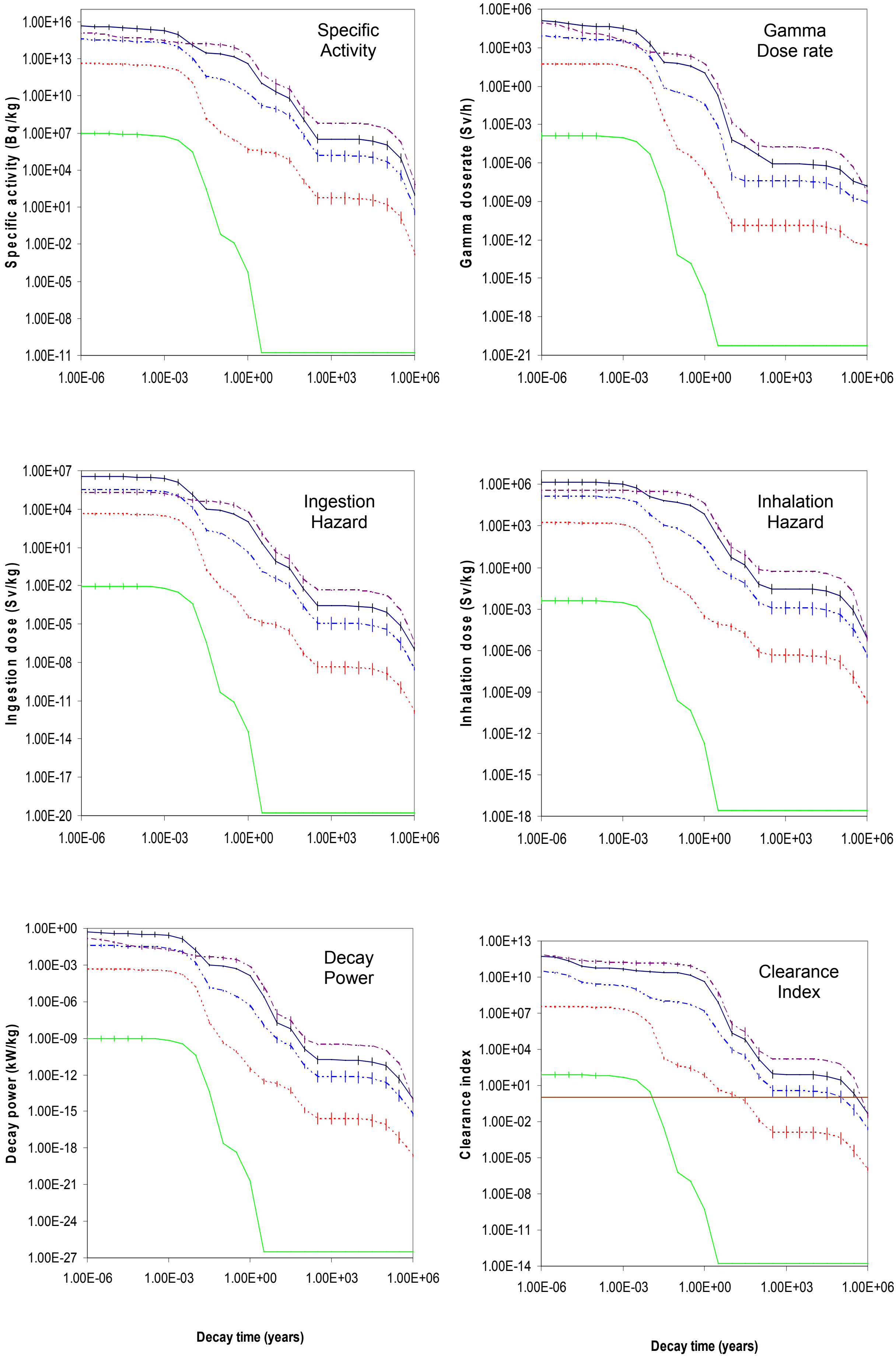
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Pr141(n,4n)Pr138(β^+)Ce138(n,4n)*Ce135*						32.0	22.5
		&Pr141(n,nt)Ce138(n,4n)*Ce135*						4.3	19.1
		Pr141(n,2n)Pr140(β^+)Ce140(n,3n)Ce138_ (n,4n)Ce135						3.3	0.6
		&Pr141(n,3n)Pr139(β^+)Ce139(n,5n)*Ce135*							7.3
Pr142	19.12 h	&Pr141(n,γ)*Pr142*	100.0	100.0	100.0	100.0	100.0	100.0	100.0
La140	1.679 d	&Pr141(n,γ)*Pr142*(β^-)Nd142(n,α)*Ce139*_ (β^+)La139(n,γ)La140	61.2		41.0				
		Pr141(n,α)La138(n,γ)La139(n,γ)La140	20.6	19.3	23.5				
		&Pr141(n,γ)*Pr142*(n,α)La139(n,γ)La140	17.0	80.3	35.3				
		Pr141(n,2n)Pr140(β^+)Ce140(n,p)La140				97.8	85.4	70.8	55.1
		Pr141(n,d)Ce140(n,p)La140				0.5	12.3	24.4	25.3
		Pr141(n,3n)Pr139(β^+)Ce139(β^+)La139(n,γ)La140					1.9	2.2	
		Pr141(n,2p)La140						2.0	17.7
Nd147	10.98 d	&Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147	99.7	88.0	93.7				
		&Pr141(n,γ)*Pr142*(n,γ)Pr143(β^-)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147	0.2	11.4	2.9				
Pr143	13.56 d	&Pr141(n,γ)*Pr142*(n,γ)Pr143	97.9	98.2	98.9	39.8	34.5	42.3	58.4
		&Pr141(n,γ)*Pr142*(β^+)Ce142(n,γ)Ce143_ (β^-)Pr143	1.7	1.8	1.1	3.7	2.7	3.3	4.3
		&Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,p)Pr143				55.6	62.0	53.6	36.7
Eu156	15.19 d	Very long pathways of (n,γ), β^-	100.0	100.0	100.0				
Ce141	32.5 d	&Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,α)Ce140(n,γ)Ce141	75.6	59.5	75.9				
		&Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,γ)Nd144(n,α)Ce141	21.5	21.6	21.6				
		&Pr141(n,γ)*Pr142*(n,α)La139(n,γ)La140_ (n,γ)La141(β^-)Ce141		10.3					
		&Pr141(n,γ)*Pr142*(n,γ)Pr143(β^-)Nd143_ (n,α)Ce140(n,γ)Ce141		4.4	1.5				
		Pr141(n,α)La138(n,γ)La139(n,γ)La140_ (n,γ)La141(β^-)Ce141		2.4					
		Pr141(n,p)Ce141				97.5	99.1	99.2	99.3
		Pr141(n,2n)Pr140(β^+)Ce140(n,γ)Ce141				1.9			
Xe127	36.40 d	Pathways involving (n,α), (n,nα), (n,2n), β^-,β^+				100.0	100.0	100.0	100.0
Pm148m	41.05 d	&Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147(n,γ)Pm148m	97.0	83.7	91.4				
		&Pr141(n,γ)*Pr142*(n,γ)Pr143(β^-)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147(n,γ)Pm148m	0.3	12.1	3.4				
Ce139	137.64 d	&Pr141(n,γ)*Pr142*(β^-)Nd142(n,α)*Ce139*	100.0	100.0	100.0				
		&Pr141(n,2n)Pr140(β^+)Ce140(n,2n)*Ce139*				99.3	3.9		
		Pr141(n,3n)Pr139(β^+)Ce139					93.6	90.1	72.4
		&Pr141(n,t)*Ce139*					1.8	8.0	25.6
Ce144	285.0 d	&Pr141(n,γ)*Pr142*(β^+)Ce142(n,γ)Ce143_ (n,γ)Ce144	92.3	100.0	100.0	87.7	85.9	89.7	94.8
		Pr141(n,p)Ce141(n,γ)Ce142(n,γ)Ce143_ (n,γ)Ce144				11.6	13.1	9.6	4.8
Cs134	2.065 y	&Pr141(n,α)La138(n,2n)La137(n,α)*Cs134*				13.9			
		&Pr141(n,α)La138(n,α)*Cs135*(n,2n)*Cs134*				11.4			
		&Pr141(n,2n)Pr140(β^+)Ce140(n,2n)_ *Ce139*(β^+)La139(n,2n)La138(n,nα)*Cs134*				9.9			
		Pr141(n,2n)Pr140(β^+)Ce140(n,2n)*Ce139*(β^+)_ La139(n,2n)La138(n,2n)La137(n,α)Cs134				8.6			
	►	&Pr141(n,nα)La137(n,α)*Cs134*				6.0	3.7	0.3	0.5

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Pr141(n,2n)Pr140(β^+)Ce140(n,2n)*Ce139*(β^+)_ La139(n,2n)La138(n,α)*Cs135*(n,2n)Cs134				5.7			
		&Pr141(n,2n)Pr140(β^+)Ce140(n,2n)_ *Ce139*(β^+)La139(n,nα)*Cs135*(n,2n)*Cs134*				5.2			
		&Pr141(n,α)La138(n,nα)*Cs134*				4.6	3.7	0.3	0.5
		Pr141(n,2n)Pr140(β^+)Ce140(n,2n)Ce139(n,2n)_ Ce138(n,2n)Ce137(β^+)La137(n,α)*Cs134*				2.0			
		Pr141(n,3n)Pr139(β^+)Ce139(β^+)La139_ (n,2n)La138(n,nα)Cs134					13.6	0.7	
		&Pr141(n,3n)Pr139(β^+)Ce139(β^+)La139_ (n,2nα)*Cs134*					10.6	56.5	19.6
		Pr141(n,3n)Pr139(β^+)Ce139(β^+)La139_ (n,3n)La137(n,α)Cs134					9.6	0.3	
		Pr141(n,3n)Pr139(β^+)Ce139(β^+)La139_ (n,nα)Cs135(n,2n)Cs134					5.8	0.4	
		&Pr141(n,nα)La137(n,3n)La135(β^+)_ Ba135(n,d)*Cs134*					3.9	0.4	
		&Pr141(n,2nα)*La136*(β^+)Ba136(n,t)*Cs134*						6.0	10.0
		&Pr141(n,t)*Ce139*(β^+)La139(n,2nα)*Cs134*						5.0	6.9
		&Pr141(n,3nα)La135(β^+)Ba135(n,d)*Cs134*						0.2	11.0
		&Pr141(n,5n)Pr137(β^+)Ce137(β^+)La137_ (n,α)Cs134							14.8
		Other pathways involving (n,2n), (n,α), β^+				32.7	49.1	29.9	36.7
Pm147	2.623 y	**&**Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147	99.7	87.1	96.3				
		&Pr141(n,γ)*Pr142*(n,γ)Pr143(β^-)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147	0.3	12.2	3.4				
Eu154	8.593 y	Very long pathways of (n,γ), β^-	100.0	100.0	100.0				
Ba133	10.54 y	**&**Pr141(n,nα)La137(n,2n)La136(β^+)*Ba136*_ (n,2n)*Ba135*(n,2n)Ba134(n,2n)*Ba133*				6.1			
		&Pr141(n,2n)Pr140(β^+)Ce140(n,2n)*Ce139*_ (n,2n)Ce138(n,nα)Ba134(n,2n)*Ba133*				3.6			
		&Pr141(n,α)La138(n,2n)La137(n,α)_ *Cs134*(β^-)Ba134(n,2n)*Ba133*				2.3			
		&Pr141(n,nα)La137(n,3n)La135(β^+)_ Ba135(n,3n)*Ba133*					18.9	0.6	
		&Pr141(n,3n)Pr139(β^+)Ce139(n,nα)_ *Ba135*(n,3n)*Ba133*					3.6	0.1	
		&Pr141(n,2nα)*La136*(β^+)Ba136(n,4n)*Ba133*						18.4	1.8
		&Pr141(n,4n)Pr138m(β^+)Ce138(n,2nα)*Ba133*						6.4	1.4
		&Pr141(n,4n)Pr138(β^+)Ce138(n,2nα)*Ba133*						4.2	0.7
		Pr141(n,5n)Pr137(β^+)Ce137(β^+)La137_ (n,5n)La133(β^+)Ba133							64.3
		&Pr141(n,2nt)*Ce137*(β^+)La137(n,5n)_ La133(β^+)Ba133							6.3
		&Pr141(n,5n)Pr137(β^+)Ce137(β^+)La137_ (n,2nt)*Ba133*							6.1
		Pr141(n,nα)La137(n,5n)La133(β^+)Ba133							2.0
		Other pathways involving (n,2n), (n,α), β^+				88.0	77.5	70.3	17.4
H3	12.33 y	**&**Pr141(n,γ)*Pr142*(n,X)H1(n,γ)H2(n,γ)H3	100.0	100.0					
		Pr141(n,X)H3				99.3	92.5	90.1	89.4
Eu152	13.525 y	Very long pathways of (n,γ), β^-	100.0	100.0					
Cs137	30.041 y	**&**Pr141(n,γ)*Pr142*(β^-)Nd142(n,α)*Ce139*_ (β^+)La139(n,γ)La140(n,α)Cs137	54.2		25.0				
		&Pr141(n,γ)*Pr142*(n,α)La139(n,γ)La140_ (n,α)Cs137	22.9	0.8	35.0				
	►	Pr141(n,α)La138(n,γ)La139(n,γ)La140_ (n,α)Cs137	21.2	0.2	15.7				

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Pr141(n,α)La138(n,α)*Cs135*(n,γ)_ *Cs136*(n,γ)Cs137	1.6	99.0	24.1				
		&Pr141(n,2n)Pr140(β^+)Ce140(n,α)_ *Ba137*(n,p)Cs137				98.3	2.2		
		Pr141(n,3n)Pr139(β^+)Ce139(β^+)La139_ (n,d)Ba138(n,d)Cs137					60.0	21.7	12.6
		Pr141(n,3n)Pr139(β^+)Ce139(β^+)La139(n,h)Cs137					29.0	66.0	57.9
		&Pr141(n,t)*Ce139*(β^+)La139(n,d)Ba138_ (n,d)Cs137					1.1	1.9	4.5
		&Pr141(n,t)*Ce139*(β^+)La139(n,h)Cs137					0.5	5.8	20.4
Sm151	90.0 y	&Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147(n,γ)Pm148(n,γ)Pm149_ (β^-)Sm149(n,γ)Sm150(n,γ)Sm151	13.4	1.2	3.1				
		&Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(n,γ)Nd148(n,γ)Nd149(β^-)Pm149_ (β^-)Sm149(n,γ)Sm150(n,γ)Sm151	1.0	10.5	0.8				
		&Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147(β^-)Sm147(n,γ)Sm148_ (n,γ)Sm149(n,γ)Sm150(n,γ)Sm151	0.2	3.4	4.4				
		&Pr141(n,γ)*Pr142*(n,γ)Pr143(β^-)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147(β^-)Sm147(n,γ)Sm148_ (n,γ)Sm149(n,γ)Sm150(n,γ)Sm151		0.8	0.3				
		Other long pathways of (n,γ), β^-	85.4	84.1	91.4				
Ho166m	1200.0 y	Very long pathways of (n,γ), β^-	100.0						
La137	$6.0\ 10^4$ y	&Pr141(n,2n)Pr140(β^+)Ce140(n,2n)_ *Ce139*(β^+)La139(n,2n)La138(n,2n)La137				46.5			
		Pr141(n,α)La138(n,2n)La137				22.5	0.1		
		&Pr141(n,2n)Pr140(β^+)Ce140(n,2n)_ *Ce139*(n,2n)Ce138(n,2n)*Ce137*(β^+)La137				16.5			
		Pr141(n,nα)La137				7.3	12.6	18.2	2.6
		Pr141(n,3n)Pr139(β^+)Ce139(β^+)La139_ (n,3n)La137					65.6	35.6	
		&Pr141(n,3n)Pr139(β^+)Ce139(n,3n)_ *Ce137*(β^+)La137					15.3	8.8	
		&Pr141(n,t)*Ce139*(β^+)La139(n,3n)La137					1.3	3.1	
		&Pr141(n,2n)Pr140(β^+)Ce140(n,4n)_ *Ce137*(β^+)La137						12.4	
		&Pr141(n,4n)Pr138m(β^+)Ce138(n,2n)_ *Ce137*(β^+)La137						5.6	
		&Pr141(n,d)Ce140(n,4n)*Ce137*(β^+)La137						4.3	
		&Pr141(n,4n)Pr138(β^+)Ce138(n,2n)_ *Ce137*(β^+)La137						3.6	
		&Pr141(n,2nt)Ce137(β^+)La137						0.4	8.2
		Pr141(n,5n)Pr137(β^+)Ce137(β^+)La137							82.9
Cs135	$2.3\ 10^6$ y	&Pr141(n,α)La138(n,α)*Cs135*	100.0	100.0	100.0	25.5			0.5
		&Pr141(n,2n)Pr140(β^+)Ce140(n,2n)_ *Ce139*(β^+)La139(n,2n)La138(n,α)*Cs135*				51.7			
		&Pr141(n,2n)Pr140(β^+)Ce140(n,2n)_ *Ce139*(β^+)La139(n,nα)*Cs135*				17.5	0.4		
		&Pr141(n,2n)Pr140(β^+)Ce140(n,2n)_ *Ce139*(β^+)La139(n,α)*Cs136*(n,2n)*Cs135*				2.5			
		&Pr141(n,3n)Pr139(β^+)Ce139(β^+)La139_ (n,nα)*Cs135*					92.3	63.6	30.6
		&Pr141(n,t)*Ce139*(β^+)La139(n,nα)*Cs135*					1.7	5.5	10.9
		&Pr141(n,2nα)*La136*(β^+)Ba136(n,d)*Cs135*					0.1	8.3	20.2
	►	&Pr141(n,5n)Pr137(β^+)Ce137(β^+)La137_ (n,h)*Cs135*							9.5

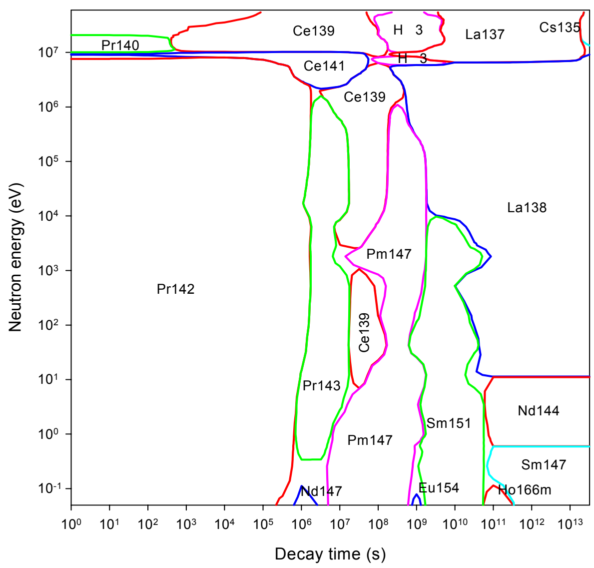
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Pr141(n,3nα)La135(β^+)Ba135(n,p)*Cs135*							1.4
La138	1.0 10^{11} y	Pr141(n,α)La138	100.0	100.0	100.0	18.1	9.1	8.8	45.3
		&Pr141(n,2n)Pr140(β^+)Ce140(n,2n)_ *Ce139*(β^+)La139(n,2n)La138				80.9			
		&Pr141(n,t)*Ce139*(β^+)La139(n,2n)La138				0.2	1.6	6.1	8.7
		Pr141(n,3n)Pr139(β^+)Ce139(β^+)La139_ (n,2n)La138					83.4	69.0	24.8
		Pr141(n,3n)Pr139(β^+)Ce139(n,d)La138					2.9	5.2	2.6
		Pr141(n,2n)Pr140(β^+)Ce140(n,t)La138					0.8	5.6	10.1
		Pr141(n,d)Ce140(n,t)La138					0.1	1.9	4.6
		Pr141(n,4n)Pr138m(β^+)Ce138(n,p)La138						1.1	1.2
Sm147	1.1 10^{11} y	**&**Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147(β^-)Sm147	99.6	86.2	95.7				
		&Pr141(n,γ)*Pr142*(n,γ)Pr143(β^-)Nd143_ (n,γ)Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147(β^-)Sm147	0.3	13.1	4.0				
Nd144	2.3 10^{15} y	**&**Pr141(n,γ)*Pr142*(β^-)Nd142(n,γ)Nd143_ (n,γ)Nd144	99.8	92.9	98.1	99.6	99.4	99.5	99.6
		&Pr141(n,γ)*Pr142*(n,γ)Pr143(β^-)Nd143_ (n,γ)Nd144	0.1	6.7	1.8	0.1	0.1	0.2	0.2

Praseodymium activation characteristics

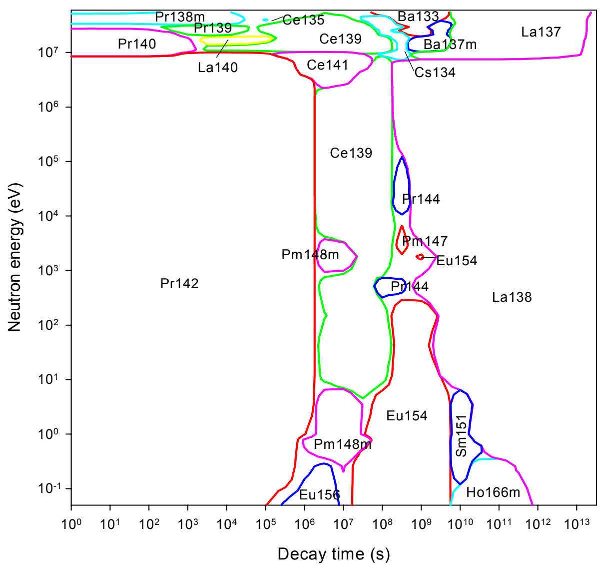


Praseodymium importance diagrams & transmutation

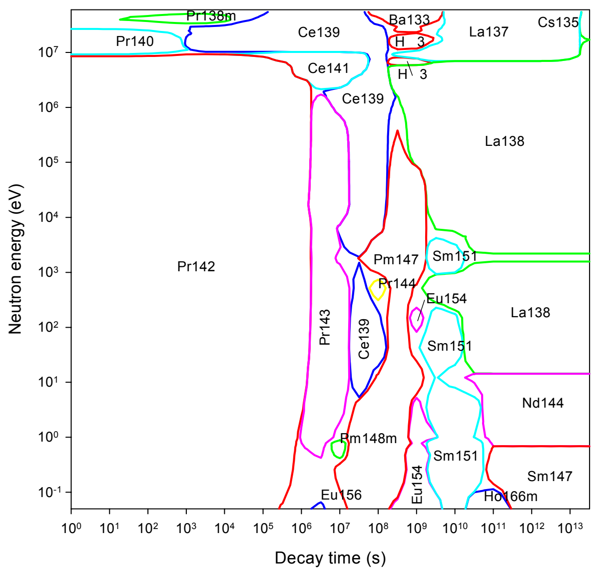
Activity



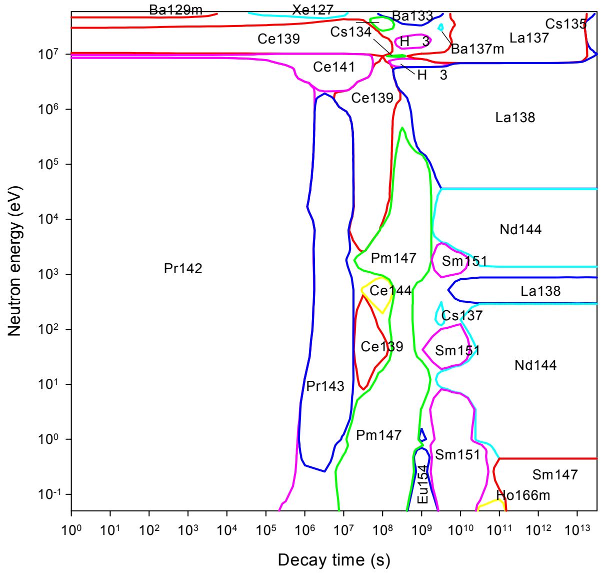
Dose rate



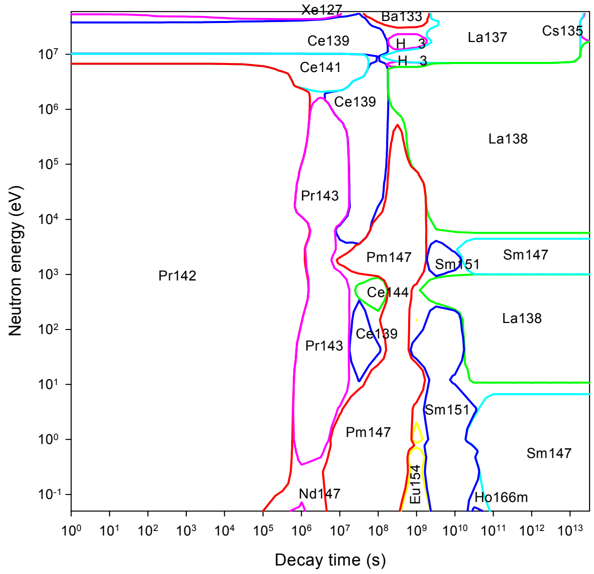
Heat output



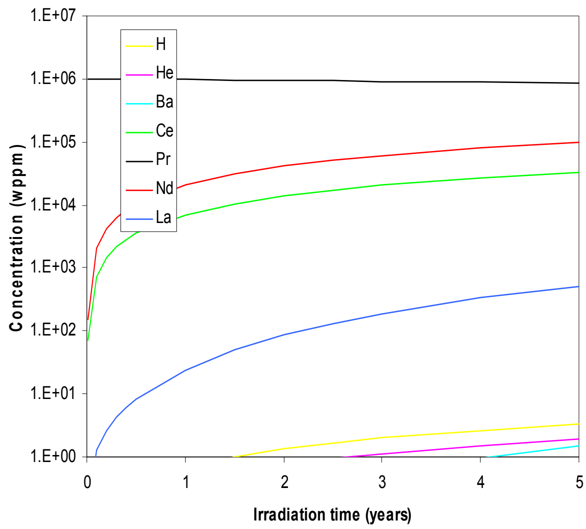
Ingestion dose



Inhalation dose



First wall transmutation



Neodymium

General properties

Property	Value	Isotopes	Isotopic abundances / %
Atomic number	60		
Crustal abundance / wppm	41.5	Nd142	27.2
Melting point / K	1289	Nd143	12.2
Boiling point / K	3339	Nd144	23.8 ($T_{1/2}$ = 2.29 10^{15} y)
Density / kgm^{-3}	7008	Nd145	8.3
Thermal conductivity / $Wm^{-1}K^{-1}$	16.5	Nd146	17.2
Electrical resistivity /Ωm	6.4 10^{-7}	Nd148	5.7 ($T_{1/2}$ = 2.70 10^{18} y)
Coefficient of thermal expansion / K^{-1}	9.6 10^{-6}	Nd150	5.6 ($T_{1/2}$ = 2.10 10^{19} y)
Crystal structure	Hexagonal		
Number of stable isotopes	4 (7)		
Mean atomic weight	144.24		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.71E15	1.57E15	4.70E14	5.49E13	8.81E11	3.17E4
Nd141	15.39	16.39				
Pm149	13.34	14.53	15.93			
Nd149	12.79	13.45				
Sm153	12.14	13.20	11.88			
Nd147	9.71	10.57	28.04			
Nd151	7.51	6.10				
Pm151	7.50	8.17	3.24			
Nd141m	5.04	0.16				
Pm148	3.99	4.34	9.23	0.01		
Pm148m	2.78	3.03	9.50	0.18		
Eu156	2.38	2.59	7.33			
Pm147	2.37	2.58	8.66	59.21		
Pr142	1.69	1.84	0.26			
Eu154	0.70	0.76	2.53	19.99	0.42	
Eu155	0.61	0.67	2.23	16.49		
Pr142m	0.61	0.52				
Sm151	0.11	0.12	0.40	3.43	99.48	
Sm146						43.04
La137						41.25
Gd150						10.85
Sm147						4.82

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	1.77E-1	1.55E-1	5.52E-2	3.25E-3	3.87E-6	7.80E-12
Nd149	17.24	18.98				
Nd151	16.82	14.31				
Pm148m	9.25	10.55	27.91	1.06		
Pm148	8.03	9.15	16.39	0.03		
Pm149	7.80	8.89	8.21			
Pm151	7.31	8.33	2.78			
Nd141m	6.83	0.23				
Eu156	6.19	7.06	16.82			
Sm153	6.19	7.04	5.34			
Nd147	6.10	6.96	15.55			
Pr142	2.27	2.59	0.31			
Nd141	2.13	2.37				
Eu154	1.63	1.86	5.24	82.09	23.49	
Pm147	0.23	0.26	0.73	9.92		
Eu155	0.12	0.13	0.38	5.54		
Eu152			0.05	0.76	4.02	
Sm151			0.01	0.18	72.26	
Sm146						72.07
Gd150						19.76
Sm147						7.26
La137						0.86

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	1.07E5	8.52E4	4.27E4	3.52E3	1.38E0	3.47E-9
Nd151	21.55	20.27				
Pm148m	17.31	21.83	40.94	1.11		
Nd141m	14.70	0.54				
Eu156	13.38	16.87	28.50			
Pm148	9.67*	12.19*	15.49*	0.02		
Nd149	7.95	9.68				
Pm151	4.68	5.90	1.40			
Eu154	3.46	4.37	8.71	97.56	84.35	
Nd141	2.53	3.12				
Nd147	2.23	2.81	4.45			
Pr140	0.72	0.31				
Pm150	0.48	0.59				
Eu152	0.03	0.04	0.08	0.94	14.93	
Eu150					0.66	
La137						94.20
La138						5.80

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.12E6	1.12E6	5.82E5	3.39E4	9.45E1	9.93E04
Pm149	20.11	20.16	12.73			
Pm148	16.38	16.41	20.11	0.04		
Nd147	16.26	16.29	24.88			
Sm153	13.67	13.69	7.09			
Pm151	8.34	8.36	1.91			
Eu156	7.97	7.99	13.00			
Pm148m	7.19	7.21	13.03	0.50		
Pr142	3.35	3.35	0.27			
Nd149	2.34	2.26				
Eu154	2.12	2.12	4.08	64.66	7.89	
Pm147	0.94	0.94	1.82	24.90		
Eu155	0.30	0.30	0.57	8.53		
Sm151			0.03	0.54	90.93	
Sm146						74.25
Gd150						18.02
Sm147						7.55

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y	Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	2.28E6	2.28E6	1.81E6	8.21E5	3.74E3	4.51E-1		5.94E11	4.90E11	3.01E11	1.20E11	4.58E7	2.10E0
Eu154	27.61	27.63	34.79	70.81	5.29		Eu154	19.99	24.25	39.44	91.13	81.48	
Nd147	17.44	17.45	17.47				Nd151	19.61	17.74				
Pm148m	11.85	11.86	14.06	0.07			Pm148m	15.97	19.36	29.64	0.17		
Pm147	8.85	8.86	11.24	19.79			Nd141m	12.08	0.43				
Pm149	7.29	7.30	3.02				Eu156	8.77	10.63	14.65			
Pm148	6.56	6.57	5.27				Pm151	7.70	9.34	1.80			
Eu156	6.06	6.06	6.47				Pm148	7.64	9.25	9.60			
Sm153	5.72	5.72	1.94				Nd141	3.40	4.04				
Eu155	3.16	3.17	3.99	7.60			Nd149	0.37	0.43				
Pm151	2.58	2.59	0.39				Sm153	0.35	0.42	0.19			
Nd149	0.85	0.82					Nd147	0.28	0.34	0.44			
Pr142	0.70	0.70	0.04				Eu152	0.21	0.26	0.42	1.00	16.48	
Sm151	0.33	0.33	0.42	0.92	93.80		Pm149		0.05	0.03			
Ce141	0.27	0.27	0.32				Sm151					1.92	
Eu152	0.23	0.23	0.29	0.62	0.85		Eu150					0.12	
Pr143	0.11	0.11	0.12				Sm147						72.68
Gd150					0.01	63.39	La137						16.37
Sm146						33.33	Gd150						6.82
Sm147						3.26	Sm146						3.61

Neodymium

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Nd141m	1.033 m	Nd142(n,2n)Nd141m				85.7	42.1	15.2	16.6
		Nd143(n,2n)Nd142(n,2n)Nd141m				10.9	1.7	0.4	0.3
		Nd144(n,2n)Nd143(n,2n)Nd142(n,2n)Nd141m				2.9			
		Nd143(n,3n)Nd141m					33.9	21.7	10.9
		Nd144(n,3n)Nd142(n,2n)Nd141m					8.0	1.2	0.6
		Nd144(n,2n)Nd143(n,3n)Nd141m					4.4	2.0	0.6
		Nd145(n,3n)Nd143(n,3n)Nd141m					4.1	0.8	0.2
		Nd146(n,4n)Nd143(n,3n)Nd141m					1.8	4.2	0.6
		Nd144(n,4n)Nd141m						47.0	27.5
		Nd145(n,5n)Nd141m						0.4	17.8
		Nd146(n,6n)Nd141m							16.4
Ba137m	2.552 m	Nd142(n,α)Ce139(n,α)Ba136(n,γ)_ Ba137m	75.7						
		Nd142(n,γ)Nd143(n,α)Ce140(n,α)_ Ba137m	10.8						
		Nd143(n,α)Ce140(n,α)Ba137m	8.1						
		Nd142(n,α)Ce139(β$^+$)La139(n,γ)La140_ (n,α)Cs137(β$^-$)Ba137m	4.7						
		Other pathways involving (n,α), (n,nα), (n,2n), β$^-$,β$^+$	0.1			100.0	100.0	100.0	100.0
Pr140	3.39 m	&Nd142(n,2n)*Nd141*(β$^+$)Pr141(n,2n)Pr140				90.4	2.2	0.7	0.6
		&Nd143(n,2n)Nd142(n,2n)*Nd141*(β$^+$)_ Pr141(n,2n)Pr140				5.8			
		Nd142(n,3n)Nd140(β$^+$)Pr140					69.0	57.2	20.3
		Nd144(n,3n)Nd142(n,3n)Nd140(β$^+$)Pr140					12.4	4.4	0.8
		Nd143(n,2n)Nd142(n,3n)Nd140(β$^+$)Pr140					2.7	1.3	0.3
		Nd142(n,t)Pr140					0.9	4.7	8.2
		Nd145(n,4n)Nd142(n,3n)Nd140(β$^+$)Pr140					0.8	2.5	0.3
		Nd143(n,4n)Nd140(β$^+$)Pr140						15.7	12.5
		Nd146(n,4n)Nd143(n,4n)Nd140(β$^+$)Pr140						2.8	0.6
		Nd143(n,nt)Pr140						0.6	3.5
		Nd144(n,5n)Nd140(β$^+$)Pr140							34.8
		Nd144(n,2nt)Pr140							3.2
		Nd145(n,6n)Nd140(β$^+$)Pr140							2.9
Nd151	12.44 m	Nd150(n,γ)Nd151	100.0	100.0	100.0	100.0	99.7	99.7	99.9
Nd149	1.728 h	Nd148(n,γ)Nd149	95.3	97.6	100.0		0.2	0.2	0.1
		Nd146(n,γ)Nd147(n,γ)Nd148(n,γ)Nd149	3.4	1.7					
		Nd145(n,γ)Nd146(n,γ)Nd147(n,γ)_ Nd148(n,γ)Nd149	1.0	0.6					
		Nd150(n,2n)Nd149				99.9	92.4	85.0	78.6
		Nd150(n,d)Pr149(β$^-$)Nd149						14.8	21.3
Nd141	2.49 h	&Nd142(n,2n)*Nd141*				86.7	47.7	26.2	25.8
		&Nd143(n,2n)Nd142(n,2n)*Nd141*				10.7	1.9	0.6	0.4
		&Nd144(n,2n)Nd143(n,2n)Nd142(n,2n)*Nd141*				2.6			
		&Nd143(n,3n)*Nd141*					29.9	17.7	10.8
		&Nd144(n,3n)Nd142(n,2n)*Nd141*					8.6	2.1	0.9
		&Nd144(n,2n)Nd143(n,3n)*Nd141*					3.7	1.4	0.6
		&Nd145(n,3n)Nd143(n,3n)*Nd141*					3.5	0.5	0.1
		&Nd146(n,4n)Nd143(n,3n)*Nd141*					1.5	3.2	0.5
		&Nd144(n,4n)*Nd141*					0.1	42.1	26.3
		&Nd145(n,5n)*Nd141*						0.5	15.2
		&Nd146(n,6n)*Nd141*							12.2
Nd139m	5.50 h	&Nd142(n,2n)*Nd141*(n,2n)Nd140_ (n,2n)Nd139m				85.8			
	►	&Nd143(n,2n)Nd142(n,2n)*Nd141*_ (n,2n)Nd140(n,2n)Nd139m				10.9			

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Nd144(n,2n)Nd143(n,2n)Nd142_ (n,2n)*Nd141*(n,2n)Nd140(n,2n)Nd139m				2.8			
		Nd142(n,3n)Nd140(n,2n)Nd139m					74.5		
		Nd144(n,3n)Nd142(n,3n)Nd140(n,2n)Nd139m					14.1		
		Nd143(n,2n)Nd142(n,3n)Nd140(n,2n)Nd139m					3.1		
		&Nd142(n,2n)*Nd141*(n,3n)Nd139m					2.2		
		Nd142(n,4n)Nd139m						83.1	59.3
		Nd144(n,3n)Nd142(n,4n)Nd139m						6.7	2.2
		Nd145(n,4n)Nd142(n,4n)Nd139m						3.9	0.9
		Nd143(n,2n)Nd142(n,4n)Nd139m						2.1	0.9
		Nd146(n,5n)Nd142(n,4n)Nd139m						1.2	3.4
		Nd143(n,5n)Nd139m							23.7
		Nd144(n,6n)Nd139m							2.0
Nd140	3.37 d	&Nd142(n,2n)*Nd141*(n,2n)Nd140				88.4			
		&Nd143(n,2n)Nd142(n,2n)*Nd141*(n,2n)Nd140				10.2			
		Nd144(n,2n)Nd143(n,2n)Nd142(n,2n)_ Nd141(n,2n)Nd140				1.4			
		Nd142(n,3n)Nd140					77.9	63.5	25.5
		Nd144(n,3n)Nd142(n,3n)Nd140					14.8	5.1	1.0
		Nd143(n,2n)Nd142(n,3n)Nd140					3.2	1.6	0.4
		Nd145(n,4n)Nd142(n,3n)Nd140					0.9	3.0	0.4
		Nd143(n,4n)Nd140						17.1	15.7
		Nd146(n,4n)Nd143(n,4n)Nd140						3.3	0.8
		Nd144(n,2n)Nd143(n,4n)Nd140						1.6	0.9
		Nd146(n,5n)Nd142(n,3n)Nd140						0.9	1.5
		Nd144(n,5n)Nd140							43.8
		Nd145(n,6n)Nd140							3.6
		Nd146(n,3n)Nd144(n,5n)Nd140							1.1
Nd147	10.98 d	Nd146(n,γ)Nd147	58.8	71.1	97.3	0.2	0.2		
		Nd145(n,γ)Nd146(n,γ)Nd147	25.8	28.3	2.6				
		Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)Nd147	8.8	0.4					
		Nd143(n,γ)Nd144(n,γ)Nd145(n,γ)_ Nd146(n,γ)Nd147	4.1	0.2					
		Nd142(n,γ)Nd143(n,γ)Nd144(n,γ)_ Nd145(n,γ)Nd146(n,γ)Nd147	2.6						
		Nd148(n,2n)Nd147				96.1	31.9	28.4	36.3
		Nd150(n,3n)Nd148(n,2n)Nd147				3.6			
		Nd150(n,4n)Nd147					60.3	62.0	37.9
		Nd150(n,nt)Pr147(β^-)Nd147							13.5
		Nd148(n,d)Pr147(β^-)Nd147							12.1
Eu156	15.19 d	&Nd148(n,γ)Nd149(β^-)Pm149(β^-)_ Sm149(n,γ)Sm150(n,γ)Sm151(n,γ)_ Sm152(n,γ)Sm153(β^-)Eu153(n,γ)*Eu154*_ (n,γ)Eu155(n,γ)Eu156	31.3	99.5					
		&Nd150(n,γ)Nd151(β^-)Pm151(β^-)_ Sm151(n,γ)Sm152(n,γ)Sm153(β^-)_ Eu153(n,γ)*Eu154*(n,γ)Eu155(n,γ)Eu156	18.6	0.3	94.7				
		&Nd146(n,γ)Nd147(β^-)Pm147(n,γ)_ Pm148m(n,γ)Pm149(β^-)Sm149(n,γ)_ Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)_ Sm153(β^-)Eu153(n,γ)*Eu154*(n,γ)Eu155_ (n,γ)Eu156	18.0						
		&Nd148(n,γ)Nd149(β^-)Pm149(n,γ)_ Pm150(β^-)Sm150(n,γ)Sm151(n,γ)_ Sm152(n,γ)Sm153(β^-)Eu153(n,γ)*Eu154*_ (n,γ)Eu155(n,γ)Eu156	7.1						
	►	&Nd145(n,γ)Nd146(n,γ)Nd147(β^-)_ Pm147(n,γ)Pm148m(n,γ)Pm149(β^-)_ Sm149(n,γ)Sm150(n,γ)Sm151(n,γ)_ Sm152(n,γ)Sm153(β^-)Eu153(n,γ)*Eu154*_ (n,γ)Eu155(n,γ)Eu156	5.7						

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Nd146(n,γ)Nd147(β$^-$)Pm147(n,γ)_ Pm148m(n,γ)Pm149(n,γ)Pm150(β$^-$)_ Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)_ Sm153(β$^-$)Eu153(n,γ)*Eu154*(n,γ)Eu155_ (n,γ)Eu156	4.1						
		&Nd146(n,γ)Nd147(β$^-$)Pm147(n,γ)_ Pm148(n,γ)Pm149(β$^-$)Sm149(n,γ)_ Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)_ Sm153(β$^-$)Eu153(n,γ)*Eu154*(n,γ)Eu155_ (n,γ)Eu156	4.0						
		&Nd150(n,γ)Nd151(β$^-$)Pm151(β$^-$)_ Sm151(β$^-$)Eu151(n,γ)Eu152(n,γ)Eu153_ (n,γ)*Eu154*(n,γ)Eu155(n,γ)Eu156			4.8				
Xe127	36.40 d	Pathways involving (n,α), (n,nα), (n,2n), β$^-$,β$^+$				100.0	100.0	100.0	100.0
Pm148m	41.05 d	Nd146(n,γ)Nd147(β$^-$)Pm147(n,γ)Pm148m	60.8	72.3	98.4				
		Nd145(n,γ)Nd146(n,γ)Nd147(β$^-$)Pm147_ (n,γ)Pm148m	25.7	27.3	1.6				
		Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β$^-$)Pm147(n,γ)Pm148m	7.8	0.3					
		Nd143(n,γ)Nd144(n,γ)Nd145(n,γ)Nd146_ (n,γ)Nd147(β$^-$)Pm147(n,γ)Pm148m	3.6	0.1					
		Nd142(n,γ)Nd143(n,γ)Nd144(n,γ)_ Nd145(n,γ)Nd146(n,γ)Nd147(β$^-$)Pm147_ (n,γ)Pm148m	2.1						
		Nd150(n,2n)Nd149(β$^-$)Pm149(n,2n)Pm148m				37.6	0.8	0.5	0.3
		Nd150(n,2n)Nd149(β$^-$)Pm149(β$^-$)_ Sm149(n,2n)Sm148(n,p)Pm148m				37.4	2.5	1.0	0.4
		Nd150(n,2n)Nd149(β$^-$)Pm149(β$^-$)_ Sm149(n,d)Pm148m				15.3	86.0	81.7	77.6
		Nd148(n,2n)Nd147(β$^-$)Pm147(n,γ)Pm148m				9.1	1.0	0.5	0.4
		Nd150(n,d)Pr149(β$^-$)Nd149(β$^-$)Pm149_ (β$^-$)Sm149(n,d)Pm148m					6.6	14.0	19.6
		Nd150(n,4n)Nd147(β$^-$)Pm147(n,γ)Pm148m					1.8	1.1	0.4
Ta182	114.7 d	Very long pathways of (n,γ), β$^-$	100.0						
Ce139	137.64 d	&Nd142(n,α)*Ce139*	100.0	100.0	99.9	10.2	2.2	0.7	0.8
		&Nd142(n,2n)*Nd141*(β$^+$)Pr141(n,2n)_ Pr140(β$^+$)Ce140(n,2n)*Ce139*				79.3			
		&Nd143(n,2n)Nd142(n,2n)*Nd141*(β$^+$)_ Pr141(n,2n)Pr140(β$^+$)Ce140(n,2n)*Ce139*				2.6			
		&Nd143(n,2n)Nd142(n,α)*Ce139*				1.2			
		&Nd143(n,nα)*Ce139*				0.6	3.4	1.9	0.7
		&Nd142(n,2n)*Nd141*(β$^+$)Pr141(n,2n)_ Pr140(β$^+$)Ce140(n,2n)*Ce139*					28.6		
		&Nd143(n,3n)*Nd141*(β$^+$)Pr141(n,3n)_ Pr139(β$^+$)Ce139					20.6	5.8	0.5
		&Nd142(n,2n)*Nd141*(β$^+$)Pr141(n,3n)_ Pr139(β$^+$)Ce139					19.8	3.5	0.4
		&Nd142(n,3n)Nd140(β$^+$)Pr140(β$^+$)_ Ce140(n,2n)*Ce139*					18.1	6.6	0.8
		Nd142(n,2n)Nd141(β$^+$)Pr141(n,3n)_ Pr139(β$^+$)Ce139					12.6	5.3	0.7
		Nd142(n,d)Pr141(n,3n)Pr139(β$^+$)Ce139					3.4	2.3	0.4
		&Nd144(n,2nα)*Ce139*					0.5	2.7	1.4
		Nd142(n,4n)Nd139m(β$^+$)Pr139(β$^+$)Ce139						21.5	31.6
		&Nd144(n,4n)*Nd141*(β$^+$)Pr141(n,3n)_ Pr139(β$^+$)Ce139						13.9	1.1
		&Nd142(n,4n)*Nd139*(β$^+$)Pr139(β$^+$)Ce139						13.3	9.7
		Nd142(n,nt)Pr139(β$^+$)Ce139						1.8	10.7
		Nd143(n,5n)Nd139m(β$^+$)Pr139(β$^+$)Ce139							12.6
	►	Nd143(n,5n)Nd139(β$^+$)Pr139(β$^+$)Ce139							4.3

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Nd143(n,2nt)Pr139(β^+)Ce139							2.0
Pm144	363.0 d	Nd148(n,2n)Nd147(β^-)Pm147(n,2n)_ Pm146(n,2n)Pm145(n,2n)Pm144				72.9			
		Nd148(n,2n)Nd147(β^-)Pm147(β^-)_ Sm147(n,2n)Sm146(n,2n)Sm145(β^+)_ Pm145(n,2n)Pm144				10.5			
		Nd148(n,2n)Nd147(β^-)Pm147(n,3n)_ Pm145(n,2n)Pm144				8.7	4.0	0.2	0.3
		Nd148(n,2n)Nd147(β^-)Pm147(n,2n)_ Pm146(n,3n)Pm144				4.8	2.9	0.2	0.2
		Nd148(n,2n)Nd147(β^-)Pm147(n,2n)_ Pm146(β^-)Sm146(n,2n)Sm145(β^+)_ Pm145(n,2n)Pm144				1.5			
		Nd150(n,4n)Nd147(β^-)Pm147(n,4n)Pm144					44.9	59.2	27.3
		Nd148(n,2n)Nd147(β^-)Pm147(n,4n)Pm144					24.1	27.2	26.1
		Nd150(n,4n)Nd147(β^-)Pm147(n,3n)_ Pm145(n,2n)Pm144					7.4	0.4	0.3
		Nd150(n,4n)Nd147(β^-)Pm147(n,2n)_ Pm146(n,3n)Pm144					5.5	0.3	0.2
		Nd150(n,3n)Nd148(n,2n)Nd147(β^-)_ Pm147(n,4n)Pm144					1.0	0.4	0.2
		Nd148(n,d)Pr147(β^-)Nd147(β^-)Pm147_ (n,4n)Pm144						5.9	8.1
		Nd150(n,nt)Pr147(β^-)Nd147(β^-)Pm147_ (n,4n)Pm144						1.5	9.1
		Nd150(n,4n)Nd147(β^-)Pm147(β^-)_ Sm147(n,nt)Pm144						1.4	7.2
		Nd148(n,2n)Nd147(β^-)Pm147(β^-)_ Sm147(n,nt)Pm144						0.6	6.9
		Nd148(n,d)Pr147(β^-)Nd147(β^-)Pm147_ (β^-)Sm147(n,nt)Pm144						0.1	2.1
		Nd150(n,2n)Nd149(β^-)Pm149(β^-)_ Sm149(n,3nt)Pm144							3.2
		Nd150(n,nt)Pr147(β^-)Nd147(β^-)Pm147_ (β^-)Sm147(n,nt)Pm144							2.4
Pm147	2.623 y	Nd146(n,γ)Nd147(β^-)Pm147	60.8	72.1	98.3	0.2	0.2		0.2
		Nd145(n,γ)Nd146(n,γ)Nd147(β^-)Pm147	25.7	27.5	1.6				
		Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147	7.8	0.3					
		Nd143(n,γ)Nd144(n,γ)Nd145(n,γ)_ Nd146(n,γ)Nd147(β^-)Pm147	3.6	0.1					
		Nd142(n,γ)Nd143(n,γ)Nd144(n,γ)_ Nd145(n,γ)Nd146(n,γ)Nd147(β^-)Pm147	2.1						
		Nd148(n,2n)Nd147(β^-)Pm147				97.5	32.5	28.5	36.3
		Nd150(n,3n)Nd148(n,2n)Nd147(β^-)Pm147				2.2			0.4
		Nd150(n,4n)Nd147(β^-)Pm147					60.9	62.2	37.9
		Nd150(n,nt)Pr147(β^-)Nd147(β^-)Pm147							12.6
		Nd148(n,d)Pr147(β^-)Nd147(β^-)Pm147							11.3
Eu155	4.753 y	**&**Nd148(n,γ)Nd149(β^-)Pm149(β^-)_ Sm149(n,γ)Sm150(n,γ)Sm151(n,γ)_ Sm152(n,γ)Sm153(β^-)Eu153(n,γ)*Eu154*_ (n,γ)Eu155	31.2	99.5					
		&Nd150(n,γ)Nd151(β^-)Pm151(β^-)_ Sm151(n,γ)Sm152(n,γ)Sm153(β^-)_ Eu153(n,γ)*Eu154*(n,γ)Eu155	18.5	0.3	94.7	98.6	89.0	97.1	
	►	**&**Nd146(n,γ)Nd147(β^-)Pm147(n,γ)_ Pm148m(n,γ)Pm149(β^-)Sm149(n,γ)_ Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)_ Sm153(β^-)Eu153(n,γ)*Eu154*(n,γ)Eu155	18.0						

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Nd148(n,γ)Nd149(β^-)Pm149(n,γ)_ Pm150(β^-)Sm150(n,γ)Sm151(n,γ)_ Sm152(n,γ)Sm153(β^-)Eu153(n,γ)*Eu154*_ (n,γ)Eu155	7.0						
		&Nd145(n,γ)Nd146(n,γ)Nd147(β^-)Pm147_ (n,γ)Pm148m(n,γ)Pm149(β^-)Sm149(n,γ)_ Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)Sm153_ (β^-)Eu153(n,γ)*Eu154*(n,γ)Eu155	5.7						
		Nd146(n,γ)Nd147(β^-)Pm147(n,γ)_ Pm148m(n,γ)Pm149(n,γ)Pm150(β^-)_ Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)_ Sm153(β^-)Eu153(n,γ)Eu154(n,γ)Eu155	4.0						
		&Nd146(n,γ)Nd147(β^-)Pm147(n,γ)_ Pm148m(n,γ)Pm149(β^-)Sm149(n,γ)_ Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)_ Sm153(β^-)Eu153(n,γ)*Eu154*(n,γ)Eu155	3.9						
		Nd146(n,γ)Nd147(β^-)Pm147(n,γ)_ Pm148(n,γ)Pm149(β^-)Sm149(n,γ)_ Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)_ Sm153(β^-)Eu153(n,γ)Eu154(n,γ)Eu155	3.9						
		Nd150(n,γ)Nd151(β^-)Pm151(β^-)Sm151_ (n,γ)Sm152(n,γ)Sm153(n,γ)Sm154(n,γ)_ Sm155(β^-)Eu155	0.2			0.3	1.3	2.9	
		&Nd150(n,γ)Nd151(β^-)Pm151(β^-)_ Sm151(β^-)Eu151(n,γ)Eu152(n,γ)Eu153_ (n,γ)*Eu154*(n,γ)Eu155			4.8	0.3			
Pm146	5.531 y	Nd148(n,2n)Nd147(β^-)Pm147(n,2n)Pm146				98.2	28.9	22.4	21.2
		Nd150(n,3n)Nd148(n,2n)Nd147(β^-)_ Pm147(n,2n)Pm146				1.4	1.0	0.3	0.2
		Nd150(n,4n)Nd147(β^-)Pm147(n,2n)Pm146					53.8	48.8	22.1
		Nd150(n,4n)Nd147(β^-)Pm147(β^-)_ Sm147(n,d)Pm146					5.8	8.7	5.3
		Nd148(n,2n)Nd147(β^-)Pm147(β^-)_ Sm147(n,d)Pm146					3.1	4.0	5.1
		Nd148(n,d)Pr147(β^-)Nd147(β^-)Pm147_ (n,2n)Pm146					3.0	4.8	6.6
		Nd150(n,2n)Nd149(β^-)Pm149(β^-)_ Sm149(n,nt)Pm146					0.6	4.8	21.0
		Nd148(n,d)Pr147(β^-)Nd147(β^-)Pm147_ (β^-)Sm147(n,d)Pm146					0.3	0.9	1.6
		Nd150(n,nt)Pr147(β^-)Nd147(β^-)Pm147_ (n,2n)Pm146					0.1	1.2	7.3
		Nd150(n,d)Pr149(β^-)Nd149(β^-)Pm149_ (β^-)Sm149(n,nt)Pm146						0.2	5.3
		Nd150(n,nt)Pr147(β^-)Nd147(β^-)Pm147_ (β^-)Sm147(n,d)Pm146						0.2	1.8
Eu154	8.593 y	**&**Nd148(n,γ)Nd149(β^-)Pm149(β^-)_ Sm149(n,γ)Sm150(n,γ)Sm151(n,γ)_ Sm152(n,γ)Sm153(β^-)Eu153(n,γ)*Eu154*	31.5	99.5					
		&Nd150(n,γ)Nd151(β^-)Pm151(β^-)_ Sm151(n,γ)Sm152(n,γ)Sm153(β^-)_ Eu153(n,γ)*Eu154*	18.7	0.3	93.9	99.0	99.0	99.1	99.3
		&Nd146(n,γ)Nd147(β^-)Pm147(n,γ)_ Pm148m(n,γ)Pm149(β^-)Sm149(n,γ)_ Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)_ Sm153(β^-)Eu153(n,γ)*Eu154*	18.2						
	►	**&**Nd148(n,γ)Nd149(β^-)Pm149(n,γ)_ Pm150(β^-)Sm150(n,γ)Sm151(n,γ)_ Sm152(n,γ)Sm153(β^-)Eu153(n,γ)*Eu154*	7.1						

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Nd146(n,γ)Nd147(β^-)Pm147(n,γ)Pm148_(n,γ)Pm149(β^-)Sm149(n,γ)Sm150(n,γ)_Sm151(n,γ)Sm152(n,γ)Sm153(β^-)Eu153_(n,γ)Eu154	4.0						
		&Nd145(n,γ)Nd146(n,γ)Nd147(β^-)_Pm147(n,γ)Pm148m(n,γ)Pm149(β^-)_Sm149(n,γ)Sm150(n,γ)Sm151(n,γ)_Sm152(n,γ)Sm153(β^-)Eu153(n,γ)*Eu154*	1.3						
		Nd145(n,γ)Nd146(n,γ)Nd147(β^-)_Pm147(n,γ)Pm148m(n,γ)Pm149(n,γ)_Pm150(β^-)Sm150(n,γ)Sm151(n,γ)_Sm152(n,γ)Sm153(β^-)Eu153(n,γ)Eu154	1.3						
		&Nd150(n,γ)Nd151(β^-)Pm151(β^-)Sm151_(β^-)Eu151(n,γ)Eu152(n,γ)Eu153(n,γ)*Eu154*			5.6	0.3			
Ba133	10.54 y	Pathways involving (n,α), (n,nα), (n,2n), β^-,β^+				100.0	100.0	100.0	100.0
H3	12.33 y	Nd150(n,γ)Nd151(β^-)Pm151(β^-)Sm151_(β^-)Eu151(n,γ)Eu152(n,X)H1(n,γ)H2_(n,γ)H3	26.0	0.4					
		Nd150(n,γ)Nd151(β^-)Pm151(β^-)Sm151_(β^-)Eu151(n,γ)Eu152m(n,X)H1(n,γ)H2_(n,γ)H3	3.7						
		Nd143(n,X)H3				41.7	17.5	14.3	13.0
		Nd145(n,X)H3				18.4	10.7	9.1	8.5
		Nd144(n,2n)Nd143(n,X)H3				11.0	1.1	0.7	0.4
		Nd146(n,2n)Nd145(n,X)H3				5.4	0.7	0.4	0.3
		Nd142(n,2n)Nd141(β^+)Pr141(n,X)H3				5.3	1.0	0.6	0.4
		Nd144(n,X)H3				4.5	20.2	20.9	21.3
		Nd146(n,X)H3				2.5	12.9	13.9	14.3
		Nd148(n,2n)Nd147(β^-)Pm147(n,X)H3				2.3	0.2	0.1	
		Nd142(n,X)H3				0.3	15.7	19.3	21.3
		Nd148(n,X)H3				0.3	3.5	4.0	4.2
		Nd150(n,X)H3					2.7	3.3	3.7
		Nd144(n,3n)Nd142(n,X)H3					1.5	0.8	0.4
		Nd146(n,3n)Nd144(n,X)H3					1.5	0.5	0.3
		Nd146(n,4n)Nd143(n,X)H3					0.5	1.4	0.3
		&Nd144(n,4n)*Nd141*(β^+)Pr141(n,X)H3						1.7	0.3
		Nd142(n,3n)Nd140(β^+)Pr140(β^+)Ce140_(n,X)H3						1.4	0.5
		Other pathways involving (n,γ), β^-,β^+	70.3	99.6		8.3	10.3	7.6	10.8
Eu152	13.525 y	Nd148(n,γ)Nd149(β^-)Pm149(β^-)Sm149_(n,γ)Sm150(n,γ)Sm151(β^-)Eu151(n,γ)_Eu152	29.9	99.6					
		Nd146(n,γ)Nd147(β^-)Pm147(n,γ)_Pm148m(n,γ)Pm149(β^-)Sm149(n,γ)_Sm150(n,γ)Sm151(β^-)Eu151(n,γ)Eu152	17.8						
		&Nd150(n,γ)Nd151(β^-)Pm151(β^-)_Sm151(β^-)Eu151(n,γ)*Eu152*	17.7	0.3	99.9	99.9	99.7	99.8	99.9
		Nd148(n,γ)Nd149(β^-)Pm149(n,γ)_Pm150(β^-)Sm150(n,γ)Sm151(β^-)Eu151_(n,γ)Eu152	6.8						
		Nd145(n,γ)Nd146(n,γ)Nd147(β^-)Pm147_(n,γ)Pm148m(n,γ)Pm149(β^-)Sm149(n,γ)_Sm150(n,γ)Sm151(β^-)Eu151(n,γ)Eu152	6.6						
		Nd146(n,γ)Nd147(β^-)Pm147(n,γ)_Pm148m(n,γ)Pm149(n,γ)Pm150(β^-)_Sm150(n,γ)Sm151(β^-)Eu151(n,γ)Eu152	4.0						
	►	Nd146(n,γ)Nd147(β^-)Pm147(n,γ)_Pm148(n,γ)Pm149(β^-)Sm149(n,γ)_Sm150(n,γ)Sm151(β^-)Eu151(n,γ)Eu152	3.9						

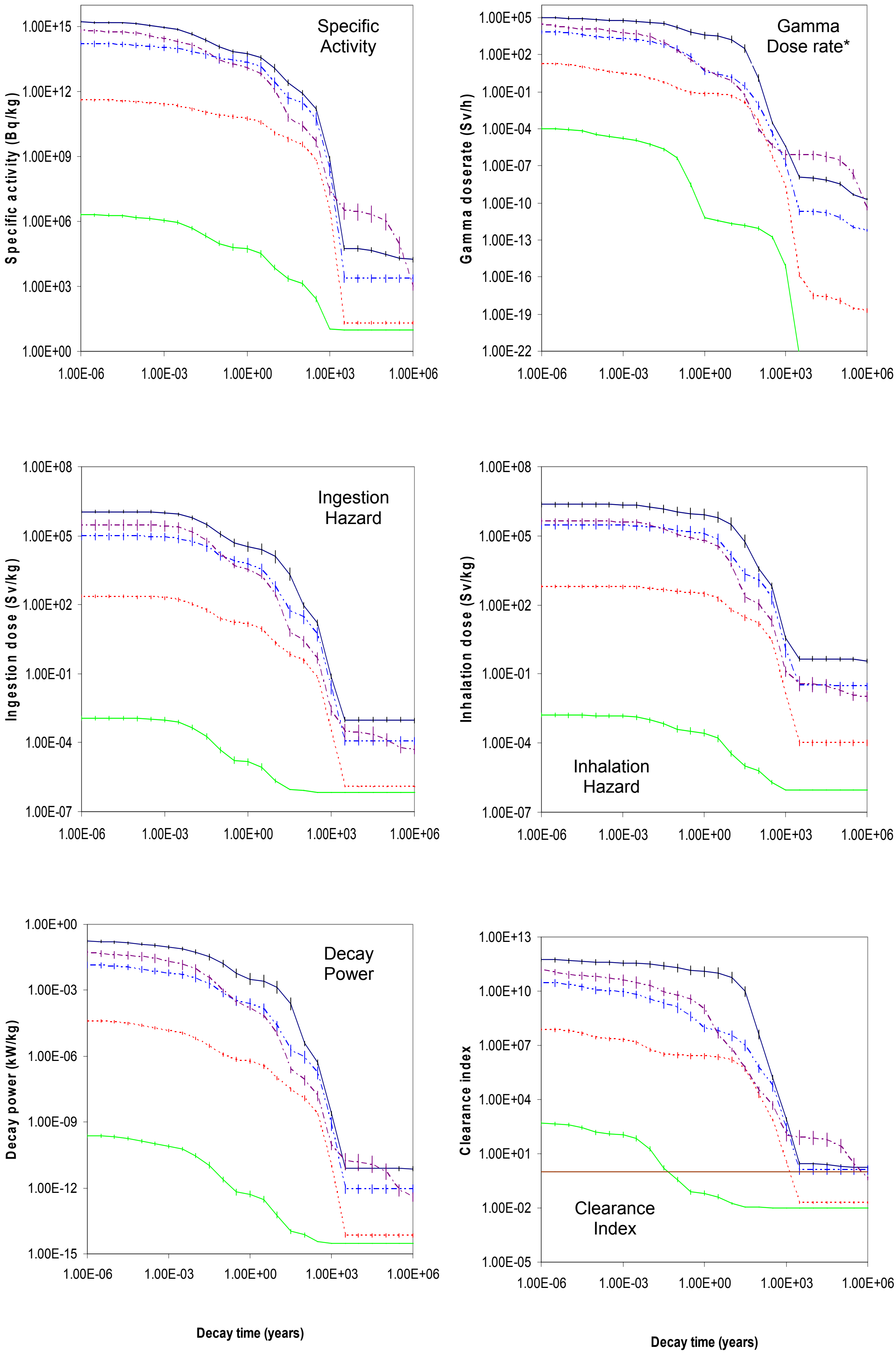
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Nd146(n,γ)Nd147(β^-)Pm147(n,γ)_ Pm148(β^-)Sm148(n,γ)Sm149(n,γ)_ Sm150(n,γ)Sm151(β^-)Eu151(n,γ)Eu152	2.0						
		Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_ Nd147(β^-)Pm147(n,γ)Pm148m(n,γ)_ Pm149(β^-)Sm149(n,γ)Sm150(n,γ)_ Sm151(β^-)Eu151(n,γ)Eu152	1.6						
		Nd145(n,γ)Nd146(n,γ)Nd147(β^-)Pm147_ (n,γ)Pm148(n,γ)Pm149(β^-)Sm149(n,γ)_ Sm150(n,γ)Sm151(β^-)Eu151(n,γ)Eu152	1.5						
		Nd145(n,γ)Nd146(n,γ)Nd147(β^-)Pm147_ (n,γ)Pm148m(n,γ)Pm149(n,γ)Pm150(β^-)_ Sm150(n,γ)Sm151(β^-)Eu151(n,γ)Eu152	1.5						
Pm145	17.70 y	Nd148(n,2n)Nd147(β^-)Pm147(n,2n)_ Pm146(n,2n)Pm145				74.8	0.1	0.2	
		Nd148(n,2n)Nd147(β^-)Pm147(β^-)Sm147_ (n,2n)Sm146(n,2n)Sm145(β^+)Pm145				14.0			
		Nd148(n,2n)Nd147(β^-)Pm147(n,3n)Pm145				7.5	25.0	17.4	12.5
		Nd148(n,2n)Nd147(β^-)Pm147(n,2n)_ Pm146(β^-)Sm146(n,2n)Sm145(β^+)Pm145				2.0			
		Nd150(n,4n)Nd147(β^-)Pm147(n,3n)Pm145					46.7	38.0	13.0
		Nd150(n,4n)Nd147(β^-)Pm147(β^-)_ Sm147(n,3n)Sm145(β^+)Pm145					12.8	12.1	3.8
		Nd148(n,2n)Nd147(β^-)Pm147(β^-)_ Sm147(n,3n)Sm145(β^+)Pm145					6.9	5.5	3.6
		Nd150(n,2n)Nd149(β^-)Pm149(β^-)_ Sm149(n,5n)Sm145(β^+)Pm145						5.9	28.7
		Nd150(n,4n)Nd147(β^-)Pm147(β^-)_ Sm147(n,t)Pm145						4.7	3.0
		Nd148(n,d)Pr147(β^-)Nd147(β^-)Pm147_ (n,3n)Pm145						3.8	3.9
		Nd148(n,2n)Nd147(β^-)Pm147(β^-)_ Sm147(n,t)Pm145						2.1	2.9
		Nd150(n,nt)Pr147(β^-)Nd147(β^-)Pm147_ (n,3n)Pm145						1.0	4.3
		Nd150(n,2n)Nd149(β^-)Pm149(β^-)_ Sm149(n,2nt)Pm145						0.3	7.4
		Nd150(n,d)Pr149(β^-)Nd149(β^-)Pm149_ (β^-)Sm149(n,5n)Sm145(β^+)Pm145							7.2
Eu150	36.359 y	Nd150(n,γ)Nd151(β^-)Pm151(β^-)Sm151_ (β^-)Eu151(n,2n)Eu150				100.0	99.9	99.9	99.9
Sm151	90.0 y	Nd148(n,γ)Nd149(β^-)Pm149(β^-)Sm149_ (n,γ)Sm150(n,γ)Sm151	29.9	99.6	0.2				
		Nd146(n,γ)Nd147(β^-)Pm147(n,γ)_ Pm148m(n,γ)Pm149(β^-)Sm149(n,γ)_ Sm150(n,γ)Sm151	17.8						
		Nd150(n,γ)Nd151(β^-)Pm151(β^-)Sm151	17.7	0.3	99.8	100.0	99.8	99.9	99.9
		Nd148(n,γ)Nd149(β^-)Pm149(n,γ)_ Pm150(β^-)Sm150(n,γ)Sm151	6.8						
		Nd145(n,γ)Nd146(n,γ)Nd147(β^-)_ Pm147(n,γ)Pm148m(n,γ)Pm149(β^-)_ Sm149(n,γ)Sm150(n,γ)Sm151	6.7						
		Nd146(n,γ)Nd147(β^-)Pm147(n,γ)_ Pm148m(n,γ)Pm149(n,γ)Pm150(β^-)_ Sm150(n,γ)Sm151	4.0						
		Nd146(n,γ)Nd147(β^-)Pm147(n,γ)_ Pm148(n,γ)Pm149(β^-)Sm149(n,γ)_ Sm150(n,γ)Sm151	3.9						
	►	Nd146(n,γ)Nd147(β^-)Pm147(n,γ)_ Pm148(β^-)Sm148(n,γ)Sm149(n,γ)_ Sm150(n,γ)Sm151	2.0						

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	Nd145(n,γ)Nd146(n,γ)Nd147(β^-)_ Pm147(n,γ)Pm148(n,γ)Pm149(β^-)_ Sm149(n,γ)Sm150(n,γ)Sm151	1.5						
		Nd145(n,γ)Nd146(n,γ)Nd147(β^-)_ Pm147(n,γ)Pm148m(n,γ)Pm149(n,γ)_ Pm150(β^-)Sm150(n,γ)Sm151	1.5						
Ho166m	1200.0 y	Very long pathways of (n,γ), β^-	100.0	100.0					
La137	$6.0\,10^4$ y	**&**Nd142(n,α)*Ce139*(β^+)La139(n,2n)_ La138(n,2n)La137				22.1			
		&Nd142(n,2n)*Nd141*(β^+)Pr141(n,α)_ La138(n,2n)La137				15.6			
		&Nd142(n,nα)Ce138(n,2n)*Ce137*(β^+)La137				9.3	3.9	0.5	0.1
		&Nd142(n,α)*Ce139*(n,2n)Ce138(n,2n)_ *Ce137*(β^+)La137				8.3			
		&Nd142(n,2n)*Nd141*(β^+)Pr141(n,nα)La137				7.6	4.7	0.5	0.1
		&Nd143(n,nα)*Ce139*(β^+)La139(n,3n)La137					4.7	0.4	
		&Nd143(n,3n)*Nd141*(β^+)Pr141(n,nα)La137					3.0	0.3	
		&Nd142(n,α)*Ce139*(β^+)La139(n,3n)La137					3.0	0.1	
		&Nd142(n,2nα)*Ce137*(β^+)La137					1.7	14.0	11.5
		Nd142(n,3n)Nd140(β^+)Pr140(β^+)Ce140_ (n,4n)Ce137(β^+)La137						8.7	0.7
		Nd142(n,4n)Nd139m(β^+)Pr139(β^+)_ Ce139(β^+)La139(n,3n)La137						4.9	3.1
		&Nd142(n,t)Pr140(β^+)Ce140(n,4n)_ *Ce137*(β^+)La137						3.1	2.0
		&Nd143(n,3nα)*Ce137*(β^+)La137						0.4	7.8
		&Nd144(n,4nα)*Ce137*(β^+)La137							4.5
		Nd142(n,2n)Nd141(β^+)Pr141(n,5n)_ Pr137(β^+)Ce137(β^+)La137							3.2
		Other pathways involving (n,2n), (n,α), β^+				37.1	79.0	67.1	67.0
Cs135	$2.3\,10^6$ y	Nd143(n,α)Ce140(n,γ)Ce141(β^-)Pr141_ (n,α)La138(n,α)Cs135	38.9	42.7					
		Nd144(n,α)Ce141(β^-)Pr141(n,α)La138_ (n,α)Cs135	25.1	41.7					
		Nd142(n,γ)Nd143(n,α)Ce140(n,γ)_ Ce141(β^-)Pr141(n,α)La138(n,α)Cs135	18.7						
		Nd143(n,γ)Nd144(n,α)Ce141(β^-)Pr141_ (n,α)La138(n,α)Cs135	11.2	15.5					
		Nd142(n,γ)Nd143(n,γ)Nd144(n,α)_ Ce141(β^-)Pr141(n,α)La138(n,α)Cs135	5.4						
		Pathways involving (n,α), (n,nα), (n,2n), β^-, β^+	0.1	0.1		100.0	100.0	100.0	100.0
Sm146	$1.0\,10^8$ y	Nd148(n,2n)Nd147(β^-)Pm147(β^-)_ Sm147(n,2n)Sm146				85.4	16.0	5.6	10.2
		Nd148(n,2n)Nd147(β^-)Pm147(n,2n)_ Pm146(β^-)Sm146				11.5	1.8	0.7	1.2
		Nd150(n,2n)Nd149(β^-)Pm149(β^-)Sm149_ (n,2n)Sm148(n,2n)Sm147(n,2n)Sm146				1.6			
		Nd150(n,2n)Nd149(β^-)Pm149(β^-)_ Sm149(n,3n)Sm147(n,2n)Sm146				0.2	3.4	0.4	0.4
		Nd150(n,2n)Nd149(β^-)Pm149(β^-)_ Sm149(n,4n)Sm146					33.9	64.8	51.3
		Nd150(n,4n)Nd147(β^-)Pm147(β^-)_ Sm147(n,2n)Sm146					29.8	12.3	10.7
		Nd150(n,2n)Nd149(β^-)Pm149(β^-)_ Sm149(n,2n)Sm148(n,3n)Sm146					3.4	0.4	0.4
		Nd150(n,4n)Nd147(β^-)Pm147(n,2n)_ Pm146(β^-)Sm146					3.3	1.5	1.3
	►	Nd150(n,d)Pr149(β^-)Nd149(β^-)Pm149_ (β^-)Sm149(n,4n)Sm146					2.6	11.1	13.0

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Nd148(n,d)Pr147(β^-)Nd147(β^-)Pm147_(β^-)Sm147(n,2n)Sm146					1.7	1.2	3.2
		Nd150(n,nt)Pr147(β^-)Nd147(β^-)Pm147_(β^-)Sm147(n,2n)Sm146						0.3	3.5
La138	1.0 10^{11} y	Nd143(n,α)Ce140(n,γ)Ce141(β^-)Pr141_(n,α)La138	36.6	43.8	2.1				
		Nd142(n,γ)Nd143(n,α)Ce140(n,γ)_Ce141(β^-)Pr141(n,α)La138	23.8						
		Nd144(n,α)Ce141(β^-)Pr141(n,α)La138	21.7	40.2	97.2	0.1			
		Nd143(n,γ)Nd144(n,α)Ce141(β^-)Pr141_(n,α)La138	10.3	15.9	0.6				
		Nd142(n,γ)Nd143(n,γ)Nd144(n,α)_Ce141(β^-)Pr141(n,α)La138	6.8						
		&Nd142(n,α)*Ce139*(β^+)La139(n,2n)La138				30.5	4.4	0.5	0.5
		&Nd142(n,2n)*Nd141*(β^+)Pr141(n,α)La138				19.7	4.0	0.5	0.6
		&Nd142(n,2n)*Nd141*(β^+)Pr141(n,2n)Pr140_(β^+)Ce140(n,2n)*Ce139*(β^+)La139(n,2n)La138				13.8			
		&Nd143(n,nα)*Ce139*(β^+)La139(n,2n)La138				1.6	7.0	1.4	0.4
		&Nd143(n,2n)Nd142(n,α)*Ce139*(β^+)_La139(n,2n)La138				1.2			
		&Nd144(n,nα)Ce140(n,2n)*Ce139*(β^+)_La139(n,2n)La138				0.5	0.2		
		Nd142(n,3n)Nd140(β^+)Pr140(β^+)Ce140_(n,t)La138					8.9	28.7	9.1
		Nd142(n,d)Pr141(n,3n)Pr139(β^+)Ce139_(β^+)La139(n,2n)La138					2.3	0.6	
		Nd142(n,t)Pr140(β^+)Ce140(n,t)La138					0.1	2.4	3.7
		Nd142(n,nt)Pr139(β^+)Ce139(β^+)La139_(n,2n)La138					0.1	1.4	5.9
		Nd142(n,4n)Nd139m(β^+)Pr139(β^+)_Ce139(β^+)La139(n,2n)La138						16.6	17.6
		Nd142(n,4n)Nd139(β^+)Pr139(β^+)Ce139_(β^+)La139(n,2n)La138						8.0	3.0
		Nd143(n,4n)Nd140(β^+)Pr140(β^+)Ce140_(n,t)La138						7.7	5.6
		Nd144(n,5n)Nd140(β^+)Pr140(β^+)Ce140_(n,t)La138							15.7
		Nd143(n,5n)Nd139m(β^+)Pr139(β^+)_Ce139(β^+)La139(n,2n)La138							7.0
		Other pathways involving (n,2n), (n,α), β^+	0.8	0.1	0.1	32.6	73.0	32.2	30.9
Sm147	1.1 10^{11} y	Nd146(n,γ)Nd147(β^-)Pm147(β^-)Sm147	67.6	73.2	99.0	0.2	0.2	0.2	0.2
		Nd145(n,γ)Nd146(n,γ)Nd147(β^-)_Pm147(β^-)Sm147	23.6	26.4	1.0				
		Nd144(n,γ)Nd145(n,γ)Nd146(n,γ)_Nd147(β^-)Pm147(β^-)Sm147	5.3	0.3					
		Nd143(n,γ)Nd144(n,γ)Nd145(n,γ)_Nd146(n,γ)Nd147(β^-)Pm147(β^-)Sm147	2.4	0.1					
		Nd148(n,2n)Nd147(β^-)Pm147(β^-)Sm147				95.5	30.1	27.7	35.4
		Nd150(n,2n)Nd149(β^-)Pm149(β^-)_Sm149(n,2n)Sm148(n,2n)Sm147				2.7			
		Nd150(n,3n)Nd148(n,2n)Nd147(β^-)_Pm147(β^-)Sm147				1.3	1.0	0.3	0.2
		Nd150(n,2n)Nd149(β^-)Pm149(β^-)_Sm149(n,3n)Sm147				0.3	7.0	1.9	1.5
		Nd150(n,4n)Nd147(β^-)Pm147(β^-)Sm147					56.1	60.4	37.0
		Nd148(n,d)Pr147(β^-)Nd147(β^-)Pm147_(β^-)Sm147					3.2	6.0	11.0
		Nd150(n,nt)Pr147(β^-)Nd147(β^-)Pm147_(β^-)Sm147					0.1	1.5	12.3
Nd144	2.3 10^{15} y	Nd142(n,γ)Nd143(n,γ)Nd144	32.6						
	►	Nd143(n,γ)Nd144	23.0	33.9	1.9				

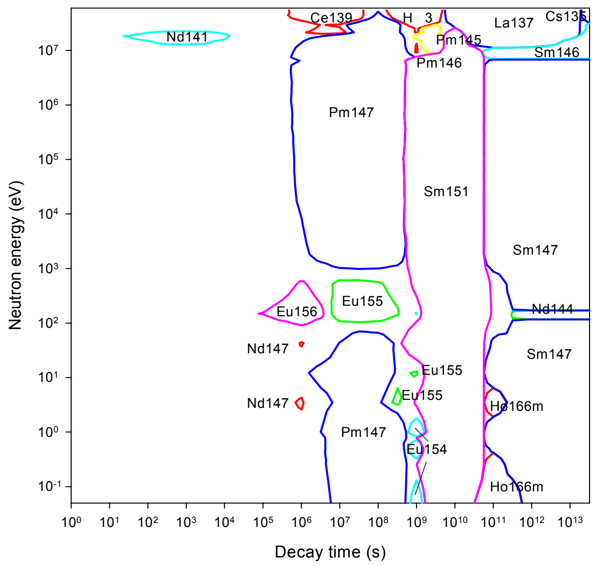
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	Nd145(n,2n)Nd144				8.5	1.6	1.2	0.8
		Nd146(n,2n)Nd145(n,2n)Nd144				2.5	0.1		
		Nd146(n,3n)Nd144				0.9	12.7	4.0	2.4
		Nd148(n,3n)Nd146(n,3n)Nd144					0.3		
		&Nd145(n,d)*Pr144*(β^-)Nd144					0.2	0.3	0.3
		Nd148(n,5n)Nd144						1.2	1.2
		&Nd146(n,t)*Pr144*(β^-)Nd144						0.6	0.8
		Nd150(n,7n)Nd144							0.4
		Nuclide also present in starting material	44.4	66.1	98.1	88.1	85.1	92.7	94.1

Neodymium activation characteristics

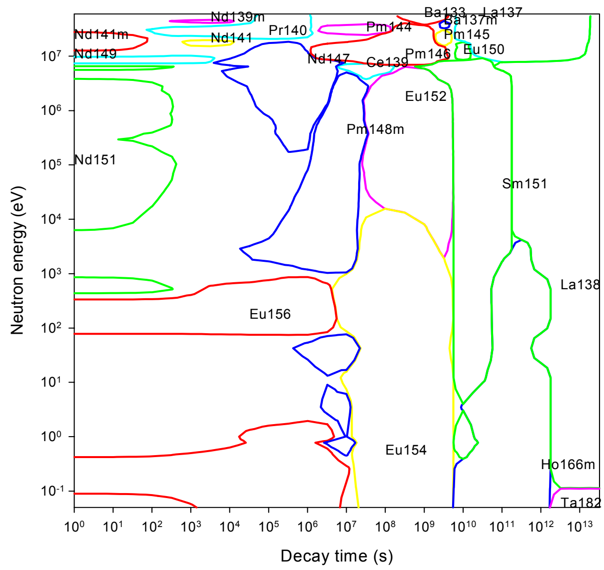


Neodymium importance diagrams & transmutation

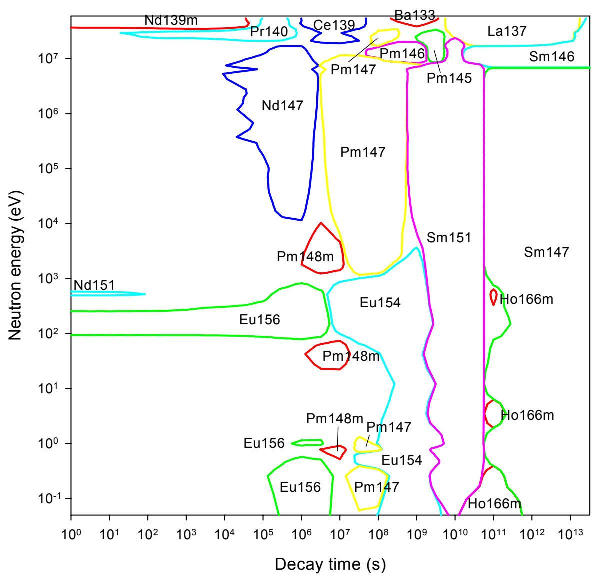
Activity



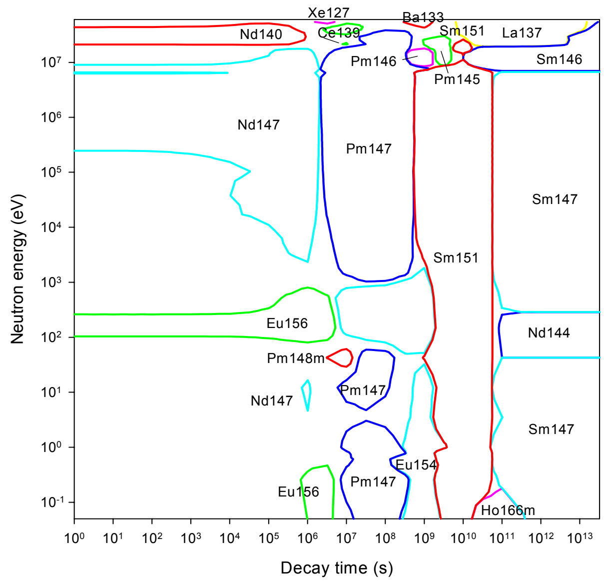
Dose rate



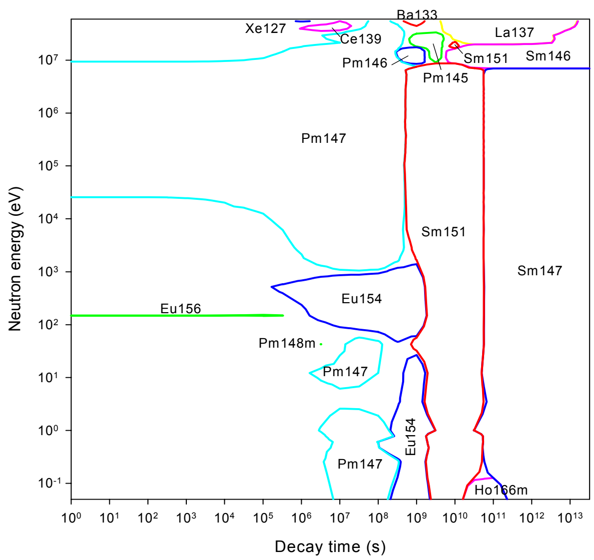
Heat output



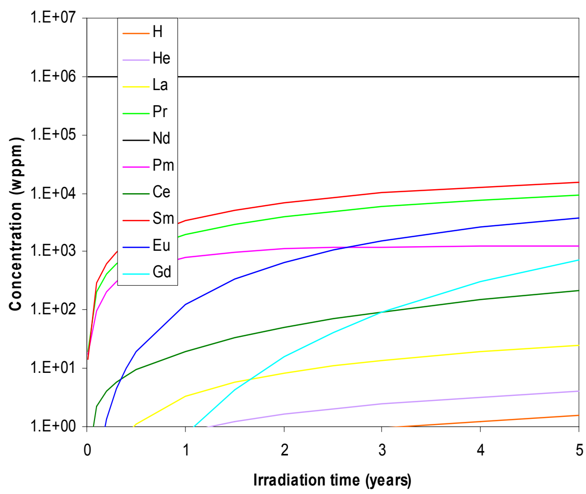
Ingestion dose



Inhalation dose



First wall transmutation



Samarium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	62		
Crustal abundance / wppm	7.05	Sm144	3.07
Melting point / K	1345	Sm147	14.99 ($T_{1/2}$ = 1.06 10^{11} y)
Boiling point / K	2063	Sm148	11.24 ($T_{1/2}$ = 8.00 10^{15} y)
Density / kgm^{-3}	7520	Sm149	13.82 ($T_{1/2}$ = 2.00 10^{15} y)
Thermal conductivity / $Wm^{-1}K^{-1}$	13.3	Sm150	7.38
Electrical resistivity /Ωm	9.4 10^{-7}	Sm152	26.75
Coefficient of thermal expansion / K^{-1}	1.27 10^{-5}	Sm154	22.75
Crystal structure	Rhombohedral		
Number of stable isotopes	4 (7)		
Mean atomic weight	150.36		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.18E16	1.17E16	7.36E15	1.83E15	1.11E13	2.28E6	kW kg^{-1}	1.90E0	1.88E0	1.43E0	1.87E-1	9.65E-5	9.40E-10
Eu156	43.34	43.95	59.11				Eu156	73.09	73.76	82.05			
Sm153	28.53	28.90	12.37				Sm153	9.42	9.50	3.36			
Eu155	10.83	10.98	17.42	60.70	0.01		Eu154	9.33	9.42	12.36	87.19	57.51	
Sm155	7.61	6.56					Sm155	5.11	4.38				
Eu154	6.13	6.22	9.87	36.69	2.05		Eu155	1.35	1.36	1.78	11.79	0.01	
Eu157	0.96	0.97	0.03				Eu152	0.05	0.05	0.07	0.52	6.30	
Eu154m	0.90	0.85					Sm151			0.01	0.04	35.69	
Sm151	0.20	0.20	0.32	1.27	97.39		Sm146						96.38
Sm146						96.57	Gd150						3.10
Gd150						2.86	Sm147						0.51
Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	2.06E6	2.05E6	1.76E6	2.11E5	7.92E1	8.21E-13	Sv kg^{-1}	1.58E7	1.58E7	1.21E7	1.71E6	1.56E3	1.23E-1
Eu156	87.95	88.05	86.77				Eu156	71.31	71.34	78.74			
Eu154	10.98	10.99	12.79	98.76	89.49		Sm153	15.79	15.78	5.54			
Eu157	0.21	0.21					Eu154	9.17	9.18	11.95	78.40	29.19	
Tb160	0.12	0.12	0.14	0.04			Eu155	2.59	2.59	3.38	20.75	0.01	
Eu152	0.07	0.07	0.08	0.61	10.13		Eu152	0.04	0.04	0.06	0.39	2.64	
Eu155	0.03	0.03	0.04	0.26			Sm151	0.01	0.01	0.02	0.13	67.83	
La137						92.24	Sm146					0.01	96.73
La138						7.76	Gd150						2.76
Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	6.75E7	6.75E7	6.31E7	4.35E7	5.68E4	2.97E1		1.55E13	1.54E13	1.42E13	7.86E12	2.59E9	2.80E1
Eu154	57.04	57.05	60.93	81.64	21.28		Eu154	47.02	47.12	51.13	85.24	88.06	
Eu156	25.87	25.87	23.41				Eu156	42.62	42.70	39.26			
Eu155	13.11	13.12	14.00	17.58	0.01		Eu155	8.30	8.32	9.02	14.10	0.02	
Sm153	3.16	3.15	0.91				Sm155	0.93	0.79				
Eu152	0.31	0.31	0.33	0.46	2.18		Eu152	0.32	0.32	0.35	0.60	11.40	
Sm151	0.14	0.14	0.15	0.21	76.17		Sm153	0.22	0.22	0.06			
Sm146					0.04	81.40	Sm151					0.42	
Gd150					0.01	18.18	Sm147						46.62
Sm147						0.42	Sm146						43.68
							Gd150						9.69

Samarium

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Sm155	22.3 m	Sm154(n,γ)Sm155	92.5	97.3	100.0	99.9	99.6	99.7	99.9
		Sm152(n,γ)Sm153(n,γ)Sm154(n,γ)Sm155	3.9	1.9					
		Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)_ Sm153(n,γ)Sm154(n,γ)Sm155	1.1	0.2					
Sm153	1.928 d	Sm147(n,γ)Sm148(n,γ)Sm149(n,γ)Sm150_ (n,γ)Sm151(n,γ)Sm152(n,γ)Sm153	39.5	27.5					
		Sm148(n,γ)Sm149(n,γ)Sm150(n,γ)_ Sm151(n,γ)Sm152(n,γ)Sm153	33.3	21.8					
		Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)Sm153	9.3	16.7	0.3				
		Sm149(n,γ)Sm150(n,γ)Sm151(n,γ)_ Sm152(n,γ)Sm153	2.9	32.4					
		Sm152(n,γ)Sm153		1.7	99.7		0.2	0.1	
		Sm154(n,2n)Sm153				99.8	91.3	83.3	77.6
		Sm154(n,d)Pm153(β^-)Sm153						16.3	23.7
Tb161	6.89 d	**&**Sm152(n,γ)Sm153(β^-)Eu153(n,γ)_ *Eu154*(n,γ)Eu155(n,γ)Eu156(n,γ)Eu157_ (β^-)Gd157(n,γ)Gd158(n,γ)Gd159(β^-)_ Tb159(n,γ)Tb160(n,γ)Tb161	46.7	0.6					
		Sm154(n,γ)Sm155(β^-)Eu155(n,γ)Eu156_ (n,γ)Eu157(β^-)Gd157(n,γ)Gd158(n,γ)_ Gd159(β^-)Tb159(n,γ)Tb160(n,γ)Tb161	10.4		0.4				
		&Sm152(n,γ)Sm153(β^-)Eu153(n,γ)_ *Eu154*(n,γ)Eu155(n,γ)Eu156(β^-)Gd156_ (n,γ)Gd157(n,γ)Gd158(n,γ)Gd159(β^-)_ Tb159(n,γ)Tb160(n,γ)Tb161	5.7	80.5	0.6				
		Sm154(n,γ)Sm155(β^-)Eu155(n,γ)Eu156_ (β^-)Gd156(n,γ)Gd157(n,γ)Gd158(n,γ)_ Gd159(β^-)Tb159(n,γ)Tb160(n,γ)Tb161	1.0	0.2	73.1				
		Sm152(n,γ)Sm153(n,γ)Sm154(n,γ)_ Sm155(β^-)Eu155(n,γ)Eu156(n,γ)Eu157_ (β^-)Gd157(n,γ)Gd158(n,γ)Gd159(β^-)_ Tb159(n,γ)Tb160(n,γ)Tb161	0.4						
		&Sm152(n,γ)Sm153(β^-)Eu153(n,γ)_ *Eu154*(n,γ)Eu155(n,γ)Eu156(n,γ)Eu157_ (n,γ)Eu158(β^-)Gd158(n,γ)Gd159(β^-)_ Tb159(n,γ)Tb160(n,γ)Tb161	0.2						
		&Sm152(n,γ)Sm153(β^-)Eu153(n,γ)_ *Eu154*(n,γ)Eu155(β^-)Gd155(n,γ)Gd156_ (n,γ)Gd157(n,γ)Gd158(n,γ)Gd159(β^-)_ Tb159(n,γ)Tb160(n,γ)Tb161		6.1	0.2				
		&Sm152(n,γ)Sm153(β^-)Eu153(n,γ)_ *Eu154*(β^-)Gd154(n,γ)Gd155(n,γ)Gd156_ (n,γ)Gd157(n,γ)Gd158(n,γ)Gd159(β^-)_ Tb159(n,γ)Tb160(n,γ)Tb161		2.7					
		Sm154(n,γ)Sm155(β^-)Eu155(β^-)Gd155_ (n,γ)Gd156(n,γ)Gd157(n,γ)Gd158(n,γ)_ Gd159(β^-)Tb159(n,γ)Tb160(n,γ)Tb161			25.7				
		Other pathways involving (n,γ), β^-	35.6	9.9					
Eu156	15.19 d	Sm154(n,γ)Sm155(β^-)Eu155(n,γ)Eu156	51.5	0.6	94.9	99.9	99.7	99.8	99.9
	►	**&**Sm147(n,γ)Sm148(n,γ)Sm149(n,γ)_ Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)_ Sm153(β^-)Eu153(n,γ)*Eu154*(n,γ)Eu155_ (n,γ)Eu156	12.1	16.6					

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Sm148(n,γ)Sm149(n,γ)Sm150(n,γ)_ Sm151(n,γ)Sm152(n,γ)Sm153(β^-)_ Eu153(n,γ)*Eu154*(n,γ)Eu155(n,γ)Eu156	11.0	14.5					
		&Sm149(n,γ)Sm150(n,γ)Sm151(n,γ)_ Sm152(n,γ)Sm153(β^-)Eu153(n,γ)*Eu154*_ (n,γ)Eu155(n,γ)Eu156	9.5	31.1					
		&Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)_ Sm153(β^-)Eu153(n,γ)*Eu154*(n,γ)Eu155_ (n,γ)Eu156	7.0	16.5					
		Sm152(n,γ)Sm153(n,γ)Sm154(n,γ)_ Sm155(β^-)Eu155(n,γ)Eu156	2.1						
		&Sm152(n,γ)Sm153(β^-)Eu153(n,γ)_ *Eu154*(n,γ)Eu155(n,γ)Eu156	0.8	20.5	5.6				
		Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)_ Sm153(n,γ)Sm154(n,γ)Sm155(β^-)_ Eu155(n,γ)Eu156	0.6						
Tb160	72.3 d	**&**Sm152(n,γ)Sm153(β^-)Eu153(n,γ)_ *Eu154*(n,γ)Eu155(n,γ)Eu156(n,γ)Eu157_ (β^-)Gd157(n,γ)Gd158(n,γ)Gd159(β^-)_ Tb159(n,γ)Tb160	47.0	0.6					
		&Sm149(n,γ)Sm150(n,γ)Sm151(n,γ)_ Sm152(n,γ)Sm153(β^-)Eu153(n,γ)*Eu154*_ (n,γ)Eu155(n,γ)Eu156(n,γ)Eu157(β^-)_ Gd157(n,γ)Gd158(n,γ)Gd159(β^-)Tb159_ (n,γ)Tb160	13.8						
		Sm154(n,γ)Sm155(β^-)Eu155(n,γ)Eu156_ (n,γ)Eu157(β^-)Gd157(n,γ)Gd158(n,γ)_ Gd159(β^-)Tb159(n,γ)Tb160	10.4		0.4				
		&Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)_ Sm153(β^-)Eu153(n,γ)*Eu154*(n,γ)Eu155_ (n,γ)Eu156(n,γ)Eu157(β^-)Gd157(n,γ)_ Gd158(n,γ)Gd159(β^-)Tb159(n,γ)Tb160	10.4						
		&Sm152(n,γ)Sm153(β^-)Eu153(n,γ)_ *Eu154*(n,γ)Eu155(n,γ)Eu156(β^-)Gd156_ (n,γ)Gd157(n,γ)Gd158(n,γ)Gd159(β^-)_ Tb159(n,γ)Tb160	5.7	81.3	0.6				
		Sm154(n,γ)Sm155(β^-)Eu155(n,γ)Eu156_ (β^-)Gd156(n,γ)Gd157(n,γ)Gd158(n,γ)_ Gd159(β^-)Tb159(n,γ)Tb160	1.0	0.3	73.1				
		&Sm152(n,γ)Sm153(β^-)Eu153(n,γ)_ *Eu154*(n,γ)Eu155(β^-)Gd155(n,γ)Gd156_ (n,γ)Gd157(n,γ)Gd158(n,γ)Gd159(β^-)_ Tb159(n,γ)Tb160		6.2	0.2				
		&Sm152(n,γ)Sm153(β^-)Eu153(n,γ)_ Eu154(β^-)Gd154(n,γ)Gd155(n,γ)Gd156_ (n,γ)Gd157(n,γ)Gd158(n,γ)Gd159(β^-)_ Tb159(n,γ)Tb160		2.7					
		Sm154(n,γ)Sm155(β^-)Eu155(β^-)Gd155_ (n,γ)Gd156(n,γ)Gd157(n,γ)Gd158(n,γ)_ Gd159(β^-)Tb159(n,γ)Tb160			25.7				
Ta182	114.7 d	Very long pathways of (n,γ), β^-	100.0						
Sm145	340.0 d	Sm144(n,γ)Sm145	100.0	100.0	100.0				
		Sm147(n,2n)Sm146(n,2n)Sm145				91.4	1.2	0.6	0.3
		Sm148(n,2n)Sm147(n,2n)Sm146(n,2n)Sm145				7.6			
		Sm147(n,3n)Sm145					77.3	28.5	18.6
		Sm149(n,3n)Sm147(n,3n)Sm145					9.8	1.1	0.4
		Sm148(n,3n)Sm146(n,2n)Sm145					3.1	0.7	0.3
		Sm148(n,2n)Sm147(n,3n)Sm145					3.0	0.8	0.3
		Sm148(n,4n)Sm145					1.9	46.6	16.8
		Sm149(n,5n)Sm145						6.9	33.3
	►	Sm152(n,5n)Sm148(n,4n)Sm145						3.2	1.8

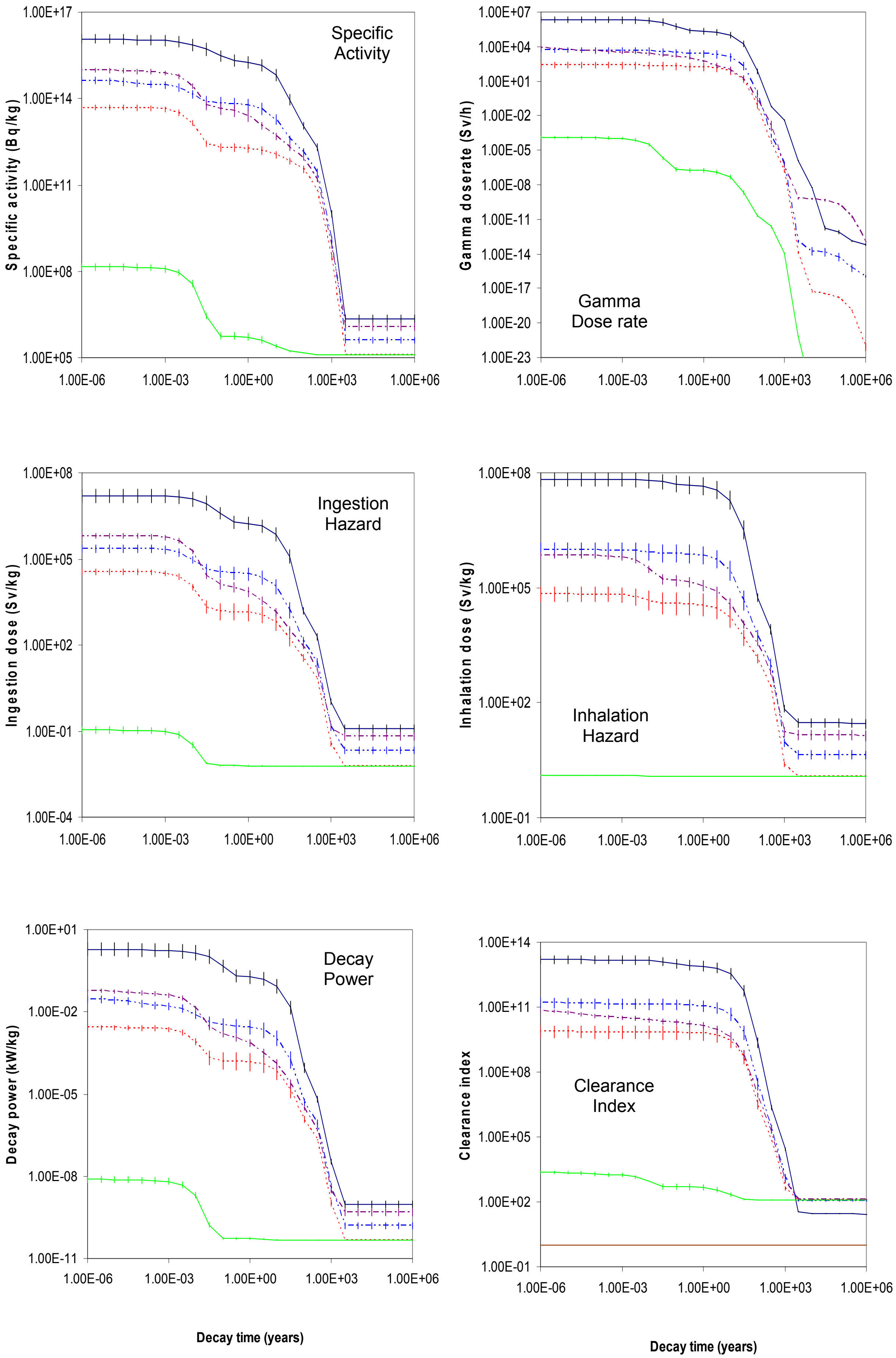
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Sm150(n,6n)Sm145							13.1
		Sm154(n,6n)Sm149(n,5n)Sm145							3.2
		Sm154(n,5n)Sm150(n,6n)Sm145							2.0
Pm144	363.0 d	Sm147(n,2n)Sm146(n,2n)Sm145(β^+)_ Pm145(n,2n)Pm144				78.5			
		Sm144(n,p)Pm144				15.7	10.1	4.6	1.2
		Sm148(n,2n)Sm147(n,2n)Sm146(n,2n)_ Sm145(β^+)Pm145(n,2n)Pm144				3.9			
		Sm147(n,3n)Sm145(β^+)Pm145(n,2n)Pm144					45.4	6.5	1.1
		Sm147(n,d)Pm146(n,3n)Pm144					9.6	2.2	0.6
		Sm147(n,3n)Sm145(n,d)Pm144					5.5	1.3	0.3
		Sm147(n,nt)Pm144					4.9	29.0	42.0
		Sm148(n,3n)Sm146(n,t)Pm144					3.3	2.7	0.8
		Sm148(n,4n)Sm145(β^+)Pm145(n,2n)Pm144					1.1	10.7	1.0
		Sm148(n,d)Pm147(n,4n)Pm144					0.9	3.5	0.4
		Sm149(n,4n)Sm146(n,t)Pm144					0.7	7.0	1.1
		Sm149(n,t)Pm147(n,4n)Pm144					0.4	3.8	0.6
		Sm148(n,2nt)Pm144						1.1	20.3
		Sm149(n,3nt)Pm144							5.9
		Sm152(n,6n)Sm147(n,nt)Pm144							4.2
Tm171	1.917 y	Very long pathways of (n,γ), β^-	100.0	100.0					
Eu155	4.753 y	Sm154(n,γ)Sm155(β^-)Eu155	51.9	0.6	94.1	100.0	99.8	99.9	99.9
		&Sm147(n,γ)Sm148(n,γ)Sm149(n,γ)_ Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)_ Sm153(β^-)Eu153(n,γ)*Eu154*(n,γ)Eu155	14.4	17.1					
		&Sm148(n,γ)Sm149(n,γ)Sm150(n,γ)_ Sm151(n,γ)Sm152(n,γ)Sm153(β^-)_ Eu153(n,γ)*Eu154*(n,γ)Eu155	11.1	14.9					
		&Sm149(n,γ)Sm150(n,γ)Sm151(n,γ)_ Sm152(n,γ)Sm153(β^-)Eu153(n,γ)*Eu154*_ (n,γ)Eu155	9.1	31.3					
		&Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)_ Sm153(β^-)Eu153(n,γ)*Eu154*(n,γ)Eu155	6.8	16.6					
		Sm152(n,γ)Sm153(n,γ)Sm154(n,γ)_ Sm155(β^-)Eu155	2.2						
		&Sm152(n,γ)Sm153(β^-)Eu153(n,γ)_ *Eu154*(n,γ)Eu155	0.8	19.3	5.8				
		Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)_ Sm153(n,γ)Sm154(n,γ)Sm155(β^-)Eu155	0.6						
Pm146	5.531 y	Sm144(n,γ)Sm145(β^+)Pm145(n,γ)Pm146	100.0	100.0	100.0				
		Sm147(n,2n)Sm146(n,p)Pm146				36.7	1.3	0.4	
		Sm147(n,d)Pm146				31.3	67.0	43.8	25.7
		Sm147(n,p)Pm147(n,2n)Pm146				18.1	0.5	0.1	
		Sm148(n,2n)Sm147(n,d)Pm146				3.5	1.9	0.9	0.3
		Sm148(n,2n)Sm147(n,2n)Sm146(n,p)Pm146				2.6			
		Sm150(n,α)Nd147(β^-)Pm147(n,2n)Pm146				2.3			
		Sm148(n,t)Pm146				0.3	10.2	27.2	22.2
		Sm149(n,3n)Sm147(n,d)Pm146					6.2	1.2	0.4
		Sm149(n,nt)Pm146					3.6	14.1	28.2
		Sm148(n,3n)Sm146(n,p)Pm146					3.4	0.4	
		Sm150(n,2nt)Pm146						0.5	9.5
Eu154	8.593 y	**&**Sm147(n,γ)Sm148(n,γ)Sm149(n,γ)_ Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)_ Sm153(β^-)Eu153(n,γ)*Eu154*	28.4	22.4					
		&Sm148(n,γ)Sm149(n,γ)Sm150(n,γ)_ Sm151(n,γ)Sm152(n,γ)Sm153(β^-)_ Eu153(n,γ)*Eu154*	25.4	18.7					
		&Sm149(n,γ)Sm150(n,γ)Sm151(n,γ)_ Sm152(n,γ)Sm153(β^-)Eu153(n,γ)*Eu154*	20.7	33.7					
		&Sm150(n,γ)Sm151(n,γ)Sm152(n,γ)_ Sm153(β^-)Eu153(n,γ)*Eu154*	15.3	17.5					
	►	**&**Sm152(n,γ)Sm153(β^-)Eu153(n,γ)*Eu154*	1.8	7.5	99.9				

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Sm154(n,2n)Sm153(β^-)Eu153(n,γ)*Eu154*				59.8	31.4	29.6	29.0
		&Sm154(n,γ)Sm155(β^-)Eu155(n,2n)*Eu154*				40.1	62.5	59.3	56.0
		&Sm154(n,γ)Sm155(β^-)Eu155(β^-)_ Gd155(n,d)*Eu154*					3.0	5.1	6.6
		&Sm154(n,d)Pm153(β^-)Sm153(β^-)_ Eu153(n,γ)*Eu154*					2.8	5.7	8.2
Eu152	13.525 y	Sm147(n,γ)Sm148(n,γ)Sm149(n,γ)_ Sm150(n,γ)Sm151(β^-)Eu151(n,γ)Eu152	45.6	28.8					
		Sm148(n,γ)Sm149(n,γ)Sm150(n,γ)_ Sm151(β^-)Eu151(n,γ)Eu152	37.0	22.6					
		Sm150(n,γ)Sm151(β^-)Eu151(n,γ)Eu152	5.9	16.5	87.6				
		Sm149(n,γ)Sm150(n,γ)Sm151(β^-)_ Eu151(n,γ)Eu152	1.8	32.1	12.2				
		&Sm154(n,2n)Sm153(β^-)Eu153(n,2n)*Eu152*				99.9	91.3	83.1	77.5
		Sm154(n,d)Pm153(β^-)Sm153(β^-)_ Eu153(n,2n)Eu152					8.1	16.3	22.0
Pm145	17.70 y	Sm144(n,γ)Sm145(β^+)Pm145	100.0	100.0	100.0				
		Sm147(n,2n)Sm146(n,2n)Sm145(β^+)Pm145				92.8	0.7	0.3	0.1
		Sm148(n,2n)Sm147(n,2n)Sm146(n,2n)_ Sm145(β^+)Pm145				5.4			
		Sm147(n,t)Pm145				0.3	2.3	7.5	8.6
		Sm147(n,3n)Sm145(β^+)Pm145					81.5	27.3	15.2
		Sm149(n,3n)Sm147(n,3n)Sm145(β^+)Pm145					5.7	0.6	0.2
		Sm148(n,4n)Sm145(β^+)Pm145					2.0	44.8	13.7
		Sm149(n,5n)Sm145(β^+)Pm145						6.6	27.2
		Sm149(n,2nt)Pm145						0.3	5.7
		Sm150(n,6n)Sm145(β^+)Pm145							10.6
Eu150	36.359 y	Sm152(n,2n)Sm151(β^-)Eu151(n,2n)Eu150				68.5	2.9	0.3	0.8
		&Sm154(n,2n)Sm153(β^-)Eu153(n,2n)_ *Eu152*(n,2n)Eu151(n,2n)Eu150				26.9			
		Sm154(n,2n)Sm153(β^-)Eu153(n,2n)_ Eu152m(β^-)Gd152(n,2n)Gd151(β^+)_ Eu151(n,2n)Eu150				2.8			
		Sm154(n,2n)Sm153(β^-)Eu153(n,2n)_ Eu152(n,3n)Eu150				1.2	11.9	0.3	0.5
		Sm154(n,2n)Sm153(β^-)Eu153(n,4n)Eu150					57.0	81.7	74.7
		Sm154(n,2n)Sm153(β^-)Eu153(n,3n)_ Eu151(n,2n)Eu150					17.5	0.4	0.7
		Sm154(n,4n)Sm151(β^-)Eu151(n,2n)Eu150					1.6	0.7	0.7
		Sm154(n,d)Pm153(β^-)Sm153(β^-)_ Eu153(n,4n)Eu150						16.0	21.3
Gd148	74.60 y	Sm152(n,2n)Sm151(β^-)Eu151(n,2n)Eu150m_ (β^-)Gd150(n,2n)Gd149(n,2n)Gd148				69.0			
		Sm154(n,2n)Sm153(β^-)Eu153(n,2n)_ Eu152(n,2n)Eu151(n,2n)Eu150m(β^-)_ Gd150(n,2n)Gd149(n,2n)Gd148				21.7			
		Sm154(n,2n)Sm153(β^-)Eu153(n,2n)_ Eu152m(β^-)Gd152(n,2n)Gd151(n,2n)_ Gd150(n,2n)Gd149(n,2n)Gd148				4.3			
		Sm154(n,2n)Sm153(β^-)Eu153(n,2n)Eu152m_ (β^-)Gd152(n,2n)Gd151(β^+)Eu151(n,2n)_ Eu150m(β^-)Gd150(n,2n)Gd149(n,2n)Gd148				2.1			
		Sm154(n,2n)Sm153(β^-)Eu153(n,2n)_ Eu152(n,3n)Eu150m(β^-)Gd150(n,2n)_ Gd149(n,2n)Gd148				1.4			
		Sm154(n,2n)Sm153(β^-)Eu153(n,4n)_ Eu150m(β^-)Gd150(n,3n)Gd148					60.2	81.4	45.2
		Sm154(n,2n)Sm153(β^-)Eu153(n,3n)Eu151_ (n,2n)Eu150m(β^-)Gd150(n,3n)Gd148					11.7	0.3	0.2
	►	Sm154(n,2n)Sm153(β^-)Eu153(n,2n)Eu152_ (n,3n)Eu150m(β^-)Gd150(n,3n)Gd148					10.2	0.3	0.2

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Sm154(n,2n)Sm153(β^-)Eu153(n,2n)Eu152m_ (β^-)Gd152(n,3n)Gd150(n,3n)Gd148					4.6	0.1	
		Sm152(n,2n)Sm151(β^-)Eu151(n,2n)_ Eu150m(β^-)Gd150(n,3n)Gd148					2.0	0.2	0.3
		Sm154(n,4n)Sm151(β^-)Eu151(n,2n)_ Eu150m(β^-)Gd150(n,3n)Gd148					1.1	0.5	0.2
		Sm154(n,d)Pm153(β^-)Sm153(β^-)Eu153_ (n,4n)Eu150m(β^-)Gd150(n,3n)Gd148						15.9	12.9
		Sm154(n,2n)Sm153(β^-)Eu153(n,2n)_ Eu152m(β^-)Gd152(n,5n)Gd148						0.2	26.6
		Sm154(n,d)Pm153(β^-)Sm153(β^-)Eu153_ (n,2n)Eu152m(β^-)Gd152(n,5n)Gd148							7.6
		Sm154(n,2n)Sm153(β^-)Eu153(n,2n)_ Eu152(β^-)Gd152(n,5n)Gd148							4.0
		Sm154(n,d)Pm153(β^-)Sm153(β^-)Eu153_ (n,2n)Eu152(β^-)Gd152(n,5n)Gd148							1.1
Sm151	90.0 y	Sm147(n,γ)Sm148(n,γ)Sm149(n,γ)_ Sm150(n,γ)Sm151	46.0	30.7					
		Sm148(n,γ)Sm149(n,γ)Sm150(n,γ)Sm151	37.2	23.6	0.3				
		Sm150(n,γ)Sm151	5.7	15.5	78.9				
		Sm149(n,γ)Sm150(n,γ)Sm151	1.6	30.2	20.8				
		Sm152(n,2n)Sm151				99.5	56.2	25.6	37.3
		Sm154(n,3n)Sm152(n,2n)Sm151				0.2	4.7		
		Sm154(n,4n)Sm151					30.4	65.5	34.4
		Sm152(n,d)Pm151(β^-)Sm151					7.1		13.8
		Sm154(n,nt)Pm151(β^-)Sm151							13.0
Ho166m	1200 y	Very long pathways of (n,γ), β^-	100.0	100.0	100.0				
La137	$6.0\ 10^4$ y	Very long pathways of (n,2n), β^+, (n,α)				100.0	100.0	100.0	100.0
Gd150	$1.8\ 10^6$ y	Sm152(n,2n)Sm151(β^-)Eu151(n,2n)_ Eu150m(β^-)Gd150				64.7	2.3	0.2	0.6
		Sm154(n,2n)Sm153(β^-)Eu153(n,2n)Eu152_ (n,2n)Eu151(n,2n)Eu150m(β^-)Gd150				25.2			
		Sm154(n,2n)Sm153(β^-)Eu153(n,2n)Eu152m_ (β^-)Gd152(n,2n)Gd151(n,2n)Gd150				4.3			
		Sm154(n,2n)Sm153(β^-)Eu153(n,2n)_ Eu152m(β^-)Gd152(n,2n)Gd151(β^+)_ Eu151(n,2n)Eu150m(β^-)Gd150				2.6			
		Sm154(n,2n)Sm153(β^-)Eu153(n,2n)_ Eu152(n,3n)Eu150m(β^-)Gd150				1.3	12.1	0.4	0.5
		Sm154(n,2n)Sm153(β^-)Eu153(n,4n)_ Eu150m(β^-)Gd150					54.0	81.2	74.8
		Sm154(n,2n)Sm153(β^-)Eu153(n,3n)_ Eu151(n,2n)Eu150m(β^-)Gd150					13.9	0.4	0.5
		Sm154(n,2n)Sm153(β^-)Eu153(n,2n)_ Eu152m(β^-)Gd152(n,3n)Gd150					5.4	0.2	0.2
		Sm154(n,d)Pm153(β^-)Sm153(β^-)_ Eu153(n,4n)Eu150m(β^-)Gd150					4.8	15.9	21.3
		Sm154(n,4n)Sm151(β^-)Eu151(n,2n)_ Eu150m(β^-)Gd150					1.3	0.6	0.5
		Sm154(n,2n)Sm153(β^-)Eu153(n,2n)_ Eu152(β^-)Gd152(n,3n)Gd150					1.1		
Sm146	$1.0\ 10^8$ y	Sm144(n,γ)Sm145(n,γ)Sm146	100.0	95.2	84.2				
		Sm144(n,γ)Sm145(β^+)Pm145(n,γ)_ Pm146(β^-)Sm146		4.8	15.8				
		Sm147(n,2n)Sm146				89.5	22.0	16.5	17.9
		Sm148(n,2n)Sm147(n,2n)Sm146				9.1	0.6	0.3	0.2
		Sm148(n,3n)Sm146					54.7	19.0	17.0
		Sm149(n,4n)Sm146					12.2	48.7	22.8
		Sm150(n,3n)Sm148(n,3n)Sm146					3.6	0.3	0.2
		Sm152(n,4n)Sm149(n,4n)Sm146					0.4	6.3	0.7
	►	Sm150(n,5n)Sm146						3.1	23.1

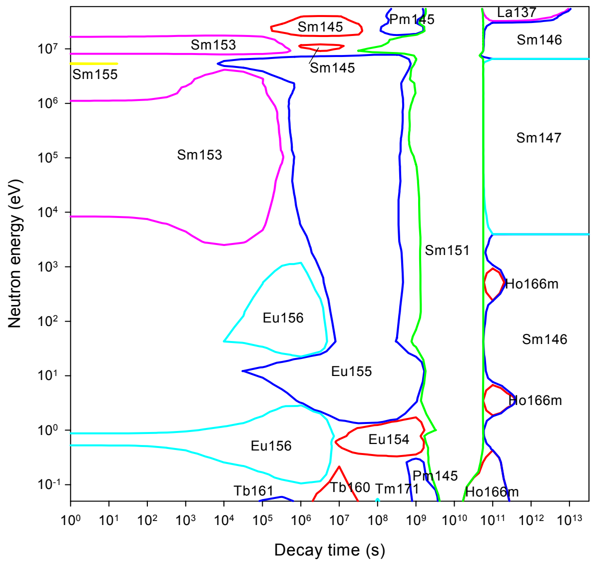
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Sm154(n,5n)Sm150(n,5n)Sm146						0.2	2.4
Lu176	4.0 10^{10} y	Very long pathways of (n,γ), β^-	100.0	100.0					
La138	1.0 10^{11} y	**&**Sm144(n,α)*Nd141*(β^+)Pr141(n,α)La138	99.9	99.9	99.9	7.7	1.0		
		&Sm144(n,nα)Nd140(β^+)Pr140(β^+)_ Ce140(n,2n)*Ce139*(β^+)La139(n,2n)La138				23.5			
		&Sm144(n,2n)Sm143(β^+)Pm143(β^+)_ Nd143(n,nα)*Ce139*(β^+)La139(n,2n)La138				6.2			
		&Sm144(n,2n)*Sm143*(β^+)Pm143(n,nα)_ Pr139(β^+)Ce139(β^+)La139(n,2n)La138				5.4			
		&Sm144(n,α)*Nd141*(β^+)Pr141(n,2n)Pr140_ (β^+)Ce140(n,2n)*Ce139*(β^+)La139(n,2n)La138				4.7			
		&Sm144(n,2n)*Sm143*(β^+)Pm143(n,α)_ Pr140(β^+)Ce140(n,2n)*Ce139*(β^+)La139_ (n,2n)La138				1.6			
		&Sm144(n,2n)*Sm143*(β^+)Pm143(β^+)_ Nd143(n,2n)Nd142(n,2n)*Nd141*(β^+)_ Pr141(n,α)La138				1.6			
		&Sm144(n,2n)*Sm143*(β^+)Pm143(β^+)_ Nd143(n,α)Ce140(n,2n)*Ce139*(β^+)_ La139(n,2n)La138				1.2			
		&Sm144(n,2n)*Sm143*(β^+)Pm143_ (n,2n)Pm142(β^+)Nd142(n,2n)*Nd141*_ (β^+)Pr141(n,α)La138				1.2			
		&Sm144(n,2n)*Sm143*(β^+)Pm143(β^+)_ Nd143(n,2n)Nd142(n,α)*Ce139*(β^+)_ La139(n,2n)La138				1.0			
		Sm144(n,nα)Nd140(β^+)Pr140(β^+)_ Ce140(n,t)La138					3.5	6.2	2.0
		Sm144(n,2nα)Nd139m(β^+)Pr139(β^+)_ Ce139(β^+)La139(n,2n)La138					2.4	12.9	3.0
		Sm144(n,2nα)Nd139(β^+)Pr139(β^+)_ Ce139(β^+)La139(n,2n)La138					1.8	4.1	0.5
		Sm144(n,4n)Sm141m(β^+)Pm141(β^+)_ Nd141(β^+)Pr141(n,α)La138						0.2	2.4
		Sm147(n,4nα)Nd140(β^+)Pr140(β^+)_ Ce140(n,t)La138							7.7
		Sm144(n,2nt)Pm140(β^+)Nd140(β^+)_ Pr140(β^+)Ce140(n,t)La138							3.0
		Sm144(n,2nt)Pm140m(β^+)Nd140(β^+)_ Pr140(β^+)Ce140(n,t)La138							1.9
		Other long pathways	0.1	0.1	0.1	45.9	91.3	76.6	79.5
Sm147	1.1 10^{11} y	Sm144(n,γ)Sm145(n,γ)Sm146(n,γ)Sm147	3.3	9.0					
		Sm144(n,γ)Sm145(β^+)Pm145(n,γ)_ Pm146(n,γ)Pm147(β^-)Sm147	0.1	10.3					
		Sm148(n,2n)Sm147				16.4	4.0	3.0	1.8
		Sm149(n,2n)Sm148(n,2n)Sm147				2.9	0.1		
		Sm149(n,3n)Sm147				0.2	13.3	4.1	2.4
		Sm150(n,4n)Sm147					1.0	6.0	1.5
		Sm152(n,6n)Sm147							10.8
		Nuclide also present in starting material	96.6	80.7	100.0	80.5	81.6	86.9	83.5

Samarium activation characteristics

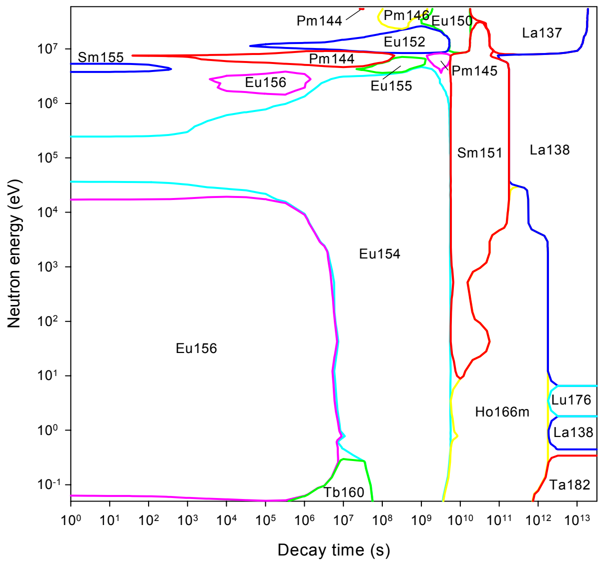


Samarium importance diagrams & transmutation

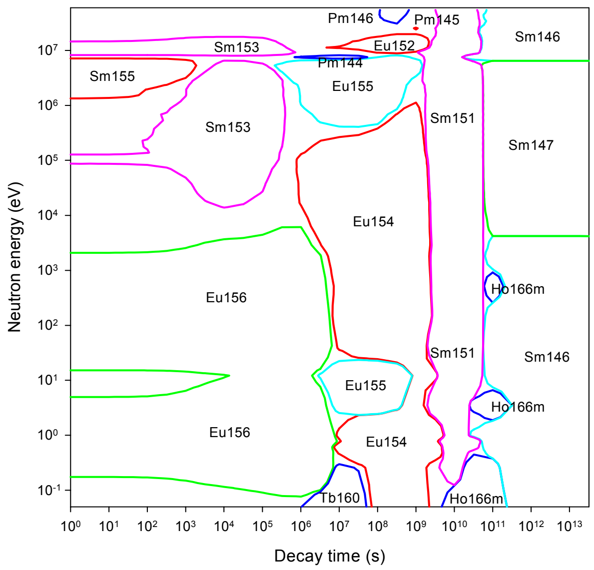
Activity



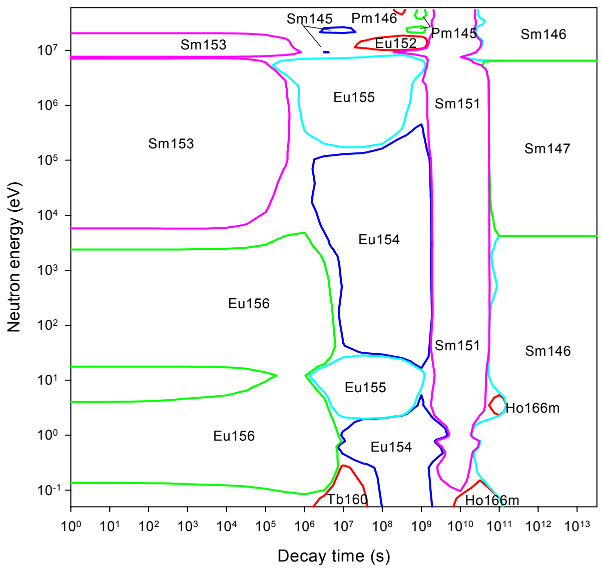
Dose rate



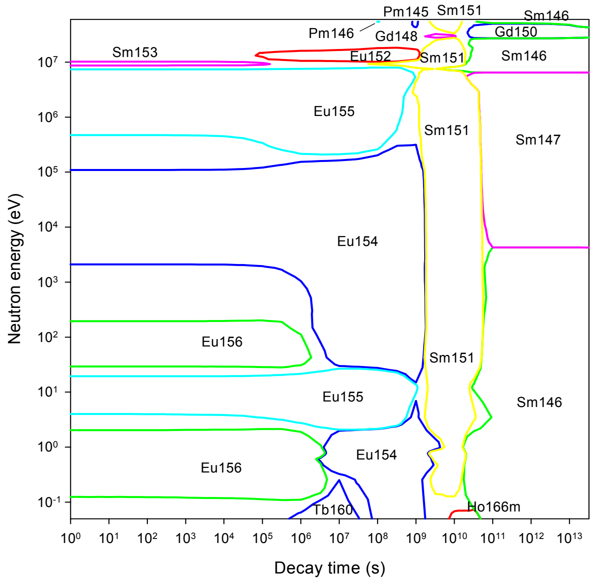
Heat output



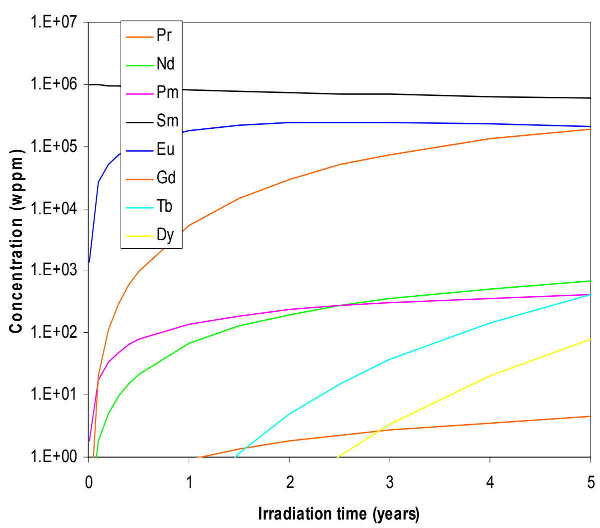
Ingestion dose



Inhalation dose



First wall transmutation



Europium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	63		
Crustal abundance / wppm	2	Eu151	47.81
Melting point / K	1095	Eu153	52.19
Boiling point / K	1869		
Density / kgm^{-3}	5244		
Thermal conductivity / $Wm^{-1}K^{-1}$	13.9		
Electrical resistivity /Ωm	$9.0\ 10^{-7}$		
Coefficient of thermal expansion / K^{-1}	$3.5\ 10^{-5}$		
Crystal structure	BCC		
Number of stable isotopes	2		
Mean atomic weight	151.965		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.69E16	1.68E16	1.41E16	4.00E15	1.29E12	3.86E7
Eu156	63.94	64.00	64.78			
Eu155	15.88	15.90	18.98	57.86	0.10	
Eu154	9.09	9.10	10.88	35.36	37.41	
Gd153	2.82	2.83	3.35	4.15		
Sm153	2.27	2.27	0.73			
Eu157	1.41	1.41	0.03			
Eu152m	1.41	1.41				
Eu154m	1.11	1.03				
Gd159	0.97	0.96	0.04			
Eu152	0.62	0.62	0.74	2.48	48.19	
Eu150	0.01	0.01	0.01	0.02	10.86	
Sm151					3.25	
Gd150						99.93

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	3.47E0	3.46E0	2.93E0	4.15E-1	2.80E-4	1.73E-8
Eu156	83.89	83.90	83.91			
Eu154	10.77	10.77	12.71	82.94	41.81	
Eu155	1.54	1.54	1.81	11.10	0.01	
Eu152m	0.90	0.89				
Eu157	0.75	0.75	0.02			
Eu152	0.62	0.62	0.73	4.91	45.58	
Sm153	0.58	0.58	0.19			
Gd153	0.32	0.32	0.37	0.93		
Gd159	0.28	0.27	0.01			
Tb160	0.18	0.18	0.21	0.05		
Eu154m	0.14	0.13				
Eu150	0.01	0.01	0.01	0.06	12.43	
Gd150					0.01	99.94

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	4.29E6	4.28E6	3.68E6	4.62E5	3.49E2	2.03E-20
Eu156	87.52	87.52	86.22			
Eu154	10.98	10.98	12.77	93.89	42.25	
Eu152	0.65	0.65	0.76	5.75	47.56	
Eu152m	0.39	0.39				
Tb160	0.18	0.18	0.20	0.05		
Eu150	0.01	0.01	0.01	0.05	10.08	
La137						91.00
La138						9.00

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	2.86E7	2.86E7	2.44E7	3.75E6	2.02E3	2.01E0
Eu156	82.92	82.93	82.26			
Eu154	10.72	10.73	12.56	75.31	47.62	
Eu155	3.00	3.00	3.51	19.71	0.02	
Sm153	0.99	0.99	0.31			
Eu152	0.51	0.51	0.60	3.69	42.94	
Gd153	0.45	0.45	0.52	1.19		
Eu150			0.01	0.03	8.99	
Gd150					0.10	99.93

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.42E8	1.42E8	1.36E8	9.54E7	6.25E4	3.20E3
Eu154	57.04	57.04	59.54	78.49	40.77	
Eu156	25.73	25.72	22.75			
Eu155	12.97	12.97	13.53	16.72	0.01	
Eu152	3.07	3.07	3.21	4.36	41.62	
Gd153	0.70	0.70	0.73	0.37		
Eu150	0.04	0.04	0.04	0.05	11.84	
Gd150					5.32	99.99

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	3.30E13	3.30E13	3.08E13	1.75E13	1.12E10	1.61E3
Eu154	46.38	46.38	49.71	80.97	42.85	
Eu156	41.81	41.80	37.96			
Eu155	8.10	8.10	8.68	13.25	0.01	
Eu152	3.15	3.15	3.38	5.67	55.20	
Gd153	0.14	0.14	0.15	0.10		
Eu150			0.01	0.01	1.92	
Gd150						99.99

Europium

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Eu152m	9.275 h	Eu151(n,γ)Eu152m	100.0	100.0	100.0				
		Eu153(n,2n)Eu152m				90.0	90.2	93.6	95.7
		&Eu153(n,2n)*Eu152*(n,n′)Eu152m				9.8	9.2		
Tb161	6.89 d	&Eu153(n,γ)*Eu154*(n,γ)Eu155(n,γ)Eu156_ (n,γ)Eu157(β^-)Gd157(n,γ)Gd158(n,γ)_ Gd159(β^-)Tb159(n,γ)Tb160(n,γ)Tb161	50.1	0.3	0.5				
		&Eu151(n,γ)*Eu152*(n,γ)Eu153(n,γ)_ *Eu154*(n,γ)Eu155(n,γ)Eu156(n,γ)Eu157_ (β^-)Gd157(n,γ)Gd158(n,γ)Gd159(β^-)_ Tb159(n,γ)Tb160(n,γ)Tb161	29.4	0.2					
		&Eu153(n,γ)*Eu154*(n,γ)Eu155(n,γ)Eu156_ (β^-)Gd156(n,γ)Gd157(n,γ)Gd158(n,γ)_ Gd159(β^-)Tb159(n,γ)Tb160(n,γ)Tb161	6.8	53.0	72.8				
		&Eu151(n,γ)Eu152(n,γ)Eu153(n,γ)_ *Eu154*(n,γ)Eu155(n,γ)Eu156(β^-)Gd156_ (n,γ)Gd157(n,γ)Gd158(n,γ)Gd159(β^-)_ Tb159(n,γ)Tb160(n,γ)Tb161	4.0	25.4	0.3				
		Eu151(n,γ)Eu152m(β^-)Gd152(n,γ)_ Gd153(n,γ)Gd154(n,γ)Gd155(n,γ)_ Gd156(n,γ)Gd157(n,γ)Gd158(n,γ)_ Gd159(β^-)Tb159(n,γ)Tb160(n,γ)Tb161		4.7					
		&Eu153(n,γ)*Eu154*(n,γ)Eu155(β^-)Gd155_ (n,γ)Gd156(n,γ)Gd157(n,γ)Gd158(n,γ)_ Gd159(β^-)Tb159(n,γ)Tb160(n,γ)Tb161		4.2	22.7				
		&Eu151(n,γ)Eu152(n,γ)Eu153(n,γ)_ *Eu154*(n,γ)Eu155(β^-)Gd155(n,γ)Gd156_ (n,γ)Gd157(n,γ)Gd158(n,γ)Gd159(β^-)_ Tb159(n,γ)Tb160(n,γ)Tb161		2.0					
		&Eu153(n,γ)*Eu154*(β^-)Gd154(n,γ)Gd155_ (n,γ)Gd156(n,γ)Gd157(n,γ)Gd158(n,γ)_ Gd159(β^-)Tb159(n,γ)Tb160(n,γ)Tb161		1.8	3.6				
Eu156	15.19 d	&Eu153(n,γ)*Eu154*(n,γ)Eu155(n,γ)Eu156	34.0	14.4	97.9	99.7	99.5	99.6	99.8
		Eu151(n,γ)Eu152m(β^+)Sm152(n,γ)_ Sm153(n,γ)Sm154(n,γ)Sm155(β^-)_ Eu155(n,γ)Eu156	28.9						
		&Eu151(n,γ)*Eu152*(n,γ)Eu153(n,γ)_ *Eu154*(n,γ)Eu155(n,γ)Eu156	22.0	29.9	2.0				
		&Eu151(n,γ)Eu152m(β^+)Sm152(n,γ)_ Sm153(β^-)Eu153(n,γ)*Eu154*(n,γ)Eu155_ (n,γ)Eu156	12.1	13.5					
		Eu151(n,γ)Eu152m(n,γ)Eu153(n,γ)_ Eu154(n,γ)Eu155(n,γ)Eu156	2.3						
		&Eu151(n,γ)Eu152(β^+)Sm152(n,γ)_ Sm153(β^-)Eu153(n,γ)*Eu154*(n,γ)Eu155_ (n,γ)Eu156	0.1	1.7					
		&Eu151(n,γ)Eu152m(β^-)Gd152(n,γ)_ Gd153(β^+)Eu153(n,γ)*Eu154*(n,γ)Eu155_ (n,γ)Eu156		39.8					
Eu148	54.50 d	Eu151(n,2n)Eu150(n,2n)Eu149(n,2n)Eu148				70.6			
		Eu151(n,2n)Eu150m(β^-)Gd150(n,2n)_ Gd149(β^+)Eu149(n,2n)Eu148				26.8			
		Eu151(n,3n)Eu149(n,2n)Eu148				0.8	4.3		
		Eu151(n,4n)Eu148					39.3	89.2	36.4
		Eu151(n,2n)Eu150(n,3n)Eu148					31.9	1.0	
	►	Eu153(n,3n)Eu151(n,4n)Eu148					8.7	5.2	

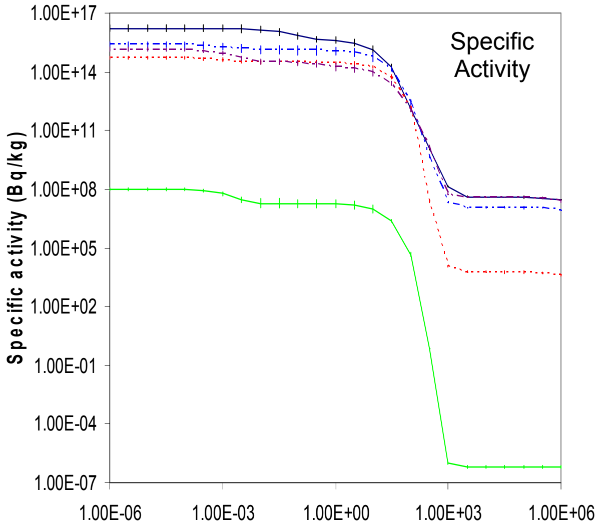
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Eu153(n,4n)Eu150(n,3n)Eu148					8.1	3.5	
		Eu153(n,3n)Eu151(n,2n)Eu150(n,3n)Eu148					3.6		
		Eu153(n,2n)Eu152(n,3n)Eu150(n,3n)Eu148					3.4		
		Eu153(n,6n)Eu148							59.0
Tb160	72.30 d	**&**Eu153(n,γ)*Eu154*(n,γ)Eu155(n,γ)_ Eu156(n,γ)Eu157(β^-)Gd157(n,γ)Gd158_ (n,γ)Gd159(β^-)Tb159(n,γ)Tb160	50.1	0.3	0.5				
		&Eu151(n,γ)*Eu152*(n,γ)Eu153(n,γ)_ *Eu154*(n,γ)Eu155(n,γ)Eu156(n,γ)Eu157_ (β^-)Gd157(n,γ)Gd158(n,γ)Gd159(β^-)_ Tb159(n,γ)Tb160	29.4	0.2					
		&Eu153(n,γ)*Eu154*(n,γ)Eu155(n,γ)_ Eu156(β^-)Gd156(n,γ)Gd157(n,γ)Gd158_ (n,γ)Gd159(β^-)Tb159(n,γ)Tb160	6.8	53.0	72.8				
		&Eu151(n,γ)Eu152(n,γ)Eu153(n,γ)_ *Eu154*(n,γ)Eu155(n,γ)Eu156(β^-)Gd156_ (n,γ)Gd157(n,γ)Gd158(n,γ)Gd159(β^-)_ Tb159(n,γ)Tb160	4.0	25.4	0.3				
		Eu151(n,γ)Eu152m(β^-)Gd152(n,γ)Gd153_ (n,γ)Gd154(n,γ)Gd155(n,γ)Gd156(n,γ)Gd157_ (n,γ)Gd158(n,γ)Gd159(β^-)Tb159(n,γ)Tb160		4.7					
		&Eu153(n,γ)*Eu154*(n,γ)Eu155(β^-)_ Gd155(n,γ)Gd156(n,γ)Gd157(n,γ)_ Gd158(n,γ)Gd159(β^-)Tb159(n,γ)Tb160		4.2	22.7				
		&Eu151(n,γ)Eu152(n,γ)Eu153(n,γ)*Eu154*_ (n,γ)Eu155(β^-)Gd155(n,γ)Gd156(n,γ)Gd157_ (n,γ)Gd158(n,γ)Gd159(β^-)Tb159(n,γ)Tb160		2.0					
		&Eu153(n,γ)*Eu154*(β^-)Gd154(n,γ)_ Gd155(n,γ)Gd156(n,γ)Gd157(n,γ)_ Gd158(n,γ)Gd159(β^-)Tb159(n,γ)Tb160		1.8	3.6				
Eu149	93.10 d	Eu151(n,2n)Eu150(n,2n)Eu149				70.6	0.8	1.1	
		Eu151(n,2n)Eu150m(β^-)Gd150(n,2n)_ Gd149(β^+)Eu149				26.8			
		Eu151(n,3n)Eu149				0.8	80.0	64.3	31.5
		Eu153(n,3n)Eu151(n,3n)Eu149					17.2	3.5	
		Eu153(n,2n)Eu152(n,4n)Eu149					1.0	4.8	
		Eu153(n,4n)Eu150(n,2n)Eu149					0.2	3.9	
		Eu153(n,5n)Eu149						18.6	65.1
Ta182	114.7 d	Very long pathways of (n,γ), β^-	100.0						
Gd153	240.4 d	Eu151(n,γ)Eu152m(β^-)Gd152(n,γ)Gd153	93.6	98.2	93.6				
		Eu151(n,γ)Eu152(β^-)Gd152(n,γ)Gd153	6.4	1.8	6.4				
		&Eu153(n,γ)*Eu154*(β^-)Gd154(n,2n)Gd153				52.1	29.9	27.5	28.2
		Eu153(n,2n)Eu152m(β^-)Gd152(n,γ)Gd153				38.3	50.4	55.0	56.2
		&Eu153(n,2n)*Eu152*(β^-)Gd152(n,γ)Gd153				7.7	17.1	15.7	14.4
		Eu153(n,2n)Eu152(n,n′)Eu152m(β^-)_ Gd152(n,γ)Gd153				1.8	2.3	1.6	1.1
Tm171	1.917 y	Very long pathways of (n,γ), β^-	100.0	100.0					
Eu155	4.753 y	**&**Eu153(n,γ)*Eu154*(n,γ)Eu155	33.1	14.0	97.8	99.9	99.6	99.7	99.8
		Eu151(n,γ)Eu152m(β^+)Sm152(n,γ)_ Sm153(n,γ)Sm154(n,γ)Sm155(β^-)Eu155	30.7						
		&Eu151(n,γ)*Eu152*(n,γ)Eu153(n,γ)_ *Eu154*(n,γ)Eu155	21.4	29.2	2.0				
		&Eu151(n,γ)Eu152m(β^+)Sm152(n,γ)_ Sm153(β^-)Eu153(n,γ)*Eu154*(n,γ)Eu155	11.9	13.6					
		Eu151(n,γ)Eu152m(n,γ)Eu153(n,γ)_ Eu154(n,γ)Eu155	2.2						
		&Eu151(n,γ)Eu152(β^+)Sm152(n,γ)_ Sm153(β^-)Eu153(n,γ)*Eu154*(n,γ)Eu155	0.1	1.7					
		&Eu151(n,γ)Eu152m(β^-)Gd152(n,γ)_ Gd153(β^+)Eu153(n,γ)*Eu154*(n,γ)Eu155		40.9					
Eu154	8.593 y►	**&**Eu153(n,γ)*Eu154*	48.3	2.6	95.9	100.0	99.9	99.9	100.0

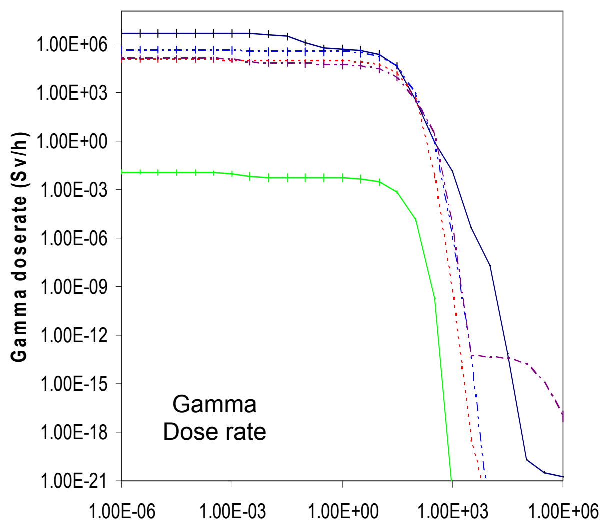
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Eu151(n,γ)Eu152(n,γ)Eu153(n,γ)*Eu154*	31.1	10.8	3.7				
		Eu151(n,γ)Eu152m(β^+)Sm152(n,γ)_ Sm153(β^-)Eu153(n,γ)Eu154	16.6	14.6					
		Eu151(n,γ)Eu152m(n,γ)Eu153(n,γ)Eu154	3.3						
		Eu151(n,γ)Eu152(β^+)Sm152(n,γ)Sm153_ (β^-)Eu153(n,γ)Eu154	0.2	2.1					
		Eu151(n,γ)Eu152m(β^-)Gd152(n,γ)_ Gd153(β^+)Eu153(n,γ)Eu154		67.2	0.2				
		Eu151(n,γ)Eu152(β^-)Gd152(n,γ)Gd153_ (β^+)Eu153(n,γ)Eu154		1.2					
Eu152	13.525 y	**&**Eu151(n,γ)*Eu152*	100.0	99.8	100.0				
		&Eu153(n,2n)*Eu152*				99.8	99.9	97.0	97.0
Eu150	36.359 y	Eu151(n,2n)Eu150				98.5	68.8	21.2	44.0
		Eu153(n,2n)Eu152(n,2n)Eu151(n,2n)Eu150				1.2			
		Eu153(n,4n)Eu150					17.4	77.5	54.5
		Eu153(n,3n)Eu151(n,2n)Eu150					8.1		
		Eu153(n,2n)Eu152(n,3n)Eu150					5.4		
Gd148	74.602 y	Eu151(n,2n)Eu150m(β^-)Gd150(n,2n)_ Gd149(n,2n)Gd148				98.1			
		Eu151(n,2n)Eu150(n,n′)Eu150m(β^-)_ Gd150(n,2n)Gd149(n,2n)Gd148				1.0			
		Eu151(n,2n)Eu150m(β^-)Gd150(n,3n)Gd148					66.9	18.4	24.9
		Eu153(n,4n)Eu150m(β^-)Gd150(n,3n)Gd148					19.9	79.6	43.1
		Eu153(n,3n)Eu151(n,2n)Eu150m(β^-)_ Gd150(n,3n)Gd148					5.1		
		Eu153(n,2n)Eu152(n,3n)Eu150m(β^-)_ Gd150(n,3n)Gd148					4.5		
		Eu153(n,2n)Eu152m(β^-)Gd152(n,3n)_ Gd150(n,3n)Gd148					2.0		
		Eu153(n,2n)Eu152m(β^-)Gd152(n,5n)Gd148							25.3
		Eu153(n,2n)Eu152(β^-)Gd152(n,5n)Gd148							5.0
Sm151	90.0 y	Eu151(n,γ)Eu152(n,α)Pm149(β^-)_ Sm149(n,γ)Sm150(n,γ)Sm151	35.8	36.9	0.8				
		Eu151(n,γ)Eu152m(β^-)Gd152(n,γ)_ Gd153(n,γ)Gd154(n,α)Sm151	35.3	1.7	0.5				
		Eu151(n,γ)Eu152m(β^-)Gd152(n,α)_ Sm149(n,γ)Sm150(n,γ)Sm151	16.0	56.9	3.0				
		Eu151(n,γ)Eu152(n,α)Pm149(n,γ)_ Pm150(β^-)Sm150(n,γ)Sm151	8.1						
		Eu151(n,γ)Eu152m(β^-)Gd152(n,γ)_ Gd153(n,α)Sm150(n,γ)Sm151	2.5	3.4	0.2				
		&Eu153(n,γ)*Eu154*(β^-)Gd154(n,α)Sm151	0.5		86.3				
		Eu151(n,γ)Eu152(n,γ)Eu153(n,γ)Eu154_ (β^-)Gd154(n,α)Sm151	0.3		1.0				
		&Eu153(n,γ)*Eu154*(n,α)Pm151(β^-)Sm151			7.8				
		&Eu153(n,2n)*Eu152*(β^+)Sm152(n,2n)Sm151				35.7	1.7		
		Eu153(n,2n)Eu152m(β^+)Sm152(n,2n)Sm151				33.7	1.0		
		Eu151(n,p)Sm151				24.7	38.0	13.3	6.6
		Eu153(n,2n)Eu152(n,d)Sm151				1.8	4.7		
		Eu153(n,d)Sm152(n,2n)Sm151				1.6	5.5		
		Eu153(n,2n)Eu152(n,n′)Eu152m(β^+)_ Sm152(n,2n)Sm151				1.2			
		Eu153(n,t)Sm151				0.4	42.9	79.1	88.5
		Eu153(n,3n)Eu151(n,p)Sm151					4.4		
Ho166m	1200 y	Very long pathways of (n,γ), β^-	100.0	100.0	100.0				
La137	6.0 10^4 y	Long pathways of (n,2n), (n,α), (n,α)				100.0	100.0	100.0	100.0
Gd150	1.8 10^6 y	Eu151(n,2n)Eu150m(β^-)Gd150				96.9	62.7	18.3	35.8
		Eu151(n,2n)Eu150(n,n′)Eu150m(β^-)Gd150				1.5	0.9		
		Eu153(n,2n)Eu152(n,2n)Eu151(n,2n)_ Eu150m(β^-)Gd150				1.1			
		Eu153(n,4n)Eu150m(β^-)Gd150					18.7	79.3	62.0

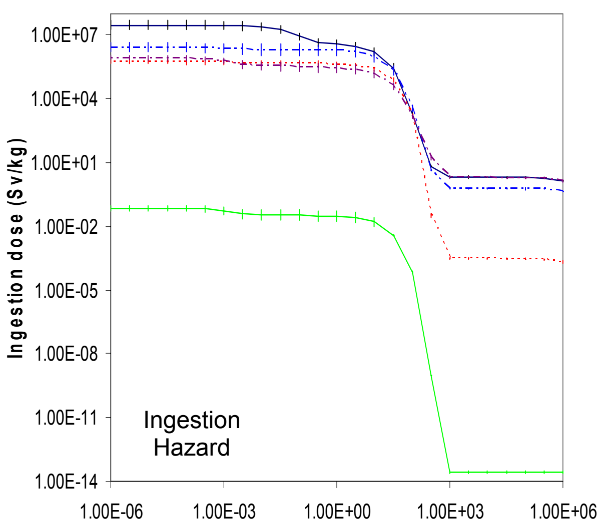
Nuclide	$T_{1/2}$	Pathway	210	186	151	42	30	21	6
		Eu153(n,3n)Eu151(n,2n)Eu150m(β^-)Gd150					7.2		
		Eu153(n,2n)Eu152(n,3n)Eu150m(β^-)Gd150					6.1		
		Eu153(n,2n)Eu152m(β^-)Gd152(n,3n)Gd150					2.8		
Hf182	9.0 10^6 y	Very long pathways of (n,γ), β^-	100.0						
Sm146	1.0 10^8 y	Eu151(n,2n)Eu150m(β^-)Gd150(n,nα)Sm146				29.9	0.4		
		Eu151(n,nα)Pm147(β^-)Sm147(n,2n)Sm146				16.4	0.5		
		Eu151(n,2n)Eu150(n,2n)Eu149(β^+)Sm149_ (n,2n)Sm148(n,2n)Sm147(n,2n)Sm146				10.6			
		Eu151(n,α)Pm148m(β^-)Sm148(n,2n)_ Sm147(n,2n)Sm146				6.0			
		&Eu151(n,α)*Pm148*(β^-)Sm148(n,2n)_ Sm147(n,2n)Sm146				5.8			
		Eu151(n,2n)Eu150m(β^-)Gd150(n,α)_ Sm147(n,2n)Sm146				5.0			
		Eu151(n,2n)Eu150(n,nα)Pm146(β^-)Sm146				4.1			
		Eu151(n,2n)Eu150(n,2n)Eu149(n,2n)_ Eu148(β^+)Sm148(n,2n)Sm147(n,2n)Sm146				3.3			
		Eu151(n,nα)Pm147(n,2n)Pm146(β^-)Sm146				2.2			
		Eu151(n,3n)Eu149(β^+)Sm149(n,4n)Sm146					51.7	27.6	1.1
		Eu151(n,4n)Eu148(β^+)Sm148(n,3n)Sm146					11.2	26.9	0.9
		Eu151(n,3n)Eu149(β^+)Sm149(n,2n)_ Sm148(n,3n)Sm146					4.9	0.2	
		Eu151(n,3n)Eu149(β^+)Sm149(n,3n)_ Sm147(n,2n)Sm146					4.9	0.1	
		Eu153(n,3n)Eu151(n,3n)Eu149(β^+)_ Sm149(n,4n)Sm146					3.7	0.5	
		Eu151(n,2n)Eu150(n,3n)Eu148(β^+)_ Sm148(n,3n)Sm146					3.1		
		Eu151(n,t)Sm149(n,4n)Sm146					1.0	5.2	0.4
		Eu151(n,3n)Eu149(n,4n)Eu146(β^+)Sm146					0.8	4.2	0.2
		Eu153(n,5n)Eu149(β^+)Sm149(n,4n)Sm146						8.0	2.3
		Eu153(n,4n)Eu150(n,5n)Eu146(β^+)Sm146						3.5	1.3
		Eu151(n,6n)Eu146(β^+)Sm146							74.8
		Eu151(n,3nt)Sm146							4.9
		Pathways involving (n,α), (n,nα), (n,2n), β^-,β^+				16.7	17.8	23.8	14.1
Lu176	4.0 10^{10} y	Very long pathways of (n,γ), β^-	100.0	100.0					
La138	1.0 10^{11} y	Long pathways of (n,2n), (n,α), (n,α)				100.0	100.0	100.0	100.0
Sm147	1.1 10^{11} y	Eu151(n,γ)Eu152(n,α)Pm149(β^-)_ Sm149(n,γ)Sm150(n,α)Nd147(β^-)_ Pm147(β^-)Sm147	33.9	38.8	0.5				
		Eu151(n,γ)Eu152(n,α)Pm149(β^-)_ Sm149(n,α)Nd146(n,γ)Nd147(β^-)_ Pm147(β^-)Sm147	28.8	0.2	18.5				
		Eu151(n,γ)Eu152m(β^-)Gd152(n,α)_ Sm149(n,γ)Sm150(n,α)Nd147(β^-)_ Pm147(β^-)Sm147	14.6	56.8	1.8				
		Eu151(n,γ)Eu152m(β^-)Gd152(n,α)_ Sm149(n,α)Nd146(n,γ)Nd147(β^-)_ Pm147(β^-)Sm147	12.0	0.3	72.9				
		Eu151(n,γ)Eu152(n,α)Pm149(n,γ)_ Pm150(β^-)Sm150(n,α)Nd147(β^-)_ Pm147(β^-)Sm147	7.7						
		Eu151(n,γ)Eu152m(β^-)Gd152(n,γ)_ Gd153(n,α)Sm150(n,α)Nd147(β^-)_ Pm147(β^-)Sm147	2.3	3.4	0.1				
		Eu151(n,γ)Eu152m(β^-)Gd152(n,α)Sm149_ (n,α)Nd146(n,γ)Nd147(β^-)Pm147(β^-)Sm147		2.1					
		Eu151(n,2n)Eu150(n,2n)Eu149(β^+)_ Sm149(n,2n)Sm148(n,2n)Sm147				24.0			
	►	Eu151(n,nα)Pm147(β^-)Sm147				19.2	5.3	2.4	0.8

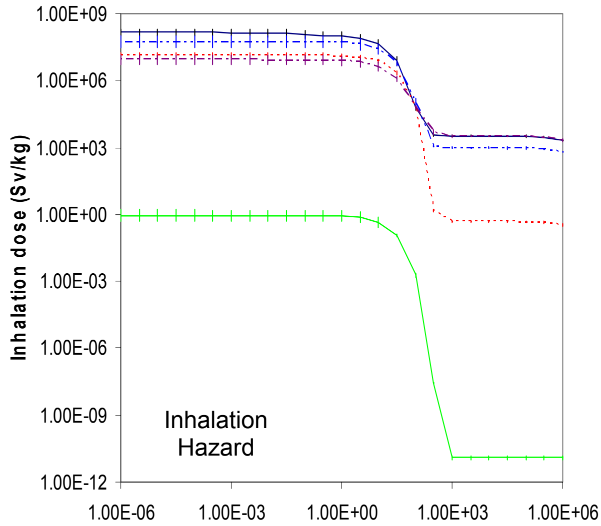
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Eu151(n,2n)Eu150m(β$^-$)Gd150(n,2n)_ Gd149(β$^+$)Eu149(β$^+$)Sm149(n,2n)_ Sm148(n,2n)Sm147				8.5			
		Eu151(n,α)Pm148m(β$^-$)Sm148(n,2n)Sm147				7.9			
		&Eu151(n,α)*Pm148*(β$^-$)Sm148(n,2n)Sm147				7.5			
		Eu151(n,2n)Eu150m(β$^-$)Gd150(n,α)Sm147				6.5			
		Eu151(n,2n)Eu150(n,2n)Eu149(n,2n)_ Eu148(β$^+$)Sm148(n,2n)Sm147				6.2			
		Eu151(n,2n)Eu150(n,2n)Eu149(β$^+$)_ Sm149(n,3n)Sm147				3.4	0.2		
		Eu151(n,2n)Eu150(n,α)Pm147(β$^-$)Sm147				3.2			
		Eu151(n,2n)Eu150m(β$^-$)Gd150(n,2n)_ Gd149(β$^+$)Eu149(n,2n)Eu148(β$^+$)_ Sm148(n,2n)Sm147				2.2			
		Eu151(n,3n)Eu149(β$^+$)Sm149(n,3n)Sm147				0.1	66.1	4.4	0.6
		Eu151(n,3n)Eu149(n,3n)Eu147(β$^+$)Sm147					11.3	0.8	
		Eu153(n,3n)Eu151(n,3n)Eu149(β$^+$)_ Sm149(n,3n)Sm147					4.7		
		Eu151(n,2n)Eu150(n,4n)Eu147(β$^+$)Sm147					1.7	5.1	0.4
		Eu151(n,4n)Eu148(β$^+$)Sm148(n,2n)Sm147					1.0	8.1	0.5
		Eu151(n,d)Sm150(n,4n)Sm147					0.6	2.8	0.3
		Eu153(n,4n)Eu150(n,4n)Eu147(β$^+$)Sm147					0.4	18.7	0.4
		Eu151(n,5n)Eu147(β$^+$)Sm147						32.1	72.6
		Eu151(n,2nt)Sm147						1.8	13.2
		Eu153(n,4n)Eu150m(β$^-$)Gd150(n,4n)_ Gd147(β$^+$)Eu147(β$^+$)Sm147							6.6
Gd152	$1.1\ 10^{14}$ y	Eu151(n,γ)Eu152m(β$^-$)Gd152	93.5	98.2	92.8				
		Eu151(n,γ)Eu152(β$^-$)Gd152	6.5	1.8	7.2				
		Eu153(n,2n)Eu152m(β$^-$)Gd152				77.5	68.9	73.2	75.7
		&Eu153(n,2n)*Eu152*(β$^-$)Gd152				18.0	27.1	24.1	22.6
		&Eu153(n,2n)*Eu152*(n,n′)Eu152m(β$^-$)Gd152				4.4	3.8	2.4	1.7
Gd160	$1.3\ 10^{17}$ y	**&**Eu153(n,γ)*Eu154*(n,γ)Eu155(n,γ)_ Eu156(n,γ)Eu157(β$^-$)Gd157(n,γ)Gd158_ (n,γ)Gd159(n,γ)Gd160	51.0	0.5	0.5				
		&Eu151(n,γ)Eu152(n,γ)Eu153(n,γ)*Eu154*_ (n,γ)Eu155(n,γ)Eu156(n,γ)Eu157(β$^-$)_ Gd157(n,γ)Gd158(n,γ)Gd159(n,γ)Gd160	30.3	0.2					
		&Eu153(n,γ)*Eu154*(n,γ)Eu155(n,γ)_ Eu156(β$^-$)Gd156(n,γ)Gd157(n,γ)Gd158_ (n,γ)Gd159(n,γ)Gd160	6.0	56.0	72.1				
		Eu151(n,γ)Eu152m(β$^-$)Gd152(n,γ)Gd153_ (n,γ)Gd154(n,γ)Gd155(n,γ)Gd156(n,γ)_ Gd157(n,γ)Gd158(n,γ)Gd159(n,γ)Gd160	4.3						
		&Eu151(n,γ)Eu152(n,γ)Eu153(n,γ)*Eu154*_ (n,γ)Eu155(n,γ)Eu156(β$^-$)Gd156(n,γ)_ Gd157(n,γ)Gd158(n,γ)Gd159(n,γ)Gd160	3.5	24.4	0.3				
		&Eu153(n,γ)*Eu154*(n,γ)Eu155(β$^-$)_ Gd155(n,γ)Gd156(n,γ)Gd157(n,γ)_ Gd158(n,γ)Gd159(n,γ)Gd160		4.1	23.2				
		Eu153(n,γ)Eu154(β$^-$)Gd154(n,γ)_ Gd155(n,γ)Gd156(n,γ)Gd157(n,γ)_ Gd158(n,γ)Gd159(n,γ)Gd160		1.8	3.7				
		Eu151(n,γ)Eu152(n,γ)Eu153(n,γ)Eu154_ (n,γ)Eu155(β$^-$)Gd155(n,γ)Gd156(n,γ)_ Gd157(n,γ)Gd158(n,γ)Gd159(n,γ)Gd160		1.7					

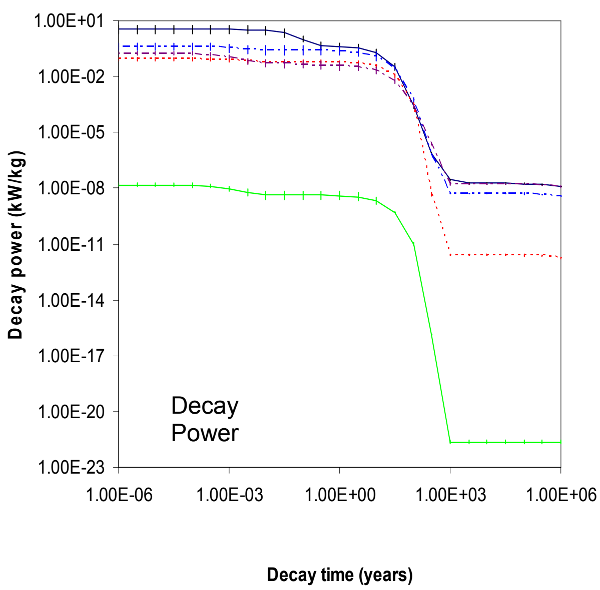
Europium activation characteristics

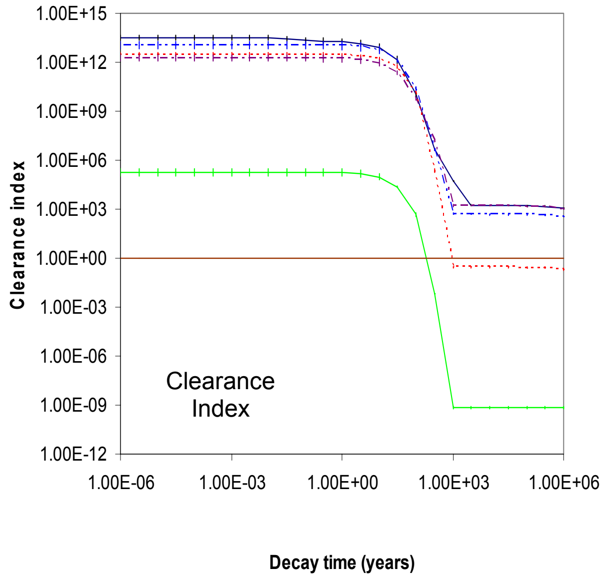






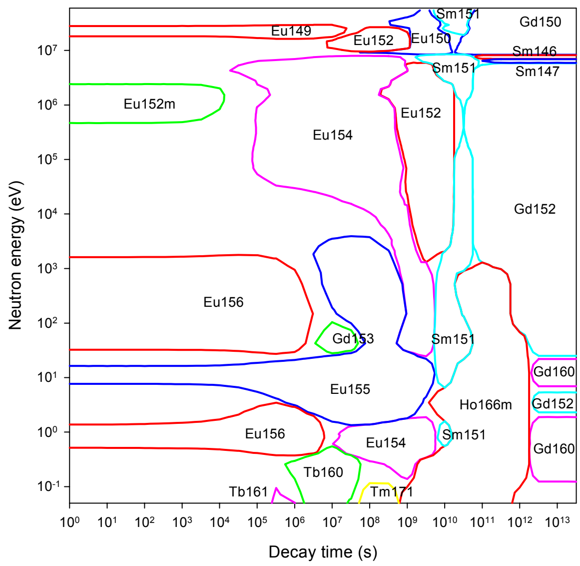




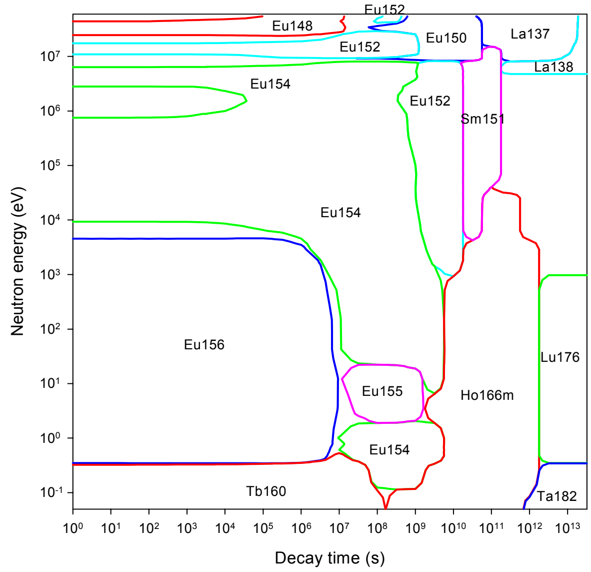


Europium importance diagrams & transmutation

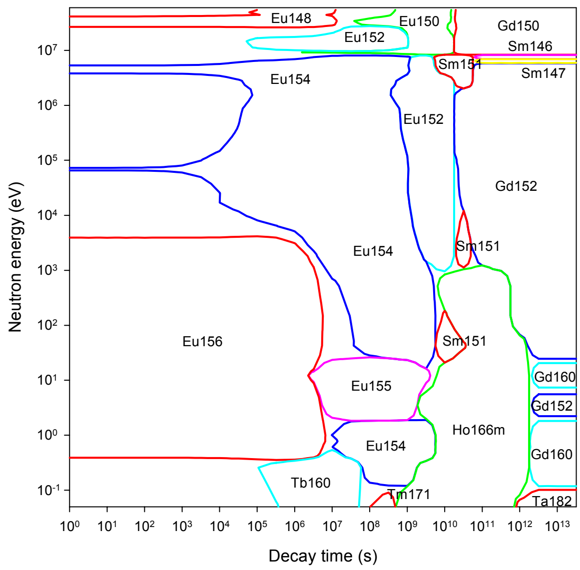
Activity



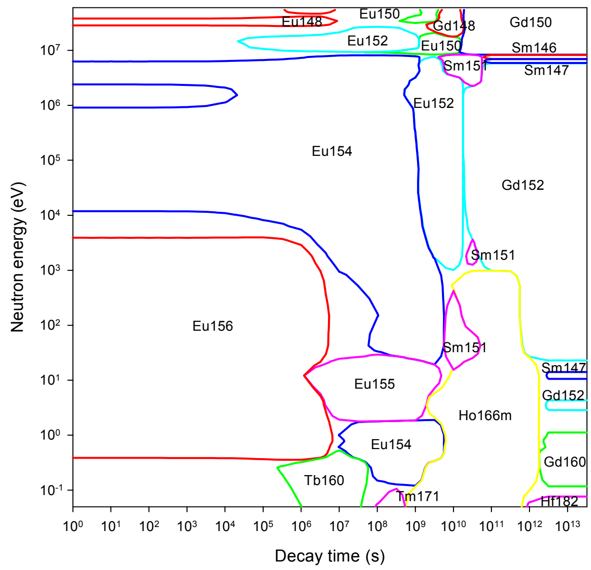
Dose rate



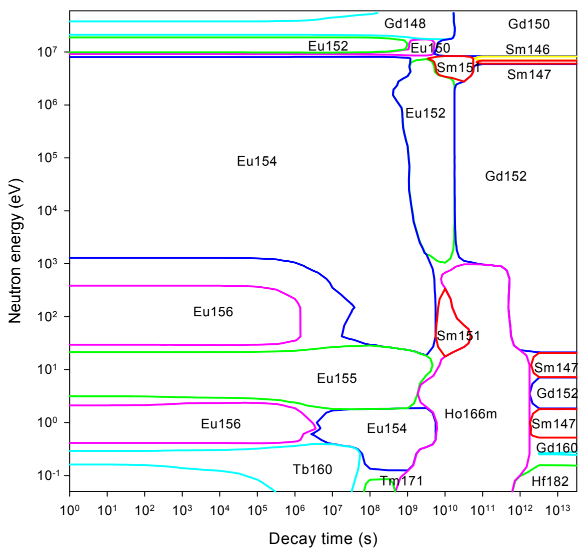
Heat output



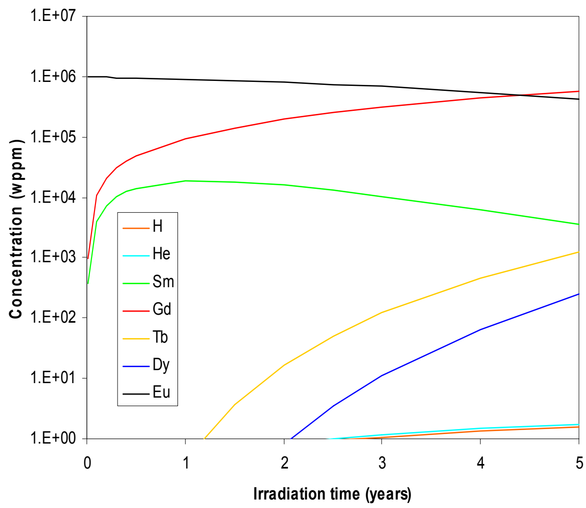
Ingestion dose



Inhalation dose



First wall transmutation



Gadolinium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	64		
Crustal abundance / wppm	6.2	Gd152	0.20 ($T_{1/2}$=1.08 10^{14} y)
Melting point / K	1587	Gd154	2.18
Boiling point / K	3537	Gd155	14.80
Density / kgm^{-3}	7901	Gd156	20.47
Thermal conductivity / Wm^{-1}K^{-1}	10.6	Gd157	15.65
Electrical resistivity /Ωm	1.34 10^{-6}	Gd158	24.84
Coefficient of thermal expansion / K^{-1}	9.0 10^{-6}	Gd160	21.86 ($T_{1/2}$=1.30 10^{17} y)
Crystal structure	HCP		
Number of stable isotopes	5 (7)		
Mean atomic weight	157.25		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	4.66E15	4.42E15	1.79E15	4.82E13	1.90E11	6.31E3
Gd159	50.51	53.07	4.90			
Tb160	28.97	30.53	72.75	84.33		
Tb161	11.56	12.18	20.83			
Gd161	6.60	2.57				
Gd153	0.15	0.16	0.39	5.09		
Dy159	0.12	0.13	0.32	2.07		
Eu155	0.05	0.06	0.14	4.42		
Eu154	0.04	0.04	0.10	3.38	0.29	
Tb158		0.01	0.02	0.57	97.92	
Tb157				0.01	1.54	
Gd150						99.92

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	5.15E-1	4.83E-1	3.12E-1	9.59E-3	2.78E-5	2.83E-12
Tb160	58.17	62.05	92.83	94.24		
Gd159	26.71	28.40	1.65			
Gd161	9.35	3.68				
Tb161	3.93	4.19	4.49			
Eu156	0.54	0.57	0.75			
Dy165	0.42	0.44				
Tb162	0.31	0.20				
Eu154	0.08	0.09	0.14	4.14	0.49	
Gd153	0.03	0.03	0.05	0.60		
Tb158	0.01	0.01	0.01	0.42	99.20	
Gd150						99.93

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	3.85E5	3.78E5	3.51E5	1.14E4	3.42E1	6.62E-21
Tb160	93.33	94.99	98.81	95.02		
Gd159	2.54	2.58	0.10			
Gd161	2.53	0.95				
Eu156	0.94	0.96	0.87			
Eu154	0.14	0.15	0.16	4.44	0.50	
Tb158	0.01	0.01	0.01	0.44	99.22	
Lu176						99.75

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	3.87E6	3.82E6	2.42E6	7.01E4	2.07E2	3.28E-4
Tb160	55.80	56.55	86.00	92.80		
Gd159	29.80	30.10	1.78			
Tb161	10.02	10.15	11.08			
Eu154	0.09	0.09	0.15	4.65	0.54	
Eu155	0.02	0.02	0.03	0.97		
Tb158	0.01	0.01	0.01	0.43	99.14	
Gd150						99.92

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.11E7	1.10E7	9.80E6	4.05E5	8.63E3	5.23E01
Tb160	85.04	85.47	93.06	70.28		
Tb161	6.30	6.33	4.95			
Gd159	5.72	5.73	0.24			
Eu154	0.84	0.85	0.96	21.32	0.34	
Eu155	0.15	0.15	0.17	3.63		
Gd153	0.13	0.13	0.15	1.27		
Tb158	0.11	0.11	0.13	3.10	99.32	
Gd150					0.01	99.99

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	1.59E12	1.49E12	1.36E12	5.99E10	1.63E8	2.63E-1
Tb160	85.10	90.37	96.07	67.89		
Gd161	8.81	3.46				
Tb161	1.79	1.90	1.45			
Gd159	1.48	1.57	0.07			
Eu154	1.11	1.18	1.30	27.20	3.40	
Eu156	0.83	0.88	0.82			
Tb158	0.01	0.02	0.02	0.38	95.32	
Gd150						99.93

Gadolinium

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Gd161	3.66 m	Gd160(n,γ)Gd161	100.0	100.0	100.0	100.0	99.8	99.8	99.9
Tb162	7.60 m	Gd160(n,γ)Gd161(β^-)Tb161(n,γ)Tb162	99.1	34.2	100.0	84.0	41.8	47.2	61.8
		Gd158(n,γ)Gd159(β^-)Tb159(n,γ)Tb160_ (n,γ)Tb161(n,γ)Tb162	0.5	22.4					
		Gd157(n,γ)Gd158(n,γ)Gd159(β^-)Tb159_ (n,γ)Tb160(n,γ)Tb161(n,γ)Tb162	0.4	14.5					
		Gd156(n,γ)Gd157(n,γ)Gd158(n,γ)Gd159_ (β^-)Tb159(n,γ)Tb160(n,γ)Tb161(n,γ)Tb162		16.2					
		Gd155(n,γ)Gd156(n,γ)Gd157(n,γ)_ Gd158(n,γ)Gd159(β^-)Tb159(n,γ)Tb160_ (n,γ)Tb161(n,γ)Tb162		11.1					
		Gd154(n,γ)Gd155(n,γ)Gd156(n,γ)_ Gd157(n,γ)Gd158(n,γ)Gd159(β^-)Tb159_ (n,γ)Tb160(n,γ)Tb161(n,γ)Tb162		1.6					
		Gd160(n,γ)Gd161(β^-)Tb161(β^-)Dy161_ (n,γ)Dy162(n,p)Tb162				15.8	57.8	52.4	38.0
Tb154m	9.00 h	**&**Gd160(n,2n)Gd159(β^-)Tb159(n,2n)_ *Tb158*(n,2n)Tb157(n,2n)*Tb156*(n,2n)_ Tb155(n,2n)Tb154m				88.2			
		&Gd160(n,2n)Gd159(β^-)Tb159(n,2n)_ *Tb158*(n,2n)Tb157(n,2n)Tb156m(n,2n)_ Tb155(n,2n)Tb154m				6.7			
		Gd160(n,2n)Gd159(β^-)Tb159(n,3n)_ Tb157(n,4n)Tb154m					48.3	82.1	1.4
		Gd160(n,2n)Gd159(β^-)Tb159(n,3n)_ Tb157(n,3n)Tb155(n,2n)Tb154m					13.8		
		&Gd160(n,2n)Gd159(β^-)Tb159(n,2n)_ *Tb158*(n,3n)*Tb156*(n,3n)Tb154m					11.9		
		&Gd160(n,2n)Gd159(β^-)Tb159(n,3n)_ Tb157(n,2n)*Tb156*(n,3n)Tb154m					11.3		
		Gd160(n,d)Eu159(β^-)Gd159(β^-)Tb159_ (n,3n)Tb157(n,4n)Tb154m					3.8	14.2	0.3
		&Gd160(n,2n)Gd159(β^-)Tb159(n,4n)_ *Tb156*(n,3n)Tb154m					3.8	0.3	
		Gd160(n,d)Eu159(β^-)Gd159(β^-)Tb159_ (n,3n)Tb157(n,3n)Tb155(n,2n)Tb154m					1.1		
		&Gd160(n,2n)Gd159(β^-)Tb159(n,2n)_ *Tb158*(n,5n)Tb154m						2.2	3.9
		Gd160(n,2n)Gd159(β^-)Tb159(n,6n)Tb154m							74.0
		Gd160(n,d)Eu159(β^-)Gd159(β^-)Tb159_ (n,6n)Tb154m							18.7
Gd159	18.479 h	Gd158(n,γ)Gd159	61.2	33.0	87.8	0.2	0.6	0.5	
		Gd157(n,γ)Gd158(n,γ)Gd159	38.6	20.8	11.5				
		Gd156(n,γ)Gd157(n,γ)Gd158(n,γ)Gd159	0.1	25.6	0.7				
		Gd155(n,γ)Gd156(n,γ)Gd157(n,γ)_ Gd158(n,γ)Gd159		17.9					
		Gd154(n,γ)Gd155(n,γ)Gd156(n,γ)_ Gd157(n,γ)Gd158(n,γ)Gd159		2.6					
		Gd160(n,2n)Gd159				99.7	91.7	84.2	78.6
		Gd160(n,d)Eu159(β^-)Gd159						15.8	21.4
Tb161	6.89 d	Gd160(n,γ)Gd161(β^-)Tb161	99.1	34.5	99.5	100.0	99.5	99.6	99.8
		Gd158(n,γ)Gd159(β^-)Tb159(n,γ)Tb160_ (n,γ)Tb161	0.6	22.5	0.5				
	►	Gd157(n,γ)Gd158(n,γ)Gd159(β^-)Tb159_ (n,γ)Tb160(n,γ)Tb161	0.3	14.1					

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Gd156(n,γ)Gd157(n,γ)Gd158(n,γ)_ Gd159(β^-)Tb159(n,γ)Tb160(n,γ)Tb161		16.3					
		Gd155(n,γ)Gd156(n,γ)Gd157(n,γ)Gd158_ (n,γ)Gd159(β^-)Tb159(n,γ)Tb160(n,γ)Tb161		11.1					
		Gd154(n,γ)Gd155(n,γ)Gd156(n,γ)_ Gd157(n,γ)Gd158(n,γ)Gd159(β^-)Tb159_ (n,γ)Tb160(n,γ)Tb161		1.5					
Eu156	15.19 d	Gd152(n,γ)Gd153(β^+)Eu153(n,γ)Eu154_ (n,γ)Eu155(n,γ)Eu156	98.4	98.4	98.3				
		Gd156(n,p)Eu156				62.4	13.4	5.5	2.3
		Gd157(n,2n)Gd156(n,p)Eu156				13.2	0.6		
		Gd160(n,2n)Gd159(β^-)Tb159(n,α)Eu156				12.6			
		Gd157(n,d)Eu156				5.9	49.2	35.6	24.5
		Gd158(n,2n)Gd157(n,2n)Gd156(n,p)Eu156				2.9			
		Gd158(n,2n)Gd157(n,d)Eu156				2.6	2.6	1.4	
		Gd160(n,nα)Sm156(β^-)Eu156				0.2	10.1	4.3	
		Gd158(n,t)Eu156					11.1	40.5	44.3
		Gd160(n,4n)Gd157(n,d)Eu156					5.6	7.0	
		Gd158(n,3n)Gd156(n,p)Eu156					3.6		
		Gd160(n,3n)Gd158(n,t)Eu156					1.6	1.7	
		Gd160(n,2nt)Eu156						1.0	21.1
Tb160	72.30 d	Gd158(n,γ)Gd159(β^-)Tb159(n,γ)Tb160	61.9	34.2	93.5	0.2	0.6	0.5	0.5
		Gd157(n,γ)Gd158(n,γ)Gd159(β^-)Tb159_ (n,γ)Tb160	38.0	21.5	6.2				
		Gd156(n,γ)Gd157(n,γ)Gd158(n,γ)_ Gd159(β^-)Tb159(n,γ)Tb160		24.8	0.2				
		Gd155(n,γ)Gd156(n,γ)Gd157(n,γ)_ Gd158(n,γ)Gd159(β^-)Tb159(n,γ)Tb160		16.9					
		Gd154(n,γ)Gd155(n,γ)Gd156(n,γ)Gd157_ (n,γ)Gd158(n,γ)Gd159(β^-)Tb159(n,γ)Tb160		2.4					
		Gd160(n,2n)Gd159(β^-)Tb159(n,γ)Tb160				99.2	89.0	79.9	73.2
		Gd160(n,γ)Gd161(β^-)Tb161(n,2n)Tb160				0.4	0.1		
		Gd160(n,d)Eu159(β^-)Gd159(β^-)Tb159_ (n,γ)Tb160					6.9	13.9	18.5
		Gd160(n,γ)Gd161(β^-)Tb161(β^-)Dy161_ (n,d)Tb160					3.4	5.5	7.6
Ta182	114.7 d	Very long pathways of (n,γ), β^-	100.0	100.0					
Tm170	128.6 d	Very long pathways of (n,γ), β^-	100.0	100.0	100.0				
Gd153	240.4 d	Gd152(n,γ)Gd153	100.0	100.0	100.0				
		Gd155(n,2n)Gd154(n,2n)Gd153				55.8	1.2	0.5	0.3
		Gd154(n,2n)Gd153				34.5	3.9	2.2	1.9
		Gd156(n,2n)Gd155(n,2n)Gd154(n,2n)Gd153				9.1			
		Gd155(n,3n)Gd153					66.0	13.9	10.3
		Gd157(n,3n)Gd155(n,3n)Gd153					10.6	0.6	0.3
		Gd156(n,3n)Gd154(n,2n)Gd153					7.1	1.1	0.5
		Gd156(n,2n)Gd155(n,3n)Gd153					2.5		0.2
		Gd158(n,4n)Gd155(n,3n)Gd153					2.0	3.0	0.5
		Gd156(n,4n)Gd153					1.9	60.1	17.5
		Gd157(n,4n)Gd154(n,2n)Gd153					1.1	2.2	0.5
		Gd158(n,3n)Gd156(n,4n)Gd153					0.4	3.5	0.6
		Gd157(n,5n)Gd153						4.4	24.6
		Gd160(n,5n)Gd156(n,4n)Gd153						3.0	1.0
		Gd157(n,2n)Gd156(n,4n)Gd153						1.5	0.3
		Gd160(n,4n)Gd157(n,5n)Gd153						0.7	1.0
		Gd158(n,6n)Gd153							34.8
		Gd158(n,5n)Gd154(n,2n)Gd153							1.5
		Gd160(n,6n)Gd155(n,3n)Gd153							1.0
Tm171	1.917 y	Very long pathways of (n,γ), β^-	100.0	100.0	100.0				
Eu155	4.753 y	**&**Gd152(n,γ)Gd153(β^+)Eu153(n,γ)_ *Eu154*(n,γ)Eu155	100.0	100.0	100.0				
		Gd155(n,p)Eu155				51.1	10.3	4.2	1.5
	►	Gd158(n,α)Sm155(β^-)Eu155				28.0	7.9	1.4	

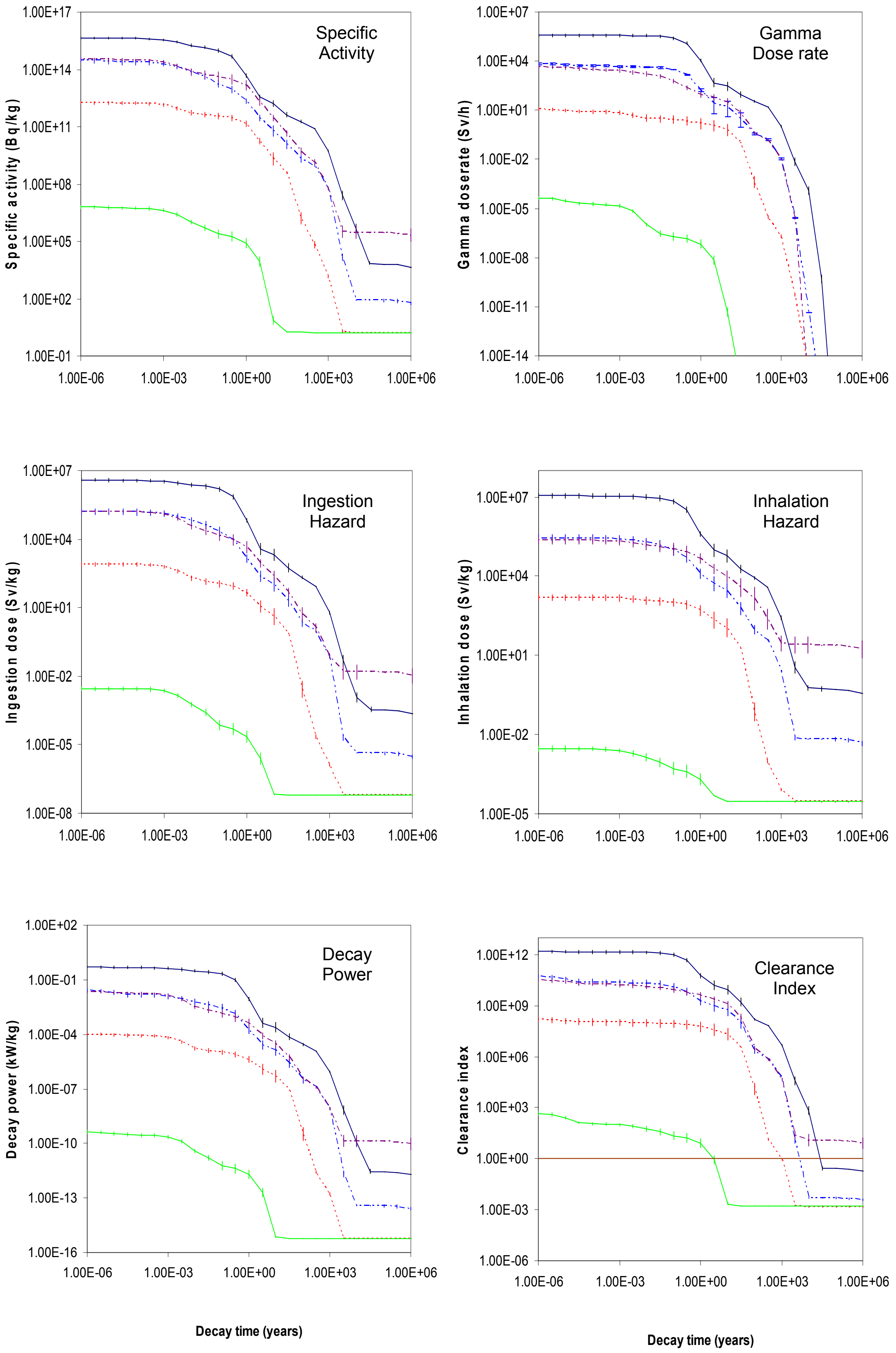
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	Gd156(n,2n)Gd155(n,p)Eu155				10.9	0.3		
		Gd156(n,d)Eu155				6.3	54.3	44.0	27.7
		Gd157(n,t)Eu155				0.8	10.9	26.8	24.0
		Gd157(n,2n)Gd156(n,d)Eu155				0.8	1.3	0.7	
		Gd158(n,3n)Gd156(n,d)Eu155					8.3	1.8	
		Gd158(n,nt)Eu155					1.4	9.7	35.4
		Gd157(n,3n)Gd155(n,p)Eu155					1.1		
		Gd160(n,4n)Gd157(n,t)Eu155					0.7	2.9	
		Gd160(n,2nα)Sm155(β^-)Eu155					0.4	3.6	
		Gd160(n,5n)Gd156(n,d)Eu155						1.5	
		Gd160(n,3nt)Eu155							3.2
Eu154	8.593 y	**&**Gd152(n,γ)Gd153(β^+)Eu153(n,γ)_ *Eu154*	100.0	100.0	100.0				
		&Gd155(n,2n)Gd154(n,p)*Eu154*				24.3	0.7		
		&Gd154(n,p)*Eu154*				22.9	3.8	1.2	
		&Gd155(n,d)*Eu154*				16.7	60.8	36.3	19.2
		&Gd155(n,p)Eu155(n,2n)*Eu154*				15.3	0.2		
		&Gd158(n,α)Sm155(β^-)Eu155(n,2n)*Eu154*				8.3			
		&Gd156(n,2n)Gd155(n,d)*Eu154*				3.4	1.1		
		&Gd156(n,2n)Gd155(n,2n)Gd154(n,p)*Eu154*				3.1			
		&Gd156(n,d)Eu155(n,2n)*Eu154*				3.0			
		&Gd156(n,2n)Gd155(n,p)Eu155(n,2n)*Eu154*				2.1			
		&Gd156(n,d)Eu155(n,2n)*Eu154*				1.9	1.3	0.6	
		&Gd156(n,t)*Eu154*					11.2	36.8	30.3
		Gd157(n,3n)Gd155(n,d)Eu154					4.8	0.8	
		Gd156(n,3n)Gd154(n,p)Eu154					4.1		
		&Gd157(n,nt)*Eu154*					1.8	8.5	22.9
		Gd158(n,3n)Gd156(n,t)Eu154					1.3	1.0	
		Gd158(n,4n)Gd155(n,d)Eu154					0.9	3.8	
		&Gd158(n,2nt)*Eu154*						0.5	18.3
Eu152	13.525 y	**&**Gd154(n,α)Sm151(β^-)Eu151(n,γ)*Eu152*	90.1	0.3	99.9				
		Gd152(n,α)Sm149(n,γ)Sm150(n,γ)_ Sm151(β^-)Eu151(n,γ)Eu152	4.8	90.3					
		Gd152(n,γ)Gd153(n,γ)Gd154(n,α)_ Sm151(β^-)Eu151(n,γ)Eu152	4.4	3.7					
		Gd152(n,γ)Gd153(n,α)Sm150(n,γ)_ Sm151(β^-)Eu151(n,γ)Eu152	0.6	5.4					
		&Gd154(n,2n)Gd153(β^+)Eu153(n,2n)*Eu152*				59.7	3.2	0.9	0.2
		&Gd155(n,2n)Gd154(n,2n)Gd153(β^+)_ Eu153(n,2n)*Eu152*				35.1	0.4		
		&Gd155(n,3n)Gd153(β^+)Eu153(n,2n)*Eu152*					54.9	5.9	1.2
		&Gd155(n,d)*Eu154*(n,3n)*Eu152*					7.3	1.3	0.2
		Gd157(n,3n)Gd155(n,3n)Gd153(β^+)_ Eu153(n,2n)Eu152					3.1		
		&Gd155(n,nt)*Eu152*					2.5	15.3	35.6
		&Gd154(n,t)*Eu152*					1.6	6.4	4.7
		&Gd156(n,4n)Gd153(β^+)Eu153(n,2n)*Eu152*					1.5	25.2	2.0
		&Gd156(n,d)Eu155(n,4n)*Eu152*					0.6	6.4	0.7
		&Gd157(n,4n)Gd154(n,t)*Eu152*					0.3	4.0	0.7
		&Gd157(n,t)Eu155(n,4n)*Eu152*						3.9	0.6
		&Gd156(n,2nt)*Eu152*						0.7	23.6
		&Gd158(n,6n)Gd153(β^+)Eu153(n,2n)*Eu152*							4.0
		&Gd157(n,3nt)*Eu152*							3.0
Eu150	36.359 y	Gd152(n,2n)Gd151(β^+)Eu151(n,2n)Eu150				89.0	1.2		
		Gd154(n,2n)Gd153(β^+)Eu153(n,2n)_ Eu152(n,2n)Eu151(n,2n)Eu150				3.7			
		Gd155(n,3n)Gd153(β^+)Eu153(n,4n)Eu150					39.3	12.0	2.2
		Gd155(n,3n)Gd153(β^+)Eu153(n,3n)_ Eu151(n,2n)Eu150					10.5		
		Gd155(n,3n)Gd153(β^+)Eu153(n,2n)_ Eu152(n,3n)Eu150					7.2		
	►	Gd155(n,3n)Gd153(n,3n)Gd151(β^+)_ Eu151(n,2n)Eu150					5.0		

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Gd156(n,4n)Gd153(β^+)Eu153(n,4n)Eu150					1.1	51.9	3.7
		Gd155(n,4n)Gd152(n,t)Eu150					1.1	3.2	1.3
		Gd155(n,t)Eu153(n,4n)Eu150					0.9	4.2	1.6
		Gd157(n,5n)Gd153(β^+)Eu153(n,4n)Eu150						3.8	5.2
		Gd155(n,5n)Gd151(β^+)Eu151(n,2n)Eu150						0.9	5.1
		Gd156(n,5n)Gd152(n,t)Eu150						0.2	4.0
		Gd154(n,2nt)Eu150						0.1	7.4
		Gd155(n,3nt)Eu150							8.8
		Gd158(n,6n)Gd153(β^+)Eu153(n,4n)Eu150							7.3
		Gd156(n,6n)Gd151(β^+)Eu151(n,2n)Eu150							5.0
		Gd158(n,nt)Eu155(n,6n)Eu150							3.8
		Gd158(n,5n)Gd154(n,2nt)Eu150							3.6
Gd148	74.602 y	Gd152(n,2n)Gd151(n,2n)Gd150(n,2n)_ Gd149(n,2n)Gd148				51.4			
		Gd152(n,2n)Gd151(β^+)Eu151(n,2n)_ Eu150m(β^-)Gd150(n,2n)Gd149(n,2n)Gd148				40.7			
		Gd152(n,3n)Gd150(n,3n)Gd148					27.4	2.0	
		Gd154(n,3n)Gd152(n,3n)Gd150(n,3n)Gd148					21.8	0.5	
		Gd155(n,4n)Gd152(n,3n)Gd150(n,3n)Gd148					19.4	7.7	
		Gd156(n,3n)Gd154(n,3n)Gd152(n,3n)_ Gd150(n,3n)Gd148					12.1		
		Gd155(n,3n)Gd153(n,4n)Gd150(n,3n)Gd148					5.8	2.2	
		Gd156(n,4n)Gd153(n,4n)Gd150(n,3n)Gd148					0.2	9.7	
		Gd154(n,4n)Gd151(n,4n)Gd148						15.0	
		Gd155(n,4n)Gd152(n,5n)Gd148						9.9	10.4
		Gd157(n,4n)Gd154(n,4n)Gd151(n,4n)Gd148						8.1	
		Gd155(n,5n)Gd151(n,4n)Gd148						7.4	1.6
		Gd156(n,3n)Gd154(n,4n)Gd151(n,4n)Gd148						4.3	
		Gd156(n,4n)Gd153(β^+)Eu153(n,4n)_ Eu150m(β^-)Gd150(n,3n)Gd148						3.9	
		Gd155(n,4n)Gd152(n,2n)Gd151(n,4n)Gd148						2.9	
		Gd152(n,5n)Gd148						1.7	7.2
		Gd156(n,5n)Gd152(n,5n)Gd148						0.8	32.0
		Gd157(n,6n)Gd152(n,5n)Gd148							18.7
		Gd155(n,6n)Gd150(n,3n)Gd148							6.3
		Gd158(n,6n)Gd153(n,6n)Gd148							4.2
		Gd157(n,5n)Gd153(n,6n)Gd148							2.9
Sm151	90.0 y	Gd154(n,α)Sm151	88.2		99.7	27.8	3.1	0.8	1.0
		Gd152(n,α)Sm149(n,γ)Sm150(n,γ)Sm151	5.7	92.2	0.2				
		Gd152(n,γ)Gd153(n,γ)Gd154(n,α)Sm151	5.3	2.1					
		Gd152(n,γ)Gd153(n,α)Sm150(n,γ)Sm151	0.8	5.5					
		Gd155(n,2n)Gd154(n,α)Sm151				27.8	0.6	0.1	
		Gd155(n,α)Sm152(n,2n)Sm151				15.4	0.3		
		Gd155(n,nα)Sm151				7.4	66.0	28.7	13.5
		Gd154(n,2n)Gd153(β^+)Eu153(n,2n)_ Eu152m(β^+)Sm152(n,2n)Sm151				4.7			
		Gd156(n,2n)Gd155(n,2n)Gd154(n,α)Sm151				3.5			
		&Gd154(n,2n)Gd153(β^+)Eu153(n,2n)_ *Eu152*(β^+)Sm152(n,2n)Sm151				3.2			
		Gd156(n,2n)Gd155(n,α)Sm152(n,2n)Sm151				1.9			
		Gd156(n,2n)Gd155(n,nα)Sm151				1.4	1.6	0.5	0.1
		Gd156(n,nα)Sm152(n,2n)Sm151				0.4	1.9	0.8	0.3
		Gd157(n,3n)Gd155(n,nα)Sm151					6.6	0.8	0.2
		Gd156(n,3n)Gd154(n,α)Sm151					3.5	0.3	0.2
		Gd156(n,2nα)Sm151					2.7	31.0	17.7
		Gd158(n,4n)Gd155(n,nα)Sm151					1.2	3.8	0.4
		Gd158(n,nα)Sm154(n,4n)Sm151					1.2	2.1	0.2
		Gd158(n,3n)Gd156(n,2nα)Sm151					0.4	1.1	0.4
		Gd156(n,4n)Gd153(β^+)Eu153(n,t)Sm151						10.4	1.9
		Gd157(n,3nα)Sm151						3.4	21.6
		Gd155(n,3n)Gd153(β^+)Eu153(n,t)Sm151						2.4	1.1
	►	Gd160(n,5n)Gd156(n,2nα)Sm151						1.0	0.6

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Gd157(n,5n)Gd153(β^+)Eu153(n,t)Sm151						0.8	2.7
		Gd156(n,nt)Eu153(n,t)Sm151						0.2	1.1
		Gd158(n,4nα)Sm151							17.3
		Gd158(n,6n)Gd153(β^+)Eu153(n,t)Sm151							3.8
Tb157	99.0 y	**&**Gd160(n,2n)Gd159(β^-)Tb159(n,2n)_ *Tb158*(n,2n)Tb157				99.7		1.5	1.2
		Gd160(n,2n)Gd159(β^-)Tb159(n,3n)Tb157					91.1	83.2	78.1
		Gd160(n,d)Eu159(β^-)Gd159(β^-)Tb159_ (n,3n)Tb157						14.4	19.7
Tb158	180.0 y	**&**Gd160(n,2n)Gd159(β^-)Tb159(n,2n)*Tb158*				99.8	92.0	84.7	79.3
		&Gd158(n,γ)Gd159(β^-)Tb159(n,2n)*Tb158*				0.1	0.6	0.5	0.6
		&Gd160(n,d)Eu159(β^-)Gd159(β^-)_ Tb159(n,2n)*Tb158*						14.7	20.1
Ho166m	1200 y	**&**Gd160(n,γ)Gd161(β^-)Tb161(β^-)_ Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)Dy164_ (n,γ)*Dy165*(β^-)Ho165(n,γ)Ho166m	95.6	33.6	93.1				
		&Gd160(n,γ)Gd161(β^-)Tb161(n,γ)Tb162_ (β^-)Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β^-)Ho165(n,γ)Ho166m	0.3	1.3	2.3				
		&Gd158(n,γ)Gd159(β^-)Tb159(n,γ)_ Tb160(n,γ)Tb161(β^-)Dy161(n,γ)Dy162_ (n,γ)Dy163(n,γ)Dy164(n,γ)*Dy165*(β^-)_ Ho165(n,γ)Ho166m	0.1	14.1	0.1				
		&Gd158(n,γ)Gd159(β^-)Tb159(n,γ)_ Tb160(β^-)Dy160(n,γ)Dy161(n,γ)Dy162_ (n,γ)Dy163(n,γ)Dy164(n,γ)*Dy165*(β^-)_ Ho165(n,γ)Ho166m		20.4	0.1				
		&Gd157(n,γ)Gd158(n,γ)Gd159(β^-)Tb159_ (n,γ)Tb160(β^-)Dy160(n,γ)Dy161(n,γ)_ Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)*Dy165*_ (β^-)Ho165(n,γ)Ho166m		8.8					
		&Gd157(n,γ)Gd158(n,γ)Gd159(β^-)Tb159_ (n,γ)Tb160(n,γ)Tb161(β^-)Dy161(n,γ)_ Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)*Dy165*_ (β^-)Ho165(n,γ)Ho166m		6.4					
		&Gd156(n,γ)Gd157(n,γ)Gd158(n,γ)Gd159_ (β^-)Tb159(n,γ)Tb160(β^-)Dy160(n,γ)Dy161_ (n,γ)Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β^-)Ho165(n,γ)Ho166m		4.5					
		&Gd156(n,γ)Gd157(n,γ)Gd158(n,γ)Gd159_ (β^-)Tb159(n,γ)Tb160(n,γ)Tb161(β^-)Dy161_ (n,γ)Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β^-)Ho165(n,γ)Ho166m		3.5					
		&Gd155(n,γ)Gd156(n,γ)Gd157(n,γ)Gd158_ (n,γ)Gd159(β^-)Tb159(n,γ)Tb160(β^-)Dy160_ (n,γ)Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_ Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)Ho166m		2.1					
		Gd155(n,γ)Gd156(n,γ)Gd157(n,γ)Gd158(n,γ)_ Gd159(β^-)Tb159(n,γ)Tb160(n,γ)Tb161(β^-)_ Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ Dy165(β^-)Ho165(n,γ)Ho166m		1.7					
La137	6.0 10^4 y	Very long pathways of (n,α), (n,nα), β^-				100.0	100.0	100.0	100.0
Gd150	1.8 10^6 y	Gd152(n,2n)Gd151(β^+)Eu151(n,2n)_ Eu150m(β^-)Gd150				48.5			
		Gd152(n,2n)Gd151(n,2n)Gd150				40.9			
		Gd154(n,2n)Gd153(n,2n)Gd152(n,2n)_ Gd151(n,2n)Gd150				2.3			
		Gd154(n,3n)Gd152(n,3n)Gd150					22.6	1.3	
		Gd155(n,4n)Gd152(n,3n)Gd150					20.1	22.0	0.7
		Gd152(n,3n)Gd150					19.0	3.9	0.5
	►	Gd156(n,3n)Gd154(n,3n)Gd152(n,3n)Gd150					16.7	0.3	

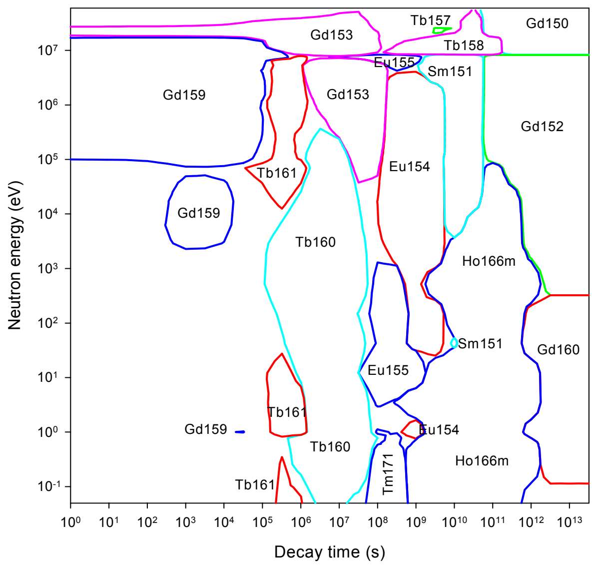
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Gd155(n,3n)Gd153(n,4n)Gd150					4.7	5.0	0.2
		Gd155(n,2n)Gd154(n,3n)Gd152(n,3n)Gd150					2.9	0.1	
		Gd157(n,4n)Gd154(n,3n)Gd152(n,3n)Gd150					2.7	0.5	
		Gd156(n,4n)Gd153(n,4n)Gd150					0.1	21.7	0.3
		Gd156(n,4n)Gd153(β^+)Eu153(n,4n)_ Eu150m(β^-)Gd150						12.9	0.2
		Gd154(n,5n)Gd150						3.2	12.6
		Gd155(n,3n)Gd153(β^+)Eu153(n,4n)_ Eu150m(β^-)Gd150						3.0	0.1
		Gd156(n,5n)Gd152(n,3n)Gd150						1.7	2.1
		Gd156(n,3n)Gd154(n,5n)Gd150						1.0	2.1
		Gd158(n,5n)Gd154(n,5n)Gd150						0.4	6.1
		Gd155(n,6n)Gd150							55.5
		Gd160(n,6n)Gd155(n,6n)Gd150							3.5
Hf182	9.0 10^6 y	Very long pathways of (n,γ), β^-	100.0						
Lu176	4.0 10^{10} y	Very long pathways of (n,γ), β^-	100.0						
La138	1.0 10^{11} y	Very long pathways of (n,α), (n,nα), β^-				100.0	100.0	100.0	100.0
Gd152	1.1 10^{14} y	Gd154(n,α)Sm151(β^-)Eu151(n,γ)_ Eu152m(β^-)Gd152	86.5						
		Gd154(n,2n)Gd153(n,2n)Gd152				10.7			
		Gd155(n,2n)Gd154(n,2n)Gd153(n,2n)Gd152				9.1			
		Gd154(n,2n)Gd153(β^+)Eu153(n,2n)_ Eu152m(β^-)Gd152				2.9			
		Gd155(n,2n)Gd154(n,2n)Gd153(β^+)_ Eu153(n,2n)Eu152m(β^-)Gd152				1.7			
		Gd156(n,2n)Gd155(n,2n)Gd154(n,2n)_ Gd153(n,2n)Gd152				1.0			
		Gd156(n,3n)Gd154(n,3n)Gd152					26.6	1.2	0.3
		Gd154(n,3n)Gd152					23.8	4.0	1.8
		Gd155(n,4n)Gd152					21.3	65.9	14.2
		Gd155(n,2n)Gd154(n,3n)Gd152					4.6	0.6	0.2
		Gd157(n,4n)Gd154(n,3n)Gd152					4.3	2.3	0.3
		Gd158(n,3n)Gd156(n,3n)Gd154(n,3n)Gd152					2.4		
		Gd157(n,3n)Gd155(n,4n)Gd152					2.1	1.8	0.2
		Gd155(n,3n)Gd153(n,2n)Gd152					1.3	0.1	
		Gd156(n,2n)Gd155(n,4n)Gd152					0.5	1.1	0.2
		Gd158(n,4n)Gd155(n,4n)Gd152					0.4	8.7	0.4
		Gd156(n,5n)Gd152						5.2	43.7
		Gd160(n,5n)Gd156(n,5n)Gd152						0.2	1.6
		Gd157(n,6n)Gd152							25.5
		Nuclide present in starting material	13.5	100.0	100.0	74.6	12.7	8.9	11.6
Gd160	1.3 10^{17} y	Nuclide present in starting material	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Gadolinium activation characteristics

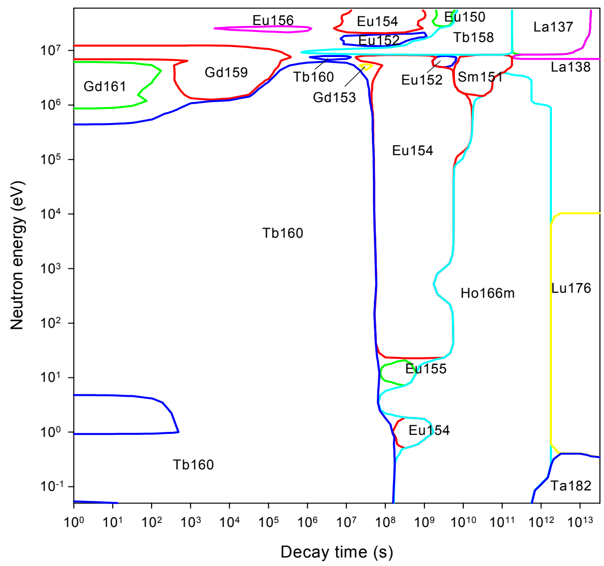


Gadolinium importance diagrams & transmutation

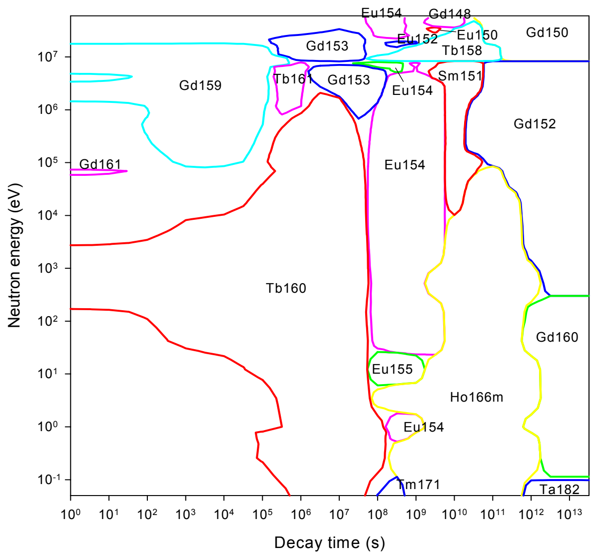
Activity



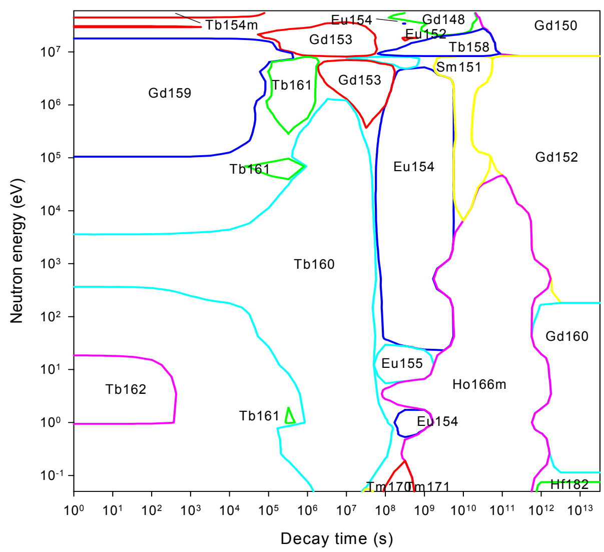
Dose rate



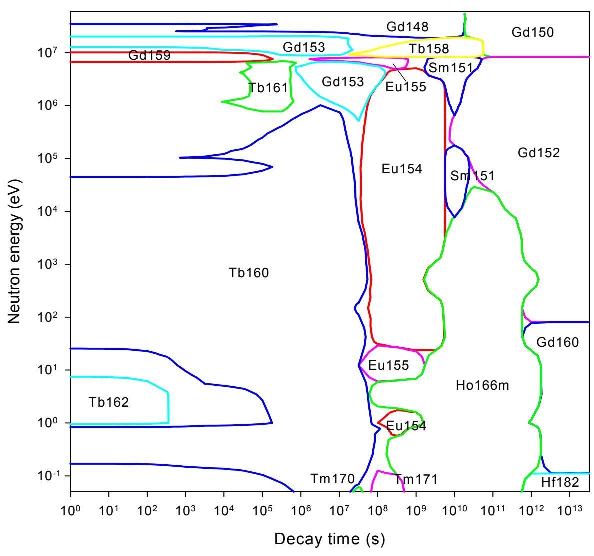
Heat output



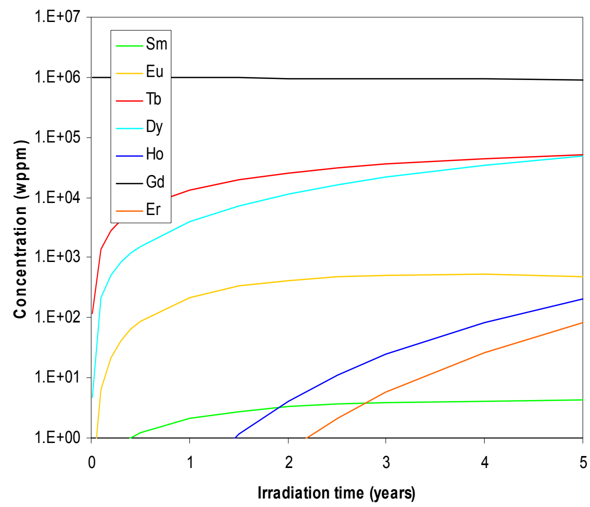
Ingestion dose



Inhalation dose



First wall transmutation



Terbium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	65		
Crustal abundance / wppm	1.2	Tb159	100.0
Melting point / K	1632		
Boiling point / K	3494		
Density / kgm^{-3}	8230		
Thermal conductivity / $Wm^{-1}K^{-1}$	11.1		
Electrical resistivity /Ωm	$1.14\ 10^{-6}$		
Coefficient of thermal expansion / K^{-1}	$1.03\ 10^{-5}$		
Crystal structure	Rhombic		
Number of stable isotopes	1		
Mean atomic weight	158.92534		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.03E16	9.78E15	8.22E15	2.40E14	2.11E12	5.68E-1
Tb160	72.58	76.45	87.89	93.85		
Tb161	12.63	13.30	10.97			
Dy165	6.46	6.67				
Dy165m	4.14	0.24				
Ho166	2.22	2.33	0.29			
Dy159	0.65	0.69	0.80	4.83		
Tb158	0.03	0.03	0.04	1.25	97.18	
Tb157				0.05	2.65	
Ho163						100.0

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	1.80E0	1.79E0	1.64E0	5.07E-2	3.05E-4	2.45E-19
Tb160	92.09	92.74	97.70	98.90		
Dy165	2.80	2.77				
Tb161	2.71	2.73	2.06			
Ho166	1.47	1.48	0.17			
Dy165m	0.47	0.03				
Tb162	0.22	0.13				
Tb158	0.03	0.03	0.03	0.88	99.65	
Ho163						98.61
Gd150						1.05

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	1.98E6	1.97E6	1.90E6	5.98E4	3.69E2	1.00E-19
Tb160	99.56	99.66	99.94	99.09		
Tb162	0.16	0.10				
Dy165	0.10	0.10				
Tb158	0.03	0.03	0.03	0.90	99.73	
Ho166m					0.27	
Lu176						99.94

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.36E7	1.35E7	1.22E7	3.65E5	2.26E3	1.34E-11
Tb160	87.86	88.65	94.33	98.77		
Tb161	6.88	6.94	5.30			
Ho166	2.35	2.37	0.28			
Tb158	0.02	0.03	0.03	0.90	99.62	
Ho163						97.61
Gd150						2.23

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	5.48E7	5.46E7	5.19E7	1.72E6	9.46E4	5.08E-10
Tb160	95.61	95.85	97.39	91.70		
Tb161	3.09	3.10	2.26			
Ho166	0.27	0.27	0.03			
Tb158	0.25	0.25	0.27	8.01	99.51	
Gd150						93.96
Ho163						5.93

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	7.60E12	7.57E12	7.28E12	2.29E11	1.71E9	1.50E-7
Tb160	98.47	98.78	99.26	98.66		
Tb161	0.90	0.90	0.65			
Tb158	0.03	0.03	0.03	1.09	99.65	
Ho166	0.03	0.03				
Dy165	0.01	0.01				
Ho163						99.50

Terbium

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Tb158m	10.8 s	Tb159(n,2n)Tb158m				99.6	99.7	99.8	99.9
Tb162	7.60 m	Tb159(n,γ)Tb160(n,γ)Tb161(n,γ)Tb162	100.0	100.0	100.0	47.8	7.7	10.0	16.5
		Tb159(n,γ)Tb160(β$^-$)Dy160(n,γ)Dy161_ (n,γ)Dy162(n,p)Tb162				43.5	82.2	79.9	74.1
		Tb159(n,γ)Tb160(n,γ)Tb161(β$^-$)Dy161_ (n,γ)Dy162(n,p)Tb162				8.1	9.6	9.6	9.0
Tb154m	9.00 h	&Tb159(n,2n)*Tb158*(n,2n)Tb157(n,2n)_ *Tb156*(n,2n)Tb155(n,2n)Tb154m				91.5			
		&Tb159(n,2n)*Tb158*(n,2n)Tb157(n,2n)_ Tb156m(n,2n)Tb155(n,2n)Tb154m				6.7			
		Tb159(n,3n)Tb157(n,4n)Tb154m					53.2	94.5	3.2
		Tb159(n,3n)Tb157(n,3n)Tb155(n,2n)Tb154m					14.2		
		&Tb159(n,2n)*Tb158*(n,3n)*Tb156*(n,3n)_ Tb154m					12.8		
		&Tb159(n,3n)Tb157(n,2n)*Tb156*(n,3n)_ Tb154m					11.2		
		&Tb159(n,4n)*Tb156*(n,3n)Tb154m					2.2		
		&Tb159(n,2n)*Tb158*(n,5n)Tb154m						2.6	6.4
		Tb159(n,6n)Tb154m							87.3
Ho166	1.117 d	&Tb159(n,γ)Tb160(n,γ)Tb161(β$^-$)_ Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_ Dy164(n,γ)*Dy165*(β$^-$)Ho165(n,γ)Ho166	60.0	61.8	46.8				
		&Tb159(n,γ)Tb160(β$^-$)Dy160(n,γ)_ Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_ Dy164(n,γ)*Dy165*(β$^-$)Ho165(n,γ)Ho166	35.1	35.4	50.7				
Tm172	2.65 d	&Tb159(n,γ)Tb160(n,γ)Tb161(β$^-$)Dy161_ (n,γ)Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β$^-$)Ho165(n,γ)Ho166(β$^-$)Er166_ (n,γ)*Er167*(n,γ)Er168(n,γ)Er169(β$^-$)_ Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)Tm172	49.4	33.4	52.2				
		&Tb159(n,γ)Tb160(n,γ)Tb161(β$^-$)Dy161_ (n,γ)Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β$^-$)Ho165(n,γ)Ho166m(n,γ)Ho167_ (β$^-$)*Er167*(n,γ)Er168(n,γ)Er169(β$^-$)_ Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)Tm172	27.3	8.8	8.6				
		&Tb159(n,γ)Tb160(β$^-$)Dy160(n,γ)Dy161_ (n,γ)Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β$^-$)Ho165(n,γ)Ho166(β$^-$)Er166_ (n,γ)*Er167*(n,γ)Er168(n,γ)Er169(β$^-$)_ Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)Tm172	13.4	38.4	31.2				
		&Tb159(n,γ)Tb160(β$^-$)Dy160(n,γ)Dy161_ (n,γ)Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β$^-$)Ho165(n,γ)Ho166m(n,γ)Ho167_ (β$^-$)*Er167*(n,γ)Er168(n,γ)Er169(β$^-$)_ Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)Tm172	8.8	10.5	5.2				
Tb156	5.17 d	&Tb159(n,2n)*Tb158*(n,2n)Tb157(n,2n)*Tb156*				93.4	0.5		
		&Tb159(n,2n)*Tb158*(n,3n)*Tb156*					48.2	1.6	2.4
		&Tb159(n,3n)Tb157(n,2n)*Tb156*					41.8	1.4	2.0
		&Tb159(n,4n)*Tb156*					7.5	95.2	92.7
Tb155	5.32 d	&Tb159(n,2n)*Tb158*(n,2n)Tb157(n,2n)_ *Tb156*(n,2n)Tb155				91.5			
		&Tb159(n,2n)*Tb158*(n,2n)Tb157(n,2n)_ Tb156m(n,2n)Tb155				6.7			
		Tb159(n,3n)Tb157(n,3n)Tb155					94.3	20.2	
		&Tb159(n,2n)*Tb158*(n,4n)Tb155					4.1	46.3	
		Tb159(n,5n)Tb155						32.7	96.1

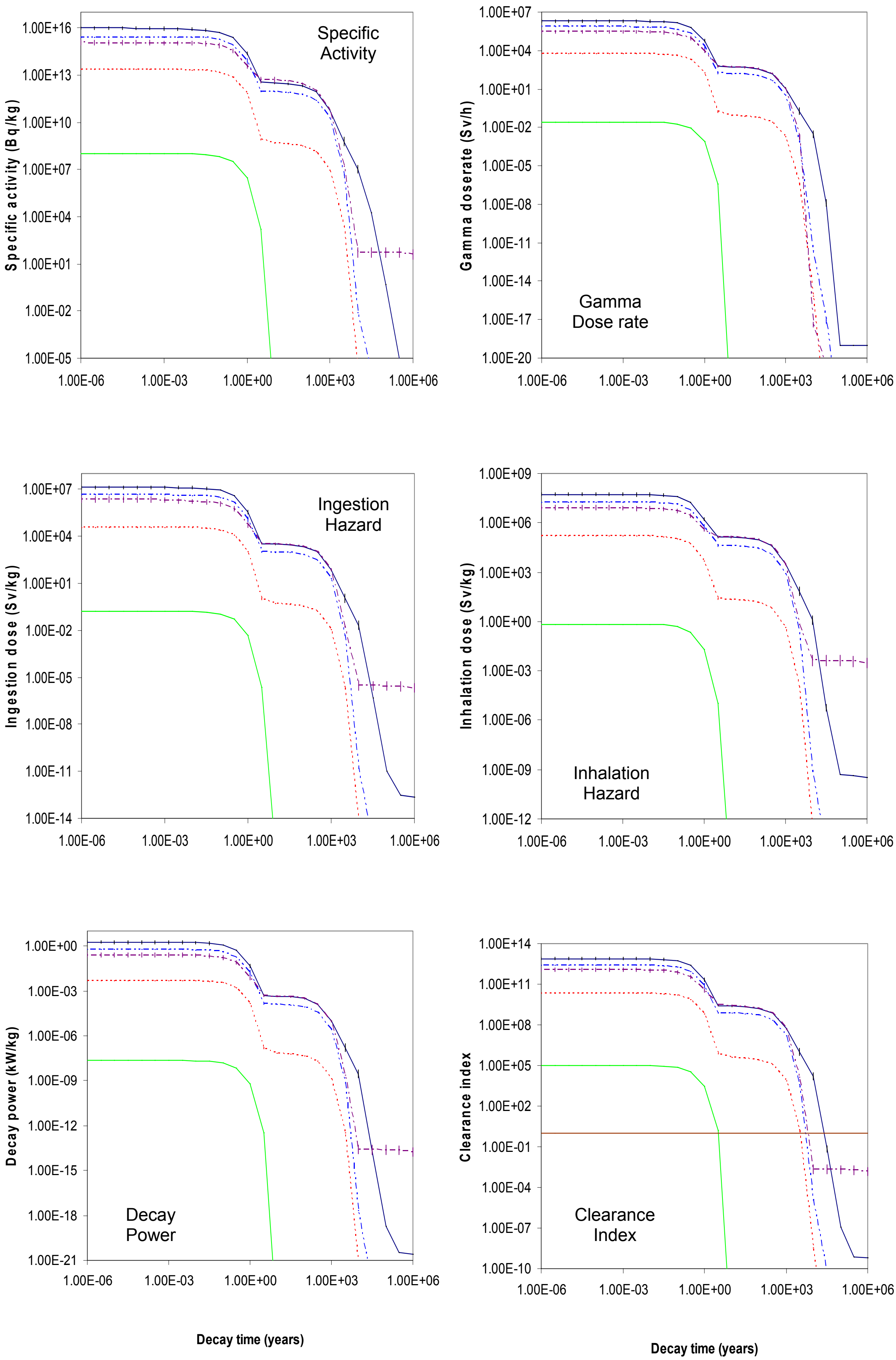
Nuclide	T½	Pathway	210	186	151	42	30	21	6
Tb161	6.89 d	Tb159(n,γ)Tb160(n,γ)Tb161	100.0	100.0	99.0	99.0	96.5	97.4	98.6
		Tb159(n,γ)Tb160(β^-)Dy160(n,γ)Dy161_ (n,p)Tb161				0.7	2.9	2.2	1.2
Tb160	72.3 d	Tb159(n,γ)Tb160	100.0	100.0	100.0	99.8	99.7	99.8	99.9
Ta182	114.7 d	Very long pathways of (n,γ), β^-	100.0						
Tm170	128.6 d	**&**Tb159(n,γ)Tb160(n,γ)Tb161(β^-)_ Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_ Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)Ho166_ (β^-)Er166(n,γ)*Er167*(n,γ)Er168(n,γ)_ Er169(β^-)Tm169(n,γ)Tm170	53.6	32.7	47.2				
		&Tb159(n,γ)Tb160(β^-)Dy160(n,γ)_ Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_ Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)Ho166_ (β^-)Er166(n,γ)*Er167*(n,γ)Er168(n,γ)_ Er169(β^-)Tm169(n,γ)Tm170	15.7	40.5	30.6				
		&Tb159(n,γ)Tb160(n,γ)Tb161(β^-)_ Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_ Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)_ Ho166m(n,γ)Ho167(β^-)*Er167*(n,γ)Er168_ (n,γ)Er169(β^-)Tm169(n,γ)Tm170	15.3	6.8	4.5				
		&Tb159(n,γ)Tb160(β^-)Dy160(n,γ)_ Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_ Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)_ Ho166m(n,γ)Ho167(β^-)*Er167*(n,γ)Er168_ (n,γ)Er169(β^-)Tm169(n,γ)Tm170	5.3	8.7	2.9				
		&Tb159(n,γ)Tb160(n,γ)Tb161(n,γ)_ Tb162(β^-)Dy162(n,γ)Dy163(n,γ)Dy164_ (n,γ)*Dy165*(β^-)Ho165(n,γ)Ho166(β^-)_ Er166(n,γ)*Er167*(n,γ)Er168(n,γ)(β^-)_ Tm169(n,γ)Tm170	0.8	1.4	1.9				
Gd153	240.4 d	**&**Tb159(n,2n)*Tb158*(n,2n)Tb157(n,2n)_ *Tb156*(β^+)Gd156(n,2n)Gd155(n,2n)_ Gd154(n,2n)Gd153				52.8			
		Tb159(n,α)Eu156(β^-)Gd156(n,2n)_ Gd155(n,2n)Gd154(n,2n)Gd153				23.8			
		Tb159(n,2n)Tb158(n,α)Eu155(β^-)_ Gd155(n,2n)Gd154(n,2n)Gd153				2.2			
		Tb159(n,3n)Tb157(n,3n)Tb155(β^+)_ Gd155(n,3n)Gd153					84.4	0.6	0.1
		&Tb159(n,2n)*Tb158*(n,4n)Tb155(β^+)_ Gd155(n,3n)Gd153					3.6	1.1	0.1
		&Tb159(n,4n)*Tb156*(β^+)Gd156(n,4n)Gd153					0.1	82.2	5.8
		Tb159(n,nt)Gd156(n,4n)Gd153						3.3	3.6
		Tb159(n,5n)Tb155(β^+)Gd155(n,3n)Gd153						2.4	19.6
		Tb159(n,3n)Tb157(n,5n)Tb153(β^+)Gd153						1.1	24.7
		Tb159(n,t)Gd157(n,5n)Gd153						0.8	5.8
		&Tb159(n,2n)*Tb158*(n,6n)Tb153(β^+)Gd153							17.2
		Tb159(n,6n)Tb154m(β^+)Gd154(n,2n)Gd153							4.7
		Tb159(n,d)Gd158(n,6n)Gd153							4.4
		Tb159(n,3n)Tb157(n,2nt)Gd153							2.2
Tm171	1.917 y	**&**Tb159(n,γ)Tb160(n,γ)Tb161(β^-)Dy161_ (n,γ)Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β^-)Ho165(n,γ)Ho166(β^-)Er166_ (n,γ)*Er167*(n,γ)Er168(n,γ)Er169(β^-)_ Tm169(n,γ)Tm170(n,γ)Tm171	52.4	32.8	32.8				
	►	**&**Tb159(n,γ)Tb160(n,γ)Tb161(β^-)Dy161_ (n,γ)Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β^-)Ho165(n,γ)Ho166m(n,γ)Ho167_ (β^-)*Er167*(n,γ)Er168(n,γ)Er169(β^-)_ Tm169(n,γ)Tm170(n,γ)Tm171	16.7	7.1	7.1				

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Tb159(n,γ)Tb160(β$^-$)Dy160(n,γ)Dy161_ (n,γ)Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β$^-$)Ho165(n,γ)Ho166(β$^-$)Er166_ (n,γ)*Er167*(n,γ)Er168(n,γ)Er169(β$^-$)_ Tm169(n,γ)Tm170(n,γ)Tm171	14.3	39.1	39.1				
		&Tb159(n,γ)Tb160(β$^-$)Dy160(n,γ)Dy161_ (n,γ)Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β$^-$)Ho165(n,γ)Ho166m(n,γ)Ho167_ (β$^-$)*Er167*(n,γ)Er168(n,γ)Er169(β$^-$)_ Tm169(n,γ)Tm170(n,γ)Tm171	5.4	8.7	8.7				
Eu155	4.753 y	Tb159(n,γ)Tb160(β$^-$)Dy160(n,α)Gd157_ (n,α)Sm154(n,γ)Sm155(β$^-$)Eu155	99.2	39.8	54.2				
		Tb159(n,γ)Tb160(n,α)Eu157(β$^-$)Gd157_ (n,α)Sm154(n,γ)Sm155(β$^-$)Eu155	0.8	45.8	38.1				
		&Tb159(n,α)Eu156(β$^-$)Gd156(n,α)_ Sm153(β$^-$)Eu153(n,γ)*Eu154*(n,γ)Eu155		12.4	2.1				
		&Tb159(n,2n)*Tb158*(n,α)Eu155				83.2	1.6		
		Tb159(n,nα)Eu155				13.3	92.2	64.5	69.0
		Tb159(n,α)Eu156(n,2n)Eu155				2.3			
		&Tb159(n,4n)*Tb156*(β$^+$)Gd156(n,d)Eu155					0.5	27.8	7.8
		Tb159(n,t)Gd157(n,t)Eu155					0.2	2.4	5.6
		Tb159(n,nt)Gd156(n,d)Eu155					0.1	1.1	5.7
		Tb159(n,d)Gd158(n,nt)Eu155						0.6	4.5
		Tb159(n,5n)Tb155(β$^+$)Gd155(n,p)Eu155							2.8
Eu154	8.593 y	Tb159(n,α)Eu156(β$^-$)Gd156(n,α)_ Sm153(β$^-$)Eu153(n,γ)Eu154	63.7	95.0	87.2				
		Tb159(n,α)Eu156(n,α)Pm153(β$^-$)_ Sm153(β$^-$)Eu153(n,γ)Eu154	34.7	3.4	11.2				
		&Tb159(n,2n)*Tb158*(n,2n)Tb157(n,α)*Eu154*				44.9	0.2		
		&Tb159(n,2n)*Tb158*(n,α)Eu155(n,2n)*Eu154*				30.2			
		&Tb159(n,2n)*Tb158*(n,nα)*Eu154*				15.7	28.1	3.2	1.5
		&Tb159(n,nα)Eu155(n,2n)*Eu154*				7.4	7.5	0.8	0.4
		&Tb159(n,3n)Tb157(n,α)*Eu154*					25.3	0.6	0.5
		&Tb159(n,2nα)*Eu154*					16.8	68.5	57.1
		&Tb159(n,3n)Tb157(n,3n)Tb155(β$^+$)_ Gd155(n,d)*Eu154*					16.8		
		&Tb159(n,4n)*Tb156*(β$^+$)Gd156(n,t)*Eu154*					0.2	17.6	5.9
		&Tb159(n,5n)Tb155(β$^+$)Gd155(n,d)*Eu154*						2.3	21.5
		&Tb159(n,nt)Gd156(n,t)*Eu154*						0.5	3.6
		&Tb159(n,t)Gd157(n,nt)*Eu154*							3.2
		&Tb159(n,2nt)Gd155(n,d)*Eu154*							1.8
		&Tb159(n,d)Gd158(n,2nt)*Eu154*							1.4
H3	12.33 y	Tb159(n,X)H3				85.9	82.6	86.3	85.7
		&Tb159(n,2n)*Tb158*(n,X)H3				9.8	4.7	3.2	1.9
		&Tb159(n,2n)*Tb158*(n,2n)Tb157(n,X)H3				4.1	1.7	1.3	
		Tb159(n,3n)Tb157(n,X)H3					9.1	3.2	1.7
		Tb159(n,4n)Tb156(β$^+$)Gd156(n,X)H3						2.6	
		Tb159(n,5n)Tb155(β$^+$)Gd155(n,X)H3							4.1
Gd148	74.60 y	Tb159(n,3n)Tb157(n,3n)Tb155(β$^+$)Gd155_ (n,4n)Gd152(n,3n)Gd150(n,3n)Gd148					41.5	0.2	
		Tb159(n,3n)Tb157(n,3n)Tb155(β$^+$)Gd155_ (n,3n)Gd153(n,4n)Gd150(n,3n)Gd148					16.2		
		&Tb159(n,4n)Tb156(β$^+$)Gd156(n,4n)_ Gd153(n,4n)Gd150(n,3n)Gd148						21.3	
		Tb159(n,4n)Tb156(β$^+$)Gd156(n,3n)_ Gd154(n,4n)Gd151(n,4n)Gd148						8.6	
		Tb159(n,3n)Tb157(n,4n)Tb154m(β$^+$)_ Gd154(n,4n)Gd151(n,4n)Gd148						7.8	
	►	&Tb159(n,3n)Tb157(n,4n)*Tb154*(β$^+$)_ Gd154(n,4n)Gd151(n,4n)Gd148						4.3	

Nuclide	$T_{1/2}$	Pathway	210	186	151	42	30	21	6
	◄	Tb159(n,5n)Tb155(β^+)Gd155(n,4n)_ Gd152(n,5n)Gd148						3.3	19.2
		Tb159(n,5n)Tb155(β^+)Gd155(n,5n)_ Gd151(n,4n)Gd148						3.3	4.0
		Tb159(n,4n)Tb156(β^+)Gd156(n,5n)_ Gd152(n,5n)Gd148						1.7	8.6
		Tb159(n,5n)Tb155(β^+)Gd155(n,6n)_ Gd150(n,3n)Gd148							11.6
		Tb159(n,nt)Gd156(n,5n)Gd152(n,5n)Gd148							6.3
		Tb159(n,t)Gd157(n,6n)Gd152(n,5n)Gd148							4.2
		Tb159(n,3n)Tb157(n,5n)Tb153(β^+)_ Gd153(n,6n)Gd148							3.7
		Tb159(n,6n)Tb154m(β^+)Gd154(n,5n)_ Gd150(n,3n)Gd148							3.5
		Tb159(n,6n)Tb154m(β^+)Gd154(n,3n)_ Gd152(n,5n)Gd148							3.2
		Many other similar pathways				100.0	42.3	49.5	35.7
Sm151	90.0 y	**&**Tb159(n,2n)*Tb158*(n,2n)Tb157(n,2n)*Tb156*_ (β^+)Gd156(n,2n)Gd155(n,2n)Gd154(n,α)Sm151				16.8			
		&Tb159(n,2n)*Tb158*(n,2n)Tb157(n,2n)_ *Tb156*(β^+)Gd156(n,2n)Gd155(n,nα)Sm151				15.5			
		Tb159(n,α)Eu156(β^-)Gd156(n,2n)_ Gd155(n,2n)Gd154(n,α)Sm151				9.1			
		&Tb159(n,2n)*Tb158*(n,2n)Tb157(n,2n)*Tb156*_ (β^+)Gd156(n,2n)Gd155(n,α)Sm152(n,2n)Sm151				8.6			
		Tb159(n,α)Eu156(β^-)Gd156(n,2n)_ Gd155(n,α)Sm152(n,2n)Sm151				5.0			
		Tb159(n,α)Eu156(β^-)Gd156(n,2n)_ Gd155(n,nα)Sm151				4.9			
		&Tb159(n,2n)*Tb158*(n,2n)Tb157(n,α)_ *Eu154*(n,α)Pm151(β^-)Sm151				3.8			
		&Tb159(n,2n)*Tb158*(n,2n)Tb157(n,2n)_ *Tb156*(β^+)Gd156(n,nα)Sm152(n,2n)Sm151				3.0			
		Tb159(n,nα)Eu155(n,nα)Pm151(β^-)Sm151				0.1	3.8	0.7	0.2
		Tb159(n,3n)Tb157(n,3n)Tb155(β^+)_ Gd155(n,nα)Sm151					75.3	1.4	0.2
		Tb159(n,2n)Tb158(n,4n)Tb155(β^+)_ Gd155(n,nα)Sm151					2.4	2.3	0.2
		Tb159(n,4n)Tb156(β^+)Gd156(n,2nα)Sm151					0.2	55.6	7.4
		Tb159(n,4n)Tb156(β^+)Gd156(n,4n)_ Gd153(β^+)Eu153(n,t)Sm151						9.2	0.4
		Tb159(n,5n)Tb155(β^+)Gd155(n,nα)Sm151						6.6	33.1
		Tb159(n,nt)Gd156(n,2nα)Sm151						2.2	4.6
		Tb159(n,2nα)Eu154(n,nt)Sm151						1.6	2.7
		Tb159(n,3nα)Eu153(n,t)Sm151						0.8	6.9
		Tb159(n,t)Gd157(n,3nα)Sm151						0.8	6.5
		Tb159(n,2nt)Gd155(n,nα)Sm151						0.2	2.7
		Tb159(n,3n)Tb157(n,5n)Tb153(β^+)_ Gd153(β^+)Eu153(n,t)Sm151						0.1	2.1
		Tb159(n,6n)Tb154m(β^+)Gd154(n,α)Sm151							3.1
		Tb159(n,d)Gd158(n,4nα)Sm151							2.8
		Many other similar long pathways				33.2	18.3	18.5	27.1
Tb157	99.0 y	**&**Tb159(n,2n)*Tb158*(n,2n)Tb157				99.9		1.9	
		Tb159(n,3n)Tb157					98.4	97.3	97.8
Tb158	180.0 y	**&**Tb159(n,2n)*Tb158*				99.9	99.9	99.9	99.9
Ho166m	1200 y	**&**Tb159(n,γ)Tb160(n,γ)Tb161(β^-)Dy161_ (n,γ)Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β^-)Ho165(n,γ)Ho166m	61.2	36.4	48.7				
		&Tb159(n,γ)Tb160(β^-)Dy160(n,γ)Dy161_ (n,γ)Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β^-)Ho165(n,γ)Ho166m	36.6	60.5	46.9				

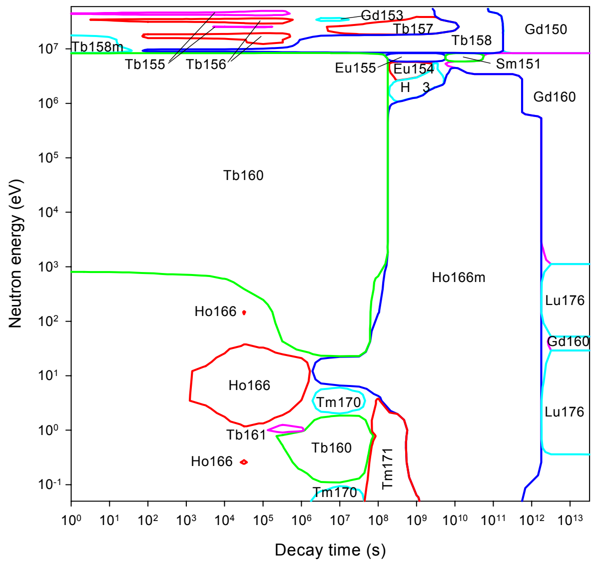
Nuclide	T½	Pathway	210	186	151	42	30	21	6
La137	$6.0\ 10^{4}$ y	Pathways involving (n,α), (n,nα), (n,2n), β^+				100.0	100.0	100.0	100.0
Gd150	$1.8\ 10^{6}$ y	**&**Tb159(n,2n)*Tb158*(n,2n)Tb157(n,nα)_ Eu153(n,2n)*Eu152*(n,2n)Eu151(n,2n)_ Eu150m(β^-)Gd150				8.0			
		Tb159(n,α)Eu156(β^-)Gd156(n,2n)_ Gd155(n,2n)Gd154(n,2n)Gd153(n,2n)_ Gd152(n,2n)Gd151(n,2n)Gd150				7.5			
		&Tb159(n,2n)*Tb158*(n,2n)Tb157(n,α)_ *Eu154*(n,2n)Eu153(n,2n)*Eu152*(n,2n)_ Eu151(n,2n)Eu150m(β^-)Gd150				4.7			
		&Tb159(n,2n)*Tb158*(n,nα)*Eu154*(n,2n)_ Eu153(n,2n)*Eu152*(n,2n)Eu151(n,2n)_ Eu150m(β^-)Gd150				4.5			
		Tb159(n,α)Eu156(β^-)Gd156(n,α)_ Sm153(β^-)Eu153(n,2n)Eu152(n,2n)_ Eu151(n,2n)Eu150m(β^-)Gd150				4.0			
		&Tb159(n,2n)*Tb158*(n,α)Eu155(n,2n)_ Eu154(n,2n)Eu153(n,2n)Eu152(n,2n)_ Eu151(n,2n)Eu150m(β^-)Gd150				2.8			
		&Tb159(n,nα)Eu155(n,2n)*Eu154*(n,2n)_ Eu153(n,2n)*Eu152*(n,2n)Eu151(n,2n)_ Eu150m(β^-)Gd150				2.4			
		Tb159(n,3n)Tb157(n,3n)Tb155(β^+)_ Gd155(n,4n)Gd152(n,3n)Gd150					42.3	0.7	
		Tb159(n,3n)Tb157(n,3n)Tb155(β^+)_ Gd155(n,3n)Gd153(n,4n)Gd150					14.8	0.2	
		Tb159(n,3n)Tb157(n,3n)Tb155(β^+)Gd155_ (n,2n)Gd154(n,3n)Gd152(n,3n)Gd150					3.7		
		&Tb159(n,2n)Tb158(n,3n)*Tb156*(β^+)Gd156_ (n,3n)Gd154(n,3n)Gd152(n,3n)Gd150					2.9		
		Tb159(n,4n)Tb156(β^+)Gd156(n,3n)_ Gd154(n,3n)Gd152(n,3n)Gd150					2.7	0.3	
		Tb159(n,3n)Tb157(n,3n)Tb155(β^+)_ Gd155(n,3n)Gd153(β^+)Eu153(n,4n)_ Eu150m(β^-)Gd150					2.5		
		Tb159(n,3n)Tb157(n,2n)Tb156(β^+)Gd156_ (n,3n)Gd154(n,3n)Gd152(n,3n)Gd150					2.0		
		&Tb159(n,4n)*Tb156*(β^+)Gd156(n,4n)_ Gd153(n,4n)Gd150						41.8	0.4
		Tb159(n,4n)Tb156(β^+)Gd156(n,4n)Gd153_ (β^+)Eu153(n,4n)Eu150m(β^-)Gd150						15.1	
		Tb159(n,4n)Tb156(β^+)Gd156(n,5n)_ Gd152(n,3n)Gd150						2.3	0.2
		Tb159(n,5n)Tb155(β^+)Gd155(n,6n)Gd150							52.1
		Tb159(n,6n)Tb154m(β^+)Gd154(n,5n)Gd150							15.7
		&Tb159(n,6n)Tb154(β^+)Gd154(n,5n)Gd150							11.1
		Tb159(n,6n)Tb154n(β^+)Gd154(n,5n)Gd150							4.2
		Tb159(n,2nt)Gd155(n,6n)Gd150							4.2
		Many other similar pathways				66.1	29.1	39.6	12.1
Hf182	$9.0\ 10^{6}$ y	Very long pathways of (n,γ), β^-	100.0	100.0					
Lu176	$4.0\ 10^{10}$ y	Very long pathways of (n,γ), β^-	100.0	100.0					
La138	$1.0\ 10^{11}$ y	Pathways involving (n,α), (n,nα), (n,2n), β^+				100.0	100.0	100.0	100.0
Gd160	$1.3\ 10^{17}$ y	Tb159(n,γ)Tb160(n,γ)Tb161(β^-)Dy161_ (n,γ)Dy162(n,γ)Dy163(n,α)Gd160	67.2	37.4	42.0				
		Tb159(n,γ)Tb160(β^-)Dy160(n,γ)Dy161_ (n,γ)Dy162(n,γ)Dy163(n,α)Gd160	31.5	60.8	55.8				
		Tb159(n,γ)Tb160(n,γ)Tb161(n,γ)Tb162_ (β^-)Dy162(n,γ)Dy163(n,α)Gd160	0.9	1.4	0.7				
		Tb159(n,γ)Tb160(n,p)Gd160				99.0	99.2	99.3	99.4

Terbium activation characteristics

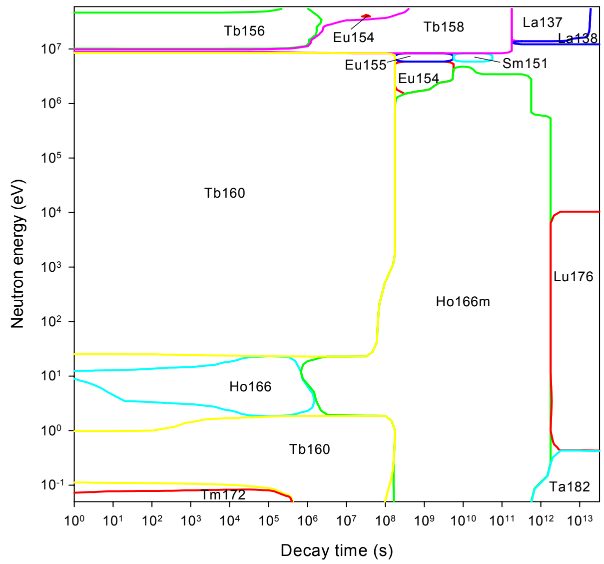


Terbium importance diagrams & transmutation

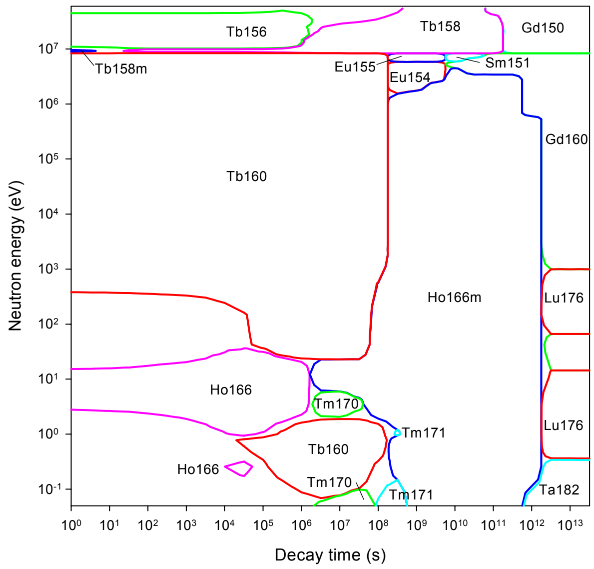
Activity



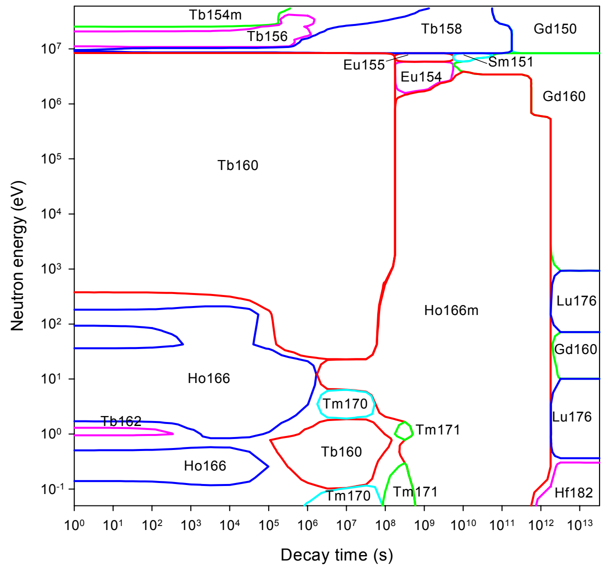
Dose rate



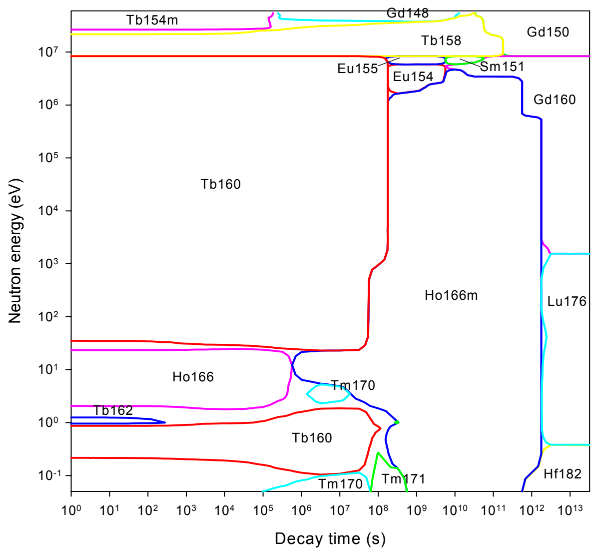
Heat output



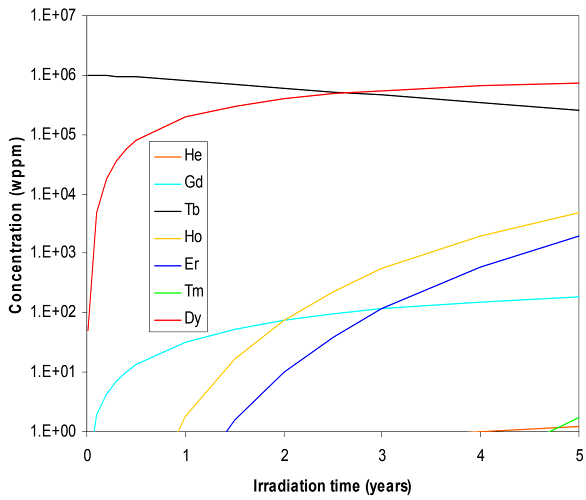
Ingestion dose



Inhalation dose



First wall transmutation



Dysprosium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	66		
Crustal abundance / wppm	5.2	Dy156	0.06 ($T_{1/2}$=1.00 10^{18} y)
Melting point / K	1684	Dy158	0.10
Boiling point / K	2834	Dy160	2.34
Density / kgm^{-3}	8551	Dy161	18.91
Thermal conductivity / $Wm^{-1}K^{-1}$	10.7	Dy162	25.51
Electrical resistivity /Ωm	5.7 10^{-7}	Dy163	24.90
Coefficient of thermal expansion / K^{-1}	9.9 10^{-6}	Dy164	28.18
Crystal structure	Rhombic		
Number of stable isotopes	6 (7)		
Mean atomic weight	162.5		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.05E16	7.38E15	3.62E14	2.78E12	1.64E11	3.18E1	kW kg^{-1}	7.36E-1	6.62E-1	3.88E-2	1.71E-4	2.56E-5	7.98E-16
Dy165	38.52	53.44					Ho166	46.13	51.20	91.37			
Ho166	27.95	39.51	84.36				Dy165	41.58	45.30				
Dy165m	24.64	1.92					Dy165m	6.99	0.43				
Er167m	5.28	0.22					Er167m	2.50	0.08				
Ho167	1.30	1.80					Ho167	1.74	1.90				
Er169	0.37	0.53	8.19				Tb160	0.30	0.34	5.53	39.18		
Tb160	0.10	0.14	2.67	10.85			Er169	0.09	0.10	1.25			
Tm170	0.08	0.12	2.29	42.51			Tm170	0.06	0.07	1.14	36.70		
Dy159	0.04	0.06	1.22	27.91			Dy159	0.01	0.01	0.11	4.24		
Tm171		0.01	0.10	9.29			Tm168	0.01	0.01	0.11	1.67		
Tb157			0.03	3.76	31.74		Ho166m			0.05	11.44	72.26	
Ho166m			0.02	2.49	39.65		Tb158			0.03	5.96	27.22	
Tb158			0.02	2.47	28.53		Dy154						94.55
Ho163					0.07	94.76	Gd150						3.85
Dy154						5.02	Ho163						1.60
Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	4.23E4	3.63E4	4.42E3	1.16E2	2.78E1	1.44E-15	Sv kg^{-1}	4.63E6	4.60E6	4.69E5	2.35E3	1.84E2	9.69E-8
Ho166	39.57	46.03	39.55				Ho166	88.49	88.87	90.97			
Dy165	29.19	33.33					Dy165	9.58	9.45				
Ho167	9.89	11.31					Tb160	0.35	0.35	3.29	20.49		
Dy165m	8.31	0.53					Er169	0.31	0.31	2.34			
Tb160	6.20	7.23	57.34	68.52			Tm170	0.24	0.24	2.30	65.21		
Er167m	5.00	0.17					Ho167	0.24	0.24				
Tb164	0.82	0.28					Dy159	0.01	0.01	0.09	3.29		
Tm168	0.11	0.13	1.05	2.72		2.60	Ho166m			0.03	5.87	70.95	
Ho166m	0.05	0.06	0.47	17.81	69.73		Tb158			0.02	3.21	28.08	
Tb158	0.03	0.03	0.28	10.68	30.24		Tm171			0.01	1.21		
Tm170				0.02*			Dy154						95.61
Tb156						80.07	Gd150						3.67
Lu176						17.28							

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	2.37E6	2.35E6	3.74E5	2.26E4	1.00E4	4.24E-5
Ho166	80.07	80.59	53.07			
Dy165	10.19	10.06				
Tb160	2.95	2.98	18.09	9.32		
Tm170	2.49	2.52	15.54	36.50		
Er169	1.63	1.65	7.93	0.82	0.28	
Ho167	0.41	0.40				
Ho166m	0.35	0.35	2.22	36.58	77.89	
Dy166	0.31	0.31	0.93			
Tb158	0.13	0.14	0.85	13.95	21.49	
Dy159	0.07	0.07	0.44	1.27		
Tm171	0.02	0.02	0.14	1.60		
Tb157			0.03	0.55	0.62	
Dy154						86.60
Gd150						13.39

Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
	2.45E11	1.11E11	1.38E10	5.40E8	1.47E8	2.92E-5
Dy165m	31.83	3.88				
Er167m	24.21	1.54				
Ho167	21.30	46.19				
Ho166	11.92	26.29	22.09			
Tb160	4.08	9.01	69.93	55.77		
Dy165	1.64	3.56				
Dy165m	1.64	3.56				
Er167m	1.31	2.67				
Ho167	1.12	2.45	0.06			
Ho166	0.63	0.41				
Tb160	0.59	1.19				
Dy165	0.54	1.19	0.01			
Ho164	0.11	0.21				
Er165	0.10	0.23	1.80	3.12		
Tm168	0.10	0.23	1.80	3.12		
Tb164	0.10	0.23	1.20			0.02
Dy159	0.09	0.19	1.52	6.83		
Ho166m	0.05	0.10	0.82	20.94	72.93	
Tm170		0.08	0.60	2.19		
Tb158			0.42	10.59	26.68	
Dy154						62.97
Ho163						27.20
Gd150						9.78

Dysprosium

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Er167m	2.269 s	**&**Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_*Dy165*(β^-)Ho165(n,γ)Ho166(β^-)Er166_(n,γ)Er167m	25.6	0.5					
		&Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)_Ho166(β^-)Er166(n,γ)Er167m	25.4	48.9	94.1	91.7	94.2	94.0	93.6
		&Dy163(n,γ)Dy164(n,γ)*Dy165*(β^-)_Ho165(n,γ)Ho166(β^-)Er166(n,γ)Er167m	24.1	48.1	2.9				
		&Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)Ho166_(β^-)Er166(n,γ)Er167m	19.2						
		&Dy160(n,γ)Dy161(n,γ)Dy162(n,γ)_Dy163(n,γ)Dy164(n,γ)*Dy165*(β^-)Ho165_(n,γ)Ho166(β^-)Er166(n,γ)Er167m	2.2						
		Dy164(n,γ)Dy165m(β^-)Ho165(n,γ)_Ho166(β^-)Er166(n,γ)Er167m	0.4	0.8	1.4	0.5	0.5	0.5	0.5
		&Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)_Ho166m(n,γ)Ho167(β^-)Er167m		0.1	1.0	5.7	3.9	4.2	4.7
Tb163	19.5 m	**&**Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_*Dy165*(β^-)Ho165(n,γ)Ho166(n,α)Tb163	24.1	0.1					
		&Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)Ho166_(n,α)Tb163	20.8	0.1					
		&Dy163(n,γ)Dy164(n,γ)*Dy165*(β^-)_Ho165(n,γ)Ho166(n,α)Tb163	16.6	3.5					
		&Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)_Ho166(n,α)Tb163	11.2	1.0	3.1				
		&Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_*Dy165*(β^-)Ho165(n,γ)Ho166m(n,α)Tb163	7.4	1.9					
		&Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)_Ho166m(n,α)Tb163	6.3	1.3					
		&Dy163(n,γ)Dy164(n,γ)*Dy165*(β^-)_Ho165(n,γ)Ho166m(n,α)Tb163	5.0	62.3	2.9				
		&Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)_Ho166m(n,α)Tb163	3.2	28.2	91.8				
		Dy160(n,γ)Dy161(n,γ)Dy162(n,γ)_Dy163(n,γ)Dy164(n,γ)Dy165(β^-)Ho165_(n,γ)Ho166(n,α)Tb163	2.1						
		Dy163(n,γ)Dy164(n,γ)Dy165m(β^-)_Ho165(n,γ)Ho166m(n,α)Tb163		1.0					
		Dy164(n,γ)Dy165m(β^-)Ho165(n,γ)_Ho166m(n,α)Tb163		0.4	1.4				
		Dy163(n,p)Tb163				71.0	16.2	8.5	5.0
		Dy164(n,2n)Dy163(n,p)Tb163				25.2			
		Dy164(n,d)Tb163				3.7	82.6	90.9	94.7
Dy165	2.334 h	**&**Dy160(n,γ)Dy161(n,γ)Dy162(n,γ)_Dy163(n,γ)Dy164(n,γ)*Dy165*	50.0	0.8					
		&Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_Dy164(n,γ)*Dy165*	20.2	17.1					
		&Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)*Dy165*	19.0	22.2	0.1				
		&Dy163(n,γ)Dy164(n,γ)*Dy165*	5.9	59.8	7.9				
		&Dy158(n,γ)Dy159(n,γ)Dy160(n,γ)_Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_Dy164(n,γ)*Dy165*	4.9						
		&Dy164(n,γ)Dy165		0.1	91.8	100.0	100.0	100.0	100.0

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Dy157	8.14 h	Dy156(n,γ)Dy157	100.0	100.0	100.0				
		Dy158(n,2n)Dy157				64.9	2.2		
		Dy161(n,2n)Dy160(n,2n)Dy159(n,2n)_ Dy158(n,2n)Dy157				17.4			
		Dy160(n,2n)Dy159(n,2n)Dy158(n,2n)Dy157				15.1			
		Dy162(n,2n)Dy161(n,2n)Dy160(n,2n)_ Dy159(n,2n)Dy158(n,2n)Dy157				2.2			
		Dy161(n,3n)Dy159(n,3n)Dy157					24.2		
		Dy162(n,3n)Dy160(n,3n)Dy158(n,2n)Dy157					15.3		
		Dy161(n,4n)Dy158(n,2n)Dy157					12.9	8.4	
		Dy160(n,3n)Dy158(n,2n)Dy157					11.8		
		Dy163(n,3n)Dy161(n,3n)Dy159(n,3n)Dy157					4.9		
		Dy163(n,4n)Dy160(n,3n)Dy158(n,2n)Dy157					4.7		
		Dy162(n,3n)Dy160(n,4n)Dy157					1.2	10.6	
		Dy160(n,4n)Dy157					0.5	16.2	2.6
		Dy163(n,4n)Dy160(n,4n)Dy157					0.4	27.9	1.1
		Dy161(n,2n)Dy160(n,4n)Dy157					0.2	5.6	
		Dy164(n,5n)Dy160(n,4n)Dy157						8.8	2.3
		Dy161(n,5n)Dy157						6.8	40.1
		Dy162(n,6n)Dy157							34.3
Tb154m	9.0 h	Dy156(n,2n)Dy155(β^+)Tb155(n,2n)Tb154m				100.0	0.1		
		Dy161(n,4n)Dy158(n,3n)Dy156(n,t)Tb154m					11.5	0.7	
		Dy156(n,t)Tb154m					10.8	0.3	0.2
		Dy160(n,3n)Dy158(n,3n)Dy156(n,t)Tb154m					10.6		
		Dy162(n,3n)Dy160(n,3n)Dy158(n,3n)_ Dy156(n,t)Tb154m					9.1		
		Dy156(n,3n)Dy154(n,p)Tb154m					9.1		
		Dy161(n,3n)Dy159(β^+)Tb159(n,3n)_ Tb157(n,4n)Tb154m					6.2	1.9	
		Dy162(n,4n)Dy159(β^+)Tb159(n,3n)_ Tb157(n,4n)Tb154m					0.6	7.4	0.1
		Dy161(n,4n)Dy158(n,2n)Dy157(β^+)_ Tb157(n,4n)Tb154m					0.4	5.4	0.1
		Dy160(n,4n)Dy157(β^+)Tb157(n,4n)Tb154m						21.0	0.7
		Dy163(n,4n)Dy160(n,4n)Dy157(β^+)_ Tb157(n,4n)Tb154m						18.1	0.2
		Dy161(n,5n)Dy157(β^+)Tb157(n,4n)Tb154m						8.8	11.1
		Dy162(n,3n)Dy160(n,4n)Dy157(β^+)_ Tb157(n,4n)Tb154m						6.9	0.1
		Dy164(n,5n)Dy160(n,4n)Dy157(β^+)_ Tb157(n,4n)Tb154m						5.7	0.3
		Dy164(n,6n)Dy159(β^+)Tb159(n,6n)Tb154m							15.4
		Dy163(n,5n)Dy159(β^+)Tb159(n,6n)Tb154m							12.0
		Dy162(n,6n)Dy157(β^+)Tb157(n,4n)Tb154m							9.5
		Dy162(n,4n)Dy159(β^+)Tb159(n,6n)Tb154m							6.7
		Many other similar long pathways					41.6	23.8	43.6
Ho166	1.117 d	**&**Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β^-)Ho165(n,γ)Ho166	30.8	4.8					
		&Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_ Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)Ho166	26.1	3.5					
		&Dy163(n,γ)Dy164(n,γ)*Dy165*(β^-)_ Ho165(n,γ)Ho166	20.8	69.7	4.3				
		&Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)Ho166	13.0	20.1	94.1	99.2	99.1	99.2	99.4
		&Dy160(n,γ)Dy161(n,γ)Dy162(n,γ)Dy163_ (n,γ)Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)Ho166	7.1	0.5					
		Dy163(n,γ)Dy164(n,γ)Dy165m(β^-)_ Ho165(n,γ)Ho166	0.3	1.1					
		Dy164(n,γ)Dy165m(β^-)Ho165(n,γ)Ho166	0.2	0.3	1.4	0.6	0.5	0.5	0.5
Tm172	2.650 d ►	**&**Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)_ Ho166(β^-)Er166(n,γ)*Er167*(n,γ)Er168_ (n,γ)Er169(β^-)Tm169(n,γ)Tm170(n,γ)_ Tm171(n,γ)Tm172	29.3	51.5	82.8				

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Dy163(n,γ)Dy164(n,γ)*Dy165*(β^-)_ Ho165(n,γ)Ho166(β^-)Er166(n,γ)*Er167*_ (n,γ)Er168(n,γ)Er169(β^-)Tm169(n,γ)_ Tm170(n,γ)Tm171(n,γ)Tm172	20.2	29.9	1.1				
		&Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β^-)Ho165(n,γ)Ho166(β^-)Er166_ (n,γ)*Er167*(n,γ)Er168(n,γ)Er169(β^-)_ Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)Tm172	16.8	0.1					
		&Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_ Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)Ho166_ (β^-)Er166(n,γ)*Er167*(n,γ)Er168(n,γ)_ Er169(β^-)Tm169(n,γ)Tm170(n,γ)_ Tm171(n,γ)Tm172	11.3						
		&Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)_ Ho166m(n,γ)Ho167(β^-)*Er167*(n,γ)_ Er168(n,γ)Er169(β^-)Tm169(n,γ)Tm170_ (n,γ)Tm171(n,γ)Tm172	4.8	7.8	7.9				
		&Dy163(n,γ)Dy164(n,γ)*Dy165*(β^-)_ Ho165(n,γ)Ho166m(n,γ)Ho167(β^-)_ *Er167*(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170(n,γ)Tm171(n,γ)Tm172	3.8	5.1	0.1				
		&Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β^-)Ho165(n,γ)Ho166m(n,γ)Ho167_ (β^-)*Er167*(n,γ)Er168(n,γ)Er169(β^-)_ Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)Tm172	3.6						
		&Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)Dy164_ (n,γ)*Dy165*(β^-)Ho165(n,γ)Ho166m(n,γ)_ Ho167(β^-)*Er167*(n,γ)Er168(n,γ)Er169(β^-)_ Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)Tm172	2.5						
Tb156	5.17 d	Dy156(β^+)Tb156	100.0		100.0				
		&Dy158(n,2n)Dy157(β^+)Tb157(n,2n)*Tb156*				59.7	0.5		
		&Dy160(n,2n)Dy159(β^+)Tb159(n,2n)_ *Tb158*(n,2n)Tb157(n,2n)*Tb156*				15.3			
		&Dy161(n,2n)Dy160(n,2n)Dy159(β^+)_ Tb159(n,2n)Tb158(n,2n)Tb157(n,2n)*Tb156*				6.8			
		&Dy160(n,2n)Dy159(n,2n)Dy158_ (n,2n)Dy157(β^+)Tb157(n,2n)*Tb156*				6.3			
		&Dy161(n,2n)Dy160(n,2n)Dy159(n,2n)_ Dy158(n,2n)Dy157(β^+)Tb157(n,2n)*Tb156*				4.8			
		&Dy161(n,3n)Dy159(β^+)Tb159(n,2n)_ *Tb158*(n,3n)*Tb156*					23.8		
		&Dy161(n,3n)Dy159(β^+)Tb159(n,3n)_ Tb157(n,2n)*Tb156*					21.4		
		&Dy161(n,3n)Dy159(β^+)Tb159(n,4n)*Tb156*					8.4	12.6	3.4
		&Dy161(n,3n)Dy159(n,3n)Dy157(β^+)_ Tb157(n,2n)*Tb156*					5.0		
		&Dy162(n,4n)Dy159(β^+)Tb159(n,4n)*Tb156*					0.8	48.9	5.6
		&Dy163(n,5n)Dy159(β^+)Tb159(n,4n)*Tb156*						8.6	10.0
		&Dy161(n,5n)Dy157(β^+)Tb157(n,2n)*Tb156*						0.7	11.1
		&Dy162(n,5n)Dy158(n,t)*Tb156*						0.2	5.4
		&Dy164(n,6n)Dy159(β^+)Tb159(n,4n)*Tb156*							12.9
		&Dy162(n,6n)Dy157(β^+)Tb157(n,2n)*Tb156*							9.5
		&Dy163(n,6n)Dy158(n,t)*Tb156*							4.2
		Many other similar long pathways				7.1	40.1	29.0	37.9
Tb161	6.89 d	**&**Dy156(n,γ)Dy157(β^+)Tb157(n,γ)_ *Tb158*(n,γ)Tb159(n,γ)Tb160(n,γ)Tb161	98.3	60.3	2.3				
		Dy158(n,γ)Dy159(β^+)Tb159(n,γ)Tb160_ (n,γ)Tb161	1.9	41.8	97.7				
		Dy161(n,p)Tb161				52.1	11.5	5.1	1.9
		Dy162(n,2n)Dy161(n,p)Tb161				22.1	0.8		
	►	Dy164(n,α)Gd161(β^-)Tb161				13.7	4.2	0.8	

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Dy162(n,d)Tb161				5.4	50.5	43.4	28.5
		Dy163(n,2n)Dy162(n,2n)Dy161(n,p)Tb161				3.4			
		Dy163(n,2n)Dy162(n,d)Tb161				1.7	2.8	1.7	
		Dy163(n,t)Tb161				0.9	12.2	32.7	31.4
		Dy164(n,2n)Dy163(n,t)Tb161				0.3	0.7	1.3	
		Dy164(n,3n)Dy162(n,d)Tb161					11.4	2.6	
		Dy163(n,3n)Dy161(n,p)Tb161					2.7		
		Dy164(n,nt)Tb161					1.3	8.7	33.3
		Dy164(n,4n)Dy161(n,p)Tb161					1.0	1.2	
Er169	9.4 d	**&**Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)Ho166_ (β^-)Er166(n,γ)*Er167*(n,γ)Er168(n,γ)Er169	28.2	50.7	85.3	79.4	88.1	87.3	86.0
		&Dy163(n,γ)Dy164(n,γ)*Dy165*(β^-)_ Ho165(n,γ)Ho166(β^-)Er166(n,γ)*Er167*_ (n,γ)Er168(n,γ)Er169	21.6	35.1	1.6				
		&Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β^-)Ho165(n,γ)Ho166(β^-)Er166_ (n,γ)*Er167*(n,γ)Er168(n,γ)Er169	19.7	0.2					
		&Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_ Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)Ho166_ (β^-)Er166(n,γ)*Er167*(n,γ)Er168(n,γ)Er169	13.8	0.1					
		&Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)_ Ho166m(n,γ)Ho167(β^-)*Er167*(n,γ)_ Er168(n,γ)Er169	3.2	5.8	8.1	11.9	8.3	9.2	10.6
		&Dy163(n,γ)Dy164(n,γ)*Dy165*(β^-)_ Ho165(n,γ)Ho166m(n,γ)Ho167(β^-)_ *Er167*(n,γ)Er168(n,γ)Er169	2.8	4.6	0.2				
		&Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β^-)Ho165(n,γ)Ho166m(n,γ)_ Ho167(β^-)*Er167*(n,γ)Er168(n,γ)Er169	2.8						
		&Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_ Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)_ Ho166m(n,γ)Ho167(β^-)*Er167*(n,γ)_ Er168(n,γ)Er169	2.0						
		&Dy160(n,γ)Dy161(n,γ)Dy162(n,γ)_ Dy163(n,γ)Dy164(n,γ)*Dy165*(β^-)Ho165_ (n,γ)Ho166(β^-)Er166(n,γ)*Er167*(n,γ)_ Er168(n,γ)Er169	1.1						
Tb160	72.3 d	**&**Dy156(n,γ)Dy157(β^+)Tb157(n,γ)_ *Tb158*(n,γ)Tb159(n,γ)Tb160	98.1	59.0	1.3				
		Dy158(n,γ)Dy159(β^+)Tb159(n,γ)Tb160	1.9	40.9	97.7				
		Dy161(n,2n)Dy160(n,p)Tb160				41.2	0.8		
		Dy161(n,d)Tb160				18.0	52.2	34.8	19.2
		Dy160(n,p)Tb160				17.1	1.7	0.7	
		Dy162(n,2n)Dy161(n,2n)Dy160(n,p)Tb160				8.3			
		Dy162(n,2n)Dy161(n,d)Tb160				7.2	3.4	1.7	
		Dy162(n,t)Tb160				2.2	12.2	34.0	28.8
		Dy161(n,2n)Dy160(n,2n)Dy159(β^+)_ Tb159(n,γ)Tb160				1.3			
		Dy160(n,2n)Dy159(β^+)Tb159(n,γ)Tb160				1.2			
		Dy163(n,2n)Dy162(n,2n)Dy161(n,d)Tb160				1.1			
		Dy163(n,2n)Dy162(n,t)Tb160				0.6	0.6	1.3	
		Dy163(n,3n)Dy161(n,d)Tb160					11.4	2.2	
		Dy162(n,3n)Dy160(n,p)Tb160					4.2		
		Dy164(n,4n)Dy161(n,d)Tb160					4.1	7.5	
		Dy164(n,3n)Dy162(n,t)Tb160					2.6	1.9	
		Dy163(n,nt)Tb160					2.1	10.1	27.9
		Dy163(n,4n)Dy160(n,p)Tb160					1.3	1.1	
		Dy164(n,2nt)Tb160						0.8	16.7
Ta182	114.7 d	Very long pathways of (n,γ), β^-	100.0	100.0					
Tm170	128.6 d ►	**&**Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)_ Ho166(β^-)Er166(n,γ)*Er167*(n,γ)Er168_ (n,γ)Er169(β^-)Tm169(n,γ)Tm170	29.1	51.5	87.9				

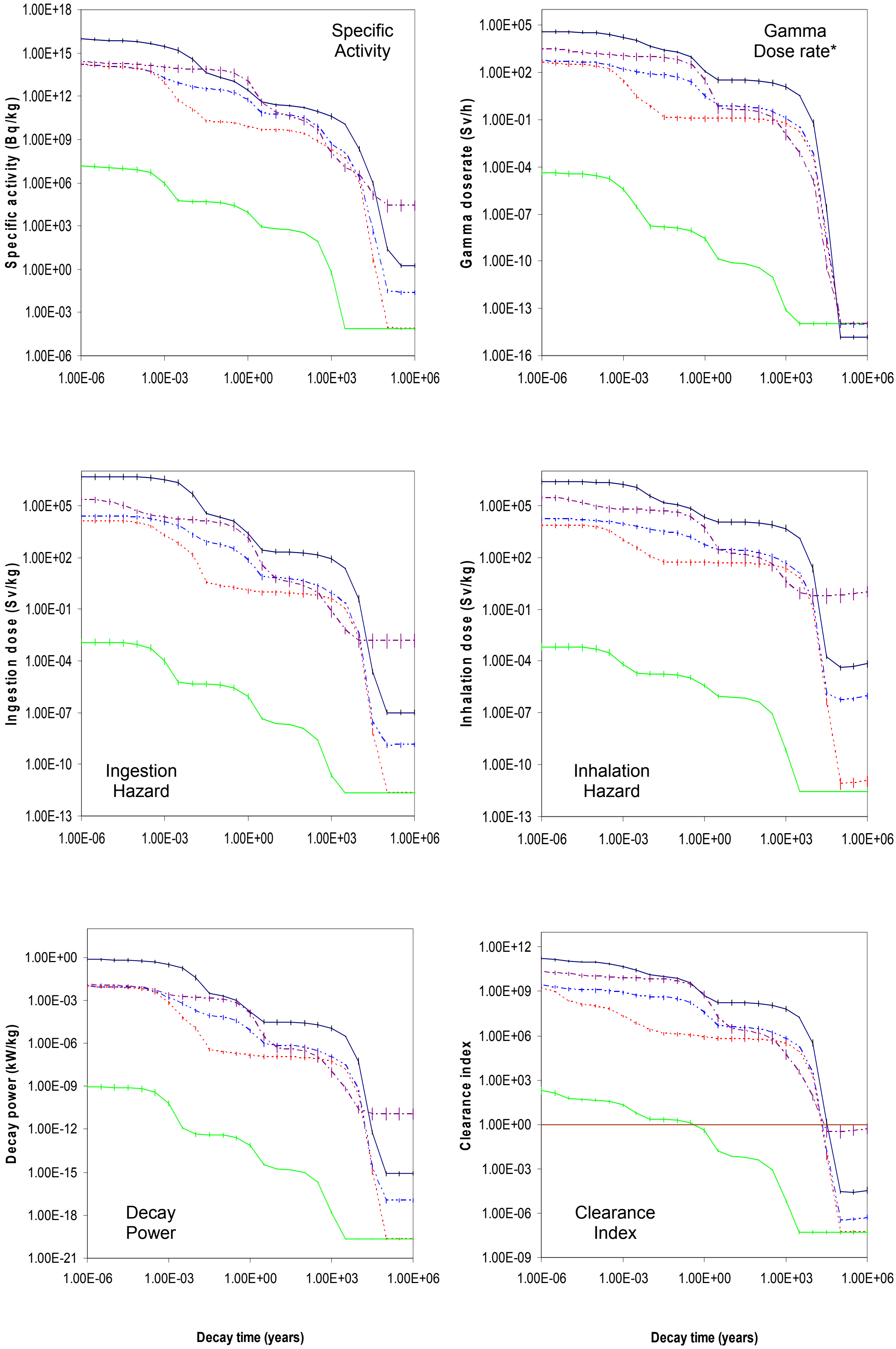
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Dy163(n,γ)Dy164(n,γ)*Dy165*(β^-)Ho165_ (n,γ)Ho166(β^-)Er166(n,γ)*Er167*(n,γ)_ Er168(n,γ)Er169(β^-)Tm169(n,γ)Tm170	20.8	31.7	1.3				
		&Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)*Dy165*_ (β^-)Ho165(n,γ)Ho166(β^-)Er166(n,γ)*Er167*_ (n,γ)Er168(n,γ)Er169(β^-)Tm169(n,γ)Tm170	17.9	0.1					
		&Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_ Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)Ho166_ (β^-)Er166(n,γ)*Er167*(n,γ)Er168(n,γ)_ Er169(β^-)Tm169(n,γ)Tm170	12.2	0.1					
		&Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)_ Ho166m(n,γ)Ho167(β^-)*Er167*(n,γ)_ Er168(n,γ)Er169(β^-)Tm169(n,γ)Tm170	4.2	7.2	1.3				
		&Dy163(n,γ)Dy164(n,γ)*Dy165*(β^-)Ho165_ (n,γ)Ho166m(n,γ)Ho167(β^-)*Er167*(n,γ)_ Er168(n,γ)Er169(β^-)Tm169(n,γ)Tm170	3.5	5.0					
		&Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β^-)Ho165(n,γ)Ho166m(n,γ)_ Ho167(β^-)*Er167*(n,γ)Er168(n,γ)Er169_ (β^-)Tm169(n,γ)Tm170	3.4						
		&Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_ Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)_ Ho166m(n,γ)Ho167(β^-)*Er167*(n,γ)_ Er168(n,γ)Er169(β^-)Tm169(n,γ)Tm170	2.4						
		&Dy160(n,γ)Dy161(n,γ)Dy162(n,γ)_ Dy163(n,γ)Dy164(n,γ)*Dy165*(β^-)Ho165_ (n,γ)Ho166(β^-)Er166(n,γ)*Er167*(n,γ)_ Er168(n,γ)Er169(β^-)Tm169(n,γ)Tm170	0.8						
Dy159	144.4 d	Dy158(n,γ)Dy159	95.8	99.6	100.0				
		Dy156(n,γ)Dy157(n,γ)Dy158(n,γ)Dy159	4.0	0.2					
		Dy161(n,2n)Dy160(n,2n)Dy159				60.4	1.2	0.5	
		Dy160(n,2n)Dy159				26.6	2.7	1.7	1.3
		Dy162(n,2n)Dy161(n,2n)Dy160(n,2n)Dy159				11.6			
		Dy163(n,2n)Dy162(n,2n)Dy161(n,2n)_ Dy160(n,2n)Dy159				1.1			
		Dy161(n,3n)Dy159					58.0	14.7	10.1
		Dy163(n,3n)Dy161(n,3n)Dy159					11.9	0.9	
		Dy162(n,3n)Dy160(n,2n)Dy159					6.3	1.0	
		Dy162(n,4n)Dy159					5.5	56.6	16.2
		Dy164(n,4n)Dy161(n,3n)Dy159					4.3	3.0	
		Dy162(n,2n)Dy161(n,3n)Dy159					3.6	0.7	
		Dy163(n,4n)Dy160(n,2n)Dy159					1.9	2.6	
		Dy164(n,3n)Dy162(n,4n)Dy159					1.1	3.0	
		Dy163(n,2n)Dy162(n,4n)Dy159					0.3	2.0	
		Dy163(n,5n)Dy159						9.9	28.8
		Dy164(n,6n)Dy159							37.0
Tm171	1.917 y	&Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)Ho166_ (β^-)Er166(n,γ)*Er167*(n,γ)Er168(n,γ)Er169_ (β^-)Tm169(n,γ)Tm170(n,γ)Tm171	29.4	51.7	87.6				
		&Dy163(n,γ)Dy164(n,γ)*Dy165*(β^-)_ Ho165(n,γ)Ho166(β^-)Er166(n,γ)*Er167*_ (n,γ)Er168(n,γ)Er169(β^-)Tm169(n,γ)_ Tm170(n,γ)Tm171	20.3	30.1	0.6				
		&Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β^-)Ho165(n,γ)Ho166(β^-)Er166_ (n,γ)*Er167*(n,γ)Er168(n,γ)Er169(β^-)_ Tm169(n,γ)Tm170(n,γ)Tm171	16.9	0.1					
	►	&Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_ Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)Ho166_ (β^-)Er166(n,γ)*Er167*(n,γ)Er168(n,γ)_ Er169(β^-)Tm169(n,γ)Tm170(n,γ)Tm171	11.3	0.1					

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)_ Ho166m(n,γ)Ho167(β^-)*Er167*(n,γ)_ Er168(n,γ)Er169(β^-)Tm169(n,γ)Tm170_ (n,γ)Tm171	4.8	7.9					
		&Dy163(n,γ)Dy164(n,γ)*Dy165*(β^-)_ Ho165(n,γ)Ho166m(n,γ)Ho167(β^-)_ *Er167*(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170(n,γ)Tm171	3.8	5.1					
		&Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β^-)Ho165(n,γ)Ho166m(n,γ)_ Ho167(β^-)*Er167*(n,γ)Er168(n,γ)Er169_ (β^-)Tm169(n,γ)Tm170(n,γ)Tm171	3.6						
		&Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_ Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)_ Ho166m(n,γ)Ho167(β^-)*Er167*(n,γ)_ Er168(n,γ)Er169(β^-)Tm169(n,γ)Tm170_ (n,γ)Tm171	2.6						
Gd148	74.602 y	Dy156(n,nα)Gd152(n,2n)Gd151(n,2n)_ Gd150(n,2n)Gd149(n,2n)Gd148				28.8			
		Dy156(n,nα)Gd152(n,2n)Gd151(β^+)_ Eu151(n,2n)Eu150m(β^-)Gd150(n,2n)_ Gd149(n,2n)Gd148				17.2			
		Dy156(n,α)Gd153(n,2n)Gd152(n,2n)Gd151_ (n,2n)Gd150(n,2n)Gd149(n,2n)Gd148				12.5			
		Dy156(n,3n)Dy154(n,3nα)Gd148					17.8	3.8	
		Dy156(n,3n)Dy154(n,nα)Gd150(n,3n)Gd148					8.7	0.1	
		Dy156(n,nα)Gd152(n,3n)Gd150(n,3n)Gd148					6.4		
		Dy156(n,3n)Dy154(n,3n)Dy152(α)Gd148					5.2	0.2	
		Dy161(n,4n)Dy158(n,3n)Dy156(n,3n)_ Dy154(n,3nα)Gd148					3.2	1.5	
		Dy161(n,6n)Dy156(n,5n)Dy152(β^+)_ Tb152(β^+)Gd152(n,5n)Gd148							13.4
		Dy161(n,5n)Dy157(β^+)Tb157(n,5n)_ Tb153(β^+)Gd153(n,6n)Gd148							5.0
		Dy162(n,6n)Dy157(β^+)Tb157(n,5n)_ Tb153(β^+)Gd153(n,6n)Gd148							4.2
		Dy160(n,5n)Dy156(n,5n)Dy152(β^+)_ Tb152(β^+)Gd152(n,5n)Gd148							3.4
		Many other similar long pathways				41.5	58.7	94.4	74.0
Tb157	99.0 y	Dy156(n,γ)Dy157(β^+)Tb157	99.2	100.0	100.0				
		Dy158(n,2n)Dy157(β^+)Tb157				60.5	1.2	0.4	
		&Dy160(n,2n)Dy159(β^+)Tb159(n,2n)_ *Tb158*(n,2n)Tb157				16.6			
		&Dy161(n,2n)Dy160(n,2n)Dy159(β^+)_ Tb159(n,2n)*Tb158*(n,2n)Tb157				6.9			
		Dy160(n,2n)Dy159(n,2n)Dy158(n,2n)_ Dy157(β^+)Tb157				6.4			
		Dy161(n,2n)Dy160(n,2n)Dy159(n,2n)_ Dy158(n,2n)Dy157(β^+)Tb157				4.9			
		Dy161(n,3n)Dy159(β^+)Tb159(n,3n)Tb157					48.4	2.0	0.2
		Dy161(n,3n)Dy159(n,3n)Dy157(β^+)Tb157					11.2	0.4	
		Dy162(n,4n)Dy159(β^+)Tb159(n,3n)Tb157					4.6	7.6	0.4
		Dy161(n,4n)Dy158(n,2n)Dy157(β^+)Tb157					3.4	5.6	0.4
		Dy163(n,3n)Dy161(n,3n)Dy159(β^+)_ Tb159(n,3n)Tb157					3.4		
		Dy162(n,3n)Dy160(n,4n)Dy157(β^+)Tb157					0.3	7.1	0.5
		Dy160(n,4n)Dy157(β^+)Tb157					0.2	21.6	2.6
		Dy163(n,4n)Dy160(n,4n)Dy157(β^+)Tb157						18.7	0.6
		Dy161(n,5n)Dy157(β^+)Tb157						9.0	39.7
		Dy164(n,5n)Dy160(n,4n)Dy157(β^+)Tb157						5.9	1.1
	►	Dy161(n,2n)Dy160(n,4n)Dy157(β^+)Tb157						3.8	0.3

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Dy161(n,2nt)Tb157						0.3	4.4
		Dy162(n,6n)Dy157(β^+)Tb157							33.9
Tb158	180.0 y	**&**Dy156(n,γ)Dy157(β^+)Tb157(n,γ)_ *Tb158*	100.0	100.0	100.0				
		&Dy160(n,2n)Dy159(β^+)Tb159(n,2n)*Tb158*				53.1	3.0	1.1	0.2
		&Dy161(n,2n)Dy160(n,2n)Dy159(β^+)_ Tb159(n,2n)*Tb158*				41.3	0.4		
		&Dy162(n,2n)Dy161(n,2n)Dy160_ (n,2n)Dy159(β^+)Tb159(n,2n)*Tb158*				2.9			
		&Dy161(n,3n)Dy159(β^+)Tb159(n,2n)*Tb158*					63.3	9.2	1.9
		&Dy162(n,4n)Dy159(β^+)Tb159(n,2n)*Tb158*					6.0	35.4	3.0
		&Dy163(n,3n)Dy161(n,3n)Dy159(β^+)_ Tb159(n,2n)*Tb158*					4.5	0.1	
		&Dy161(n,nt)*Tb158*					1.9	14.7	34.6
		&Dy160(n,t)*Tb158*					1.3	5.8	4.4
		&Dy163(n,4n)Dy160(n,t)*Tb158*					0.5	5.1	0.9
		&Dy163(n,5n)Dy159(β^+)Tb159(n,2n)*Tb158*						6.2	5.3
		&Dy162(n,2nt)*Tb158*						0.9	23.9
		&Dy164(n,6n)Dy159(β^+)Tb159(n,2n)*Tb158*							6.8
		&Dy163(n,3nt)*Tb158*							4.3
Ho166m	1200 y	**&**Dy162(n,γ)Dy163(n,γ)Dy164(n,γ)_ *Dy165*(β^-)Ho165(n,γ)Ho166m	30.8	2.0					
		&Dy161(n,γ)Dy162(n,γ)Dy163(n,γ)_ Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)Ho166m	26.2	1.4					
		&Dy163(n,γ)Dy164(n,γ)*Dy165*(β^-)_ Ho165(n,γ)Ho166m	20.9	65.4	3.0				
		&Dy164(n,γ)Dy165(β^-)Ho165(n,γ)_ Ho166m	13.1	29.5	95.5	99.4	99.2	99.4	99.4
		&Dy160(n,γ)Dy161(n,γ)Dy162(n,γ)_ Dy163(n,γ)Dy164(n,γ)*Dy165*(β^-)Ho165_ (n,γ)Ho166m	7.1						
		Dy164(n,γ)Dy165m(β^-)Ho165(n,γ)_ Ho166m	0.2	0.5	1.5	0.6	0.5	0.5	
		Dy163(n,γ)Dy164(n,γ)Dy165m(β^-)_ Ho165(n,γ)Ho166m		1.0					
Ho163	4570.1 y	**&**Dy164(n,γ)*Dy165*(β^-)Ho165(n,2n)_ *Ho164*(β^-)Er164(n,2n)Er163(β^+)Ho163				99.1			
		&Dy164(n,γ)*Dy165*(β^-)Ho165(n,3n)Ho163					97.3	98.9	98.6
La137	6.0 10^4 y	Very long pathways of (n,α), β^+, (n,nα)				100.0	100.0	100.0	100.0
Gd150	1.8 10^6 y	Dy156(n,nα)Gd152(n,2n)Gd151(n,2n)Gd150				21.8			
		Dy156(n,nα)Gd152(n,2n)Gd151(β^+)_ Eu151(n,2n)Eu150m(β^-)Gd150				17.4			
		Dy156(n,α)Gd153(n,2n)Gd152(n,2n)_ Gd151(n,2n)Gd150				10.9			
		&Dy156(n,α)Gd153(β^+)Eu153(n,2n)*Eu152*_ (n,2n)Eu151(n,2n)Eu150m(β^-)Gd150				9.5			
		Dy156(n,α)Gd153(n,2n)Gd152(n,2n)_ Gd151(β^+)Eu151(n,2n)Eu150m(β^-)Gd150				7.6			
		Dy156(n,3n)Dy154(n,3n)Dy152(β^+)_ Tb152(β^+)Gd152(n,3n)Gd150					26.7	0.2	
		Dy156(n,3n)Dy154(n,nα)Gd150					9.9	0.4	
		Dy156(n,nα)Gd152(n,3n)Gd150					7.3	0.2	
		Dy156(n,4n)Dy153(β^+)Tb153(β^+)_ Gd153(n,4n)Gd150						5.5	
		Dy161(n,6n)Dy156(n,3nα)Gd150							4.3
		Dy162(n,5n)Dy158(n,5n)Dy154(n,5n)_ Dy150(β^+)Tb150(β^+)Gd150							3.5
		Dy161(n,4nα)Gd154(n,5n)Gd150							3.4
	►	Dy164(n,6n)Dy159(β^+)Tb159(n,5n)_ Tb155(β^+)Gd155(n,6n)Gd150							3.2

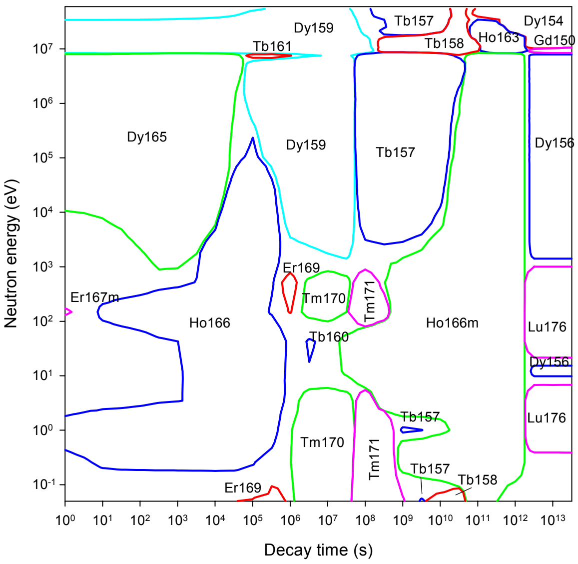
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	Dy160(n,6n)Dy155(β^+)Tb155(β^+)_ Gd155(n,6n)Gd150							3.2
		Dy161(n,3nα)Gd155(n,6n)Gd150							3.1
		Many other similar long pathways				32.8	63.4	93.7	79.3
Dy154	3.0 10^6 y	Dy156(n,2n)Dy155(n,2n)Dy154				100.0			
		Dy156(n,3n)Dy154					43.7	30.9	
		Dy161(n,4n)Dy158(n,3n)Dy156(n,3n)Dy154					15.5	24.4	
		Dy160(n,3n)Dy158(n,3n)Dy156(n,3n)Dy154					14.3	1.4	
		Dy162(n,3n)Dy160(n,3n)Dy158(n,3n)_ Dy156(n,3n)Dy154					9.2		
		Dy158(n,3n)Dy156(n,3n)Dy154					7.9	2.3	
		Dy161(n,3n)Dy159(n,4n)Dy156(n,3n)Dy154					1.2	4.1	
		Dy162(n,4n)Dy159(n,4n)Dy156(n,3n)Dy154					0.1	15.8	
		Dy161(n,4n)Dy158(n,5n)Dy154						4.1	12.7
		Dy162(n,5n)Dy158(n,5n)Dy154							35.7
		Dy163(n,6n)Dy158(n,5n)Dy154							27.8
		Dy161(n,6n)Dy156(n,3n)Dy154							5.6
Hf182	9.0 10^6 y	Very long pathways of (n,γ), β^-	100.0	100.0					
Lu176	4.0 10^{10} y	Very long pathways of (n,γ), β^-	100.0	100.0	100.0				
La138	1.0 10^{11} y	Very long pathways of (n,α), β^+, (n,nα)				100.0	100.0	100.0	100.0
Gd152	1.1 10^{14} y	Dy156(n,α)Gd153(n,γ)Gd154(n,α)_ Sm151(β^-)Eu151(n,γ)Eu152m(β^-)Gd152	88.9	50.6	63.6				
		Dy156(n,α)Gd153(n,α)Sm150(n,γ)_ Sm151(β^-)Eu151(n,γ)Eu152m(β^-)Gd152	10.7	45.4	28.9				
		Dy156(n,α)Gd153(β^+)Eu153(n,γ)Eu154_ (β^-)Gd154(n,α)Sm151(β^-)Eu151(n,γ)_ Eu152m(β^-)Gd152		2.5	3.6				
		Dy156(n,2n)Dy155(β^+)Tb155(β^+)Gd155_ (n,2n)Gd154(n,2n)Gd153(n,2n)Gd152				41.3			
		Dy156(n,nα)Gd152				27.8	5.2	0.5	
		Dy156(n,α)Gd153(n,2n)Gd152				16.8			
		Dy156(n,α)Gd153(β^+)Eu153(n,2n)_ Eu152m(β^-)Gd152				4.5			
		Dy156(n,3n)Dy154(n,3n)Dy152(β^+)_ Tb152(β^+)Gd152					28.9	1.0	
		Dy161(n,4n)Dy158(n,4n)Dy155(β^+)_ Tb155(β^+)Gd155(n,4n)Gd152						35.5	0.1
		Dy162(n,5n)Dy158(n,4n)Dy155(β^+)_ Tb155(β^+)Gd155(n,4n)Gd152						4.1	0.4
		Dy158(n,4n)Dy155(β^+)Tb155(β^+)_ Gd155(n,4n)Gd152						3.4	
		Dy161(n,6n)Dy156(n,5n)Dy152(β^+)_ Tb152(β^+)Gd152							22.2
		&Dy161(n,5n)Dy157(β^+)Tb157(n,6n)_ *Tb152*(β^+)Gd152							8.3
		&Dy162(n,6n)Dy157(β^+)Tb157(n,6n)_ *Tb152*(β^+)Gd152							7.1
		Dy160(n,5n)Dy156(n,5n)Dy152(β^+)_ Tb152(β^+)Gd152							5.6
		Many other similar long pathways	0.4	1.5	3.9	9.6	65.9	55.5	56.3
Dy156	1.0 10^{18} y	Dy161(n,4n)Dy158(n,3n)Dy156					21.0	36.2	0.9
		Dy160(n,3n)Dy158(n,3n)Dy156					19.4	2.0	
		Dy162(n,3n)Dy160(n,3n)Dy158(n,3n)Dy156					16.6	0.4	
		Dy158(n,3n)Dy156					7.2	2.3	0.2
		Dy163(n,4n)Dy160(n,3n)Dy158(n,3n)Dy156					5.1	1.2	
		Dy161(n,3n)Dy159(n,4n)Dy156					1.2	4.5	0.2
		Dy162(n,4n)Dy159(n,4n)Dy156					0.1	17.4	0.3
		Dy160(n,5n)Dy156						1.6	13.7
		Dy164(n,5n)Dy160(n,5n)Dy156						0.4	6.1
		Dy161(n,6n)Dy156							54.1
		Nuclide present in starting material	100.0	100.0	100.0	100.0	29.4	34.0	24.5

Dysprosium activation characteristics

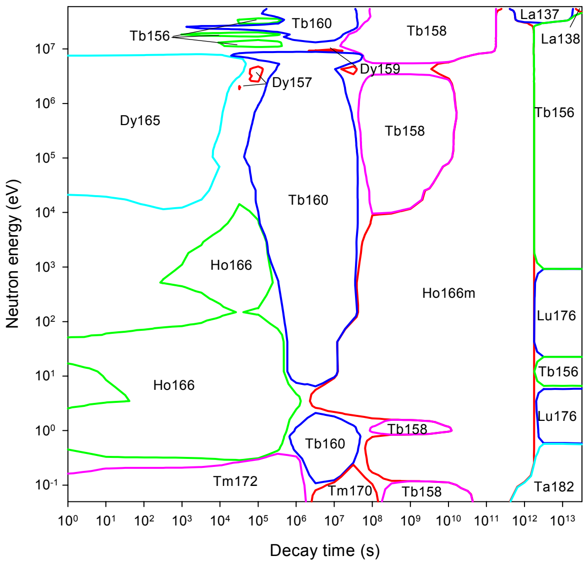


Dysprosium importance diagrams & transmutation

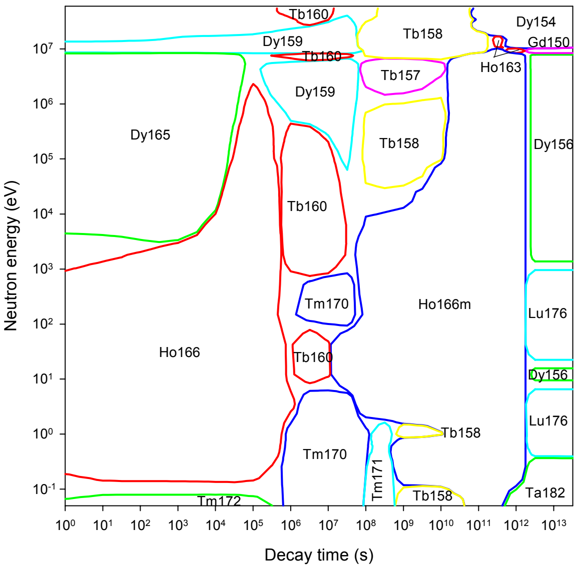
Activity



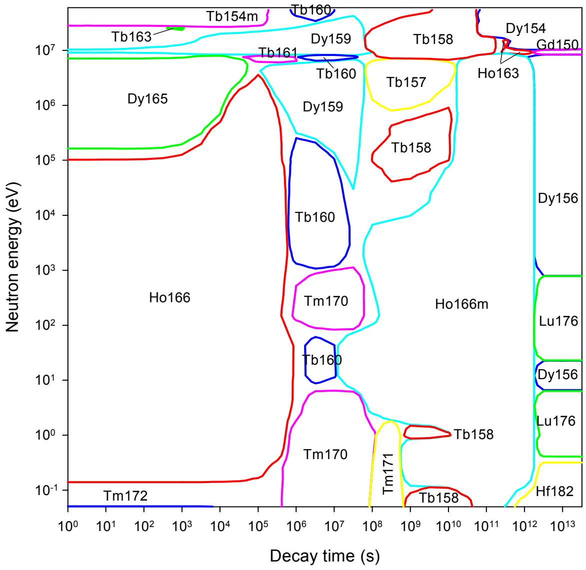
Dose rate



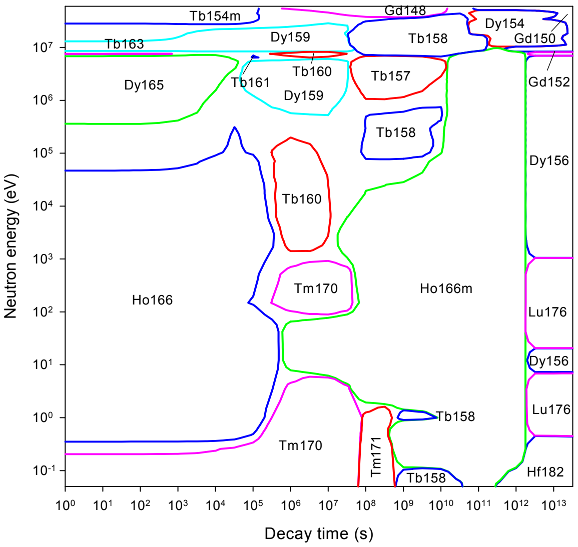
Heat output



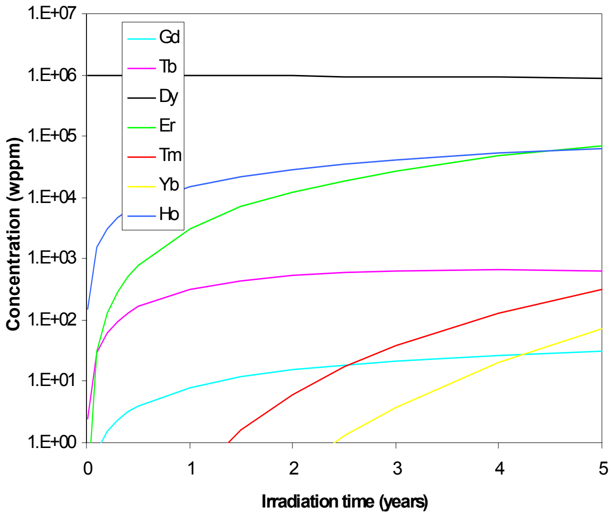
Ingestion dose



Inhalation dose



First wall transmutation



Holmium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	67		
Crustal abundance / wppm	1.3	Ho165	100.0
Melting point / K	1745		
Boiling point / K	2967		
Density / kgm^{-3}	8795		
Thermal conductivity / $Wm^{-1}K^{-1}$	16.2		
Electrical resistivity /Ωm	$8.70\ 10^{-7}$		
Coefficient of thermal expansion / K^{-1}	$1.12\ 10^{-5}$		
Crystal structure	HCP		
Number of stable isotopes	1		
Mean atomic weight	164.93032		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.43E16	8.71E15	1.73E15	5.86E13	2.35E11	4.85E2	kW kg^{-1}	9.67E-1	7.80E-1	1.03E-1	2.65E-3	6.61E-5	2.06E-16
Ho166	41.19	67.40	35.29				Ho166	70.67	87.40	68.69			
Er167m	38.90	0.64					Er167m	19.13	0.24				
Er169	6.99	11.46	44.15				Ho167	4.68	5.68				
Er165	5.04	8.22	0.12				Tm170	1.79	2.22	16.47	91.34		
Ho167	3.35	5.39					Er169	1.68	2.09	12.07			
Tm170	2.28	3.74	18.49	77.71			Er165	0.51	0.63	0.01			
Ho164	0.98	1.48					Tm168	0.17	0.21	1.54	4.06		
Tm171	0.12	0.20	1.02	20.94			Ho166m	0.01	0.01	0.07	2.64	100.0	
Ho166m			0.01	0.42	99.16		Tm171	0.01	0.01	0.07	1.95		
Ho163					0.78	100.0	Ho163						99.94
Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	7.29E4	5.22E4	6.14E3	2.00E2	6.85E1	3.30E-14	Sv kg^{-1}	9.13E6	9.11E6	1.57E6	6.15E4	4.66E2	1.11E-8
Ho166	45.93	64.12	57.10				Ho166	90.22	90.22	54.28			
Er167m	28.20	0.40					Tm170	4.64	4.65	26.41	96.21		
Ho167	19.73	27.08					Er169	4.05	4.05	17.95			
Tm172	2.80	3.92	12.94				Ho167	0.44	0.43				
Tm168	2.43	3.40	28.41	61.36		6.27	Tm172	0.28	0.28	0.62			
Ho166m	0.10	0.14	1.20	38.10	100.0		Tm168	0.08	0.08	0.46	0.79		
Tm170	0.01*	0.01*	0.12*	0.52*			Tm171	0.02	0.02	0.12	2.19		
Lu176						83.31	Ho166m	0.01	0.01	0.03	0.80	99.99	
Ta182						10.14	Ho163					0.01	99.97
Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	7.25E6	7.24E6	3.49E6	3.67E5	2.80E4	2.58E-8		9.03E11	3.05E11	2.38E10	1.51E9	3.82E8	1.29E-4
Ho166	52.74	52.69	11.37				Er167m	66.22	1.98	0.01			
Tm170	31.44	31.49	64.13	86.82			Ho167	20.39	59.13				
Er169	13.77	13.78	21.87				Ho166	6.52	19.24	25.61			
Ho167	0.47	0.46					Er165	3.07	9.02	0.33			
Ho166m	0.41	0.41	0.85	8.08	100.0		Tm168	1.07	3.16	39.42	42.14		0.01
Tm171	0.34	0.34	0.70	4.68			Tm172	0.88	2.59	12.76			
Tm168	0.33	0.33	0.67	0.43			Tm170	0.36	1.07	13.42	30.17		
Tm172	0.23	0.23	0.18				Er169	0.11	0.33	3.20			
Yb169	0.11	0.11	0.22				Ho166m	0.05	0.13	1.70	26.84	100.0	
Ho163						99.74	Tm171		0.01	0.07	0.81		
Lu176						0.24	Ho163						99.21

Holmium

Pathway analysis

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Er167m	2.269 s	Ho165(n,γ)Ho166(β^-)Er166(n,γ)Er167m	99.8	99.8	98.5	91.8	94.5	94.3	94.0
		Ho165(n,γ)Ho166m(n,γ)Ho167(β^-)Er167m				6.1	4.2	4.6	5.1
Tb162	7.6 m	Ho165(n,α)Tb162	100.0	100.0	100.0	96.8	78.0	20.4	48.9
		&Ho165(n,2n)*Ho164*(β^+)Dy164(n,t)Tb162					6.2	19.2	16.7
		Ho165(n,t)Dy163(n,d)Tb162					3.5	12.3	13.0
		&Ho165(n,4n)*Ho162*(β^+)Dy162(n,p)Tb162					2.1	25.1	3.3
		Ho165(n,d)Dy164(n,t)Tb162					2.0	11.5	14.2
		&Ho165(n,3n)Ho163(n,2n)*Ho162*(β^+)_ Dy162(n,p)Tb162					2.0		
		Ho165(n,4n)Ho162m(β^+)Dy162(n,p)Tb162					0.5	8.5	1.2
		Ho165(n,nt)Dy162(n,p)Tb162					0.2	0.8	1.5
Ho162	15.0 m	&Ho165(n,2n)*Ho164*(β^-)Er164(n,2n)_ Er163(β^+)Ho163(n,2n)*Ho162*				94.0			
		&Ho165(n,3n)*Ho163*(n,2n)*Ho162*					64.2	0.8	1.0
		&Ho165(n,4n)*Ho162*					32.8	99.2	99.0
Ho164	28.6 m	&Ho165(n,2n)*Ho164*				100.0	100.0	100.0	100.0
Ho162m	1.117 h	&Ho165(n,2n)*Ho164*(β^-)Er164(n,2n)_ Er163(β^+)Ho163(n,2n)Ho162m				99.5			
		&Ho165(n,3n)*Ho163*(n,2n)Ho162m					72.9	1.6	
		Ho165(n,4n)Ho162m					26.3	98.0	97.3
Ho161	2.48 h	&Ho165(n,3n)*Ho163*(n,3n)*Ho161*					98.0	31.3	
		&Ho165(n,5n)*Ho161*						50.5	91.5
		Ho165(n,2n)Ho164(β^-)Er164(n,4n)_ Er161(β^+)Ho161						9.2	
Ho167	3.10 h	Ho165(n,γ)Ho166m(n,γ)Ho167	95.0	96.7	98.3	99.4	98.8	99.1	99.5
		Ho165(n,γ)Ho166(n,γ)Ho167	5.0	3.3	1.7	0.3	0.3	0.3	0.2
Tb154m	9.00 h	Ho165(n,nα)Tb161(β^-)Dy161(n,4n)_ Dy158(n,3n)Dy156(n,t)Tb154m					2.7		
		Ho165(n,3n)Ho163(n,nα)Tb159(n,3n)_ Tb157(n,4n)Tb154m					2.5	0.1	
		Ho165(n,2nα)Tb160(β^-)Dy160(n,4n)_ Dy157(β^+)Tb157(n,4n)Tb154m						8.2	
		Ho165(n,t)Dy163(n,4n)Dy160(n,4n)_ Dy157(β^+)Tb157(n,4n)Tb154m						3.0	
		Ho165(n,5n)Ho161(β^+)Dy161(n,5n)_ Dy157(β^+)Tb157(n,4n)Tb154m						2.5	15.2
		&Ho165(n,4nα)*Tb158*(n,5n)Tb154m							9.5
		Ho165(n,3nα)Tb159(n,6n)Tb154m							8.7
		Ho165(n,3n)Ho163(n,5n)Ho159(β^+)_ Dy159(β^+)Tb159(n,6n)Tb154m							5.4
		Ho165(n,5n)Ho161(β^+)Dy161(n,3n)_ Dy159(β^+)Tb159(n,6n)Tb154m							5.1
		&Ho165(n,5n)Ho161(β^+)Dy161(n,nt)_ *Tb158*(n,5n)Tb154m							5.1
		Ho165(n,5n)Ho161(β^+)Dy161(n,6n)_ Dy156(n,t)Tb154m							3.7
		&Ho165(n,5n)*Ho161*(β^+)Dy161(n,t)_ Tb159(n,6n)Tb154m							2.9
		Plus many other similar long pathways				100.0	94.8	86.2	44.4
Ho166	1.117 d	Ho165(n,γ)Ho166	100.0	100.0	100.0	99.6	99.6	99.7	99.8
Tm172	2.650 d	&Ho165(n,γ)Ho166(β^-)Er166(n,γ)_ *Er167*(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170(n,γ)Tm171(n,γ)Tm172	83.9	84.6	86.1				
	▶	&Ho165(n,γ)Ho166m(n,γ)Ho167(β^-)_ *Er167*(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170(n,γ)Tm171(n,γ)Tm172	13.5	12.0	8.2				

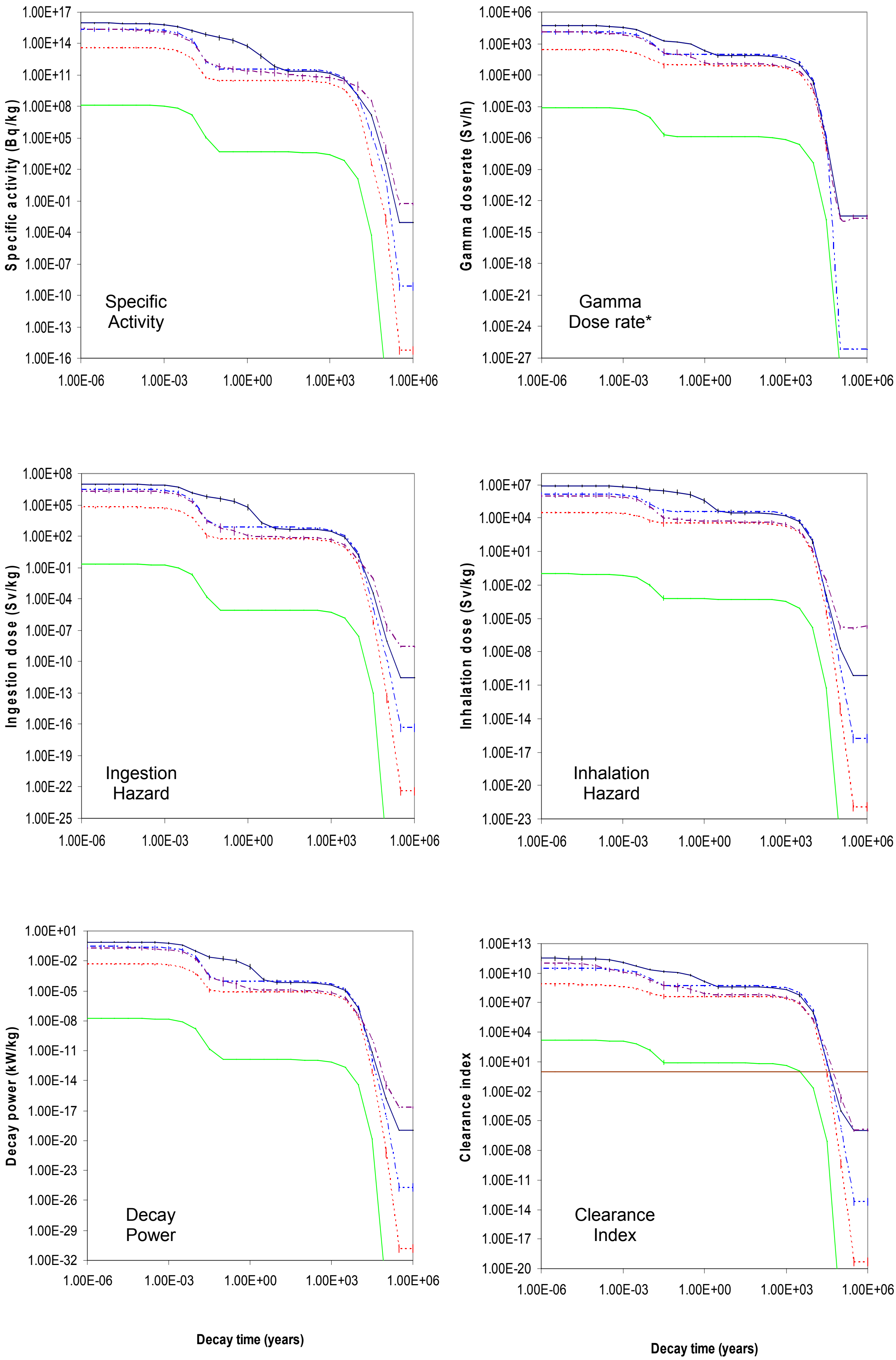
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Ho165(n,γ)Ho166(n,γ)Ho167(β^-)_ *Er167*(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170(n,γ)Tm171(n,γ)Tm172	0.6	1.5	0.7				
Er169	9.40 d	&Ho165(n,γ)Ho166(β^-)Er166(n,γ)_ *Er167*(n,γ)Er168(n,γ)Er169	90.0	89.5	91.0	86.7	90.8	89.9	88.5
		&Ho165(n,γ)Ho166(n,γ)Ho167(β^-)_ *Er167*(n,γ)Er168(n,γ)Er169	0.5	1.0	0.4	0.1			
		&Ho165(n,γ)Ho166m(n,γ)Ho167(β^-)_ *Er167*(n,γ)Er168(n,γ)Er169				12.5	8.5	9.4	10.9
Tb160	72.3 d	Ho165(n,α)Tb162(β^-)Dy162(n,α)_ Gd159(β^-)Tb159(n,γ)Tb160	100.0	100.0	100.0				
		&Ho165(n,2n)*Ho164*(β^-)Er164(n,2n)_ Er163(β^+)Ho163(n,α)Tb160				96.6	0.1		
		&Ho165(n,3n)*Ho163*(n,3n)*Ho161*(β^+)_ Dy161(n,d)Tb160					37.6	0.8	0.2
		&Ho165(n,3n)*Ho163*(n,α)Tb160					36.3	0.8	0.6
		Ho165(n,2nα)Tb160					13.8	47.4	39.2
		Ho165(n,nα)Tb161(β^-)Dy161(n,d)Tb160					2.4	0.5	0.3
		&Ho165(n,4n)*Ho162*(β^+)Dy162(n,t)Tb160					1.2	30.2	9.8
		Ho165(n,4n)Ho162m(β^+)Dy162(n,t)Tb160					0.3	10.3	3.5
		Ho165(n,nt)Dy162(n,t)Tb160					0.1	0.9	4.5
		Ho165(n,t)Dy163(n,nt)Tb160					0.1	0.7	3.7
		&Ho165(n,5n)*Ho161*(β^+)Dy161(n,d)Tb160						2.8	28.7
		&Ho165(n,2n)*Ho164*(β^+)Dy164(n,2nt)Tb160							2.2
		Ho165(n,2nt)Dy161(n,d)Tb160							2.2
		Ho165(n,d)Dy164(n,2nt)Tb160							1.9
Ta182	114.7 d	Very long pathways of (n,γ), β^-	100.0	100.0					
Tm170	128.6 d	&Ho165(n,γ)Ho166(β^-)Er166(n,γ)*Er167*_ (n,γ)Er168(n,γ)Er169(β^-)Tm169(n,γ)Tm170	86.3	86.3	88.0	84.5	88.5	87.6	86.2
		&Ho165(n,γ)Ho166m(n,γ)Ho167(β^-)_ *Er167*(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170	12.3	11.3	8.4	12.3	8.3	9.2	10.6
		&Ho165(n,γ)Ho166(n,γ)Ho167(β^-)_ *Er167*(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170	0.5	1.4	0.5	0.1			
Dy159	144.4 d	&Ho165(n,2n)*Ho164*(β^+)Dy164(n,2n)_ Dy163(n,2n)Dy162(n,2n)Dy161(n,2n)_ Dy160(n,2n)Dy159				27.8			
		&Ho165(n,2n)*Ho164*(β^-)Er164(n,α)_ Dy161(n,2n)Dy160(n,2n)Dy159				9.7			
		&Ho165(n,2n)*Ho164*(β^-)Er164(n,nα)_ Dy160(n,2n)Dy159				8.2			
		&Ho165(n,2n)*Ho164*(β^+)Dy164(n,3n)Dy162_ (n,2n)Dy161(n,2n)Dy160(n,2n)Dy159				8.0			
		Ho165(n,α)Tb162(β^-)Dy162(n,2n)_ Dy161(n,2n)Dy160(n,2n)Dy159				7.1			
		&Ho165(n,2n)*Ho164*(β^-)Er164(n,2n)Er163_ (β^+)Ho163(n,α)Tb160(β^-)Dy160(n,2n)Dy159				5.4			
		&Ho165(n,2n)*Ho164*(β^+)Dy164(n,α)_ Gd161(β^-)Tb161(β^-)Dy161(n,2n)_ Dy160(n,2n)Dy159				3.2			
		Ho165(n,nα)Tb161(β^-)Dy161(n,2n)_ Dy160(n,2n)Dy159				2.7			
		&Ho165(n,3n)*Ho163*(n,3n)*Ho161*(β^+)_ Dy161(n,3n)Dy159					79.6		0.1
		Ho165(n,nα)Tb161(β^-)Dy161(n,3n)Dy159					5.4		0.2
		&Ho165(n,4n)*Ho162*(β^+)Dy162(n,4n)Dy159					1.1	65.4	8.3
		Ho165(n,4n)Ho162m(β^+)Dy162(n,4n)Dy159					0.3	22.2	2.9
		Ho165(n,nt)Dy162(n,4n)Dy159					0.1	2.0	3.8
		&Ho165(n,5n)*Ho161*(β^+)Dy161(n,3n)Dy159						1.5	23.4
	►	&Ho165(n,3n)*Ho163*(n,5n)*Ho159*(β^+)Dy159						0.9	27.6

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◀	Ho165(n,t)Dy163(n,5n)Dy159						0.9	5.7
		&Ho165(n,2n)*Ho164*(β^+)Dy164(n,6n)Dy159							7.3
		Ho165(n,d)Dy164(n,6n)Dy159							6.2
		&Ho165(n,6n)*Ho160*(β^+)Dy160(n,2n)Dy159							4.0
		Ho165(n,3n)Ho163(n,2nt)Dy159							2.2
		Ho165(n,2nt)Dy161(n,3n)Dy159							1.7
		Many other similar long pathways				27.9	13.5	7.1	6.6
Tm171	1.917 y	**&**Ho165(n,γ)Ho166(β^-)Er166(n,γ)_ *Er167*(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170(n,γ)Tm171	84.2	85.0	87.0				
		&Ho165(n,γ)Ho166m(n,γ)Ho167(β^-)_ *Er167*(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170(n,γ)Tm171	13.5	12.1	8.3				
		&Ho165(n,γ)Ho166(n,γ)Ho167(β^-)_ *Er167*(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170(n,γ)Tm171	0.6	1.5	0.7				
H3	12.33 y	Ho165(n,X)H3				99.6	86.7	86.9	87.4
		&Ho165(n,3n)*Ho163*(n,X)H3					9.9	3.2	1.7
		Ho165(n,4n)Ho162(β^+)Dy162(n,X)H3						1.7	
		Ho165(n,4n)Ho162m(β^+)Dy162(n,X)H3						1.4	
		Ho165(n,5n)Ho161(β^+)Dy161(n,X)H3							4.1
Gd148	74.602 y	Very long pathways				100.0	100.0	100.0	100.0
Tb157	99.0 y	**&**Ho165(n,2n)*Ho164*(β^-)Er164(n,nα)_ Dy160(n,2n)Dy159(β^+)Tb159(n,2n)_ *Tb158*(n,2n)Tb157				7.5			
		&Ho165(n,2n)*Ho164*(β^-)Er164(n,2n)_ Er163(β^+)Ho163(n,nα)Tb159(n,2n)_ *Tb158*(n,2n)Tb157				5.4			
		&Ho165(n,2n)*Ho164*(β^-)Er164(n,nα)_ Dy160(n,2n)Dy159(n,2n)Dy158(n,2n)_ Dy157(β^+)Tb157				5.3			
		Ho165(n,3n)Ho163(n,3n)Ho161(β^+)Dy161_ (n,3n)Dy159(β^+)Tb159(n,3n)Tb157					34.1		
		Ho165(n,3n)Ho163(n,3n)Ho161(β^+)Dy161_ (n,3n)Dy159(n,3n)Dy157(β^+)Tb157					15.5		
		Ho165(n,3n)Ho163(n,nα)Tb159(n,3n)Tb157					10.4	0.1	
		Ho165(n,nα)Tb161(β^-)Dy161(n,3n)_ Dy159(β^+)Tb159(n,3n)Tb157					5.3		
		&Ho165(n,4n)*Ho162*(β^+)Dy162(n,4n)_ Dy159(β^+)Tb159(n,3n)Tb157					1.1	14.6	
		&Ho165(n,4n)*Ho162*(β^+)Dy162(n,4n)_ Dy159(n,3n)Dy157(β^+)Tb157					0.4	4.7	
		Ho165(n,4n)Ho162m(β^+)Dy162(n,4n)_ Dy159(β^+)Tb159(n,3n)Tb157					0.3	5.0	
		&Ho165(n,4n)*Ho162*(β^+)Dy162(n,3n)_ Dy160(n,4n)Dy157(β^+)Tb157						14.9	
		&Ho165(n,3n)Ho163(n,4n)*Ho160*(β^+)_ Dy160(n,4n)Dy157(β^+)Tb157						8.8	
		Ho165(n,2nα)Tb160(β^-)Dy160(n,4n)_ Dy157(β^+)Tb157						8.5	0.3
		Ho165(n,4n)Ho162m(β^+)Dy162(n,3n)_ Dy160(n,4n)Dy157(β^+)Tb157						5.1	
		Ho165(n,t)Dy163(n,4n)Dy160(n,4n)_ Dy157(β^+)Tb157						3.1	
		&Ho165(n,5n)*Ho161*(β^+)Dy161(n,5n)_ Dy157(β^+)Tb157						2.9	53.7
		Ho165(n,2nt)Dy161(n,5n)Dy157(β^+)Tb157						0.1	4.0
		&Ho165(n,4n)*Ho162*(β^+)Dy162(n,6n)_ Dy157(β^+)Tb157							10.1
		Ho165(n,5n)Ho161(β^+)Dy161(n,2nt)Tb157							5.5
		Ho165(n,nt)Dy162(n,6n)Dy157(β^+)Tb157							4.6

Nuclide	T½	Pathway	210	186	151	42	30	21	6
		&Ho165(n,6n)*Ho160*(β^+)Dy160(n,4n)_ Dy157(β^+)Tb157							3.7
		Ho165(n,4n)Ho162m(β^+)Dy162(n,6n)_ Dy157(β^+)Tb157							3.6
		Many other similar long pathways				81.8	32.9	32.2	14.5
Tb158	180.0 y	**&**Ho165(n,2n)*Ho164*(β^-)Er164(n,nα)_ Dy160(n,2n)Dy159(β^+)Tb159(n,2n)*Tb158*				10.5			
		&Ho165(n,2n)*Ho164*(β^+)Dy164(n,2n)_ Dy163(n,2n)Dy162(n,α)Gd159(β^-)_ Tb159(n,2n)*Tb158*				8.0			
		&Ho165(n,2n)*Ho164*(β^-)Er164(n,2n)_ Er163(β^+)Ho163(n,nα)Tb159(n,2n)*Tb158*				6.9			
		&Ho165(n,2n)*Ho164*(β^-)Er164(n,α)_ Dy161(n,2n)Dy160(n,2n)Dy159(β^+)_ Tb159(n,2n)*Tb158*				6.8			
		&Ho165(n,α)Tb162(β^-)Dy162(n,2n)_ Dy161(n,2n)Dy160(n,2n)Dy159(β^+)_ Tb159(n,2n)*Tb158*				5.6			
		&Ho165(n,2n)*Ho164*(β^+)Dy164(n,2n)_ Dy163(n,α)Gd160(n,2n)Gd159(β^-)_ Tb159(n,2n)*Tb158*				4.9			
		&Ho165(n,nα)Tb161(β^-)Dy161(n,2n)_ Dy160(n,2n)Dy159(β^+)Tb159(n,2n)*Tb158*				3.5			
		Ho165(n,3n)Ho163(n,3n)Ho161(β^+)_ Dy161(n,3n)Dy159(β^+)Tb159(n,2n)Tb158					25.3		
		&Ho165(n,3n)*Ho163*(n,2nα)*Tb158*					20.1	14.9	1.2
		&Ho165(n,3n)Ho163(n,nα)Tb159(n,2n)*Tb158*					10.5	0.2	
		&Ho165(n,nα)Tb161(β^-)Dy161(n,3n)_ Dy159(β^+)Tb159(n,2n)*Tb158*					5.3	0.1	
		Ho165(n,3n)Ho163(n,3n)Ho161(β^+)_ Dy161(n,nt)Tb158					2.5	0.5	0.1
		&Ho165(n,4n)*Ho162*(β^+)Dy162(n,4n)_ Dy159(β^+)Tb159(n,2n)*Tb158*					1.0	33.0	
		&Ho165(n,4n)Ho162m(β^+)Dy162_ (n,4n)Dy159(β^+)Tb159(n,2n)*Tb158*					0.2	13.4	
		&Ho165(n,5n)*Ho161*(β^+)Dy161(n,nt)*Tb158*						2.7	26.7
		&Ho165(n,4nα)*Tb158*							47.0
		&Ho165(n,6n)*Ho160*(β^+)Dy160(n,t)*Tb158*							4.3
		Many other similar long pathways				51.9	35.1	35.2	20.7
Ho166m	1200 y	Ho165(n,γ)Ho166m	100.0	100.0	100.0	99.9	99.8	99.8	99.9
Ho163	4570 y	**&**Ho165(n,2n)*Ho164*(β^-)Er164(n,2n)_ Er163(β^+)Ho163				99.8			
		&Ho165(n,3n)*Ho163*					99.4	98.9	91.4
La137	6.0 10^4 y	Very long pathways of (n,α), β^+, (n,nα)				100.0	100.0	100.0	100.0
Gd150	1.8 10^6 y	Very long pathways of (n,α), β^+, (n,nα)				100.0	100.0	100.0	100.0
Dy154	3.0 10^6 y	**&**Ho165(n,3n)*Ho163*(n,3n)*Ho161*(β^+)Dy161_ (n,4n)Dy158(n,3n)Dy156(n,3n)Dy154					48.6	0.6	
		&Ho165(n,4n)*Ho162*(β^+)Dy162(n,3n)Dy160_ (n,3n)Dy158(n,3n)Dy156(n,3n)Dy154					7.7	0.2	
		Ho165(n,nα)Tb161(β^-)Dy161(n,4n)_ Dy158(n,3n)Dy156(n,3n)Dy154					7.3	1.0	
		Ho165(n,3n)Ho163(n,3n)Ho161(β^+)Dy161_ (n,3n)Dy159(n,4n)Dy156(n,3n)Dy154					4.5	0.2	
		&Ho165(n,4n)*Ho162*(β^+)Dy162(n,4n)_ Dy159(n,4n)Dy156(n,3n)Dy154						46.8	
		Ho165(n,4n)Ho162m(β^+)Dy162(n,4n)_ Dy159(n,4n)Dy156(n,3n)Dy154						15.9	
		&Ho165(n,4n)*Ho162*(β^+)Dy162(n,5n)_ Dy158(n,3n)Dy156(n,3n)Dy154						6.8	
		Ho165(n,5n)Ho161(β^+)Dy161(n,4n)_ Dy158(n,3n)Dy156(n,3n)Dy154						5.3	

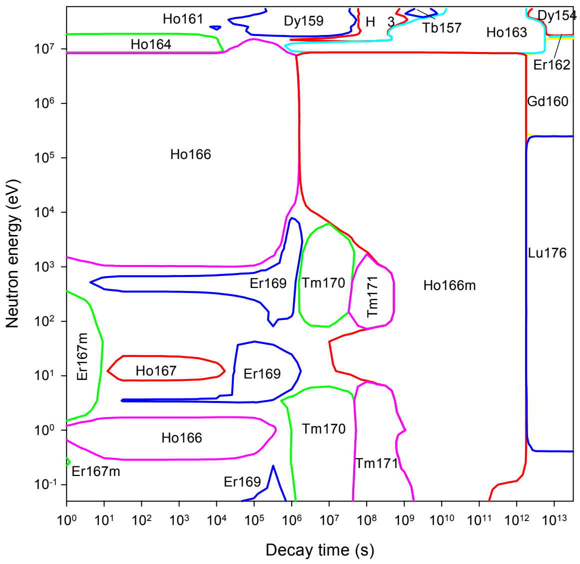
Nuclide	T½	Pathway	210	186	151	42	30	21	6
		&Ho165(n,4n)*Ho162*(β^+)Dy162(n,5n)_ Dy158(n,5n)Dy154						1.5	16.2
		Ho165(n,5n)Ho161(β^+)Dy161(n,4n)_ Dy158(n,5n)Dy154						1.2	24.3
		Ho165(n,4n)Ho162m(β^+)Dy162(n,5n)_ Dy158(n,5n)Dy154						0.5	5.7
		Ho165(n,5n)Ho161(β^+)Dy161(n,6n)_ Dy156(n,3n)Dy154							10.7
		Ho165(n,nt)Dy162(n,5n)Dy158(n,5n)Dy154							7.3
		Ho165(n,t)Dy163(n,6n)Dy158(n,5n)Dy154							4.8
		Many other similar long pathways				100.0	31.9	20.0	31.0
Hf182	9.0 10^6 y	Very long pathways of (n,γ), β^-	100.0	100.0					
Lu176	4.0 10^{10} y	**&**Ho165(n,γ)Ho166(β^-)Er166(n,γ)_ *Er167*(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170(n,γ)Tm171(n,γ)Tm172(β^-)_ Yb172(n,γ)Yb173(n,γ)Yb174(n,γ)_ Yb175(β^-)Lu175(n,γ)Lu176	36.7	62.9	44.2				
		&Ho165(n,γ)Ho166(β^-)Er166(n,γ)_ *Er167*(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170(n,γ)Tm171(n,γ)Tm172(n,γ)_ Tm173(β^-)Yb173(n,γ)Yb174(n,γ)_ Yb175(β^-)Lu175(n,γ)Lu176	23.2	1.6	2.3				
		&Ho165(n,γ)Ho166m(n,γ)Ho167(β^-)_ *Er167*(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170(n,γ)Tm171(n,γ)Tm172(β^-)_ Yb172(n,γ)Yb173(n,γ)Yb174(n,γ)_ Yb175(β^-)Lu175(n,γ)Lu176	16.0	14.2	4.2				
		&Ho165(n,γ)Ho166m(n,γ)Ho167(β^-)_ *Er167*(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170(n,γ)Tm171(n,γ)Tm172(n,γ)_ Tm173(β^-)Yb173(n,γ)Yb174(n,γ)_ Yb175(β^-)Lu175(n,γ)Lu176	8.3	0.3	0.2				
		&Ho165(n,γ)Ho166(β^-)Er166(n,γ)_ *Er167*(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170(β^-)Yb170(n,γ)Yb171(n,γ)_ Yb172(n,γ)Yb173(n,γ)Yb174(n,γ)_ Yb175(β^-)Lu175(n,γ)Lu176	3.0	0.3	22.1				
		&Ho165(n,γ)Ho166(β^-)Er166(n,γ)_ *Er167*(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170(n,γ)Tm171(β^-)Yb171(n,γ)_ Yb172(n,γ)Yb173(n,γ)Yb174(n,γ)_ Yb175(β^-)Lu175(n,γ)Lu176	2.1	7.4	10.5				
		&Ho165(n,γ)Ho166(n,γ)Ho167(β^-)*Er167*(n,γ) Er168(n,γ)Er169(β^-)Tm169(n,γ)Tm170(n,γ)_ Tm171(n,γ)Tm172(β^-)Yb172(n,γ)Yb173_ (n,γ)Yb174(n,γ)Yb175(β^-)Lu175(n,γ)Lu176	0.7	3.0	0.7				
Er162	1.4 10^{14} y	**&**Ho165(n,2n)*Ho164*(β^-)Er164(n,3n)Er162					99.8	99.9	97.6
		Ho165(n,γ)Ho166(β^-)Er166(n,5n)Er162							2.3
Gd160	1.3 10^{17} y	Ho165(n,γ)Ho166(β^-)Er166(n,α)Dy163_ (n,α)Gd160	85.0	99.9	99.8				
		Ho165(n,α)Tb162(β^-)Dy162(n,γ)_ Dy163(n,α)Gd160	14.9		0.2				
		&Ho165(n,2n)*Ho164*(β^+)Dy164(n,2n)_ Dy163(n,α)Gd160				91.4	0.3		
		&Ho165(n,2n)*Ho164*(β^+)Dy164(n,nα)Gd160				7.3	73.5	41.4	41.6
		Ho165(n,t)Dy163(n,α)Gd160				0.9	1.6	2.7	12.7
		Ho165(n,d)Dy164(n,nα)Gd160					23.5	24.8	26.7
		&Ho165(n,4n)*Ho162*(β^+)Dy162(n,h)Gd160						21.3	12.3
		Ho165(n,4n)Ho162m(β^+)Dy162(n,h)Gd160						7.3	4.3
		Ho165(n,nt)Dy162(n,h)Gd160						0.7	5.6
		&Ho165(n,5n)*Ho161*(β^+)Dy161(n,2p)Gd160							2.8

Holmium activation characteristics

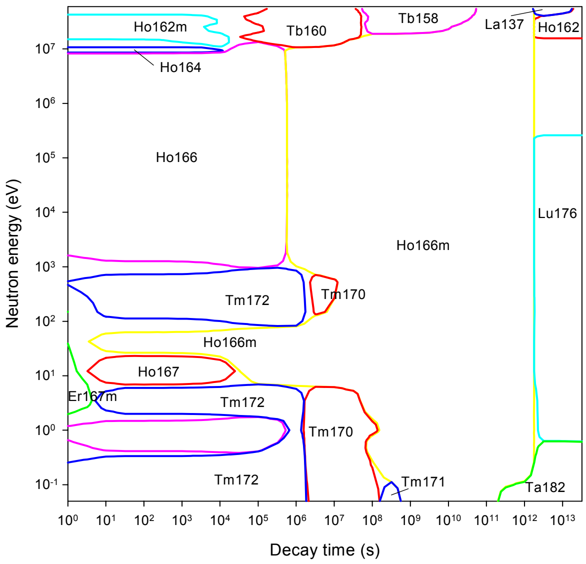


Holmium importance diagrams & transmutation

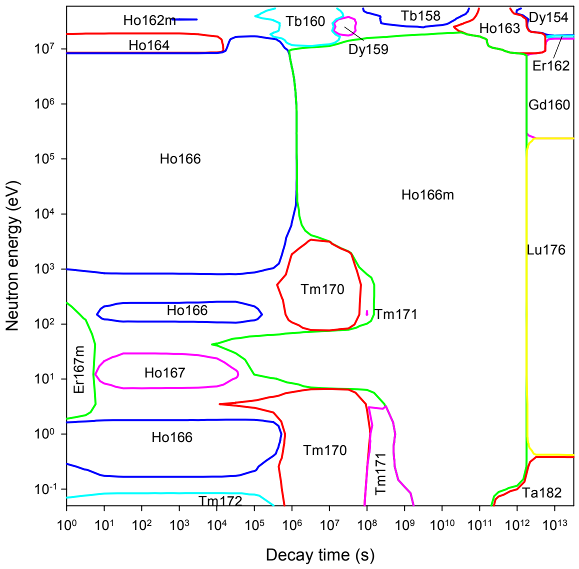
Activity



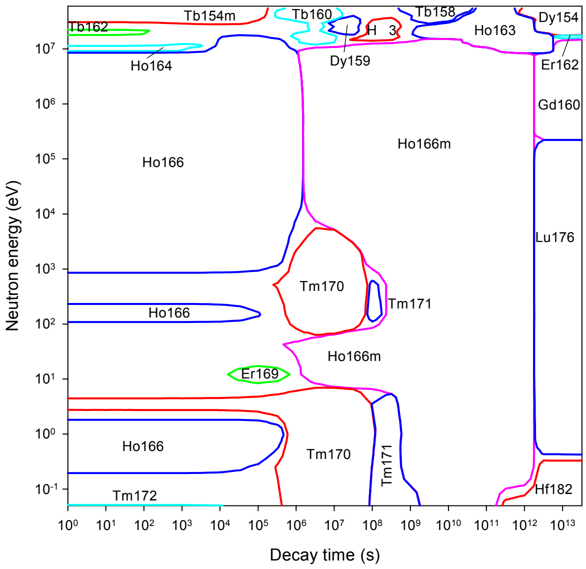
Dose rate



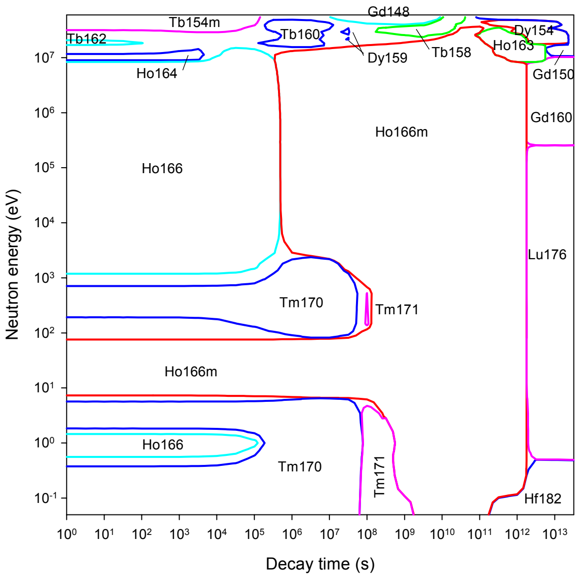
Heat output



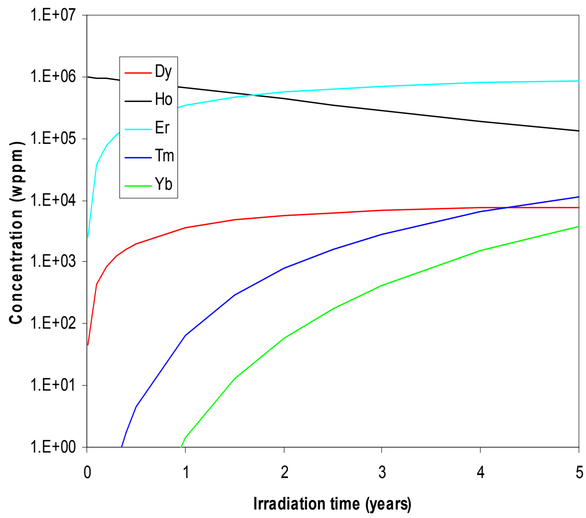
Ingestion dose



Inhalation dose



First wall transmutation



Erbium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	68	Er162	0.139 ($T_{1/2}$=1.40 10^{14} y)
Crustal abundance / wppm	3.5	Er164	1.601
Melting point / K	1802	Er166	33.503
Boiling point / K	3135	Er167	22.869
Density / kgm^{-3}	9066	Er168	26.978
Thermal conductivity / Wm^{-1}K^{-1}	14.3	Er170	14.910
Electrical resistivity /Ωm	8.7 10^{-7}		
Coefficient of thermal expansion / K^{-1}	1.22 10^{-5}		
Crystal structure	HCP		
Number of stable isotopes	5 (6)		
Mean atomic weight	167.259		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	9.20E15	7.14E15	4.80E15	6.28E14	1.85E10	2.53E3
Er169	30.66	39.47	44.89			
Er167m	22.06	0.03				
Tm170	20.51	26.41	38.54	41.95		
Er171	7.09	9.05				
Tm171	5.64	7.26	10.78	57.59		
Tm172	4.81	6.19	3.55			
Ho166	3.71	4.77	0.74			
Er165	3.69	4.72	0.02			
Tm168	0.47	0.60	0.87	0.45		
Ho164	0.35	0.40				
Yb169	0.34	0.44	0.60			
Ho163					51.97	99.96
Ho166m					47.96	

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	4.27E-1	3.58E-1	1.78E-1	1.61E-2	2.52E-6	1.21E-15
Tm170	23.47	27.98	55.21	86.85		
Er171	19.29	22.81	0.01			
Tm172	16.74	19.93	15.45			
Er167m	15.82	0.02				
Er169	10.77	12.84	19.74			
Ho166	9.29	11.05	2.31			
Tm168	2.12	2.53	4.95	3.70		
Tm171	0.51	0.61	1.22	9.43		
Yb169	0.50	0.59	1.10	0.01		
Ho166m				0.02	99.84	
Ho163					0.16	88.67
Lu176						6.77
Ta182						1.09

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	9.64E4	8.88E4	3.32E4	7.01E2	2.57E0	3.94E-11
Tm172	62.29	67.53	70.03			
Er171	16.83	18.12	0.02			
Tm168	10.12	10.98	28.77	98.55		0.08
Er167m	7.54	0.01				
Ho166	2.01	2.18	0.61			
Ho167	0.56	0.60				
Tm170	0.04*	0.05*	0.12*	0.85*		
Ho166m			0.01	0.42	100.0	
Lu176						49.80
Ta182						45.35
Hf182						1.24

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	5.09E6	5.09E6	3.66E6	3.85E5	1.80E1	6.88E-8
Tm170	48.17	48.21	65.73	88.96		
Er169	20.50	20.51	21.79			
Tm172	14.78	14.77	7.91			
Ho166	9.39	9.38	1.35			
Er171	4.61	4.58				
Tm171	1.12	1.12	1.56	10.33		
Tm168	0.81	0.81	1.09	0.70		
Yb169	0.43	0.43	0.56			
Ho166m				0.01	98.76	
Ho163					1.23	84.41
Er162						13.49
Lu176						1.72

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.78E7	1.78E7	1.62E7	2.36E6	1.06E3	2.27E-7
Tm170	74.04	74.04	79.66	78.13		
Er169	15.81	15.81	13.26			
Tm171	4.07	4.07	4.46	21.45		
Tm172	2.73	2.73	1.15			
Ho166	1.25	1.24	0.14			
Er171	0.80	0.80				
Tm168	0.74	0.74	0.79	0.37		
Yb169	0.52	0.52	0.53			
Ho166m	0.01	0.01	0.01	0.05	99.95	
Ho163					0.05	59.06
Lu176						20.28
Er162						12.87
Hf182						7.53
Ta182						0.24

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	5.71E11	3.52E11	1.73E11	6.54E9	1.45E7	1.91E-3
Tm172	40.74	66.05	51.93			
Er167m	38.17	0.07	0.01			
Tm168	9.36	15.18	30.17	53.90		0.01
Tm170	3.30	5.36	10.72	40.27		
Er165	2.28	3.68	0.02			
Yb169	1.75	2.85	5.37	0.06		
Ho167	1.28	1.98				
Er171	1.14	1.84				
Ho166	0.60	0.97	0.21			
Er169	0.49	0.80	1.25			
Tm171	0.09	0.15	0.30	5.53		
Ho166m			0.01	0.24	99.97	
Ho163					0.02	34.83
Lu176						34.41
Ta182						28.84
Hf182						0.70
Er162						0.63
Ho162						0.56

Erbium

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Er167m	2.269 s	Er166(n,γ)Er167m	97.0	93.9	100.0		0.2	0.2	0.2
		Er164(n,γ)Er165(β^+)Ho165(n,γ)Ho166_ (β^-)Er166(n,γ)Er167m	2.8	5.5					
		Er168(n,2n)Er167m				87.1	40.5	47.5	53.1
		Er167(n,n′)Er167m				5.5	7.6	7.8	7.3
		Er170(n,3n)Er168(n,2n)Er167m				1.9	3.7	1.3	0.9
		Er170(n,2n)Er169(β^-)Tm169(n,2n)_ Tm168(β^+)Er168(n,2n)Er167m				1.9			
		Er170(n,2n)Er169(β^-)Tm169(n,3n)_ Tm167(β^+)Er167m					23.8	11.5	5.4
		Er170(n,4n)Er167m					16.7	20.8	17.6
		Er168(n,d)Ho167(β^-)Er167m					2.4	5.6	7.6
		Er170(n,d)Ho169(β^-)Er169(β^-)Tm169_ (n,3n)Tm167(β^+)Er167m						2.2	1.5
		Er170(n,nt)Ho167(β^-)Er167m						0.7	4.7
Ho158	11.0 m	**&**Er162(n,2n)Er161(n,2n)Er160(n,t)*Ho158*				100.0			
		Er166(n,3n)Er164(n,3n)Er162(n,3n)_ Er160(n,3n)Er158(β^+)Ho158					42.5	0.9	
		Er164(n,3n)Er162(n,3n)Er160(n,3n)_ Er158(β^+)Ho158					18.6	1.3	
		Er162(n,3n)Er160(n,3n)Er158(β^+)Ho158					9.2	1.8	
		Er167(n,4n)Er164(n,3n)Er162(n,3n)_ Er160(n,3n)Er158(β^+)Ho158					5.0	1.5	
		Er166(n,5n)Er162(n,5n)Er158(β^+)Ho158						14.6	48.2
		Er162(n,5n)Er158(β^+)Ho158						10.5	2.3
		Er167(n,4n)Er164(n,3n)Er162(n,5n)_ Er158(β^+)Ho158						9.9	0.2
		Er164(n,3n)Er162(n,5n)Er158(β^+)Ho158						8.9	0.9
		Er166(n,3n)Er164(n,3n)Er162(n,5n)_ Er158(β^+)Ho158						5.9	0.3
		Er167(n,4n)Er164(n,4n)Er161(n,4n)_ Er158(β^+)Ho158						5.3	
		&Er166(n,5n)Er162(n,2nt)*Ho158*						3.6	2.4
		Er166(n,3n)Er164(n,4n)Er161(n,4n)_ Er158(β^+)Ho158						3.2	
		Er167(n,6n)Er162(n,5n)Er158(β^+)Ho158							19.9
		&Er167(n,5n)Er163(β^+)Ho163(n,6n)*Ho158*							4.2
		&Er168(n,6n)Er163(β^+)Ho163(n,6n)*Ho158*							4.1
		Many other similar long pathways					24.7	32.6	17.5
Ho162	15.0 m	Er162(β^+)Ho162	100.0		100.0				
		&Er164(n,2n)Er163(β^+)Ho163(n,2n)*Ho162*				83.1	3.9	0.1	
		&Er166(n,2n)Er165(β^+)Ho165(n,2n)Ho164_ (β^-)Er164(n,2n)Er163(β^+)Ho163(n,2n)Ho162				11.3			
		&Er167(n,3n)Er165(β^+)Ho165(n,4n)*Ho162*					15.0	11.2	3.6
		&Er167(n,3n)Er165(β^+)Ho165(n,3n)_ *Ho163*(n,2n)*Ho162*					14.2		
		&Er166(n,3n)Er164(n,2n)Er163(β^+)_ Ho163(n,2n)*Ho162*					9.3		
		&Er166(n,2n)Er165(β^+)Ho165(n,4n)*Ho162*					8.4	15.4	5.8
		&Er166(n,2n)Er165(β^+)Ho165(n,3n)_ *Ho163*(n,2n)*Ho162*					8.0		
		&Er166(n,3n)Er164(n,t)*Ho162*					7.1	1.3	1.9
		&Er166(n,4n)Er163(β^+)Ho163(n,2n)*Ho162*					3.7	12.4	4.4
		&Er168(n,4n)Er165(β^+)Ho165(n,4n)*Ho162*					2.7	38.6	5.2
	►	**&**Er168(n,4n)Er165(β^+)Ho165(n,3n)_ *Ho163*(n,2n)*Ho162*					2.6	0.2	

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Er166(n,3n)Er164(n,3n)Er162(n,p)*Ho162*					2.3		
		&Er164(n,t)*Ho162*					1.5	1.0	2.9
		&Er166(n,d)Ho165(n,4n)*Ho162*					1.0	3.7	1.9
		&Er167(n,4n)Er164(n,t)*Ho162*					0.9	2.1	1.6
		&Er167(n,t)Ho165(n,4n)*Ho162*					0.1	2.1	1.5
		&Er167(n,5n)Er163(β^+)Ho163(n,2n)*Ho162*						0.7	5.8
		&Er168(n,nt)Ho165(n,4n)*Ho162*						0.7	1.7
		&Er168(n,5n)Er164(n,t)*Ho162*						0.4	3.8
		&Er168(n,t)Ho166m(n,5n)*Ho162*						0.2	1.5
		&Er166(n,2nt)*Ho162*						0.1	29.0
		&Er170(n,6n)Er165(β^+)Ho165(n,4n)*Ho162*							6.9
		&Er168(n,6n)Er163(β^+)Ho163(n,2n)*Ho162*							5.6
		&Er167(n,3nt)*Ho162*							3.1
		Many other similar long pathways				15.6	19.3	9.8	13.8
Ho160	25.3 m	**&**Er162(n,2n)Er161(n,2n)Er160(β^+)*Ho160*				93.4			
		&Er162(n,t)*Ho160*				6.6			
		&Er166(n,3n)Er164(n,3n)Er162(n,3n)_ Er160(β^+)*Ho160*					42.3	0.9	
		&Er164(n,3n)Er162(n,3n)Er160(β^+)*Ho160*					21.4	1.5	0.2
		&Er162(n,3n)Er160(β^+)*Ho160*					8.6	1.8	0.4
		&Er167(n,4n)Er164(n,3n)Er162(n,3n)_ Er160(β^+)*Ho160*					5.0	1.5	
		&Er168(n,3n)Er166(n,3n)Er164(n,3n)_ Er162(n,3n)Er160(β^+)*Ho160*					2.6		
		&Er166(n,4n)Er163(β^+)Ho163(n,4n)*Ho160*						67.6	2.8
		&Er167(n,5n)Er163(β^+)Ho163(n,4n)*Ho160*						3.8	3.7
		&Er166(n,5n)Er162(n,3n)Er160(β^+)*Ho160*						2.3	9.3
		&Er168(n,4n)Er165(β^+)Ho165(n,3n)_ Ho163(n,4n)*Ho160*						1.8	
		&Er168(n,3n)Er166(n,4n)Er163(β^+)_ Ho163(n,4n)*Ho160*						1.5	
		&Er167(n,4n)Er164(n,2n)Er163(β^+)_ Ho163(n,4n)*Ho160*						1.3	
		&Er167(n,4n)Er164(n,5n)Er160(β^+)*Ho160*						0.4	7.2
		&Er164(n,5n)Er160(β^+)*Ho160*						0.2	12.8
		&Er166(n,3n)Er164(n,5n)Er160(β^+)*Ho160*						0.2	8.6
		&Er166(n,5n)Er162(n,t)*Ho160*						0.1	2.5
		&Er168(n,5n)Er164(n,5n)Er160(β^+)*Ho160*							17.0
		&Er168(n,6n)Er163(β^+)Ho163(n,4n)*Ho160*							3.6
		&Er167(n,6n)Er162(n,3n)Er160(β^+)*Ho160*							3.4
		&Er170(n,6n)Er165(β^+)Ho165(n,6n)*Ho160*							2.6
		&Er166(n,2n)Er165(β^+)Ho165(n,6n)*Ho160*							2.2
		&Er168(n,4n)Er165(β^+)Ho165(n,6n)*Ho160*							2.0
		&Er167(n,3n)Er165(β^+)Ho165(n,6n)*Ho160*							1.3
		Many other similar long pathways					20.1	15.1	20.4
Er171	7.516 h	Er170(n,γ)Er171	99.2	99.8	100.0	99.9	99.7	99.8	99.9
Tb154m	9.00 h	**&**Er162(n,nα)Dy158(n,2n)Dy157(β^+)Tb157_ (n,2n)*Tb156*(n,2n)Tb155(n,2n)Tb154m				15.5			
		Er162(n,α)Dy159(β^+)Tb159(n,2n)_ Tb158(n,2n)Tb157(n,2n)Tb156(n,2n)_ Tb155(n,2n)Tb154m				9.8			
		Er162(n,α)Dy159(n,2n)Dy158(n,2n)_ Dy157(β^+)Tb157(n,2n)Tb156(n,2n)_ Tb155(n,2n)Tb154m				5.3			
		Er166(n,3n)Er164(n,3n)Er162(n,nα)_ Dy158(n,3n)Dy156(n,t)Tb154m					3.1		
		Er162(n,nα)Dy158(n,3n)Dy156(n,t)Tb154m					2.8		
		Er166(n,3n)Er164(n,nα)Dy160(n,3n)_ Dy158(n,3n)Dy156(n,t)Tb154m					2.7		
	►	Er164(n,3n)Er162(n,nα)Dy158(n,3n)_ Dy156(n,t)Tb154m					2.5		

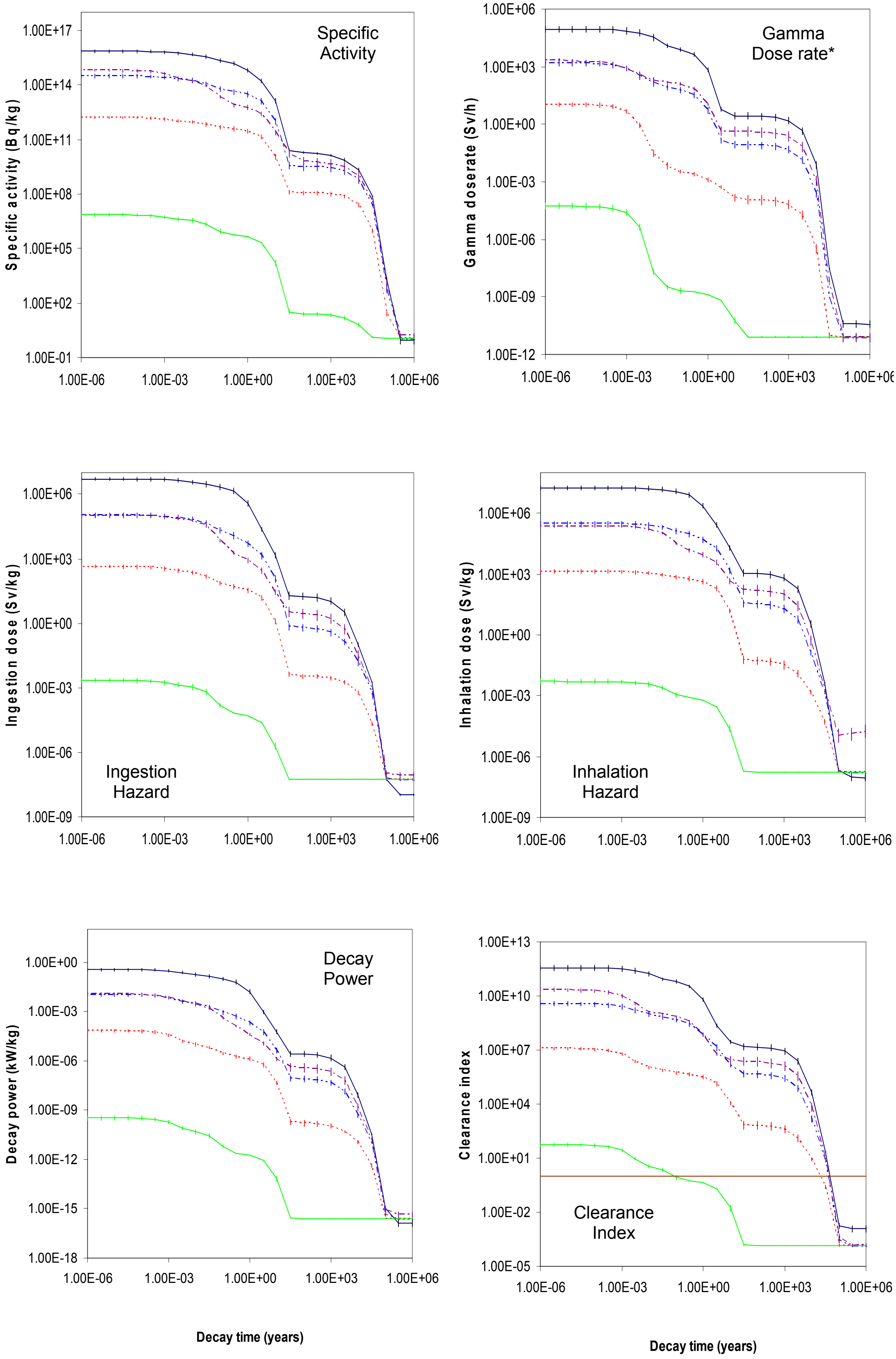
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Er164(n,nα)Dy160(n,3n)Dy158(n,3n)_ Dy156(n,t)Tb154m					2.2		
		Er166(n,4n)Er163(β^{+})Ho163(n,3nα)_ Tb157(n,4n)Tb154m						2.4	0.2
		Er166(n,3nα)Dy160(n,4n)Dy157(β^{+})_ Tb157(n,4n)Tb154m						2.1	0.2
		Er166(n,4nα)Dy159(β^{+})Tb159(n,6n)Tb154m							4.5
		Er166(n,5n)Er162(n,5n)Er158(β^{+})_ Ho158(β^{+})Dy158(n,2nt)Tb154m							2.9
		Many other similar long pathways				69.4	86.7	95.5	92.2
Er165	10.360 h	Er164(n,γ)Er165	96.9	1.4	99.9				
		&Er162(n,γ)Er163(β^{+})Ho163(n,γ)_ *Ho164*(β^{-})Er164(n,γ)Er165	2.8	89.2					
		Er166(n,2n)Er165				79.3	27.1	22.1	25.3
		Er167(n,2n)Er166(n,2n)Er165				17.2	1.1		
		Er168(n,2n)Er167(n,2n)Er166(n,2n)Er165				2.4			
		Er168(n,3n)Er166(n,2n)Er165				0.1	5.0		
		Er167(n,3n)Er165					48.9	16.3	16.2
		Er168(n,4n)Er165					9.0	54.5	22.7
		Er170(n,4n)Er167(n,3n)Er165					3.0		
		Er168(n,2n)Er167(n,3n)Er165					2.4		
		Er170(n,6n)Er165							30.1
Tm172	2.650 d	Er170(n,γ)Er171(β^{-})Tm171(n,γ)Tm172	56.0	58.6	99.2	99.8	99.5	99.6	99.8
		Er168(n,γ)Er169(β^{-})Tm169(n,γ)Tm170_ (n,γ)Tm171(n,γ)Tm172	18.0	17.6	0.7				
		Er167(n,γ)Er168(n,γ)Er169(β^{-})Tm169_ (n,γ)Tm170(n,γ)Tm171(n,γ)Tm172	15.3	14.7					
		&Er166(n,γ)*Er167*(n,γ)Er168(n,γ)_ Er169(β^{-})Tm169(n,γ)Tm170(n,γ)_ Tm171(n,γ)Tm172	10.1	8.8					
Er169	9.40 d	Er168(n,γ)Er169	38.1	38.3	87.8		0.2	0.1	
		Er167(n,γ)Er168(n,γ)Er169	32.4	32.5	11.3				
		&Er166(n,γ)*Er167*(n,γ)Er168(n,γ)Er169	29.3	28.0	0.9				
		Er170(n,2n)Er169				99.8	91.4	83.8	76.8
		Er170(n,d)Ho169(β^{-})Er169						15.8	23.2
Hf181	42.38 d	Very long pathways of (n,γ), β^{-}	100.0	100.0	100.0				
Tb160	72.3 d	Er162(n,α)Dy159(β^{+})Tb159(n,γ)Tb160	99.0	100.0	99.2				
		Er164(n,2n)Er163(β^{+})Ho163(n,α)Tb160				78.7	2.4		
		Er166(n,2n)Er165(β^{+})Ho165(n,2n)Ho164_ (β^{-})Er164(n,2n)Er163(β^{+})Ho163(n,α)Tb160				7.3			
		Er162(n,2n)Er161(β^{+})Ho161(β^{+})Dy161_ (n,2n)Dy160(n,p)Tb160				3.5			
		&Er167(n,3n)Er165(β^{+})Ho165(n,3n)_ *Ho163*(n,α)Tb160					9.2		
		Er167(n,3n)Er165(β^{+})Ho165(n,2nα)Tb160					7.0	4.9	2.0
		Er166(n,3n)Er164(n,2n)Er163(β^{+})_ Ho163(n,α)Tb160					5.8		
		Er167(n,3n)Er165(β^{+})Ho165(n,3n)Ho163_ (n,3n)Ho161(β^{+})Dy161(n,d)Tb160					5.4		
		Er166(n,2n)Er165(β^{+})Ho165(n,3n)_ Ho163(n,α)Tb160					4.8		
		Er166(n,3n)Er164(n,3n)Er162(n,2n)_ Er161(β^{+})Ho161(β^{+})Dy161(n,d)Tb160					4.2		
		Er166(n,2n)Er165(β^{+})Ho165(n,2nα)Tb160					3.9	6.7	3.1
		Er166(n,3n)Er164(n,2n)Er163(β^{+})Ho163_ (n,3n)Ho161(β^{+})Dy161(n,d)Tb160					3.7		
		Er166(n,4n)Er163(β^{+})Ho163(n,α)Tb160					2.4	5.6	1.6
		Er166(n,4n)Er163(β^{+})Ho163(n,3n)_ Ho161(β^{+})Dy161(n,d)Tb160					2.3	5.4	0.5
	►	Er168(n,4n)Er165(β^{+})Ho165(n,2nα)Tb160					1.3	16.5	2.7

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Er167(n,4n)Er164(n,4n)Er161(β^+)_ Ho161(β^+)Dy161(n,d)Tb160						7.6	0.4
		Er164(n,4n)Er161(β^+)Ho161(β^+)Dy161_ (n,d)Tb160						6.4	1.4
		Er166(n,3n)Er164(n,4n)Er161(β^+)_ Ho161(β^+)Dy161(n,d)Tb160						4.6	0.5
		Er166(n,6n)Er161(β^+)Ho161(β^+)Dy161_ (n,d)Tb160							25.3
		Er170(n,6n)Er165(β^+)Ho165(n,2nα)Tb160							3.7
		Many other similar long pathways	1.0		0.8	10.5	47.6	42.3	58.8
Tm168	93.10 d	Er170(n,2n)Er169(β^-)Tm169(n,2n)Tm168				99.9	91.6	83.4	77.5
		Er170(n,d)Ho169(β^-)Er169(β^-)Tm169_ (n,2n)Tm168						15.7	21.7
Ta182	114.7 d	Very long pathways of (n,γ), β^-	100.0	100.0	100.0				
Tm170	128.6 d	Er168(n,γ)Er169(β^-)Tm169(n,γ)Tm170	40.4	41.2	94.0		0.1		
		Er167(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170	34.3	34.7	5.7				
		&Er166(n,γ)*Er167*(n,γ)Er168(n,γ)_ Er169(β^-)Tm169(n,γ)Tm170	25.2	23.2	0.2				
		Er170(n,2n)Er169(β^-)Tm169(n,γ)Tm170				65.5	65.5	59.2	54.6
		Er170(n,γ)Er171(β^-)Tm171(n,2n)Tm170				34.3	23.3	21.4	19.9
		Er170(n,d)Ho169(β^-)Er169(β^-)Tm169_ (n,γ)Tm170					5.8	11.2	15.3
		Er170(n,γ)Er171(β^-)Tm171(β^-)Yb171_ (n,d)Tm170					4.6	7.5	9.6
Dy159	144.4 d	Er162(n,α)Dy159	99.9	100.0	100.0	9.9	0.4		
		Er162(n,2n)Er161(β^+)Ho161(β^+)Dy161_ (n,2n)Dy160(n,2n)Dy159				80.0			
		&Er167(n,3n)Er165(β^+)Ho165(n,3n)_ Ho163(n,3n)*Ho161*(β^+)Dy161(n,3n)Dy159					10.1		
		Er166(n,3n)Er164(n,3n)Er162(n,2n)_ Er161(β^+)Ho161(β^+)Dy161(n,3n)Dy159					7.1		
		&Er166(n,3n)Er164(n,2n)Er163(β^+)_ Ho163(n,3n)*Ho161*(β^+)Dy161(n,3n)Dy159					6.8		
		&Er166(n,2n)Er165(β^+)Ho165(n,3n)_ Ho163(n,3n)*Ho161*(β^+)Dy161(n,3n)Dy159					5.6		
		Er164(n,3n)Er162(n,2n)Er161(β^+)_ Ho161(β^+)Dy161(n,3n)Dy159					4.6		
		&Er164(n,2n)Er163(β^+)Ho163(n,3n)_ *Ho161*(β^+)Dy161(n,3n)Dy159					4.4		
		&Er166(n,4n)Er163(β^+)Ho163(n,3n)_ *Ho161*(β^+)Dy161(n,3n)Dy159					4.3	2.8	
		&Er168(n,4n)Er165(β^+)Ho165(n,4n)_ *Ho162*(β^+)Dy162(n,4n)Dy159						10.1	
		&Er166(n,4n)Er163(β^+)Ho163(n,5n)_ *Ho159*(β^+)Dy159						5.9	10.1
		&Er166(n,5n)Er162(n,4n)Er159(β^+)_ *Ho159*(β^+)Dy159						5.5	11.1
		&Er166(n,2n)Er165(β^+)Ho165(n,4n)_ Ho162(β^+)Dy162(n,4n)Dy159						4.1	
		&Er167(n,5n)Er163(β^+)Ho163(n,5n)_ *Ho159*(β^+)Dy159						0.3	13.4
		&Er166(n,5n)Er162(n,nt)*Ho159*(β^+)Dy159						0.2	4.4
		&Er168(n,6n)Er163(β^+)Ho163(n,5n)_ *Ho159*(β^+)Dy159							13.0
		&Er167(n,6n)Er162(n,4n)Er159(β^+)_ *Ho159*(β^+)Dy159							4.6
		Er166(n,4nα)Dy159							4.1
		Many other similar long pathways	0.1			10.1	56.7	70.8	39.3
Tm171	1.917 y►	Er170(n,γ)Er171(β^-)Tm171	56.1	58.6	99.2	100.0	99.8	99.9	99.9

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Er168(n,γ)Er169(β^-)Tm169(n,γ)Tm170_ (n,γ)Tm171	18.0	17.6	0.7				
		Er167(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170(n,γ)Tm171	15.3	14.7					
		&Er166(n,γ)*Er167*(n,γ)Er168(n,γ)_ Er169(β^-)Tm169(n,γ)Tm170(n,γ)Tm171	10.1	8.8					
H3	12.33 y	Er166(n,2n)Er165(β^+)Ho165(n,X)H3				47.5	1.7	0.9	0.6
		Er167(n,X)H3				30.4	27.0	23.2	22.0
		&Er168(n,2n)*Er167*(n,X)H3				5.9	0.8		0.3
		Er170(n,2n)Er169(β^-)Tm169(n,X)H3				4.4	0.7		0.2
		Er166(n,X)H3				2.5	26.2	27.7	28.8
		Er168(n,X)H3				2.1	20.1	21.1	21.9
		Er170(n,X)H3				1.7	6.7	9.0	10.7
		Er164(n,X)H3				0.1	1.4	1.4	1.2
		Er166(n,3n)Er164(n,X)H3					3.4	1.0	0.4
		Er167(n,3n)Er165(β^+)Ho165(n,X)H3					3.1	0.7	0.4
		Er168(n,3n)Er166(n,X)H3					2.4	0.7	0.4
		Er170(n,4n)Er167(n,X)H3					0.8	1.0	0.2
		Er168(n,4n)Er165(β^+)Ho165(n,X)H3					0.6	2.3	0.5
		Er167(n,4n)Er164(n,X)H3					0.4	1.7	0.4
		Er166(n,4n)Er163(β^+)Ho163(n,X)H3						3.1	0.7
		Er166(n,5n)Er162(n,X)H3							1.5
		Er167(n,5n)Er163(β^+)Ho163(n,X)H3							1.0
Gd148	74.602 y	Very long pathways				100.0	100.0	100.0	100.0
Ho166m	1200 y	Er164(n,γ)Er165(β^+)Ho165(n,γ)Ho166m	93.2	74.2	100.0				
		&Er162(n,γ)Er163(β^+)Ho163(n,γ)*Ho164*_ (β^-)Er164(n,γ)Er165(β^+)Ho165(n,γ)Ho166m		13.3					
		&Er162(n,γ)Er163(β^+)Ho163(n,γ)*Ho164*(β^+)_ Dy164(n,γ)*Dy165*(β^-)Ho165(n,γ)Ho166m		11.1					
		Er166(n,p)Ho166m				62.9	15.7	7.6	3.7
		Er167(n,d)Ho166m				11.5	64.4	44.8	31.7
		Er170(n,2n)Er169(β^-)Tm169(n,α)Ho166m				10.5			
		Er167(n,2n)Er166(n,p)Ho166m				6.9			
		Er166(n,2n)Er165(β^+)Ho165(n,γ)Ho166m				4.4			
		Er168(n,2n)Er167(n,d)Ho166m				1.6			
		Er168(n,t)Ho166m				0.1	12.0	42.0	45.9
		Er170(n,2nt)Ho166m						0.8	16.6
Ho163	4570 y	Er162(n,γ)Er163(β^+)Ho163	100.0	100.0	100.0				
		Er164(n,2n)Er163(β^+)Ho163				84.6	7.4	1.3	
		&Er166(n,2n)Er165(β^+)Ho165(n,2n)_ *Ho164*(β^-)Er164(n,2n)Er163(β^+)Ho163				14.0			
		Er167(n,3n)Er165(β^+)Ho165(n,3n)Ho163					27.4	0.6	
		Er166(n,3n)Er164(n,2n)Er163(β^+)Ho163					18.5	0.9	
		Er166(n,2n)Er165(β^+)Ho165(n,3n)Ho163					15.3	0.9	
		Er166(n,4n)Er163(β^+)Ho163					7.2	78.4	22.1
		Er168(n,4n)Er165(β^+)Ho165(n,3n)Ho163					5.0	2.1	
		&Er166(n,3n)Er164(n,d)*Ho163*					2.4	0.2	
		Er167(n,4n)Er164(n,2n)Er163(β^+)Ho163					2.2	1.6	
		&Er166(n,nt)*Ho163*					0.3	1.3	7.6
		Er167(n,5n)Er163(β^+)Ho163						4.6	29.4
		Er168(n,6n)Er163(β^+)Ho163							28.4
		Er167(n,2nt)Ho163							3.0
Gd150	1.8 10^6 y	Very long pathways				100.0	100.0	100.0	100.0
Dy154	3.0 10^6 y	Er162(n,nα)Dy158(n,2n)Dy157(n,2n)_ Dy156(n,2n)Dy155(n,2n)Dy154				47.5			
		Er162(n,α)Dy159(n,2n)Dy158(n,2n)Dy157_ (n,2n)Dy156(n,2n)Dy155(n,2n)Dy154				26.7			
		Er164(n,4n)Er161(β^+)Ho161(β^+)Dy161_ (n,4n)Dy158(n,3n)Dy156(n,3n)Dy154						9.6	
	►	**&**Er162(n,4n)Er159(β^+)*Ho159*(β^+)_ Dy159(n,4n)Dy156(n,3n)Dy154						6.7	

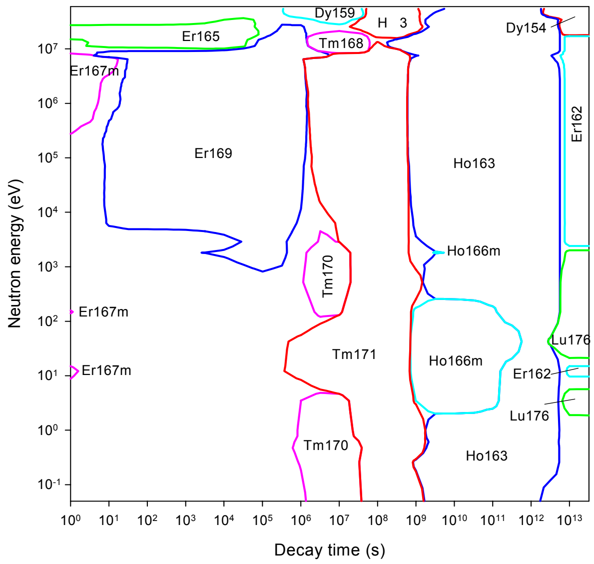
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Er167(n,4n)Er164(n,4n)Er161(β^+)_ Ho161(β^+)Dy161(n,4n)Dy158(n,3n)_ Dy156(n,3n)Dy154						4.6	
		Er166(n,4n)Er163(β^+)Ho163(n,3n)_ Ho161(β^+)Dy161(n,4n)Dy158(n,3n)_ Dy156(n,3n)Dy154						3.3	
		Er166(n,4n)Er163(β^+)Ho163(n,5n)Ho159_ (β^+)Dy159(n,4n)Dy156(n,3n)Dy154						3.1	
		Er166(n,5n)Er162(n,5n)Er158(β^+)_ Ho158(β^+)Dy158(n,5n)Dy154							27.3
		Er167(n,6n)Er162(n,5n)Er158(β^+)_ Ho158(β^+)Dy158(n,5n)Dy154							11.2
		Er166(n,6n)Er161(β^+)Ho161(β^+)_ Dy161(n,4n)Dy158(n,5n)Dy154							4.9
		Er162(n,5n)Er158(β^+)Ho158(β^+)_ Dy158(n,5n)Dy154							3.4
		Many other similar long pathways				25.8	100.0	72.7	53.2
Hf182	9.0 10^6 y	Very long pathways of (n,γ), β^-	100.0	100.0	100.0				
Lu176	4.0 10^{10} y	Er170(n,γ)Er171(β^-)Tm171(n,γ)Tm172_ (β^-)Yb172(n,γ)Yb173(n,γ)Yb174(n,γ)_ Yb175(β^-)Lu175(n,γ)Lu176	54.2	70.0	70.2				
		Er170(n,γ)Er171(β^-)Tm171(n,γ)Tm172_ (n,γ)Tm173(β^-)Yb173(n,γ)Yb174(n,γ)_ Yb175(β^-)Lu175(n,γ)Lu176	18.1	1.3	2.0				
		Er168(n,γ)Er169(β^-)Tm169(n,γ)Tm170_ (n,γ)Tm171(n,γ)Tm172(β^-)Yb172(n,γ)_ Yb173(n,γ)Yb174(n,γ)Yb175(β^-)Lu175_ (n,γ)Lu176	7.1	8.6					
		Er167(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170(n,γ)Tm171(n,γ)Tm172(β^-)_ Yb172(n,γ)Yb173(n,γ)Yb174(n,γ)_ Yb175(β^-)Lu175(n,γ)Lu176	5.9	5.5					
		Er170(n,γ)Er171(β^-)Tm171(β^-)Yb171_ (n,γ)Yb172(n,γ)Yb173(n,γ)Yb174(n,γ)_ Yb175(β^-)Lu175(n,γ)Lu176	4.4	10.9	27.6				
		Er168(n,γ)Er169(β^-)Tm169(n,γ)Tm170_ (n,γ)Tm171(n,γ)Tm172(n,γ)Tm173(β^-)_ Yb173(n,γ)Yb174(n,γ)Yb175(β^-)Lu175_ (n,γ)Lu176	3.0	0.2					
		Er167(n,γ)Er168(n,γ)Er169(β^-)Tm169_ (n,γ)Tm170(n,γ)Tm171(n,γ)Tm172(n,γ)_ Tm173(β^-)Yb173(n,γ)Yb174(n,γ)_ Yb175(β^-)Lu175(n,γ)Lu176	2.5	0.1					
		Er168(n,γ)Er169(β^-)Tm169(n,γ)Tm170_ (n,γ)Tm171(β^-)Yb171(n,γ)Yb172(n,γ)_ Yb173(n,γ)Yb174(n,γ)Yb175(β^-)Lu175_ (n,γ)Lu176	0.5	1.2					
Er162	1.4 10^{14} y	Er166(n,3n)Er164(n,3n)Er162					56.6	11.8	0.4
		Er164(n,3n)Er162					22.5	16.3	1.2
		Er167(n,4n)Er164(n,3n)Er162					6.7	19.7	0.4
		Er168(n,3n)Er166(n,3n)Er164(n,3n)Er162					3.5	0.2	
		Er166(n,5n)Er162						26.8	64.0
		Er168(n,5n)Er164(n,3n)Er162						3.5	0.8
		Er168(n,3n)Er166(n,5n)Er162						0.6	0.9
		Er170(n,5n)Er166(n,5n)Er162						0.5	1.0
		Er167(n,6n)Er162							26.4
		Nuclide present in starting material	100.0	100.0	100.0	100.0	10.7	20.9	4.9

Erbium activation characteristics

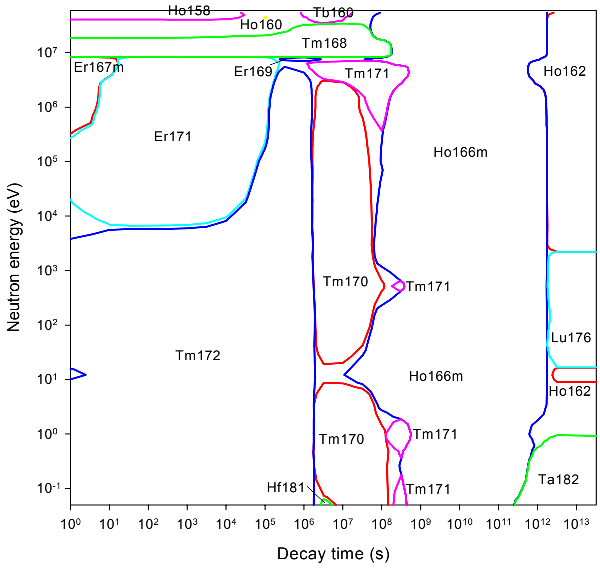


Erbium importance diagrams & transmutation

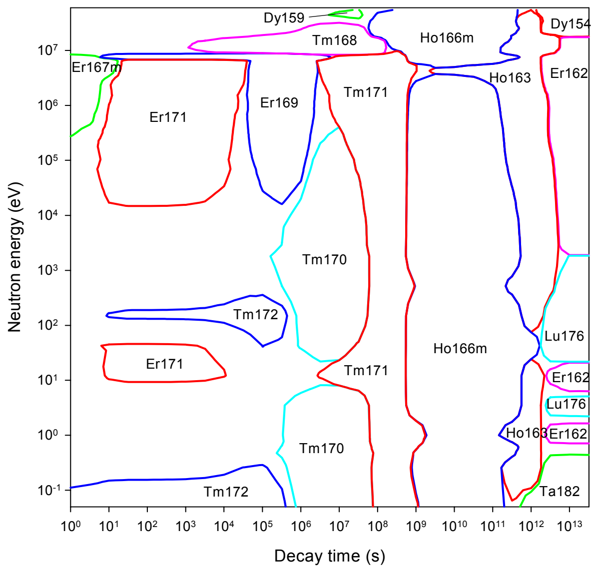
Activity



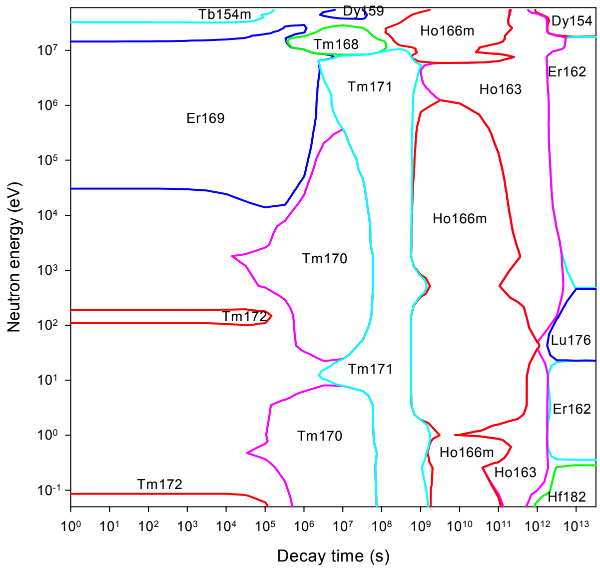
Dose rate



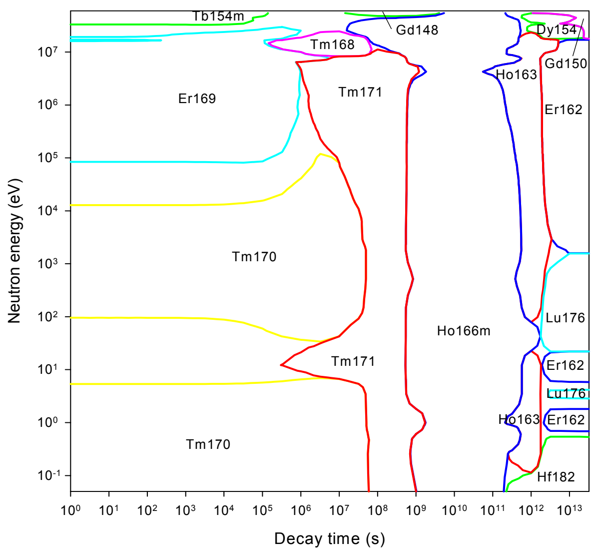
Heat output



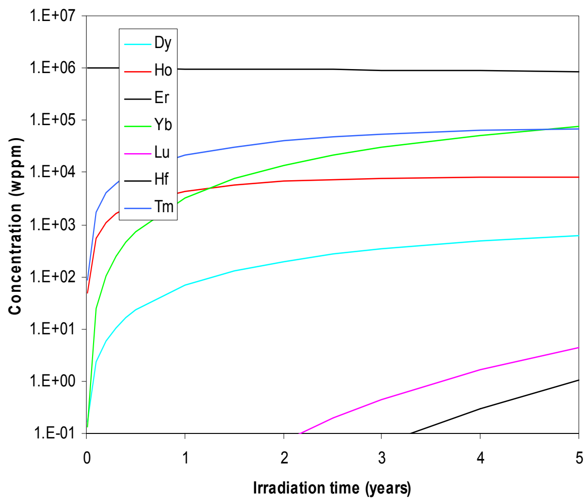
Ingestion dose



Inhalation dose



First wall transmutation



Thulium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	69	Tm169	100.0
Crustal abundance / wppm	0.52		
Melting point / K	1818		
Boiling point / K	2219		
Density / kgm^{-3}	9321		
Thermal conductivity / $Wm^{-1}K^{-1}$	16.8		
Electrical resistivity /Ωm	$7.9\ 10^{-7}$		
Coefficient of thermal expansion / K^{-1}	$1.33\ 10^{-5}$		
Crystal structure	HCP		
Number of stable isotopes	1		
Mean atomic weight	168.93421		

Activation properties

Act	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Bq kg^{-1}	8.62E15	8.49E15	7.73E15	1.61E15	1.71E8	5.51E0
Tm170	67.67	68.67	74.04	50.71		
Tm171	13.05	13.24	14.51	48.77		
Tm172	11.13	11.28	4.78			
Yb169	4.18	4.24	4.31	0.01		
Tm168	1.44	1.46	1.57	0.51		0.04
Er169	0.90	0.91	0.77			
Ho166m					72.00	
H3					27.98	
Lu176						88.81
Ta182						5.53
Hf182						5.53

Heat	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
kW kg^{-1}	5.24E-1	5.23E-1	4.18E-1	4.83E-2	3.49E-8	6.98E-16
Tm170	59.20	59.28	72.79	89.58		
Tm172	29.59	29.61	14.28			
Tm168	5.02	5.03	6.13	3.59		0.07
Yb169	4.68	4.69	5.42	0.02		
Tm171	0.90	0.90	1.13	6.82		
Er169	0.24	0.24	0.23			
Ho166m					99.85	
Hf178n					0.01	
Lu176						87.38
Ta182						10.48
Hf182						1.90

Dose	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv h^{-1}	1.59E5	1.59E5	7.91E4	2.00E3	3.50E-2	2.42E-10
Tm172	81.10	81.09	63.19			
Tm168	17.56	17.58	34.62	98.95		0.21
Yb169	1.08	1.08	2.02	0.03		
Tm170	0.08*	0.08*	0.15*	0.89*		
Er171	0.07	0.07				
Ho166m					99.99	
Hf178n					0.01	
Lu176						58.37
Ta182						40.34
Hf182						1.08

Ing	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	9.75E6	9.75E6	8.56E6	1.15E6	2.48E-1	1.04E-8
Tm170	77.80	77.81	86.85	91.84		
Tm172	16.73	16.72	7.33			
Yb169	2.62	2.62	2.76	0.01		
Tm171	1.27	1.27	1.44	7.48		
Tm168	1.22	1.22	1.36	0.68		0.02
Ho166m					99.16	
H3					0.81	
Hf178n					0.03	
Lu176						84.40
Hf182						8.76
Ta182						4.38

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	4.50E7	4.50E7	4.34E7	6.82E6	1.48E1	4.40E-7
Tm170	90.72	90.72	92.15	83.55		
Tm171	3.50	3.50	3.61	16.07		
Yb169	2.40	2.40	2.30	0.01		
Tm172	2.35	2.34	0.93			
Tm168	0.86	0.86	0.86	0.37		
Ho166m					99.89	
Hf178n					0.03	
Lu176						77.73
Hf182						21.43
Ta182						0.69

Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
	8.39E11	8.37E11	5.11E11	1.92E10	2.02E5	8.01E-3
Tm172	60.20	60.24	38.00			
Tm168	18.53	18.56	29.58	53.30		0.04
Yb169	13.84	13.86	20.99	0.22		
Tm170	6.96	6.97	11.19	42.39		
Tm171	0.13	0.13	0.22	4.08		
Ho166m					99.74	
Hf178n					0.01	
Lu176						61.04
Ta182						38.00
Hf182						0.93

Thulium

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ho162	15.0 m	&Tm169(n,α)Ho166m(n,2n)Ho165_ (n,2n)*Ho164*(β^-)Er164(n,2n)Er163(β^+)_ Ho163(n,2n)*Ho162*				15.7			
		&Tm169(n,nα)Ho165(n,2n)*Ho164*(β^-)_ Er164(n,2n)Er163(β^+)Ho163(n,2n)*Ho162*				9.6			
		&Tm169(n,2n)Tm168(n,nα)*Ho164*(β^-)_ Er164(n,2n)Er163(β^+)Ho163(n,2n)*Ho162*				2.7			
		&Tm169(n,2n)Tm168(n,α)Ho165_ (n,2n)Ho164(β^-)Er164(n,2n)Er163(β^+)_ Ho163(n,2n)*Ho162*				1.7			
		&Tm169(n,3n)Tm167(β^+)*Er167*(n,3n)_ Er165(β^+)Ho165(n,4n)*Ho162*					26.4	5.2	
		&Tm169(n,nα)Ho165(n,4n)*Ho162*					3.6	7.1	0.7
		&Tm169(n,nα)Ho165(n,3n)*Ho163*_ (n,2n)*Ho162*					3.5		
		&Tm169(n,3n)Tm167(β^+)*Er167*(n,4n)_ Er164(n,t)*Ho162*					2.4	2.2	
		&Tm169(n,2n)Tm168(β^+)Er168(n,4n)_ Er165(β^+)Ho165(n,4n)*Ho162*					1.5	12.4	0.1
		&Tm169(n,3n)Tm167(β^+)*Er167*(n,t)_ Ho165(n,4n)*Ho162*					0.5	2.1	
		&Tm169(n,d)Er168(n,4n)Er165(β^+)_ Ho165(n,4n)*Ho162*					0.2	3.9	
		&Tm169(n,2n)Tm168(n,4n)Tm165(β^+)_ Er165(β^+)Ho165(n,4n)*Ho162*					0.1	2.1	
		&Tm169(n,5n)Tm165(β^+)Er165(β^+)_ Ho165(n,4n)*Ho162*						14.7	57.6
		&Tm169(n,4n)Tm166(β^+)Er166(n,2n)_ Er165(β^+)Ho165(n,4n)*Ho162*						13.2	0.2
		&Tm169(n,4n)Tm166(β^+)Er166(n,4n)_ Er163(β^+)Ho163(n,2n)*Ho162*						10.6	0.1
		&Tm169(n,4n)Tm166(β^+)Er166(n,d)_ Ho165(n,4n)*Ho162*						3.2	
		&Tm169(n,2nt)Er165(β^+)Ho165(n,4n)*Ho162*						1.1	3.9
		&Tm169(n,4n)Tm166(β^+)Er166(n,2nt)*Ho162*						0.4	3.5
		&Tm169(n,4nα)*Ho162*							16.9
		&Tm169(n,6n)Tm164(β^+)Er164(n,t)*Ho162*							1.6
		Many other similar long pathways				70.3	61.8	21.8	15.4
Tm166	7.70 h	Tm169(n,2n)Tm168(n,2n)Tm167(n,2n)Tm166				100.0			
		Tm169(n,2n)Tm168(n,3n)Tm166					61.0		
		Tm169(n,4n)Tm166					32.7	99.7	99.8
		Tm169(n,3n)Tm167(n,2n)Tm166					6.1		
Tb154m	9.00 h	Pathways involving (n,2n), β^+, (n,α)				100.0	100.0	100.0	100.0
Tm172	2.650 d	Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)Tm172	98.9	99.9	99.9	98.6	97.7	98.0	98.6
		Tm169(n,γ)Tm170(β^+)Er170(n,γ)Er171_ (β^-)Tm171(n,γ)Tm172	1.1			0.7	07	0.7	0.7
Yb175	4.185 d	Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(β^-)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175	66.1	82.1	36.0				
		Tm169(n,γ)Tm170(β^-)Yb170(n,γ)_ Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175	15.2	1.3	44.5				
	►	Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(n,γ)Tm173(β^-)Yb173(n,γ)_ Yb174(n,γ)Yb175	11.6	1.2	0.7				

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Tm169(n,γ)Tm170(n,γ)Tm171(β⁻)_ Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175	7.0	15.5	18.8				
Tm167	9.25 d	Tm169(n,2n)Tm168(n,2n)Tm167				99.8			
		Tm169(n,3n)Tm167					99.7	99.7	99.8
Hf181	42.38 d	**&**Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(β⁻)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175(β⁻)Lu175(n,γ)Lu176_ (n,γ)Lu177(β⁻)Hf177(n,γ)Hf178(n,γ)_ *Hf179*(n,γ)Hf180(n,γ)Hf181	31.6	74.5	29.4				
		&Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(n,γ)Tm173(β⁻)Yb173(n,γ)_ Yb174(n,γ)Yb175(β⁻)Lu175(n,γ)Lu176_ (n,γ)Lu177(β⁻)Hf177(n,γ)Hf178(n,γ)_ *Hf179*(n,γ)Hf180(n,γ)Hf181	20.6	1.9	1.6				
		&Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(β⁻)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175(β⁻)Lu175(n,γ)Lu176_ (n,γ)Lu177(n,γ)Lu178(β⁻)Hf178(n,γ)_ *Hf179*(n,γ)Hf180(n,γ)Hf181	12.7	3.7	1.0				
		&Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(β⁻)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175(β⁻)Lu175(n,γ)_ Lu176m(β⁻)Hf176(n,γ)Hf177(n,γ)_ Hf178(n,γ)*Hf179*(n,γ)Hf180(n,γ)Hf181	7.9	0.8	20.8				
		&Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(n,γ)Tm173(β⁻)Yb173(n,γ)_ Yb174(n,γ)Yb175(β⁻)Lu175(n,γ)Lu176_ (n,γ)Lu177(n,γ)Lu178(β⁻)Hf178(n,γ)_ *Hf179*(n,γ)Hf180(n,γ)Hf181	7.9	0.1					
		&Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(n,γ)Tm173(β⁻)Yb173(n,γ)_ Yb174(n,γ)Yb175(β⁻)Lu175(n,γ)_ Lu176m(β⁻)Hf176(n,γ)Hf177(n,γ)_ Hf178(n,γ)*Hf179*(n,γ)Hf180(n,γ)Hf181	6.1		1.1				
		&Tm169(n,γ)Tm170(β⁻)Yb170(n,γ)_ Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175(β⁻)Lu175(n,γ)Lu176_ (n,γ)Lu177(β⁻)Hf177(n,γ)Hf178(n,γ)_ *Hf179*(n,γ)Hf180(n,γ)Hf181	2.5	0.4	14.3				
		&Tm169(n,γ)Tm170(n,γ)Tm171(β⁻)_ Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175(β⁻)Lu175(n,γ)Lu176_ (n,γ)Lu177(β⁻)Hf177(n,γ)Hf178(n,γ)_ *Hf179*(n,γ)Hf180(n,γ)Hf181	1.7	8.6	6.9				
		&Tm169(n,γ)Tm170(n,γ)Tm171(β⁻)_ Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175(β⁻)Lu175(n,γ)_ Lu176m(β⁻)Hf176(n,γ)Hf177(n,γ)_ Hf178(n,γ)_*Hf179*(n,γ)Hf180(n,γ)Hf181	0.6	0.1	4.9				
		&Tm169(n,γ)Tm170(β⁻)Yb170(n,γ)_ Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175(β⁻)Lu175(n,γ)_ Lu176m(β⁻)Hf176(n,γ)Hf177(n,γ)_ Hf178(n,γ)*Hf179*(n,γ)Hf180(n,γ)Hf181	0.5		10.2				
Tm168	93.10 d	Tm169(n,2n)Tm168				99.9	99.9	99.9	99.9

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ta182	114.7 d	**&**Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(β$^-$)Yb172(n,γ)Yb173(n,γ)Yb174_ (n,γ)Yb175(β$^-$)Lu175(n,γ)Lu176(n,γ)_ Lu177(β$^-$)Hf177(n,γ)Hf178(n,γ)*Hf179*_ (n,γ)Hf180(n,γ)Hf181(β$^-$)Ta181(n,γ)Ta182	32.7	81.6	33.0				
		&Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(n,γ)Tm173(β$^-$)Yb173(n,γ)Yb174_ (n,γ)Yb175(β$^-$)Lu175(n,γ)Lu176(n,γ)_ Lu177(β$^-$)Hf177(n,γ)Hf178(n,γ)*Hf179*_ (n,γ)Hf180(n,γ)Hf181(β$^-$)Ta181(n,γ)Ta182	24.9	2.4	2.0				
		&Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(β$^-$)Yb172(n,γ)Yb173(n,γ)Yb174_ (n,γ)Yb175(β$^-$)Lu175(n,γ)Lu176(n,γ)_ Lu177(n,γ)Lu178(β$^-$)Hf178(n,γ)*Hf179*_ (n,γ)Hf180(n,γ)Hf181(β$^-$)Ta181(n,γ)Ta182	13.6	4.5	3.5				
		&Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(n,γ)Tm173(β$^-$)Yb173(n,γ)Yb174_ (n,γ)Yb175(β$^-$)Lu175(n,γ)Lu176(n,γ)_ Lu177(n,γ)Lu178(β$^-$)Hf178(n,γ)*Hf179*_ (n,γ)Hf180(n,γ)Hf181(β$^-$)Ta181(n,γ)Ta182	9.9	0.1	0.1				
		&Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(β$^-$)Yb172(n,γ)Yb173(n,γ)Yb174_ (n,γ)Yb175(β$^-$)Lu175(n,γ)Lu176m(β$^-$)_ Hf176(n,γ)Hf177(n,γ)Hf178(n,γ)*Hf179*_ (n,γ)Hf180(n,γ)Hf181(β$^-$)Ta181(n,γ)Ta182	7.3	2.4	23.5				
		&Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(n,γ)Tm173(β$^-$)Yb173(n,γ)Yb174_ (n,γ)Yb175(β$^-$)Lu175(n,γ)Lu176m(β$^-$)_ Hf176(n,γ)Hf177(n,γ)Hf178(n,γ)*Hf179*_ (n,γ)Hf180(n,γ)Hf181(β$^-$)Ta181(n,γ)Ta182	6.4		1.4				
		&Tm169(n,γ)Tm170(β$^-$)Yb170(n,γ)_ Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)Yb174_ (n,γ)Yb175(β$^-$)Lu175(n,γ)Lu176(n,γ)_ Lu177(β$^-$)Hf177(n,γ)Hf178(n,γ)*Hf179*_ (n,γ)Hf180(n,γ)Hf181(β$^-$)Ta181(n,γ)Ta182	2.0	0.3	14.0				
		&Tm169(n,γ)Tm170(n,γ)Tm171(β$^-$)_ Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)Yb174_ (n,γ)Yb175(β$^-$)Lu175(n,γ)Lu176(n,γ)_ Lu177(β$^-$)Hf177(n,γ)Hf178(n,γ)*Hf179*_ (n,γ)Hf180(n,γ)Hf181(β$^-$)Ta181(n,γ)Ta182	1.7	8.6	6.9				
		&Tm169(n,γ)Tm170(β$^-$)Yb170(n,γ)_ Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)Yb174_ (n,γ)Yb175(β$^-$)Lu175(n,γ)Lu176(n,γ)_ Lu177(n,γ)Lu178(β$^-$)Hf178(n,γ)*Hf179*_ (n,γ)Hf180(n,γ)Hf181(β$^-$)Ta181(n,γ)Ta182	0.9		0.6				
		&Tm169(n,γ)Tm170(β$^-$)Yb170(n,γ)_ Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)Yb174_ (n,γ)Yb175(β$^-$)Lu175(n,γ)Lu176m(β$^-$)_ Hf176(n,γ)Hf177(n,γ)Hf178(n,γ)*Hf179*_ (n,γ)Hf180(n,γ)Hf181(β$^-$)Ta181(n,γ)Ta182	0.3		10.1				
		&Tm169(n,γ)Tm170(n,γ)Tm171(β$^-$)_ Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)Yb174_ (n,γ)Yb175(β$^-$)Lu175(n,γ)Lu176m(β$^-$)_ Hf176(n,γ)Hf177(n,γ)Hf178(n,γ)*Hf179*_ (n,γ)Hf180(n,γ)Hf181(β$^-$)Ta181(n,γ)Ta182	0.3	0.1	4.9				
Tm170	128.6 d	Tm169(n,γ)Tm170	100.0	100.0	100.0	99.8	99.6	99.7	99.9
Tm171	1.917 y	Tm169(n,γ)Tm170(n,γ)Tm171	98.9	99.9	99.9	98.9	98.5	98.7	99.0
		Tm169(n,γ)Tm170(β$^+$)Er170(n,γ)Er171_ (β$^-$)Tm171	1.1			0.7	0.7	0.7	0.7
H3	12.33 y▶	Tm169(n,X)H3				87.8	86.2	87.3	86.7

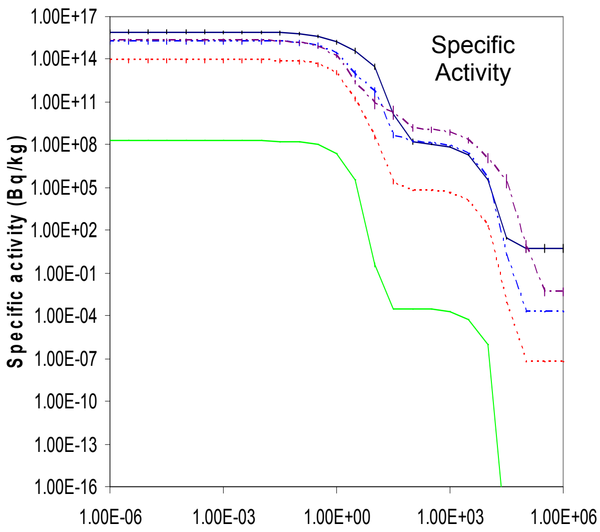
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Tm169(n,2n)Tm168(n,X)H3				10.5	0.6	0.3	0.2
		Tm169(n,2n)Tm168(β^+)Er168(n,X)H3				0.5	1.4	1.2	0.8
		&Tm169(n,3n)Tm167(β^+)*Er167*(n,X)H3					9.5	3.9	1.9
		Tm169(n,4n)Tm166(β^+)Er166(n,X)H3						4.3	1.5
		Tm169(n,5n)Tm165(β^+)Er165(β^+)_ Ho165(n,X)H3						0.2	4.6
Gd148	74.602 y	Pathways involving (n,2n), β^+, (n,α)				100.0	100.0	100.0	100.0
Tb158	180.0 y	**&**Tm169(n,nα)Ho165(n,3n)Ho163_ (n,2nα)*Tb158*					2.9	0.3	
		&Tm169(n,4n)Tm166(β^+)Er166(n,4n)_ Er163(β^+)Ho163(n,2nα)*Tb158*						49.4	0.3
		&Tm169(n,3n)Tm167(β^+)*Er167*(n,5n)_ Er163(β^+)Ho163(n,2nα)Tb158						3.0	0.6
		Tm169(n,3nα)Ho163(n,2nα)Tb158						1.5	1.3
		Tm169(n,nt)Er166(n,4n)Er163(β^+)_ Ho163(n,2nα)Tb158						1.4	0.1
		&Tm169(n,5n)Tm165(β^+)Er165(β^+)_ Ho165(n,4nα)*Tb158*							39.6
		Tm169(n,5n)Tm165(β^+)Er165(β^+)Ho165_ (n,5n)Ho161(β^+)Dy161(n,nt)Tb158							13.4
		&Tm169(n,2nt)Er165(β^+)Ho165(n,4nα)*Tb158*							2.6
		Tm169(n,4n)Tm166(β^+)Er166(n,6n)_ Er161(β^+)Ho161(β^+)Dy161(n,nt)Tb158							1.9
		&Tm169(n,4nα)Ho162(β^+)Dy162_ (n,2nt)*Tb158*							1.8
		Tm169(n,5n)Tm165(β^+)Er165(β^+)_ Ho165(n,6n)Ho160(β^+)Dy160(n,t)Tb158							1.6
		Tm169(n,5n)Tm165(β^+)Er165(β^+)_ Ho165(n,2nt)Dy161(n,nt)Tb158							1.1
		Tm169(n,5n)Tm165(β^+)Er165(β^+)_ Ho165(n,nt)Dy162(n,2nt)Tb158							1.0
		Many other similar long pathways				100.0	97.1	44.4	34.7
Ho166m	1200 y	Tm169(n,α)Ho166m	100.0	100.0	100.0	99.7	59.7	45.5	56.6
		&Tm169(n,3n)Tm167(β^+)*Er167*(n,d)Ho166m					37.6	32.4	18.5
		Tm169(n,2n)Tm168(β^+)Er168(n,t)Ho166m					1.4	10.0	11.6
		&Tm169(n,t)*Er167*(n,d)Ho166m					0.3	3.3	5.1
		Tm169(n,d)Er168(n,t)Ho166m					0.2	3.2	5.5
		Tm169(n,4n)Tm166(β^+)Er166(n,p)Ho166m						4.8	1.3
Ho163	4570 y	**&**Tm169(n,α)Ho166m(n,2n)Ho165(n,2n)_ *Ho164*(β^-)Er164(n,2n)Er163(β^+)Ho163				20.0			
		&Tm169(n,nα)Ho165(n,2n)*Ho164*(β^-)_ Er164(n,2n)Er163(β^+)Ho163				10.2			
		&Tm169(n,α)Ho166(β^-)Er166(n,2n)_ Er165(β^+)Ho165(n,2n)*Ho164*(β^-)_ Er164(n,2n)Er163(β^+)Ho163				5.8			
		&Tm169(n,2n)Tm168(β^+)Er168(n,α)_ Dy165(β^-)Ho165(n,2n)*Ho164*(β^-)_ Er164(n,2n)Er163(β^+)Ho163				3.3			
		&Tm169(n,2n)Tm168(n,α)Ho165(n,2n)_ *Ho164*(β^-)Er164(n,2n)Er163(β^+)Ho163				2.9			
		&Tm169(n,2n)Tm168(n,nα)*Ho164*(β^-)_ Er164(n,2n)Er163(β^+)Ho163				2.8			
		&Tm169(n,3n)Tm167(β^+)*Er167*(n,3n)_ Er165(β^+)Ho165(n,3n)*Ho163*					64.3		
		&Tm169(n,nα)Ho165(n,3n)*Ho163*					9.0	0.4	0.2
		&Tm169(n,3n)Tm167(β^+)*Er167*(n,4n)_ Er164(n,2n)Er163(β^+)Ho163					5.0		
		&Tm169(n,2n)Tm168(β^+)Er168(n,4n)_ Er165(β^+)Ho165(n,3n)*Ho163*					2.4	0.5	
	►	**&**Tm169(n,3n)Tm167(n,3n)Tm165(β^+)_ Er165(β^+)Ho165(n,3n)*Ho163*					1.8		

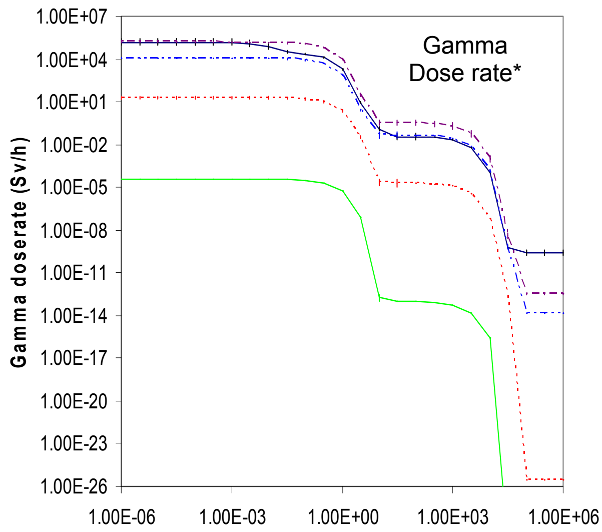
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Tm169(n,α)Ho166m(n,4n)Ho163					1.6	0.3	
		Tm169(n,4n)Tm166(β^+)Er166(n,4n)_ Er163(β^+)Ho163						78.8	7.5
		&Tm169(n,3n)Tm167(β^+)*Er167*(n,5n)_ Er163(β^+)Ho163						5.1	16.6
		Tm169(n,nt)Er166(n,4n)Er163(β^+)Ho163						2.4	2.7
		&Tm169(n,3nα)*Ho163*						1.9	23.4
		&Tm169(n,4n)Tm166(β^+)Er166(n,nt)*Ho163*						1.3	2.8
		&Tm169(n,5n)Tm165(β^+)Er165(β^+)_ Ho165(n,3n)*Ho163*						0.9	19.0
		&Tm169(n,t)*Er167*(n,5n)Er163(β^+)Ho163						0.5	4.5
		Tm169(n,2n)Tm168(β^+)Er168(n,6n)_ Er163(β^+)Ho163							6.9
		Tm169(n,d)Er168(n,6n)Er163(β^+)Ho163							3.2
		&Tm169(n,6n)*Tm164*(β^+)Er164(n,2n)_ Er163(β^+)Ho163							2.8
		&Tm169(n,3n)Tm167(β^+)*Er167*(n,2nt)*Ho163*							1.7
		Tm169(n,2nt)Er165(β^+)Ho165(n,3n)Ho163							1.2
		Many other similar long pathways				55.0	15.9	7.9	7.5
Gd150	1.8 10^6 y	Pathways involving (n,2n), β^+, (n,α)				100.0	100.0	100.0	100.0
Dy154	3.0 10^6 y	Pathways involving (n,2n), β^+, (n,α)				100.0	100.0	100.0	100.0
Hf182	9.0 10^6 y	**&**Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(β^-)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175(β^-)Lu175(n,γ)Lu176_ (n,γ)Lu177(β^-)Hf177(n,γ)Hf178(n,γ)_ *Hf179*(n,γ)Hf180(n,γ)Hf181(n,γ)Hf182	29.7	73.2	33.3				
		&Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(n,γ)Tm173(β^-)Yb173(n,γ)_ Yb174(n,γ)Yb175(β^-)Lu175(n,γ)Lu176_ (n,γ)Lu177(β^-)Hf177(n,γ)Hf178(n,γ)_ *Hf179*(n,γ)Hf180(n,γ)Hf181(n,γ)Hf182	22.9	2.1	1.9				
		&Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(β^-)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175(β^-)Lu175(n,γ)Lu176_ (n,γ)Lu177(n,γ)Lu178(β^-)Hf178(n,γ)_ *Hf179*(n,γ)Hf180(n,γ)Hf181(n,γ)Hf182	12.4	4.0	1.2				
		&Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(n,γ)Tm173(β^-)Yb173(n,γ)_ Yb174(n,γ)Yb175(β^-)Lu175(n,γ)Lu176_ (n,γ)Lu177(n,γ)Lu178(β^-)Hf178(n,γ)_ *Hf179*(n,γ)Hf180(n,γ)Hf181(n,γ)Hf182	9.1	0.1	0.1				
		&Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(β^-)Yb172(n,γ)Yb173(n,γ)Yb174_ (n,γ)Yb175(β^-)Lu175(n,γ)Lu176m(β^-)_ Hf176(n,γ)Hf177(n,γ)Hf178(n,γ)*Hf179*_ (n,γ)Hf180(n,γ)Hf181(n,γ)Hf182	6.6	0.7	23.7				
		&Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(n,γ)Tm173(β^-)Yb173(n,γ)_ Yb174(n,γ)Yb175(β^-)Lu175(n,γ)Lu176m_ (β^-)Hf176(n,γ)Hf177(n,γ)Hf178(n,γ)_ *Hf179*(n,γ)Hf180(n,γ)Hf181(n,γ)Hf182	5.8		1.4				
	►	**&**Tm169(n,γ)Tm170(β^-)Yb170(n,γ)_ Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175(β^-)Lu175(n,γ)Lu176_ (n,γ)Lu177(β^-)Hf177(n,γ)Hf178(n,γ)_ *Hf179*(n,γ)Hf180(n,γ)Hf181(n,γ)Hf182	2.0	0.3	14.8				

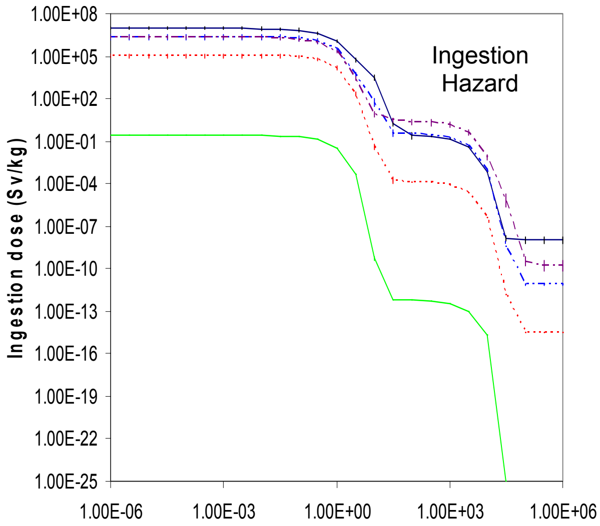
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Tm169(n,γ)Tm170(n,γ)Tm171(β$^-$)_ Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175(β$^-$)Lu175(n,γ)Lu176_ (n,γ)Lu177(β$^-$)Hf177(n,γ)Hf178(n,γ)_ *Hf179*(n,γ)Hf180(n,γ)Hf181(n,γ)Hf182	1.5	7.8	7.2				
		&Tm169(n,γ)Tm170(β$^-$)Yb170(n,γ)_ Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)Yb174_ (n,γ)Yb175(β$^-$)Lu175(n,γ)Lu176m(β$^-$)_ Hf176(n,γ)Hf177(n,γ)Hf178(n,γ)*Hf179*_ (n,γ)Hf180(n,γ)Hf181(n,γ)Hf182	0.4		10.6				
		&Tm169(n,γ)Tm170(n,γ)Tm171(β$^-$)_ Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)Yb174_ (n,γ)Yb175(β$^-$)Lu175(n,γ)Lu176m(β$^-$)_ Hf176(n,γ)Hf177(n,γ)Hf178(n,γ)*Hf179*_ (n,γ)Hf180(n,γ)Hf181(n,γ)Hf182	0.3	0.1	5.2				
Lu176	4.0 10^{10} y	Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(β$^-$)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175(β$^-$)Lu175(n,γ)Lu176	65.0	84.1	44.9				
		Tm169(n,γ)Tm170(n,γ)Tm171(n,γ)_ Tm172(n,γ)Tm173(β$^-$)Yb173(n,γ)_ Yb174(n,γ)Yb175(β$^-$)Lu175(n,γ)Lu176	18.8	1.4	1.4				
		Tm169(n,γ)Tm170(β$^-$)Yb170(n,γ)_ Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175(β$^-$)Lu175(n,γ)Lu176	10.5	0.9	37.1				
		Tm169(n,γ)Tm170(n,γ)Tm171(β$^-$)_ Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175(β$^-$)Lu175(n,γ)Lu176	5.6	13.6	16.6				
Yb168	1.3 10^{14} y	Tm169(n,2n)Tm168(β$^-$)Yb168				99.4	48.6	75.0	83.9
		&Tm169(n,γ)Tm170(β$^-$)Yb170(n,2n)_ *Yb169*(n,2n)Yb168				0.6			
		Tm169(n,γ)Tm170(β$^-$)Yb170(n,3n)Yb168					51.3	25.0	16.1
Gd160	1.3 10^{17} y	Tm169(n,α)Ho166(β$^-$)Er166(n,α)_ Dy163(n,α)Gd160	99.6	97.6		2.0			
		&Tm169(n,α)Ho166m(n,2n)Ho165(n,2n)_ *Ho164*(β$^+$)Dy164(n,2n)Dy163(n,α)Gd160				10.7			
		Tm169(n,2n)Tm168(β$^+$)Er168(n,2n)_ Er167(n,2n)Er166(n,α)Dy163(n,α)Gd160				6.7			
		Tm169(n,2n)Tm168(β$^+$)Er168(n,2n)_ Er167(n,nα)Dy163(n,α)Gd160				5.4			
		Tm169(n,2n)Tm168(β$^+$)Er168(n,2n)_ Er167(n,α)Dy164(n,2n)Dy163(n,α)Gd160				5.3			
		Tm169(n,nα)Ho165(n,2n)Ho164(β$^+$)_ Dy164(n,2n)Dy163(n,α)Gd160				4.3			
		Tm169(n,2n)Tm168(β$^+$)Er168(n,nα)_ Dy164(n,2n)Dy163(n,α)Gd160				3.2			
		&Tm169(n,2n)Tm168(n,2n)Tm167(β$^+$)_ *Er167*(n,2n)Er166(n,α)Dy163(n,α)Gd160				3.2			
		Tm169(n,α)Ho166(β$^-$)Er166(n,2n)_ Er165(β$^+$)Ho165(n,2n)Ho164(β$^+$)_ Dy164(n,2n)Dy163(n,α)Gd160				3.1			
		Tm169(n,2n)Tm168(β$^+$)Er168(n,nα)_ Dy164(n,nα)Gd160				0.4	6.7	1.1	0.2
		&Tm169(n,2nα)*Ho164*(β$^+$)Dy164(n,nα)Gd160					13.4	60.9	25.0
		&Tm169(n,3n)Tm167(β$^+$)*Er167*(n,nα)_ Dy163(n,α)Gd160					10.7	0.5	0.2
		&Tm169(n,α)Ho166m(n,3n)*Ho164*(β$^+$)_ Dy164(n,nα)Gd160					7.2	0.3	
	►	**&**Tm169(n,3n)Tm167(β$^+$)*Er167*(n,α)_ Dy164(n,nα)Gd160					4.9	0.4	0.2

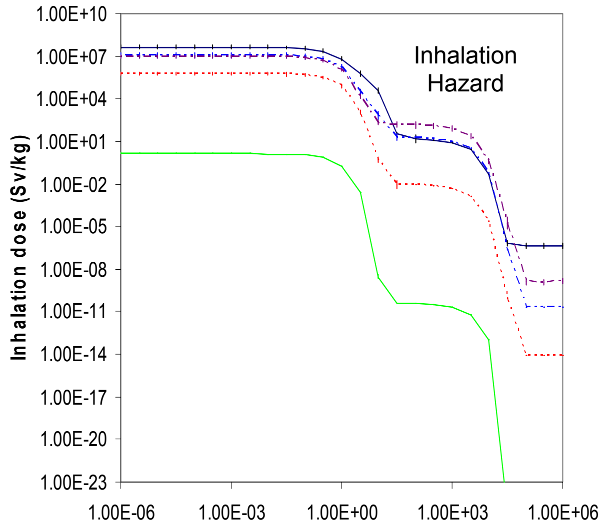
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Tm169(n,4n)Tm166(β^+)Er166(n,t)_ *Ho164*(β^+)Dy164(n,nα)Gd160						13.5	2.7
		Tm169(n,5n)Tm165(β^+)Er165(β^+)_ Ho165(n,d)Dy164(n,nα)Gd160						1.0	13.1
		Tm169(n,5n)Tm165(β^+)Er165(β^+)Ho165_ (n,2n)Ho164(β^+)Dy164(n,nα)Gd160						1.0	9.1
		Tm169(n,5n)Tm165(β^+)Er165(β^+)_ Ho165(n,t)Dy163(n,α)Gd160						0.1	6.2
		Plus many other similar long pathways	0.4	2.4		55.7	57.1	21.2	43.3

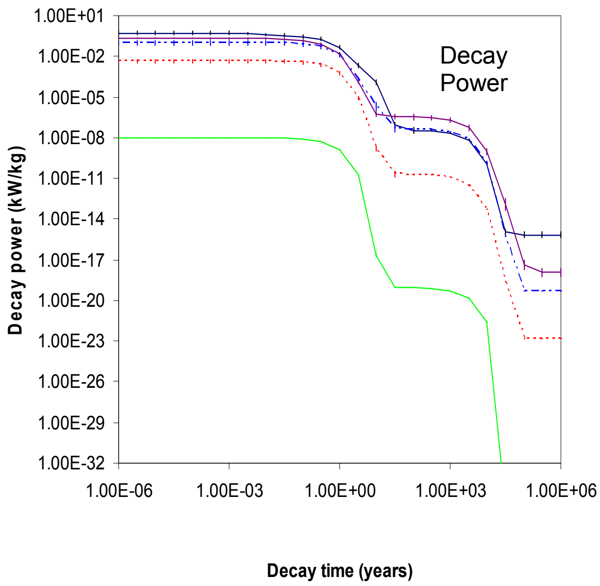
Thulium activation characteristics

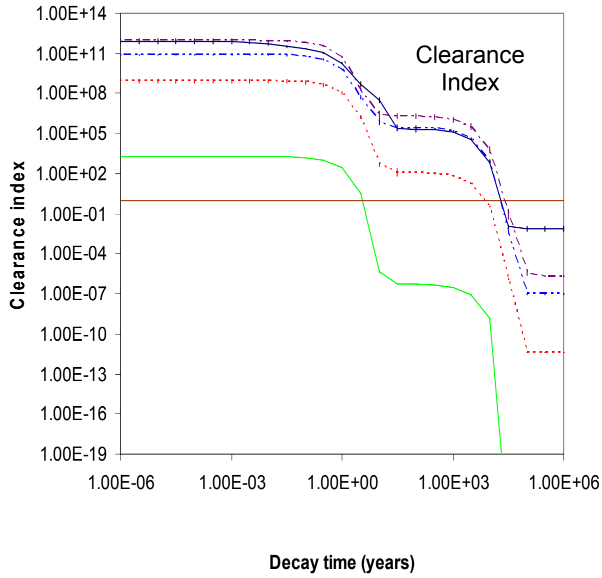






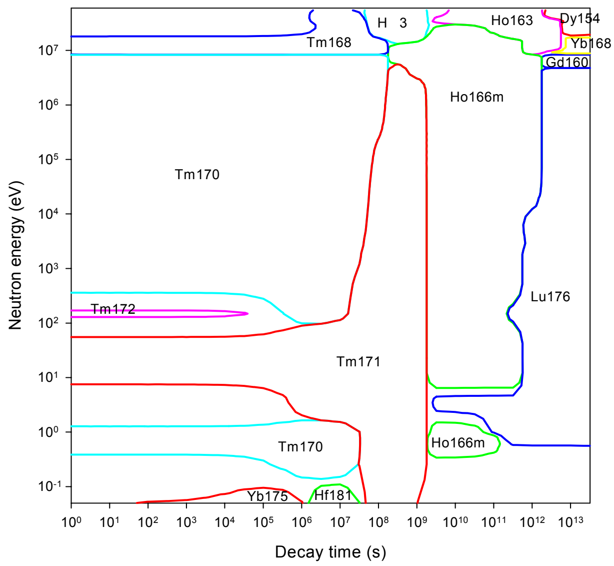




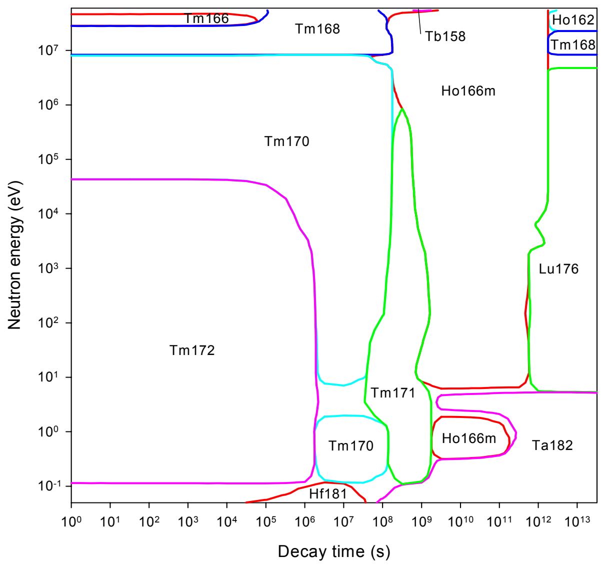


Thulium importance diagrams & transmutation

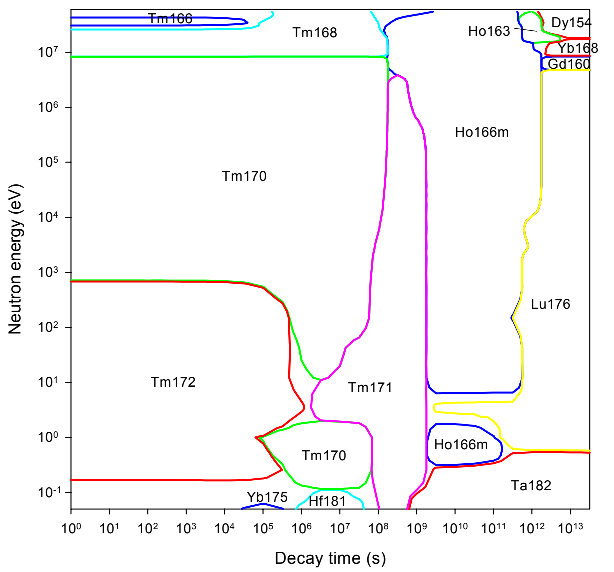
Activity



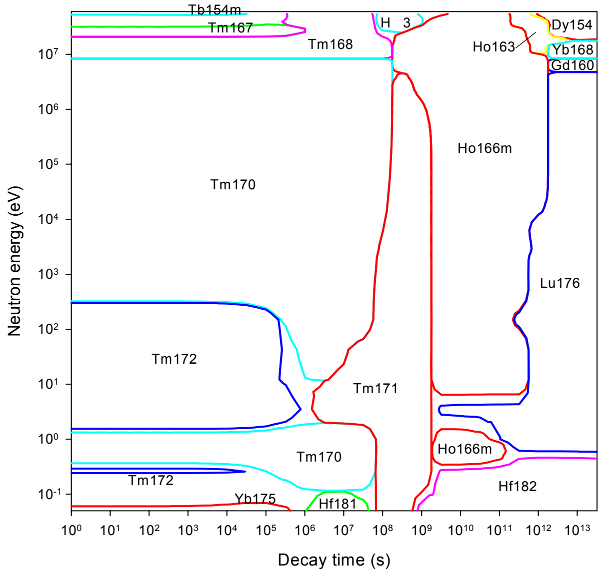
Dose rate



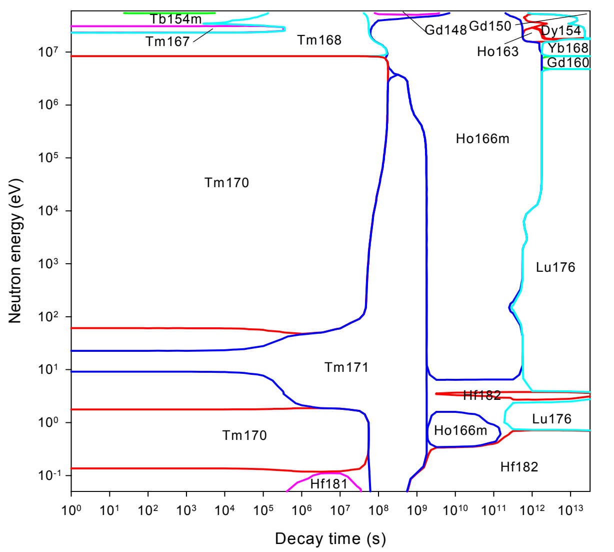
Heat output



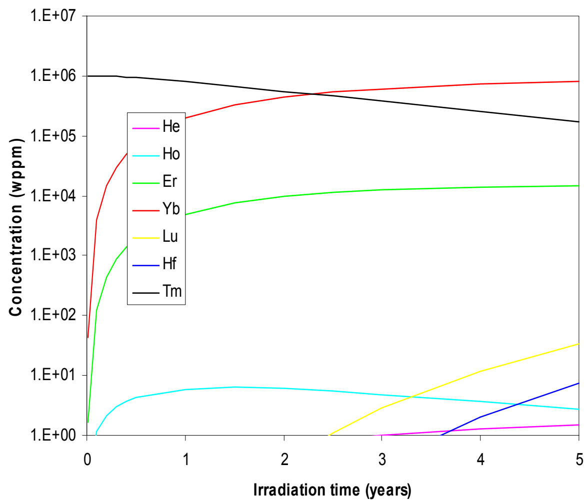
Ingestion dose



Inhalation dose



First wall transmutation



Ytterbium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	70		
Crustal abundance / wppm	3.2	Yb168	0.13 ($T_{1/2}$=1.30 10^{14} y)
Melting point / K	1097	Yb170	3.04
Boiling point / K	1467	Yb171	14.28
Density / kgm^{-3}	6903	Yb172	21.83
Thermal conductivity / $Wm^{-1}K^{-1}$	34.9	Yb173	16.13
Electrical resistivity /Ωm	2.9 10^{-7}	Yb174	31.83
Coefficient of thermal expansion / K^{-1}	2.63 10^{-5}	Yb176	12.76
Crystal structure	FCC		
Number of stable isotopes	6 (7)		
Mean atomic weight	173.04		

Activation properties

Act	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y	Heat	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Bq kg^{-1}	1.69E15	1.45E15	5.89E14	9.61E12	4.68E8	7.90E4	kW kg^{-1}	8.81E-2	7.32E-2	2.08E-2	3.46E-4	8.97E-8	1.11E-11
Yb175	40.06	46.78	62.78				Lu176m	31.68	37.51				
Lu176m	21.45	24.64					Yb175	24.83	29.87	57.48			
Lu177	13.15	15.37	25.95	0.05			Yb177	12.95	15.11				
Hf179m	9.69						Hf179m	11.16					
Yb177	6.74	7.63					Lu177	7.31	8.80	21.31	0.04		
Yb177m	3.37						Yb177m	3.40					
Tm170	1.53	1.79	4.31	37.64			Tm170	1.56	1.88	6.49	55.47		
Yb169	1.01	1.18	2.68	0.07			Yb169	1.32	1.59	5.17	0.12		
Lu178	0.48	0.49					Lu178	1.30	1.37				
Hf181	0.35	0.41	0.95	0.16			Hf181	0.79	0.95	3.16	0.51		
Hf175	0.34	0.39	0.93	1.60			Hf175	0.42	0.51	1.73	2.90		
Lu174m	0.20	0.23	0.56	5.87			Hf178m	0.36			0.11	46.87	
Tm171	0.19	0.22	0.53	22.68			Ta182	0.30	0.36	1.25	8.43	0.01	80.02
Lu174	0.18	0.21	0.53	29.29			Tm168	0.14	0.17	0.57	2.31		
Hf178m	0.10			0.02	48.85		Lu174m		0.13	0.45	4.65		
Ta182		0.08	0.18	1.27	0.01	46.90	Lu174		0.11	0.39	21.02		
Lu173			0.02	0.56			Tm171			0.06	2.64		
Hf178n				0.02	48.85		Hf178n				0.13	52.97	
Hf182					0.01	46.90	Hf182						14.49
Lu176						6.20	Lu176						5.49

Dose	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y	Ing	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv h^{-1}	1.22E4	1.02E4	3.21E3	1.08E2	5.17E-2	1.24E-5	Sv kg^{-1}	5.57E5	5.54E5	3.05E5	6.36E3	1.08E0	1.76E-4
Yb177	39.71	46.05					Yb175	53.56	53.73	53.33			
Yb175	26.21	31.34	54.59				Lu177	21.18	21.26	26.55	0.04		
Hf179m	10.51						Lu176m	11.08	10.94				
Tm172	3.53	4.22	5.18				Tm170	6.05	6.07	10.82	73.90		
Ta182	2.91	3.48	10.84	36.02	0.02	96.37	Yb169	2.18	2.19	3.67	0.07		
Hf181	2.80	3.34	10.04	0.80			Yb177	1.80	1.75				
Lu178	2.17	2.29					Hf181	1.17	1.18	2.01	0.26		
Lu177	1.79	2.14	4.69				Tm172	0.98	0.99	0.69			
Hf178m	1.22		0.01	0.17	37.98		Hf175	0.42	0.42	0.74	0.99		
Hf175	1.13	1.35	4.14	3.41			Lu174m	0.32	0.32	0.57	4.70		
Tm174	1.12	0.68					Ta182	0.30	0.30	0.53	2.87	0.01	31.66
Tm168	1.05	1.25	3.89	7.78			Hf179n	0.21	0.21	0.35			
Hf177m	0.94	0.07	0.12	0.77			Lu174	0.15	0.15	0.27	11.95		
Yb169	0.65	0.77	2.28	0.03			Tm168	0.10	0.10	0.18	0.57		
Hf179n	0.60	0.72	2.07				Tm171	0.06	0.06	0.11	3.77		
Lu174	0.48	0.58	1.83	49.29			Lu177m			0.05	0.52		
Hf178n			0.01	0.27	61.74		Hf178n				0.16	99.86	
Hf182						2.51	Hf182					0.01	63.32
Lu176						1.12	Lu176						5.02

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y	Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	1.14E6	1.14E6	7.65E5	4.52E4	5.95E1	1.22E-2		1.49E11	9.06E10	3.19E10	1.79E9	5.17E5	3.85E2
Yb175	43.46	43.50	35.32				Hf179m	28.10					
Lu177	23.45	23.49	24.00	0.01			Yb177	18.60	29.73				
Tm170	15.93	15.96	23.25	56.07			Lu176m	15.17	24.60				
Yb169	4.50	4.51	6.19	0.04			Ta182	7.39	12.19	33.83	67.96	0.07	96.38
Lu176m	3.83	3.77					Yb177m	6.35					
Hf181	2.60	2.61	3.65	0.17			Yb175	4.53	7.47	11.58			
Lu174m	1.24	1.24	1.81	5.24			Hf181	3.97	6.54	17.47	0.84		
Lu174	1.14	1.14	1.70	26.18			Yb169	3.69	6.08	15.94	0.11		
Ta182	0.97	0.97	1.41	2.69		3.04	Hf177m	1.50	0.15	0.24	0.91		
Yb177	0.69	0.67					Lu177	1.49	2.45	4.79			
Hf175	0.60	0.60	0.86	0.41			Hf175	1.41	2.33	6.38	3.18		
Tm171	0.39	0.39	0.57	6.76			Hf178m	1.18			0.12	45.14	
Hf179n	0.33	0.33	0.44				Tm172	1.13	1.87	2.04			
Tm172	0.31	0.31	0.18				Lu178	1.09	1.57				
Tm168	0.16	0.16	0.23	0.26			Hf179n	0.60	0.99	2.54			
Lu177m	0.13	0.13	0.19	0.69			Tm168	0.48	0.79	2.19	2.65		
Hf178n	0.05	0.05	0.07	1.20	99.88		Lu174	0.25	0.41	1.17	18.96		
Er169	0.04	0.04	0.05				Tm170		0.29	0.80	2.02		
Ta183	0.04	0.04	0.03				Lu174m		0.26	0.74	2.25		
Lu173			0.03	0.29			Lu173			0.05	0.53		
Hf182					0.02	94.16	Hf178n			0.01	0.14	54.62	
Lu176						2.81	Hf182						2.35
							Lu176						1.27

Ytterbium

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Hf177m	1.08 s	Yb174(n,γ)Yb175(β⁻)Lu175(n,γ)_ Lu176m(β⁻)Hf176(n,γ)Hf177m	48.6	1.5	53.9				
		Yb174(n,γ)Yb175(β⁻)Lu175(n,γ)Lu176_ (n,γ)Lu177m(β⁻)Hf177m	31.7	56.4	44.0				
		Yb173(n,γ)Yb174(n,γ)Yb175(β⁻)Lu175_ (n,γ)Lu176(n,γ)Lu177m(β⁻)Hf177m	10.0	16.1	0.8				
		Yb173(n,γ)Yb174(n,γ)Yb175(β⁻)Lu175_ (n,γ)Lu176m(β⁻)Hf176(n,γ)Hf177m	8.9	0.3	1.1				
		Yb172(n,γ)Yb173(n,γ)Yb174(n,γ)_ Yb175(β⁻)Lu175(n,γ)Lu176(n,γ)_ Lu177m(β⁻)Hf177m	0.3	16.8					
		Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175(β⁻)Lu175(n,γ)_ Lu176(n,γ)Lu177m(β⁻)Hf177m		8.4					
		&Yb176(n,γ)*Yb177*(β⁻)Lu177(β⁻)_ Hf177(n,n′)*Hf177m*				99.4	96.5	96.4	96.5
Yb176m	11.4 s	Yb173(n,γ)Yb174(n,γ)Yb175(n,γ)Yb176m	65.8	18.6	4.9				
		Yb174(n,γ)Yb175(n,γ)Yb176m	28.9	44.7	94.8				
		Yb172(n,γ)Yb173(n,γ)Yb174(n,γ)_ Yb175(n,γ)Yb176m	3.8	23.0	0.2				
		Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175(n,γ)Yb176m	1.5	13.6					
		Yb176(n,n′)Yb176m				100.0	99.8	99.8	99.9
Yb177	1.911 h	**&**Yb176(n,γ)*Yb177*	98.5	100.0	100.0	100.0	100.0	100.0	100.0
		&Yb174(n,γ)Yb175(n,γ)Yb176(n,γ)*Yb177*	1.3						
Lu176m	3.635 h	Yb174(n,γ)Yb175(β⁻)Lu175(n,γ)Lu176m	72.9	50.3	97.0	0.1	0.2	0.2	0.2
		Yb173(n,γ)Yb174(n,γ)Yb175(β⁻)Lu175_ (n,γ)Lu176m	26.0	17.8	3.0				
		Yb172(n,γ)Yb173(n,γ)Yb174(n,γ)_ Yb175(β⁻)Lu175(n,γ)Lu176m	0.8	20.6					
		Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)Yb174_ (n,γ)Yb175(β⁻)Lu175(n,γ)Lu176m	0.3	11.3					
		Yb176(n,2n)Yb175(β⁻)Lu175(n,γ)Lu176m				95.3	82.8	73.2	65.3
		Yb176(n,2n)Yb175(β⁻)Lu175(n,γ)_ Lu176(n,n′)Lu176m				3.9	2.1	1.5	0.9
		Yb176(n,d)Tm175(β⁻)Yb175(β⁻)Lu175_ (n,γ)Lu176m					7.7	13.9	18.1
		&Yb176(n,γ)*Yb177*(β⁻)Lu177(β⁻)_ Hf177(n,d)Lu176m					6.3	10.3	14.6
Tm166	7.70 h	Yb168(n,2n)Yb167(β⁺)Tm167(n,2n)Tm166				71.7			
		&Yb170(n,2n)*Yb169*(β⁺)Tm169(n,2n)_ Tm168(n,2n)Tm167(n,2n)Tm166				11.2			
		&Yb171(n,2n)Yb170(n,2n)*Yb169*(β⁺)Tm169_ (n,2n)Tm168(n,2n)Tm167(n,2n)Tm166				7.7			
		&Yb170(n,2n)*Yb169*(n,2n)Yb168(n,2n)_ Yb167(β⁺)Tm167(n,2n)Tm166				4.1			
		&Yb171(n,2n)Yb170(n,2n)*Yb169*(n,2n)_ Yb168(n,2n)Yb167(β⁺)Tm167(n,2n)Tm166				2.9			
		Yb170(n,3n)Yb168(n,3n)Yb166(β⁺)Tm166					28.5	1.7	0.2
		Yb172(n,3n)Yb170(n,3n)Yb168(n,3n)_ Yb166(β⁺)Tm166					24.8	0.4	
		Yb171(n,4n)Yb168(n,3n)Yb166(β⁺)Tm166					20.2	18.9	1.0
		Yb173(n,4n)Yb170(n,3n)Yb168(n,3n)_ Yb166(β⁺)Tm166					5.3	0.8	
	►	Yb168(n,3n)Yb166(β⁺)Tm166					4.9	1.0	0.2

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Yb171(n,2n)Yb170(n,3n)Yb168(n,3n)_ Yb166(β^+)Tm166					4.1	0.2	
		Yb174(n,3n)Yb172(n,3n)Yb170(n,3n)_ Yb168(n,3n)Yb166(β^+)Tm166					2.5		
		Yb173(n,3n)Yb171(n,4n)Yb168(n,3n)_ Yb166(β^+)Tm166					2.2	0.6	
		Yb174(n,4n)Yb171(n,4n)Yb168(n,3n)_ Yb166(β^+)Tm166					1.4	3.5	
		&Yb171(n,3n)*Yb169*(β^+)Tm169(n,4n)Tm166					0.2	7.9	0.7
		&Yb172(n,4n)*Yb169*(β^+)Tm169(n,4n)Tm166						35.7	1.4
		&Yb173(n,5n)*Yb169*(β^+)Tm169(n,4n)Tm166						4.5	1.9
		Yb172(n,5n)Yb168(n,3n)Yb166(β^+)Tm166						2.7	3.4
		Yb170(n,5n)Yb166(β^+)Tm166						0.7	13.1
		Yb173(n,4n)Yb170(n,5n)Yb166(β^+)Tm166						0.6	3.0
		Yb174(n,5n)Yb170(n,5n)Yb166(β^+)Tm166						0.3	11.2
		Yb171(n,6n)Yb166(β^+)Tm166							28.7
		&Yb174(n,6n)*Yb169*(β^+)Tm169(n,4n)Tm166							4.1
		Yb176(n,6n)Yb171(n,6n)Yb166(β^+)Tm166							2.8
		Yb174(n,4n)Yb171(n,6n)Yb166(β^+)Tm166							2.5
Yb175	4.185 d	Yb173(n,γ)Yb174(n,γ)Yb175	65.8	18.6	5.5				
		Yb174(n,γ)Yb175	28.8	44.7	94.2	0.2	0.3		0.2
		Yb172(n,γ)Yb173(n,γ)Yb174(n,γ)Yb175	3.8	23.0	0.2				
		Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175	1.5	13.6					
		Yb176(n,2n)Yb175				99.7	90.8	83.6	77.9
		Yb176(n,d)Tm175(β^-)Yb175					9.2	17.3	21.6
Lu177	6.647 d	Yb174(n,γ)Yb175(β^-)Lu175(n,γ)Lu176_ (n,γ)Lu177	59.1		2.1				
		Yb173(n,γ)Yb174(n,γ)Yb175(β^-)Lu175_ (n,γ)Lu176(n,γ)Lu177	21.1						
		&Yb176(n,γ)*Yb177*(β^-)Lu177	18.7	100.0	97.9	100.0	99.4	99.6	99.8
Yb169	32.018 d	&Yb168(n,γ)Yb169		100.0	99.7				
		&Yb171(n,2n)Yb170(n,2n)*Yb169*				51.5	0.8		0.1
		&Yb170(n,2n)*Yb169*				34.7	3.1	1.8	1.4
		&Yb172(n,2n)Yb171(n,2n)Yb170(n,2n)Yb169				12.3			
		&Yb171(n,3n)*Yb169*					53.1	12.2	8.1
		&Yb173(n,3n)Yb171(n,3n)Yb169					11.1	0.5	0.2
		&Yb174(n,4n)Yb171(n,3n)*Yb169*					7.1	3.1	0.7
		&Yb172(n,4n)*Yb169*					6.6	55.7	14.9
		&Yb172(n,3n)Yb170(n,2n)*Yb169*					5.3	0.6	0.3
		&Yb172(n,2n)Yb171(n,3n)*Yb169*					4.3	0.5	0.2
		&Yb174(n,3n)Yb172(n,4n)Yb169					1.9	3.3	0.7
		Yb173(n,2n)Yb172(n,4n)Yb169					0.2	1.3	0.2
		&Yb173(n,5n)*Yb169*						6.9	20.8
		&Yb176(n,5n)Yb172(n,4n)*Yb169*						2.4	0.6
		&Yb174(n,6n)*Yb169*							44.2
Hf181	42.38 d	&Yb174(n,γ)Yb175(β^-)Lu175(n,γ)_ Lu176(n,γ)Lu177(β^-)Hf177(n,γ)Hf178_ (n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181	40.6	0.1	0.1				
		&Yb174(n,γ)Yb175(β^-)Lu175(n,γ)_ Lu176m(β^-)Hf176(n,γ)Hf177(n,γ)_ Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181	19.5						
		&Yb174(n,γ)Yb175(β^-)Lu175(n,γ)_ Lu176(n,γ)Lu177(n,γ)Lu178(β^-)Hf178_ (n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181	14.1						
		&Yb176(n,γ)*Yb177*(β^-)Lu177(β^-)Hf177_ (n,γ)*Hf178*(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181	6.4	48.3	49.3	95.0			
	►	&Yb176(n,γ)*Yb177*(β^-)Lu177(n,γ)Lu178_ (β^-)Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181	4.4	3.2	1.2	2.0			

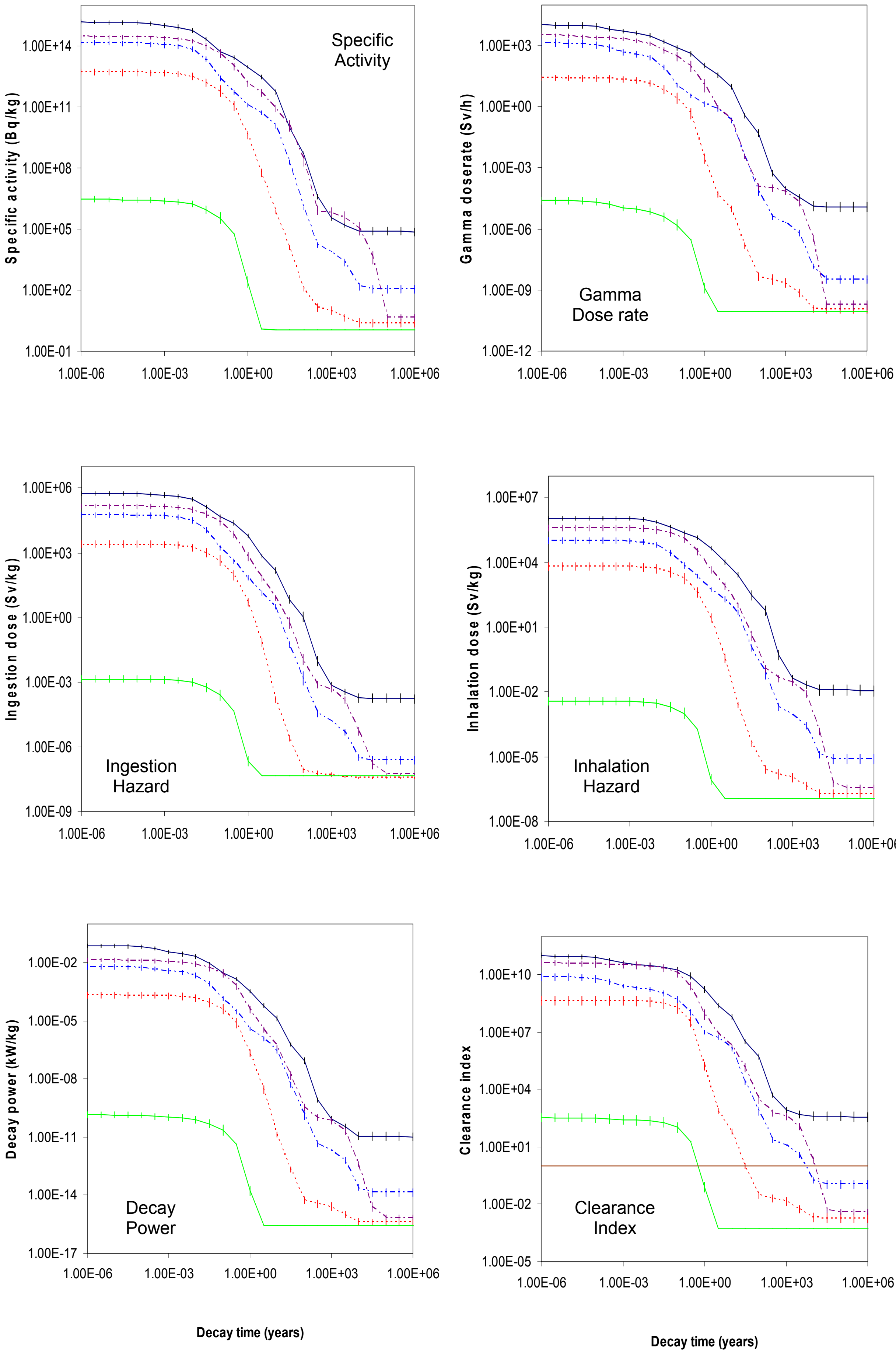
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Yb173(n,γ)Yb174(n,γ)Yb175(β^-)Lu175_ (n,γ)Lu176(n,γ)Lu177(β^-)Hf177(n,γ)_ Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181	4.2						
		&Yb173(n,γ)Yb174(n,γ)Yb175(β^-)Lu175_ (n,γ)Lu176m(β^-)Hf176(n,γ)Hf177(n,γ)_ Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181	1.6						
		&Yb173(n,γ)Yb174(n,γ)Yb175(β^-)Lu175_ (n,γ)Lu176(n,γ)Lu177(n,γ)Lu178(β^-)_ Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181	1.6						
Tm168	93.10 d	Yb168(β^+)Tm168		100.0	100.0				
		&Yb170(n,2n)*Yb169*(β^+)Tm169(n,2n)Tm168				55.1	3.1	1.0	0.2
		&Yb171(n,2n)Yb170(n,2n)*Yb169*(β^+)_ Tm169(n,2n)Tm168				37.9	0.4		
		&Yb172(n,2n)Yb171(n,2n)Yb170_ (n,2n)*Yb169*(β^+)Tm169(n,2n)Tm168				3.9			
		&Yb171(n,3n)Yb169(β^+)*Tm169*(n,2n)Tm168					54.1	6.7	1.5
		&Yb172(n,4n)*Yb169*(β^+)Tm169(n,2n)Tm168					6.8	30.5	2.8
		&Yb173(n,3n)Yb171(n,3n)*Yb169*(β^+)_ Tm169(n,2n)Tm168					5.2	0.1	
		&Yb174(n,4n)Yb171(n,3n)*Yb169*(β^+)_ Tm169(n,2n)Tm168					3.3	1.1	
		Yb172(n,3n)Yb170(n,t)Tm168					2.9	2.7	1.3
		&Yb172(n,3n)Yb170(n,2n)*Yb169*(β^+)_ Tm169(n,2n)Tm168					2.5	0.1	
		&Yb172(n,2n)Yb171(n,3n)*Yb169*(β^+)_ Tm169(n,2n)Tm168					2.0	0.1	
		Yb170(n,t)Tm168					1.8	6.4	5.5
		Yb171(n,nt)Tm168					1.4	10.0	25.9
		Yb172(n,d)Tm171(n,4n)Tm168					1.3	3.9	0.5
		Yb173(n,4n)Yb170(n,t)Tm168					0.6	5.4	1.2
		Yb173(n,t)Tm171(n,4n)Tm168					0.3	2.3	0.4
		Yb174(n,4n)Yb171(n,nt)Tm168					0.2	3.4	2.1
		&Yb173(n,5n)*Yb169*(β^+)Tm169(n,2n)Tm168						3.8	3.9
		Yb174(n,5n)Yb170(n,t)Tm168						2.8	4.3
		Yb172(n,2nt)Tm168						0.8	21.4
		&Yb174(n,6n)*Yb169*(β^+)Tm169(n,2n)Tm168							8.3
		Yb173(n,3nt)Tm168							3.1
		Yb176(n,6n)Yb171(n,nt)Tm168							2.3
Ta182	114.7 d	&Yb174(n,γ)Yb175(β^-)Lu175(n,γ)_ Lu176(n,γ)Lu177(β^-)Hf177(n,γ)Hf178_ (n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181(β^-)_ Ta181(n,γ)Ta182	41.5						
		&Yb174(n,γ)Yb175(β^-)Lu175(n,γ)_ Lu176m(β^-)Hf176(n,γ)Hf177(n,γ)_ Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181_ (β^-)Ta181(n,γ)Ta182	15.9						
		&Yb174(n,γ)Yb175(β^-)Lu175(n,γ)_ Lu176(n,γ)Lu177(n,γ)Lu178(β^-)Hf178_ (n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181(β^-)_ Ta181(n,γ)Ta182	15.1						
		&Yb176(n,γ)*Yb177*(β^-)Lu177(β^-)_ Hf177(n,γ)Hf178(n,γ)*Hf179*(n,γ)*Hf180*_ (n,γ)Hf181(β^-)Ta181(n,γ)Ta182	14.8	96.0	97.7				
		&Yb176(n,γ)*Yb177*(β^-)Lu177(n,γ)_ Lu178(β^-)Hf178(n,γ)*Hf179*(n,γ)*Hf180*_ (n,γ)Hf181(β^-)Ta181(n,γ)Ta182	5.4	3.4	1.6				
		&Yb173(n,γ)Yb174(n,γ)Yb175(β^-)_ Lu175(n,γ)Lu176(n,γ)Lu177(β^-)Hf177_ (n,γ)Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)_ Hf181(β^-)Ta181(n,γ)Ta182	1.3						
Tm170	128.6 d►	&Yb168(n,γ)*Yb169*(β^+)Tm169(n,γ)Tm170	100.0	98.2	100.0				

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Yb171(n,2n)Yb170(n,p)Tm170				26.6	0.8		
		Yb170(n,p)Tm170				19.5	3.2	1.2	0.4
		Yb171(n,d)Tm170				16.1	46.8	29.4	16.2
		Yb171(n,p)Tm171(n,2n)Tm170				10.2	0.2		
		Yb172(n,2n)Yb171(n,d)Tm170				7.1	3.4	1.6	0.6
		Yb172(n,2n)Yb171(n,2n)Yb170(n,p)Tm170				5.9			
		Yb174(n,α)Er171(β^-)Tm171(n,2n)Tm170				5.6	0.2		
		Yb172(n,2n)Yb171(n,p)Tm171(n,2n)Tm170				2.9			
		Yb172(n,t)Tm170				0.3	12.4	34.3	27.8
		Yb173(n,3n)Yb171(n,d)Tm170					8.9	1.6	0.5
		Yb174(n,4n)Yb171(n,d)Tm170					5.7	9.6	1.3
		Yb172(n,3n)Yb170(n,p)Tm170					5.0		
		Yb174(n,3n)Yb172(n,t)Tm170					3.4	2.5	1.2
		Yb173(n,nt)Tm170					1.8	8.1	20.5
		Yb174(n,2nt)Tm170						1.3	23.2
Lu177m	160.3 d	Yb174(n,γ)Yb175(β^-)Lu175(n,γ)Lu176_ (n,γ)Lu177m	75.3	57.7	98.1				
		Yb173(n,γ)Yb174(n,γ)Yb175(β^-)Lu175_ (n,γ)Lu176(n,γ)Lu177m	23.7	16.5	1.8				
		Yb172(n,γ)Yb173(n,γ)Yb174(n,γ)_ Yb175(β^-)Lu175(n,γ)Lu176(n,γ)Lu177m	0.6	17.2					
		Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)Yb174_ (n,γ)Yb175(β^-)Lu175(n,γ)Lu176(n,γ)Lu177m	0.2	8.6					
		&Yb176(n,γ)*Yb177*(β^-)Lu177(n,n′)Lu177m				72.3	47.9	54.3	68.7
		&Yb176(n,γ)*Yb177*(β^-)Lu177(β^-)_ Hf177(n,p)Lu177m				24.8	50.9	44.9	30.7
Lu173	1.336 y	**&**Yb176(n,2n)Yb175(β^-)Lu175(n,2n)_ Lu174(n,2n)Lu173				88.4	0.4	0.7	0.4
		Yb176(n,2n)Yb175(β^-)Lu175(n,2n)_ Lu174m(n,2n)Lu173				9.7			
		Yb176(n,2n)Yb175(β^-)Lu175(n,3n)Lu173				1.4	90.7	83.0	77.3
		Yb176(n,d)Tm175(β^-)Yb175(β^-)Lu175_ (n,3n)Lu173						15.7	21.5
Tm171	1.917 y	**&**Yb168(n,γ)*Yb169*(β^+)Tm169(n,γ)_ Tm170(n,γ)Tm171	99.4	97.2	99.9				
		Yb174(n,α)Er171(β^-)Tm171	0.2			25.5	6.4	1.2	
		Yb171(n,γ)Yb172(n,α)Er169(β^-)Tm169_ (n,γ)Tm170(n,γ)Tm171		1.4					
		Yb171(n,p)Tm171				46.4	8.7	3.5	1.2
		Yb172(n,2n)Yb171(n,p)Tm171				14.7	0.5		
		Yb172(n,d)Tm171				7.8	54.0	43.2	26.2
		Yb173(n,2n)Yb172(n,2n)Yb171(n,p)Tm171				1.3			
		Yb173(n,2n)Yb172(n,d)Tm171				1.2	1.5	0.8	
		Yb173(n,t)Tm171				0.9	10.5	25.9	22.0
		Yb174(n,2n)Yb173(n,t)Tm171				0.4	0.7	1.2	
		Yb174(n,3n)Yb172(n,d)Tm171					10.5	2.2	
		Yb174(n,nt)Tm171					2.2	13.4	41.2
		Yb173(n,3n)Yb171(n,p)Tm171					1.2		
		Yb176(n,4n)Yb173(n,t)Tm171					0.8	1.7	
		Yb176(n,2nα)Er171(β^-)Tm171					0.4	2.2	
		Yb176(n,5n)Yb172(n,d)Tm171						1.6	
		Yb176(n,3nt)Tm171							2.4
Lu174	3.559 y	**&**Yb176(n,2n)Yb175(β^-)Lu175(n,2n)*Lu174*				99.6	9.0	83.6	77.9
		&Yb176(n,d)Tm175(β^-)Yb175(β^-)_ Lu175(n,2n)*Lu174*						15.9	21.7
H3	12.33 y	**&**Yb168(n,γ)*Yb169*(n,X)H1(n,γ)H2(n,γ)H3	92.6						
		Yb171(n,X)H3				34.8	16.7	14.8	14.1
		Yb173(n,X)H3				23.9	16.3	15.0	14.6
		Yb172(n,2n)Yb171(n,X)H3				8.5	0.7		0.3
		Yb174(n,2n)Yb173(n,X)H3				7.5	0.8	0.5	0.3
		Yb176(n,2n)Yb175(β^-)Lu175(n,X)H3				6.0	0.5		0.2
		Yb174(n,X)H3				5.2	22.1	23.8	24.9
	►	Yb172(n,X)H3				4.6	16.7	17.7	18.4

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	Yb176(n,X)H3				1.7	8.1	8.8	9.3
		Yb170(n,X)H3				0.6	2.5	2.6	2.7
		Yb174(n,3n)Yb172(n,X)H3					2.5	0.7	0.4
		Yb172(n,3n)Yb170(n,X)H3					2.1	0.6	0.3
		Yb173(n,3n)Yb171(n,X)H3					1.8		0.3
		Yb171(n,3n)Yb169(β^+)Tm169(n,X)H3					1.3		0.2
		Yb174(n,4n)Yb171(n,X)H3					1.1	2.7	0.6
		Yb173(n,4n)Yb170(n,X)H3					0.5	1.2	0.3
		&Yb172(n,4n)*Yb169*(β^+)Tm169(n,X)H3					0.2	1.4	0.4
		Yb174(n,5n)Yb170(n,X)H3						0.6	1.2
Hf178n	31.00 y	Yb174(n,γ)Yb175(β^-)Lu175(n,γ)Lu176m_ (β^-)Hf176(n,γ)Hf177(n,γ)Hf178n	39.9		0.3				
		Yb174(n,γ)Yb175(β^-)Lu175(n,γ)Lu176_ (n,γ)Lu177(β^-)Hf177(n,γ)Hf178n	35.5	0.3	0.4				
		&Yb176(n,γ)*Yb177*(β^-)Lu177(β^-)_ Hf177(n,γ)Hf178n	9.6	99.4	98.8	1.4	5.5	6.8	9.4
		Yb173(n,γ)Yb174(n,γ)Yb175(β^-)Lu175_ (n,γ)Lu176(n,γ)Lu177(β^-)Hf177(n,γ)Hf178n	8.6						
		&Yb176(n,γ)*Yb177*(β^-)Lu177(β^-)_ Hf177(n,γ)Hf178(n,n′)Hf178n				92.9	88.8	88.2	84.7
		&Yb176(n,γ)*Yb177*(β^-)Lu177(n,γ)_ Lu178(β^-)Hf178(n,n′)Hf178n				1.3	1.4	1.7	2.6
Ho166m	1200 y	Yb168(n,α)Er165(β^+)Ho165(n,γ)Ho166m	52.0	41.1	28.3				
		&Yb168(n,γ)*Yb169*(β^+)Tm169(n,α)_ Ho166m	48.0	56.8	71.7				
		&Yb170(n,2n)*Yb169*(β^+)Tm169(n,α)Ho166m				63.2	2.3	0.4	
		&Yb171(n,2n)Yb170(n,2n)*Yb169*(β^+)_ Tm169(n,α)Ho166m				31.3	0.2		
		&Yb172(n,2n)Yb171(n,2n)Yb170_ (n,2n)*Yb169*(β^+)Tm169(n,α)Ho166m				2.6			
		&Yb171(n,3n)*Yb169*(β^+)Tm169(n,α)Ho166m					40.5	2.5	0.7
		&Yb171(n,3n)Yb169(β^+)Tm169(n,3n)_ Tm167(β^+)*Er167*(n,d)Ho166m					12.2	0.8	
		&Yb172(n,4n)*Yb169*(β^+)Tm169(n,α)Ho166m					3.7	8.6	0.9
		&Yb171(n,nα)*Er167*(n,d)Ho166m					2.8	1.3	0.3
		&Yb173(n,3n)Yb171(n,3n)*Yb169*(β^+)_ Tm169(n,α)Ho166m					2.8		
		&Yb172(n,4n)Yb169(β^+)Tm169(n,3n)_ Tm167(β^+)*Er167*(n,d)Ho166m					1.4	3.8	0.2
		&Yb170(n,4n)Yb167(β^+)Tm167(β^+)_ Er167(n,d)Ho166m					0.3	21.8	2.6
		&Yb172(n,3n)Yb170(n,4n)Yb167(β^+)_ Tm167(β^+)*Er167*(n,d)Ho166m					0.2	3.2	0.2
		&Yb173(n,4n)Yb170(n,4n)Yb167(β^+)_ Tm167(β^+)*Er167*(n,d)Ho166m						6.6	0.2
		&Yb171(n,5n)Yb167(β^+)Tm167(β^+)_ *Er167*(n,d)Ho166m						5.5	24.2
		&Yb174(n,5n)Yb170(n,4n)Yb167(β^+)_ Tm167(β^+)*Er167*(n,d)Ho166m						3.3	0.7
		Yb171(n,nt)Tm168(β^+)Er168(n,t)Ho166m						1.6	4.4
		&Yb171(n,2nt)Tm167(β^+)*Er167*(n,d)Ho166m						0.2	2.7
		Yb172(n,2nt)Tm168(β^+)Er168(n,t)Ho166m						0.1	3.7
		&Yb172(n,6n)Yb167(β^+)Tm167(β^+)_ *Er167*(n,d)Ho166m							22.7
		&Yb174(n,6n)*Yb169*(β^+)Tm169(n,α)Ho166m							3.7
Ho163	4570 y	Yb168(n,nα)Er164(n,2n)Er163(β^+)Ho163				28.8	0.3		
		&Yb168(n,α)Er165(β^+)Ho165(n,2n)_ *Ho164*(β^-)Er164(n,2n)Er163(β^+)Ho163				20.0			
	►	&Yb171(n,nα)Er167(n,3n)Er165(β^+)_ Ho165(n,3n)*Ho163*					4.2		

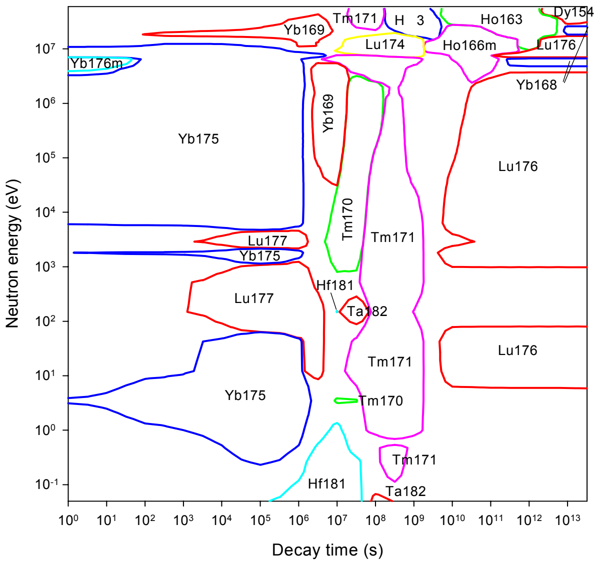
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◀	&Yb171(n,3n)Yb169(β^+)Tm169(n,nα)_ Ho165(n,3n)*Ho163*					2.8		
		Yb171(n,2nα)Er166(n,4n)Er163(β^+)Ho163					0.2	4.4	0.2
		Yb171(n,6n)Yb166(β^+)Tm166(β^+)_ Er166(n,4n)Er163(β^+)Ho163							5.1
		Yb172(n,5n)Yb168(n,6n)Yb163(β^+)_ Tm163(β^+)Er163(β^+)Ho163							3.0
		Many other similar long pathways				51.2	91.4	95.6	91.7
Gd150	1.8 10^{6} y	Very long pathways of (n,α), (n,2n), β^+				100.0	100.0	100.0	100.0
Dy154	3.0 10^{6} y	Very long pathways of (n,α), (n,2n), β^+				100.0	100.0	100.0	100.0
Hf182	9.0 10^{6} y	&Yb174(n,γ)Yb175(β^-)Lu175(n,γ)Lu176_ (n,γ)Lu177(β^-)Hf177(n,γ)Hf178(n,γ)_ *Hf179*(n,γ)*Hf180*(n,γ)Hf181(n,γ)Hf182	41.8						
		&Yb174(n,γ)Yb175(β^-)Lu175(n,γ)_ Lu176m(β^-)Hf176(n,γ)Hf177(n,γ)_ Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181_ (n,γ)Hf182	15.5						
		&Yb174(n,γ)Yb175(β^-)Lu175(n,γ)Lu176_ (n,γ)Lu177(n,γ)Lu178(β^-)Hf178(n,γ)_ *Hf179*(n,γ)*Hf180*(n,γ)Hf181(n,γ)Hf182	15.1						
		&Yb176(n,γ)*Yb177*(β^-)Lu177(β^-)_ Hf177(n,γ)Hf178(n,γ)*Hf179*(n,γ)*Hf180*_ (n,γ)Hf181(n,γ)Hf182	13.0	96.2	98.1				
		&Yb176(n,γ)*Yb177*(β^-)Lu177(n,γ)_ Lu178(β^-)Hf178(n,γ)*Hf179*(n,γ)*Hf180*_ (n,γ)Hf181(n,γ)Hf182	5.4	3.6	1.6				
		&Yb173(n,γ)Yb174(n,γ)Yb175(β^-)_ Lu175(n,γ)Lu176(n,γ)Lu177(β^-)Hf177_ (n,γ)Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)_ Hf181(n,γ)Hf182	3.4						
		&Yb173(n,γ)Yb174(n,γ)Yb175(β^-)_ Lu175(n,γ)Lu176(n,γ)Lu177(n,γ)Lu178_ (β^-)Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)_ Hf181(n,γ)Hf182	1.3						
Lu176	4.0 10^{10} y	Yb174(n,γ)Yb175(β^-)Lu175(n,γ)Lu176	73.1	54.1	97.9	0.1	0.2	0.2	0.2
		Yb173(n,γ)Yb174(n,γ)Yb175(β^-)Lu175_ (n,γ)Lu176	25.9	17.1	2.0				
		Yb172(n,γ)Yb173(n,γ)Yb174(n,γ)_ Yb175(β^-)Lu175(n,γ)Lu176	0.8	18.8					
		Yb171(n,γ)Yb172(n,γ)Yb173(n,γ)_ Yb174(n,γ)Yb175(β^-)Lu175(n,γ)Lu176	0.2	9.8					
		Yb176(n,2n)Yb175(β^-)Lu175(n,γ)Lu176				99.3	85.3	75.7	68.8
		Yb176(n,d)Tm175(β^-)Yb175(β^-)Lu175_ (n,γ)Lu176					7.9	14.4	19.1
		&Yb176(n,γ)*Yb177*(β^-)Lu177(β^-)_ Hf177(n,d)Lu176					5.9	9.2	11.6
Yb168	1.3 10^{14} y	&Yb170(n,2n)*Yb169*(n,2n)Yb168				5.1			
		&Yb171(n,2n)Yb170(n,2n)*Yb169*(n,2n)Yb168				3.8			
		Yb170(n,3n)Yb168					29.2	5.5	2.4
		Yb172(n,3n)Yb170(n,3n)Yb168					25.3	1.2	0.3
		Yb171(n,4n)Yb168					20.7	60.1	13.7
		Yb173(n,4n)Yb170(n,3n)Yb168					5.4	2.5	0.3
		Yb171(n,2n)Yb170(n,3n)Yb168					4.2	0.6	0.2
		Yb174(n,3n)Yb172(n,3n)Yb170(n,3n)Yb168					2.6		
		Yb173(n,3n)Yb171(n,4n)Yb168					2.2	1.9	0.3
		Yb174(n,4n)Yb171(n,4n)Yb168					1.4	11.0	0.6
		Yb172(n,2n)Yb171(n,4n)Yb168					0.8	1.8	0.3
		Yb172(n,5n)Yb168						8.5	45.3
		Yb173(n,6n)Yb168							26.0
		Nuclide present in starting material		100.0	100.0	91.1	8.2	5.3	7.4

Ytterbium activation characteristics

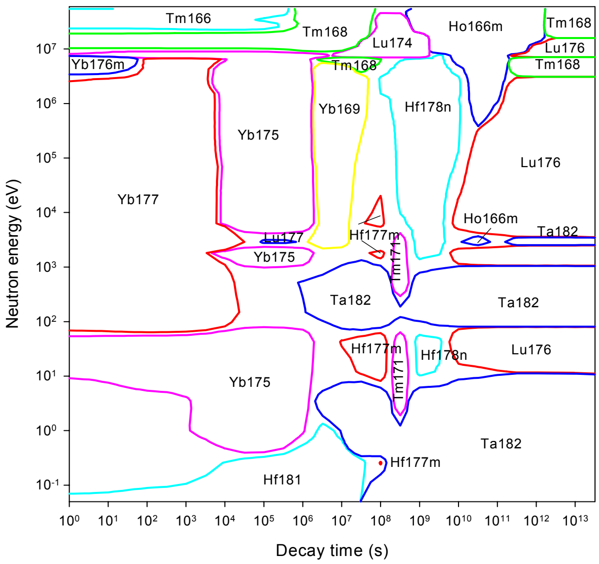


Ytterbium importance diagrams & transmutation

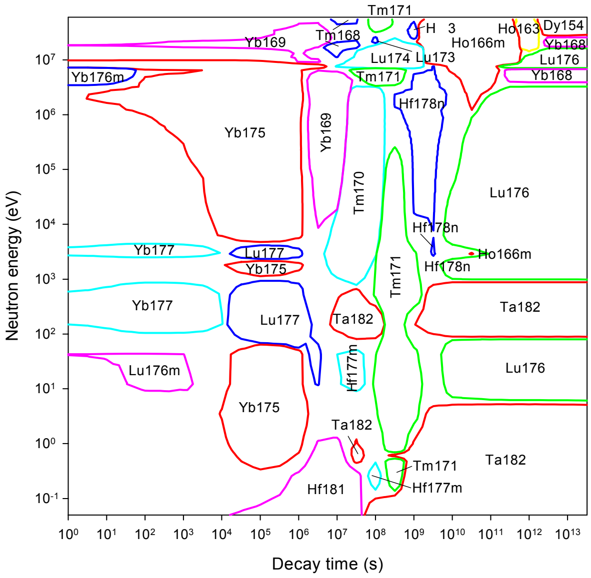
Activity



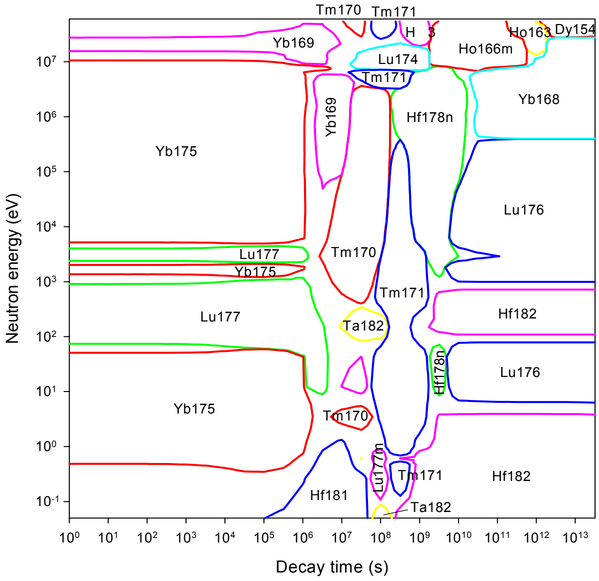
Dose rate



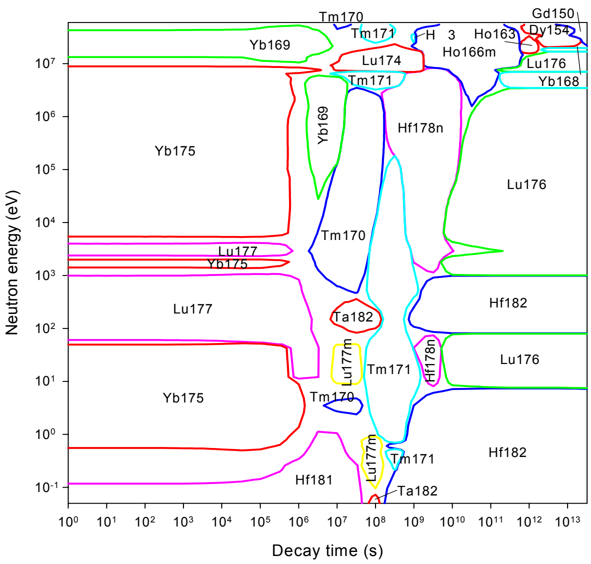
Heat output



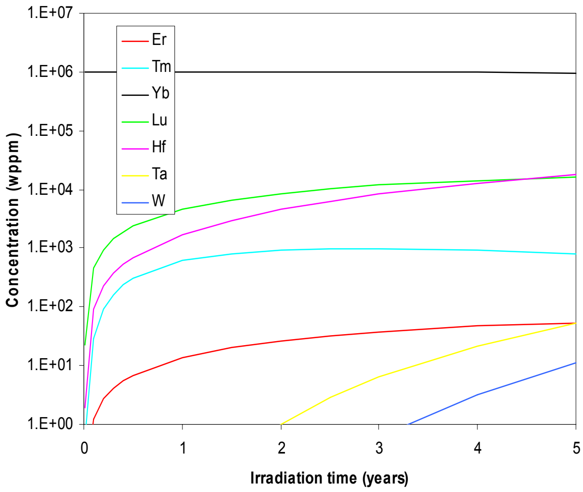
Ingestion dose



Inhalation dose



First wall transmutation



Lutetium

General properties

Property	Value	Isotopes	Isotopic abundances / %
Atomic number	71	Lu175	97.41
Crustal abundance / wppm	0.8	Lu176	2.59 ($T_{1/2}$ = 4.00 10^{10} y)
Melting point / K	1936		
Boiling point / K	3666		
Density / kgm^{-3}	9841		
Thermal conductivity / $Wm^{-1}K^{-1}$	16.4		
Electrical resistivity /Ωm	7.9 10^{-7}		
Coefficient of thermal expansion / K^{-1}	9.9 10^{-6}		
Crystal structure	HCP		
Number of stable isotopes	1 (2)		
Mean atomic weight	174.967		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.63E16	8.98E15	3.28E15	9.51E13	2.30E10	4.01E6
Hf179m	43.53					
Lu176m	26.83	48.01				
Lu177	22.50	40.93	76.56	0.19		
Hf181	1.93	3.52	9.08	0.84		
Hf175	1.40	2.54	6.72	6.46		
Lu178	0.82	1.31				
Hf178m	0.52			0.11	49.85	
Lu174	0.48	0.88	2.42	73.16		
Ta182	0.35	0.64	1.71	6.64	0.01	48.00
Hf180m	0.34	0.62				
Lu174m	0.30	0.55	1.48	8.78		
Hf179n	0.29	0.54	1.34			
Lu177m	0.02	0.04	0.11	0.85		
Lu173	0.02	0.03	0.10	2.10		
Hf178n				0.11	49.85	
Hf182					0.01	48.00
Lu176						3.99

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	1.01E0	5.47E-1	1.49E-1	4.34E-3	4.49E-6	5.66E-10
Hf179m	42.19					
Lu176m	33.34	60.68				
Lu177	10.52	19.47	48.90	0.12		
Hf181	3.68	6.81	23.58	2.19		
Lu178	1.87	3.04				
Hf178m	1.56		0.01	0.45	46.94	
Hf177m	1.50	0.18	0.42	3.02		
Hf175	1.48	2.74	9.70	9.28		
Ta182	1.36	2.52	9.07	35.03	0.01	81.68
Hf180m	1.02	1.87				
Hf179n	0.85	1.57	5.23	0.01		
Lu174	0.20	0.37	1.38	41.52		
Lu174m	0.14	0.26	0.93	5.50		
Lu173	0.01	0.02	0.07	1.60		
Hf178n			0.01	0.50	53.04	
Hf182						14.79
Lu176						3.52

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	1.25E5	6.00E4	4.74E4	3.60E3	2.52E0	6.32E-4
Hf179m	42.97					
Ta182	14.58	30.46	37.75	55.84	0.02	96.84
Hf181	14.21	29.69	35.44	1.25		
Hf178m	5.73		0.01	0.24	38.05	
Hf175	4.28	8.95	10.93	4.00		
Hf180m	3.95	8.16				
Lu178	3.47	6.38				
Hf177m	3.13	0.43	0.34	0.94		
Hf179n	2.81	5.88	6.73			
Lu177	2.78*	5.81*	5.03*	0.01		
Lu174	1.19	2.49	3.16	36.34		
Hf178n			0.03	0.39	61.92	
Hf182						2.46

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	3.37E6	3.36E6	1.95E6	3.86E4	5.39E1	8.95E-3
Lu177	57.81	58.04	68.19	0.25		
Lu176m	22.11	21.84				
Hf181	10.33	10.37	16.79	2.29		
Hf175	2.78	2.80	4.63	6.53		
Ta182	2.56	2.57	4.32	24.57	0.01	32.26
Hf179n	1.73	1.74	2.71	0.01		
Lu174m	0.78	0.78	1.32	11.47		
Lu174	0.64	0.64	1.10	48.67		
Lu177m	0.19	0.19	0.33	3.56		
Lu173	0.02	0.02	0.04	1.35		
Hf178n	0.01	0.01	0.02	1.27	99.87	
Hf182					0.01	64.52
Lu176						3.21

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	8.24E6	8.22E6	6.15E6	4.47E5	2.98E3	6.27E-1
Lu177	53.56	53.62	49.00	0.05		
Hf181	19.20	19.23	24.22	0.90		
Ta182	6.98	6.99	9.14	14.14		3.07
Lu176m	6.39	6.29				
Lu174	4.07	4.07	5.44	65.35		
Hf175	3.33	3.34	4.30	1.65		
Lu174m	2.53	2.54	3.33	7.84		
Hf179n	2.25	2.25	2.72			
Lu177m	0.76	0.76	1.01	2.89		
Hf178n	0.33	0.33	0.45	6.09	99.97	
Ta183	0.26	0.26	0.21			
Lu173	0.09	0.09	0.13	1.07		
Hf180m	0.08	0.08				
Hf182					0.02	95.15
Lu176						1.78

Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
	3.43E12	1.43E12	1.03E12	7.67E10	2.59E7	1.99E4
Hf179m	53.19					
Ta182	16.76	40.07	54.73	82.42	0.08	96.83
Hf181	9.23	22.06	29.01	1.05		
Lu176m	7.99	18.78				
Hf178m	2.55		0.01	0.14	45.22	
Hf175	2.47	5.90	7.95	2.96		
Hf177m	2.30	0.36	0.31	0.88		
Hf180m	1.67	3.94				
Hf179n	1.29	3.08	3.89			
Lu177	1.07	2.56	2.44			
Lu178	0.78	1.64				
Lu174	0.28	0.67	0.93	10.92		
Lu174m	0.10	0.24	0.33	0.77		
Lu173	0.01	0.04	0.05	0.45		
Hf178n		0.01	0.01	0.16	54.70	
Hf182						2.36
Lu176						0.80

Lutetium

Pathway analysis

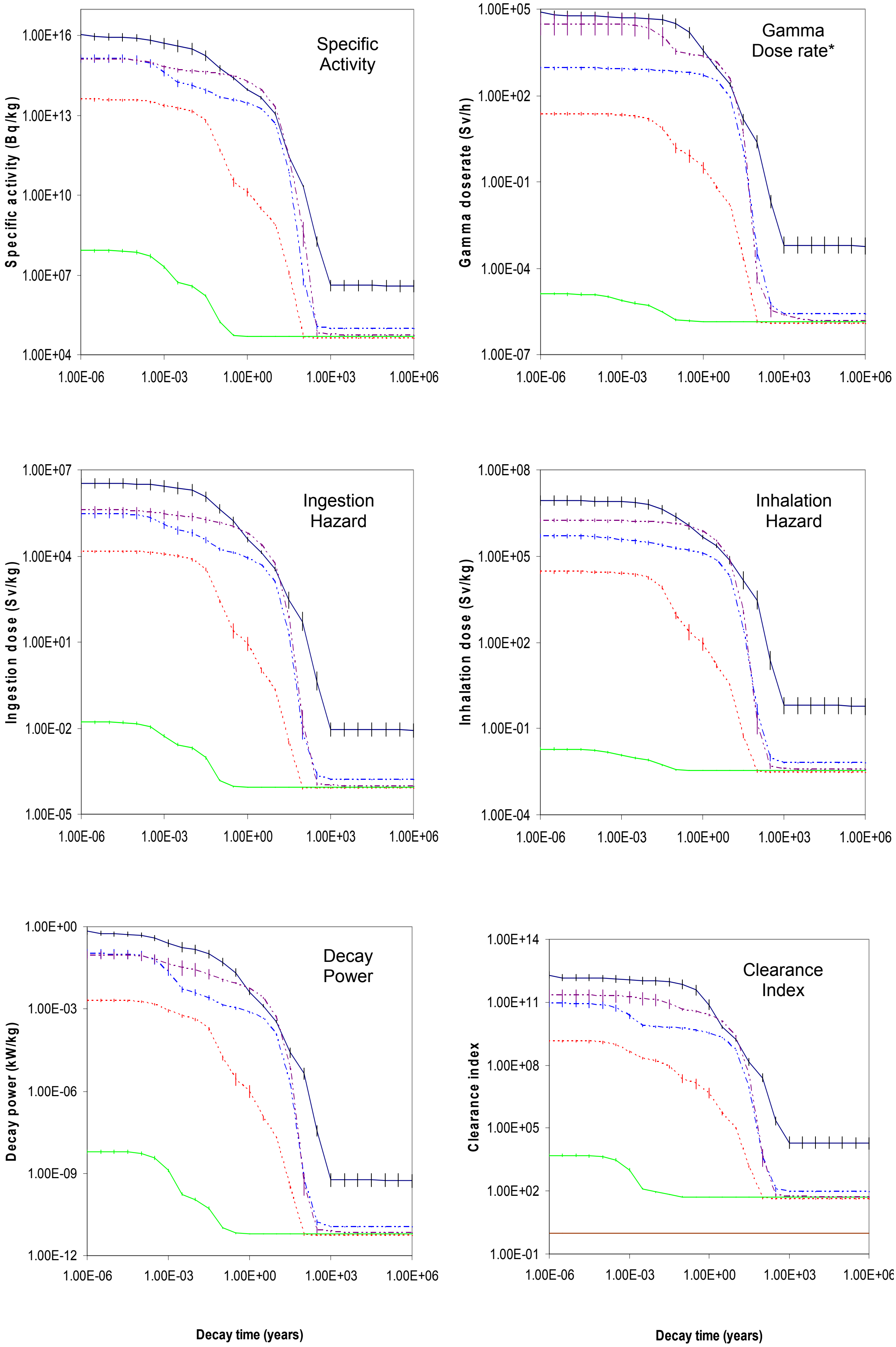
Nuclide	T½	Pathway	210	186	151	42	30	21	6
Hf177m	1.08 s	Lu175(n,γ)Lu176(n,γ)Lu177m(β^-)_ Hf177m	94.9	90.8	38.2	0.2	0.1		
		Lu175(n,γ)Lu176m(β^-)Hf176(n,γ)_ Hf177m	3.8	8.5	42.4				
		Lu176(n,γ)Lu177m(β^-)Hf177m	1.3	0.7	19.4	26.4	40.4	41.2	42.8
		&Lu176(n,γ)Lu177(β^-)Hf177(n,n′)*Hf177m*				71.5	58.3	57.6	56.1
Hf179m	18.67 s	&Lu176(n,γ)Lu177(β^-)Hf177(n,γ)_ *Hf178*(n,γ)Hf179m	77.6		44.2	95.9	96.9	96.9	96.5
		&Lu175(n,γ)Lu176(n,γ)Lu177(β^-)_ Hf177(n,γ)*Hf178*(n,γ)Hf179m	19.5	88.3	32.6	0.2			
		Lu176(n,γ)Lu177(n,γ)Lu178(β^-)Hf178_ (n,γ)Hf179m	1.3		0.3	1.0	1.0	1.3	1.9
		Lu175(n,γ)Lu176(n,γ)Lu177(n,γ)Lu178_ (β^-)Hf178(n,γ)Hf179m	0.6	2.2	0.3				
		&Lu175(n,γ)Lu176m(β^-)Hf176(n,γ)_ Hf177(n,γ)*Hf178*(n,γ)Hf179m	0.4	2.5	22.4				
Lu178	28.4 m	Lu175(n,γ)Lu176(n,γ)Lu177(n,γ)Lu178	100.0	99.6	62.9	0.7	0.3	0.2	0.1
		&Lu176(n,γ)*Lu177*(n,γ)Lu178		0.4	32.2	84.0	81.3	84.6	87.7
		Lu176(n,γ)Lu177m(n,γ)Lu178				11.8	10.3	10.0	10.1
		&Lu176(n,γ)Lu177(β^-)Hf177(n,γ)_ *Hf178*(n,p)Lu178				3.3	7.6	4.9	1.8
Lu176m	3.635 h	Lu175(n,γ)Lu176m	100.0	100.0	100.0	9.3	6.4	5.7	5.6
		Lu176(n,n′)Lu176m				89.8	93.2	94.0	94.2
Lu170	2.002 d	&Lu175(n,2n)*Lu174*(n,2n)Lu173(n,2n)_ *Lu172*(n,2n)*Lu171*(n,2n)*Lu170*				89.4			
		&Lu175(n,2n)Lu174m(n,2n)Lu173_ (n,2n)*Lu172*(n,2n)*Lu171*(n,2n)*Lu170*				7.0			
		&Lu175(n,3n)Lu173(n,4n)*Lu170*					79.4	86.9	
		&Lu175(n,4n)*Lu172*(n,3n)*Lu170*					9.8	0.8	
		&Lu175(n,3n)Lu173(n,3n)*Lu171*(n,2n)*Lu170*					3.3		
		&Lu175(n,2n)*Lu174*(n,3n)*Lu172*(n,3n)*Lu170*					2.9		
		&Lu175(n,3n)Lu173(n,2n)*Lu172*(n,3n)*Lu170*					2.1		
		&Lu176(n,4n)Lu173(n,4n)*Lu170*					0.6	5.7	
		&Lu175(n,2n)*Lu174*(n,5n)*Lu170*						4.4	1.5
		&Lu175(n,6n)*Lu170*							97.0
Tm172	2.650 d	Lu175(n,α)Tm172	100.0	100.0	100.0	94.7	17.0	9.9	37.0
		Lu176(n,2n)Lu175(n,α)Tm172				0.8			
		Lu176(n,nα)Tm172				0.2	3.3	2.8	2.3
		Lu175(n,3n)Lu173(β^+)Yb173(n,d)Tm172					68.4	33.7	20.9
		&Lu175(n,4n)*Lu172*(β^+)Yb172(n,p)Tm172					2.9	24.4	3.0
		Lu175(n,t)Yb173(n,d)Tm172					1.4	8.2	11.2
		&Lu175(n,2n)*Lu174*(β^+)Yb174(n,t)Tm172					1.3	7.1	9.7
		Lu175(n,d)Yb174(n,t)Tm172					0.7	6.5	10.2
		Lu176(n,4n)Lu173(β^+)Yb173(n,d)Tm172					0.5	2.2	
		Lu175(n,nt)Yb172(n,p)Tm172						0.6	1.4
Lu177	6.647 d	Lu175(n,γ)Lu176(n,γ)Lu177	100.0	99.2	69.4	0.8	0.3	0.2	0.2
		&Lu176(n,γ)*Lu177*		0.3	30.6	99.0	99.4	99.6	99.7
Lu172	6.70 d	&Lu175(n,2n)*Lu174*(n,2n)Lu173(n,2n)*Lu172*				90.5			
		&Lu175(n,2n)Lu174m(n,2n)Lu173_ (n,2n)*Lu172*				7.0			
		&Lu175(n,3n)Lu173(n,2n)*Lu172*				0.9	14.1		
		&Lu175(n,4n)*Lu172*					59.8	98.6	94.3
		&Lu175(n,2n)*Lu174*(n,3n)*Lu172*					22.0		
		&Lu176(n,3n)*Lu174*(n,3n)*Lu172*					1.7		
		&Lu175(n,2n)Lu174m(n,3n)*Lu172*					1.3		
		Lu176(n,5n)Lu172							4.0

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Hf181	42.38 d	**&**Lu176(n,γ)Lu177(β^-)Hf177(n,γ)_ Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181	85.6	10.7	57.2	94.0			
		&Lu175(n,γ)Lu176(n,γ)Lu177(β^-)_ Hf177(n,γ)Hf178(n,γ)*Hf179*(n,γ)*Hf180*_ (n,γ)Hf181	9.5	84.5	24.5				
		&Lu176(n,γ)Lu177(n,γ)Lu178(β^-)_ Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181	2.8	0.3	0.7	1.9			
		&Lu175(n,γ)Lu176(n,γ)Lu177(n,γ)_ Lu178(β^-)Hf178(n,γ)*Hf179*(n,γ)*Hf180*_ (n,γ)Hf181	0.5	2.7	0.3				
		&Lu175(n,γ)Lu176m(β^-)Hf176(n,γ)Hf177_ (n,γ)Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181		1.3	16.5				
Tm168	93.10 d	**&**Lu175(n,2n)*Lu174*(n,2n)Lu173(n,nα)_ Tm169(n,2n)Tm168				7.6			
		&Lu175(n,2n)*Lu174*(n,nα)Tm170(β^-)_ Yb170(n,2n)*Yb169*(β^+)Tm169(n,2n)Tm168				7.0			
		&Lu175(n,α)Tm172(β^-)Yb172(n,2n)_ Yb171(n,2n)Yb170(n,2n)*Yb169*(β^+)_ Tm169(n,2n)Tm168				4.7			
		Lu175(n,2n)Lu174(n,2n)Lu173(β^+)_ Yb173(n,α)Er170(n,2n)Er169(β^-)_ Tm169(n,2n)Tm168				4.5			
		&Lu175(n,2n)*Lu174*(n,2n)Lu173(n,2n)_ *Lu172*(β^+)Yb172(n,α)Er169(β^-)Tm169_ (n,2n)Tm168				4.5			
		&Lu175(n,nα)Tm171(n,2n)Tm170(β^-)_ Yb170(n,2n)*Yb169*(β^+)Tm169(n,2n)Tm168				3.5			
		Lu175(n,nα)Tm171(n,4n)Tm168					17.4	8.2	0.4
		Lu175(n,3n)Lu173(n,3n)Lu171(β^+)Yb171_ (n,3n)Yb169(β^+)Tm169(n,2n)Tm168					9.9		
		Lu175(n,3n)Lu173(n,2nα)Tm168					8.0	4.2	0.5
		Lu175(n,3n)Lu173(β^+)Yb173(n,3n)Yb171_ (n,3n)Yb169(β^+)Tm169(n,2n)Tm168					8.0		
		&Lu175(n,4n)*Lu172*(β^+)Yb172(n,4n)_ *Yb169*(β^+)Tm169(n,2n)Tm168					2.9	38.5	0.2
		&Lu175(n,4n)*Lu172*(β^+)Yb172(n,d)_ Tm171(n,4n)Tm168					0.8	6.7	
		&Lu175(n,5n)*Lu171*(β^+)Yb171(n,nt)Tm168						4.8	26.6
		Lu175(n,4n)Lu172(β^+)Yb172(n,2nt)Tm168						1.8	4.5
		Lu175(n,4nα)Tm168							34.1
		&Lu175(n,6n)*Lu170*(β^+)Yb170(n,t)Tm168							14.5
		Plus many other similar long pathways				68.2	53.0	35.8	19.2
Ta182	114.7 d	**&**Lu176(n,γ)Lu177(β^-)Hf177(n,γ)_ Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181_ (β^-)Ta181(n,γ)Ta182	86.1	12.6	62.6				
		&Lu175(n,γ)Lu176(n,γ)Lu177(β^-)_ Hf177(n,γ)Hf178(n,γ)*Hf179*(n,γ)*Hf180*_ (n,γ)Hf181(β^-)Ta181(n,γ)Ta182	7.5	82.0	21.0				
		&Lu176(n,γ)Lu177(n,γ)Lu178(β^-)_ Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181_ (β^-)Ta181(n,γ)Ta182	5.0	0.5	1.1				
		&Lu175(n,γ)Lu176(n,γ)Lu177(n,γ)_ Lu178(β^-)Hf178(n,γ)*Hf179*(n,γ)*Hf180*_ (n,γ)Hf181(β^-)Ta181(n,γ)Ta182	0.5	3.0	0.5				
		&Lu175(n,γ)Lu176m(β^-)Hf176(n,γ)_ Hf177(n,γ)Hf178(n,γ)*Hf179*(n,γ)*Hf180*_ (n,γ)Hf181(β^-)Ta181(n,γ)Ta182		1.1	14.1				
Lu177m	160.3 d	Lu175(n,γ)Lu176(n,γ)Lu177m	98.7	99.2	66.3	0.7	0.3	0.2	0.1
		Lu176(n,γ)Lu177m	1.3	0.8	33.6	99.0	99.4	99.5	99.7
Lu173	1.336 y	**&**Lu175(n,2n)*Lu174*(n,2n)Lu173				91.4			
	►	Lu175(n,2n)Lu174m(n,2n)Lu173				6.9			

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Lu175(n,3n)Lu173				0.9	98.1	92.3	95.7
		Lu176(n,4n)Lu173					0.7	6.0	3.1
Tm171	1.917 y	Lu176(n,γ)Lu177(β^-)Hf177(n,α)Yb174_ (n,α)Er171(β^-)Tm171	47.1						
		Lu176(n,α)Tm173(β^-)Yb173(n,γ)_ Yb174(n,α)Er171(β^-)Tm171	36.2						
		Lu175(n,γ)Lu176(n,γ)Lu177(β^-)Hf177_ (n,α)Yb174(n,α)Er171(β^-)Tm171	8.5						
		Lu175(n,γ)Lu176(n,α)Tm173(β^-)_ Yb173(n,γ)Yb174(n,α)Er171(β^-)Tm171	6.1						
		Lu176(n,α)Tm173(β^-)Yb173(n,α)_ Er170(n,γ)Er171(β^-)Tm171	0.7		23.7				
		Lu175(n,α)Tm172(β^-)Yb172(n,α)_ Er169(β^-)Tm169(n,γ)Tm170(n,γ)Tm171	0.2	99.4	0.7				
		Lu175(n,α)Tm172(β^-)Yb172(n,γ)_ Yb173(n,α)Er170(n,γ)Er171(β^-)Tm171		0.6	2.1				
		Lu175(n,γ)Lu176m(β^-)Hf176(n,α)_ Yb173(n,α)Er170(n,γ)Er171(β^-)Tm171			59.0				
		&Lu175(n,2n)*Lu174*(n,α)Tm171				53.3	0.4		
		Lu175(n,nα)Tm171				23.8	82.5	44.3	52.3
		&Lu175(n,2n)*Lu174*(β^+)Yb174(n,α)_ Er171(β^-)Tm171				17.2	0.2		
		Lu175(n,2n)Lu174m(n,α)Tm171				3.9			
		Lu175(n,3n)Lu173(β^+)Yb173(n,t)Tm171					7.3	7.0	8.2
		&Lu175(n,4n)*Lu172*(β^+)Yb172(n,d)Tm171					4.1	39.8	11.3
		Lu176(n,2nα)Tm171					0.3	1.5	1.8
		Lu175(n,t)Yb173(n,t)Tm171					0.2	2.0	5.2
		Lu175(n,nt)Yb172(n,d)Tm171					0.1	1.0	5.2
		Lu175(n,d)Yb174(n,nt)Tm171						0.6	3.8
		Lu175(n,2n)Lu174(β^+)Yb174(n,nt)Tm171							2.3
		Lu175(n,5n)Lu171(β^+)Yb171(n,p)Tm171							1.4
Lu174	3.559 y	**&**Lu175(n,2n)*Lu174*				99.1	92.1	96.2	96.6
		&Lu176(n,3n)*Lu174*					7.3	3.4	2.2
H3	12.33 y	Lu175(n,X)H3				61.4	82.5	83.3	83.3
		&Lu175(n,2n)*Lu174*(n,X)H3				29.1	2.5	1.2	
		Lu176(n,X)H3				5.8	2.8	2.5	2.4
		Lu175(n,2n)Lu174m(n,X)H3				2.1	0.2		
		Lu175(n,3n)Lu173(n,X)H3					4.9	1.5	
		Lu175(n,3n)Lu173(β^+)Yb173(n,X)H3					3.9	1.3	
		Lu175(n,4n)Lu172(β^+)Yb172(n,X)H3					0.3	4.4	1.1
		Lu175(n,5n)Lu171(β^+)Yb171(n,X)H3						0.5	2.2
		Lu175(n,6n)Lu170(β^+)Yb170(n,X)H3							1.6
Hf178n	31.0 y	Lu176(n,γ)Lu177(β^-)Hf177(n,γ)Hf178n	79.1	6.6	44.2	5.5	5.6	6.8	9.3
		Lu175(n,γ)Lu176(n,γ)Lu177(β^-)Hf177_ (n,γ)Hf178n	20.4	90.6	33.0				
		Lu175(n,γ)Lu176m(β^-)Hf176(n,γ)_ Hf177(n,γ)Hf178n	0.4	2.6	22.7				
		&Lu176(n,γ)Lu177(β^-)Hf177(n,γ)_ *Hf178*(n,n′)Hf178n				90.5	90.7	90.3	87.0
		Lu176(n,γ)Lu177(n,γ)Lu178(β^-)Hf178_ (n,n′)Hf178n				1.3	1.4	1.8	2.6
Ho166m	1200 y	Lu175(n,α)Tm172(β^-)Yb172(n,α)_ Er169(β^-)Tm169(n,α)Ho166m		100.0		1.0			
		&Lu175(n,2n)*Lu174*(n,2n)Lu173(n,nα)_ Tm169(n,α)Ho166m				7.4			
		&Lu175(n,2n)*Lu174*(n,nα)Tm170(β^-)_ Yb170(n,2n)*Yb169*(β^+)Tm169(n,α)_ Ho166m				4.1			
	►	**&**Lu175(n,2n)*Lu174*(n,2n)Lu173(β^+)_ Yb173(n,α)Er170(n,2n)Er169(β^-)_ Tm169(n,α)Ho166m				4.1			

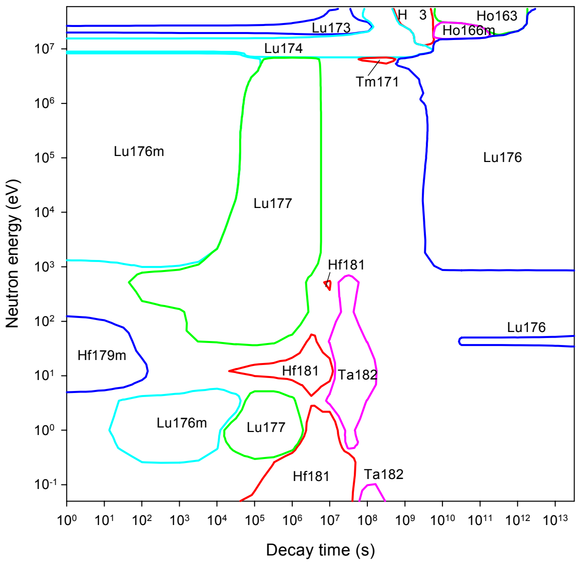
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Lu175(n,α)Tm172(β$^-$)Yb172(n,2n)_ Yb171(n,2n)Yb170(n,2n)*Yb169*(β$^+$)_ Tm169(n,α)Ho166m				3.1			
		&Lu175(n,2n)*Lu174*(n,nα)Tm170_ (n,2n)Tm169(n,α)Ho166m				2.8			
		&Lu175(n,nα)Tm171(n,2n)Tm170(β$^-$) Yb170(n,2n)*Yb169*(β$^+$)Tm169(n,α)_ Ho166m				2.7			
		&Lu175(n,2n)*Lu174*(n,2n)Lu173(n,2n) *Lu172*(β$^+$)Yb172(n,α)Er169(β$^-$)Tm169_ (n,α)Ho166m				2.5			
		Lu175(n,2n)Lu174(β$^+$)Yb174(n,2n)_ Yb173(n,α)Er170(n,2n)Er169(β$^-$)_ Tm169(n,α)Ho166m				2.2			
		Lu175(n,nα)Tm171(n,3n)Tm169(n,α)_ Ho166m				0.7	4.0		
		Lu175(n,3n)Lu173(n,nα)Tm169(n,α)Ho166m				0.2	4.7		
		Lu175(n,nα)Tm171(n,2nα)Ho166m					3.5	4.5	0.8
		Lu175(n,3n)Lu173(β$^+$)Yb173(n,nα)_ Er169(β$^-$)Tm169(n,α)Ho166m					2.4		
		Lu175(n,4n)Lu172(β$^+$)Yb172(n,4n)_ Yb169(β$^+$)Tm169(n,α)Ho166m					2.0	14.2	0.2
		Lu175(n,4n)Lu172(β$^+$)Yb172(n,2nα)_ Er167(n,d)Ho166m					0.1	2.6	0.1
		Lu175(n,5n)Lu171(β$^+$)Yb171(n,nt)_ Tm168(β$^+$)Er168(n,t)Ho166m						0.4	2.3
		Lu175(n,4nα)Tm168(β$^+$)Er168(n,t)Ho166m							16.4
		Other similar long pathways				69.2	83.3	78.3	80.2
Ho163	4570 y	Very long pathways of (n,α), (n,2n), β$^+$				100.0	100.0	100.0	100.0
Gd150	1.8 10^6 y	Very long pathways of (n,α), (n,2n), β$^+$					100.0	100.0	100.0
Dy154	3.0 10^6 y	Very long pathways of (n,α), (n,2n), β$^+$					100.0	100.0	100.0
Hf182	9.0 10^6 y	**&**Lu176(n,γ)Lu177(β$^-$)Hf177(n,γ)_ Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181_ (n,γ)*Hf182*	86.4	12.8	61.5				
		&Lu175(n,γ)Lu176(n,γ)Lu177(β$^-$)_ Hf177(n,γ)Hf178(n,γ)*Hf179*(n,γ)*Hf180*_ (n,γ)Hf181(n,γ)*Hf182*	7.5	82.1	21.9				
		&Lu176(n,γ)Lu177(n,γ)Lu178(β$^-$)_ Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181_ (n,γ)Hf182	5.0	0.5	1.0				
		&Lu175(n,γ)Lu176(n,γ)Lu177(n,γ)_ Lu178(β$^-$)Hf178(n,γ)*Hf179*(n,γ)*Hf180*_ (n,γ)Hf181(n,γ)Hf182	0.5	3.0	0.5				
		&Lu175(n,γ)Lu176m(β$^-$)Hf176(n,γ)_ Hf177(n,γ)Hf178(n,γ)*Hf179*(n,γ)*Hf180*_ (n,γ)Hf181(n,γ)Hf182		1.1	14.6				
Lu176	4.0 10^{10} y	Lu175(n,γ)Lu176	100.0	99.7	69.4	0.8	0.3	0.2	0.2
		Nuclide also present in starting material		0.3	30.6	99.2	99.7	99.8	99.8

Lutetium activation characteristics

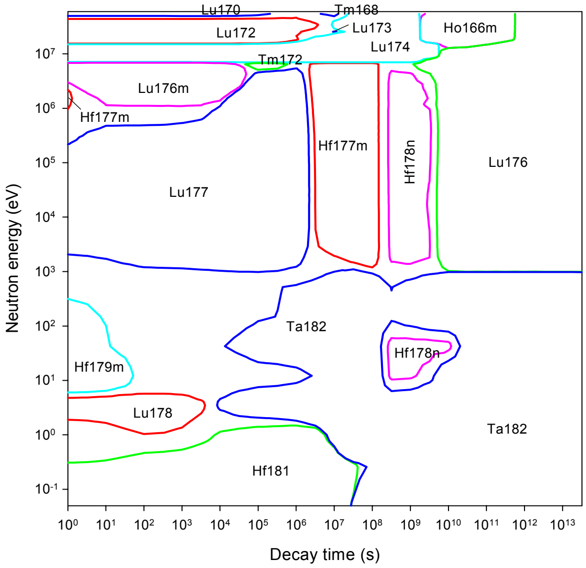


Lutetium importance diagrams & transmutation

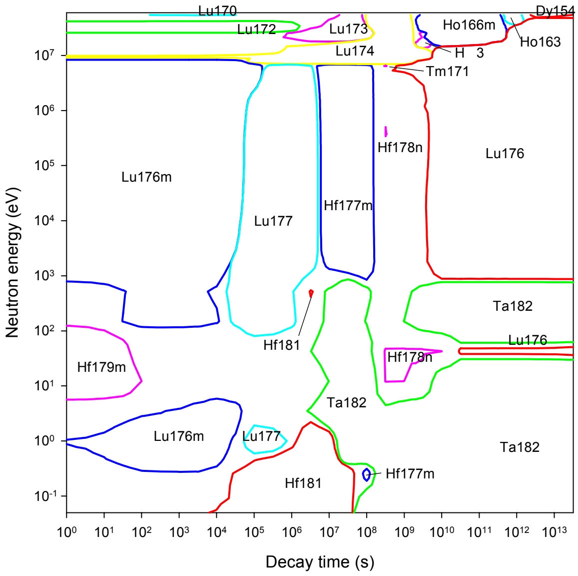
Activity



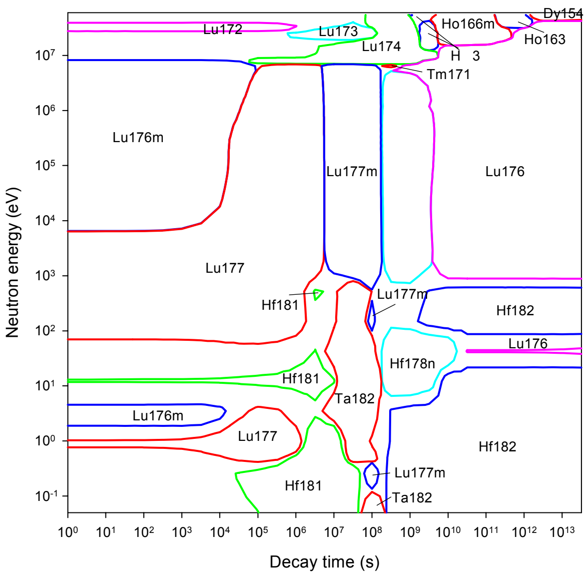
Dose rate



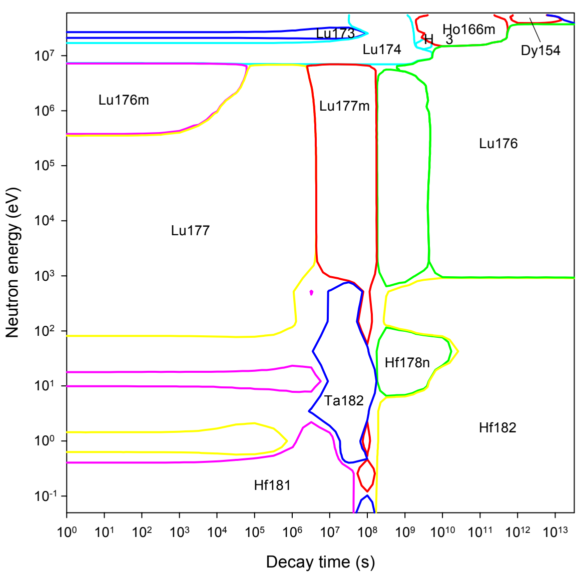
Heat output



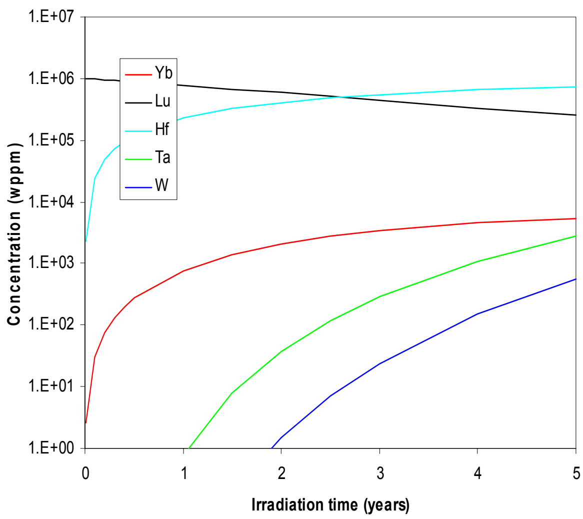
Ingestion dose



Inhalation dose



First wall transmutation



Hafnium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	72		
Crustal abundance / wppm	3.0	Hf174	0.16 ($T_{1/2}$ = 2.00 10^{15} y)
Melting point / K	2506	Hf176	5.26
Boiling point / K	4876	Hf177	18.60
Density / kgm^{-3}	13310	Hf178	27.28
Thermal conductivity / $Wm^{-1}K^{-1}$	23.0	Hf179	13.62
Electrical resistivity /Ωm	3.51 10^{-7}	Hf180	35.08
Coefficient of thermal expansion / K^{-1}	5.9 10^{-6}		
Crystal structure	HCP		
Number of stable isotopes	5 (6)		
Mean atomic weight	178.49		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	6.49E15	4.27E15	3.84E15	1.53E14	1.77E10	9.59E7	kW kg^{-1}	8.03E-1	6.57E-1	6.03E-1	3.50E-2	3.46E-6	1.36E-8
Hf181	37.89	57.60	60.36	4.11			Ta182	38.70	47.28	50.39	97.56	0.34	84.67
Hf179m	31.47						Hf181	36.11	44.11	45.28	2.11		
Ta182	19.91	30.25	32.92	93.25	0.27	49.99	Hf179m	15.29					
Ta183	3.65	5.54	3.75				Ta183	3.01	3.67	2.43			
Hf178m	1.51			0.05	49.69		Hf178m	2.25			0.04	46.76	
Hf180m	1.24	1.86					Hf180m	1.83	2.21				
W 183m	1.12	0.19	0.13				Hf179n	1.24	1.52	1.49			
Hf179n	0.87	1.32	1.32				Lu176m	0.23	0.27				
Hf175	0.38	0.58	0.62	0.44			Hf175	0.20	0.25	0.26	0.13		
W181	0.29	0.43	0.47	1.50			Hf182m	0.07	0.08				
Hf178n				0.05	49.69		Hf178n				0.05	52.85	
Hf182					0.27	49.99	Hf182					0.06	15.33
Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	5.86E5	5.62E5	5.35E5	4.55E4	1.92E0	1.56E-2	Sv kg^{-1}	5.07E6	5.07E6	4.72E6	2.21E5	4.15E1	2.16E-1
Ta182	70.05	73.00	74.95	99.15	0.80	97.58	Hf181	53.41	53.43	54.08	3.11		
Hf181	23.29	24.27	24.00	0.76			Ta182	38.26	38.27	40.22	96.39	0.17	33.33
Hf179m	2.57						Ta183	6.07	6.07	3.97			
Hf178m	1.38			0.02	37.70		Hf179n	1.33	1.33	1.29			
Hf180m	1.18	1.21					Hf180m	0.27	0.27				
Hf179n	0.68	0.71	0.68				Hf175	0.20	0.20	0.21	0.12		
Hf178n				0.02	61.48		Hf178n	0.01	0.01	0.01	0.17	99.48	
Hf182					0.02	2.42	Hf182					0.35	66.66
Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	2.60E7	2.60E7	2.48E7	1.48E6	2.30E3	1.53E1		1.63E13	1.56E13	1.51E13	1.43E12	2.03E7	4.91E5
Ta182	49.66	49.66	50.99	96.27	0.02	3.13	Ta182	79.48	82.74	83.92	99.51	2.38	97.62
Hf181	47.27	47.27	46.75	2.12			Hf181	15.13	15.75	15.39	0.44		
Ta183	1.91	1.91	1.22				Hf179m	3.22					
Hf179n	0.82	0.82	0.78				Hf178m	0.62			0.01	44.15	
Hf175	0.11	0.11	0.12	0.05			Hf180m	0.50	0.51				
Hf178n	0.08	0.08	0.09	1.42	99.33		Ta183	0.47	0.49	0.31			
Lu177	0.04	0.04	0.03				Hf179n	0.31	0.33	0.31			
Hf182					0.65	96.88	Hf178n				0.01	53.42	
							Hf182					0.06	2.38

Hafnium

Pathway analysis

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Hf177m	1.08 s	**&**Hf176(n,γ)*Hf177m*	97.0	75.2	99.2				
		Hf174(n,γ)Hf175(β^+)Lu175(n,γ)_ Lu176m(β^-)Hf176(n,γ)Hf177m	1.7	1.2					
		Hf174(n,γ)Hf175(β^+)Lu175(n,γ)_ Lu176(n,γ)Lu177m(β^-)Hf177m	0.8	23.2					
		&Hf178(n,2n)*Hf177m*				48.6	11.9	8.9	11.0
		&Hf177(n,n′)*Hf177m*				26.1	22.5	22.1	39.8
		&Hf178(n,2n)Hf177(n,n′)*Hf177m*				11.8	1.5	1.0	1.2
		&Hf179(n,2n)*Hf178*(n,2n)*Hf177m*				7.2	0.3		
		&Hf180(n,2n)*Hf179*(n,2n)*Hf178*(n,2n)Hf177m				3.0			
		&Hf180(n,3n)*Hf178*(n,2n)Hf177m				0.8	1.9		
		&Hf179(n,3n)Hf177(n,n′)*Hf177m*				0.2	2.8	0.7	
		Hf180(n,4n)Hf177m					28.4	48.3	22.7
		Hf179(n,3n)Hf177m					20.6	6.3	7.2
		&Hf180(n,4n)Hf177(n,n′)*Hf177m*					3.6	6.2	2.5
		&Hf180(n,2n)*Hf179*(n,3n)Hf177m					2.6		
		Hf178(n,d)Lu177m(β^-)Hf177m					1.1	1.7	3.1
		Hf179(n,t)Lu177m(β^-)Hf177m					0.1	0.8	2.0
		Hf180(n,nt)Lu177m(β^-)Hf177m						0.6	5.2
Hf178m	4.00 s	Hf176(n,γ)Hf177(n,γ)Hf178m	97.1	52.0	2.0				
		Hf177(n,γ)Hf178m		32.2	98.0				
		Hf174(n,γ)Hf175(β^+)Lu175(n,γ)Lu176_ (n,γ)Lu177(β^-)Hf177(n,γ)Hf178m		14.8					
		Hf179(n,2n)Hf178m				51.8	36.0	49.1	49.0
		&Hf180(n,2n)*Hf179*(n,2n)Hf178m				42.3	4.7	4.6	
		&Hf178(n,n′)*Hf178m*				4.2	14.8	21.4	21.4
		Hf180(n,3n)Hf178m					40.6	21.3	21.4
		Hf180(n,3n)Hf178(n,n′)Hf178m					1.9	0.7	
		Hf180(n,d)Lu179(β^-)Hf179(n,2n)Hf178m					0.6	1.2	
Hf179m	18.67 s	Hf176(n,γ)Hf177(n,γ)*Hf178*(n,γ)Hf179m	44.0	0.3	0.1				
		Hf178(n,γ)Hf179m	30.3	56.6	89.2				
		Hf177(n,γ)Hf178(n,γ)Hf179m	24.4	42.9	10.7				
		Hf180(n,2n)Hf179m				93.9	86.7	87.8	89.2
		Hf179(n,n′)Hf179m				3.3	11.4	10.7	9.8
		Hf180(n,2n)Hf179(n,n′)Hf179m				1.9			0.4
Hf171	12.11 h	Hf174(n,2n)Hf173(n,2n)Hf172(n,2n)Hf171				86.3			
		Hf176(n,2n)Hf175(n,2n)Hf174(n,2n)_ Hf173(n,2n)Hf172(n,2n)Hf171				9.3			
		Hf176(n,3n)Hf174(n,3n)Hf172(n,2n)Hf171					34.1		
		Hf177(n,4n)Hf174(n,3n)Hf172(n,2n)Hf171					23.8		
		Hf178(n,3n)Hf176(n,3n)Hf174(n,3n)_ Hf172(n,2n)Hf171					15.3		
		Hf174(n,3n)Hf172(n,2n)Hf171					6.6		
		Hf179(n,4n)Hf176(n,3n)Hf174(n,3n)_ Hf172(n,2n)Hf171					3.0		
		Hf177(n,2n)Hf176(n,3n)Hf174(n,3n)_ Hf172(n,2n)Hf171					2.7		
		Hf176(n,3n)Hf174(n,4n)Hf171					2.5	6.5	1.3
		Hf177(n,4n)Hf174(n,4n)Hf171					1.8	57.2	5.8
		Hf174(n,4n)Hf171					0.3	2.8	1.1
		Hf180(n,4n)Hf177(n,4n)Hf174(n,4n)Hf171					0.1	8.1	
		Hf178(n,5n)Hf174(n,4n)Hf171						14.4	17.1
		Hf176(n,6n)Hf171							27.0
		Hf180(n,5n)Hf176(n,6n)Hf171							13.5
		Hf179(n,6n)Hf174(n,4n)Hf171							8.3
		Hf178(n,3n)Hf176(n,6n)Hf171							4.8
	▶	Hf179(n,4n)Hf176(n,6n)Hf171							2.9

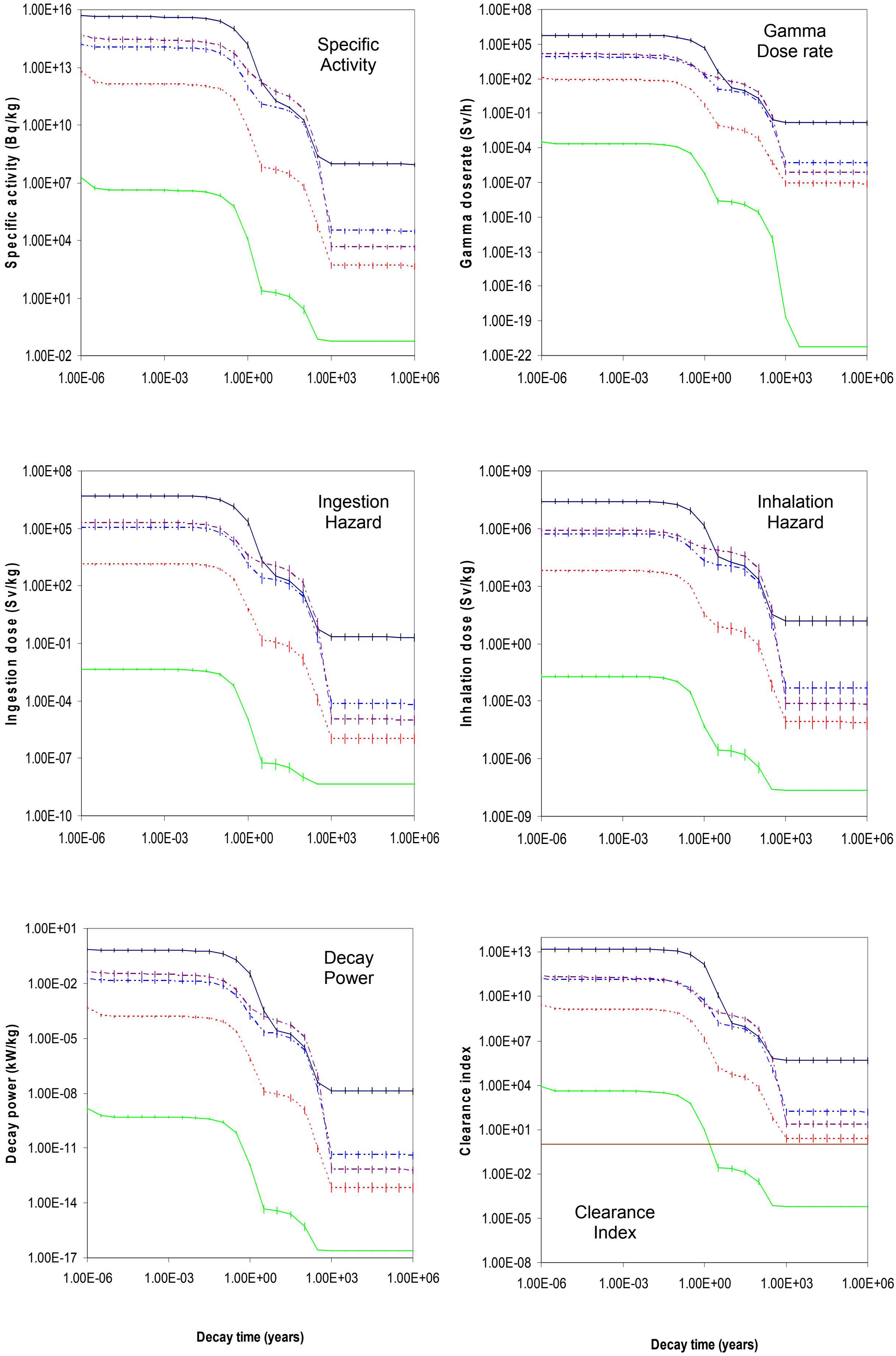
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Hf177(n,2n)Hf176(n,6n)Hf171							2.6
		Hf180(n,6n)Hf175(n,5n)Hf171							2.5
		Hf177(n,6n)Hf172(n,2n)Hf171							2.3
Ta183	5.09 d	&Hf180(n,γ)Hf181(β^{-})Ta181(n,γ)*Ta182*_ (n,γ)Ta183	49.0	55.0	95.3	96.9	96.8	97.0	97.3
		&Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181_ (β^{-})Ta181(n,γ)Ta182(n,γ)Ta183	19.8	13.2					
		&Hf177(n,γ)Hf178(n,γ)*Hf179*(n,γ)*Hf180*_ (n,γ)Hf181(β^{-})Ta181(n,γ)Ta182(n,γ)Ta183	12.7	7.2					
		&Hf179(n,γ)*Hf180*(n,γ)Hf181(β^{-})Ta181_ (n,γ)Ta182(n,γ)Ta183	13.1	20.1	2.2				
		&Hf180(n,γ)Hf181(n,γ)*Hf182*(n,γ)Hf183_ (β^{-})Ta183	2.5	2.5	2.2	2.2	0.9	0.9	0.9
Lu172	6.70 d	&Hf174(n,2n)Hf173(β^{+})Lu173(n,2n)*Lu172*				48.4			
		&Hf176(n,2n)Hf175(β^{+})Lu175(n,2n)_ *Lu174*(n,2n)Lu173(n,2n)*Lu172*				27.3			
		&Hf177(n,2n)Hf176(n,2n)Hf175(β^{+})Lu175_ (n,2n)*Lu174*(n,2n)Lu173(n,2n)*Lu172*				7.8			
		&Hf176(n,3n)Hf174(n,3n)Hf172(β^{+})*Lu172*					25.8	1.0	0.2
		&Hf177(n,4n)Hf174(n,3n)Hf172(β^{+})*Lu172*					18.0	8.6	0.7
		&Hf178(n,3n)Hf176(n,3n)Hf174(n,3n)_ Hf172(β^{+})*Lu172*					11.4	0.1	
		&Hf177(n,3n)Hf175(β^{+})Lu175(n,4n)*Lu172*					10.5	9.6	0.9
		&Hf174(n,3n)Hf172(β^{+})*Lu172*					5.0	0.6	0.2
		&Hf178(n,4n)Hf175(β^{+})Lu175(n,4n)*Lu172*					3.0	41.2	1.5
		&Hf179(n,5n)Hf175(β^{+})Lu175(n,4n)*Lu172*						5.6	1.4
		&Hf176(n,5n)Hf172(β^{+})*Lu172*						2.0	17.9
		&Hf180(n,5n)Hf176(n,5n)Hf172(β^{+})*Lu172*						0.5	5.8
		&Hf177(n,6n)Hf172(β^{+})*Lu172*							37.7
		&Hf180(n,6n)Hf175(β^{+})Lu175(n,4n)*Lu172*							5.0
Hf179n	25.10 d	Hf176(n,γ)Hf177(n,γ)Hf178(n,γ)Hf179n	42.2	0.3					
		Hf178(n,γ)Hf179n	31.3	56.7	89.3				
		Hf177(n,γ)Hf178(n,γ)Hf179n	25.2	43.0	10.7				
		Hf180(n,2n)Hf179n				47.2	26.7	21.8	18.0
		Hf179(n,n′)Hf179n				29.1	63.7	69.7	75.0
		&Hf180(n,2n)*Hf179*(n,n′)Hf179n				23.0	8.0	6.4	
		Hf180(n,d)Lu179(β^{-})Hf179(n,n′)Hf179n					1.0	1.7	
Hf181	42.38 d	Hf180(n,γ)Hf181	35.9	50.3	95.2	99.1	98.8	98.8	99.0
		&Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)Hf181	28.2	18.7	0.1				
		&Hf177(n,γ)Hf178(n,γ)*Hf179*(n,γ)_ *Hf180*(n,γ)Hf181	18.9	11.2					
		&Hf179(n,γ)*Hf180*(n,γ)Hf181	14.9	19.6	4.6				
Hf175	70.0 d	Hf174(n,γ)Hf175	100.0	100.0	100.0				
		Hf177(n,2n)Hf176(n,2n)Hf175				45.7	1.3	0.6	
		Hf176(n,2n)Hf175				42.1	6.2	4.4	3.5
		&Hf178(n,2n)*Hf177*(n,2n)Hf176(n,2n)Hf175				10.3			
		Hf178(n,3n)Hf176(n,2n)Hf175				0.8	7.1	1.3	
		Hf177(n,3n)Hf175					47.9	13.4	9.2
		Hf178(n,4n)Hf175					13.8	57.5	15.9
		&Hf180(n,4n)*Hf177*(n,3n)Hf175					7.8	3.6	
		&Hf179(n,3n)*Hf177*(n,3n)Hf175					5.9		
		&Hf178(n,2n)*Hf177*(n,3n)Hf175					3.4	0.7	
		&Hf180(n,3n)*Hf178*(n,4n)Hf175					2.0	2.0	
		Hf179(n,4n)Hf176(n,2n)Hf175					1.4	1.8	
		Hf179(n,5n)Hf175						7.8	14.3
		Hf180(n,5n)Hf176(n,2n)Hf175						1.8	
		Hf180(n,6n)Hf175							50.3
W185	75.1 d ►	&Hf180(n,γ)Hf181(β^{-})Ta181(n,γ)*Ta182*_ (n,γ)Ta183(β^{-})*W183*(n,γ)W184(n,γ)*W185*	66.7	59.3	56.2	32.0	30.5	31.1	

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)_ Hf181(β^-)Ta181(n,γ)Ta182(n,γ)Ta183_ (β^-)*W183*(n,γ)W184(n,γ)*W185*	9.3	5.8					
		&Hf179(n,γ)*Hf180*(n,γ)Hf181(β^-)Ta181_ (n,γ)Ta182(n,γ)Ta183(β^-)*W183*(n,γ)_ W184(n,γ)*W185*	9.1	16.8	0.6				
		&Hf177(n,γ)Hf178(n,γ)*Hf179*(n,γ)*Hf180*_ (n,γ)Hf181(β^-)Ta181(n,γ)Ta182(n,γ)_ Ta183(β^-)*W183*(n,γ)W184(n,γ)*W185*	5.4	2.5					
		&Hf180(n,γ)Hf181(n,γ)Hf182(n,γ)Hf183_ (β^-)Ta183(β^-)*W183*(n,γ)W184(n,γ)*W185*	2.6	2.0	1.5	0.8	0.4	0.4	
		Hf180(n,γ)Hf181(β^-)Ta181(n,γ)Ta182_ (n,γ)Ta183(n,γ)Ta184(β^-)W184(n,γ)W185	2.3	1.4	1.0				
		&Hf180(n,γ)Hf181(β^-)Ta181(n,γ)*Ta182*_ (β^-)W182(n,γ)*W183*(n,γ)W184(n,γ)*W185*		0.7	39.8	63.0	64.8	64.7	
Ta182	114.7 d	&Hf180(n,γ)Hf181(β^-)Ta181(n,γ)*Ta182*	51.2	57.4	97.5	99.8	99.5	99.6	99.8
		&Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)_ Hf181(β^-)Ta181(n,γ)Ta182	20.6	13.8					
		&Hf179(n,γ)*Hf180*(n,γ)Hf181(β^-)_ Ta181(n,γ)Ta182	13.7	21.0	2.2				
		&Hf177(n,γ)Hf178(n,γ)*Hf179*(n,γ)_ *Hf180*(n,γ)Hf181(β^-)Ta181(n,γ)Ta182	13.3	7.4					
		&Hf176(n,γ)Hf177(n,γ)Hf178(n,γ)*Hf179*_ (n,γ)*Hf180*(n,γ)Hf181(β^-)Ta181(n,γ)Ta182	0.8						
Lu173	1.336 y	Hf174(n,2n)Hf173(β^+)Lu173				48.5	0.7		
		&Hf176(n,2n)Hf175(β^+)Lu175(n,2n)_ *Lu174*(n,2n)Lu173				27.5			
		Hf177(n,2n)Hf176(n,2n)Hf175(β^+)_ Lu175(n,2n)Lu174(n,2n)Lu173				6.6			
		Hf176(n,2n)Hf175(n,2n)Hf174(n,2n)_ Hf173(β^+)Lu173				5.7			
		Hf176(n,2n)Hf175(β^+)Lu175(n,2n)_ Lu174m(n,2n)Lu173				3.1			
		Hf177(n,2n)Hf176(n,2n)Hf175(n,2n)_ Hf174(n,2n)Hf173(β^+)Lu173				2.4			
		Hf176(n,2n)Hf175(β^+)Lu175(n,3n)Lu173				0.5	5.6	0.6	0.1
		Hf177(n,3n)Hf175(β^+)Lu175(n,3n)Lu173					42.2	1.7	0.3
		Hf178(n,4n)Hf175(β^+)Lu175(n,3n)Lu173					12.2	7.3	0.5
		Hf176(n,3n)Hf174(n,2n)Hf173(β^+)Lu173					4.1		
		Hf177(n,3n)Hf175(n,3n)Hf173(β^+)Lu173					3.5		
		Hf177(n,4n)Hf174(n,2n)Hf173(β^+)Lu173					2.9	3.2	0.3
		Hf178(n,3n)Hf176(n,2n)Hf175(β^+)_ Lu175(n,3n)Lu173					2.5		
		Hf180(n,4n)Hf177(n,3n)Hf175(β^+)_ Lu175(n,3n)Lu173					2.5		
		Hf176(n,4n)Hf173(β^+)Lu173					2.4	31.5	4.5
		Hf178(n,3n)Hf176(n,4n)Hf173(β^+)Lu173					2.0	6.7	0.6
		Hf179(n,4n)Hf176(n,4n)Hf173(β^+)Lu173					0.4	9.2	0.3
		Hf177(n,2n)Hf176(n,4n)Hf173(β^+)Lu173					0.4	3.3	0.3
		Hf177(n,5n)Hf173(β^+)Lu173						10.4	32.4
		Hf180(n,5n)Hf176(n,4n)Hf173(β^+)Lu173						9.2	1.6
		Hf178(n,6n)Hf173(β^+)Lu173							38.2
		Hf177(n,2nt)Lu173							3.5
Hf172	1.870 y	Hf174(n,2n)Hf173(n,2n)Hf172				86.3			
		Hf176(n,2n)Hf175(n,2n)Hf174(n,2n)_ Hf173(n,2n)Hf172				9.3			
		Hf177(n,2n)Hf176(n,2n)Hf175(n,2n)_ Hf174(n,2n)Hf173(n,2n)Hf172				3.8			
		Hf176(n,3n)Hf174(n,3n)Hf172					36.9	4.6	
		Hf177(n,4n)Hf174(n,3n)Hf172					25.7	40.0	
	►	Hf178(n,3n)Hf176(n,3n)Hf174(n,3n)Hf172					16.5	0.5	

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Hf174(n,3n)Hf172					7.1	3.0	
		Hf179(n,4n)Hf176(n,3n)Hf174(n,3n)Hf172					3.3	0.7	
		Hf177(n,2n)Hf176(n,3n)Hf174(n,3n)Hf172					3.0		
		Hf180(n,4n)Hf177(n,4n)Hf174(n,3n)Hf172					1.6	4.3	
		Hf177(n,3n)Hf175(n,4n)Hf172					0.8	2.2	
		Hf178(n,4n)Hf175(n,4n)Hf172					0.2	9.4	
		Hf178(n,5n)Hf174(n,3n)Hf172						10.1	2.7
		Hf176(n,5n)Hf172						9.2	23.3
		Hf180(n,5n)Hf176(n,5n)Hf172						2.5	7.5
		Hf179(n,4n)Hf176(n,5n)Hf172						2.5	1.6
		Hf178(n,3n)Hf176(n,5n)Hf172						1.8	2.6
		Hf177(n,6n)Hf172							49.2
		Hf180(n,4n)Hf177(n,6n)Hf172							2.2
Lu174	3.559 y	**&**Hf176(n,2n)Hf175(β^+)Lu175(n,2n)*Lu174*				68.8	6.1	2.1	0.3
		&Hf177(n,2n)Hf176(n,2n)Hf175(β^+)_ Lu175(n,2n)*Lu174*				26.2	0.3		
		Hf178(n,2n)Hf177(n,2n)Hf176(n,2n)_ Hf175(β^+)Lu175(n,2n)Lu174				2.2			
		&Hf178(n,3n)Hf176(n,2n)Hf175(β^+)_ Lu175(n,2n)*Lu174*				0.4	2.4	0.8	
		&Hf177(n,3n)Hf175(β^+)Lu175(n,2n)*Lu174*					45.8	6.4	1.1
		&Hf178(n,4n)Hf175(β^+)Lu175(n,2n)*Lu174*					13.2	27.2	1.9
		&Hf177(n,d)Lu176(n,3n)*Lu174*					4.2	1.2	0.2
		&Hf176(n,t)*Lu174*					3.6	13.9	9.1
		&Hf177(n,nt)*Lu174*					2.5	16.8	33.3
		&Hf180(n,4n)Hf177(n,3n)Hf175(β^+)_ Lu175(n,2n)*Lu174*					2.5	0.6	
		&Hf178(n,3n)Hf176(n,t)*Lu174*					2.4	2.3	0.9
		&Hf179(n,3n)Hf177(n,3n)Hf175(β^+)_ Lu175(n,2n)*Lu174*					1.9		
		&Hf178(n,t)Lu176(n,3n)*Lu174*					1.2	1.5	0.5
		&Hf177(n,t)Lu175(n,2n)*Lu174*					0.7	1.3	0.5
		&Hf179(n,4n)Hf176(n,t)*Lu174*					0.5	3.2	0.5
		&Hf180(n,4n)Hf177(n,nt)*Lu174*					0.2	2.6	1.4
		&Hf179(n,5n)Hf175(β^+)Lu175(n,2n)*Lu174*						3.7	1.8
		&Hf180(n,5n)Hf176(n,t)*Lu174*						3.2	2.5
		&Hf178(n,2nt)*Lu174*						1.9	27.8
		&Hf180(n,6n)Hf175(β^+)Lu175(n,2n)*Lu174*							6.3
		&Hf179(n,3nt)*Lu174*							3.2
H3	12.33 y	Hf174(n,γ)Hf175(n,X)H1(n,γ)H2(n,γ)H3	100.0						
		Hf177(n,X)H3				41.8	21.1	18.8	17.9
		Hf179(n,X)H3				18.1	13.2	12.2	11.9
		Hf178(n,2n)Hf177(n,X)H3				9.4	0.8		0.3
		Hf178(n,X)H3				7.8	20.8	21.9	22.5
		&Hf180(n,2n)*Hf179*(n,X)H3				7.3	0.8		0.4
		Hf180(n,X)H3				3.9	23.3	25.1	26.5
		Hf176(n,2n)Hf175(β^+)Lu175(n,X)H3				2.1	0.3		0.1
		Hf176(n,X)H3				1.6	4.2	4.5	4.6
		Hf178(n,n′)Hf178n(n,X)H3				1.6	0.2		
		Hf179(n,3n)Hf177(n,X)H3				0.2	1.3		0.2
		Hf178(n,3n)Hf176(n,X)H3					2.5	0.7	0.4
		Hf177(n,3n)Hf175(β^+)Lu175(n,X)H3					2.0	0.5	0.3
		Hf180(n,4n)Hf177(n,X)H3					1.7	2.7	0.6
		&Hf180(n,3n)*Hf178*(n,X)H3					1.6		0.2
		Hf178(n,4n)Hf175(β^+)Lu175(n,X)H3					0.6	2.1	0.5
		Hf177(n,4n)Hf174(n,X)H3					0.4	1.5	0.4
		Hf180(n,5n)Hf176(n,X)H3						0.9	1.1
		Hf180(n,6n)Hf175(β^+)Lu175(n,X)H3							1.5
		Hf178(n,5n)Hf174(n,X)H3							1.2
Hf178n	31.0 y	Hf176(n,γ)Hf177(n,γ)Hf178n	65.1	0.7	1.0				
		Hf177(n,γ)Hf178n	33.2	99.0	99.0				
		Hf178(n,n′)Hf178n				80.7	83.6	89.9	91.6
	►	Hf179(n,2n)Hf178n				7.5	5.5	5.3	4.8

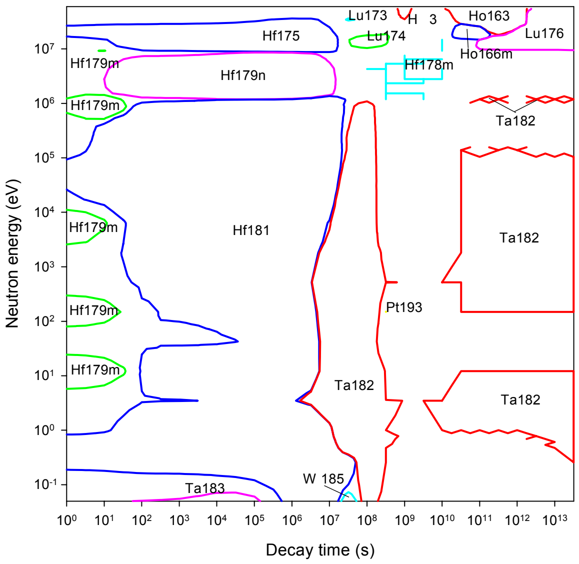
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Hf179(n,2n)*Hf178*(n,n′)Hf178n				6.1	0.5		
		&Hf180(n,2n)*Hf179*(n,2n)Hf178n				3.2	0.3		
		&Hf180(n,2n)*Hf179*(n,2n)*Hf178*(n,n′)Hf178n				1.7			
		Hf180(n,3n)Hf178(n,n′)Hf178n				0.7	6.0	1.7	
		Hf180(n,3n)Hf178n					2.3	0.8	
Pt193	50.0 y	Very long pathways of (n,γ), β^-	100.0	100.0					
Ho166m	1200 y	&Hf174(n,α)Yb171(n,α)Er168(n,α)_ *Dy165*(β^-)Ho165(n,γ)Ho166m	59.4						
		Hf174(n,α)Yb171(n,γ)Yb172(n,α)_ Er169(β^-)Tm169(n,α)Ho166m	28.2						
		Hf174(n,γ)Hf175(n,α)Yb172(n,α)_ Er169(β^-)Tm169(n,α)Ho166m	5.2						
		Hf174(n,γ)Hf175(β^+)Lu175(n,α)Tm172_ (β^-)Yb172(n,α)Er169(β^-)Tm169(n,α)_ Ho166m	4.0						
		Hf174(n,α)Yb171(n,α)Er168(n,γ)_ Er169(β^-)Tm169(n,α)Ho166m	2.3						
		&Hf174(n,nα)Yb170(n,2n)*Yb169*(β^+)_ Tm169(n,α)Ho166m				22.1			
		Hf174(n,2n)Hf173(β^+)Lu173(n,nα)_ Tm169(n,α)Ho166m				7.4			
		&Hf174(n,α)Yb171(n,2n)Yb170(n,2n)_ *Yb169*(β^+)Tm169(n,α)Ho166m				6.4			
		Hf174(n,2n)Hf173(β^+)Lu173(n,α)_ Tm170(n,2n)Tm169(n,α)Ho166m				1.4			
		&Hf176(n,3n)Hf174(n,2nα)*Yb169*(β^+)_ Tm169(n,α)Ho166m					2.0		
		Hf177(n,nα)Yb173(n,3n)Yb171(n,3n)_ Yb169(β^+)Tm169(n,α)Ho166m					1.6		
		Hf177(n,3n)Hf175(β^+)Lu175(n,nα)_ Tm171(n,2nα)Ho166m					1.5		
		&Hf176(n,2nα)Yb171(n,3n)*Yb169*(β^+)_ Tm169(n,α)Ho166m					1.3		
		Hf177(n,3n)Hf175(β^+)Lu175(n,nα)_ Tm171(n,3n)Tm169(n,α)Ho166m					1.2		
		Hf178(n,4n)Hf175(β^+)Lu175(n,nα)_ Tm171(n,2nα)Ho166m					0.4	1.0	
		Other similar long pathways	0.9			62.7	99.6	99.0	100.0
Ho163	4570 y	Very long pathways of (n,α), (n,2n), β^-				100.0	100.0	100.0	100.0
Gd150	1.8 10^{6} y	Very long pathways of (n,α), (n,2n), β^+					100.0	100.0	100.0
Dy154	3.0 10^{6} y	Very long pathways of (n,α), (n,2n), β^+					100.0	100.0	100.0
Hf182	9.0 10^{6} y	&Hf180(n,γ)Hf181(n,γ)*Hf182*	53.1	61.5	97.5	99.8	99.1	99.3	99.6
		&Hf178(n,γ)*Hf179*(n,γ)*Hf180*(n,γ)_ Hf181(n,γ)*Hf182*	19.6	11.5					
		&Hf179(n,γ)*Hf180*(n,γ)Hf181(n,γ)*Hf182*	13.3	20.6	2.4				
		Hf177(n,γ)Hf178(n,γ)Hf179(n,γ)Hf180_ (n,γ)Hf181(n,γ)Hf182	4.7	2.3					
Lu176	4.0 10^{10} y	Hf174(n,γ)Hf175(β^+)Lu175(n,γ)Lu176	100.0	100.0	100.0				
		Hf176(n,p)Lu176				42.5	6.8	2.5	
		Hf177(n,2n)Hf176(n,p)Lu176				24.6	0.7		
		Hf177(n,d)Lu176				19.2	56.0	34.7	19.7
		&Hf178(n,2n)*Hf177*(n,d)Lu176				4.6	2.1	0.9	
		&Hf178(n,2n)*Hf177*(n,2n)Hf176(n,p)Lu176				3.9			
		Hf176(n,2n)Hf175(β^+)Lu175(n,γ)Lu176				2.0			
		Hf178(n,t)Lu176				0.5	16.0	43.1	35.5
		Hf178(n,3n)Hf176(n,p)Lu176				0.4	4.0		
		&Hf180(n,4n)*Hf177*(n,d)Lu176					4.8	4.9	
		&Hf179(n,3n)*Hf177*(n,d)Lu176					3.7	0.7	
		Hf179(n,nt)Lu176					1.7	6.6	14.8
		&Hf180(n,3n)*Hf178*(n,t)Lu176					1.2	0.8	
		Hf180(n,2nt)Lu176						1.7	25.2

Hafnium activation characteristics

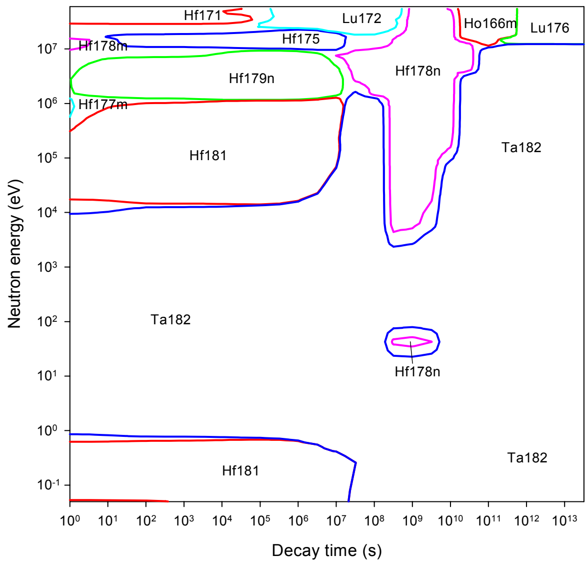


Hafnium importance diagrams & transmutation

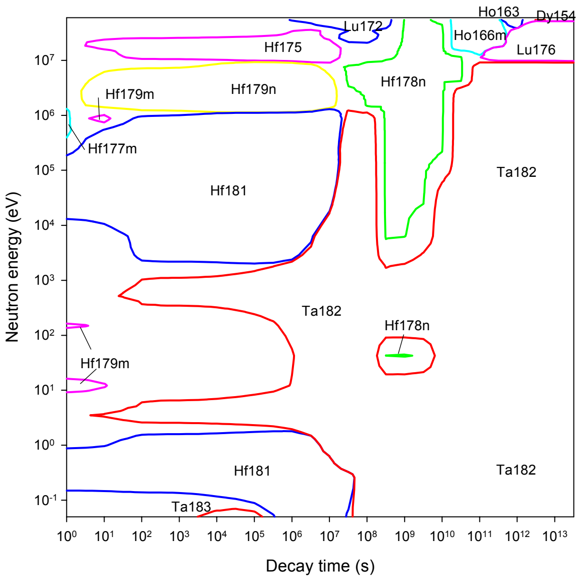
Activity



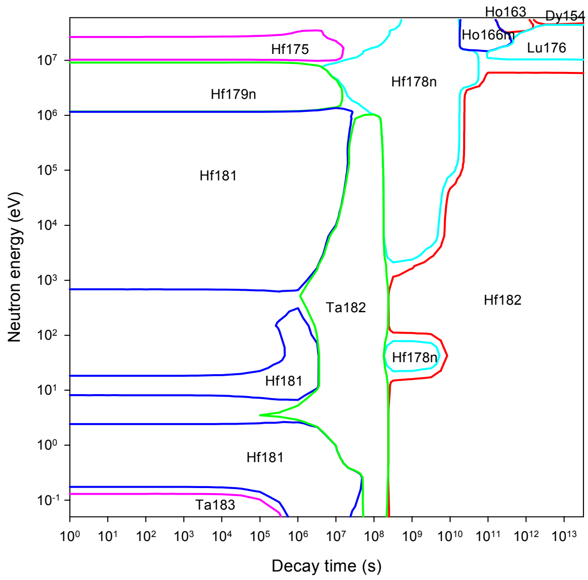
Dose rate



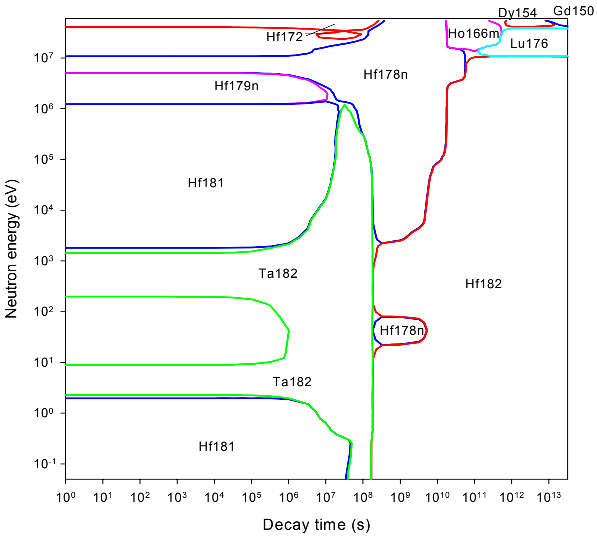
Heat output



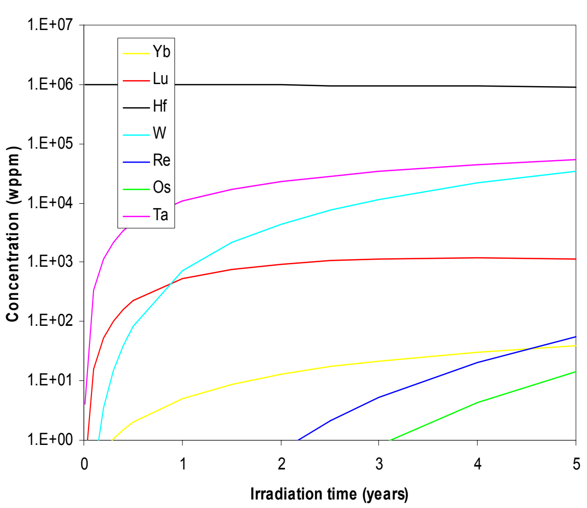
Ingestion dose



Inhalation dose



First wall transmutation



Tantalum

General properties

		Isotopes	Isotopic abundances / %
Atomic number	73		
Crustal abundance / wppm	2	Ta180m	0.012 ($T_{1/2}$ = 1.80 10^{15} y)
Melting point / K	3290	Ta181	99.988
Boiling point / K	5731		
Density / kgm^{-3}	16654		
Thermal conductivity / $Wm^{-1}K^{-1}$	57.5		
Electrical resistivity /Ωm	1.245 10^{-7}		
Coefficient of thermal expansion / K^{-1}	6.3 10^{-6}		
Crystal structure	BCC		
Number of stable isotopes	1 (2)		
Mean atomic weight	180.9479		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.00E16	8.83E15	7.94E15	7.79E14	4.24E7	2.54E6
Ta182	65.10	73.98	80.48	92.34	1.67	27.67
W183m	11.97	0.45	0.30			
W181	3.67	4.17	4.55	5.84		
W185	3.47	3.95	4.24	1.54		
Re186	1.47	1.67	0.95		1.89	22.33
Ta180	1.25	1.41				
H3					56.70	
Hf178m					18.02	
Hf178n					18.02	
Re186m					1.89	22.33
Hf182					1.67	27.67

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	1.78E0	1.72E0	1.63E0	1.73E-1	3.28E-9	2.44E-10
Ta182	88.18	91.18	94.31	99.61	5.19	69.33
Ta183	6.67	6.89	4.43			
W183m	3.35	0.11	0.07			
Re186	0.47	0.49	0.27		1.40	13.34
W185	0.40	0.41	0.42	0.14		
Hf181	0.27	0.28	0.28	0.01		
W181	0.18	0.19	0.19	0.23		
Hf178n					48.43	
Hf178m					42.85	
Hf182					0.94	12.55
H3					0.67	
Re186m					0.50	4.78

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	2.07E6	2.07E6	2.02E6	2.26E5	1.85E-3	2.27E-4
Ta182	99.19	99.23	99.54	99.98	12.09	97.49
Ta183	0.53	0.53	0.33			
Hf181	0.11	0.11	0.10			
Hf178n					54.34	
Hf178m					33.25	
Hf182					0.29	2.36
Re186m					0.02	0.09
Re186					0.01*	0.06*

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.18E7	1.18E7	1.08E7	1.09E6	4.31E-2	5.26E-3
Ta182	83.17	83.18	88.42	99.15	2.47	20.04
Ta183	12.85	12.84	8.49			
Re186	1.88	1.88	1.04		2.79	16.17
W185	1.30	1.30	1.37	0.48		
Hf178n					83.37	
Hf182					4.93	40.07
Re186m					4.10	23.72
H3					2.35	

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	6.82E7	6.82E7	6.57E7	7.19E6	2.23E0	2.32E-1
Ta182	95.78	95.78	97.23	99.93	0.32	3.03
Ta183	3.59	3.58	2.26			
Hf181	0.30	0.30	0.29	0.01		
Re186	0.24	0.24	0.13		0.04	0.27
Hf178n					89.09	
Hf182					9.84	93.77
Re186m					0.43	2.93

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	6.60E13	6.58E13	6.42E13	7.19E12	2.48E4	7.24E3
Ta182	99.01	99.26	99.52	99.93	28.57	97.10
Ta183	0.57	0.57	0.36			
W183m	0.26	0.01	0.01			
Hf178n					38.07	
Hf178m					31.47	
Hf182					0.70	2.37
Re186m					0.22	0.52

Tantalum

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ta178m	2.361 h	Ta181(n,2n)Ta180m(n,2n)Ta179(n,2n)Ta178m				76.8			
		Ta181(n,2n)Ta180(β^-)W180(n,2n)_ W179(β^+)Ta179(n,2n)Ta178m				8.8			
		Ta181(n,2n)Ta180m(n,3n)Ta178m				8.6	39.2	3.5	
		Ta181(n,3n)Ta179(n,2n)Ta178m				2.5	26.2	2.4	
		Ta181(n,4n)Ta178m					34.1	93.9	91.0
Ta180	8.08 h	Ta180m(n,n′)Ta180			100.0				
		Ta181(n,2n)Ta180				98.9	99.1	99.5	99.7
		Ta181(n,2n)Ta180m(n,n′)Ta180				1.0			
Ta176	8.09 h	Ta181(n,2n)Ta180m(n,2n)Ta179(n,3n)_ Ta177(n,2n)Ta176				84.1			
		&Ta181(n,2n)Ta180(β^-)W180(n,2n)_ *W179*(β^+)Ta179(n,3n)Ta177(n,2n)Ta176				13.1			
		Ta181(n,3n)Ta179(n,3n)Ta177(n,2n)Ta176				2.7	0.4		
		Ta181(n,3n)Ta179(n,4n)Ta176					98.0	91.9	
		Ta181(n,2n)Ta180m(n,5n)Ta176						6.5	
		Ta181(n,6n)Ta176							96.9
Hf171	12.11 h	Ta181(n,nα)Lu177(β^-)Hf177(n,2n)_ Hf176(n,2n)Hf175(n,2n)Hf174(n,2n)_ Hf173(n,2n)Hf172(n,2n)Hf171				4.2			
		Ta181(n,2n)Ta180m(n,nα)Lu176m(β^-)_ Hf176(n,2n)Hf175(n,2n)Hf174(n,2n)_ Hf173(n,2n)Hf172(n,2n)Hf171				2.4			
		Ta181(n,2n)Ta180(β^-)W180(n,nα)_ Hf176(n,2n)Hf175(n,2n)Hf174(n,2n)_ Hf173(n,2n)Hf172(n,2n)Hf171				2.2			
		Ta181(n,3n)Ta179(n,3n)Ta177(β^+)Hf177_ (n,4n)Hf174(n,3n)Hf172(n,2n)Hf171					21.1		
		Ta181(n,3n)Ta179(β^+)Hf179(n,4n)Hf176_ (n,3n)Hf174(n,3n)Hf172(n,2n)Hf171					18.7		
		Ta181(n,4n)Ta178(β^+)Hf178(n,3n)Hf176_ (n,3n)Hf174(n,3n)Hf172(n,2n)Hf171					16.5		
		Ta181(n,3n)Ta179(β^+)Hf179(n,3n)Hf177_ (n,4n)Hf174(n,3n)Hf172(n,2n)Hf171					6.9		
		Ta181(n,3n)Ta179(n,4n)Ta176(β^+)Hf176_ (n,3n)Hf174(n,3n)Hf172(n,2n)Hf171					3.1		
		Ta181(n,nα)Lu177(β^-)Hf177(n,4n)_ Hf174(n,3n)Hf172(n,2n)Hf171					3.1		
		Ta181(n,3n)Ta179(β^+)Hf179(n,4n)_ Hf176(n,3n)Hf174(n,4n)Hf171					2.5	0.8	
		Ta181(n,3n)Ta179(n,3n)Ta177(β^+)_ Hf177(n,4n)Hf174(n,4n)Hf171					2.4	1.4	
		Ta181(n,2n)Ta180m(n,4n)Ta177(β^+)_ Hf177(n,4n)Hf174(n,4n)Hf171					0.1	2.3	
		Ta181(n,5n)Ta177(β^+)Hf177(n,4n)_ Hf174(n,4n)Hf171						46.7	2.7
		Ta181(n,4n)Ta178(β^+)Hf178(n,5n)_ Hf174(n,4n)Hf171						27.0	1.5
		Ta181(n,4n)Ta178m(β^+)Hf178(n,5n)_ Hf174(n,4n)Hf171						4.1	0.2
		Ta181(n,6n)Ta176(β^+)Hf176(n,6n)Hf171							76.2
		Other similar long pathways				91.2	25.6	17.7	19.4
Ir194	19.30 h	Very long pathways of (n,γ), β^-	100.0	100.0					
Re186	3.775 d	**&**Ta181(n,γ)*Ta182*(n,γ)Ta183(β^-)*W183*_ (n,γ)W184(n,γ)*W185*(β^-)Re185(n,γ)Re186	95.0	91.6	56.9	37.4	30.7	31.2	
	►	**&**Ta181(n,γ)*Ta182*(n,γ)Ta183(n,γ)Ta184_ (β^-)W184(n,γ)W185(β^-)Re185(n,γ)Re186	2.4	1.2	0.9	0.1			

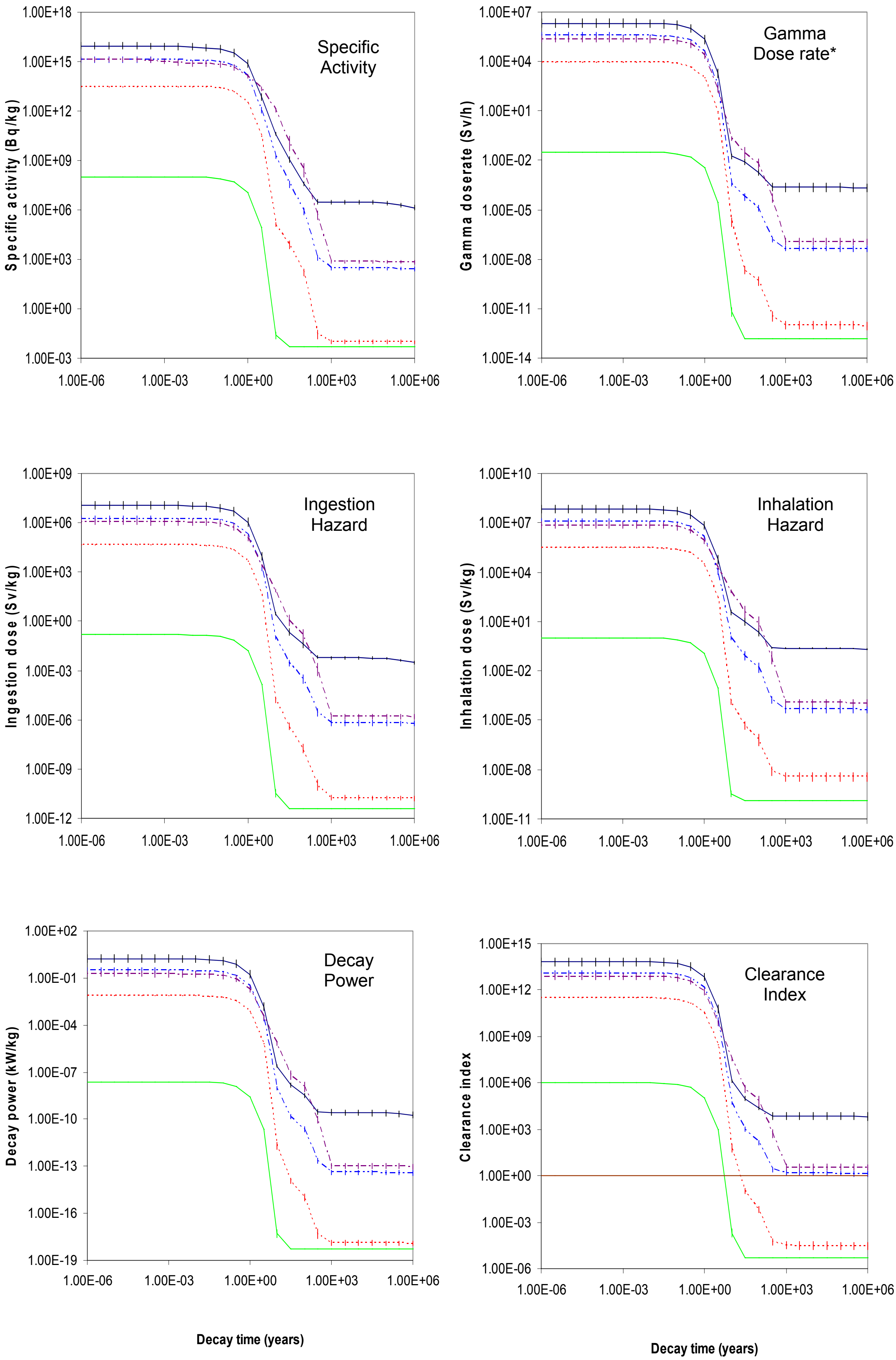
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Ta181(n,γ)*Ta182*(β^-)W182(n,γ)*W183*_ (n,γ)W184(n,γ)*W185*(β^-)Re185(n,γ)Re186	0.1	1.4	42.0	62.5	69.3	68.8	
Ta183	5.09 d	**&**Ta181(n,γ)*Ta182*(n,γ)Ta183	99.9	99.9	99.9	99.2	98.3	98.7	99.3
Lu172	6.70 d	Ta181(n,3n)Ta179(n,3n)Ta177(β^+)Hf177_ (n,3n)Hf175(β^+)Lu175(n,4n)Lu172					7.1	0.1	
		&Ta181(n,4n)Ta178(β^+)Hf178(n,4n)_ Hf175(β^+)Lu175(n,4n)*Lu172*					4.6	49.9	0.1
		Ta181(n,4n)Ta178(β^+)Hf178(n,4n)Hf175_ (n,4n)Hf172(β^+)Lu172m(IT)Lu172					0.3	3.1	
		&Ta181(n,5n)Ta177(β^+)Hf177(n,3n)_ Hf175(β^+)Lu175(n,4n)*Lu172*						5.1	0.4
		&Ta181(n,3n)Ta179(β^+)Hf179(n,5n)_ Hf175(β^+)Lu175(n,4n)*Lu172*						3.7	0.2
		Ta181(n,5n)Ta177(β^+)Hf177(n,4n)Hf174_ (n,3n)Hf172(β^+)Lu172m(IT)Lu172						3.6	
		Ta181(n,6n)Ta176(β^+)Hf176(n,5n)_ Hf172(β^+)Lu172m(IT)Lu172							43.2
		Ta181(n,5n)Ta177(β^+)Hf177(n,6n)_ Hf172(β^+)Lu172m(IT)Lu172							30.3
		&Ta181(n,6n)Ta176(β^+)Hf176(n,2nt)*Lu172*							5.9
		Other similar long pathways				100.0	88.0	34.5	19.9
Hf175	70.0 d	**&**Ta181(n,2n)Ta180(β^+)Hf180(n,2n)_ *Hf179*(n,2n)*Hf178*(n,2n)*Hf177*(n,2n)_ Hf176(n,2n)Hf175				13.1			
		&Ta181(n,2n)Ta180(β^+)Hf180(n,3n)Hf178_ (n,2n)*Hf177*(n,2n)Hf176(n,2n)Hf175				12.0			
		Ta181(n,2n)Ta180m(n,2n)Ta179(n,2n)_ Ta178(β^+)Hf178(n,2n)Hf177(n,2n)_ Hf176(n,2n)Hf175				10.1			
		&Ta181(n,2n)Ta180(β^+)Hf180(n,2n)*Hf179*_ (n,3n)Hf177(n,2n)Hf176(n,2n)Hf175				9.6			
		Ta181(n,2n)Ta180m(n,2n)Ta179(n,2n)_ Ta178m(β^+)Hf178(n,2n)Hf177(n,2n)_ Hf176(n,2n)Hf175				6.5			
		&Ta181(n,2n)Ta180m(n,2n)Ta179(β^+)_ Hf179(n,2n)*Hf178*(n,2n)*Hf177*(n,2n)_ Hf176(n,2n)Hf175				5.4			
		Ta181(n,2n)Ta180m(n,2n)Ta179(β^+)Hf179_ (n,3n)Hf177(n,2n)Hf176(n,2n)Hf175				3.9			
		Ta181(n,2n)Ta180m(n,α)Lu177(β^-)_ Hf177(n,2n)Hf176(n,2n)Hf175				3.4			
		Ta181(n,3n)Ta179(n,3n)Ta177(β^+)_ Hf177(n,3n)Hf175					36.2		
		&Ta181(n,3n)Ta179(β^+)Hf179(n,3n)_ *Hf177*(n,3n)Hf175					19.9		
		Ta181(n,4n)Ta178(β^+)Hf178(n,4n)Hf175					12.1	65.4	5.8
		Ta181(n,3n)Ta179(β^+)Hf179(n,4n)_ Hf176(n,2n)Hf175					4.8	0.5	
		Ta181(n,nα)Lu177(β^-)Hf177(n,3n)Hf175					3.7		
		Ta181(n,4n)Ta178m(β^+)Hf178(n,4n)Hf175					1.2	10.0	
		Ta181(n,5n)Ta177(β^+)Hf177(n,3n)Hf175						6.6	17.4
		Ta181(n,3n)Ta179(β^+)Hf179(n,5n)Hf175						6.1	8.8
		Ta181(n,3n)Ta179(n,5n)Ta175(β^+)Hf175						1.2	10.5
		Ta181(n,t)Hf179(n,5n)Hf175						1.1	3.5
		Ta181(n,6n)Ta176(β^+)Hf176(n,2n)Hf175							19.8
		Ta181(n,2n)Ta180(β^+)Hf180(n,6n)Hf175							6.9
		Ta181(n,2n)Ta180m(n,6n)Ta175(β^+)Hf175							6.3
		Ta181(n,7n)Ta175(β^+)Hf175							5.4
		&Ta181(n,d)*Hf180*(n,6n)Hf175							5.3
		Other similar long pathways				36.0	22.1	9.1	10.3
Ir192	73.822 d	Very long pathways of (n,γ), β^-	100.0	100.0	100.0				

Nuclide	T½	Pathway	210	186	151	42	30	21	6
W185	75.10 d	**&**Ta181(n,γ)*Ta182*(n,γ)Ta183(β$^-$)*W183*_(n,γ)W184(n,γ)*W185*	94.6	90.3	50.3	26.5	24.8	25.3	26.1
		&Ta181(n,γ)*Ta182*(n,γ)Ta183(n,γ)_Ta184(β$^-$)W184(n,γ)W185	2.1	1.0	0.6	0.1			
		&Ta181(n,γ)*Ta182*(β$^-$)W182(n,γ)*W183*_(n,γ)W184(n,γ)*W185*	0.2	1.7	48.9	73.0	71.8	71.7	71.4
Ta182	114.7 d	**&**Ta181(n,γ)*Ta182*	99.9	99.9	99.9	99.7	98.5	98.7	98.7
Ta179	1.61 y	Ta181(n,2n)Ta180m(n,2n)Ta179				84.1			
		&Ta181(n,2n)Ta180(β$^-$)W180(n,2n)_*W179*(β$^+$)Ta179				13.1			
		Ta181(n,3n)Ta179				2.7	99.2	98.6	99.0
Hf172	1.87 y	Ta181(n,2n)Ta180m(n,α)Lu177(β$^-$)_Hf177(n,2n)Hf176(n,2n)Hf175(n,2n)_Hf174(n,2n)Hf173(n,2n)Hf172				4.9			
		Ta181(n,nα)Lu177(β$^-$)Hf177(n,2n)_Hf176(n,2n)Hf175(n,2n)Hf174(n,2n)_Hf173(n,2n)Hf172				4.2			
		Ta181(n,3n)Ta179(n,3n)Ta177(β$^+$)_Hf177(n,4n)Hf174(n,3n)Hf172					23.8	0.7	
		Ta181(n,3n)Ta179(β$^+$)Hf179(n,4n)_Hf176(n,3n)Hf174(n,3n)Hf172					21.1	0.3	
		Ta181(n,4n)Ta178(β$^+$)Hf178(n,3n)_Hf176(n,3n)Hf174(n,3n)Hf172					18.6	0.6	
		Ta181(n,3n)Ta179(β$^+$)Hf179(n,3n)_Hf177(n,4n)Hf174(n,3n)Hf172					7.7	0.2	
		Ta181(n,nα)Lu177(β$^-$)Hf177(n,4n)_Hf174(n,3n)Hf172					3.5	0.9	
		Ta181(n,3n)Ta179(n,4n)Ta176(β$^+$)_Hf176(n,3n)Hf174(n,3n)Hf172					3.5	0.7	
		Ta181(n,4n)Ta178(β$^+$)Hf178(n,4n)_Hf175(n,4n)Hf172					0.6	23.1	
		Ta181(n,5n)Ta177(β$^+$)Hf177(n,4n)_Hf174(n,3n)Hf172						26.5	
		Ta181(n,4n)Ta178(β$^+$)Hf178(n,5n)_Hf174(n,3n)Hf172						15.3	
		Ta181(n,4n)Ta178m(β$^+$)Hf178(n,4n)_Hf175(n,4n)Hf172						3.5	
		Ta181(n,6n)Ta176(β$^+$)Hf176(n,5n)Hf172							52.1
		Ta181(n,5n)Ta177(β$^+$)Hf177(n,6n)Hf172							36.9
		Ta181(n,2nt)Hf177(n,6n)Hf172							3.2
		Other similar long pathways				90.9	21.2	28.2	7.8
Os194	5.989 y	Very long pathways of (n,γ), β$^-$	100.0	100.0					
H3	12.33 y	Ta181(n,X)H3				68.0	78.6	82.0	83.5
		Ta181(n,2n)Ta180m(n,X)H3				28.3	2.3	1.6	
		Ta181(n,2n)Ta180m(n,2n)Ta179(n,X)H3				1.2			
		Ta181(n,2n)Ta180(β$^+$)Hf180(n,X)H3				0.6	0.9	0.8	
		Ta181(n,3n)Ta179(n,X)H3					8.3	2.3	1.1
		Ta181(n,3n)Ta179(β$^+$)Hf179(n,X)H3					5.5	1.6	
		Ta181(n,4n)Ta178(β$^+$)Hf178(n,X)H3					1.1	5.3	1.1
		Ta181(n,5n)Ta177(β$^+$)Hf177(n,X)H3						2.0	4.6
		Ta181(n,6n)Ta176(β$^+$)Hf176(n,X)H3							3.5
Hf178n	31.0 y	**&**Ta180m(n,α)*Lu177*(β$^-$)Hf177(n,γ)Hf178n	94.7	99.4	99.6				
		&Ta181(n,2n)Ta180(β$^+$)Hf180(n,2n)_*Hf179*(n,2n)Hf178n				32.8			
		Ta181(n,2n)Ta180m(n,2n)Ta179(β$^+$)_Hf179(n,2n)Hf178n				16.3			
		&Ta181(n,2n)Ta180(β$^+$)Hf180(n,2n)_*Hf179*(n,2n)*Hf178*(n,n′)Hf178n				13.1			
		Ta181(n,2n)Ta180m(n,2n)Ta179(n,2n)_Ta178(β$^+$)Hf178(n,n′)Hf178n				8.1			
	►	**&**Ta181(n,2n)Ta180(β$^+$)Hf180(n,3n)_*Hf178*(n,n′)Hf178n				7.6	1.7		

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Ta181(n,2n)Ta180m(n,2n)Ta179(β^+)_ Hf179(n,2n)*Hf178*(n,n′)Hf178n				5.5			
		Ta181(n,2n)Ta180m(n,2n)Ta179(n,2n)_ Ta178m(β^+)Hf178(n,n′)Hf178n				5.2			
		&Ta181(n,2n)Ta180(β^-)W180(n,2n)_ *W179*(β^+)Ta179(β^+)*Hf179*(n,2n)Hf178n				2.5			
		Ta181(n,3n)Ta179(β^+)Hf179(n,2n)Hf178n				1.3	25.4	2.6	3.8
		Ta181(n,2n)Ta180m(n,3n)Ta178m(β^+)_ Hf178(n,n′)Hf178n				0.9	1.9		
		Ta181(n,3n)Ta179(n,2n)Ta178(β^+)_ Hf178(n,n′)Hf178n				0.6	3.1		
		&Ta181(n,3n)Ta179(β^+)Hf179(n,2n)_ *Hf178*(n,n′)Hf178n				0.6	2.8		
		Ta181(n,3n)Ta179(n,2n)Ta178m(β^+)_ Hf178(n,n′)Hf178n				0.4	2.0		
		Ta181(n,2n)Ta180m(n,3n)Ta178(β^+)_ Hf178(n,n′)Hf178n				0.1	3.0		
		Ta181(n,4n)Ta178(β^+)Hf178(n,n′)Hf178n					48.3	80.0	54.9
		Ta181(n,4n)Ta178m(β^+)Hf178(n,n′)Hf178n					5.0	12.2	8.7
		Ta181(n,2n)Ta180(β^+)Hf180(n,3n)Hf178n					1.0		
		&Ta181(n,nt)*Hf178*(n,n′)Hf178n					0.5	1.5	17.0
		Ta181(n,t)Hf179(n,2n)Hf178n					0.4	0.6	1.9
		Ta181(n,nt)Hf178n					0.2	0.7	9.9
Pt193	50.0 y	Very long pathways of (n,γ), β^-	100.0	100.0	100.0				
Ir192n	241.0 y	Very long pathways of (n,γ), β^-	100.0	100.0	100.0				
Ho166m	1200 y	Very long pathways of (n,α), (n,2n), β^-				100.0	100.0	100.0	100.0
Ho163	4570 y	Very long pathways of (n,α), (n,2n), β^-				100.0	100.0	100.0	100.0
Re186m	2.0 10^5 y	&Ta181(n,γ)*Ta182*(n,γ)Ta183(β^-)*W183*_ (n,γ)W184(n,γ)*W185*(β^-)Re185(n,γ)_ Re186m	93.8	93.0	60.6	36.3	34.5	35.4	36.7
		&Ta181(n,γ)*Ta182*(n,γ)Ta183(n,γ)_ Ta184(β^-)W184(n,γ)*W185*(β^-)Re185_ (n,γ)Re186m	3.5	1.3	1.3	0.2	0.1	0.1	0.1
		&Ta181(n,γ)*Ta182*(β^-)W182(n,γ)*W183*_ (n,γ)W184(n,γ)*W185*(β^-)Re185(n,γ)_ Re186m	0.1	1.3	36.7	61.7	63.7	63.5	63.2
Gd150	1.8 10^6 y	Very long pathways of (n,α), (n,2n), β^-					100.0	100.0	100.0
Dy154	3.0 10^6 y	Very long pathways of (n,α), (n,2n), β^-					100.0	100.0	100.0
Hf182	9.0 10^6 y	&Ta181(n,γ)*Ta182*(n,γ)Ta183(β^-)*W183*_ (n,α)Hf180(n,γ)Hf181(n,γ)*Hf182*	87.2	78.5	38.3				
		Ta181(n,γ)Ta182(n,α)Lu179(β^-)Hf179_ (n,γ)Hf180(n,γ)Hf181(n,γ)Hf182	6.5	3.3	7.3				
		&Ta181(n,α)Lu178(β^-)Hf178(n,γ)_ *Hf179*(n,γ)Hf180(n,γ)Hf181(n,γ)Hf182	3.2	1.3	0.1				
		&Ta181(n,α)Lu178m(β^-)Hf178(n,γ)_ *Hf179*(n,γ)Hf180(n,γ)Hf181(n,γ)Hf182	1.6	0.6					
		Ta181(n,γ)Ta182(n,γ)Ta183(β^-)W183_ (n,γ)W184(n,α)Hf181(n,γ)Hf182	0.2	1.5	1.3				
		&Ta181(n,γ)*Ta182*(β^-)W182(n,γ)*W183*_ (n,α)Hf180(n,γ)Hf181(n,γ)*Hf182*	0.1	1.2	29.1				
		&Ta181(n,γ)Ta182(n,γ)Ta183(β^-)*W183*_ (n,γ)W184(n,γ)W185(n,α)Hf182		10.7	10.1				
		&Ta181(n,γ)Ta182(β^-)W182(n,γ)*W183*_ (n,γ)W184(n,γ)W185(n,α)Hf182		0.1	7.6				
		&Ta181(n,γ)Ta182(β^-)W182(n,α)_ *Hf179*(n,γ)Hf180(n,γ)Hf181(n,γ)Hf182			3.7				
		&Ta181(n,γ)Ta182(β^-)W182(n,γ)*W183*_ (n,γ)W184(n,α)Hf181(n,γ)Hf182			1.0				
		&Ta181(n,γ)*Ta182*(n,p)*Hf182*				88.0	88.6	88.1	87.7
		&Ta181(n,p)Hf181(n,γ)*Hf182*				10.6	11.0	11.6	12.1

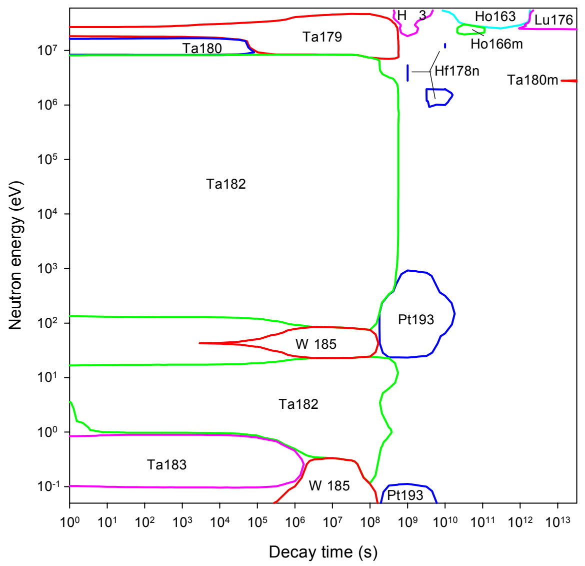
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Lu176	$4.0\ 10^{10}$ y	Ta181(n,α)Lu178(β^-)Hf178(n,α)Yb175_ (β^-)Lu175(n,γ)Lu176	65.9	66.0	85.0				
		Ta181(n,α)Lu178m(β^-)Hf178(n,α)_ Yb175(β^-)Lu175(n,γ)Lu176	34.0	34.0	14.7				
		Ta181(n,2n)Ta180m(n,nα)Lu176				49.3	9.1	0.6	
		Ta181(n,2n)Ta180m(n,2n)Ta179(n,α)Lu176				39.5			
		Ta181(n,2n)Ta180(β^-)W180(n,2n)_ W179(β^+)Ta179(n,α)Lu176				4.5			
		Ta181(n,3n)Ta179(n,α)Lu176				2.2	11.6		
		Ta181(n,2nα)Lu176					38.2	59.4	48.2
		Ta181(n,3n)Ta179(n,3n)Ta177(β^+)_ Hf177(n,d)Lu176					13.6		
		Ta181(n,4n)Ta178(β^+)Hf178(n,t)Lu176					5.7	22.2	7.9
		Ta181(n,3n)Ta179(β^+)Hf179(n,3n)_ Hf177(n,d)Lu176					5.3		
		Ta181(n,3n)Ta179(β^+)Hf179(n,nt)Lu176					4.9	1.8	4.3
		Ta181(n,nα)Lu177(β^-)Hf177(n,d)Lu176					1.8		
		Ta181(n,3n)Ta179(β^+)Hf179(n,4n)_ Hf176(n,p)Lu176					1.2		
		Ta181(n,5n)Ta177(β^+)Hf177(n,d)Lu176						7.8	22.7
		Ta181(n,4n)Ta178(β^+)Hf178(n,3n)_ Hf176(n,p)Lu176						1.0	
		Ta181(n,4n)Ta178m(β^+)Hf178(n,t)Lu176						0.6	3.4
		Ta181(n,6n)Ta176(β^+)Hf176(n,p)Lu176							3.1
		Ta181(n,t)Hf179(n,nt)Lu176							2.2
		Ta181(n,2n)Ta180(β^+)Hf180(n,2nt)Lu176							2.1
		Ta181(n,nt)Hf178(n,t)Lu176							2.1
		Ta181(n,2nt)Hf177(n,d)Lu176							2.0
		Ta181(n,d)Hf180(n,2nt)Lu176							1.2
Ta180m	$1.8\ 10^{15}$ y	**&**Ta181(n,γ)Ta182(n,γ)Ta183(β^-)*W183*_ (n,α)Hf180m(β^-)Ta180m	34.9						
		Ta181(n,γ)Ta182(n,α)Lu179(β^-)Hf179_ (n,γ)Hf180m(β^-)Ta180m	29.1						
		&Ta181(n,α)Lu178(β^-)Hf178(n,γ)_ *Hf179*(n,γ)Hf180m(β^-)Ta180m	23.4						
		&Ta181(n,α)Lu178m(β^-)Hf178(n,γ)_ *Hf179*(n,γ)Hf180m(β^-)Ta180m	12.0						
		Ta181(n,2n)Ta180m				99.9	99.6	99.4	99.2
		Nuclide also present in starting material	0.6	100.0	100.0	0.1	0.4	0.6	0.8
W183	$1.1\ 10^{17}$ y	**&**Ta181(n,γ)*Ta182*(n,γ)Ta183(β^-)*W183*	99.3	84.4	39.2	18.7	17.7	18.1	18.7
		&Ta181(n,γ)*Ta182*(β^-)W182(n,γ)*W183*	0.3	10.5	60.5	81.0	81.7	81.3	80.8

Tantalum activation characteristics

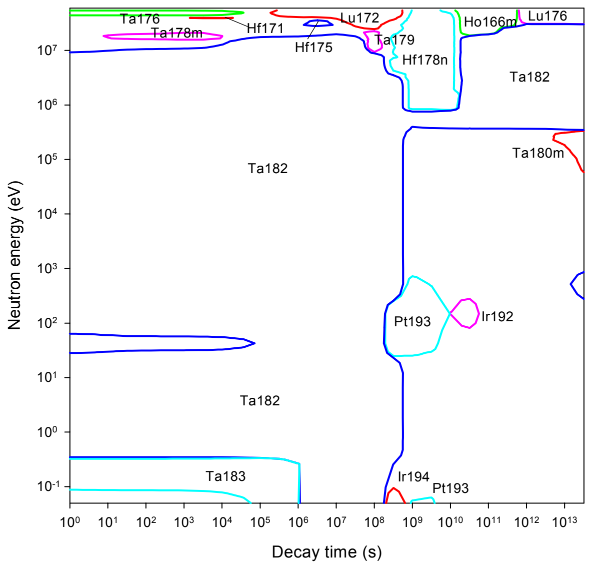


Tantalum importance diagrams & transmutation

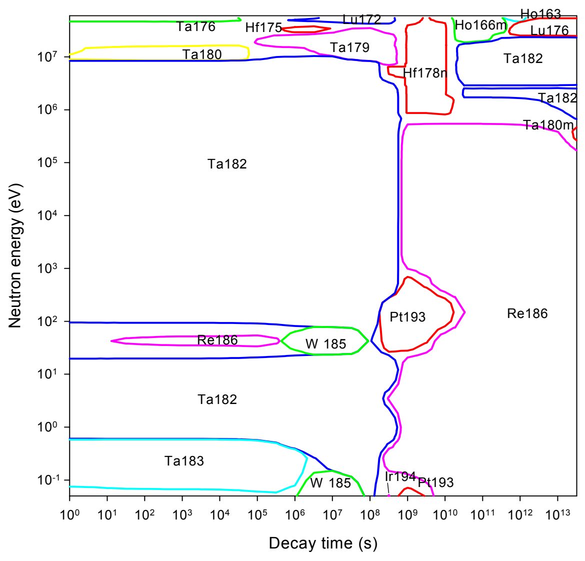
Activity



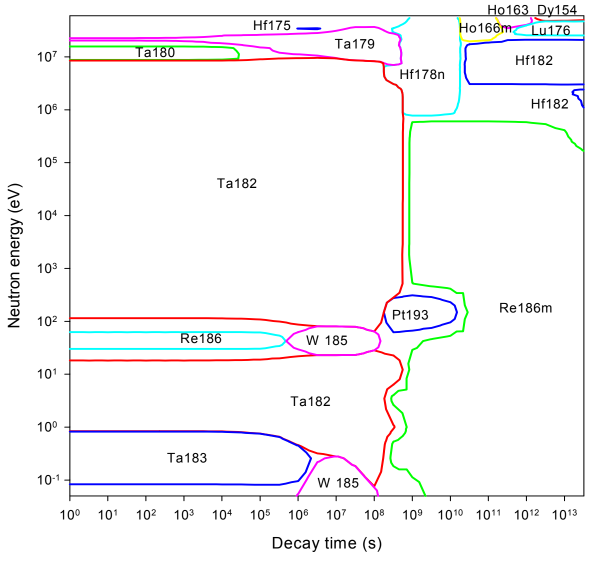
Dose rate



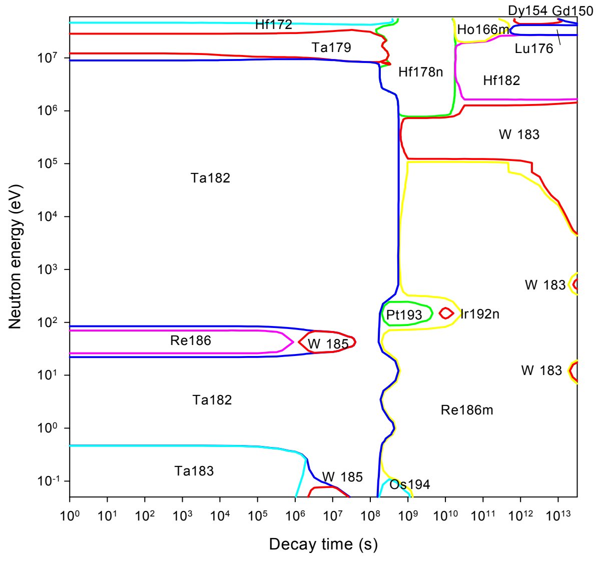
Heat output



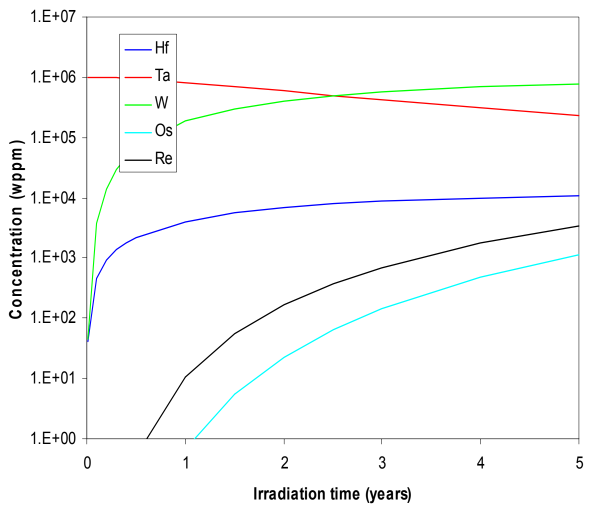
Ingestion dose



Inhalation dose



First wall transmutation



Tungsten

General properties

		Isotopes	Isotopic abundances / %
Atomic number	74		
Crustal abundance / wppm	1.25	W180	0.12
Melting point / K	3695	W182	26.50
Boiling point / K	5828	W183	14.31 ($T_{1/2}$ = 1.10 10^{17} y)
Density / kgm^{-3}	1.93 10^{4}	W184	30.64 ($T_{1/2}$ = 4.00 10^{17} y)
Thermal conductivity / $Wm^{-1}K^{-1}$	174	W186	28.43 ($T_{1/2}$ = 5.90 10^{17} y)
Electrical resistivity /Ωm	5.65 10^{-8}		
Coefficient of thermal expansion / K^{-1}	4.5 10^{-6}		
Crystal structure	BCC		
Number of stable isotopes	2 (5)		
Mean atomic weight	183.84		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.33E16	1.08E16	4.75E15	1.36E14	2.64E9	1.43E8
W185	23.55	29.05	64.00	79.30		
Re188	19.31	23.73	1.61	0.10		
Re186	16.94	20.88	24.35		3.83	49.94
W187	16.04	19.74	3.53			
W183m	8.42		0.01			
Os189m	1.00	1.22				
W181	0.78	0.97	2.16	9.47		
Ta182	0.74	0.91	2.03	7.95		0.01
Re188m	0.52	0.53				
Re184	0.22	0.27	0.58	0.94		
Os191	0.16	0.19	0.38			
Os185	0.13	0.17	0.37	0.89		
Ir192	0.05	0.06	0.13	0.15	0.21	
Pt193				0.01	91.44	
Re186m					3.83	49.94

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	9.37E-1	8.36E-1	1.92E-1	5.41E-3	2.58E-8	5.57E-9
Re188	36.91	41.24	5.36	0.33		
W187	27.20	30.42	10.40			
Re186	13.82	15.48	34.51		22.43	73.58
W185	6.82	7.64	32.18	40.56		
W183m	5.94		0.01			
Ta182	2.52	2.83	12.05	48.07	0.01	0.03
Re184	0.47	0.53	2.19	3.64		
Os185	0.23	0.25	1.07	2.63		
Ir192	0.11	0.12	0.52	0.61	3.50	
W181	0.10	0.11	0.46	2.06		
Re184m	0.05	0.06	0.26	2.04		
Pt193					62.30	
Re186m					8.04	26.38
Hf178n					1.65	
Hf178m					1.46	

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	2.02E5	2.00E5	5.01E4	3.84E3	1.32E-3	5.69E-5
W187	70.90	71.31	22.25			
Ta182	15.42	15.55	60.48	88.09	0.17	4.92
Re188	8.52*	8.56*	1.02*	0.02		
Re184	2.50	2.52	9.47	5.76		
Os185	1.13	1.14	4.41	3.95		
Re186	0.25*	0.25*	0.51*		1.72*	35.84*
Ir192	0.24	0.24	0.93	0.40	32.27	
Re184m	0.15	0.15	0.59	1.71		
Ta183	0.08	0.08	0.20			
Pt193					30.41	
Hf178n					20.21	
Hf178m					12.35	
Re186m					2.83	59.13
Ir192n					0.04	

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.00E7	9.98E6	3.53E6	6.93E4	4.68E-1	2.65E-1
Re188	36.08	36.03	3.04	0.27		
Re186	33.92	33.96	49.20		32.39	40.54
W185	13.83	13.86	37.93	68.53		
W187	13.49	13.48	3.00			
Ta182	1.48	1.48	4.10	23.42		
Re184	0.29	0.29	0.77	1.85		
Os191	0.12	0.12	0.29			
Re184m	0.09	0.09	0.25	2.81		
Os185	0.09	0.09	0.25	0.89		
Ir192	0.09	0.09	0.24	0.41	1.63	
W181	0.08	0.08	0.22	1.41		
Re186m					47.51	59.45
Pt193					15.97	
Hf178n					2.06	

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y	Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	5.90E6	5.89E6	2.90E6	1.36E5	2.16E0	9.39E-1		1.54E12	1.32E12	1.05E12	1.13E11	1.01E5	5.07E3
Re186	42.13	42.17	43.93		5.14	8.38	Ta182	64.02	74.83	91.59	96.01	0.07	1.37
Re188	23.57	23.53	1.43	0.05			W187	13.93	16.24	1.59			
Ta182	16.67	16.70	33.25	79.63		0.01	W183m	10.44		0.01			
W187	6.89	6.89	1.10				Re184	1.71	2.00	2.36	1.03		
W185	6.39	6.40	12.60	9.53			Re188	1.68	1.95	0.07			
Re184	0.93	0.93	1.79	1.79			Os185	1.17	1.36	1.66	1.07		
Ir192	0.69	0.69	1.36	0.97	1.67		W181	0.68	0.80	0.97	1.14		
Os191	0.67	0.67	1.19				Ir192	0.40	0.47	0.57	0.18	5.43	
Re184m	0.64	0.65	1.29	6.20			Ta183	0.38	0.44	0.33			
Ta183	0.64	0.64	0.79				W185	0.20	0.24	0.29	0.10		
Os185	0.49	0.49	0.96	1.42			Re184m	0.15	0.18	0.22	0.46		
W181	0.05	0.05	0.10	0.26			Re186	0.15	0.17	0.11		0.10	1.41
Os191m	0.04	0.04					Pt193					82.73	
Re186m					56.12	91.39	Re186m					6.71	94.01
Hf178n					24.69		Hf178n					2.52	
Ir192n					9.84		Hf178m					2.08	
Pt193					2.34		Ir192n					0.11	

Tungsten

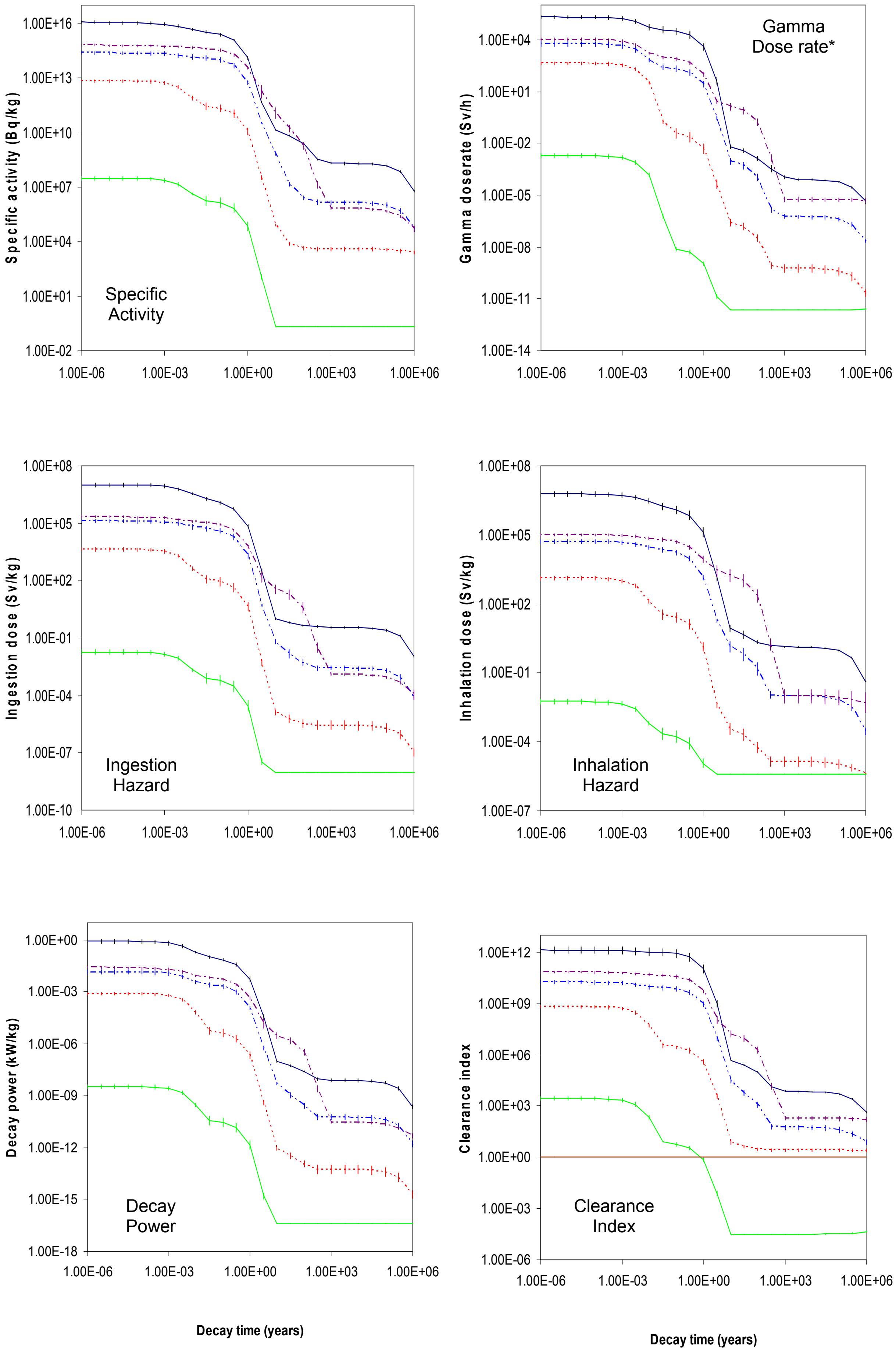
Pathway analysis

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
W183m	5.25 s	W182(n,γ)W183m	99.9	93.4	100.0	0.2	0.2		
		W184(n,γ)W185(β^-)Re185(n,γ)Re186_(β^-)Os186(n,α)W183m	0.1	6.6					
		W184(n,2n)W183m				90.5	38.7	31.9	53.1
		W186(n,3n)W184(n,2n)W183m				2.6			
		W183(n,n′)W183m				2.0	1.6	1.3	2.2
		W184(n,2n)W183(n,n′)W183m				0.9			
		W186(n,4n)W183m					52.6	63.3	38.4
Re188	16.98 h	**&**W186(n,γ)W187(β^-)Re187(n,γ)*Re188*	97.1	78.3	99.7	97.4	88.1	97.8	97.9
		&W184(n,γ)W185(β^-)Re185(n,γ)Re186_(n,γ)Re187(n,γ)*Re188*		9.7					
		&W183(n,γ)W184(n,γ)W185(β^-)Re185_(n,γ)Re186(n,γ)Re187(n,γ)*Re188*		4.4					
Ir194	19.30 h	Very long pathways of (n,γ), β^-	100.0	100.0	100.0				
W187	23.85 h	W186(n,γ)W187	91.8	98.5	100.0	99.9	99.5	99.5	99.7
		W184(n,γ)W185(β^-)Re185(n,γ)Re186_(β^+)W186(n,γ)W187	1.7	0.3					
Re186	3.775 d	**&**W184(n,γ)*W185*(β^-)Re185(n,γ)Re186	99.8	98.4	98.1				
		W183(n,γ)W184(n,γ)W185(β^-)Re185_(n,γ)Re186	0.1	1.5	1.6				
		W186(n,γ)W187(β^-)Re187(n,2n)Re186				86.9	92.1	90.7	89.6
		&W186(n,2n)*W185*(β^-)Re185(n,γ)Re186				12.8	6.3	6.1	5.8
		W186(n,d)Ta185(β^-)W185(β^-)_Re185(n,γ)Re186					1.2	2.9	4.3
Lu172	6.70 d	Very long pathways of (n,α), (n,2n), β^-				100.0	100.0	100.0	100.0
Re184	37.90 d	**&**W186(n,2n)*W185*(β^-)Re185(n,2n)*Re184*				99.9	82.7	65.2	56.6
		&186(n,d)Ta185(β^-)W185(β^-)Re185_(n,2n)*Re184*					15.5	30.5	41.7
		&186(n,γ)W187(β^-)Re187(n,4n)*Re184*					1.3	4.1	1.4
Ir192	73.82 d	**&**W186(n,γ)W187(β^-)Re187(n,γ)*Re188*_(β^-)Os188(n,γ)*Os189*(n,γ)Os190(n,γ)_*Os191*(β^-)Ir191(n,γ)*Ir192*	99.9	96.6	100.0				
		&W184(n,γ)W185(β^-)Re185(n,γ)Re186_(β^-)Os186(n,γ)Os187(n,γ)Os188(n,γ)_*Os189*(n,γ)Os190(n,γ)*Os191*(β^-)Ir191_(n,γ)*Ir192*	0.1	3.1					
		&W184(n,γ)W185(β^-)Re185(n,γ)Re186(n,γ)_Re187(n,γ)*Re188*(β^-)Os188(n,γ)*Os189*(n,γ)_Os190(n,γ)*Os191*(β^-)Ir191(n,γ)*Ir192*		0.3					
W185	75.10 d	**&**184(n,γ)*W185*	99.5	96.8	96.1				
		W183(n,γ)W184(n,γ)W185	0.2	2.9	3.0				
		&186(n,2n)*W185*				99.8	83.7	67.7	57.5
		W186(n,d)Ta185(β^-)W185					15.7	31.8	42.3
Ta182	114.7 d	**&**180(n,γ)W181(β^+)Ta181(n,γ)*Ta182*	99.9	99.9	99.9				
		&W182(n,p)*Ta182*				63.0	45.6	20.1	7.3
		&W182(n,2n)W181(β^+)Ta181(n,γ)*Ta182*				14.2			
		&W183(n,2n)W182(n,p)*Ta182*				9.7	0.1		
		&W186(n,2n)*W185*(β^-)Re185(n,α)*Ta182*				4.0			
		&W184(n,2n)*W183*(n,2n)W182(n,p)*Ta182*				2.7			
		&W183(n,d)*Ta182*				1.7	33.8	27.9	17.3
		&W184(n,2n)*W183*(n,d)*Ta182*				1.0			
		W184(n,3n)W182(n,p)Ta182				0.4	1.1		
		&184(n,t)*Ta182*					12.0	44.0	42.4
		W186(n,nα)Hf182m(β^-)Ta182					1.8		
		&186(n,2nt)*Ta182*						1.1	23.3

Nuclide	T½	Pathway	210	186	151	42	30	21	6
W181	120.98 d	W180(n,γ)W181	100.0	100.0	100.0				
		W182(n,2n)W181				82.6	36.4	22.2	17.5
		W183(n,2n)W182(n,2n)W181				12.6			
		W183(n,3n)W181				0.2	41.6	10.8	7.9
		W184(n,4n)W181					19.3	66.0	19.5
		W186(n,6n)W181							49.6
Re184m	168.0 d	**&**W186(n,2n)*W185*(β$^-$)Re185(n,2n)Re184m				99.8	81.2	59.6	55.2
		W186(n,d)Ta185(β$^-$)W185(β$^-$)Re185_ (n,2n)Re184m					15.2	28.0	40.7
		W186(n,γ)W187(β$^-$)Re187(n,4n)Re184m					3.0	12.1	3.9
Ta179	1.610 y	W182(n,2n)W181(β$^+$)Ta181(n,2n)_ Ta180m(n,2n)Ta179				48.2			
		&W182(n,2n)W181(n,2n)W180(n,2n)_ *W179*(β$^+$)Ta179				20.5			
		&W180(n,2n)*W179*(β$^+$)Ta179				16.0	2.1		
		W182(n,2n)W181(β$^+$)Ta181(n,3n)Ta179				3.0	8.3	1.0	
		W183(n,2n)W182(n,2n)W181(β$^+$)_ Ta181(n,2n)Ta180m(n,2n)Ta179				2.1			
		&W182(n,4n)*W179*(β$^+$)Ta179					57.9	71.8	19.3
		W183(n,3n)W181(β$^+$)Ta181(n,3n)Ta179					9.5	0.5	
		&W182(n,3n)W180(n,2n)*W179*(β$^+$)Ta179					6.0	0.9	
		W184(n,4n)W181(β$^+$)Ta181(n,3n)Ta179					4.4		
		W183(n,3n)W181(n,3n)W179(β$^+$)Ta179					1.5		
		W182(n,2n)W181(n,3n)W179(β$^+$)Ta179					1.3	0.2	
		W182(n,nt)Ta179					1.2	1.0	6.4
		W182(n,3n)W180(n,d)Ta179					1.0	0.2	
		W184(n,3n)W182(n,4n)W179(β$^+$)Ta179					1.0		
		&W183(n,5n)*W179*(β$^+$)Ta179						6.0	18.2
		&W186(n,5n)W182(n,4n)*W179*(β$^+$)Ta179						4.1	
		W184(n,6n)W179(β$^+$)Ta179							41.6
		W183(n,2nt)Ta179							2.1
Hf172	1.870 y	W180(n,nα)Hf176(n,2n)Hf175(n,2n)_ Hf174(n,2n)Hf173(n,2n)Hf172				9.5			
		W180(n,α)Hf177(n,2n)Hf176(n,2n)Hf175_ (n,2n)Hf174(n,2n)Hf173(n,2n)Hf172				7.4			
		W182(n,3n)W180(n,nα)Hf176(n,3n)_ Hf174(n,3n)Hf172					5.9		
		W182(n,4n)W179(β$^+$)Ta179(n,4n)_ Ta176(β$^+$)Hf176(n,5n)Hf172						11.4	0.5
		W182(n,4n)W179(β$^+$)Ta179(β$^+$)Hf179_ (n,4n)Hf176(n,5n)Hf172						6.9	0.3
		W182(n,4n)W179(β$^+$)Ta179(β$^+$)Hf179_ (n,5n)Hf175(n,4n)Hf172						6.9	
		W182(n,6n)W177(β$^+$)Ta177(β$^+$)Hf177_ (n,6n)Hf172							34.6
		Other similar long pathways				93.1	94.1	74.8	64.6
Os194	5.989 y	**&**W186(n,γ)W187(β$^-$)Re187(n,γ)*Re188*_ (β$^-$)Os188(n,γ)*Os189*(n,γ)Os190(n,γ)_ *Os191*(n,γ)Os192(n,γ)Os193(n,γ)Os194	100.0	100.0	100.0				
H3	12.33 y	W183(n,X)H3				70.8	22.7	18.5	17.0
		W182(n,X)H3				10.4	29.1	28.6	28.7
		W184(n,X)H3				6.4	20.6	27.0	30.2
		W186(n,X)H3				4.8	25.2	23.6	22.0
		&W184(n,2n)*W183*(n,X)H3				2.4			
		&W186(n,2n)*W185*(β$^-$)Re185(n,X)H3				1.8			
		W182(n,2n)W181(β$^+$)Ta181(n,X)H3				1.4	0.1		
Hf178n	31.0 y	W180(n,γ)W181(n,α)Hf178n	100.0	100.0	98.9				
		W180(n,α)Hf177(n,γ)Hf178n			1.1				
		W182(n,nα)Hf178n				51.2	98.4	85.0	59.7
		&W182(n,2n)W181(β$^+$)Ta181(n,2n)Ta180_ (β$^+$)Hf180(n,2n)*Hf179*(n,2n)Hf178n				7.9			

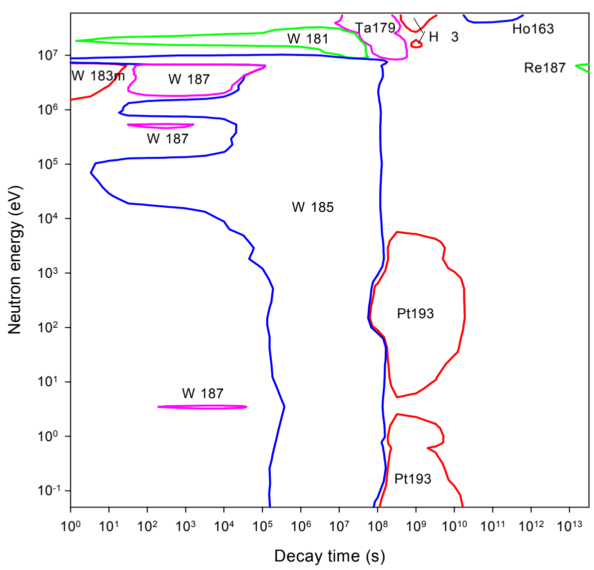
Nuclide	$T_{1/2}$	Pathway	210	186	151	42	30	21	6
		&W180(n,2n)*W179*(β^+)Ta179(β^+)Hf179_ (n,2n)Hf178n				5.2			
		W183(n,2n)W182(n,nα)Hf178n				4.4			
		W182(n,2n)W181(β^+)Ta181(n,2n)Ta180m_ (n,2n)Ta179(β^+)Hf179(n,2n)Hf178n				3.2			
		&W180(n,2n)W179(β^+)*Ta179*(n,2n)_ Ta178(β^+)Hf178(n,n′)Hf178n				2.6			
		&W182(n,2n)W181(n,2n)W180(n,2n)_ *W179*(β^+)Ta179(β^+)Hf179(n,2n)Hf178n				2.3			
		&W180(n,2n)W179(β^+)*Ta179*(β^+)_ Hf179(n,2n)Hf178(n,n′)Hf178n				2.3			
		&W182(n,α)*Hf179*(n,2n)Hf178n				1.9			
		&W180(n,2n)W179(β^+)*Ta179*(n,2n)_ Ta178m(β^+)Hf178(n,n′)Hf178n				1.7			
		W186(n,5n)W182(n,nα)Hf178n						3.7	2.1
		&W182(n,4n)W179(β^+)*Ta179*(β^+)_ Hf179(n,2n)Hf178n						1.2	0.4
		W182(n,5n)W178(β^+)Ta178(β^+)Hf178_ (n,n′)Hf178n						1.1	19.7
		W183(n,6n)W178(β^+)Ta178(β^+)Hf178_ (n,n′)Hf178n							8.2
Pt193	50.0 y	Very long pathways of (n,γ), β^-	100.0	100.0	100.0				
Ir192n	241.0 y	**&**W186(n,γ)W187(β^-)Re187(n,γ)*Re188*_ (β^-)Os188(n,γ)*Os189*(n,γ)Os190(n,γ)_ *Os191*(β^-)Ir191(n,γ)Ir192n	94.7	93.6	88.4				
		&W186(n,γ)W187(β^-)Re187(n,γ)*Re188*_ (β^-)Os188(n,γ)*Os189*(n,γ)Os190(n,γ)_ *Os191*(n,γ)Os192m(β^-)Ir192n	3.0	4.2	8.1				
Ho166m	1200 y	Very long pathways of (n,α), (n,2n), β^-				100.0	100.0	100.0	100.0
Ho163	4570 y	Very long pathways of (n,α), (n,2n), β^-				100.0	100.0	100.0	100.0
Re186m	$2.0\ 10^5$y	**&**W184(n,γ)*W185*(β^-)Re185(n,γ)Re186m	99.9	98.9	98.8				
		W183(n,γ)W184(n,γ)W185(β^-)Re185_ (n,γ)Re186m		1.0	1.1				
		W186(n,γ)W187(β^-)Re187(n,2n)Re186m				73.1	78.3	73.6	71.0
		&W186(n,2n)*W185*(β^-)Re185(n,γ)Re186m				26.9	18.1	17.8	16.7
		W186(n,d)Ta185(β^-)W185(β^-)Re185_ (n,γ)Re186m					3.4	8.4	12.2
Hf182	$9.0\ 10^6$ y	**&**W183(n,α)Hf180(n,γ)Hf181(n,γ)*Hf182*	57.7	56.9	4.7				
		&W182(n,γ)*W183*(n,α)Hf180(n,γ)_ Hf181(n,γ)*Hf182*	34.8	1.1					
		&W182(n,α)*Hf179*(n,γ)Hf180(n,γ)_ Hf181(n,γ)Hf182	2.4						
		W184(n,α)Hf181(n,γ)Hf182	1.0	2.8	10.1				
		&W184(n,γ)*W185*(n,α)Hf182	0.2	19.2	83.1				
		W183(n,γ)W184(n,α)Hf181(n,γ)Hf182	0.1	1.2	0.2				
		W183(n,γ)W184(n,γ)W185(n,α)Hf182		7.8	1.3				
		&W186(n,2n)*W185*(n,α)*Hf182*				52.4			
		&W186(n,nα)*Hf182*				45.5	89.0	82.9	77.2
		W184(n,h)Hf182					0.1	7.0	13.5
Re187	$4.3\ 10^{10}$ y	W186(n,γ)W187(β^-)Re187	97.1	78.4	100.0	100.0	99.8	99.8	99.9
		W184(n,γ)W185(β^-)Re185(n,γ)Re186_ (n,γ)Re187		9.6					
		W183(n,γ)W184(n,γ)W185(β^-)Re185_ (n,γ)Re186(n,γ)Re187		4.4					
W183	$1.1\ 10^{17}$ y	**&**W182(n,γ)*W183*	52.9	26.6	7.0				
		W184(n,γ)W185(β^-)Re185(n,γ)Re186_ (β^-)Os186(n,α)W183	1.2	10.3					
		&W186(n,4n)*W183*					15.7	20.3	6.5
		W186(n,nt)Ta183(β^-)W183						0.3	1.7
		Nuclide also present in starting material	45.9	63.1	93.0	100.0	84.3	79.4	91.8

Tungsten activation characteristics

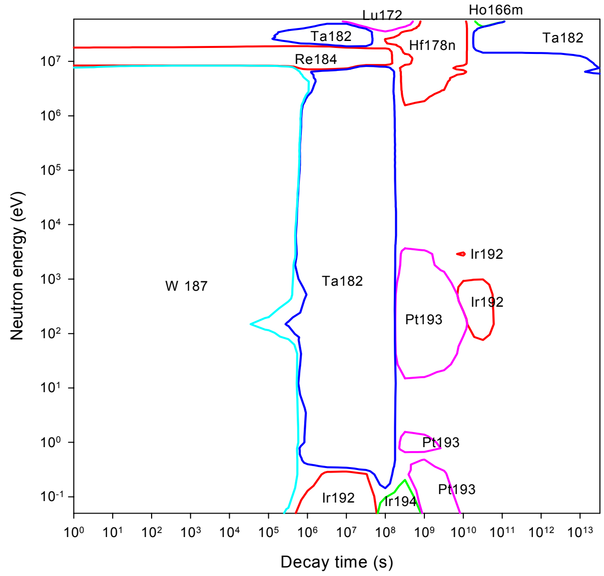


Tungsten importance diagrams & transmutation

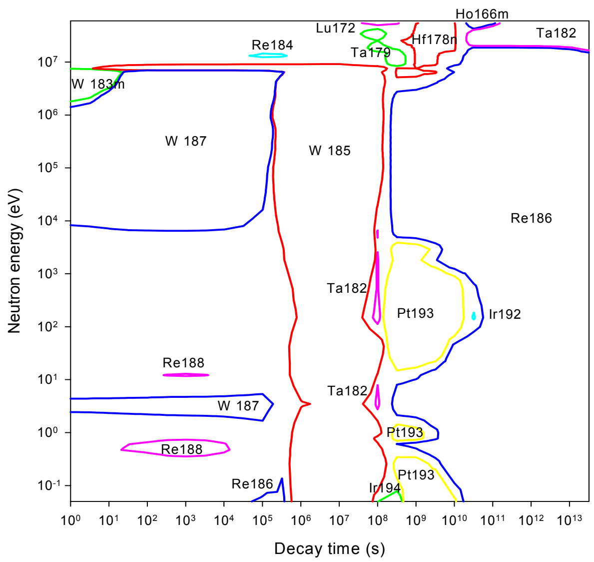
Activity



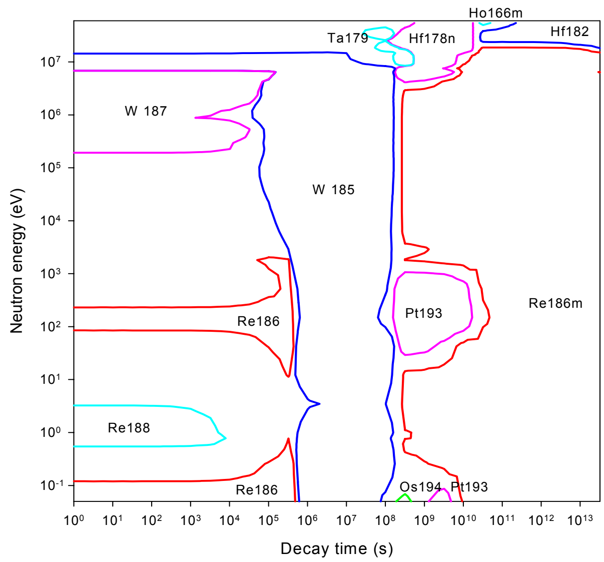
Dose rate



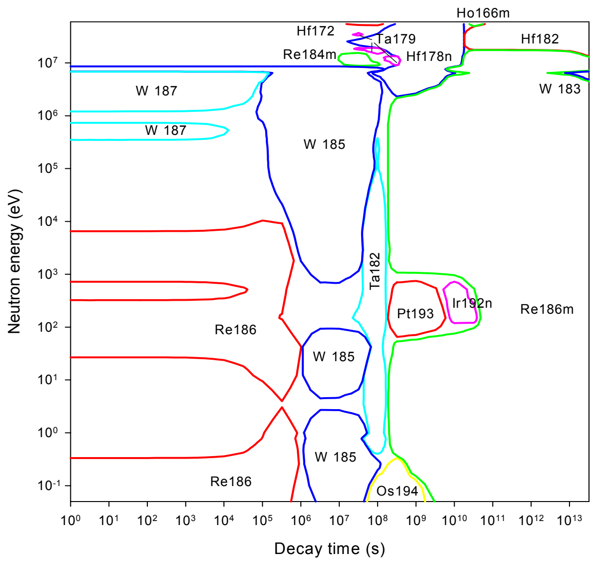
Heat output



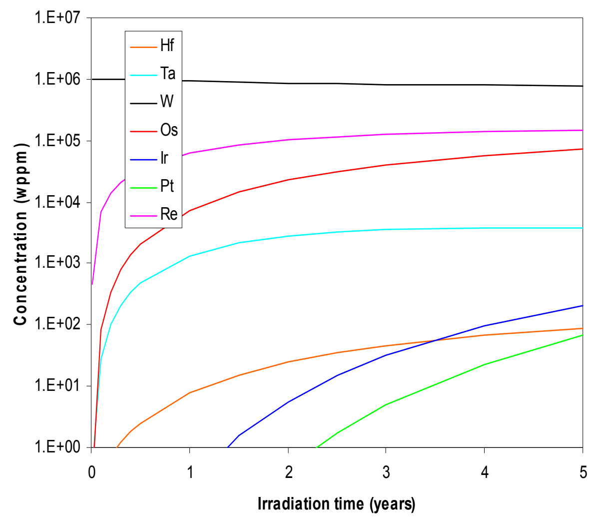
Ingestion dose



Inhalation dose



First wall transmutation



Rhenium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	75	Re185	37.4
Crustal abundance / wppm	7.0 10^{-4}	Re187	62.6 ($T_{1/2}$ = 4.35 10^{10} y)
Melting point / K	3459		
Boiling point / K	5869		
Density / kgm^{-3}	21020		
Thermal conductivity / $Wm^{-1}K^{-1}$	47.9		
Electrical resistivity /Ωm	1.93 10^{-7}		
Coefficient of thermal expansion / K^{-1}	6.2 10^{-6}		
Crystal structure	HCP		
Number of stable isotopes	1 (2)		
Mean atomic weight	186.207		

Activation properties

Act	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Bq kg^{-1}	3.00E16	2.19E16	1.13E16	2.50E14	3.04E10	4.08E8
Re186	26.92	36.81	36.49		0.95	49.96
W185	22.27	30.47	57.06	91.84		
Re188	15.97	21.78	1.19	0.01		
W187	2.13	2.90	0.44			
Os189m	1.43	1.93				
Os191	0.48	0.65	1.10			
Re188m	0.44	0.49				
Re184	0.37	0.50	0.92	2.14		
Os185	0.36	0.50	0.94	2.93		
Os191m	0.34	0.46	0.01			
Ir192m	0.20	0.02				
Ir192	0.18	0.24	0.45	0.68	0.19	
Re184m	0.08	0.11	0.21	2.17		
Pt193				0.05	97.65	
Re186m					0.95	49.96

Heat	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
kW kg^{-1}	1.71E0	1.38E0	4.36E-1	7.12E-3	2.32E-7	1.59E-8
Re188	37.62	46.29	4.16	0.07		
Re186	27.05	33.38	54.29		7.14	73.61
W185	7.94	9.80	30.12	65.47		
W187	4.44	5.47	1.37			
Re184	0.99	1.22	3.68	11.54		
Os185	0.75	0.93	2.87	12.15		
Ir192	0.51	0.63	1.93	3.96	4.07	
Re188m	0.19	0.19				
Re184m	0.12	0.15	0.47	6.47		
Os189m	0.11	0.13				
Os191	0.05	0.06	0.17			
Ir190	0.02	0.02	0.06			
Pt193			0.01		85.55	
Re186m					2.56	26.39
Ir192n					0.66	

Dose	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv h^{-1}	1.22E5	1.18E5	4.23E4	2.25E3	9.20E-3	1.51E-4
W187	35.39	36.63	7.83			
Re188	26.65*	27.56*	2.12	0.01		
Re184	16.03	16.64	42.85	40.58		
Os185	11.54	11.97	31.73	40.46		
Ir192	3.37	3.50	9.21	5.70	46.78	
Re186	1.48*	1.53*	2.14*		0.68*	37.76*
Re184m	1.04	1.08	2.91	12.06		
Os190m	0.36	0.27				
Ta182	0.21	0.21	0.57	1.18	0.01	0.67
Ir190	0.20	0.21	0.46			
Pt193					51.32	
Re186m					1.10	61.55

Ing	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	2.26E7	2.25E7	9.60E6	1.21E5	2.09E0	7.55E-1
Re186	53.67	53.73	64.52		20.75	40.54
Re188	29.73	29.68	1.97	0.04		
W185	13.02	13.05	29.60	83.55		
W187	1.78	1.78	0.33			
Re184	0.49	0.49	1.08	4.42		
Os191	0.36	0.36	0.74			
Ir192	0.33	0.33	0.74	1.97	3.82	
Os185	0.25	0.25	0.56	3.09		
Re184m	0.16	0.16	0.38	6.73		
Pt193					44.11	
Re186m					30.43	59.46
Ir192n					0.84	

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	1.36E7	1.36E7	6.51E6	9.68E4	7.01E0	2.67E0
Re186	65.18	65.36	69.77		4.53	8.39
Re188	18.99	18.99	1.12	0.02		
W185	5.88	5.90	11.90	28.44		
Ir192	2.54	2.55	5.15	11.61	5.36	
Os191	1.99	1.99	3.62			
Re184	1.53	1.54	3.04	10.48		
Os185	1.28	1.28	2.61	12.11		
Re184m	1.17	1.17	2.40	36.38		
W187	0.89	0.89	0.15			
Ta182	0.06	0.06	0.12	0.88		
Re186m					49.41	91.58
Ir192n					31.62	
Pt193					8.90	

Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
	1.19E12	4.57E11	2.99E11	1.72E10	1.10E6	1.41E4
W183m	46.08					
W185m	16.96	4.96				
Os185	9.15	23.83	35.49	42.65		
Re184	8.40	21.88	31.67	28.27		
W187	5.36	13.93	1.67			
Ir192	4.41	11.49	16.99	9.91	5.16	
Re188	4.03	10.45	0.45			
Ir191m1	1.01	2.56	3.46			
Re188m	0.91	1.95				
Re184m	0.82	2.14	3.23	12.62		
Re186	0.68	1.77	1.38		0.03	1.44
Ta182	0.65	1.70	2.55	4.99		0.18
W185	0.56	1.46	2.16	1.34		
Os191	0.12	0.31	0.42			
Ir190	0.11	0.28	0.35			
Pt193				0.02	92.92	
Re186m					1.75	96.26

Rhenium

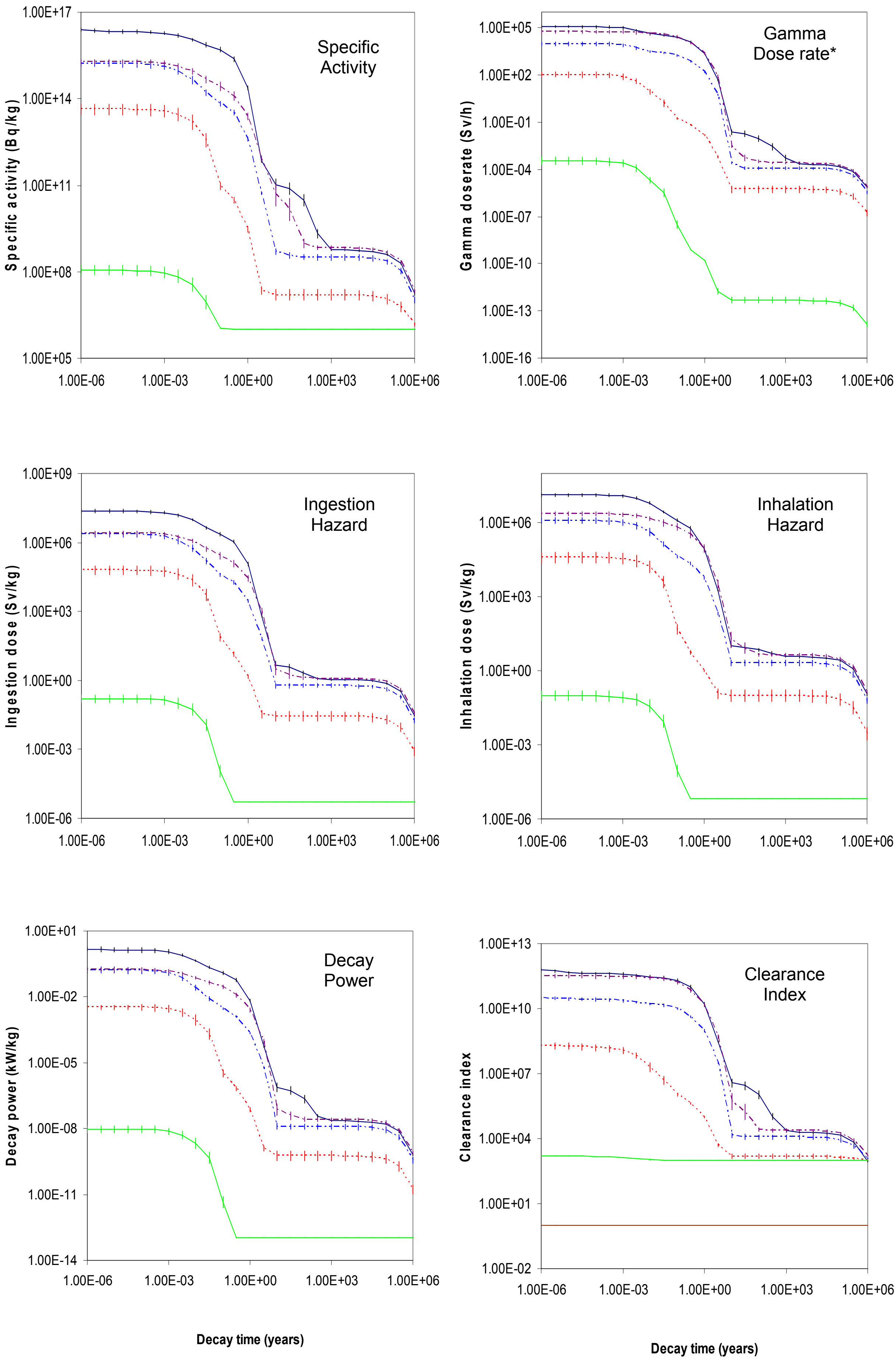
Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Re188	16.98 h	&Re187(n,γ)*Re188*	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Ir194	19.30 h	&Re187(n,γ)*Re188*(β^{-})Os188(n,γ)_ *Os189*(n,γ)Os190(n,γ)*Os191*(β^{-})Ir191_ (n,γ)*Ir192*(n,γ)*Ir193*(n,γ)Ir194	98.5	98.7	96.6				
		&Re185(n,γ)Re186(β^{-})Os186(n,γ)_ Os187(n,γ)Os188(n,γ)*Os189*(n,γ)Os190_ (n,γ)*Os191*(β^{-})Ir191(n,γ)*Ir192*(n,γ)*Ir193*_ (n,γ)Ir194	1.0	1.3					
		&Re187(n,γ)*Re188*(β^{-})Os188(n,γ)_ *Os189*(n,γ)Os190(n,γ)*Os191*(n,γ)Os192_ (n,γ)Os193(β^{-})*Ir193*(n,γ)Ir194	0.5		3.4				
W187	23.85 h	Re185(n,γ)Re186(β^{+})W186(n,γ)W187	100.0	99.2	98.8				
		Re187(n,p)W187				97.9	99.7	99.7	99.7
		Re187(n,2n)Re186(β^{+})W186(n,γ)W187				2.1			
Re186	3.775 d	Re185(n,γ)Re186	100.0	98.6	97.8				
		Re187(n,2n)Re186				99.5	99.3	99.5	99.6
Lu172	6.70 d	Very long pathways of (n,α), (n,2n), β^{-}				100.0	100.0	100.0	100.0
Re184	37.90 d	&Re185(n,2n)*Re184*				90.2	33.9	13.5	30.5
		Re187(n,2n)Re186(β^{-})Os186(n,2n)_ Os185(β^{+})Re185(n,2n)Re184				4.7			
		&Re187(n,2n)Re186m(n,2n)Re185_ (n,2n)*Re184*				1.7			
		&Re187(n,3n)Re185(n,2n)*Re184*				1.6	12.2	1.1	1.5
		&Re187(n,2n)Re186m(n,3n)*Re184*				0.1	2.7		
		&Re187(n,4n)*Re184*					50.1	83.9	65.8
Re183	70.00 d	&Re185(n,2n)*Re184*(n,2n)Re183				36.6			
		Re185(n,2n)Re184m(n,2n)Re183				33.1			
		Re185(n,3n)Re183				17.1	72.4	45.1	18.4
		Re187(n,2n)Re186(β^{-})Os186(n,2n)_ Os185(β^{+})Re185(n,3n)Re183				1.0			
		Re187(n,3n)Re185(n,3n)Re183				0.3	25.8	4.1	
		Re187(n,2n)Re186m(n,4n)Re183					0.5	2.3	
		Re187(n,5n)Re183						41.9	78.7
		Re187(n,2n)Re186(β^{-})Os186(n,4n)_ Os183(β^{+})Re183						4.3	
Ir192	73.82 d	&Re187(n,γ)*Re188*(β^{-})Os188(n,γ)_ *Os189*(n,γ)Os190(n,γ)*Os191*(β^{-})Ir191_ (n,γ)*Ir192*	99.8	99.8	99.6	90.3	93.3	95.6	96.8
W185	75.10 d	&Re187(n,γ)*Re188*(β^{-})Os188(n,α)*W185*	72.3	72.3	72.3				
		Re187(n,γ)Re188(β^{-})Os188(n,α)W185	27.6	27.6	27.6				
		&Re187(n,2n)Re186(β^{+})W186(n,2n)*W185*				89.3	1.7		
		&Re185(n,p)*W185*				8.6	30.2	9.4	4.4
		&Re187(n,d)W186(n,2n)*W185*				0.8	5.3	2.1	
		&Re187(n,2n)Re186m(n,d)*W185*				0.3	3.2	1.3	
		&Re187(n,t)*W185*				0.2	46.3	83.7	91.7
		&Re187(n,3n)Re185(n,p)*W185*					10.8		
		Re187(n,d)W186(n,d)Ta185(β^{-})W185					1.0	1.0	
Ta182	114.7 d	&Re185(n,α)*Ta182*	99.7	98.9	98.1	89.3	34.8	8.1	8.4
		Re187(n,2n)Re186(β^{-})Os186(n,2n)_ Os185(β^{+})Re185(n,α)Ta182				2.3			
		&Re187(n,3n)Re185(n,α)*Ta182*				1.5	11.9	0.7	0.5
		&Re187(n,2n)Re186m(n,2n)Re185(n,α)*Ta182*				1.5			
		&Re185(n,3n)Re183(β^{+})W183(n,d)*Ta182*					32.6	9.1	5.4
		&Re187(n,3n)Re185(n,3n)Re183(β^{+})_ W183(n,d)*Ta182*					5.2	0.3	
	►	&Re187(n,2nα)*Ta182*					4.5	28.6	27.9

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Re187(n,4n)*Re184*(β⁺)W184(n,t)*Ta182*					1.5	21.0	9.0
		&Re185(n,2n)Re184(β⁺)W184(n,t)*Ta182*					1.0	3.1	3.8
		&Re185(n,4n)Re182m(β⁺)W182(n,p)*Ta182*					0.3	5.3	0.8
		&Re185(n,4n)Re182(β⁺)W182(n,p)*Ta182*					0.2	3.5	0.6
		&Re187(n,4n)Re184m(β⁺)W184(n,t)*Ta182*					0.1	2.7	0.9
		&Re185(n,d)W184(n,t)*Ta182*					0.1	1.1	1.6
		&Re187(n,5n)Re183(β⁺)W183(n,d)*Ta182*						8.4	23.0
		&Re187(n,nt)W184(n,t)*Ta182*						0.5	3.5
		Re187(n,6n)Re182m(β⁺)W182(n,p)Ta182							2.4
		&Re187(n,2nt)*W183*(n,d)*Ta182*							1.9
		Re187(n,6n)Re182(β⁺)W182(n,p)Ta182							1.6
		&Re187(n,d)W186(n,2nt)*Ta182*							1.4
Re184m	168.0 d	Re185(n,2n)Re184m				91.6	19.9	4.9	13.9
		Re187(n,2n)Re186(β⁻)Os186(n,2n)_ Os185(β⁺)Re185(n,2n)Re184m				4.5			
		Re187(n,3n)Re185(n,2n)Re184m				1.5	6.5		
		Re187(n,2n)Re186m(n,2n)Re185(n,2n)Re184m				1.4			
		Re187(n,2n)Re186m(n,3n)Re184m				0.4	4.7		
		Re187(n,4n)Re184m					68.4	94.0	84.0
Ta179	1.610 y	Re185(n,nα)Ta181(n,2n)Ta180m(n,2n)Ta179				7.0			
		Re185(n,2n)Re184(β⁺)W184(n,3n)_ W182(n,2n)W181(β⁺)Ta181(n,2n)_ Ta180m(n,2n)Ta179				5.9			
		Re185(n,nα)Ta181(n,3n)Ta179				0.4	5.4	0.2	
		Re185(n,3n)Re183(β⁺)W183(n,3n)_ W181(β⁺)Ta181(n,3n)Ta179					39.0	0.2	
		Re185(n,3n)Re183(β⁺)W183(n,3n)_ W181(n,3n)W179(β⁺)Ta179					10.9		
		Re185(n,3n)Re183(n,3n)Re181(β⁺)_ W181(β⁺)Ta181(n,3n)Ta179					7.9		
		&Re185(n,4n)Re182m(β⁺)W182(n,4n)_ *W179*(β⁺)Ta179					0.4	40.5	2.1
		&Re185(n,4n)Re182(β⁺)W182(n,4n)_ *W179*(β⁺)Ta179					0.2	27.0	1.4
		&Re185(n,3n)Re183(β⁺)W183(n,5n)_ *W179*(β⁺)Ta179						4.2	5.2
		&Re187(n,5n)Re183(β⁺)W183(n,5n)_ *W179*(β⁺)Ta179						3.8	22.2
		Re185(n,5n)Re181(β⁺)W181(β⁺)Ta181_ (n,3n)Ta179						1.3	6.4
		Re185(n,3nα)Ta179						1.0	5.8
		&Re187(n,6n)Re182m(β⁺)W182(n,4n)_ *W179*(β⁺)Ta179							6.0
		&Re187(n,4n)Re184(β⁺)W184(n,6n)_ *W179*(β⁺)Ta179							5.7
		Other similar long pathways				86.7	36.2	21.8	45.2
Hf172	1.870 y	Very long pathways of (n,α), (n,2n), β⁻				100.0	100.0	100.0	100.0
Os194	5.989 y	&Re187(n,γ)*Re188*(β⁻)Os188(n,γ)_ *Os189*(n,γ)Os190(n,γ)*Os191*(n,γ)Os192_ (n,γ)Os193(n,γ)Os194	85.3	86.3	100.0				
		&Re185(n,γ)Re186(β⁻)Os186(n,γ)Os187_ (n,γ)Os188(n,γ)*Os189*(n,γ)Os190(n,γ)_ *Os191*(n,γ)Os192(n,γ)Os193(n,γ)Os194	12.2	11.2					
		&Re185(n,γ)Re186(n,γ)Re187(n,γ)Re188_ (β⁻)Os188(n,γ)*Os189*(n,γ)Os190(n,γ)_ *Os191*(n,γ)Os192(n,γ)Os193(n,γ)Os194		1.6					
		&Re187(n,γ)*Re188*(n,γ)Re189(β⁻)_ *Os189*(n,γ)Os190(n,γ)*Os191*(n,γ)Os192_ (n,γ)Os193(n,γ)Os194		0.9					
H3	12.33 y	Re185(n,X)H3				45.4	34.7	34.2	33.7
	►	Re187(n,X)H3				39.3	49.5	51.2	51.5

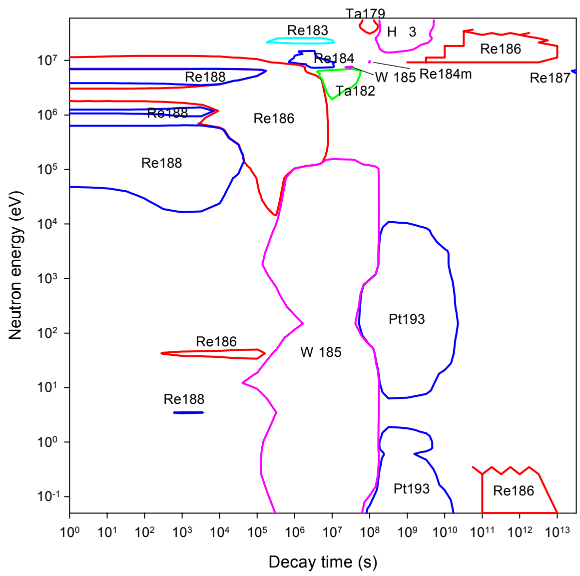
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
	◄	Re187(n,2n)Re186m(n,X)H3				8.2	0.6		0.3
		&Re185(n,2n)*Re184*(n,X)H3				1.7			
		Re185(n,2n)Re184m(n,X)H3				1.2			
		Re187(n,3n)Re185(n,X)H3				0.4	6.5	4.6	1.0
		Re185(n,3n)Re183(β^+)W183(n,X)H3					3.7	1.1	0.6
		&Re187(n,4n)*Re184*(β^+)W184(n,X)H3					0.4	1.6	0.7
		Re185(n,4n)Re182m(β^+)W182(n,X)H3						1.4	0.4
		Re187(n,5n)Re183(β^+)W183(n,X)H3						1.0	2.4
		Re185(n,5n)Re181(β^+)W181(β^+)Ta181_ (n,X)H3							1.3
		Re187(n,6n)Re182m(β^+)W182(n,X)H3							1.1
Hf178n	31.0 y	Re185(n,γ)Re186(β^-)Os186(n,α)W183_ (n,α)Hf180(n,α)Yb177(β^-)Lu177(β^-)_ Hf177(n,γ)Hf178n	15.3						
		&Re185(n,2n)*Re184*(β^+)W184(n,2n)_ *W183*(n,2n)W182(n,nα)Hf178n				49.4			
		&Re185(n,2n)*Re184*(β^+)W184(n,3n)_ W182(n,nα)Hf178n				12.7	12.8	0.3	
		&Re185(n,α)*Ta182*(β^-)W182(n,nα)Hf178n				5.2	2.5		
		&Re185(n,2n)*Re184*(n,2n)Re183(β^+)_ W183(n,2n)W182(n,nα)Hf178n				4.9			
		Re185(n,2n)Re184m(n,2n)Re183(β^+)_ W183(n,2n)W182(n,nα)Hf178n				3.9			
		Re185(n,3n)Re183(β^+)W183(n,2n)_ W182(n,nα)Hf178n				2.9	12.2	0.4	
		Re185(n,3n)Re183(β^+)W183(n,2n)_ W182(n,nα)Hf178n				2.9	12.2	0.4	
		&Re187(n,4n)*Re184*(β^+)W184(n,3n)_ W182(n,nα)Hf178n					18.0	2.0	0.1
		Re185(n,4n)Re182m(β^+)W182(n,nα)Hf178n					12.1	50.1	8.2
		Re185(n,4n)Re182(β^+)W182(n,nα)Hf178n					8.1	33.4	5.5
		Re185(n,nt)W182(n,nα)Hf178n					1.6	1.8	4.4
		Re187(n,6n)Re182m(β^+)W182(n,nα)Hf178n							23.5
		Re187(n,6n)Re182(β^+)W182(n,nα)Hf178n							15.7
		Other similar long pathways	84.7	100.0		18.1	20.5	11.6	42.6
Pt193	50.0 y	&Re187(n,γ)*Re188*(β^-)Os188(n,γ)_ *Os189*(n,γ)Os190(n,γ)*Os191*(β^-)Ir191_ (n,γ)*Ir192*(β^-)Pt192(n,γ)*Pt193*	99.1	98.7	100.0				
		&Re185(n,γ)Re186(β^-)Os186(n,γ)_ Os187(n,γ)Os188(n,γ)*Os189*(n,γ)Os190_ (n,γ)*Os191*(β^-)Ir191(n,γ)*Ir192*(β^-)Pt192_ (n,γ)*Pt193*	0.9	1.3					
Ir192n	241.0 y	&Re187(n,γ)*Re188*(β^-)Os188(n,γ)*Os189*_ (n,γ)Os190(n,γ)*Os191*(β^-)Ir191(n,γ)Ir192n	96.6	95.0	90.6	95.8			
		&Re187(n,γ)*Re188*(β^-)Os188(n,γ)_ *Os189*(n,γ)Os190(n,γ)*Os191*(n,γ)_ Os192m(β^-)Ir192n	2.5	3.6	6.8	2.2			
		&Re187(n,γ)*Re188*(β^-)Os188(n,γ)_ *Os189*(n,γ)Os190(n,γ)*Os191*(β^-)Ir191_ (n,γ)Ir192(n,n′)Ir192n				2.0			
Re186m	$2.0\ 10^5$ y	Re185(n,γ)Re186m	100.0	99.5	99.2		0.3		
		Re187(n,2n)Re186m				99.9	99.5	99.5	99.6
Re187	$4.3\ 10^{10}$ y	Re185(n,γ)Re186(β^+)W186(n,γ)W187_ (β^-)Re187	12.7	2.4					
		Re185(n,γ)Re186(n,γ)Re187	0.2	2.1					
		Nuclide also present in starting material	87.1	95.5	100.0	100.0	100.0	100.0	100.0

Rhenium activation characteristics

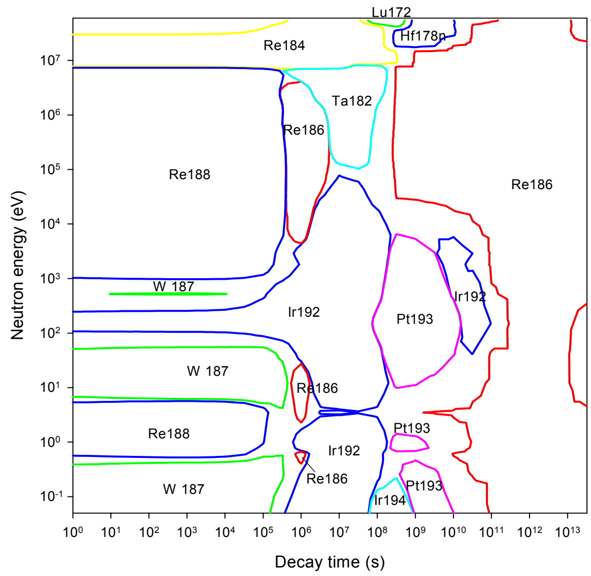


Rhenium importance diagrams & transmutation

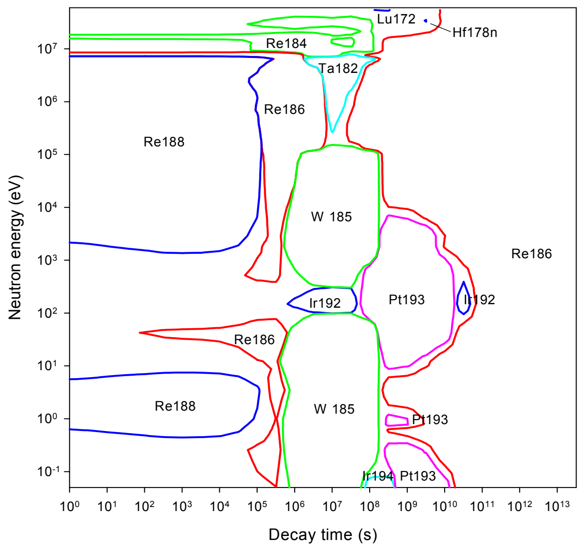
Activity



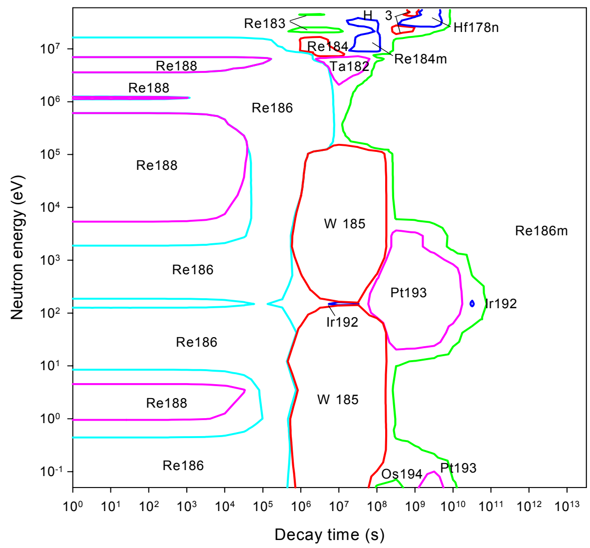
Dose rate



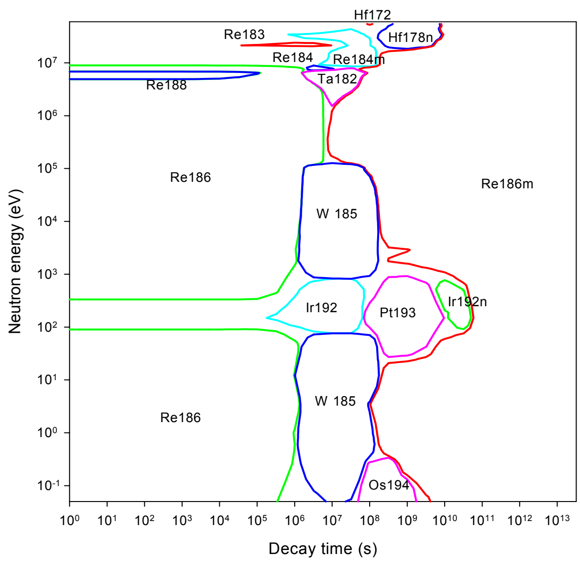
Heat output



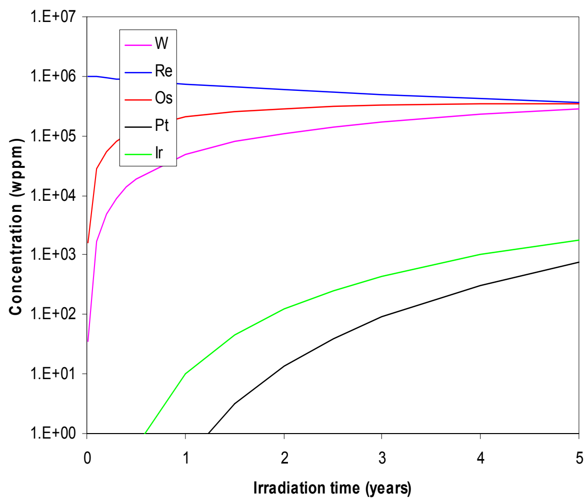
Ingestion dose



Inhalation dose



First wall transmutation



Osmium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	76		
Crustal abundance / wppm	1.5 10^{-3}	Os184	0.02 ($T_{1/2}$ = 5.60 10^{13} y)
Melting point / K	3306	Os186	1.59 ($T_{1/2}$ = 2.00 10^{15} y)
Boiling point / K	5285	Os187	1.60
Density / kgm^{-3}	22570	Os188	13.29
Thermal conductivity / $Wm^{-1}K^{-1}$	87.6	Os189	16.21
Electrical resistivity /Ωm	8.12 10^{-8}	Os190	26.36
Coefficient of thermal expansion / K^{-1}	5.1 10^{-6}	Os192	40.93
Crystal structure	HCP		
Number of stable isotopes	5 (7)		
Mean atomic weight	190.23		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.17E16	9.30E15	5.30E15	6.79E13	2.11E12	2.50E7
Ir191m	13.13	16.27	24.75			
Os191	12.91	16.26	24.75			
Re186	11.72	14.76	13.26			49.98
Ir192m	8.80	0.88				
Ir192	8.56	10.79	18.30	47.92	0.31	
Os191m	8.04	10.08	0.17			
Ir194	6.42	8.06	0.61	0.03		
W183m	6.41					
W185	5.81	7.32	12.42	34.45		
Os193	5.47	6.87	1.61			
W185m	3.81	0.54				
Ir194m	2.25					
Os189m	1.92	2.38				
W187	1.12	1.41	0.19			
Pt193m	0.99	1.24	1.22			
Ir193m	0.62	0.77	1.08			
Os185	0.19	0.24	0.42	2.25		
Pt193			0.16	12.20	99.39	
Re186m						49.98

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	5.98E-1	5.27E-1	2.84E-1	6.35E-3	1.53E-5	9.71E-10
Ir192	27.79	31.56	56.58	84.88	7.03	
Ir194	18.16	20.56	1.64	0.04		
Re186	13.16	14.94	14.18		0.01	73.59
Os193	7.66	8.68	2.15			
Ir191m	7.05	7.88	12.66			
W183m	6.22					
W187	2.61	2.96	0.43			
W185m	2.37	0.30				
W185	2.31	2.63	4.71	7.49		
Re188	2.14	2.42	0.14	0.02		
Os191m	1.88	2.12	0.04			
Ir192m	1.57	0.14				
Os191	1.52	1.73	2.78			
Os191m	1.52	1.73	2.78			
Ir194m	1.04					
Ir190	0.93	1.06	1.59			
Os190m	0.81	0.66				
Ir191n	0.60					
Re184	0.50	0.57	1.01	2.43		
Os185	0.49	0.51	0.92	2.84		
Pt193m	0.47	0.53	0.55			
Re184m			0.14	1.36		
Pt193			0.02	0.87	91.81	
Re186m						26.39

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	1.16E5	1.11E5	8.39E4	2.83E3	8.03E-1	9.26E-6
Ir192	64.58	67.52	85.81	85.31	59.76	
Ir194	7.97*	8.31*	0.47*	0.01*		
W187	7.33	7.65	0.79			
Ir190	3.47	3.63	3.87			
Os190m	2.94	2.19				
Re184	2.89	3.02	3.76	6.01		
Os193	2.67	2.78	0.49			
Os185	2.43	2.54	3.25	6.66		
Ir191n	2.25					
Ir191m	0.70	0.72	0.82			
Re188	0.54	0.59	0.02			
Ir194m	0.50					
Pt191	0.38	0.39	0.21			
Re186	0.25*	0.26*	0.18*			36.81*
Ta182		0.04	0.06	0.18		3.76
Pt193				0.05	40.16	
Re186m						59.32

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	7.14E6	6.58E6	3.68E6	5.95E4	7.62E1	4.62E-2
Re186	28.87	31.31	28.64		0.04	40.54
Ir192	19.68	21.36	36.90	76.51	11.90	
Ir194	13.70	14.82	1.14	0.04		
Os191	12.08	13.11	20.31			
Os193	7.27	7.87	1.87			
Os191m	1.27	1.37	0.02			
Pt193m	0.73	0.79	0.79			
Ir190	0.38	0.41	0.59			
Ir193m	0.27	0.30	0.42			
Pt193			0.01	0.43	85.38	
Ir192n					2.63	
Re186m					0.05	59.45

Inh	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y	Clear	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Sv kg^{-1}	1.58E7	1.23E7	1.00E7	2.31E5	3.40E2	1.64E-1		1.48E12	1.27E12	1.16E12	3.59E10	7.90E7	8.59E2
Ir192	41.98	53.66	63.73	93.04	12.59		Ir192	67.99	78.96	83.72	90.72	8.20	
Ir194m	21.75						Ir191m	8.69	9.92	9.44			
Os191	18.22	23.29	24.81				W183m	7.27					
Re186	9.58	12.24	7.70		0.01	8.38	Ir194m	2.63					
Ir194	2.67	3.40	0.18	0.01			Os190m	1.94	1.61				
Os193	2.11	2.69	0.44				Os185	1.54	1.79	1.91	4.26		
Os191m	0.96	1.22	0.02				Ir190	1.52	1.77	1.57			
Ir193m	0.59	0.76	0.74				Ir191n	1.49					
W185	0.52	0.66	0.79	1.22			W185m	1.32	0.17				
Ir190	0.34	0.44	0.44				Re184	1.21	1.40	1.46	2.54		
Re188	0.33	0.42	0.44				Os191	1.03	1.19	1.13			
Re184	0.24	0.30	0.35	0.82			W187	0.89	1.03	0.09			
Os185	0.23	0.29	0.35	1.06			Ir192m	0.54					
Re184m	0.19	0.24	0.29	2.86			Ir194	0.51	0.59	0.03			
Os194	0.01	0.02	0.02	0.70	0.01		Os193	0.43	0.50	0.07			
Ir192n				0.15	74.35		Pt191	0.15	0.17	0.08			
Pt193				0.08	12.99		Re184m	0.12	0.14	0.16	1.33		
Re186m					0.06	91.44	Ta182	0.10	0.12	0.13	0.47		1.02
							Re186	0.09	0.11	0.06			1.45
							Os191m		0.07				
							Pt193			0.03	0.80	91.64	
							Re186m						96.82
							Re187						0.69

Osmium

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ir191m	4.90 s	&Os190(n,γ)*Os191*(β^-)Ir191m	59.7	93.5	89.3		0.5	0.3	0.2
		&Os189(n,γ)Os190(n,γ)*Os191*(β^-)Ir191m	36.0	6.4	10.5				
		&Os188(n,γ)*Os189*(n,γ)Os190(n,γ)_ *Os191*(β^-)Ir191m	3.4		0.1				
		&Os192(n,2n)*Os191*(β^-)Ir191m				92.0	61.9	38.4	28.6
		Os192(n,d)Re191(β^-)Os191(β^-)Ir191m					31.7	57.0	68.3
Ir191n	5.50 s	&Os192(n,2n)*Os191*(β^-)*Ir191*(n,n′)Ir191n				98.7	69.7	46.3	32.4
		&Os192(n,d)Re191(β^-)Os191(β^-)*Ir191*_ (n,n′)Ir191n					29.8	53.4	67.3
		&Os190(n,γ)*Os191*(β^-)*Ir191*(n,n′)Ir191n					0.5	0.3	0.3
Os190m	9.90 m	Os189(n,γ)Os190m	78.6	95.7	95.6				
		&Os188(n,γ)*Os189*(n,γ)Os190m	16.7	4.3	4.3				
		&Os187(n,γ)Os188(n,γ)*Os189*(n,γ)Os190m	2.0	15.0					
		&Os186(n,γ)Os187(n,γ)Os188(n,γ)_ *Os189*(n,γ)Os190m	0.7						
		&Os192(n,2n)*Os191*(β^-)Ir191m(IT)_ Ir191(n,2n)Ir190n(β^+)Os190m				72.9			
		Os190(n,n′)Os190m				16.5	5.6	17.8	25.5
		&Os192(n,2n)*Os191*(n,2n)Os190m				1.8			
		Os192(n,3n)Os190(n,n′)Os190m				0.3		1.4	1.2
		Os192(n,3n)Os190m					91.7	79.1	71.6
Os189m	4.806 h	Os188(n,γ)Os189m	98.6	98.7	95.6				
		Os187(n,γ)Os188(n,γ)Os189m	1.4	1.2	1.5				
		Os189(n,n′)Os189m			2.8	4.7	5.4	2.3	4.5
		Os190(n,2n)Os189m				84.2	25.4	12.2	19.2
		Os192(n,3n)Os190(n,2n)Os189m				1.4	7.9		
		Os190(n,2n)Os189(n,n′)Os189m				1.2	0.2		
		Os192(n,4n)Os189m					56.7	81.1	66.4
Ir194	19.30 h	&Os190(n,γ)*Os191*(β^-)Ir191(n,γ)*Ir192*_ (n,γ)*Ir193*(n,γ)Ir194	47.2	47.5					
		&Os189(n,γ)Os190(n,γ)*Os191*(β^-)Ir191_ (n,γ)*Ir192*(n,γ)Ir193(n,γ)Ir194	24.6	38.5					
		&Os192(n,γ)Os193(β^-)*Ir193*(n,γ)*Ir194*	23.6	1.2	97.7	94.0	93.2	93.8	94.5
		&Os190(n,γ)*Os191*(n,γ)*Os192*(n,γ)_ Os193(β^-)Ir193(n,γ)Ir194	1.3						
		&Os188(n,γ)*Os189*(n,γ)Os190(n,γ)*Os191*_ (β^-)Ir191(n,γ)*Ir192*(n,γ)*Ir193*(n,γ)Ir194	1.1	6.1					
		&Os187(n,γ)Os188(n,γ)*Os189*(n,γ)_ Os190(n,γ)*Os191*(β^-)Ir191(n,γ)*Ir192*_ (n,γ)*Ir193*(n,γ)Ir194		0.4					
Os193	1.255 d	Os192(n,γ)Os193	92.2	91.9	100.0	99.9	99.2	99.3	99.6
		&Os190(n,γ)*Os191*(n,γ)Os192(n,γ)Os193	5.8	3.5					
		&Os189(n,γ)Os190(n,γ)*Os191*(n,γ)_ Os192(n,γ)Os193	1.7	2.1					
Re186	3.775 d	&Os188(n,α)*W185*(β^-)Re185(n,γ)Re186	89.0	99.5	99.2				
		Os184(n,γ)Os185(β^+)Re185(n,γ)Re186	10.4						
		&Os187(n,γ)Os188(n,α)*W185*(β^-)_ Re185(n,γ)Re186	0.6	0.6	0.7				
		Os186(n,p)Re186				23.0	3.6	1.1	0.4
		Os190(n,α)W187(β^-)Re187(n,2n)Re186				20.5	2.0	0.2	
		Os188(n,2n)Os187(n,2n)Os186(n,p)Re186				9.4			
		Os188(n,2n)Os187(n,p)Re187(n,2n)Re186				9.3			
		Os187(n,2n)Os186(n,p)Re186				7.3	0.2		
		Os187(n,p)Re187(n,2n)Re186				7.2	0.3		
		Os188(n,2n)Os187(n,d)Re186				6.7	4.4	1.6	0.5
	►	Os188(n,d)Re187(n,2n)Re186				3.5	6.2	3.1	1.0

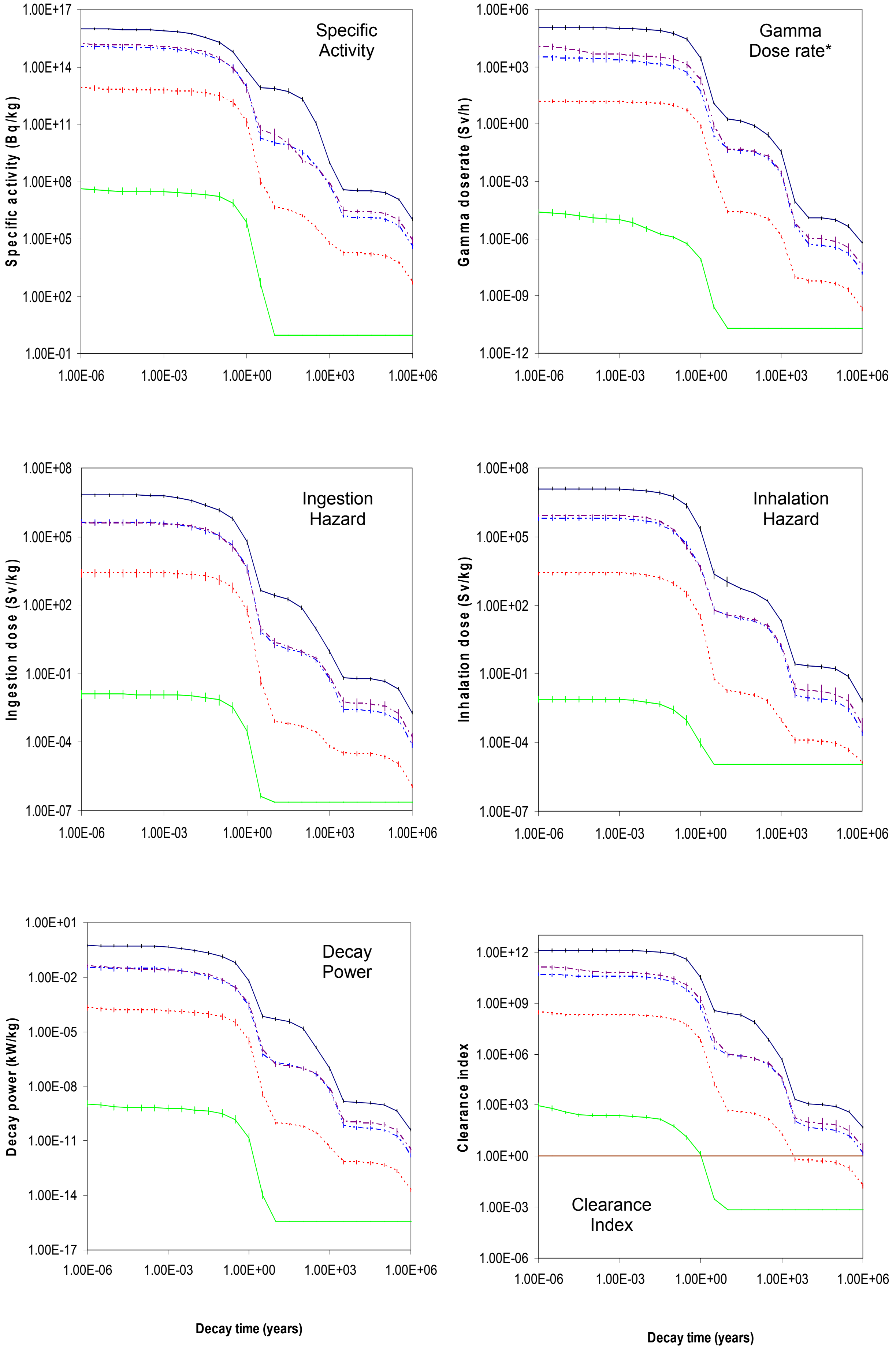
Nuclide	$T_{1/2}$	Pathway	210	186	151	42	30	21	6
	◄	Os187(n,d)Re186				2.6	9.2	4.9	2.3
		Os189(n,t)Re187(n,2n)Re186				1.4	2.1	3.0	1.4
		Os189(n,2n)Os188(n,2n)Os187(n,d)Re186				1.3	0.1		
		Os188(n,t)Re186				0.2	11.9	26.5	18.2
		Os189(n,3n)Os187(n,d)Re186				0.1	18.5	2.7	0.8
		Os188(n,3n)Os186(n,p)Re186					7.4	0.6	0.1
		Os190(n,4n)Os187(n,d)Re186					6.6	14.5	1.6
		Os190(n,3n)Os188(n,t)Re186					5.5	3.1	1.2
		Os189(n,nt)Re186					4.3	13.1	26.7
		Os189(n,4n)Os186(n,p)Re186					2.5	2.0	0.2
		Os190(n,3n)Os188(n,3n)Os186(n,p)Re186					1.7		
		Os190(n,3n)Os188(n,d)Re187(n,2n)Re186					1.4	0.2	
		Os192(n,3n)Os190(n,4n)Os187(n,d)Re186					1.0	0.6	
		Os189(n,2n)Os188(n,t)Re186					0.8	1.3	0.6
		&Os192(n,4n)*Os189*(n,nt)Re186					0.6	5.5	2.5
		Os190(n,nt)Re187(n,2n)Re186					0.3	1.1	2.1
		Os192(n,5n)Os188(n,t)Re186						4.8	4.7
		Os190(n,2nt)Re186						1.7	21.6
		Os192(n,6n)Os187(n,d)Re186							6.2
Lu172	6.70 d	Very long pathways of (n,α), (n,2n), β^-				100.0	100.0	100.0	100.0
Ir190	12.00 d	**&**Os192(n,2n)*Os191*(β^-)Ir191(n,2n)*Ir190*				94.1	63.1	37.0	28.5
		&Os192(n,d)Re191(β^-)Os191(β^-)*Ir191*_ (n,2n)*Ir190*					32.4	54.9	68.1
		&Os192(n,γ)Os193(β^-)Ir193(n,4n)*Ir190*					1.1	5.9	1.6
Os191	15.30 d	**&**Os190(n,γ)*Os191*	59.7	93.5	89.3				
		&Os189(n,γ)Os190(n,γ)*Os191*	36.0	6.4	10.5				
		&Os188(n,γ)*Os189*(n,γ)Os190(n,γ)*Os191*	3.4		0.1				
		&Os192(n,2n)*Os191*				99.5	64.9	39.7	29.2
		Os192(n,d)Re191(β^-)Os191					33.3	58.9	69.7
Re184	37.90 d	Os184(β^+)Re184		99.8	99.8				
		&Os186(n,2n)Os185(β^+)Re185(n,2n)*Re184*				78.3	6.2	1.1	0.3
		&Os187(n,2n)Os186(n,2n)Os185(β^+)_ Re185(n,2n)*Re184*				11.0	0.2		
		&Os188(n,2n)Os187(n,2n)Os186(n,2n)_ Os185(β^+)Re185(n,2n)*Re184*				7.6			
		&Os188(n,3n)Os186(n,2n)Os185(β^+)_ Re185(n,2n)*Re184*				0.1	5.6	0.3	
		&Os187(n,3n)Os185(β^+)Re185(n,2n)*Re184*					15.2	1.1	0.3
		&Os189(n,3n)Os187(n,3n)Os185(β^+)_ Re185(n,2n)*Re184*					13.8	0.3	
		&Os188(n,4n)Os185(β^+)Re185(n,2n)*Re184*					8.7	27.5	3.1
		&Os190(n,4n)Os187(n,3n)Os185(β^+)_ Re185(n,2n)*Re184*					4.9	1.6	
		&Os188(n,3n)Os186(n,t)*Re184*					3.9	2.2	1.1
		&Os188(n,d)Re187(n,4n)*Re184*					3.7	6.6	1.0
		&Os188(n,2n)Os187(n,3n)Os185(β^+)_ Re185(n,2n)*Re184*					3.2	0.2	
		&Os186(n,t)*Re184*					2.0	4.1	4.0
		&Os189(n,4n)Os186(n,2n)Os185(β^+)_ Re185(n,2n)*Re184*					1.9	0.8	
		&Os190(n,3n)Os188(n,4n)Os185(β^+)_ Re185(n,2n)*Re184*					1.8	1.4	
		&Os189(n,4n)Os186(n,t)*Re184*					1.3	7.0	1.6
		&Os189(n,t)Re187(n,4n)*Re184*					1.3	6.3	1.4
		&Os187(n,nt)*Re184*					0.4	1.5	4.1
		&Os190(n,4n)Os187(n,nt)*Re184*					0.2	4.0	2.5
		&Os190(n,nt)Re187(n,4n)*Re184*					0.1	2.4	2.1
		&Os189(n,5n)Os185(β^+)Re185(n,2n)*Re184*						5.7	7.3
		&Os190(n,5n)Os186(n,t)*Re184*						2.2	5.7
		&Os192(n,5n)Os188(n,4n)Os185(β^+)_ Re185(n,2n)*Re184*						2.2	0.3
		&Os188(n,2nt)*Re184*						0.6	16.7
	►	**&**Os190(n,6n)Os185(β^+)Re185(n,2n)*Re184*							11.2

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Os192(n,6n)Os187(n,nt)*Re184*							10.2
		&Os189(n,3nt)*Re184*							4.3
		&Os192(n,5n)Os188(n,2nt)*Re184*							4.0
Ir192	73.82 d	**&**Os190(n,γ)*Os191*(β^-)Ir191(n,γ)*Ir192*	60.4	96.8	94.5				
		&Os189(n,γ)Os190(n,γ)*Os191*(β^-)Ir191_ (n,γ)*Ir192*	35.7	3.2	5.4				
		&Os188(n,γ)*Os189*(n,γ)Os190(n,γ)_ *Os191*(β^-)Ir191(n,γ)*Ir192*	3.2						
		&Os192(n,γ)Os193(β^-)Ir193(n,2n)*Ir192*				65.4	87.7	81.6	73.8
		&Os192(n,2n)*Os191*(β^-)*Ir191*(n,γ)*Ir192*				27.6	4.1	4.1	4.1
		&Os192(n,n′)Os192m(β^-)*Ir192*				0.4	2.3	4.0	7.7
		&Os192(n,n′)Os192m(β^-)Ir192n(n,n′)*Ir192*				0.3	0.9	1.0	1.5
		&Os192(n,d)Re191(β^-)Os191(β^-)*Ir191*_ (n,γ)Ir192					1.6	4.6	7.1
W185	75.10 d	**&**Os188(n,α)*W185*	98.6	98.8	98.5	49.3	25.2	7.6	6.2
		&Os187(n,γ)Os188(n,α)*W185*	1.4	1.1	1.4				
		&Os189(n,2n)Os188(n,α)*W185*				17.7	1.5	0.3	0.1
		&Os189(n,α)W186(n,2n)*W185*				12.3	0.2		
		&Os186(n,2n)Os185(β^+)Re185(n,p)*W185*				6.1	0.4		
		&Os190(n,2n)*Os189*(n,2n)Os188(n,α)*W185*				4.3			
		&Os189(n,nα)*W185*				2.2	38.6	24.8	13.9
		&Os190(n,2n)*Os189*(n,nα)*W185*				1.0	2.9	0.9	0.3
		&Os190(n,3n)Os188(n,α)*W185*				0.5	10.9	0.8	0.3
		&Os190(n,nα)W186(n,2n)*W185*				0.1	1.5	0.7	0.2
		&Os192(n,4n)*Os189*(n,nα)*W185*					5.6	9.9	1.1
		&Os190(n,2nα)*W185*					2.5	33.8	24.5
		&Os192(n,3n)Os190(n,2nα)*W185*					0.7	2.5	1.1
		&Os188(n,4n)Os185(β^+)Re185(n,p)*W185*					0.5	3.9	0.5
		&Os189(n,t)Re187(n,t)*W185*						1.3	2.0
		&Os192(n,5n)Os188(n,α)*W185*						1.3	1.5
		&Os190(n,nt)Re187(n,t)*W185*						0.5	3.0
		&Os192(n,4nα)*W185*							30.8
Os185	93.80 d	Os184(n,γ)Os185	100.0	100.0	100.0				
		Os186(n,2n)Os185				58.4	5.7	1.9	1.2
		Os188(n,2n)Os187(n,2n)Os186(n,2n)Os185				20.7			
		Os187(n,2n)Os186(n,2n)Os185				17.2	0.3		
		Os188(n,3n)Os186(n,2n)Os185				0.2	10.9	1.0	0.3
		Os189(n,3n)Os187(n,3n)Os185					26.3	1.1	0.3
		Os187(n,3n)Os185					14.1	2.1	1.1
		Os190(n,4n)Os187(n,3n)Os185					9.4	5.7	0.7
		Os188(n,4n)Os185					8.0	48.4	11.4
		Os188(n,2n)Os187(n,3n)Os185					6.3	0.6	0.2
		Os189(n,4n)Os186(n,2n)Os185					3.6	3.3	0.5
		Os190(n,3n)Os188(n,4n)Os185					3.4	5.3	0.7
		Os190(n,3n)Os188(n,3n)Os186(n,2n)Os185					2.4		
		Os190(n,3n)Os188(n,2n)Os187(n,3n)Os185					1.4		
		Os192(n,3n)Os190(n,4n)Os187(n,3n)Os185					1.3	0.2	
		Os189(n,2n)Os188(n,4n)Os185					0.5	2.2	0.3
		Os189(n,5n)Os185						10.0	26.7
		Os192(n,5n)Os188(n,4n)Os185						8.0	2.7
		&Os192(n,4n)Os189(n,5n)*Os185*						4.0	2.3
		Os190(n,5n)Os186(n,2n)Os185						1.0	1.7
		Os190(n,6n)Os185							41.3
		Os192(n,6n)Os187(n,3n)Os185							2.6
		Os192(n,3n)Os190(n,6n)Os185							1.8
Os194	5.989 y	Os192(n,γ)Os193(n,γ)Os194	95.5	93.6	100.0	99.9	99.4	99.5	99.7
		&Os190(n,γ)*Os191*(n,γ)*Os192*(n,γ)_ Os193(n,γ)Os194	3.6	2.9					
		Os189(n,γ)Os190(n,γ)Os191(n,γ)Os192_ (n,γ)Os193(n,γ)Os194	0.3	0.5					
H3	12.33 y ►	**&**Os190(n,γ)*Os191*(β^-)Ir191(n,γ)*Ir192*_ (n,X)H1(n,γ)H2(n,γ)H3	69.4						

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Os186(n,γ)Os187(n,X)H1(n,γ)H2(n,γ)H3	29.4						
		&Os189(n,γ)Os190(n,γ)*Os191*(β$^-$)Ir191_ (n,γ)*Ir192*(n,X)H1(n,γ)H2(n,γ)H3	1.0						
		Os189(n,X)H3				43.9	21.5	17.6	16.2
		&Os192(n,2n)*Os191*(β$^-$)Ir191(n,X)H3				16.8			
		&Os190(n,2n)*Os189*(n,X)H3				11.1			0.3
		Os188(n,2n)Os187(n,X)H3				9.3			0.2
		Os187(n,X)H3				7.3	2.5	1.9	1.8
		Os188(n,X)H3				2.7	12.0	11.9	12.0
		Os190(n,X)H3				1.8	19.3	20.5	21.3
		Os189(n,2n)Os188(n,2n)Os187(n,X)H3				1.2			
		Os186(n,2n)Os185(β$^+$)Re185(n,X)H3				1.1			
		Os186(n,X)H3				0.8	1.7	1.6	1.6
		Os192(n,X)H3				0.2	23.8	27.4	29.5
		Os189(n,3n)Os187(n,X)H3				0.2	2.5		0.3
		Os192(n,3n)Os190(n,X)H3					3.0		0.5
		Os190(n,3n)Os188(n,X)H3					2.7		0.4
		Os188(n,3n)Os186(n,X)H3					1.7		0.2
		&Os192(n,4n)*Os189*(n,X)H3						3.6	0.7
		Os190(n,4n)Os187(n,X)H3						2.9	0.6
		Os189(n,4n)Os186(n,X)H3						1.5	0.3
		Os188(n,4n)Os185(β$^+$)Re185(n,X)H3						1.2	0.3
		Os192(n,5n)Os188(n,X)H3						1.1	1.5
		Os192(n,6n)Os187(n,X)H3							2.3
		Os190(n,5n)Os186(n,X)H3							1.2
		Os190(n,6n)Os185(β$^+$)Re185(n,X)H3							1.0
Hf178n	31.0 y	Very long pathways of (n,α), (n,2n), β$^-$	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Pt193	50.0 y	**&**Os190(n,γ)*Os191*(β$^-$)Ir191(n,γ)*Ir192*_ (β$^-$)Pt192(n,γ)*Pt193*	79.2	47.6	97.1				
		&Os189(n,γ)*Os190*(n,γ)*Os191*(β$^-$)Ir191_ (n,γ)*Ir192*(β$^-$)Pt192(n,γ)*Pt193*	19.5	40.2	2.8				
		&Os188(n,γ)*Os189*(n,γ)*Os190*(n,γ)*Os191*_ (β$^-$)Ir191(n,γ)*Ir192*(β$^-$)Pt192(n,γ)*Pt193*	0.5	6.8					
		&Os187(n,γ)Os188(n,γ)*Os189*(n,γ)_ *Os190*(n,γ)*Os191*(β$^-$)Ir191(n,γ)*Ir192*_ (β$^-$)Pt192(n,γ)*Pt193*		0.8					
		&Os192(n,γ)Os193(β$^-$)Ir193(n,γ)Ir194_ (β$^-$)Pt194(n,2n)*Pt193*				48.8	52.2	51.7	49.8
		&Os192(n,γ)Os193(β$^-$)Ir193(n,2n)_ *Ir192*(β$^-$)Pt192(n,γ)*Pt193*				33.7	41.7	39.3	37.1
		&Os192(n,2n)*Os191*(β$^-$)Ir191(n,γ)_ *Ir192*(β$^-$)Pt192(n,γ)*Pt193*				15.0	2.2	2.3	2.3
		&Os192(n,n′)Os192m(β$^-$)Ir192(β$^-$)_ Pt192(n,γ)*Pt193*				0.2	1.1	2.0	3.9
Ir192n	241.0 y	**&**Os190(n,γ)*Os191*(β$^-$)Ir191(n,γ)Ir192n	42.7	97.4	92.4				
		&Os189(n,γ)Os190(n,γ)*Os191*(β$^-$)*Ir191*_ (n,γ)Ir192n	25.3	0.7	3.8				
		&Os190(n,γ)*Os191*(n,γ)Os192m(β$^-$)Ir192n	17.6	1.9	3.6				
		&Os189(n,γ)Os190(n,γ)*Os191*(n,γ)_ Os192m(β$^-$)Ir192n	10.5		0.2				
		&Os188(n,γ)*Os189*(n,γ)Os190(n,γ)_ *Os191*(β$^-$)*Ir191*(n,γ)Ir192n	2.3						
		Os192(n,n′)Os192m(β$^-$)Ir192n				81.9	87.3	91.6	95.3
		Os192(n,γ)Os193(β$^-$)Ir193(n,2n)Ir192n				17.5	12.1		
Re186m	2.0 10^5 y	**&**Os188(n,α)*W185*(β$^-$)Re185(n,γ)Re186m	81.9	99.6	99.5				
		&Os187(n,γ)Os188(n,α)*W185*(β$^-$)_ Re185(n,γ)Re186m	9.5	0.4	0.4				
		Os186(n,p)Re186m				28.9	4.2	1.0	0.2
		Os190(n,α)W187(β$^-$)Re187(n,2n)Re186m				22.0			
		Os187(n,p)Re187(n,2n)Re186m				7.7			
		Os188(n,2n)Os187(n,d)Re186m				7.5	4.3	1.2	0.3
	►	Os188(n,2n)Os187(n,p)Re187(n,2n)Re186m				6.6			

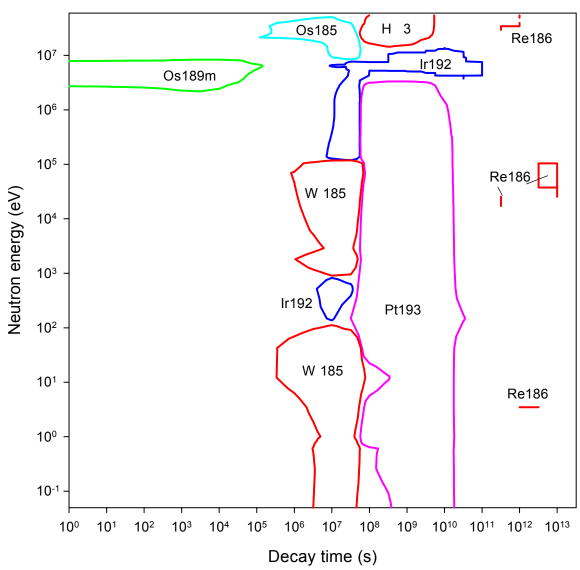
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Os187(n,d)Re186m				5.8	17.6	7.0	2.5
		Os187(n,2n)Os186(n,p)Re186m				4.6			
		Os188(n,2n)Os187(n,2n)Os186(n,p)Re186m				4.0			
		Os188(n,d)Re187(n,2n)Re186m				3.8	2.2	0.7	0.2
		Os186(n,2n)Os185(β^+)Re185(n,γ)Re186m				2.4			
		Os189(n,t)Re187(n,2n)Re186m				1.5		0.6	0.2
		Os189(n,2n)Os188(n,2n)Os187(n,d)Re186m				1.0			
		Os188(n,t)Re186m				0.4	22.2	44.1	27.5
		Os189(n,3n)Os187(n,d)Re186m				0.1	18.0	2.0	0.4
		Os190(n,4n)Os187(n,d)Re186m					6.4	10.4	0.8
		Os189(n,nt)Re186m					5.2	15.3	29.4
		Os190(n,3n)Os188(n,t)Re186m					5.1	2.6	0.9
		Os188(n,3n)Os186(n,p)Re186m					4.3	0.3	
		Os189(n,4n)Os186(n,p)Re186m					1.4	0.9	
		Os192(n,5n)Os188(n,t)Re186m						3.9	3.5
		&Os192(n,4n)*Os189*(n,nt)Re186m						3.3	1.3
		Os190(n,2nt)Re186m						1.6	24.8
		Os189(n,2n)Os188(n,t)Re186m						1.1	0.4
		Os192(n,6n)Os187(n,d)Re186m							3.3
Os184	5.6 10^{13} y	Os186(n,2n)Os185(n,2n)Os184				31.9			
		Os187(n,2n)Os186(n,2n)Os185(n,2n)Os184				4.7			
		Os188(n,2n)Os187(n,2n)Os186(n,2n)_ Os185(n,2n)Os184				3.8			
		Os188(n,3n)Os186(n,3n)Os184					32.7	2.6	0.2
		Os186(n,3n)Os184					31.8	8.9	1.7
		Os189(n,4n)Os186(n,3n)Os184					10.9	8.2	0.4
		Os190(n,3n)Os188(n,3n)Os186(n,3n)Os184					5.0	0.1	
		Os189(n,3n)Os187(n,4n)Os184					4.6	5.5	0.3
		Os187(n,4n)Os184					4.5	19.6	2.1
		Os190(n,4n)Os187(n,4n)Os184					1.6	29.1	0.7
		Os188(n,2n)Os187(n,4n)Os184					1.1	3.3	0.2
		Os187(n,2n)Os186(n,3n)Os184					1.0	0.2	
		Os188(n,5n)Os184						11.1	40.8
		Os190(n,5n)Os186(n,3n)Os184						2.5	1.3
		Os192(n,5n)Os188(n,5n)Os184						1.0	5.2
		Os190(n,3n)Os188(n,5n)Os184						0.7	1.4
		Os189(n,6n)Os184							35.7
		Os192(n,6n)Os187(n,4n)Os184							2.7
		Nuclide also present in starting material		100.0	100.0	59.6	6.8	7.2	7.3
Os186	2.0 10^{15} y	**&**Os188(n,α)*W185*(β^-)Re185(n,γ)_ Re186(β^-)Os186	73.5	3.5	9.4				
		&Os187(n,γ)Os188(n,α)*W185*(β^-)_ Re185(n,γ)Re186(β^-)Os186	9.8	2.0					
		Os188(n,2n)Os187(n,2n)Os186				22.7	0.3	0.2	
		Os187(n,2n)Os186				17.7	1.3	0.9	0.7
		Os189(n,2n)Os188(n,2n)Os187(n,2n)Os186				2.9			
		Os189(n,3n)Os187(n,2n)Os186				0.4	1.3	0.3	0.1
		Os188(n,3n)Os186				0.2	44.3	12.1	7.9
		Os189(n,4n)Os186					14.8	38.2	11.6
		Os190(n,3n)Os188(n,3n)Os186					10.3	0.7	0.3
		Os189(n,2n)Os188(n,3n)Os186					1.5	0.3	0.1
		&Os192(n,4n)*Os189*(n,4n)Os186					1.2	8.0	0.6
		Os192(n,3n)Os190(n,3n)Os188(n,3n)Os186					1.1		
		Os190(n,5n)Os186						11.9	40.8
		Os192(n,5n)Os188(n,3n)Os186						1.1	1.0
		Os189(n,nt)Re186(β^-)Os186						0.3	1.3
		Os192(n,7n)Os186							3.1
		Os192(n,6n)Os187(n,2n)Os186							1.0
		Os190(n,2nt)Re186(β^-)Os186							1.0
		Nuclide also present in starting material	16.7	94.5	90.6	56.1	23.9	26.0	30.5

Osmium activation characteristics

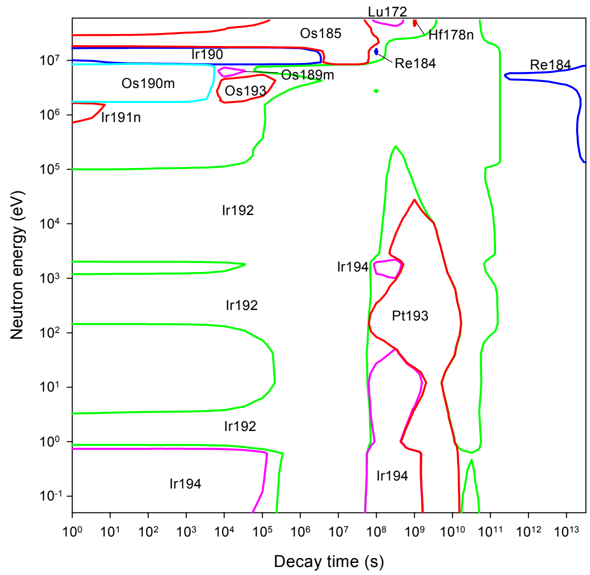


Osmium importance diagrams & transmutation

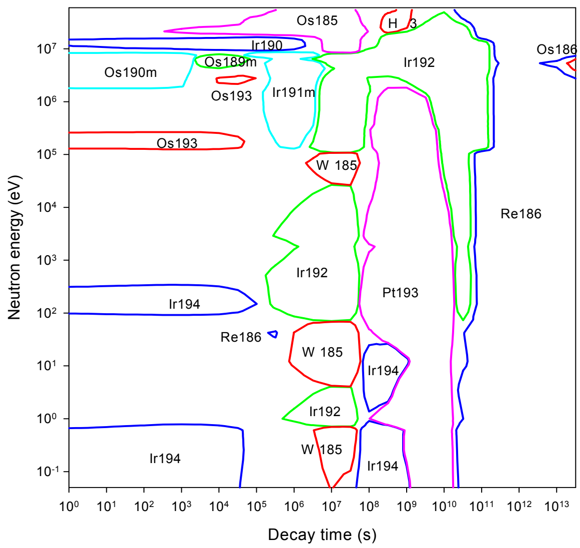
Activity



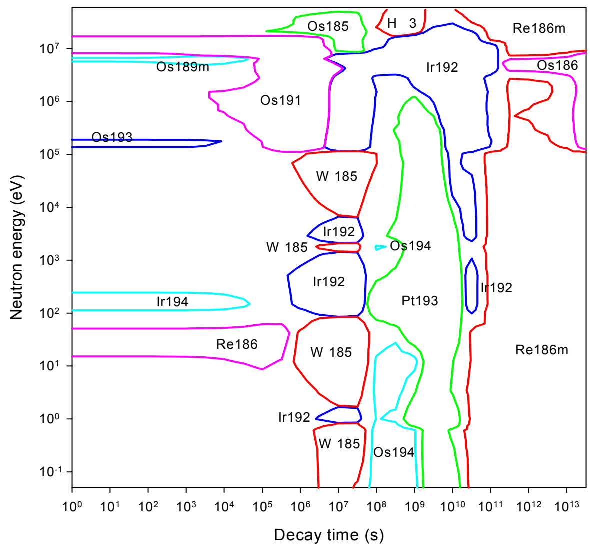
Dose rate



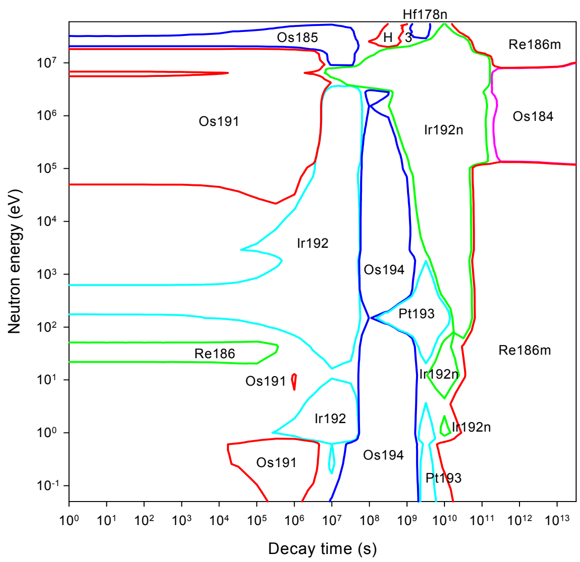
Heat output



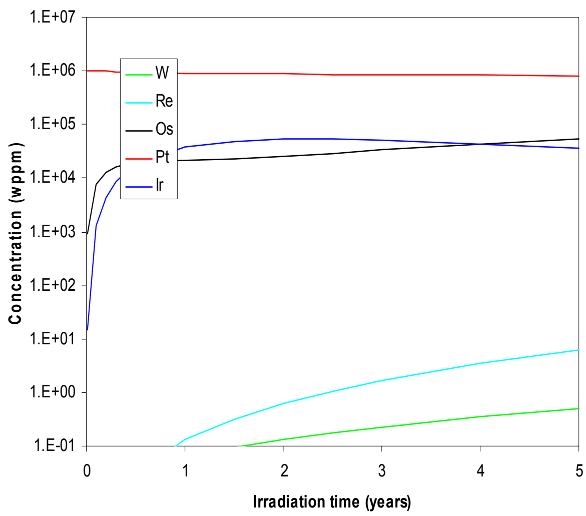
Ingestion dose



Inhalation dose



First wall transmutation



Iridium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	77		
Crustal abundance / wppm	1.0 10^{-3}	Ir191	37.3
Melting point / K	2719	Ir193	62.7
Boiling point / K	4701		
Density / kgm^{-3}	22420		
Thermal conductivity / $Wm^{-1}K^{-1}$	147		
Electrical resistivity /Ωm	5.3 10^{-8}		
Coefficient of thermal expansion / K^{-1}	6.4 10^{-6}		
Crystal structure	FCC		
Number of stable isotopes	2		
Mean atomic weight	192.217		

Activation properties

Act	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y	Heat	0	10^{-5} y	10^{-2} y	1 y	100 y	10^{5} y
Bq kg^{-1}	1.08E16	8.07E15	2.22E15	1.38E14	2.62E13	9.36E2	kW kg^{-1}	1.05E0	9.92E-1	2.31E-1	6.48E-3	1.85E-4	3.65E-14
Ir194	49.14	65.76	10.31				Ir194	73.21	77.24	14.31			
Ir194m	17.25						Ir192	16.97	17.96	74.67	89.36	5.02	
Ir192	9.93	13.33	46.89	25.33	0.21		Ir194m	4.19					
Pt193m	9.04	12.12	24.64				Pt193m	2.25	2.37	5.70			
Ir192m	8.47	0.90					Ir192m	0.80	0.07				
Ir193m	1.51	2.02	5.80				Pt191	0.72	0.77	1.34			
Pt191	1.22	1.63	2.41				Ir190	0.45	0.47	1.65			
Pt193	0.96	1.29	4.70	74.61	99.57		Pt195m	0.33	0.35	0.79			
Pt195m	0.81	1.08	2.10				Pt193	0.07	0.07	0.30	10.60	94.16	
Os191	0.26	0.35	1.09				Re186						73.52
Re186						49.98	Re186m						26.36
Re186m						49.98	Pt190						0.10
Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	1.59E5	1.53E5	8.22E4	2.56E3	1.24E1	3.81E-10	Sv kg^{-1}	1.30E7	9.06E6	2.12E6	5.21E4	9.05E2	1.73E-6
Ir192	50.30	52.50	91.75	98.71	32.64		Ir194	53.21	76.14	14.01			
Ir194	41.22*	42.88	3.34				Ir194m	30.16					
Ir194m	2.61						Ir192	11.58	16.62	68.64	93.83	8.68	
Ir190	2.13	2.23	3.26				Pt193m	3.39	4.86	11.59			
Pt191	1.70	1.77	1.30				Pt195m	0.42	0.61	1.38			
Ir191n	1.38						Ir193m	0.34	0.49	1.64			
Pt193	0.02	0.02	0.04	1.29	67.32		Pt193	0.03	0.04	0.15	6.12	89.41	
Ir192n					0.04		Ir192n				0.04	1.92	
Re186m						60.79	Re186m						59.43
Re186						36.50*	Re186						40.52
Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	3.49E7	1.06E7	7.33E6	2.36E5	3.10E3	6.15E-6		1.49E12	1.18E12	1.07E12	3.85E10	9.57E8	3.22E-2
Ir194m	69.69						Ir192	72.45	90.94	96.73	90.78	5.86	
Ir192	20.37	67.27	93.64	97.83	11.93		Ir194m	18.50					
Ir194	8.55	28.15	1.75				Ir194	3.59	4.49	0.21			
Ir193m	0.61	2.01	2.28				Ir190	1.27	1.60	1.43			
Pt193m	0.34	1.11	0.90				Ir191n	1.25					
Os191	0.15	0.50	0.63				Pt191	0.89	1.11	0.50			
Ir192n	0.01	0.03	0.04	1.23	70.42		Pt195m	0.54	0.67	0.39			
Pt193	0.01	0.02	0.03	0.92	17.66		Pt193	0.24	0.30	0.33	9.22	94.03	
Re186m						91.24	Pt193m	0.07	0.08	0.05			
Re186						8.36	Re186m						96.73
Pt190						0.26	Re186						1.45

Iridium

Pathway analysis

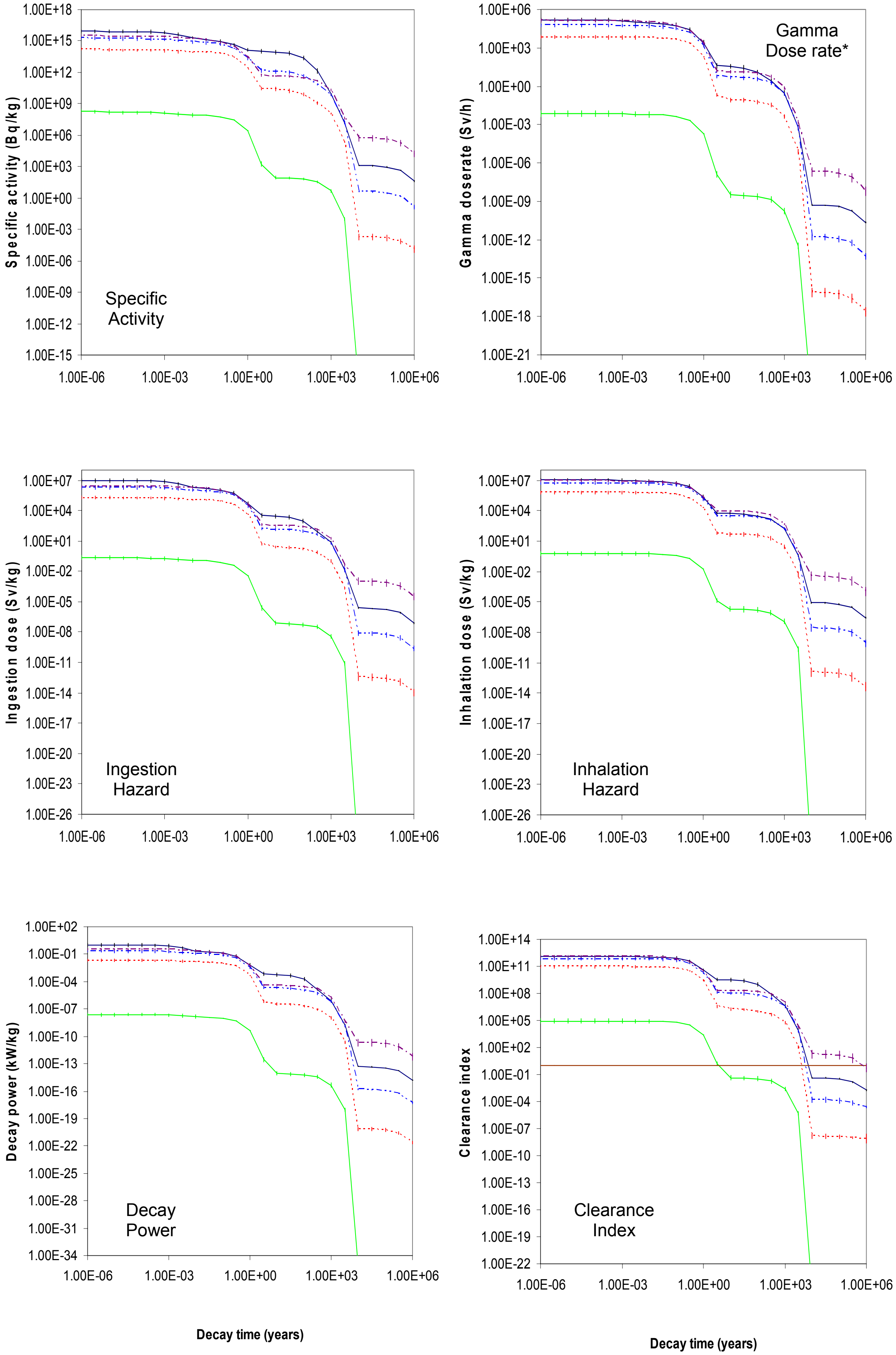
Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ir191n	5.50 s	Ir191(n,n′)Ir191n				86.9	76.1	90.1	92.7
		Ir193(n,2n)Ir192(β^-)Pt192(n,2n)Pt191_ (β^+)Ir191(n,n′)Ir191n				4.3	0.1		
		&Ir193(n,3n)*Ir191*(n,n′)Ir191n					17.0	4.9	
		Ir193(n,3n)Ir191n					3.7	1.7	1.5
Ir194	19.30 h	&Ir193(n,γ)*Ir194*	59.0	65.5	99.8	99.0	100.0	99.8	100.0
		&Ir191(n,γ)*Ir192*(n,γ)*Ir193*(n,γ)*Ir194*	37.5	34.5	0.2				
Ir188	1.729 d	&Ir191(n,2n)*Ir190*(n,2n)Ir189(n,2n)Ir188				65.9			
		Ir191(n,3n)Ir189(n,2n)Ir188				15.9	1.7		
		Ir193(n,2n)Ir192(β^-)Pt192(n,2n)Pt191(β^+)_ Ir191(n,2n)Ir190(n,2n)Ir189(n,2n)Ir188				2.8			
		&Ir191(n,2n)*Ir190*(n,3n)Ir188				1.6	0.8		
		Ir191(n,4n)Ir188					63.7	91.3	23.3
		&Ir193(n,3n)*Ir191*(n,4n)Ir188					14.3	5.0	
		Ir193(n,2n)Ir192(β^-)Pt192(n,3n)Pt190_ (n,3n)Pt188(β^+)Ir188					10.3		
		Ir193(n,6n)Ir188							71.5
Au198	2.694 d	&Ir193(n,γ)Ir194(n,γ)*Ir195*(β^-)Pt195(n,γ)_ Pt196(n,γ)*Pt197*(β^-)Au197(n,γ)*Au198*	35.4	0.8	0.2				
		&Ir193(n,γ)Ir194(β^-)Pt194(n,γ)*Pt195*(n,γ)_ Pt196(n,γ)*Pt197*(β^-)Au197(n,γ)*Au198*	23.1	68.4	99.2	100.0			
		&Ir191(n,γ)*Ir192*(n,γ)Ir193(n,γ)Ir194_ (n,γ)Ir195(β^-)Pt195(n,γ)Pt196(n,γ)*Pt197*_ (β^-)Au197(n,γ)*Au198*	19.7	0.2					
		&Ir191(n,γ)*Ir192*(n,γ)Ir193(n,γ)Ir194_ (β^-)Pt194(n,γ)*Pt195*(n,γ)Pt196(n,γ)_ *Pt197*(β^-)Au197(n,γ)*Au198*	12.4	17.1					
		&Ir193(n,γ)Ir194(n,γ)Ir195m(β^-)Pt195_ (n,γ)Pt196(n,γ)*Pt197*(β^-)Au197(n,γ)*Au198*	4.8	0.1					
		&Ir191(n,γ)*Ir192*(n,γ)Ir193(n,γ)Ir194_ (n,γ)Ir195m(β^-)Pt195(n,γ)Pt196(n,γ)_ *Pt197*(β^-)Au197(n,γ)*Au198*	2.3						
		&Ir191(n,γ)*Ir192*(β^-)Pt192(n,γ)*Pt193*_ (n,γ)Pt194(n,γ)*Pt195*(n,γ)Pt196(n,γ)_ *Pt197*(β^-)Au197(n,γ)*Au198*	0.1	11.7					
Au199	3.139 d	&Ir193(n,γ)Ir194(n,γ)*Ir195*(β^-)Pt195_ (n,γ)Pt196(n,γ)*Pt197*(β^-)Au197(n,γ)_ *Au198*(n,γ)Au199	35.7	0.8					
		&Ir193(n,γ)Ir194(β^-)Pt194(n,γ)*Pt195*_ (n,γ)Pt196(n,γ)*Pt197*(β^-)Au197(n,γ)_ *Au198*(n,γ)Au199	22.6	66.2	100.0				
		&Ir191(n,γ)*Ir192*(n,γ)Ir193(n,γ)Ir194_ (n,γ)Ir195(β^-)Pt195(n,γ)Pt196(n,γ)_ *Pt197*(β^-)Au197(n,γ)*Au198*(n,γ)Au199	19.9						
		&Ir191(n,γ)*Ir192*(n,γ)Ir193(n,γ)Ir194_ (β^-)Pt194(n,γ)*Pt195*(n,γ)Pt196(n,γ)_ *Pt197*(β^-)Au197(n,γ)*Au198*(n,γ)Au199	12.1	15.9					
		&Ir193(n,γ)Ir194(n,γ)Ir195m(β^-)Pt195_ (n,γ)Pt196(n,γ)*Pt197*(β^-)Au197(n,γ)_ *Au198*(n,γ)Au199	4.8						
		&Ir191(n,γ)*Ir192*(n,γ)Ir193(n,γ)Ir194(n,γ)_ Ir195m(β^-)Pt195(n,γ)Pt196(n,γ)*Pt197*(β^-)_ Au197(n,γ)*Au198*(n,γ)Au199	2.2						
		&Ir191(n,γ)*Ir192*(β^-)Pt192(n,γ)*Pt193*_ (n,γ)Pt194(n,γ)*Pt195*(n,γ)Pt196(n,γ)*Pt197*_ (β^-)Au197(n,γ)*Au198*(n,γ)Au199		11.2					

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Re186	3.775 d	&Ir191(n,α)Re188(β^-)Os188(n,α)_ *W185*(β^-)Re185(n,γ)Re186	100.0	100.0	100.0				
		&Ir191(n,2n)*Ir190*(β^+)Os190(n,α)_ W187(β^-)Re187(n,2n)Re186				61.8	0.2		
		Ir191(n,nα)Re187(n,2n)Re186				22.5	17.2	2.2	0.4
		Ir191(n,2n)Ir190n(β^+)Os190m(IT)_ Os190(n,α)W187(β^-)Re187(n,2n)Re186				4.0			
		&Ir191(n,2n)*Ir190*(n,α)Re187(n,2n)Re186				1.9			
		&Ir191(n,3n)Ir189(β^+)*Os189*(n,3n)_ Os187(n,d)Re186					26.2	0.6	
		Ir191(n,2nα)Re186					14.6	30.4	13.4
		&Ir191(n,3n)Ir189(β^+)*Os189*(n,nt)Re186					12.4	6.2	5.0
		&Ir191(n,3n)Ir189(β^+)*Os189*(n,4n)_ Os186(n,p)Re186					3.5	0.4	
		&Ir193(n,3n)*Ir191*(n,2nα)Re186					3.3	1.7	0.4
		&Ir191(n,3n)Ir189(β^+)*Os189*(n,t)Re187_ (n,2n)Re186					3.0	0.6	0.1
		Ir191(n,3n)Ir189(β^+)Os189(n,2n)Os188_ (n,t)Re186					1.0	0.3	
		Ir191(n,4n)Ir188(β^+)Os188(n,t)Re186					0.9	28.1	3.5
		Ir193(n,4n)Ir190(β^+)Os190(n,4n)Os187_ (n,d)Re186					0.6	3.9	
		Ir191(n,5n)Ir187(β^+)Os187(n,d)Re186						3.8	11.2
		&Ir193(n,5n)Ir189(β^+)*Os189*(n,nt)Re186						3.1	19.5
		Ir193(n,4n)Ir190(β^+)Os190(n,2nt)Re186						0.9	1.9
		Ir193(n,3nα)Re187(n,2n)Re186						0.4	1.1
		Ir193(n,4nα)Re186							17.6
		Ir193(n,6n)Ir188(β^+)Os188(n,t)Re186							10.5
		&Ir193(n,nt)*Os190*(n,2nt)Re186							1.1
Pt195m	4.020 d	&Ir193(n,γ)*Ir194*(β^-)Pt194(n,γ)Pt195m	63.1	63.4	99.6	94.5	96.4	97.5	98.4
		&Ir191(n,γ)*Ir192*(n,γ)*Ir193*(n,γ)*Ir194*_ (β^-)Pt194(n,γ)Pt195m	36.1	20.7					
		&Ir191(n,γ)*Ir192*(β^-)Pt192(n,γ)*Pt193*_ (n,γ)Pt194(n,γ)Pt195m	0.1	15.7					
		&Ir193(n,γ)*Ir194*(β^-)Pt194(n,γ)Pt195_ (n,n′)Pt195m				2.4	1.4	0.9	0.6
Pt193m	4.340 d	&Ir191(n,γ)*Ir192*(β^-)Pt192(n,γ)Pt193m	99.5	99.9	100.0				
		&Ir193(n,γ)*Ir194*(β^-)Pt194(n,2n)Pt193m				71.2	71.1	73.3	75.8
		&Ir193(n,2n)*Ir192*(β^-)Pt192(n,γ)Pt193m				24.3	25.8	24.2	22.6
Ir193m	10.602 d	&Ir191(n,γ)*Ir192*(β^+)Os192(n,γ)Os193_ (β^-)Ir193m	91.9	1.1	0.1				
		&Ir191(n,γ)*Ir192*(n,γ)Ir193m		97.8	99.5				
		Ir193(n,n′)Ir193m				99.9	99.9	99.9	99.9
Ir190	12.00 d	&Ir191(n,2n)*Ir190*				87.8	43.4	10.8	28.3
		&Ir193(n,2n)*Ir192*(β^-)Pt192(n,2n)_ Pt191(β^+)Ir191(n,2n)*Ir190*				3.8			
		&Ir193(n,4n)*Ir190*					40.9	86.8	69.0
		&Ir193(n,3n)*Ir191*(n,2n)*Ir190*					9.4		
		&Ir193(n,2n)Ir192n(n,3n)*Ir190*					3.2		
Ir189	13.20 d	&Ir191(n,2n)*Ir190*(n,2n)Ir189				67.2			
		Ir191(n,3n)Ir189				16.1	78.5	57.1	19.6
		&Ir193(n,2n)*Ir192*(β^-)Pt192(n,2n)_ Pt191(β^+)Ir191(n,2n)*Ir190*(n,2n)Ir189				4.5			
		&Ir193(n,2n)*Ir192*(β^-)Pt192(n,2n)_ Pt191(β^+)Ir191(n,3n)Ir189				1.1			
		&Ir193(n,3n)*Ir191*(n,3n)Ir189					17.6	3.1	
		Ir193(n,2n)Ir192n(n,4n)Ir189					0.4	2.9	
		Ir193(n,5n)Ir189						29.9	77.0
		Ir193(n,2n)Ir192(β^-)Pt192(n,4n)Pt189(β^+)Ir189						2.7	
Hg203	46.603 d	Very long pathways of (n,α), (n,2n), β^-	100.0	100.0	100.0				
Ir192	73.822d▶	&Ir191(n,γ)*Ir192*	100.0	99.0	100.0				

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◀	Ir193(n,2n)*Ir192*				95.9	96.9	97.7	97.5
Os185	93.80 d	Ir191(n,nα)Re187(n,2n)Re186(β$^-$)_ Os186(n,2n)Os185				65.7			
		Ir191(n,2nα)Re186(β$^-$)Os186(n,2n)Os185				25.1			
		&Ir191(n,3n)Ir189(β$^+$)*Os189*(n,3n)_ Os187(n,3n)Os185					66.7	0.3	
		&Ir191(n,3n)Ir189(β$^+$)*Os189*(n,4n)_ Os186(n,2n)Os185					9.3	1.0	
		Ir191(n,4n)Ir188(β$^+$)Os188(n,4n)Os185					1.0	67.8	3.7
		&Ir191(n,3n)Ir189(β$^+$)*Os189*(n,5n)Os185						6.3	8.6
		&Ir193(n,5n)Ir189(β$^+$)*Os189*(n,5n)Os185						3.1	33.6
		Ir191(n,5n)Ir187(β$^+$)Os187(n,3n)Os185						2.1	8.6
		Ir193(n,6n)Ir188(β$^+$)Os188(n,4n)Os185							11.3
		Ir193(n,4n)Ir190(β$^+$)Os190(n,6n)Os185							6.3
		&Ir193(n,nt)*Os190*(n,6n)Os185							3.7
		Other similar long pathways				9.2	23.0	19.4	24.2
Os194	5.989 y	**&**Ir191(n,γ)*Ir192*(β$^+$)Os192(n,γ)Os193_ (n,γ)Os194	100.0	100.0	100.0				
		Ir193(n,p)Os193(n,γ)Os194				68.2	69.8	71.0	71.4
		&Ir193(n,γ)*Ir194*(n,p)Os194				29.2	28.4	27.7	27.8
H3	12.33 y	**&**Ir191(n,γ)*Ir192*(n,X)H1(n,γ)H2(n,γ)H3	91.7						
		Ir193(n,2n)Ir192n(n,X)H3				42.3	1.3	0.7	
		Ir191(n,X)H3				25.8	33.8	33.7	33.3
		Ir193(n,X)H3				22.2	51.8	52.9	51.5
		&Ir193(n,2n)*Ir192*(n,X)H3				4.7	0.1		
		Ir191(n,3n)Ir189(β$^+$)Os189(n,X)H3					4.5	1.4	
		&Ir193(n,3n)*Ir191*(n,X)H3					3.6		
		Ir191(n,4n)Ir188(β$^+$)Os188(n,X)H3						2.4	
		Ir191(n,5n)Ir187(β$^+$)Os187(n,X)H3							2.1
		Ir193(n,6n)Ir188(β$^+$)Os188(n,X)H3							1.7
Pt193	50.0 y	**&**Ir191(n,γ)*Ir192*(β$^-$)Pt192(n,γ)*Pt193*	99.5	100.0	100.0				
		Ir191(n,γ)Ir192m(β$^-$)Pt192(n,γ)Pt193	0.3						
		&Ir193(n,γ)Ir194(β$^-$)Pt194(n,2n)*Pt193*				56.8	53.6	54.9	55.6
		&Ir193(n,2n)*Ir192*(β$^-$)Pt192(n,γ)*Pt193*				41.5	45.0	44.0	43.7
Ir192n	241.0 y	Ir191(n,γ)Ir192n	100.0	99.1	100.0				
		Ir193(n,2n)Ir192n				97.8	98.2	98.1	98.1
Re186m	2.0 10^5 y	**&**Ir191(n,α)Re188(β$^-$)Os188(n,α)_ *W185*(β$^-$)Re185(n,γ)Re186m	94.6	100.0	100.0				
		&Ir191(n,2n)*Ir190*(β$^+$)Os190(n,α)_ W187(β$^-$)Re187(n,2n)Re186m				54.1			
		Ir191(n,nα)Re187(n,2n)Re186m				30.2	9.2	0.5	0.1
		Ir191(n,2n)Ir190n(β$^+$)Os190m(IT)Os190_ (n,α)W187(β$^-$)Re187(n,2n)Re186m				3.5			
		&Ir191(n,2n)*Ir190*(n,nα)Re186m				2.6	0.2		
		&Ir191(n,2n)*Ir190*(n,α)Re187(n,2n)Re186m				2.5			
		Ir191(n,2nα)Re186m					31.4	50.9	16.1
		&Ir191(n,3n)Ir189(β$^+$)*Os189*(n,3n)_ Os187(n,d)Re186m					25.8		
		&Ir191(n,3n)Ir189(β$^+$)*Os189*(n,nt)Re186m					11.3	3.7	4.3
		&Ir193(n,3n)*Ir191*(n,2nα)Re186m					3.5	1.3	0.2
		&Ir191(n,3n)Ir189(β$^+$)*Os189*(n,4n)_ Os186(n,p)Re186m					2.1		
		Ir191(n,4n)Ir188(β$^+$)Os188(n,t)Re186m					1.3	26.4	4.2
		Ir191(n,3n)Ir189(β$^+$)Os189(n,2n)Os188_ (n,t)Re186m					1.0		
		Ir191(n,3n)Ir189(β$^+$)Os189(n,t)Re187_ (n,2n)Re186m					1.0		
		Ir191(n,3n)Ir189(n,3n)Ir187(β$^+$)Os187_ (n,d)Re186m					1.0		
	▶	Ir193(n,4n)Ir190(β$^+$)Os190(n,4n)Os187_ (n,d)Re186m					0.6	2.1	

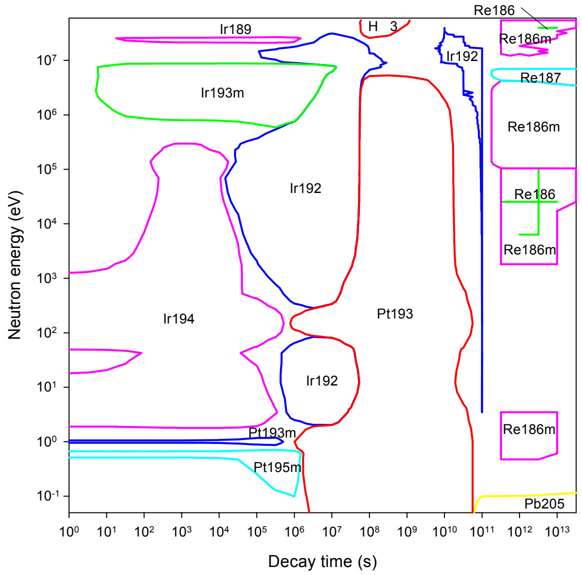
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Ir191(n,5n)Ir187(β^+)Os187(n,d)Re186m						3.1	9.4
		&Ir193(n,5n)Ir189(β^+)*Os189*(n,nt)Re186m						1.8	16.9
		Ir191(n,nt)Os188(n,t)Re186m						0.5	1.5
		Ir193(n,4nα)Re186m							22.5
		Ir193(n,6n)Ir188(β^+)Os188(n,t)Re186m							12.6
		&Ir193(n,4n)*Ir190*(β^+)Os190(n,2nt)Re186m							1.9
Pb205	1.5 10^7 y	Very long pathways of (n,α), (n,2n), β^-	100.0						
Re187	4.3 10^{10} y	Ir191(n,α)Re188(β^-)Os188(n,α)W185_ (β^-)Re185(n,γ)Re186(β^+)W186(n,γ)_ W187(β^-)Re187	34.8	0.2	6.6				
		&Ir193(n,α)*Re190*(β^-)Os190(n,α)_ W187(β^-)Re187	32.0						
		&Ir191(n,α)Re188(β^-)Os188(n,α)_ *W185*(n,γ)W186(n,γ)W187(β^-)Re187	13.3	0.6	24.3				
		&Ir191(n,α)Re188(β^-)Os188(n,α)_ *W185*(β^-)Re185(n,γ)Re186(n,γ)Re187	8.4	92.2	59.4				
		&Ir191(n,α)Re188(β^-)Os188(n,α)_ *W185*(β^-)Re185(n,γ)Re186m(n,γ)Re187	2.0	4.2	8.7				
		&Ir191(n,γ)Ir192(β^-)Pt192(n,α)Os189_ (n,γ)Os190(n,α)W187(β^-)Re187		2.4					
		&Ir191(n,2n)*Ir190*(β^+)*Os190*(n,α)_ W187(β^-)Re187				62.8	0.9		
		Ir191(n,nα)Re187				23.0	69.1	34.1	13.8
		Ir191(n,2n)Ir190n(β^+)Os190m(IT)_ Os190(n,α)W187(β^-)Re187				4.1			
		&Ir191(n,2n)*Ir190*(n,α)Re187				1.9			
		&Ir191(n,3n)Ir189(β^+)*Os189*(n,t)Re187					12.1	10.9	4.3
		&Ir193(n,3n)*Ir191*(n,nα)Re187					7.6	0.9	0.2
		Ir191(n,4n)Ir188(β^+)Os188(n,d)Re187					1.0	25.8	3.2
		Ir191(n,3n)Ir189(β^+)Os189(n,3n)Os187_ (n,p)Re187					1.0		
		&Ir193(n,4n)*Ir190*(β^+)Os190(n,nt)Re187					0.1	5.0	3.5
		&Ir191(n,2n)*Ir190*(β^+)Os190(n,nt)Re187					0.1	0.6	1.5
		Ir193(n,3nα)Re187						6.0	36.5
		&Ir193(n,5n)Ir189(β^+)*Os189*(n,t)Re187						5.4	16.8
		Ir191(n,nt)Os188(n,d)Re187						0.5	1.1
		Ir191(n,5n)Ir187(β^+)Os187(n,p)Re187						0.4	1.0
		&Ir193(n,nt)*Os190*(n,nt)Re187						0.1	1.9
		Ir193(n,6n)Ir188(β^+)Os188(n,d)Re187							9.6

Iridium activation characteristics

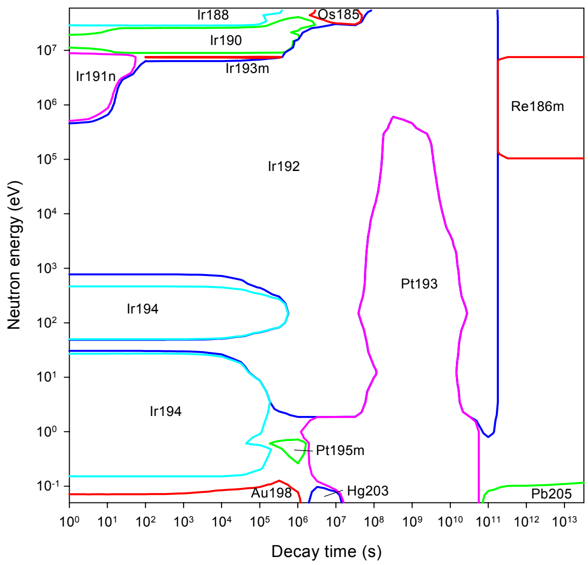


Iridium importance diagrams & transmutation

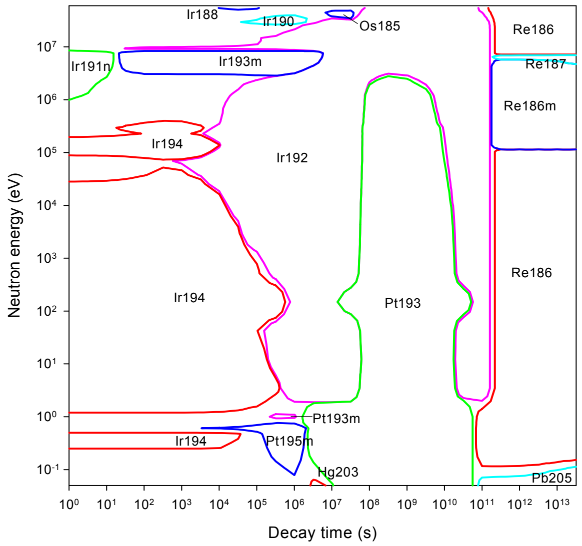
Activity



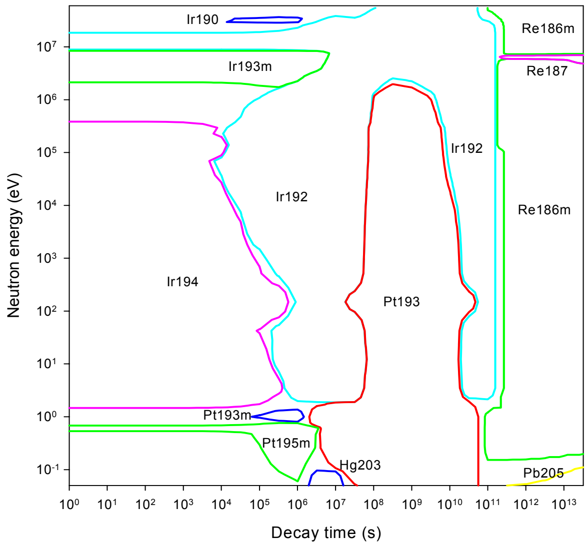
Dose rate



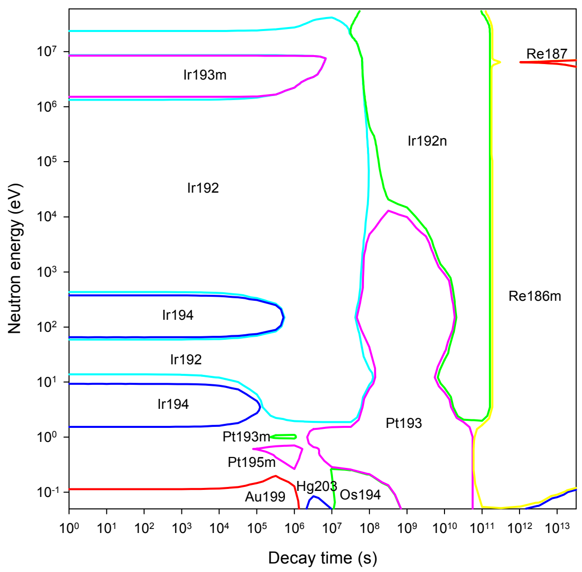
Heat output



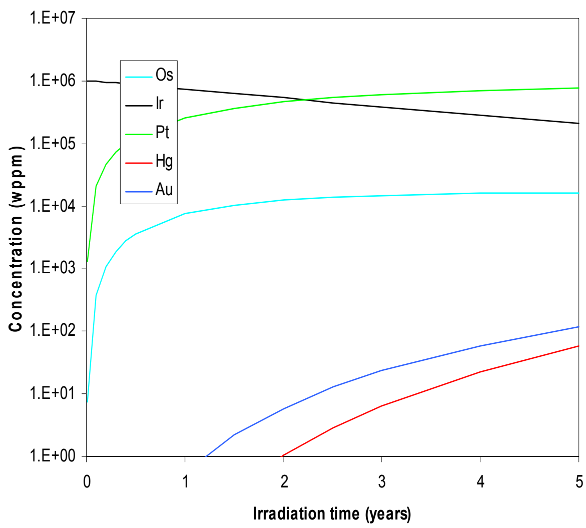
Ingestion dose



Inhalation dose



First wall transmutation



Platinum

General properties

		Isotopes	Isotopic abundances / %
Atomic number	78		
Crustal abundance / wppm	5.0 10^{-3}	Pt190	0.014 ($T_{1/2}$=6.50 10^{11} y)
Melting point / K	2041.6	Pt192	0.782
Boiling point / K	4098	Pt194	32.967
Density / kgm^{-3}	21450	Pt195	33.832
Thermal conductivity / $Wm^{-1}K^{-1}$	71.6	Pt196	25.242
Electrical resistivity /Ωm	1.06 10^{-7}	Pt198	7.163
Coefficient of thermal expansion / K^{-1}	8.8 10^{-6}		
Crystal structure	FCC		
Number of stable isotopes	5 (6)		
Mean atomic weight	195.08		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	2.36E15	2.31E15	6.82E14	1.56E13	3.92E12	1.52E1
Pt197	26.05	26.58	4.28			
Au198	20.29	20.74	27.51			
Pt195m	13.53	13.84	25.00			
Au199	12.50	12.79	19.48			
Pt199	12.24	11.13				
Pt193m	9.47	9.68	18.33			
Pt197m	1.99	1.96				
Pt193	0.66	0.67	2.29	99.16	99.99	
Au196	0.52	0.53	1.21			
Ir192	0.16	0.16	0.54	0.80		
Pt190						47.35
Re186						26.31
Re186m						26.31

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	1.56E-1	1.51E-1	3.98E-2	1.24E-4	2.62E-5	4.04E-15
Au198	35.84	36.98	55.07			
Pt199	22.22	20.38				
Pt197	17.59	18.12	3.28			
Pt195m	8.03	8.29	16.81			
Au199	7.30	7.54	12.90			
Pt193m	3.45	3.56	7.56			
Pt197m	1.89	1.88				
Ir194	0.96	0.99	0.16			
Au196	0.63	0.65	1.66			
Ir192	0.40	0.42	1.55	16.74	0.04	
Pt193	0.06	0.06	0.26	83.17	99.94	
Ir194m	0.05					
Pt190						92.31

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	3.07E4	2.99E4	9.57E3	1.37E1	1.22E0	3.16E-12
Au198	72.50	74.54	90.98			
Pt199	21.04	19.23				
Au196	1.14	1.17	2.44			
Au199	1.09	1.12	1.58			
Ir192	0.89	0.91	2.76	64.98	0.43	
Pt195m	0.76	0.78	1.30			
Pt197	0.50	0.51	0.07			
Ir194m	0.02					
Pt193		0.01	0.05	34.98	99.56	
Re186m						60.37
Re186						36.58*

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.21E6	1.20E6	4.34E5	6.56E2	1.22E2	7.36E-8
Au198	39.51	39.80	43.24			
Pt197	20.28	20.40	2.69			
Pt195m	16.60	16.73	24.76			
Au199	10.71	10.80	13.47			
Pt193m	8.30	8.36	12.96			
Ir194	1.11	1.25	0.13			
Pt199	0.93	0.83				
Ir194m	0.60					
Ir192	0.44	0.44	1.20	26.74	0.08	
Pt193	0.04	0.04	0.11	73.04	99.89	
Pt190						79.95
Re186m						11.92
Re186						8.13

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	8.79E5	8.32E5	3.46E5	1.17E3	8.57E1	1.70E-6
Au198	46.94	49.53	46.64			
Au199	26.57	28.06	30.34			
Pt195m	6.55	6.91	8.87			
Pt197	5.95	6.91	8.87			
Ir194m	5.20					
Pt193m	3.05	3.22	4.33			
Ir192	2.90	3.06	7.12	70.95	0.57	
Ir194	0.66	0.70	0.07			
Au196	0.52	0.55	0.88			
Hg197	0.39	0.42	0.47			
Pt193	0.03	0.03	0.09	27.85	96.00	
Ir192n				0.33	3.41	
Os194				0.07		
Pt190						96.92

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	1.72E11	1.61E11	4.43E10	6.59E8	1.35E8	7.45E-3
Pt199	43.10	41.06				
Au198	27.85	29.84	42.31			
Pt195m	16.89	18.09	34.96			
Au196	3.42	3.66	8.87			
Ir192	2.24	2.40	8.42	19.02	0.05	
Au199	1.71	1.84	2.99			
Pt197	0.35	0.38	0.06			
Pt193	0.31	0.33	1.21	80.90	99.94	
Ir194m	0.30					
Pt197m	0.27	0.28				
Pt193m	0.13	0.13	0.28			
Pt190						96.32
Re186m						3.56
Re186						0.05

Platinum

Pathway analysis

Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Pt199	30.80 m	**&**Pt198(n,γ)*Pt199*	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Pt197	19.892 h	**&**Pt195(n,γ)Pt196(n,γ)*Pt197*	49.9	57.5	15.8				
		&Pt196(n,γ)*Pt197*	48.1	42.7	83.9	0.5	0.5	0.4	
		&Pt194(n,γ)*Pt195*(n,γ)Pt196(n,γ)*Pt197*	2.0		0.3				
		&Pt198(n,2n)*Pt197*				99.5	95.9	84.0	77.2
		&Pt198(n,d)Ir197(β^-)*Pt197*					2.3	15.6	22.8
Au194	1.584 d	**&**Pt198(n,2n)*Pt197*(β^-)Au197(n,2n)*Au196*_ (β^-)Hg196(n,2n)*Hg195*(β^+)Au195(n,2n)*Au194*				49.5			
		&Pt198(n,2n)*Pt197*(β^-)Au197(n,2n)_ *Au196*(β^-)Hg196(n,2n)Hg195m(β^+)_ Au195(n,2n)*Au194*				27.5			
		&Pt198(n,2n)*Pt197*(β^-)Au197(n,2n)_ *Au196*(n,2n)Au195(n,2n)*Au194*				12.2			
		&Pt198(n,2n)*Pt197*(β^-)Au197(n,4n)*Au194*					62.7	81.1	74.5
		&Pt198(n,2n)*Pt197*(β^-)Au197(n,3n)_ *Au195*(n,2n)*Au194*					26.5		
		&Pt198(n,d)Ir197m(β^-)*Pt197*(β^-)_ *Au197*(n,4n)*Au194*					2.4	1.2	13.0
		&Pt198(n,d)Ir197(β^-)Pt197(β^-)*Au197*_ (n,4n)*Au194*					1.5	5.9	8.8
		&Pt198(n,2n)Pt197m(β^-)*Au197*(n,4n)*Au194*					1.5	2.0	1.9
Ir188	1.729 d	Pt190(n,2n)Pt189(β^+)Ir189(n,2n)Ir188				82.9			
		Pt192(n,2n)Pt191(β^+)Ir191(n,2n)Ir190_ (n,2n)Ir189(n,2n)Ir188				4.2			
		Pt194(n,3n)Pt192(n,3n)Pt190(n,3n)_ Pt188(β^+)Ir188					60.4	1.0	
		Pt192(n,3n)Pt190(n,3n)Pt188(β^+)Ir188					10.5	0.6	
		Pt195(n,4n)Pt192(n,3n)Pt190(n,3n)_ Pt188(β^+)Ir188					9.1	2.6	
		Pt196(n,3n)Pt194(n,3n)Pt192(n,3n)_ Pt190(n,3n)Pt188(β^+)Ir188					4.0		
		Pt194(n,4n)Pt191(β^+)Ir191(n,4n)Ir188					0.3	65.0	2.9
		Pt195(n,5n)Pt191(β^+)Ir191(n,4n)Ir188						4.8	6.5
		Pt194(n,5n)Pt190(n,3n)Pt188(β^+)Ir188						2.0	8.9
		Pt195(n,4n)Pt192(n,5n)Pt188(β^+)Ir188						0.8	10.7
		Pt194(n,3n)Pt192(n,5n)Pt188(β^+)Ir188						0.3	8.5
		Pt196(n,5n)Pt192(n,5n)Pt188(β^+)Ir188							19.4
		Pt192(n,5n)Pt188(β^+)Ir188							5.2
		Pt195(n,6n)Pt190(n,3n)Pt188(β^+)Ir188							5.2
		Other long pathways				12.9	15.7	22.9	32.7
Au198	2.694 d	**&**Pt196(n,γ)*Pt197*(β^-)Au197(n,γ)Au198	50.9	42.9	91.0	0.4	0.3	0.2	0.3
		&Pt195(n,γ)Pt196(n,γ)*Pt197*(β^-)Au197_ (n,γ)Au198	47.3	56.8	8.8				
		&Pt194(n,γ)*Pt195*(n,γ)Pt196(n,γ)*Pt197*_ (β^-)Au197(n,γ)Au198	1.5						
		&Pt198(n,2n)*Pt197*(β^-)Au197(n,γ)Au198				95.0	63.2	49.0	48.2
		Pt198(n,2n)Pt197m(β^-)Au197m(IT)_ Au197(n,γ)Au198				1.6	1.5	1.2	1.2
		&Pt198(n,γ)Pt199(β^-)Au199(β^-)Hg199_ (n,d)*Au198*					19.9	27.0	24.3
		Pt198(n,γ)Pt199m(IT)Pt199(β^-)Au199_ (β^-)Hg199(n,d)Au198					8.3	11.2	10.1
		Pt198(n,d)Ir197m(β^-)Pt197m(IT)Pt197_ (β^-)Au197(n,γ)Au198					2.4	5.4	8.4
		Pt198(n,d)Ir197(β^-)Pt197(β^-)Au197_ (n,γ)Au198					1.5	3.5	5.7

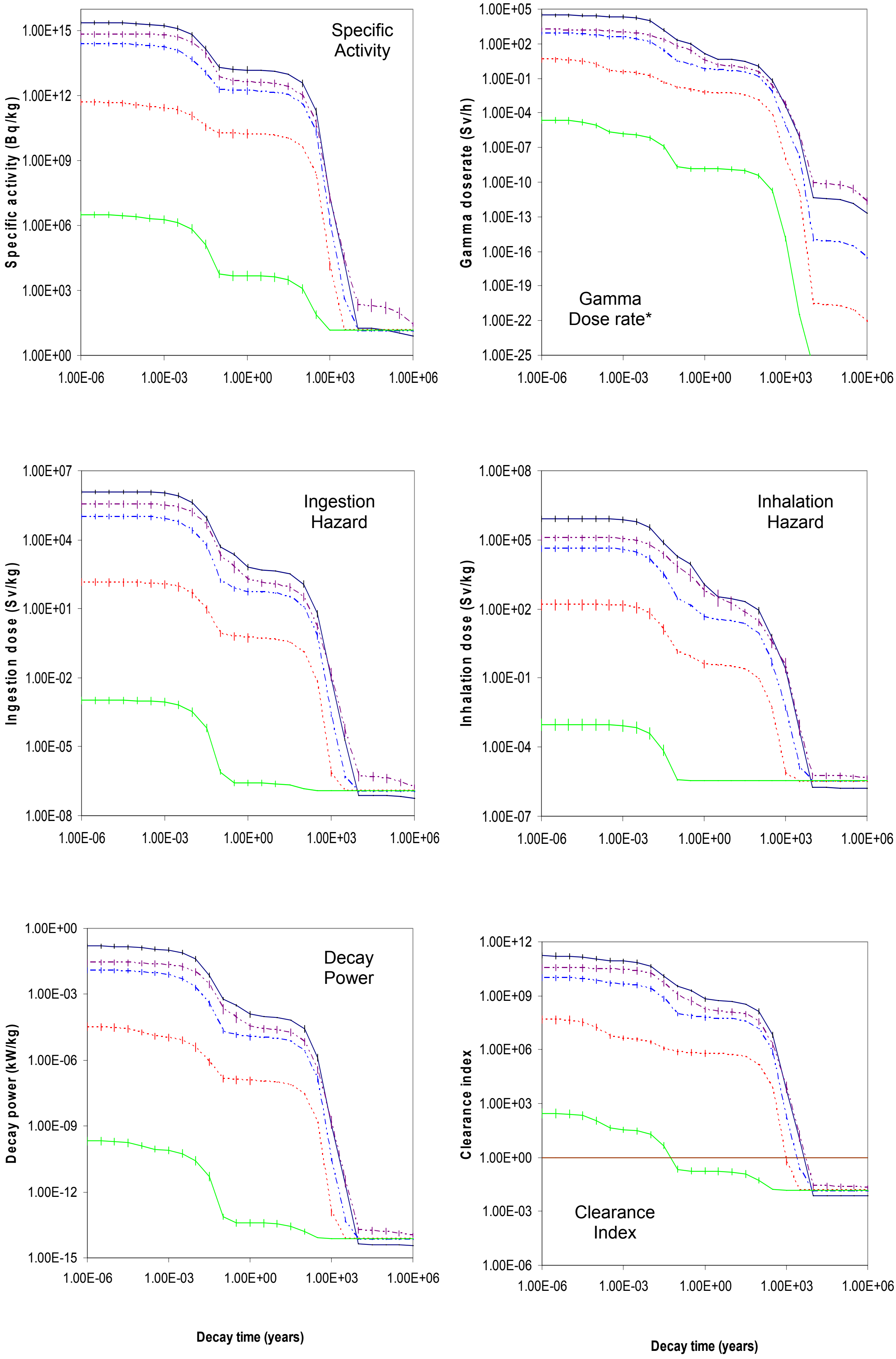
Nuclide	T½	Pathway	210	186	151	42	30	21	6
Au199	3.139 d	**&**Pt198(n,γ)*Pt199*(β^-)Au199	40.4	98.8	100.0	99.9	99.3	99.3	99.6
		&Pt196(n,γ)*Pt197*(β^-)Au197(n,γ)_ Au198(n,γ)Au199	30.8	0.4					
		&Pt195(n,γ)Pt196(n,γ)*Pt197*(β^-)Au197_ (n,γ)Au198(n,γ)Au199	28.4	0.6					
Re186	3.775 d	**&**Pt190(n,α)Os187(n,γ)Os188(n,α)_ *W185*(β^-)Re185(n,γ)Re186	90.6	91.7	84.0				
		&Pt190(n,γ)Pt191(β^+)Ir191(n,α)Re188_ (β^-)Os188(n,α)*W185*(β^-)Re185(n,γ)Re186		4.6	6.4				
		&Pt190(n,γ)Pt191(n,α)Os188(n,α)_ *W185*(β^-)Re185(n,γ)Re186		3.5	9.3				
		&Pt192(n,2n)Pt191(β^+)Ir191(n,2n)*Ir190*_ (β^+)Os190(n,α)W187(β^-)Re187(n,2n)Re186				33.7			
		Pt192(n,2n)Pt191(β^+)Ir191(n,nα)_ Re187(n,2n)Re186				21.6	0.4		
		&Pt194(n,2n)*Pt193*(n,2n)Pt192(n,2n)_ Pt191(β^+)Ir191(n,nα)Re187(n,2n)Re186				8.2			
		Pt195(n,3n)Pt193m(IT)Pt193(n,3n)_ Pt191(β^+)Ir191(n,2nα)Re186					7.6	0.2	
		Pt194(n,3n)Pt192(n,2n)Pt191(β^+)Ir191_ (n,2nα)Re186					4.3	0.3	
		Pt194(n,4n)Pt191(β^+)Ir191(n,2nα)Re186					2.5	33.9	3.0
		Pt194(n,4n)Pt191(β^+)Ir191(n,4n)Ir188_ (β^+)Os188(n,t)Re186						15.3	0.4
		Pt195(n,4n)Pt192(n,4n)Pt189(β^+)Ir189_ (β^+)Os189(n,nt)Re186						5.5	0.6
		Pt195(n,5n)Pt191(β^+)Ir191(n,2nα)Re186						2.5	6.9
		Pt194(n,6n)Pt189(β^+)Ir189(β^+)Os189_ (n,nt)Re186							24.4
		Pt196(n,6n)Pt191(β^+)Ir191(n,2nα)Re186							3.3
		Plus other long pathways	9.4	0.2	0.3	36.5	85.2	42.3	61.4
Pt195m	4.020 d	Pt194(n,γ)Pt195m	99.4	97.7	100.0				
		&Pt192(n,γ)*Pt193*(n,γ)Pt194(n,γ)Pt195m	0.5	2.3					
		Pt196(n,2n)Pt195m				83.0	54.0	32.7	46.2
		Pt195(n,n′)Pt195m				12.3	25.4	15.0	21.0
		Pt198(n,4n)Pt195m					12.3	46.0	22.2
		Pt196(n,d)Ir195m(β^-)Pt195m							6.4
		Pt198(n,nt)Ir195m(β^-)Pt195m							2.4
Pt193m	4.340 d	Pt192(n,γ)Pt193m	99.9	100.0	100.0				
		Pt194(n,2n)Pt193m				70.0	16.0	15.0	22.5
		Pt195(n,2n)Pt194(n,2n)Pt193m				23.7	1.0		
		Pt195(n,3n)Pt193m					67.5	21.4	28.2
		Pt196(n,4n)Pt193m					4.2	56.8	26.5
		Pt196(n,3n)Pt194(n,2n)Pt193m					3.2		
		&Pt196(n,2n)*Pt195*(n,3n)Pt193m					2.8		
		Pt198(n,6n)Pt193m							17.7
Ir190	12.0 d	**&**Pt192(n,2n)Pt191(β^+)*Ir191*(n,2n)*Ir190*				50.3	1.9	0.2	
		&Pt194(n,2n)*Pt193*(n,2n)Pt192(n,2n)_ Pt191(β^+)*Ir191*(n,2n)*Ir190*				37.5			
		&Pt195(n,3n)*Pt193*(n,3n)Pt191(β^+)_ *Ir191*(n,2n)*Ir190*					27.6	0.3	
		&Pt194(n,3n)Pt192(n,2n)Pt191(β^+)_ Ir191(n,2n)*Ir190*					11.1	0.3	
		&Pt194(n,2n)*Pt193*(n,3n)Pt191(β^+)_ Ir191(n,2n)*Ir190*					6.6	0.1	
		&Pt194(n,4n)Pt191(β^+)*Ir191*(n,2n)*Ir190*					6.3	39.3	6.1
		&Pt194(n,3n)Pt192(n,t)*Ir190*					5.4	3.0	2.6
		&Pt194(n,3n)Pt192(n,3n)Pt190(n,p)*Ir190*					4.5		
		&Pt194(n,d)*Ir193*(n,4n)*Ir190*					3.6	10.5	2.0
		&Pt195(n,4n)Pt192(n,t)*Ir190*					0.8	8.2	3.3
		&Pt195(n,t)*Ir193*(n,4n)*Ir190*					0.8	7.9	2.5
	►	**&**Pt196(n,4n)*Pt193*(β^+)Ir193(n,4n)*Ir190*					0.2	3.5	0.1

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Pt195(n,5n)Pt191(β^+)*Ir191*(n,2n)*Ir190*						2.9	13.9
		&Pt196(n,5n)Pt192(n,t)*Ir190*						0.5	6.0
		&Pt194(n,2nt)*Ir190*						0.4	27.2
		&Pt196(n,6n)Pt191(β^+)Ir191(n,2n)*Ir190*							6.7
		&Pt195(n,3nt)*Ir190*							4.6
		Other long pathways				12.2	32.1	22.9	25.0
Hg203	46.595 d	&Pt198(n,γ)*Pt199*(β^-)Au199(β^-)_ Hg199(n,γ)Hg200(n,γ)Hg201(n,γ)_ Hg202(n,γ)Hg203	62.8	99.6	99.1	97.8			
		&Pt196(n,γ)*Pt197*(β^-)Au197(n,γ)_ Au198(n,γ)Au199(β^-)Hg199(n,γ)_ Hg200(n,γ)Hg201(n,γ)Hg202(n,γ)Hg203	27.3	0.2					
		&Pt195(n,γ)Pt196(n,γ)*Pt197*(β^-)Au197_ (n,γ)Au198(n,γ)Au199(β^-)Hg199(n,γ)_ Hg200(n,γ)Hg201(n,γ)Hg202(n,γ)Hg203	9.2	0.2					
		&Pt198(n,γ)*Pt199*(β^-)Au199(n,γ)Au200_ (β^-)Hg200(n,γ)Hg201(n,γ)Hg202(n,γ)Hg203			0.8	1.0			
Ir192	73.822 d	&Pt190(n,γ)Pt191(β^+)*Ir191*(n,γ)*Ir192*	88.3	99.8	100.0				
		&Pt194(n,α)*Os191*(β^-)*Ir191*(n,γ)*Ir192*	7.0						
		&Pt194(n,2n)*Pt193*(β^+)Ir193(n,2n)*Ir192*				84.2	1.5	0.2	
		&Pt195(n,2n)Pt194(n,2n)*Pt193*(β^+)_ Ir193(n,2n)*Ir192*				7.3			
		&Pt192(n,p)*Ir192*				0.6	2.0	0.7	0.1
		&Pt194(n,2n)*Pt193*(n,d)*Ir192*				0.3	5.6	2.4	0.8
		&Pt195(n,3n)*Pt193*(n,d)*Ir192*					23.2	3.7	1.0
		&Pt194(n,3n)Pt192(n,p)*Ir192*					22.3	2.2	0.3
		&Pt194(n,t)*Ir192*					12.6	45.9	37.8
		&Pt195(n,3n)*Pt193*(β^+)Ir193(n,2n)*Ir192*					6.1	0.3	
		&Pt194(n,d)*Ir193*(n,2n)*Ir192*					5.5	2.6	0.7
		&Pt195(n,4n)Pt192(n,p)*Ir192*					3.4	6.0	0.4
		&Pt195(n,nt)*Ir192*					2.6	13.2	36.9
		&Pt196(n,3n)Pt194(n,t)*Ir192*					2.4	2.2	0.9
		&Pt196(n,3n)Pt194(n,3n)Pt192(n,p)*Ir192*					2.1		
		&Pt196(n,4n)*Pt193*(n,d)*Ir192*					1.4	9.4	0.9
		Pt195(n,2n)Pt194(n,t)Ir192					0.7	1.8	0.9
		&Pt196(n,2nt)*Ir192*						0.5	11.8
Os185	93.80 d	Pt190(n,2n)Pt189(β^+)Ir189(β^+)Os189(n,2n)_ Os188(n,2n)Os187(n,2n)Os186(n,2n)Os185				39.4			
		Pt190(n,nα)Os186(n,2n)Os185				8.4			
		Pt190(n,α)Os187(n,2n)Os186(n,2n)Os185				8.1			
		Pt190(n,2n)Pt189(β^+)Ir189(β^+)Os189_ (n,3n)Os187(n,2n)Os186(n,2n)Os185				7.7			
		Pt192(n,3n)Pt190(n,3n)Pt188(β^+)Ir188_ (β^+)Os188(n,4n)Os185					3.5	0.4	
		Pt194(n,3n)Pt192(n,3n)Pt190(n,2nα)Os185					3.1	0.1	
		Pt194(n,4n)Pt191(β^+)Ir191(n,4n)Ir188_ (β^+)Os188(n,4n)Os185					0.1	44.4	0.3
		Pt195(n,4n)Pt192(n,4n)Pt189(β^+)Ir189_ (β^+)Os189(n,5n)Os185						6.6	0.6
		Pt194(n,4n)Pt191(β^+)Ir191(n,3n)Ir189_ (β^+)Os189(n,5n)Os185						3.7	0.5
		Pt195(n,5n)Pt191(β^+)Ir191(n,4n)Ir188_ (β^+)Os188(n,4n)Os185						3.3	0.6
		Pt194(n,3n)Pt192(n,4n)Pt189(β^+)Ir189_ (β^+)Os189(n,5n)Os185						2.4	0.5
		&Pt194(n,6n)Pt189(β^+)Ir189(β^+)*Os189*_ (n,5n)Os185							30.2
		Pt194(n,5n)Pt190(n,6n)Pt185(β^+)Ir185(β^+)Os185							5.1
		Pt195(n,6n)Pt190(n,6n)Pt185(β^+)Ir185(β^+)Os185							3.0
		Other long pathways				36.4	93.3	39.1	59.2
Au195	186.09 d ►	&Pt198(n,2n)*Pt197*(β^-)Au197(n,2n)_ *Au196*(β^-)Hg196(n,2n)*Hg195*(β^+)*Au195*				48.5			

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Pt198(n,2n)*Pt197*(β^-)Au197(n,2n)_ *Au196*(β^-)Hg196(n,2n)Hg195m(β^+)Au195				27.9			
		&Pt198(n,2n)*Pt197*(β^-)Au197(n,2n)_ *Au196*(n,2n)*Au195*				13.2			
		&Pt198(n,2n)*Pt197*(β^-)Au197(n,3n)*Au195*					91.2	81.3	74.7
		&Pt198(n,2n)Pt197m(β^-)Au197m(IT)_ Au197(n,3n)*Au195*					2.1	2.0	1.9
		&Pt198(n,d)Ir197(β^-)Pt197(β^-)Au197_ (n,3n)*Au195*						5.9	8.8
		&Pt198(n,d)Ir197m(β^-)Pt197m(IT)_ Pt197(β^-)Au197(n,3n)*Au195*						1.7	13.0
Tl204	3.788 y	**&**Pt198(n,γ)*Pt199*(β^-)Au199(β^-)_ Hg199(n,γ)Hg200(n,γ)Hg201(n,γ)_ Hg202(n,γ)Hg203(β^-)Tl203(n,γ)Tl204	68.8	99.7	98.7				
		&Pt196(n,γ)*Pt197*(β^-)Au197(n,γ)_ Au198(n,γ)Au199(β^-)Hg199(n,γ)_ Hg200(n,γ)Hg201(n,γ)Hg202(n,γ)_ Hg203(β^-)Tl203(n,γ)Tl204	24.5	0.2					
		Pt195(n,γ)Pt196(n,γ)Pt197(β^-)Au197_ (n,γ)Au198(n,γ)Au199(β^-)Hg199(n,γ)_ Hg200(n,γ)Hg201(n,γ)Hg202(n,γ)_ Hg203(β^-)Tl203(n,γ)Tl204	5.8	0.1					
		Pt198(n,γ)Pt199(β^-)Au199(n,γ)Au200_ (β^-)Hg200(n,γ)Hg201(n,γ)Hg202(n,γ)_ Hg203(β^-)Tl203(n,γ)Tl204			1.2				
Os194	5.989 y	**&**Pt196(n,γ)*Pt197*(n,α)Os194	85.6	21.4	98.1				
		&Pt195(n,α)*Os192*(n,γ)Os193(n,γ)Os194	8.2	70.9	0.9				
		Pt196(n,α)Os193(n,γ)Os194	1.9		0.5				
		Pt198(n,nα)Os194				84.0	99.4	83.8	57.6
		&Pt198(n,2n)*Pt197*(n,α)Os194				15.4			
		Pt196(n,h)Os194					0.2	15.5	38.4
		Pt195(n,2p)Os194							3.5
Pt193	50.0 y	**&**Pt192(n,γ)*Pt193*	100.0	93.2	100.0				
		&Pt190(n,γ)Pt191(β^+)Ir191(n,γ)*Ir192*_ (β^-)Pt192(n,γ)*Pt193*		1.4					
		&Pt194(n,2n)*Pt193*				83.9	17.6	16.0	22.8
		&Pt195(n,2n)Pt194(n,2n)*Pt193*				14.4	0.2		
		&Pt195(n,3n)*Pt193*					72.2	23.3	29.4
		&Pt196(n,4n)*Pt193*					4.6	57.8	27.8
		&Pt198(n,6n)*Pt193*							17.3
Ir192n	240.84 y	**&**Pt190(n,γ)Pt191(β^+)*Ir191*(n,γ)Ir192n	54.0	99.8	99.1				
		Pt195(n,α)Os192m(β^-)Ir192n	31.3		0.8	0.2	1.1	0.2	
		&Pt194(n,α)*Os191*(β^-)*Ir191*(n,γ)Ir192n	5.9						
		&Pt194(n,γ)*Pt195*(n,α)Os192m(β^-)Ir192n	4.6						
		&Pt194(n,2n)*Pt193*(β^+)Ir193(n,2n)Ir192n				87.9	4.7	1.0	
		Pt196(n,α)Os193(β^-)Ir193(n,2n)Ir192n				0.9	4.6	0.4	
		&Pt194(n,d)*Ir193*(n,2n)Ir192n				0.4	24.1	12.1	3.8
		&Pt195(n,3n)*Pt193*(β^+)Ir193(n,2n)Ir192n					19.1	1.5	
		&Pt195(n,3n)*Pt193*(n,d)Ir192n					11.6	1.7	
		Pt194(n,t)Ir192n					7.5	42.6	35.3
		&Pt195(n,t)*Ir193*(n,2n)Ir192n					5.8	9.1	4.5
		Pt196(n,nα)Os192m(β^-)Ir192n					4.2	1.6	
		Pt195(n,nt)Ir192n					3.2	13.0	34.9
		&Pt196(n,4n)*Pt193*(β^+)Ir193(n,2n)Ir192n					1.3	3.6	
		&Pt196(n,4n)*Pt193*(n,d)Ir192n					0.7	4.3	
		Pt196(n,2nt)Ir192n						0.5	11.2
Hg194	519.68 y	**&**Pt198(n,2n)*Pt197*(β^-)Au197(n,2n)*Au196*_ (β^-)Hg196(n,2n)Hg195m(n,2n)Hg194				77.9			
	►	**&**Pt198(n,2n)*Pt197*(β^-)Au197(n,2n)_ *Au196*(β^-)Hg196(n,2n)*Hg195*(n,2n)Hg194				13.7			

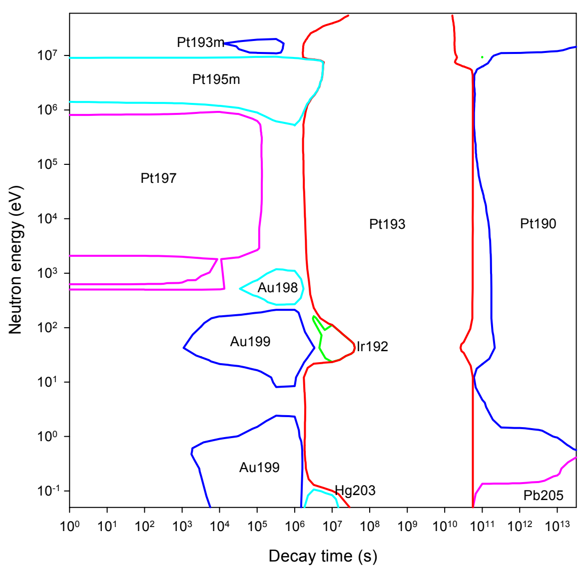
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Pt198(n,2n)Pt197m(β$^-$)*Au197(n,2n)*_ Au196(β$^-$)Hg196(n,2n)Hg195m(n,2n)Hg194				1.3			
		&Pt198(n,2n)*Pt197*(β$^-$)Au197(n,2n)_ *Au196*(β$^-$)Hg196(n,3n)Hg194					89.6	78.7	55.9
		Pt198(n,d)Ir197m(β$^-$)Pt197m(IT)Pt197(β$^-$)_ Au197(n,2n)Au196(β$^-$)Hg196(n,3n)Hg194					2.7	7.2	8.2
		&Pt198(n,d)Ir197(β$^-$)Pt197(β$^-$)Au197_ (n,2n)*Au196*(β$^-$)Hg196(n,3n)Hg194					1.7	5.7	6.6
		&Pt198(n,γ)*Pt199*(β$^-$)Au199(β$^-$)_ Hg199(n,4n)Hg196(n,3n)Hg194						2.4	0.5
		&Pt198(n,γ)*Pt199*(β$^-$)Au199(β$^-$)_ Hg199(n,6n)Hg194							22.3
Re186m	2.0 10^5 y	&Pt190(n,α)Os187(n,γ)Os188(n,α)_ *W185*(β$^-$)Re185(n,γ)Re186m	96.5	90.7	81.6				
		&Pt190(n,γ)Pt191(n,α)Os188(n,α)_ *W185*(β$^-$)Re185(n,γ)Re186m		4.6	12.0				
		&Pt190(n,γ)Pt191(β$^+$)Ir191(n,α)Re188(β$^-$)_ Os188(n,α)*W185*(β$^-$)Re185(n,γ)Re186m		4.6	6.3				
		&Pt192(n,2n)Pt191(β$^+$)Ir191(n,2n)*Ir190*(β$^+$)_ Os190(n,α)W187(β$^-$)Re187(n,2n)Re186m				31.6			
		Pt192(n,2n)Pt191(β$^+$)Ir191(n,nα)_ Re187(n,2n)Re186m				27.2	0.2		
		&Pt194(n,2n)*Pt193*(n,2n)Pt192(n,2n)_ *Pt191*(β$^+$)Ir191(n,nα)Re187(n,2n)Re186m				4.2			
		Pt192(n,2n)Pt191(β$^+$)Ir191(n,2n)Ir190_ (n,nα)Re186m				3.0			
		&Pt195(n,3n)*Pt193*(n,3n)Pt191(β$^+$)_ Ir191(n,2nα)Re186m					12.3	0.3	
		Pt194(n,3n)Pt192(n,2n)Pt191(β$^+$)Ir191_ (n,2nα)Re186m					4.9	0.3	
		Pt194(n,4n)Pt191(β$^+$)Ir191(n,2nα)Re186m					4.2	45.2	2.6
		Pt192(n,3n)Pt190(n,3n)Pt188(β$^+$)Ir188_ (β$^+$)Os188(n,t)Re186m					3.9	0.1	
		Pt194(n,4n)Pt191(β$^+$)Ir191(n,4n)Ir188_ (β$^+$)Os188(n,t)Re186m					0.1	15.6	0.4
		Pt195(n,4n)Pt192(n,4n)Pt189(β$^+$)Ir189_ (β$^+$)Os189(n,nt)Re186m						3.8	0.5
		Pt195(n,5n)Pt191(β$^+$)Ir191(n,2nα)Re186m						3.4	5.8
		Pt194(n,6n)Pt189(β$^+$)Ir189(β$^+$)Os189_ (n,nt)Re186m							30.0
		Other long pathways	3.5	0.1	0.1	34.0	74.4	31.3	60.7
Pb205	1.5 10^7 y	&Pt198(n,γ)*Pt199*(β$^-$)Au199(β$^-$)_ Hg199(n,γ)Hg200(n,γ)Hg201(n,γ)_ Hg202(n,γ)Hg203(β$^-$)Tl203(n,γ)Tl204_ (β$^-$)Pb204(n,γ)Pb205	97.5	99.7	98.3				
		Pt198(n,γ)Pt199(β$^-$)Au199(n,γ)Au200(β$^-$)_ Hg200(n,γ)Hg201(n,γ)Hg202(n,γ)Hg203_ (β$^-$)Tl203(n,γ)Tl204(β$^-$)Pb204(n,γ)Pb205			1.6				
Pt190	6.6 10^{11} y	Pt192(n,2n)Pt191(n,2n)Pt190				1.2			
		Pt194(n,3n)Pt192(n,3n)Pt190					63.9	7.3	0.4
		Pt192(n,3n)Pt190					11.0	4.6	0.5
		Pt195(n,4n)Pt192(n,3n)Pt190					9.6	20.1	0.5
		&Pt195(n,3n)*Pt193*(n,4n)Pt190					4.8	11.2	0.4
		Pt196(n,3n)Pt194(n,3n)Pt192(n,3n)Pt190					4.3	0.1	
		Pt195(n,2n)Pt194(n,3n)Pt192(n,3n)Pt190					1.3	0.1	
		&Pt194(n,2n)*Pt193*(n,4n)Pt190					1.2	7.7	0.3
		&Pt196(n,4n)*Pt193*(n,4n)Pt190					0.2	27.6	0.3
		Pt194(n,5n)Pt190						15.4	58.4
		Pt196(n,5n)Pt192(n,3n)Pt190						1.3	0.9
		Pt195(n,6n)Pt190							34.0
		Nuclide present in starting material	100.0	100.0	100.0	98.8	3.7	4.6	4.3

Platinum activation characteristics

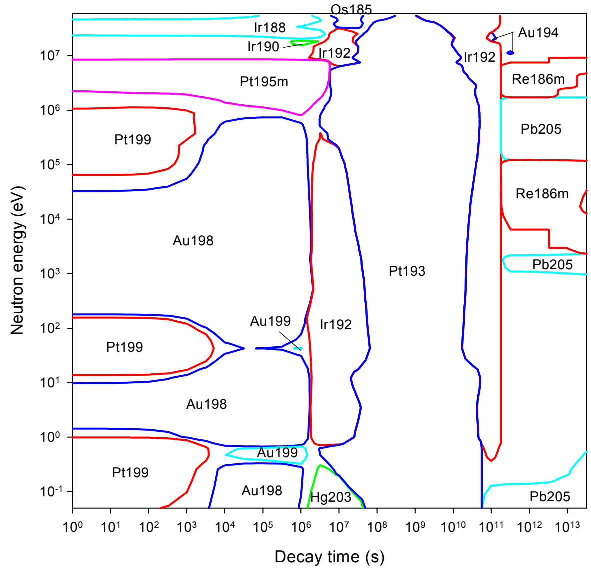


Platinum importance diagrams & transmutation

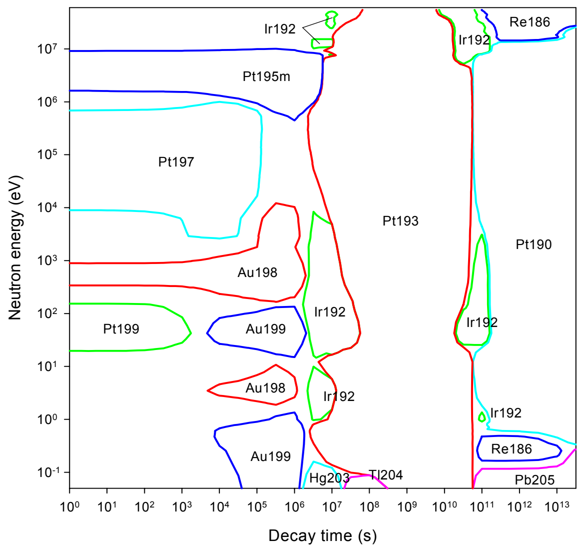
Activity



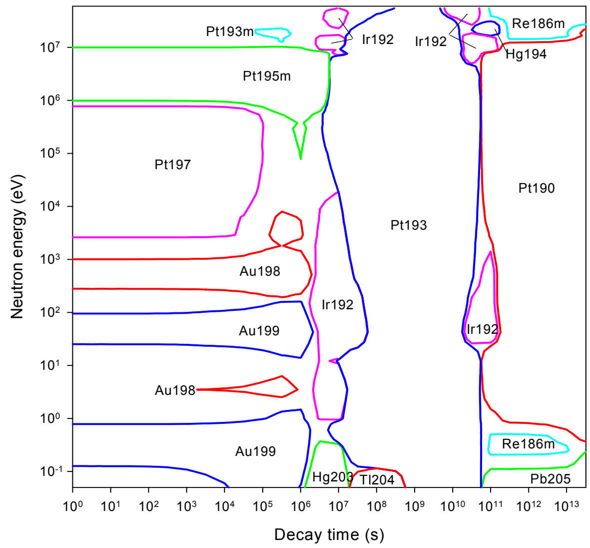
Dose rate



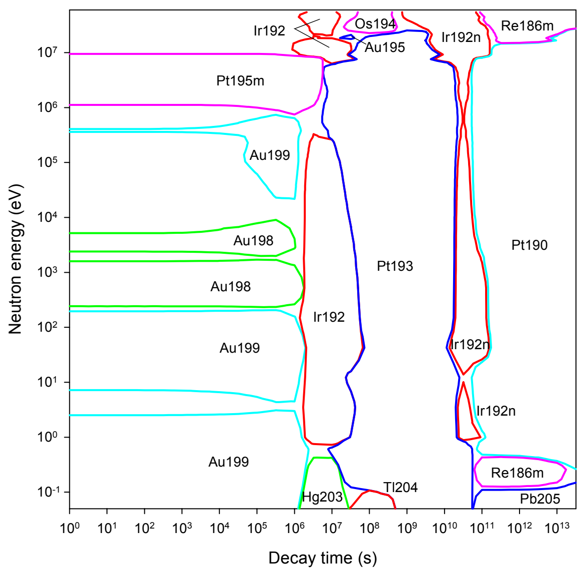
Heat output



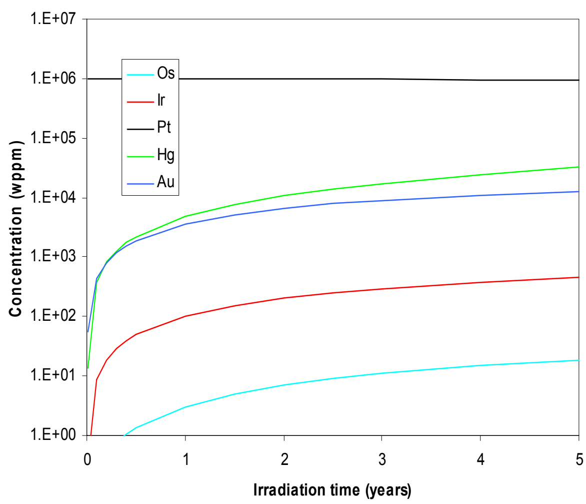
Ingestion dose



Inhalation dose



First wall transmutation



Gold

General properties

		Isotopes	Isotopic abundances / %
Atomic number	79	Au197	100.0
Crustal abundance / wppm	4.0 10^{-3}		
Melting point / K	1337.3		
Boiling point / K	3129		
Density / kgm^{-3}	19300		
Thermal conductivity / Wm^{-1}K^{-1}	317		
Electrical resistivity /Ωm	2.35 10^{-8}		
Coefficient of thermal expansion / K^{-1}	1.42 10^{-5}		
Crystal structure	FCC		
Number of stable isotopes	1		
Mean atomic weight	196.96655		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	6.62E15	6.52E15	2.50E15	2.43E11	8.21E7	1.06E-3	kW kg^{-1}	6.72E-1	6.66E-1	2.58E-1	5.00E-6	5.85E-10	1.85E-20
Au198	79.72	80.78	82.36				Au198	91.61	92.35	93.53			
Hg197	9.05	9.17	11.28				Hg197	2.03	2.05	2.50			
Hg197m	4.39	4.44	0.91				Hg197m	1.92	1.93	0.39			
Au196	2.06	2.09	3.63			2.69	Au196	1.62	1.63	2.82			12.38
Au197m	1.46	0.38	0.08				Hg199m	0.98	0.90				
Au199	1.18	1.20	1.39				Au195			0.01	99.91		
Hg199m	1.17	1.09					Pt193				0.04	90.06	
Au195	0.01	0.01	0.04	99.59			H3				0.01	0.39	
H3				0.26	3.00		Au194					8.63	
Pt193				0.13	96.22		Pb205						56.87
Pb205						90.62	Hg196						20.32
Hg196						2.69	Tl202						8.95
Tl202						1.99	Pb202						1.45
Pb202						1.99							

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	2.44E5	2.43E5	9.60E4	1.77E-1	8.70E-5	2.15E-15	Sv kg^{-1}	5.67E6	5.66E6	2.20E6	6.07E1	1.78E-2	6.13E-13
Au198	97.78	97.96	97.12				Au198	93.03	93.04	93.80			
Au196	1.54	1.54	2.61			36.82	Hg197	2.43	2.43	2.95			
Hg197	0.16	0.16	0.19				Hg197m	2.41	2.40	0.49			
Au195				99.76			Au196	1.06	1.06	1.82			2.06
Ir192				0.11	2.02		Au195			0.01	99.83		
Pt193				0.05	26.90		H3				0.04	0.58	
Au194				0.04	70.73		Hg194				0.03	84.70	
Tl202						45.09	Pt193				0.02	13.78	
Pb205						17.63	Pb205						43.99
Pb202						0.46	Pb202						30.36
							Hg196						21.95
							Tl202						1.55

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	5.00E6	5.00E6	1.94E6	4.12E2	7.66E-3	1.33E-12		6.48E11	6.28E11	2.54E11	2.21E7	3.08E3	7.64E-8
Au198	90.70	90.71	91.61				Au198	81.43	83.90	81.03			
Hg197	3.59	3.59	4.37				Au196	10.01	10.32	16.99			17.85
Hg197m	3.08	3.07	0.62				Au197m	3.64	0.96	0.18			
Au199	1.24	1.24	1.42				Hg197	0.92	0.95	1.10			
Au196	1.01	1.01	1.74			0.80	Hg197m	0.44	0.46	0.09			
Au195	0.03	0.03	0.08	99.94			Au195	0.01	0.01	0.03	99.83		
H3				0.04	8.36		Pt193				0.04	88.41	
Hg194					53.92		Au194					9.87	
Pt193					21.64		Pb205						74.24
Ir192n					12.96		Hg196						3.13
Pb205						61.80	Tl202						2.77
Pb202						19.15	Pb202						1.97
Hg196						17.71							

Gold

Pathway analysis

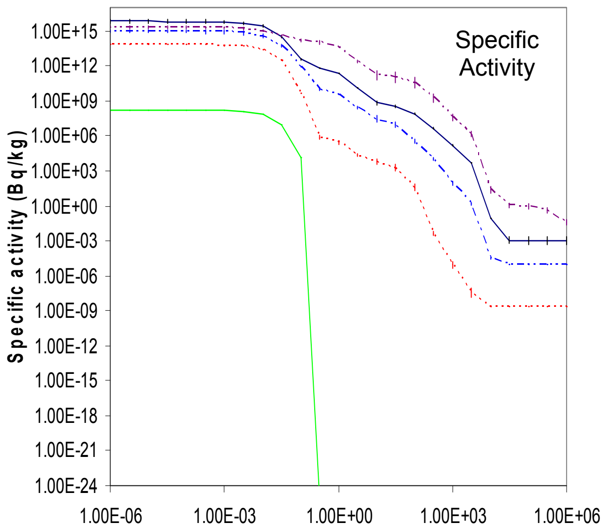
Nuclide	T½	Pathway	210	186	151	42	30	21	6
Ir191m	4.90 s	&Au197(n,α)*Ir194*(β$^-$)Pt194(n,α)_ *Os191*(β$^-$)Ir191m	98.6			0.5	0.2		
		&Au197(n,2n)Au196(β$^+$)Pt196(n,2n)_ *Pt195*(n,2n)Pt194(n,α)*Os191*(β$^-$)Ir191m				23.8			
		&Au197(n,2n)Au196(β$^+$)Pt196(n,2n)_ *Pt195*(n,α)Os192(n,2n)*Os191*(β$^-$)Ir191m				20.4			
		&Au197(n,3n)Au195(β$^+$)Pt195(n,nα)_ *Os191*(β$^-$)Ir191m					34.5	4.2	1.3
		&Au197(n,nα)*Ir193*(n,3n)Ir191m					10.1	1.0	0.3
		&Au197(n,4n)*Au194*(β$^+$)Pt194(n,α)_ Os191(β$^-$)Ir191m					0.8	5.8	1.0
		&Au197(n,4n)*Au194*(β$^+$)Pt194(n,4n)_ Pt191(β$^+$)Ir191m						21.4	1.1
		&Au197(n,4n)*Au194*(β$^+$)Pt194(n,nt)Ir191m						4.9	6.6
		&Au197(n,3nα)*Ir191m*						1.3	18.6
		&Au197(n,5n)*Au193*(β$^+$)Pt193(n,t)*Ir191m*						1.0	22.9
		&Au197(n,6n)*Au192*(β$^+$)Pt192(n,d)Ir191m							7.1
		Other very long pathways	1.4			55.3	54.4	60.4	41.1
Au197m	7.74 s	Au197(n,γ)Au198(n,γ)Au199(β$^-$)Hg199_ (n,α)Pt196(n,γ)Pt197m(β$^-$)Au197m	99.5	90.9	4.7				
		&Au197(n,γ)Au198(β$^-$)Hg198(n,γ)_ *Hg199*(n,α)Pt196(n,γ)Pt197m(β$^-$)Au197m	0.7	6.1	57.2				
		Au197(n,γ)Au198(n,α)Ir195(β$^-$)Pt195_ (n,γ)Pt196(n,γ)Pt197m(β$^-$)Au197m	0.3	1.1	0.3				
		&Au197(n,γ)Au198(β$^-$)Hg198(n,α)_ *Pt195*(n,γ)Pt196(n,γ)Pt197m(β$^-$)Au197m		0.7	36.5				
		&Au197(n,α)Ir194m(β$^-$)Pt194(n,γ)_ Pt195(n,γ)Pt196(n,γ)Pt197m(β$^-$)Au197m			1.3				
		Au197(n,n′)Au197m				99.9	99.6	99.6	99.7
Hg199m	42.10 m	Au197(n,γ)Au198(β$^-$)Hg198(n,γ)Hg199m	100.0	100.0	99.9	95.6	97.6	98.2	98.7
		&Au197(n,γ)*Au198*(β$^-$)Hg198(n,γ)_ Hg199(n,n′)Hg199m				1.7	1.0	0.9	0.7
Au192	4.94 h	&Au197(n,2n)Au196(β$^-$)Hg196(n,2n)_ Hg195m(n,2n)Hg194(n,2n)Hg193(β$^+$)_ *Au193*(n,2n)*Au192*				29.2			
		&Au197(n,2n)Au196(β$^-$)Hg196(n,2n)_ Hg195m(n,2n)Hg194(n,2n)Hg193m_ (β$^+$)Au193(n,2n)*Au192*				10.2			
		&Au197(n,2n)Au196(β$^-$)Hg196(n,2n)_ Hg195m(n,2n)Hg194(n,2n)Hg193m_ (n,2n)Hg192(β$^+$)*Au192*				8.6			
		&Au197(n,2n)Au196(β$^-$)Hg196(n,2n)_ Hg195m(n,2n)Hg194(n,2n)*Hg193*_ (n,2n)Hg192(β$^+$)Au192				7.2			
		&Au197(n,2n)Au196(β$^-$)Hg196(n,2n)_ Hg195(n,2n)Hg194(n,2n)Hg193(β$^+$)_ Au193(n,2n)*Au192*				2.8			
		&Au197(n,2n)*Au196*(β$^-$)Hg196(n,3n)_ Hg194(n,3n)Hg192(β$^+$)Au192					76.3		
		&Au197(n,3n)*Au195*(n,4n)*Au192*					11.0	97.0	
		&Au197(n,6n)*Au192*							100.0
		Other very long pathways				42.0	12.7	3.0	
Ir194	19.30 h	&Au197(n,α)*Ir194*	100.0	100.0	100.0	93.3	33.6	10.6	25.8
		&Au197(n,2n)*Au196*(β$^+$)Pt196(n,2n)_ *Pt195*(n,2n)Pt194(n,p)Ir194				1.8			
	►	&Au197(n,3n)*Au195*(β$^+$)Pt195(n,d)*Ir194*					54.8	27.7	21.5

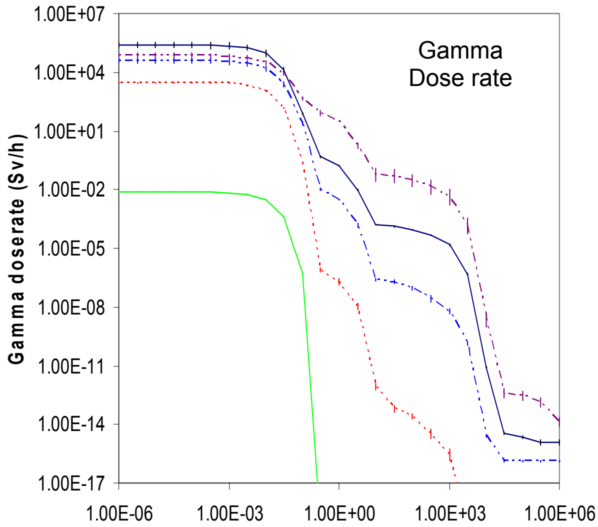
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Au197(n,2n)*Au196*(β^+)Pt196(n,t)*Ir194*					1.7	12.5	21.4
		Au197(n,2n)Au196(β^+)Pt196(n,3n)_ Pt194(n,p)Ir194					1.3	0.2	
		&Au197(n,4n)*Au194*(β^+)Pt194(n,p)*Ir194*					1.0	35.1	6.9
		&Au197(n,t)*Pt195*(n,d)*Ir194*					0.2	3.8	8.2
		&Au197(n,d)Pt196(n,t)*Ir194*					0.1	3.2	8.0
		Au197(n,nt)Pt194(n,p)Ir194						0.4	2.0
Au194	1.584 d	&Au197(n,2n)*Au196*(β^-)Hg196(n,2n)_ *Hg195*(β^+)Au195(n,2n)*Au194*				55.8			
		&Au197(n,2n)*Au196*(β^-)Hg196(n,2n)_ Hg195m(β^+)Au195(n,2n)*Au194*				31.8			
		&Au197(n,2n)*Au196*(n,2n)*Au195*(n,2n)*Au194*				7.3			
		&Au197(n,4n)*Au194*					66.5	100.0	100.0
		&Au197(n,3n)*Au195*(n,2n)*Au194*					31.8		
		&Au197(n,2n)Au196(n,3n)*Au194*					1.7		
Ir188	1.729 d	Long pathways involving (n,α), (n,nα), β^-				100.0	100.0	100.0	100.0
Au198	2.694 d	&Au197(n,γ)*Au198*	100.0	100.0	99.9	99.8	97.3	98.0	98.8
Au199	3.139 d	&Au197(n,γ)*Au198*(n,γ)Au199	100.0	100.0	100.0	83.2	59.7	63.4	73.9
		&Au197(n,γ)Au198(β^-)Hg198(n,γ)_ *Hg199*(n,p)Au199				12.3	37.5	34.6	24.6
Re186	3.775 d	Long pathways involving (n,α), (n,nα), β^-				100.0	100.0	100.0	100.0
Au196	6.183 d	&Au197(n,2n)*Au196*				100.0	100.0	100.0	100.0
Ir193m	10.602 d	&Au197(n,α)Ir194(β^-)Pt194(n,α)_ Os191(β^-)*Ir191*(n,γ)*Ir192*(n,γ)Ir193m	69.3	68.8					
		Au197(n,nα)Ir193m				39.2	65.7	31.7	33.1
		&Au197(n,2n)*Au196*(β^+)Pt196(n,α)_ Os193(β^-)Ir193(n,n′)Ir193m				21.1			
		&Au197(n,2n)*Au196*(n,α)Ir193m				4.6			
		Au197(n,2n)Au196(β^+)Pt196(n,α)_ Os193(β^-)Ir193m				3.2			
		&Au197(n,3n)*Au195*(β^+)Pt195(n,t)Ir193m					17.5	11.0	12.6
		&Au197(n,4n)*Au194*(β^+)Pt194(n,d)Ir193m					1.9	48.5	16.0
		&Au197(n,2n)Au196(β^+)Pt196(n,nt)Ir193m					0.3	1.7	13.4
		&Au197(n,t)*Pt195*(n,t)Ir193m						1.6	4.8
		Au197(n,nt)Pt194(n,d)Ir193m						0.6	4.8
		&Au197(n,5n)*Au193*(β^+)Pt193(n,p)Ir193m							3.6
		Other very long pathways	30.7	31.2		31.9	14.6	4.9	11.7
Os191	15.30 d	&Au197(n,α)*Ir194*(β^-)Pt194(n,α)*Os191*	99.9	99.9	100.0				
		Long pathways involving (n,α), (n,nα), β^-				100.0	100.0	100.0	100.0
Hg203	46.603 d	Au197(n,γ)Au198(n,γ)Au199(β^-)Hg199_ (n,γ)Hg200(n,γ)Hg201(n,γ)Hg202(n,γ)_ Hg203	99.3	96.5	9.0				
		&Au197(n,γ)Au198(β^-)Hg198(n,γ)_ *Hg199*(n,γ)Hg200(n,γ)Hg201(n,γ)_ Hg202(n,γ)Hg203	0.3	3.3	90.8				
Ir192	73.822 d	&Au197(n,α)Ir194(β^-)Pt194(n,α)_ *Os191*(β^-)*Ir191*(n,γ)*Ir192*	99.1	99.1	98.1				
		&Au197(n,2n)*Au196*(β^+)Pt196(n,α)_ Os193(β^-)Ir193(n,2n)*Ir192*				51.2	0.3		
		&Au197(n,nα)*Ir193*(n,2n)*Ir192*				6.7	10.1	1.4	0.3
		&Au197(n,3n)*Au195*(n,α)*Ir192*					26.7	0.5	
		&Au197(n,3n)*Au195*(β^+)Pt195(n,3n)_ *Pt193*(n,d)Ir192					9.4	0.1	
		&Au197(n,3n)*Au195*(β^+)Pt195(n,nt)*Ir192*					4.5	3.3	7.0
		&Au197(n,2nα)*Ir192*					4.4	31.9	25.9
		&Au197(n,4n)*Au194*(β^+)Pt194(n,t)*Ir192*					0.7	46.6	13.8
		&Au197(n,5n)*Au193*(β^+)Pt193(n,d)*Ir192*						2.4	30.2
		&Au197(n,nt)Pt194(n,t)*Ir192*						0.5	3.6
		&Au197(n,t)*Pt195*(n,nt)*Ir192*						0.5	3.3
		Other long pathways	0.9	0.9	1.9	42.1	43.9	12.8	15.9
Os185	93.80 d	Long pathways involving (n,α), (n,nα), β^-				100.0	100.0	100.0	100.0

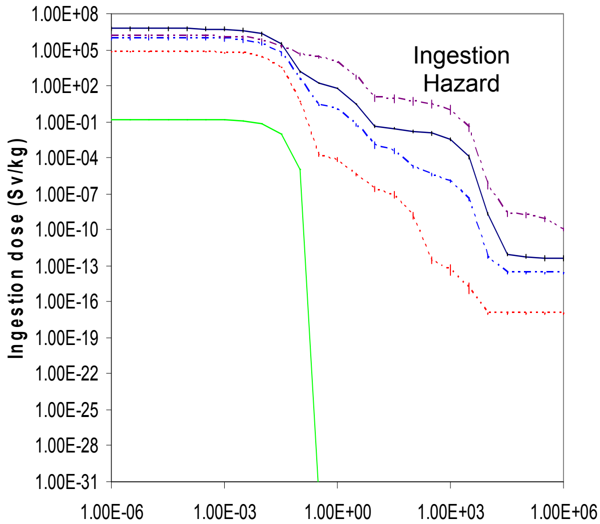
Nuclide	$T_{½}$	Pathway	210	186	151	42	30	21	6
Au195	186.09 d	&Au197(n,2n)*Au196*(β^-)Hg196(n,2n)_ *Hg195*(β^+)*Au195*				52.5			
		&Au197(n,2n)*Au196*(β^-)Hg196(n,2n)_ Hg195m(β^+)Au195				30.5			
		&Au197(n,2n)*Au196*(n,2n)*Au195*				7.5			
		&Au197(n,3n)*Au195*					99.6	99.5	99.7
Tl204	3.788 y	Au197(n,γ)Au198(n,γ)Au199(β^-)Hg199_ (n,γ)Hg200(n,γ)Hg201(n,γ)Hg202(n,γ)_ Hg203(β^-)Tl203(n,γ)Tl204	99.4	97.6	12.0				
		&Au197(n,γ)Au198(β^-)Hg198(n,γ)_ *Hg199*(n,γ)Hg200(n,γ)Hg201(n,γ)_ Hg202(n,γ)Hg203(β^-)Tl203(n,γ)Tl204	0.2	2.3	87.7				
Os194	5.989 y	Long pathways involving (n,α), (n,nα), β^-	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Pt193	50.0 y	&Au197(n,α)Ir194(β^-)Pt194(n,α)*Os191*_ (β^-)Ir191(n,γ)*Ir192*(β^-)Pt192(n,γ)*Pt193*	12.5	12.5	15.2				
		&Au197(n,2n)*Au196*(β^+)Pt196(n,2n)_ *Pt195*(n,2n)Pt194(n,2n)*Pt193*				79.7			
		&Au197(n,α)Ir194(β^-)Pt194(n,2n)*Pt193*				2.2			
		&Au197(n,2n)*Au196*(β^+)Pt196(n,3n)_ Pt194(n,2n)*Pt193*				1.7			
		&Au197(n,2n)*Au196*(β^-)Hg196(n,2n)_ *Hg195*(β^+)Au195(β^+)Pt195(n,2n)Pt194_ (n,2n)*Pt193*				1.2			
		&Au197(n,3n)*Au195*(β^+)Pt195(n,3n)*Pt193*					69.2	7.7	
		&Au197(n,3n)*Au195*(n,3n)*Au193*(β^+)Pt193					24.4	4.4	
		&Au197(n,2n)Au196(β^+)Pt196(n,4n)*Pt193*					1.7	18.3	
		&Au197(n,d)Pt196(n,4n)*Pt193*					0.2	5.2	
		&Au197(n,5n)*Au193*(β^+)Pt193						34.8	93.1
		&Au197(n,4n)*Au194*(β^+)Pt194(n,2n)*Pt193*						19.9	
		&Au197(n,t)*Pt195*(n,3n)*Pt193*						1.2	
		&Au197(n,2nt)*Pt193*							4.5
		Other long pathways	87.5	87.5	84.8	15.2	4.5	8.5	3.4
Ir192n	241.0 y	&Au197(n,γ)Au198(n,α)Ir195(β^-)_ *Pt195*(n,α)Os192m(β^-)Ir192n	64.6	13.6	0.6				
		&Au197(n,α)Ir194(β^-)Pt194(n,α)_ *Os191*(β^-)Ir191(n,γ)Ir192n	9.6						
		&Au197(n,γ)Au198(β^-)Hg198(n,α)_ *Pt195*(n,α)Os192m(β^-)Ir192n	6.8	75.8	94.7				
		&Au197(n,α)Ir194(β^-)Pt194(n,γ)_ *Pt195*(n,α)Os192m(β^-)Ir192n	6.5	2.8	4.3				
		&Au197(n,γ)Au198(n,α)Ir195m(β^-)_ *Pt195*(n,α)Os192m(β^-)Ir192n	4.9	0.6					
		&Au197(n,α)Ir194(β^-)Pt194(n,α)_ *Os191*(n,γ)Os192m(β^-)Ir192n	4.0						
		&Au197(n,α)Ir194(n,γ)Ir195(β^-)_ *Pt195*(n,α)Os192m(β^-)Ir192n	3.0						
		&Au197(n,2n)*Au196*(β^+)Pt196(n,α)_ Os193(β^-)Ir193(n,2n)Ir192n				64.5			
		&Au197(n,nα)*Ir193*(n,2n)Ir192n				10.5	46.6	8.8	3.0
		Au197(n,2nα)Ir192n					5.6	41.7	35.4
		&Au197(n,3n)*Au195*(β^+)Pt195(n,nt)Ir192n					3.4	2.4	5.6
		&Au197(n,4n)*Au194*(β^+)Pt194(n,t)Ir192n					0.2	30.3	9.2
		&Au197(n,5n)*Au193*(β^+)Pt193(n,d)Ir192n						1.5	20.0
		&Au197(n,5n)*Au193*(β^+)Pt193(β^+)_ Ir193(n,2n)Ir192n						1.2	12.0
		Au197(n,nt)Pt194(n,t)Ir192n						0.4	2.6
		Other long pathways	0.6	7.2	0.4	25.0	44.2	13.7	12.2
Hg194	440.01 y ►	&Au197(n,2n)*Au196*(β^-)Hg196(n,2n)_ Hg195m(n,2n)Hg194				84.5			

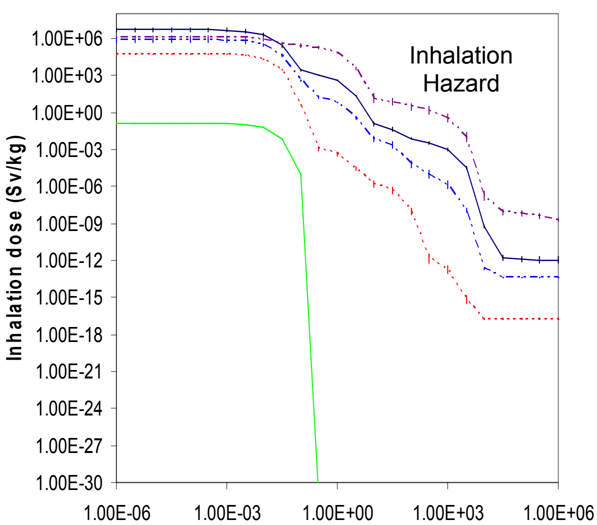
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Au197(n,2n)*Au196*(β^-)Hg196(n,2n)_ *Hg195*(n,2n)Hg194				15.5			
		&Au197(n,2n)*Au196*(β^-)Hg196(n,3n)Hg194					99.9	99.6	98.9
Re186m	$2.0\ 10^{5}$ y	Long pathways involving (n,α), (n,nα), β^-				100.0	100.0	100.0	100.0
Pb205	$1.5\ 10^{7}$ y	Au197(n,γ)Au198(n,γ)Au199(β^-)Hg199_ (n,γ)Hg200(n,γ)Hg201(n,γ)Hg202(n,γ)_ Hg203(β^-)Tl203(n,γ)Tl204(β^-)Pb204_ (n,γ)Pb205	99.4	98.1	15.0				
		&Au197(n,γ)Au198(β^-)Hg198(n,γ)_ *Hg199*(n,γ)Hg200(n,γ)Hg201(n,γ)_ Hg202(n,γ)Hg203(β^-)Tl203(n,γ)Tl204_ (β^-)Pb204(n,γ)Pb205	0.1	1.8	84.7				
Re187	$4.3\ 10^{10}$ y	Long pathways involving (n,α), (n,nα), β^-				100.0	100.0	100.0	100.0
Pt190	$6.5\ 10^{11}$ y	&Au197(n,2n)*Au196*(β^+)Pt196(n,2n)_ *Pt195*(n,2n)Pt194(n,2n)*Pt193*(n,2n)_ Pt192(n,2n)Pt191(n,2n)Pt190				8.2			
		&Au197(n,α)Ir194(β^-)Pt194(n,2n)_ *Pt193*(n,2n)Pt192(n,2n)Pt191(n,2n)Pt190				4.7			
		&Au197(n,3n)*Au195*(β^+)Pt195(n,4n)_ Pt192(n,3n)Pt190					36.6	5.4	
		&Au197(n,3n)*Au195*(β^+)Pt195(n,3n)_ *Pt193*(n,4n)Pt190					19.1	3.1	
		&Au197(n,4n)*Au194*(β^+)Pt194(n,3n)_ Pt192(n,3n)Pt190					8.1	8.4	
		&Au197(n,3n)*Au195*(n,3n)*Au193*(β^+)_ Pt193(n,4n)Pt190					8.0	2.2	
		Au197(n,2n)Au196(β^+)Pt196(n,3n)_ Pt194(n,3n)Pt192(n,3n)Pt190					5.1		
		&Au197(n,2n)Au196(β^+)Pt196(n,4n)_ *Pt193*(n,4n)Pt190					0.4	8.0	
		&Au197(n,4n)*Au194*(β^+)Pt194(n,5n)Pt190						26.4	28.8
		&Au197(n,5n)*Au193*(β^+)Pt193(n,4n)Pt190						23.3	32.7
		&Au197(n,4n)*Au194*(β^+)Pt194(n,2n)_ *Pt193*(n,4n)Pt190						5.6	
		Au197(n,nt)Pt194(n,5n)Pt190						0.3	8.3
		&Au197(n,3n)*Au195*(β^+)Pt195(n,6n)Pt190							10.3
		&Au197(n,6n)*Au192*(β^+)Pt192(n,3n)Pt190							9.4
		&Au197(n,t)*Pt195*(n,6n)Pt190							4.5
		Other very long pathways				87.1	22.7	17.3	6.0
Pb204	$1.4\ 10^{17}$ y	Au197(n,γ)Au198(n,γ)Au199(β^-)Hg199_ (n,γ)Hg200(n,γ)Hg201(n,γ)Hg202(n,γ)_ Hg203(β^-)Tl203(n,γ)Tl204(β^-)Pb204	99.4	97.9	13.6				
		&Au197(n,γ)Au198(β^-)Hg198(n,γ)*Hg199*_ (n,γ)Hg200(n,γ)Hg201(n,γ)Hg202(n,γ)_ Hg203(β^-)Tl203(n,γ)Tl204(β^-)Pb204	0.1	2.0	86.2				
Hg196	$2.5\ 10^{18}$ y	&Au197(n,2n)*Au196*(β^-)Hg196				100.0	98.8	99.2	99.4

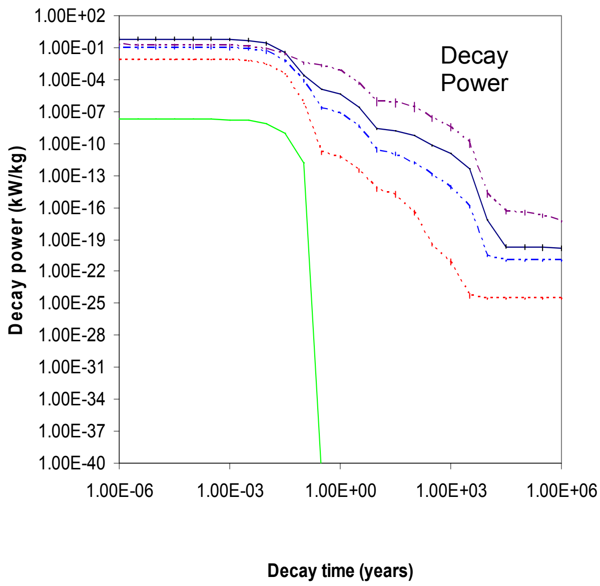
Gold activation characteristics

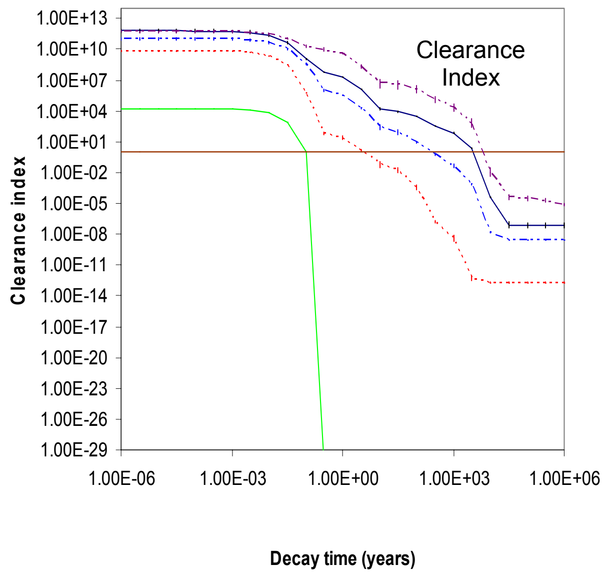






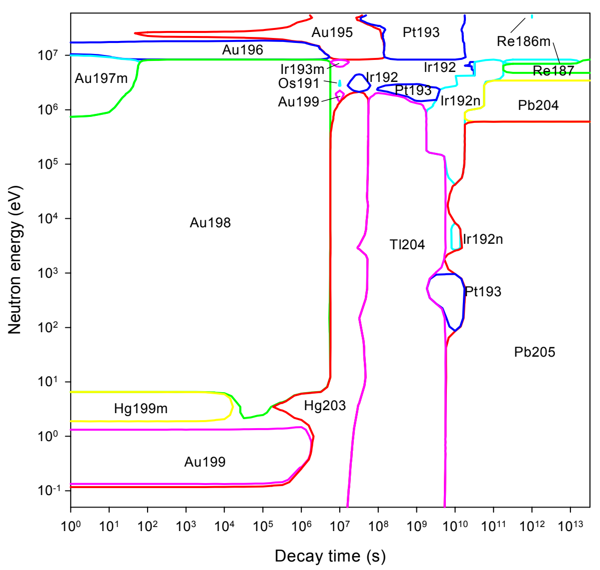




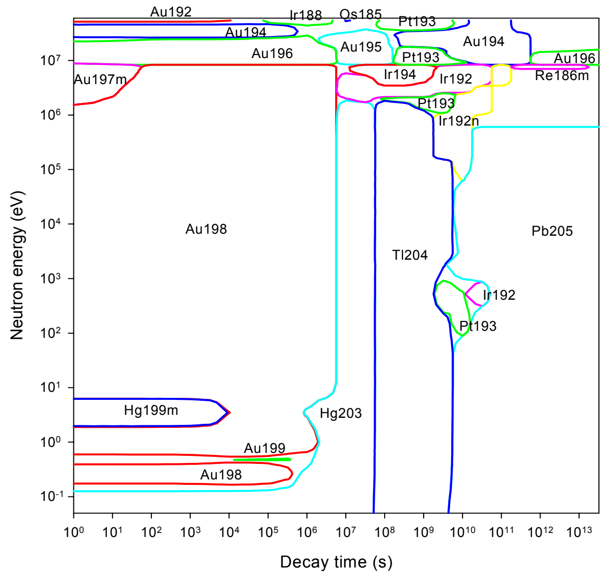


Gold importance diagrams & transmutation

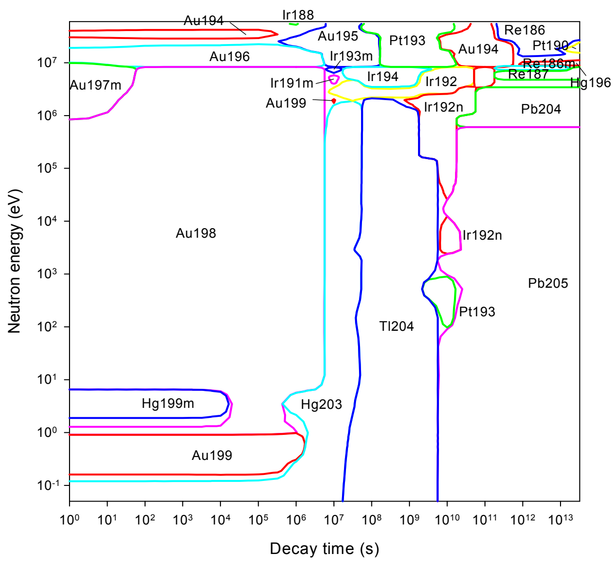
Activity



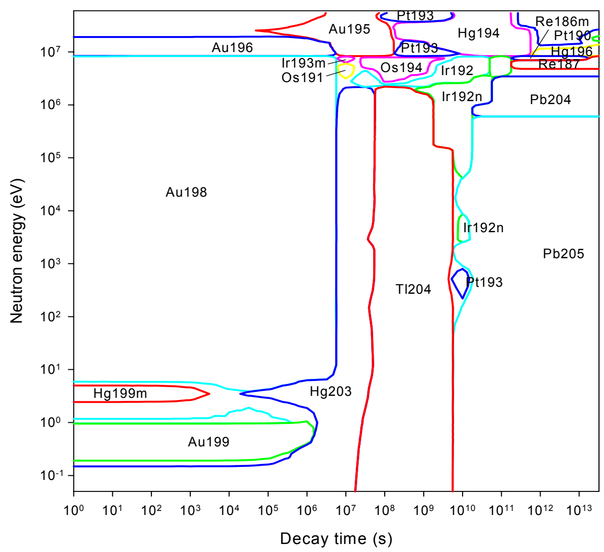
Dose rate



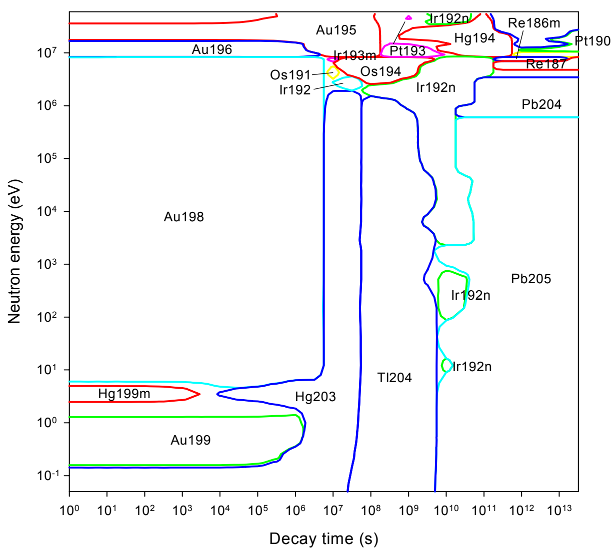
Heat output



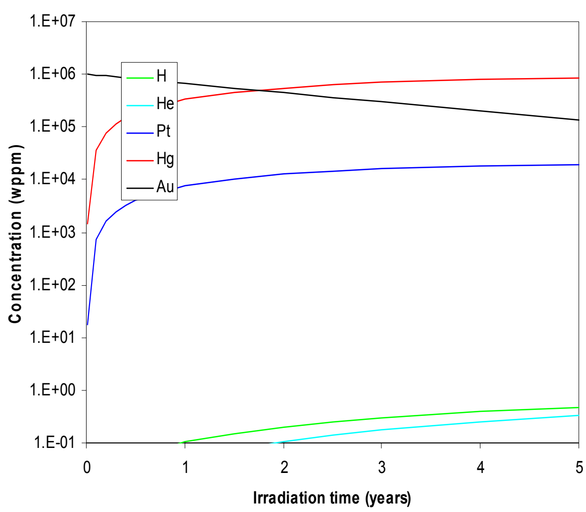
Ingestion dose



Inhalation dose



First wall transmutation



Mercury

General properties

		Isotopes	Isotopic abundances / %
Atomic number	80		
Crustal abundance / wppm	$8.5\ 10^{-2}$	Hg196	0.15 ($T_{1/2}$=$2.50\ 10^{18}$ y)
Melting point / K	234.3	Hg198	9.97
Boiling point / K	629.9	Hg199	16.87
Density / kgm^{-3}	13546	Hg200	23.10
Thermal conductivity / $Wm^{-1}K^{-1}$	8.34	Hg201	13.18
Electrical resistivity /Ωm	$9.41\ 10^{-7}$	Hg202	29.86
Coefficient of thermal expansion / K^{-1}	$1.81\ 10^{-4}$	Hg204	6.87
Crystal structure	Rhombohedral		
Number of stable isotopes	6 (7)		
Mean atomic weight	200.59		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Heat**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	4.87E14	4.70E14	2.13E14	9.91E12	1.35E7	3.63E3	kW kg^{-1}	3.29E-2	3.14E-2	1.21E-2	3.84E-4	1.49E-10	4.49E-14
Hg199m	28.16	26.76					Hg199m	35.60	34.17				
Hg203	28.06	29.07	60.80	6.03			Au198	25.76	26.94	27.36			
Hg197	15.20	15.74	16.12				Hg203	22.39	23.43	57.60	8.36		
Au198	14.88	15.40	13.30				Hg197	5.15	5.38	6.48			
Hg197m	6.66	6.89	1.20				Hg197m	4.41	4.60	0.94			
Tl204	2.25	2.33	5.14	92.21	0.91		Hg205	2.02	1.05				
Hg205	1.56	0.80					Tl204	1.27	1.33	3.45	90.70	3.16	
Tl202	1.06	1.10	1.98			2.05	Tl202	1.23	1.29	2.73		0.01	13.00
Au195	0.13	0.14	0.31	1.74			Au197m	0.75	0.58	0.12			
Pt193					86.64		Au196	0.48	0.50	0.86			
H3					6.83		Pt193					52.46	
Au194					2.78		Au194					43.30	
Hg194					2.78		H3					0.56	
Pb205					0.02	95.89	Pb205					0.03	84.88
Pb202						2.05	Pb202					0.02	2.11
Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Ing**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	5.10E3	5.01E3	2.34E3	4.69E0	8.23E-5	4.70E-9	Sv kg^{-1}	3.86E5	3.86E5	3.00E5	1.21E4	2.00E-2	1.66E-6
Au198	63.09	64.19	53.70				Hg203	67.20	67.28	82.11	9.35		
Hg203	17.18	17.49	35.43	94.59			Au198	18.75	18.76	9.46			
Hg199m	10.77	10.05					Hg197	4.40	4.41	2.63			
Tl202	4.56	4.65	8.08		0.02	71.04	Hg197m	3.95	3.94	0.40			
Au196	1.04	1.06	1.50				Tl204	3.40	3.41	4.38	90.29	0.74	
Hg197	0.90	0.91	0.90				Hg199m	1.10	1.01				
Au197m	0.35	0.35	0.06				Tl202	0.60	0.60	0.63			2.01
Au195	0.01	0.01	0.02	3.02			Hg194					96.42	
Au194	0.02	0.02	0.01	0.00	95.39		Pt193					1.82	
Tl204			0.01*	2.38*			H3					0.19	
Pt193					4.10		Pb202					0.01	39.37
Pb205						28.23	Pb205						58.61
Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**	**Clear**	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	4.43E5	4.42E5	3.54E5	5.29E3	5.94E-3	3.87E-6		6.64E10	6.32E10	2.83E10	9.21E9	9.31E2	2.18E-1
Hg203	74.07	74.15	87.77	27.09			Hg199m	44.93	43.29				
Au198	14.07	14.08	6.88				Hg203	20.59	21.63	45.70	0.64		
Hg197	5.01	5.01	2.91				Tl204	16.53	17.36	38.66	99.18	13.31	
Hg197m	3.88	3.88	0.38				Au198	10.92	11.46	10.00			
Hg199m	0.99	0.91					Au196	1.40	1.47	2.19			
Tl204	0.96	0.96	1.20	67.33	0.81		Hg197	1.11	1.17	1.21			
Au195	0.25	0.25	0.31	5.56			Tl202	0.78	0.82	1.49			3.42
Tl202	0.22	0.22	0.22			0.36	Hg197m	0.48	0.51	0.09			
Hg194					89.11		Au195	0.09	0.09	0.21	0.17		
Pt193					4.15		Pt193					43.48	
H3					4.05		Au194					41.85	
Pb205					0.05	76.53	Pb205					0.02	94.13
Pb202					0.05	23.09	Pb202						2.44

Mercury

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Hg205	5.20 m	Hg204(n,γ)Hg205	98.9	100.0	100.0	99.9	99.4	99.4	99.6
		Hg202(n,γ)Hg203(n,γ)Hg204(n,γ)Hg205	0.9						
Hg199m	42.10 m	Hg198(n,γ)Hg199m	99.9	100.0	100.0				
		Hg200(n,2n)Hg199m				74.1	20.6	10.0	16.9
		Hg201(n,2n)Hg200(n,2n)Hg199m				14.0	0.7		
		Hg202(n,2n)Hg201(n,2n)Hg200(n,2n)Hg199m				5.4			
		Hg199(n,n′)Hg199m				4.5	1.9	1.0	1.7
		Hg201(n,3n)Hg199m					51.6	10.0	14.0
		Hg202(n,4n)Hg199m					7.3	73.1	43.0
		Hg202(n,2n)Hg201(n,3n)Hg199m					7.2		
		Hg202(n,3n)Hg200(n,2n)Hg199m					7.2		
		Hg204(n,6n)Hg199m							19.7
Au194	1.584 d	&Hg196(n,2n)*Hg195*(β^+)Au195(n,2n)*Au194*				50.1			
		&Hg196(n,2n)Hg195m(β^+)Au195(n,2n)*Au194*				27.6			
		&Hg198(n,2n)*Hg197*(β^+)*Au197*(n,2n)_ Au196(β^-)Hg196(n,2n)*Hg195*(β^+)_ Au195(n,2n)*Au194*				5.6			
		&Hg198(n,2n)*Hg197*(β^+)*Au197*(n,2n)_ Au196(β^-)Hg196(n,2n)Hg195m(β^+)_ Au195(n,2n)*Au194*				4.0			
		&Hg198(n,2n)*Hg197*(β^+)*Au197*(n,2n)_ *Au196*(n,2n)Au195(n,2n)*Au194*				2.0			
		&Hg199(n,3n)*Hg197*(β^+)Au197(n,4n)*Au194*					39.3	16.6	5.9
		&Hg199(n,3n)*Hg197*(β^+)Au197(n,3n)_ *Au195*(n,2n)*Au194*					16.6		
		&Hg201(n,3n)*Hg199*(n,3n)*Hg197*(β^+)_ Au197(n,4n)*Au194*					4.0		
		&Hg198(n,3n)Hg196(n,2n)*Hg195*(β^+) Au195(n,2n)*Au194*					2.5		
		&Hg198(n,3n)Hg196(n,3n)Hg194(n,p)*Au194*					2.5		
		&Hg198(n,3n)Hg196(n,t)*Au194*					2.3		
		&Hg199(n,3n)Hg197m(β^+)*Au197*(n,4n)*Au194*					2.2		
		&Hg200(n,4n)*Hg197*(β^+)Au197(n,4n)*Au194*						56.1	
		&Hg200(n,4n)Hg197m(β^+)Au197(n,4n)*Au194*						3.1	
		&Hg202(n,3n)Hg200(n,4n)*Hg197*(β^+)_ Au197(n,4n)*Au194*						2.4	
		&Hg202(n,4n)Hg199(n,3n)*Hg197*(β^+)_ Au197(n,4n)*Au194*						2.3	
		&Hg201(n,5n)*Hg197*(β^+)Au197(n,4n)*Au194*						2.1	11.1
		&Hg199(n,t)Au197(n,4n)*Au194*						1.8	2.1
		&Hg202(n,6n)*Hg197*(β^+)Au197(n,4n)*Au194*							17.2
		&Hg201(n,5n)*Hg197*(β^+)Au197(n,4n)*Au194*							14.1
		&Hg198(n,2nt)*Au194*							9.4
		&Hg200(n,5n)Hg196(n,t)*Au194*							5.4
		&Hg202(n,5n)Hg198(n,2nt)*Au194*							3.4
		&Hg200(n,nt)Au197(n,4n)*Au194*							2.5
		Other very long pathways				10.7	30.6	15.6	28.9
Ir188	1.729 d	Long pathways involving (n,α), (n,nα), β^-				100.0	100.0	100.0	100.0
Hg197	2.692 d	&Hg196(n,γ)*Hg197*		100.0	100.0				
		&Hg198(n,2n)*Hg197*				60.3	2.6	1.4	
		&Hg199(n,2n)Hg198(n,2n)*Hg197*				33.0	0.3		
		&Hg200(n,2n)*Hg199*(n,2n)Hg198(n,2n)*Hg197*				5.7			
		&Hg199(n,3n)*Hg197*					67.3	17.6	11.2
		&Hg201(n,3n)*Hg199*(n,3n)*Hg197*					13.8	0.9	
		&Hg200(n,2n)*Hg199*(n,3n)*Hg197*					6.1	1.0	
		&Hg202(n,4n)*Hg199*(n,3n)*Hg197*					2.2	6.8	
	►	&Hg200(n,4n)*Hg197*					1.3	59.6	21.1

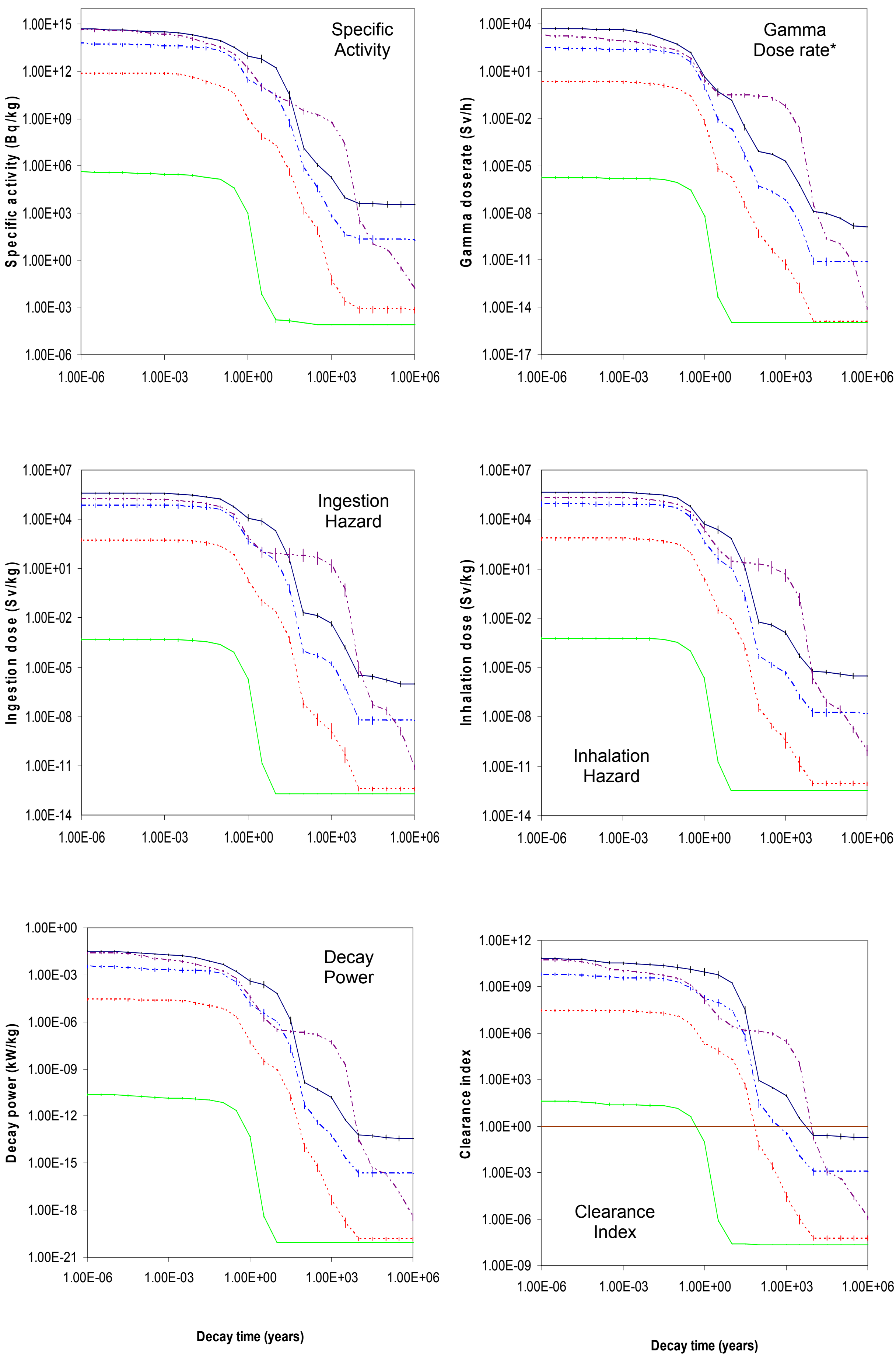
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Hg202(n,3n)Hg200(n,4n)*Hg197*					0.5	5.1	
		&Hg201(n,5n)*Hg197*						2.3	26.7
		&Hg202(n,6n)*Hg197*							32.5
Au198	2.694 d	&Hg196(n,γ)*Hg197*(β^+)Au197(n,γ)Au198	99.7	99.7	99.7				
		&Hg198(n,p)*Au198*				53.9	16.3	6.4	2.3
		&Hg199(n,2n)Hg198(n,p)*Au198*				30.2	1.7	0.5	0.1
		&Hg200(n,2n)*Hg199*(n,2n)Hg198(n,p)Au198				5.5			
		&Hg199(n,d)*Au198*				3.7	42.6	34.1	20.5
		&Hg198(n,2n)*Hg197*(β^+)Au197(n,γ)Au198				3.3			
		&Hg200(n,2n)*Hg199*(n,d)Au198				1.4	3.7	1.9	0.8
		Hg200(n,3n)Hg198(n,p)Au198					9.8	1.2	0.2
		&Hg201(n,3n)*Hg199*(n,d)*Au198*					8.6	1.8	0.6
		&Hg200(n,t)*Au198*					6.5	27.7	33.5
		Hg202(n,3n)Hg200(n,t)Au198					2.3	2.3	1.5
		Hg202(n,3n)Hg200(n,3n)Hg198(n,p)Au198					1.7		
		&Hg202(n,4n)*Hg199*(n,d)*Au198*					1.4	13.1	1.9
		&Hg201(n,nt)*Au198*					0.6	3.9	17.2
		Hg201(n,4n)Hg198(n,p)Au198					0.5	1.7	0.1
		&Hg202(n,2nt)*Au198*						0.3	13.7
Re186	3.775 d	Long pathways involving (n,α), (n,nα), β^-				100.0	100.0	100.0	100.0
Au196	6.183 d	Hg196(β^+)Au196		100.0	100.0				
		&Hg198(n,2n)*Hg197*(β^+)Au197(n,2n)*Au196*				69.9	2.4	0.8	0.3
		&Hg199(n,2n)Hg198(n,2n)*Hg197*(β^+)_ Au197(n,2n)*Au196*				18.8			
		&Hg198(n,2n)Hg197m(β^+)*Au197*(n,2n)*Au196*				2.9			
		&Hg199(n,3n)*Hg197*(β^+)Au197(n,2n)*Au196*					66.3	13.1	
		&Hg201(n,3n)Hg199(n,3n)*Hg197*(β^+)_ Au197(n,2n)*Au196*					5.8		
		&Hg199(n,3n)Hg197m(β^+)Au197(n,2n)*Au196*					3.7	0.3	
		&Hg198(n,3n)Hg196(n,p)*Au196*					2.5	0.8	
		&Hg200(n,2n)Hg199(n,3n)*Hg197*(β^+)_ Au197(n,2n)*Au196*					2.5	0.3	
		&Hg200(n,4n)*Hg197*(β^+)Au197(n,2n)*Au196*					1.3	44.2	
		&Hg198(n,t)*Au196*					1.0	8.5	
		&Hg202(n,4n)Hg199(n,3n)*Hg197*(β^+)_ Au197(n,2n)*Au196*					0.9	2.2	
		&Hg199(n,nt)*Au196*					0.2	3.4	
		&Hg200(n,4n)Hg197m(β^+)Au197(n,2n)*Au196*					0.1	2.5	
		&Hg199(n,4n)Hg196(n,p)*Au196*						2.5	
		&Hg201(n,4n)Hg198(n,t)*Au196*						2.2	1.5
		&Hg200(n,5n)Hg196(n,t)*Au194*						0.2	5.4
		&Hg198(n,2nt)*Au194*						0.1	9.4
		&Hg202(n,6n)*Hg197*(β^+)Au197(n,4n)*Au194*							17.2
		&Hg201(n,5n)*Hg197*(β^+)Au197(n,4n)*Au194*							14.1
		&Hg200(n,4n)*Hg197*(β^+)Au197(n,4n)*Au194*							11.1
		&Hg199(n,3n)*Hg197*(β^+)Au197(n,4n)*Au194*							5.9
		&Hg202(n,5n)Hg198(n,2nt)*Au194*							3.4
		&Hg200(n,nt)Au197(n,4n)*Au194*							2.5
		&Hg199(n,t)Au197(n,4n)*Au194*							2.1
Tl202	12.240 d	Hg204(n,2n)Hg203(β^-)Tl203(n,2n)Tl202				99.8	92.1	80.6	72.9
		Hg204(n,d)Au203(β^-)Hg203(β^-)Tl203_ (n,2n)Tl202					6.4	17.4	25.5
Hg203	46.603 d	Hg202(n,γ)Hg203	84.7	99.4	98.4	0.2		0.5	
		Hg201(n,γ)Hg202(n,γ)Hg203	13.6	0.6	1.6				
		Hg200(n,γ)Hg201(n,γ)Hg202(n,γ)Hg203	0.9						
		Hg204(n,2n)Hg203				99.7	92.3	81.3	73.4
		Hg204(n,d)Au203(β^-)Hg203						17.6	25.7
Au195	186.09 d	&Hg196(n,2n)*Hg195*(β^+)Au195				50.1	0.5	0.1	
		Hg196(n,2n)Hg195m(β^+)Au195				32.0	0.4		
	►	&Hg198(n,2n)*Hg197*(β^+)*Au197*(n,2n)_ *Au196*(β^-)Hg196(n,2n)*Hg195*(β^+)Au195				5.4			

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Hg198(n,2n)*Hg197*(β^+)*Au197*(n,2n)_ *Au196*(β^-)Hg196(n,2n)Hg195m(β^+)Au195				4.3			
		&Hg198(n,2n)*Hg197*(β^+)*Au197*(n,2n)_ *Au196*(n,2n)*Au195*				2.0			
		&Hg199(n,2n)Hg198(n,2n)*Hg197*(β^+)_ *Au197*(n,2n)*Au196*(β^-)Hg196(n,2n)_ *Hg195*(β^+)Au195				0.4			
		&Hg199(n,3n)*Hg197*(β^+)Au197(n,3n)*Au195*					54.8	2.1	0.4
		&Hg198(n,3n)Hg196(n,2n)Hg195(β^+)Au195					8.4	0.7	
		Hg198(n,3n)Hg196(n,2n)Hg195m(β^+)Au195					5.8	0.5	
		&Hg199(n,3n)Hg197m(β^+)*Au197*(n,3n)*Au195*					3.1		
		&Hg200(n,3n)Hg198(n,3n)Hg196_ (n,2n)*Hg195*(β^+)Au195					2.2		
		&Hg200(n,4n)Hg197(β^+)Au197(n,3n)*Au195*					0.6	2.8	0.3
		&Hg198(n,4n)*Hg195*(β^+)*Au195*					0.3	30.6	6.7
		&Hg199(n,4n)Hg196(n,2n)*Hg195*(β^+)Au195					0.3	2.3	0.2
		Hg199(n,4n)Hg196(n,2n)Hg195m(β^+)Au195					0.3	1.7	0.2
		Hg198(n,4n)Hg195m(β^+)Au195						18.3	4.4
		&Hg201(n,4n)Hg198(n,4n)*Hg195*(β^+)*Au195*						6.9	0.3
		&Hg200(n,3n)Hg198(n,4n)*Hg195*(β^+)Au195						4.8	0.4
		Hg201(n,4n)Hg198(n,4n)Hg195m(β^+)Au195						4.1	0.2
		Hg200(n,3n)Hg198(n,4n)Hg195m(β^+)Au195						2.9	0.3
		&Hg199(n,5n)*Hg195*(β^+)*Au195*						0.9	25.5
		Hg199(n,5n)Hg195m(β^+)Au195						0.5	17.7
		&Hg198(n,nt)*Au195*						0.4	2.7
		&Hg200(n,6n)*Hg195*(β^+)*Au195*							8.3
		Hg200(n,6n)Hg195m(β^+)Au195							4.8
Tl204	3.788 y	Hg202(n,γ)Hg203(β^-)Tl203(n,γ)Tl204	93.6	99.8	99.4	0.1	0.3	0.3	0.4
		Hg201(n,γ)Hg202(n,γ)Hg203(β^-)Tl203_ (n,γ)Tl204	6.1	0.2	0.6				
		Hg204(n,γ)Hg205(β^-)Tl205(n,2n)Tl204				50.3	35.1	31.9	28.7
		Hg204(n,2n)Hg203(β^-)Tl203(n,γ)Tl204				49.5	60.2	55.6	52.4
		Hg204(n,d)Au203(β^-)Hg203(β^-)Tl203_ (n,γ)Tl204					4.2	12.0	18.3
H3	12.33 y	Hg199(n,X)H3				44.0	20.4	13.9	15.1
		Hg201(n,X)H3				23.2	15.2	13.6	11.9
		Hg202(n,2n)Hg201(n,X)H3				8.9	1.1	0.7	0.4
		&Hg200(n,2n)*Hg199*(n,X)H3				8.1		0.4	0.2
		Hg204(n,2n)Hg203(β^-)Tl203(n,X)H3				3.8		0.1	
		&Hg198(n,2n)*Hg197*(β^+)Au197(n,X)H3				2.6			
		Hg198(n,X)H3				2.5			
		Hg200(n,X)H3				1.9	17.9	19.4	16.8
		Hg202(n,X)H3				1.6	20.6	23.3	24.5
		Hg198(n,X)H3				0.5	4.8	7.5	9.0
		Hg204(n,X)H3				0.2	4.2	4.9	5.3
		Hg202(n,3n)Hg200(n,X)H3					3.1	0.8	0.4
		&Hg202(n,4n)*Hg199*(n,X)H3						2.7	0.7
		Hg202(n,5n)Hg198(n,X)H3						0.1	1.6
Pt193	50.0 y	&Hg196(n,α)*Pt193*	100.0	100.0	100.0	3.3	0.4		
		&Hg196(n,2n)*Hg195*(β^+)Au195(β^+)_ Pt195(n,2n)Pt194(n,2n)*Pt193*				27.3			
		&Hg196(n,2n)Hg195m(β^+)Au195(β^+)_ Pt195(n,2n)Pt194(n,2n)*Pt193*				15.1			
		&Hg196(n,2n)*Hg195*(β^+)Au195(n,2n)_ *Au194*(β^+)Pt194(n,2n)*Pt193*				8.2			
		&Hg196(n,2n)Hg195m(β^+)Au195_ (n,2n)*Au194*(β^+)Pt194(n,2n)*Pt193*				6.8			
		Hg198(n,3n)Hg196(n,3n)Hg194(n,2n)_ Hg193(β^+)Au193(β^+)Pt193					6.9	0.2	
	►	Hg198(n,3n)Hg196(n,3n)Hg194(n,2n)_ Hg193m(β^+)Au193(β^+)Pt193					3.5		

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	**&**Hg198(n,3n)Hg196(n,α)*Pt193*					3.0	0.1	
		&Hg199(n,4n)Hg196(n,4n)Hg193(β$^+$)_ *Au193*(β$^+$)Pt193						24.7	1.6
		Hg199(n,4n)Hg196(n,4n)Hg193m(β$^+$)_ Au193(β$^+$)Pt193						11.1	0.8
		&Hg198(n,3n)Hg196(n,4n)*Hg193*(β$^+$)_ *Au193*(β$^+$)Pt193						7.6	0.7
		Hg198(n,3n)Hg196(n,4n)Hg193m(β$^+$)_ Au193(β$^+$)Pt193						3.4	0.3
		&Hg200(n,5n)Hg196(n,4n)*Hg193*(β$^+$)_ *Au193*(β$^+$)Pt193						0.4	6.5
		&Hg198(n,6n)*Hg193*(β$^+$)*Au193*(β$^+$)Pt193							7.9
		Hg198(n,6n)Hg193m(β$^+$)Au193(β$^+$)Pt193							3.7
		Other long pathways				39.3	86.2	52.5	78.5
Hg194	440.01 y	Hg196(n,2n)Hg195m(n,2n)Hg194				76.7			
		&Hg196(n,2n)*Hg195*(n,2n)Hg194				14.1			
		Hg198(n,3n)Hg196(n,3n)Hg194					68.7	17.8	
		Hg200(n,3n)Hg198(n,3n)Hg196(n,3n)Hg194					14.1	1.1	
		Hg196(n,3n)Hg194					7.7	5.3	
		Hg199(n,4n)Hg196(n,3n)Hg194					3.5	58.1	
		Hg199(n,2n)Hg198(n,3n)Hg196(n,3n)Hg194					2.4	0.4	
		Hg202(n,3n)Hg200(n,3n)Hg198(n,3n)_ Hg196(n,3n)Hg194					1.2		
		Hg201(n,4n)Hg198(n,3n)Hg196(n,3n)Hg194					0.7	1.6	
		&Hg202(n,4n)*Hg199*(n,4n)Hg196(n,3n)Hg194						7.5	
		Hg198(n,5n)Hg194						2.0	53.8
		Hg200(n,5n)Hg196(n,3n)Hg194						1.1	2.7
		Hg201(n,4n)Hg198(n,5n)Hg194						0.3	1.6
		Hg200(n,3n)Hg198(n,5n)Hg194						0.2	2.3
		Hg199(n,6n)Hg194							21.1
		Hg202(n,5n)Hg198(n,5n)Hg194							9.8
		Hg199(n,2n)Hg198(n,5n)Hg194							1.3
Pb202	5.3 10^4 y	**&**Hg204(n,γ)Hg205(β$^-$)Tl205(n,2n)_ Tl204(β$^-$)Pb204(n,2n)*Pb203*(n,2n)*Pb202*				52.3			
		&Hg204(n,2n)Hg203(β$^-$)Tl203(n,γ)_ Tl204(β$^-$)Pb204(n,2n)*Pb203*(n,2n)*Pb202*				47.7			
		&Hg204(n,2n)Hg203(β$^-$)Tl203(n,γ)_ Tl204(β$^-$)Pb204(n,3n)*Pb202*					58.7	54.2	50.4
		&Hg204(n,γ)Hg205(β$^-$)Tl205(n,2n)_ Tl204(β$^-$)Pb204(n,3n)*Pb202*					36.6	33.4	29.6
		Hg204(n,d)Au203(β$^-$)Hg203(β$^-$)Tl203_ (n,γ)Tl204(β$^-$)Pb204(n,3n)Pb202					3.3	9.6	14.5
		&Hg204(n,γ)Hg205(β$^-$)Tl205(n,γ)_ Tl206(β$^-$)Pb206(n,5n)*Pb202*							1.7
Re186m	2.0 10^5 y	Long pathways involving (n,α), (n,nα), β$^-$				100.0	100.0	100.0	100.0
Pb205	1.5 10^7 y	Hg202(n,γ)Hg203(β$^-$)Tl203(n,γ)Tl204_ (β$^-$)Pb204(n,γ)Pb205	96.4	99.9	99.7				
		Hg201(n,γ)Hg202(n,γ)Hg203(β$^-$)Tl203_ (n,γ)Tl204(β$^-$)Pb204(n,γ)Pb205	3.4	0.1	0.3				
		&Hg204(n,γ)Hg205(β$^-$)Tl205(n,γ)_ Tl206(β$^-$)*Pb206*(n,2n)Pb205				76.3	83.5	82.7	82.3
		Hg204(n,γ)Hg205(β$^-$)Tl205(n,2n)Tl204_ (β$^-$)Pb204(n,γ)Pb205				12.4	5.9	5.6	5.2
		Hg204(n,2n)Hg203(β$^-$)Tl203(n,γ)Tl204_ (β$^-$)Pb204(n,γ)Pb205				11.3	9.4	9.1	8.9
Pt190	6.5 10^{11} y	**&**Hg196(n,α)*Pt193*(n,2n)Pt192(n,2n)_ Pt191(n,2n)Pt190				10.3			
		Hg196(n,2n)Hg195m(n,2n)Hg194(n,nα)Pt190				4.3			
		Hg196(n,3n)Hg194(n,3n)Hg192(β$^+$)_ Au192(β$^+$)Pt192(n,3n)Pt190					6.6	0.2	
	►	Hg198(n,3n)Hg196(n,3n)Hg194(n,nα)Pt190					4.7	0.2	

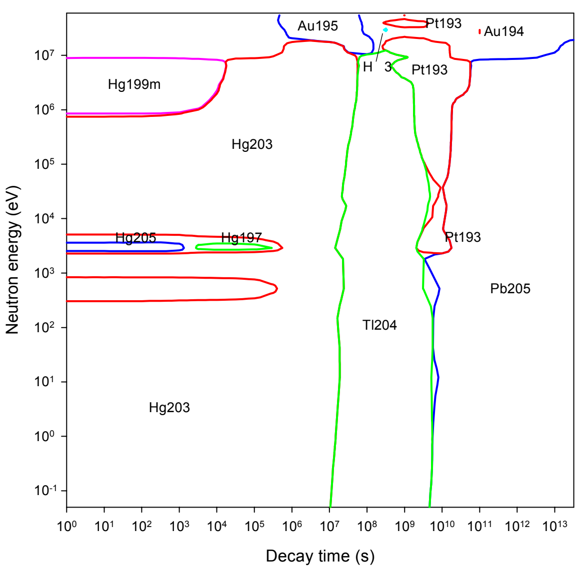
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Hg198(n,3n)Hg196(n,nα)Pt192(n,3n)Pt190					4.0		
		Hg198(n,nα)Pt194(n,3n)Pt192(n,3n)Pt190					3.1		
		Hg199(n,4n)Hg196(n,4n)Hg193(β^+)_ Au193(β^+)Pt193(n,4n)Pt190						16.6	
		Hg199(n,4n)Hg196(n,4n)Hg193m(β^+)_ Au193(β^+)Pt193(n,4n)Pt190						8.0	
		Hg198(n,3n)Hg196(n,4n)Hg193(β^+)_ Au193(β^+)Pt193(n,4n)Pt190						5.1	
		Hg198(n,4n)Hg195m(β^+)Au195(β^+)_ Pt195(n,4n)Pt192(n,3n)Pt190						3.5	
		Hg198(n,5n)Hg194(n,5n)Hg190(β^+)_ Au190(β^+)Pt190							23.2
		Hg199(n,6n)Hg194(n,5n)Hg190(β^+)_ Au190(β^+)Pt190							9.2
		&Hg199(n,5n)*Hg195*(β^+)Au195(β^+)_ Pt195(n,6n)Pt190							8.8
		Hg199(n,5n)Hg195m(β^+)Au195(β^+)_ Pt195(n,6n)Pt190							7.6
		Other very long pathways				85.4	81.6	66.4	51.2

Mercury activation characteristics

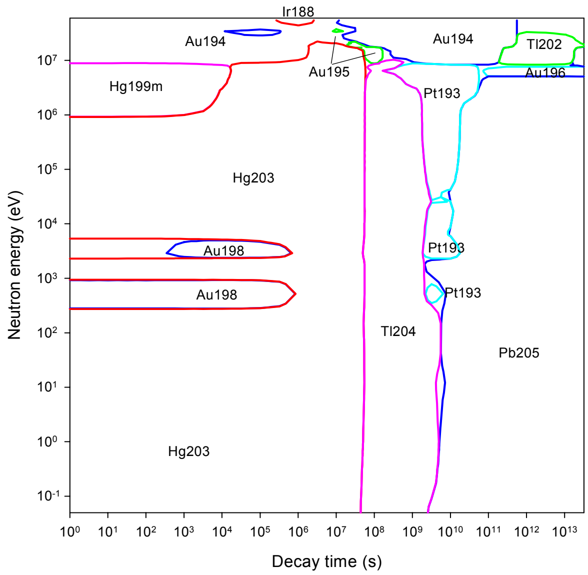


Mercury importance diagrams & transmutation

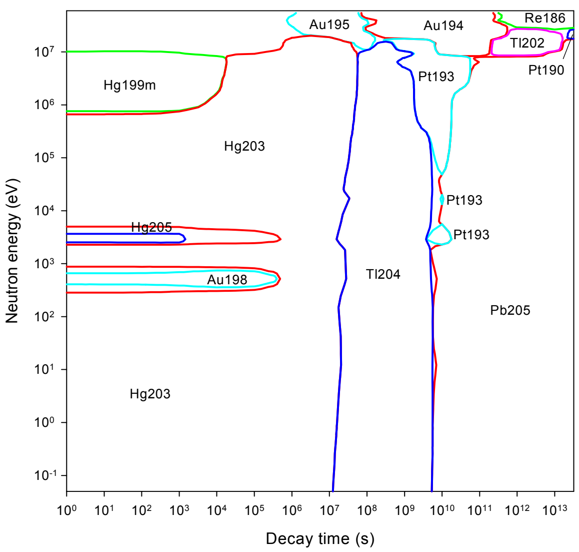
Activity



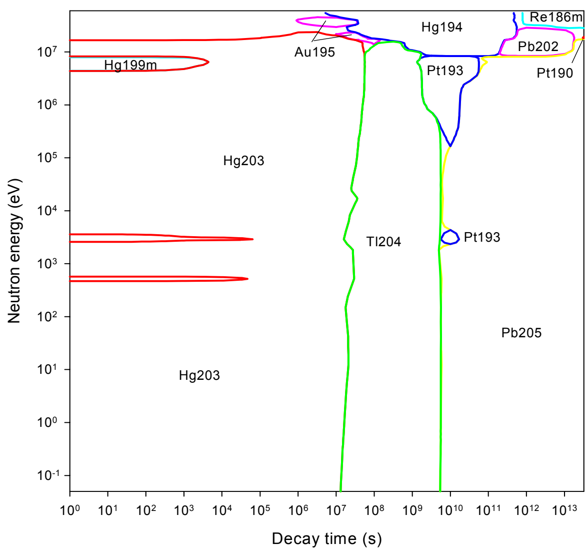
Dose rate



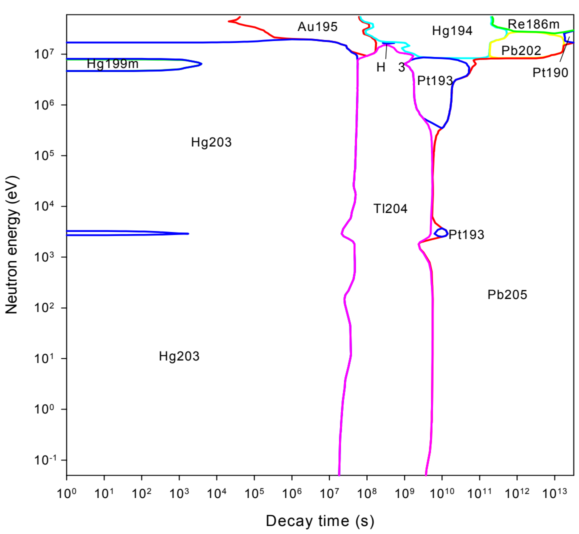
Heat output



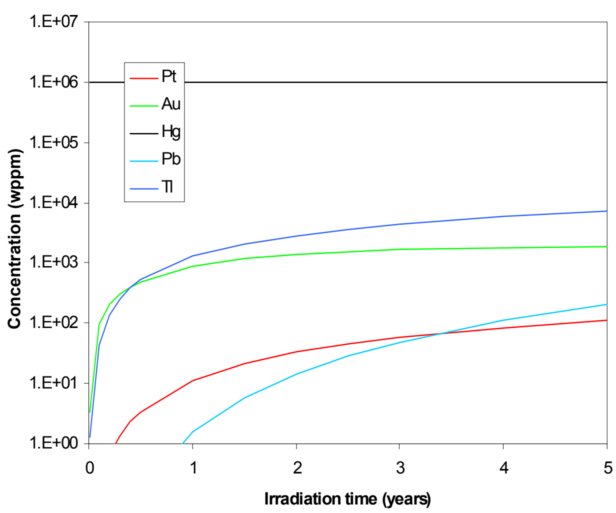
Ingestion dose



Inhalation dose



First wall transmutation



Thallium

General properties

		Isotopes	Isotopic abundances / %
Atomic number	81		
Crustal abundance / wppm	0.85	Tl203	29.524
Melting point / K	577	Tl205	70.476
Boiling point / K	1746		
Density / kgm^{-3}	11850		
Thermal conductivity / $Wm^{-1}K^{-1}$	46.1		
Electrical resistivity /Ωm	$1.8\ 10^{-7}$		
Coefficient of thermal expansion / K^{-1}	$2.99\ 10^{-5}$		
Crystal structure	Hexagonal		
Number of stable isotopes	2		
Mean atomic weight	204.3833		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.37E15	1.31E15	1.21E15	8.75E14	2.16E7	1.31E6
Tl204	76.52	80.36	86.60	99.99	54.90	
Tl202	13.28	13.95	12.25		0.30	1.34
Tl206	6.16	2.72				
Pb203	2.38	2.50	0.83			
Pb203m	1.16					
Hg203	0.28	0.29	0.30			
H3					38.54	
Pb205					5.94	97.30
Pb202					0.30	1.34

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	6.66E-2	6.01E-2	5.24E-2	3.34E-2	4.80E-10	1.56E-11
Tl204	60.15	66.64	76.33	99.99	94.25	
Tl202	21.44	23.75	22.16		1.06	8.90
Tl206	10.96	5.10				
Pb203m	3.16					
Pb203	2.84	3.15	1.12			
Pb204m	0.89	0.94				
Pb205					2.92	89.66
H3					1.58	
Pb202					0.17	1.44

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	1.14E4	9.12E3	6.76E3	6.93E1	4.34E-6	1.26E-6
Tl202	71.33	89.30	89.15		82.22	61.94
Pb203m	19.11					
Pb204m	5.80	6.88				
Pb203	2.56	3.21	1.34			
Hg203	0.21	0.26	0.34	1.16		
Tl204	0.09*	0.11*	0.16*	98.83*	3.44*	
Pb205					13.51	37.44

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	1.36E6	1.36E6	1.33E6	1.05E6	1.55E-2	5.22E-4
Tl204	92.82	92.83	94.29	99.99	91.54	
Tl202	6.04	6.04	5.00		0.18	1.52
Pb203	0.57	0.57	0.18			
Hg203	0.54	0.54	0.52			
Pb202					3.70	29.86
Pb205					2.31	68.60
H3					2.24	

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	4.61E5	4.61E5	4.48E5	3.41E5	8.68E-3	1.30E-3
Tl204	88.87	88.89	91.25	99.98	53.29	
Tl202	7.51	7.51	6.28		0.14	0.25
Hg203	2.01	2.01	1.95	0.01		
Pb203	1.56	1.56	0.49			
Pb204m	0.01	0.01				
Tl206	0.01	0.01				
H3					24.94	
Pb205					12.57	83.43
Pb202					9.04	16.31

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	1.17E12	1.11E12	1.06E12	8.75E11	1.20E4	7.82E1
Tl204	89.65	94.51	98.47	100.0	98.58	
Tl206	7.22	3.20				
Tl202	1.55	1.64	1.39		0.05	2.26
Pb203m	0.90					
Pb204m	0.30	0.30				
Pb203	0.27	0.29	0.09			
H3					0.69	
Pb205					0.62	96.11
Pb202					0.03	1.62

Thallium

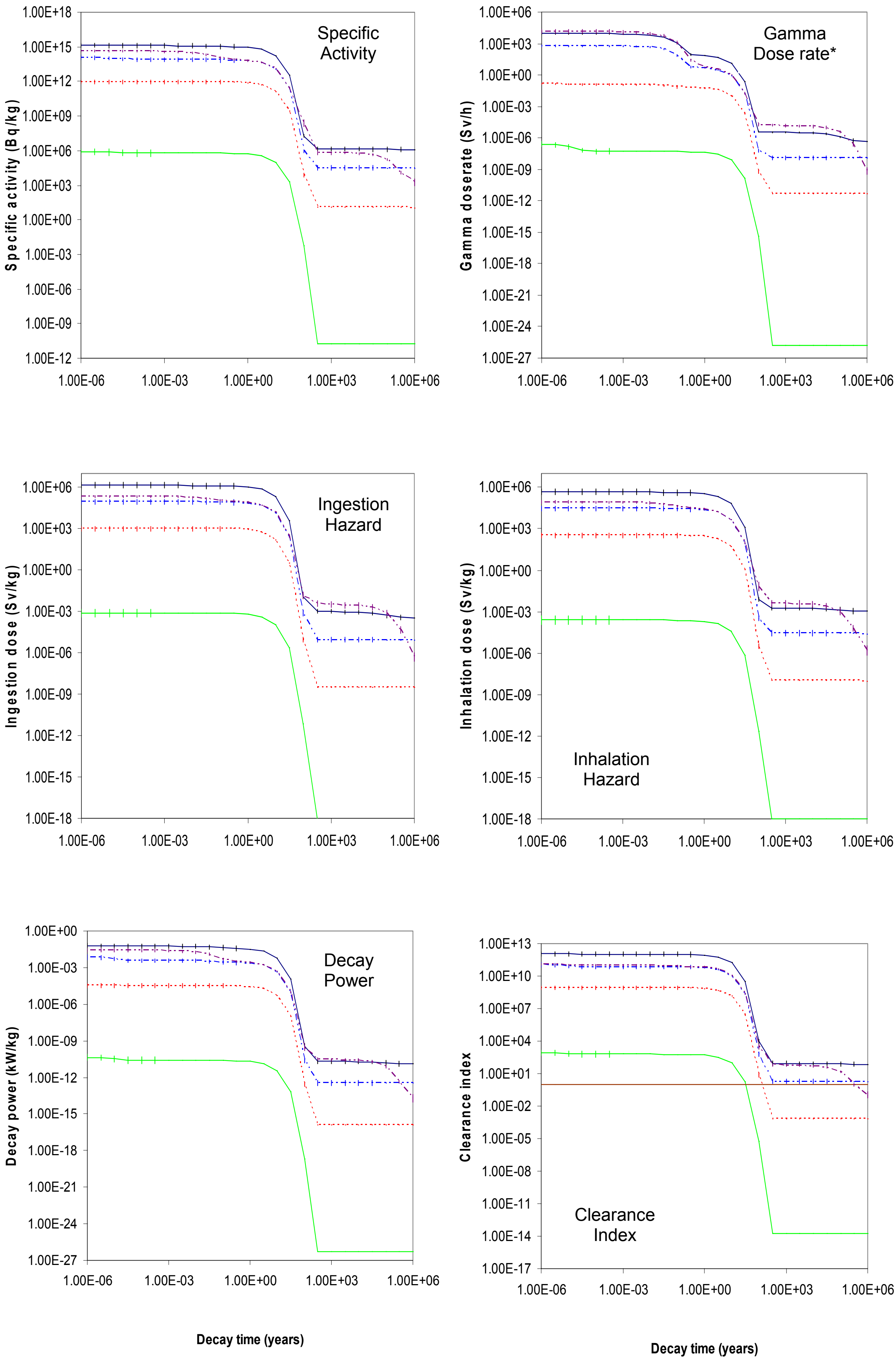
Pathway analysis

Nuclide	$T_{1/2}$	Pathway	210	186	151	42	30	21	6
Tl206	4.20 m	**&**Tl205(n,γ)*Tl206*	93.8	100.0	100.0	99.9	99.6	99.6	99.8
		Tl203(n,γ)Tl204(n,γ)Tl205(n,γ)Tl206	6.2						
Pb204m	1.125 h	Tl205(n,2n)Tl204(β^-)Pb204(n,n′)Pb204m				99.7	91.6	97.3	98.3
		Tl205(n,γ)Tl206(β^-)Pb206(n,3n)Pb204m					8.1	2.5	1.5
Tl200	1.088 d	Tl203(n,2n)Tl202(n,2n)Tl201(n,2n)Tl200				93.5			
		Tl205(n,2n)Tl204(n,2n)Tl203(n,2n)_ Tl202(n,2n)Tl201(n,2n)Tl200				6.5			
		Tl203(n,4n)Tl200					48.9	84.7	22.5
		Tl205(n,3n)Tl203(n,4n)Tl200					32.2	12.8	
		Tl205(n,2n)Tl204(β^-)Pb204(n,3n)_ Pb202(n,3n)Pb200(β^+)Tl200					8.2		
		Tl203(n,2n)Tl202(n,3n)Tl200					1.9		
		Tl205(n,3n)Tl203(n,2n)Tl202(n,3n)Tl200					1.1		
		Tl205(n,4n)Tl202(n,3n)Tl200					1.1		
		Tl205(n,6n)Tl200							71.2
Au194	1.584 d	Tl203(n,4n)Tl200(β^+)Hg200(n,4n)_ Hg197(β^+)Au197(n,4n)Au194						3.6	0.1
		&Tl205(n,6n)Tl200(β^+)Hg200(n,5n)_ Hg196(n,t)*Au194*							3.1
		&Tl205(n,5n)Tl201(β^+)Hg201(n,6n)_ Hg196(n,t)*Au194*							2.5
		&Tl203(n,6n)Tl198(β^+)Hg198(n,2nt)*Au194*							2.3
		&Tl203(n,5n)Tl199(β^+)Hg199(n,3nt)*Au194*							1.8
		Tl205(n,5n)Tl201(β^+)Hg201(n,5n)_ Hg197(β^+)Au197(n,4n)Au194							1.3
		Other very long pathways				100.0	100.0	96.4	88.9
Tl201	3.041 d	Tl203(n,2n)Tl202(n,2n)Tl201				91.6			
		Tl205(n,2n)Tl204(n,2n)Tl203(n,2n)_ Tl202(n,2n)Tl201				7.4			
		Tl203(n,3n)Tl201				0.1	59.6	61.3	13.1
		Tl205(n,3n)Tl203(n,3n)Tl201					39.2	9.3	
		Tl205(n,5n)Tl201						14.7	84.5
		Tl205(n,2n)Tl204(n,4n)Tl201						9.1	
Re186	3.777 d	Long pathways involving (n,α), (n,nα), β^-				100.0	100.0	100.0	100.0
Tl202	12.240 d	Tl203(n,2n)Tl202				88.7	37.0	6.8	16.8
		Tl205(n,2n)Tl204(n,2n)Tl203(n,2n)Tl202				8.5			
		&Tl205(n,2n)Tl204(β^-)Pb204(n,2n)_ *Pb203*(β^+)Tl203(n,2n)Tl202				1.3			
		Tl205(n,3n)Tl203(n,2n)Tl202					24.4		
		Tl205(n,4n)Tl202					21.2	90.9	79.9
		Tl205(n,2n)Tl204(n,3n)Tl202					16.6		
Hg203	46.603 d	Tl203(n,α)Au200(β^-)Hg200(n,γ)Hg201_ (n,γ)Hg202(n,γ)Hg203	99.5	96.9	0.2				
		Tl203(n,γ)Tl204(n,α)Au201(β^-)Hg201_ (n,γ)Hg202(n,γ)Hg203		1.3					
		Tl203(n,γ)Tl204(β^-)Pb204(n,γ)Pb205_ (n,α)Hg202(n,γ)Hg203		1.2					
		Tl205(n,γ)Tl206(β^-)Pb206(n,α)Hg203		0.2	99.8				
		Tl205(n,2n)Tl204(β^+)Hg204(n,2n)Hg203				69.1			
		Tl203(n,p)Hg203				22.7	26.4	10.0	4.4
		Tl205(n,2n)Tl204(n,2n)Tl203(n,p)Hg203				2.0			
		Tl203(n,2n)Tl202(β^+)Hg202(n,γ)Hg203				1.5			
		Tl205(n,d)Hg204(n,2n)Hg203				1.3	6.4		
		Tl205(n,2n)Tl204(n,d)Hg203				1.2	5.8		
		Tl205(n,2n)Tl204(n,p)Hg204(n,2n)Hg203				1.0			
		Tl205(n,t)Hg203				0.5	42.6	80.6	91.2
		Tl205(n,3n)Tl203(n,p)Hg203					16.9		

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Au195	186.09 d	Tl203(n,3n)Tl201(β^+)Hg201(n,4n)_ Hg198(n,4n)Hg195m(β^+)Au195						7.2	
		Tl203(n,4n)Tl200(β^+)Hg200(n,3n)_ Hg198(n,4n)Hg195m(β^+)Au195						7.1	
		Tl203(n,3n)Tl201(β^+)Hg201(n,4n)_ Hg198(n,4n)Hg195(β^+)Au195						3.4	
		Tl203(n,4n)Tl200(β^+)Hg200(n,3n)_ Hg198(n,4n)Hg195(β^+)Au195						3.4	
		Tl205(n,4n)Tl202(β^+)Hg202(n,5n)_ Hg198(n,4n)Hg195m(β^+)Au195						2.1	0.3
		Tl205(n,5n)Tl201(β^+)Hg201(n,4n)_ Hg198(n,4n)Hg195m(β^+)Au195						1.7	0.3
		Tl203(n,4n)Tl200(β^+)Hg200(n,4n)_ Hg197(β^+)Au197(n,3n)Au195						1.3	
		Tl205(n,4n)Tl202(β^+)Hg202(n,5n)_ Hg198(n,4n)Hg195(β^+)Au195						1.0	
		&Tl203(n,5n)Tl199(β^+)Hg199(n,5n)_ *Hg195*(β^+)*Au195*							27.5
		Tl203(n,5n)Tl199(β^+)Hg199(n,5n)_ Hg195m(β^+)Au195							19.3
		&Tl205(n,6n)Tl200(β^+)Hg200(n,6n)_ Hg195(β^+)*Au195*							7.6
		Tl205(n,6n)Tl200(β^+)Hg200(n,6n)_ Hg195m(β^+)Au195							4.5
		&Tl203(n,4n)Tl200(β^+)Hg200(n,6n) *Hg195*(β^+)Au195							2.4
		&Tl203(n,5n)Tl199(β^+)Hg199(n,2nt)*Au195*							2.0
		Tl203(n,4n)Tl200(β^+)Hg200(n,6n)_ Hg195m(β^+)Au195							1.4
		Other very long pathways				100.0	100.0	72.8	34.7
Tl204	3.788 y	Tl203(n,γ)Tl204	100.0	100.0	100.0				
		Tl205(n,2n)Tl204				100.0	99.7	99.8	99.8
H3	12.33 y	Tl205(n,X)H3				57.7	69.6	64.9	61.0
		Tl205(n,2n)Tl204(n,X)H3				24.3	1.3		
		Tl203(n,X)H3				16.3	18.4	22.7	25.3
		Tl205(n,2n)Tl204(n,2n)Tl203(n,X)H3				2.3			
		Tl205(n,3n)Tl203(n,X)H3					5.9	1.7	1.0
		Tl203(n,3n)Tl201(β^+)Hg201(n,X)H3					2.5		
		Tl205(n,4n)Tl202(β^+)Hg202(n,X)H3						4.1	1.1
		Tl203(n,4n)Tl200(β^+)Hg200(n,X)H3						1.7	
		Tl205(n,5n)Tl201(β^+)Hg201(n,X)H3							3.1
		Tl203(n,5n)Tl199(β^+)Hg199(n,X)H3							1.5
		Tl205(n,6n)Tl200(β^+)Hg200(n,X)H3							1.4
Pt193	50.0 y	Long pathways involving (n,α), (n,nα), β^-				100.0	100.0	100.0	100.0
Hg194	440.01 y	Tl203(n,3n)Tl201(β^+)Hg201(n,4n)_ Hg198(n,3n)Hg196(n,3n)Hg194					42.0	3.9	
		&Tl203(n,3n)Tl201(β^+)Hg201(n,3n)_ *Hg199*(n,4n)Hg196(n,3n)Hg194					14.0	2.7	
		Tl203(n,4n)Tl200(β^+)Hg200(n,3n)_ Hg198(n,3n)Hg196(n,3n)Hg194					5.8	3.8	
		Tl205(n,3n)Tl203(n,3n)Tl201(β^+)Hg201_ (n,4n)Hg198(n,3n)Hg196(n,3n)Hg194					5.4	0.1	
		Tl203(n,3n)Tl201(β^+)Hg201(n,2n)Hg200_ (n,3n)Hg198(n,3n)Hg196(n,3n)Hg194					5.2		
		Tl203(n,2n)Tl202(β^+)Hg202(n,3n)Hg200_ (n,3n)Hg198(n,3n)Hg196(n,3n)Hg194					4.3		
		&Tl205(n,4n)Tl202(β^+)Hg202(n,4n)_ *Hg199*(n,4n)Hg196(n,3n)Hg194						47.6	
	►	Tl203(n,4n)Tl200(β^+)Hg200(n,5n)_ Hg196(n,3n)Hg194						4.8	0.7

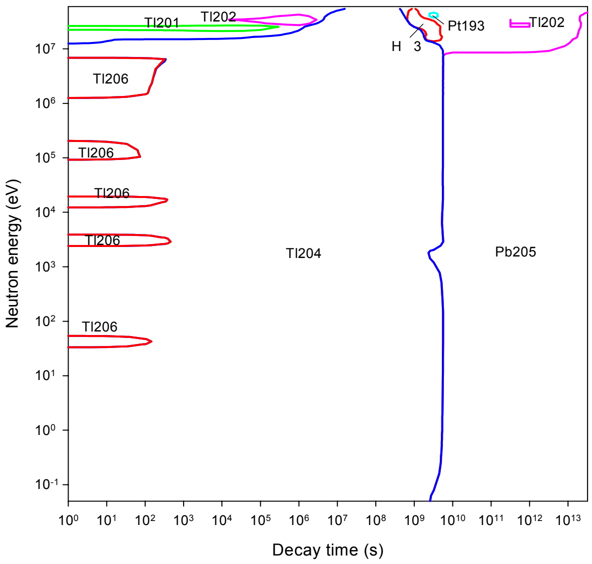
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Tl203(n,5n)Tl199(β^+)Hg199(n,4n)_ Hg196(n,3n)Hg194						4.5	0.7
		&Tl203(n,2n)Tl202(β^+)Hg202(n,4n)_ *Hg199*(n,4n)Hg196(n,3n)Hg194						3.6	
		Tl205(n,4n)Tl202(β^+)Hg202(n,5n)_ Hg198(n,5n)Hg194						0.3	4.3
		Tl205(n,5n)Tl201(β^+)Hg201(n,4n)_ Hg198(n,5n)Hg194						0.2	4.2
		Tl203(n,5n)Tl199(β^+)Hg199(n,6n)Hg194							31.2
		&Tl203(n,6n)*Tl198*(β^+)Hg198(n,5n)Hg194							22.0
		Tl203(n,6n)Tl198m(β^+)Hg198(n,5n)Hg194							9.8
		Other very long pathways				100.0	23.3	27.5	27.1
Pb202	5.3 10^4 y	**&**Tl205(n,2n)Tl204(β^-)Pb204(n,2n)_ *Pb203*(n,2n)*Pb202*				100.0			
		&Tl205(n,2n)Tl204(β^-)Pb204(n,3n)*Pb202*					99.8	99.8	95.5
		Tl205(n,γ)Tl206(β^-)Pb206(n,5n)Pb202							3.5
Re186m	2.0 10^5 y	Long pathways involving (n,α), (n,nα), β^-				100.0	100.0	100.0	100.0
Pb205	1.5 10^7 y	Tl203(n,γ)Tl204(β^-)Pb204(n,γ)Pb205	100.0	100.0	100.0				
		&Tl205(n,γ)*Tl206*(β^-)Pb206(n,2n)Pb205				82.8	91.4	91.7	92.1
		Tl205(n,2n)Tl204(β^-)Pb204(n,γ)Pb205				17.2	8.2	7.9	7.5

Thallium activation characteristics

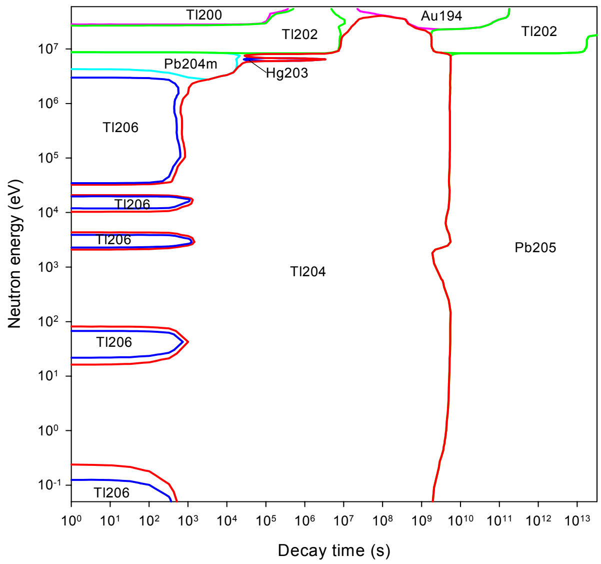


Thallium importance diagrams & transmutation

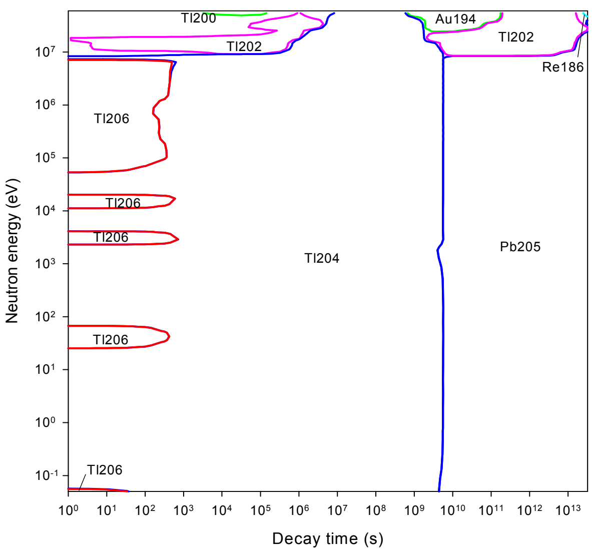
Activity



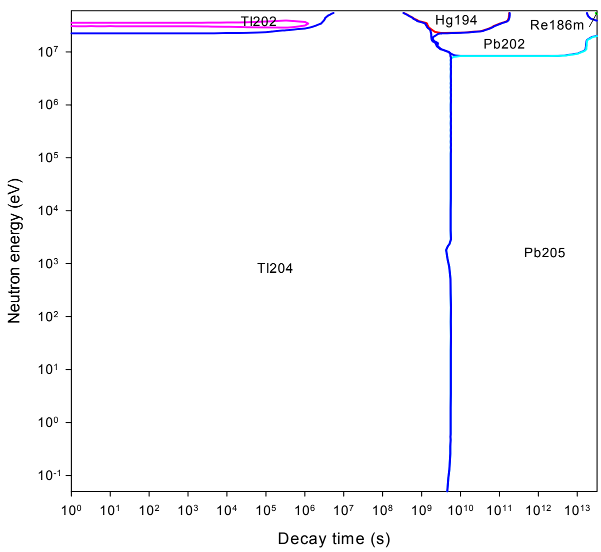
Dose rate



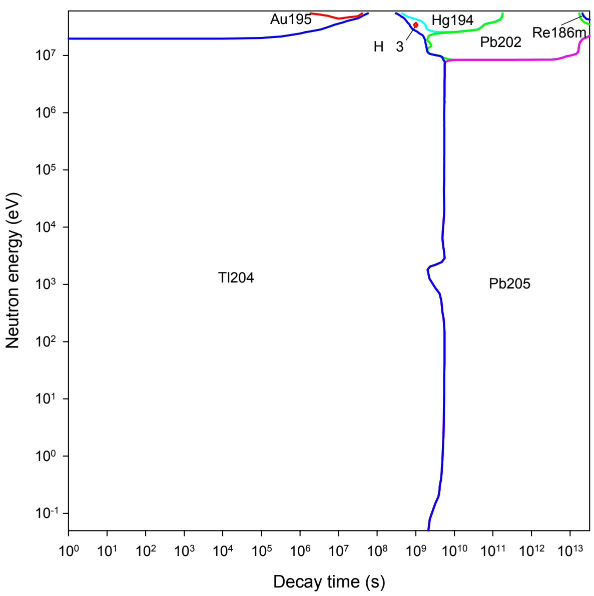
Heat output



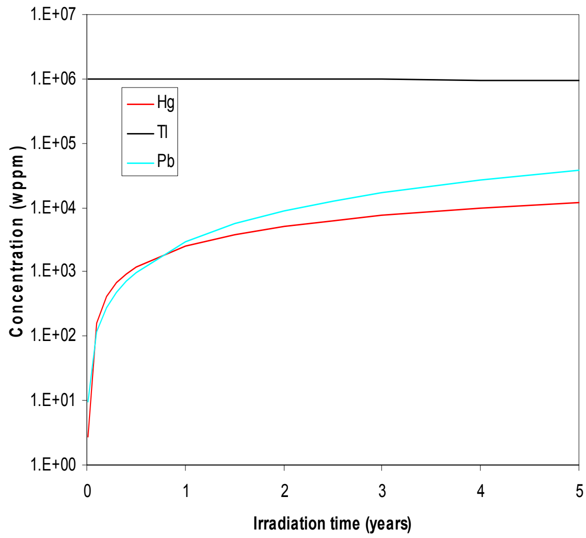
Ingestion dose



Inhalation dose



First wall transmutation



Lead

General properties

		Isotopes	Isotopic abundances / %
Atomic number	82	Pb204	1.4 ($T_{1/2}$=1.40 10^{17} y)
Crustal abundance / wppm	14.0	Pb206	24.1
Melting point / K	600.6	Pb207	22.1
Boiling point / K	2022	Pb208	52.4
Density / kgm^{-3}	11350		
Thermal conductivity / $Wm^{-1}K^{-1}$	35.3		
Electrical resistivity /Ωm	2.07 10^{-7}		
Coefficient of thermal expansion / K^{-1}	2.89 10^{-5}		
Crystal structure	FCC		
Number of stable isotopes	3 (4)		
Mean atomic weight	207.2		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	3.09E14	1.83E13	5.58E12	9.30E11	5.62E7	4.97E7
Pb207m	91.81					
Pb203	4.18	70.28	71.75			
Pb203m	2.04					
Pb204m	0.93	14.76				
Tl204	0.36	6.08	19.96	99.94	0.02	
Pb209	0.27	4.46				
Tl202	0.17	2.79	7.47		0.12	0.04
Tl206	0.07	0.52				
Hg203	0.02	0.25	0.78	0.02		
H3				0.02	1.01	
Pb205				0.01	88.53	99.56
Bi207				0.01	9.72	

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	7.69E-2	1.85E-3	3.11E-4	3.56E-5	2.13E-9	6.21E-10
Pb207m	96.29					
Pb204m	1.30	51.23				
Pb203m	1.08					
Pb203	0.97	40.45	74.77			
Tl204	0.06	2.30	13.69	99.57	0.02	
Tl202	0.05	2.17	10.52		0.26	0.24
Pb209	0.03	1.40				
Bi207				0.04	68.19	
Pb205					25.57	87.19
Bi208					4.40	12.50
Po209					1.48	
H3					0.02	

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	8.41E4	1.19E3	5.31E1	8.71E-2	1.77E-3	1.54E-4
Pb207m	97.38					
Pb204m	1.29	86.11				
Pb203m	1.01					
Pb203	0.13	9.34	65.29			
Tl208	0.12	2.64				
Tl202	0.03	1.87	34.15	0.01	0.17	0.53
Hg203		0.02	0.50	5.03		
Tl206m		0.01				
Bi207			0.03	56.47	89.54	
Tl204			0.02*	37.74*		
Bi208				0.67	9.26	87.81
Pb205				0.07	1.02	11.66

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	6.01E3	6.00E3	3.62E3	1.29E3	5.28E-2	1.43E-2
Pb203	51.52	51.60	26.50			
Tl204	22.27	22.33	36.87	86.27	0.03	
Po210	17.60	17.65	29.14	13.69	0.48	
Tl202	3.84	3.85	5.18		0.06	0.06
Pb204m	2.42	2.30				
Hg203	1.46	1.46	2.29	0.03		
Po209				0.01	57.58	
Bi207				0.01	13.44	
Pb205					26.36	96.98
Pb202					1.15	1.16
Bi208					0.58	1.78
H3					0.05	

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	7.52E3	7.50E3	5.34E3	9.97E2	1.72E-1	4.39E-2
Po210	50.42	50.54	70.88	63.55	0.52	
Pb203	37.76	37.80	16.49			
Tl204	5.79	5.80	8.14	36.34		
Hg203	1.47	1.47	1.96	0.05		
Tl202	1.30	1.30	1.48		0.01	0.01
Bi210	1.22	1.23	1.04		0.01	
Pb204m	1.22	1.16				
Bi207			0.01	0.03	17.73	
Po209				0.02	54.95	
Pb205					24.50	95.83
Bi210m					0.52	2.00
Bi208					0.51	1.66
H3					0.09	

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	4.44E11	9.06E9	1.56E9	9.30E8	5.81E4	3.39E3
Pb207m	96.84					
Pb204m	1.34	62.23				
Pb203m	0.95					
Pb203	0.29	14.23	25.62			
Tl204	0.25	12.31	71.30	99.93	0.02	
Tl208	0.03	0.42				
Tl202	0.01	0.57	2.67		0.01	0.06
Hg203		0.05	0.28			
Po210		0.01	0.06	0.02		
Bi207		0.01	0.03	0.05	93.92	
Pb205					5.03	85.81
Bi208					0.99	14.09
H3					0.01	

Lead

Pathway analysis

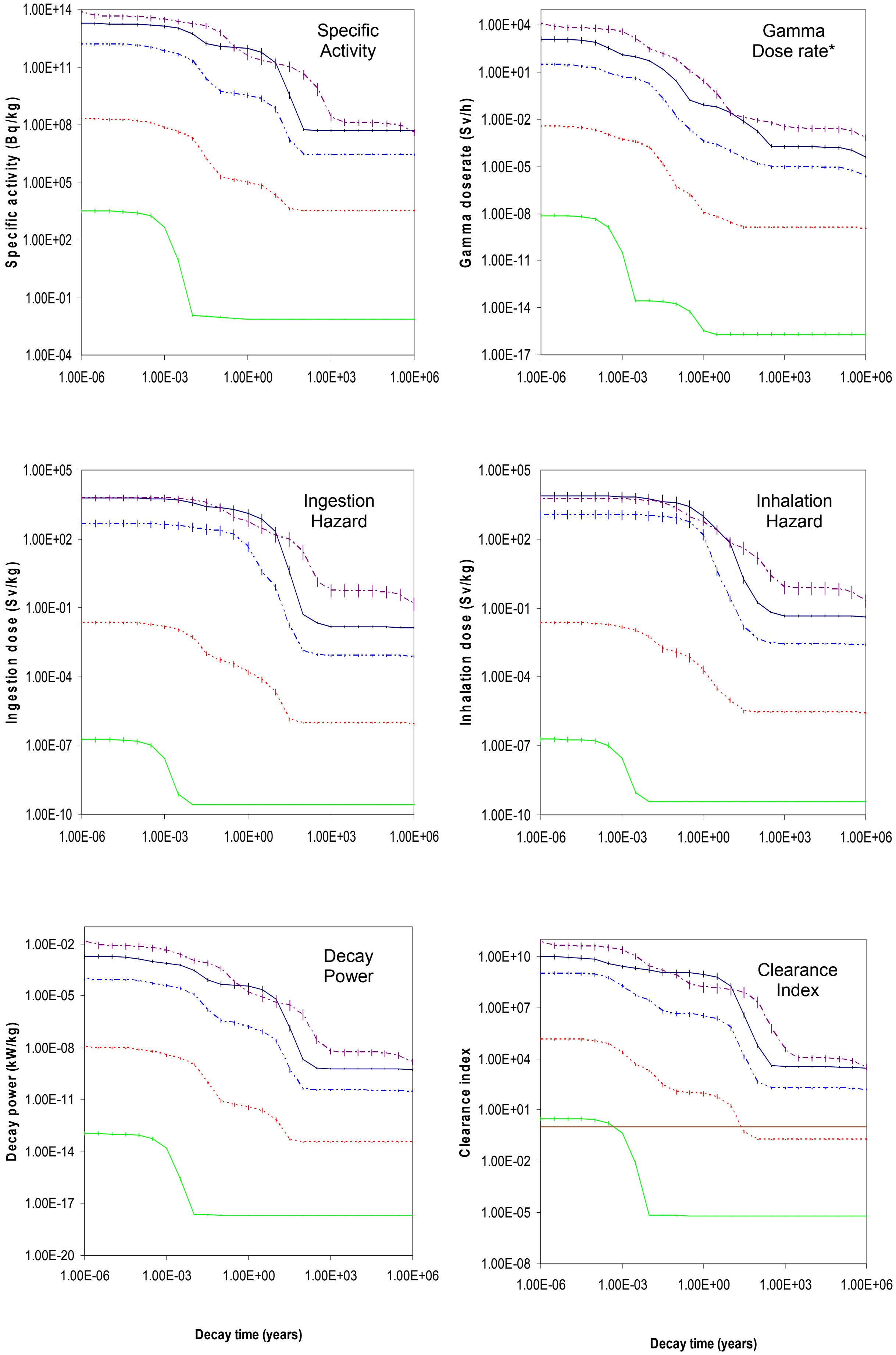
Nuclide	T½	Pathway	210	186	151	42	30	21	6
Pb207m	0.806 s	Pb206(n,γ)Pb207m	100.0	100.0	100.0				
		Pb208(n,2n)Pb207m				94.3	92.6	92.4	92.7
		Pb207(n,n′)Pb207m				3.2	6.2	6.6	6.7
		Pb208(n,2n)Pb207(n,n′)Pb207m				1.1			
Hg205	5.20 m	Pb208(n,α)Hg205	98.5	99.9	99.9	99.9	99.2	93.4	86.0
		Pb207(n,γ)Pb208(n,α)Hg205	1.5		0.1				
		Pb206(n,d)Tl205(n,p)Hg205					0.3	1.5	0.9
		Pb207(n,h)Hg205						3.0	8.4
		Pb207(n,t)Tl205(n,p)Hg205						0.8	1.0
		Pb208(n,nt)Tl205(n,p)Hg205						0.3	1.9
Pb204m	1.125 h	Pb206(n,2n)Pb205(n,2n)Pb204m				80.7	0.9	0.7	
		Pb207(n,2n)Pb206(n,2n)Pb205(n,2n)Pb204m				12.1			
		&Pb208(n,2n)*Pb207*(n,2n)Pb206(n,2n)_ Pb205(n,2n)Pb204m				3.0			
		Pb204(n,n′)Pb204m				1.8	0.3		
		Pb206(n,2n)Pb205(n,2n)Pb204(n,n′)Pb204m				1.5			
		Pb206(n,3n)Pb204m					53.8	23.0	10.6
		Pb208(n,3n)Pb206(n,3n)Pb204m					32.1	3.8	
		Pb207(n,2n)Pb206(n,3n)Pb204m					3.3	0.9	
		Pb207(n,3n)Pb205(n,2n)Pb204m					3.2	0.8	
		Pb207(n,4n)Pb204m					2.3	51.6	11.8
		Pb206(n,3n)Pb204(n,n′)Pb204m					1.0		
		Pb208(n,4n)Pb205(n,2n)Pb204m					0.3	5.5	
		&Pb208(n,2n)*Pb207*(n,4n)Pb204m					0.3	5.4	
		Pb208(n,5n)Pb204m						3.9	70.7
		Pb207(n,4n)Pb204(n,n′)Pb204m						1.0	
Pb209	3.253 h	Pb208(n,γ)Pb209	98.5	99.9	99.9	99.9	99.7	99.8	99.9
		Pb207(n,γ)Pb208(n,γ)Pb209	1.5		0.1				
Tl200	1.088 d	**&**Pb204(n,2n)*Pb203*(β^+)Tl203(n,2n)_ Tl202(n,2n)Tl201(n,2n)Tl200				61.6			
		&Pb206(n,2n)Pb205(n,2n)*Pb204*(n,2n)_ *Pb203*(β^+)Tl203(n,2n)Tl202(n,2n)_ Tl201(n,2n)Tl200				18.1			
		&Pb204(n,2n)*Pb203*(n,2n)Pb202(n,2n)_ Pb201(β^+)*Tl201*(n,2n)Tl200				6.7			
		&Pb206(n,3n)*Pb204*(n,3n)*Pb202*(n,3n)_ Pb200(β^+)Tl200					48.3	1.2	
		&Pb204(n,3n)*Pb202*(n,3n)Pb200(β^+)Tl200					21.9	2.1	
		&Pb207(n,4n)Pb204(n,3n)*Pb202*(n,3n)_ Pb200(β^+)Tl200					1.8	2.5	
		&Pb206(n,4n)*Pb203*(β^+)Tl203(n,4n)Tl200						48.1	1.3
		&Pb208(n,4n)Pb205(n,4n)*Pb202*(n,3n)_ Pb200(β^+)Tl200						12.7	
		&Pb208(n,4n)Pb205(n,3n)*Pb203*(β^+)_ Tl203(n,4n)Tl200						4.2	
		&Pb208(n,3n)Pb206(n,4n)*Pb203*(β^+)_ Tl203(n,4n)Tl200						4.1	
		&Pb206(n,5n)*Pb202*(n,3n)Pb200(β^+)Tl200						1.0	5.8
		&Pb207(n,4n)*Pb204*(n,5n)Pb200(β^+)Tl200						0.1	5.8
		&Pb208(n,5n)*Pb204*(n,5n)Pb200(β^+)Tl200							36.4
		Pb204(n,5n)Pb200(β^+)Tl200							8.5
		&Pb206(n,3n)*Pb204*(n,5n)Pb200(β^+)Tl200							5.0
		Pb208(n,4n)Pb205(n,6n)Pb200(β^+)Tl200							3.8
		&Pb208(n,6n)*Pb203*(β^+)Tl203(n,4n)Tl200							3.6
		&Pb206(n,5n)*Pb202*(n,t)Tl200							2.4
		Pb207(n,6n)Pb202(n,3n)Pb200(β^+)Tl200							2.2
		Other very long pathways				13.6	28.0	24.0	25.2

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Au194	1.584 d	Long pathways involving (n,α), (n,nα), β^-				100.0	100.0	100.0	100.0
Pb203	2.162 d	&Pb204(n,2n)*Pb203*				47.3	5.3	1.4	
		&Pb206(n,2n)Pb205(n,2n)*Pb204*(n,2n)*Pb203*				45.2			
		&Pb207(n,2n)Pb206(n,2n)Pb205(n,2n)_ *Pb204*(n,2n)*Pb203*				4.0			
		&Pb207(n,3n)Pb205(n,3n)*Pb203*					37.2	1.4	
		&Pb206(n,3n)*Pb204*(n,2n)*Pb203*					22.5	1.4	
		&Pb206(n,2n)Pb205(n,3n)*Pb203*					10.7	1.2	
		&Pb208(n,3n)Pb206(n,3n)*Pb204*(n,2n)*Pb203*					6.3		
		&Pb208(n,4n)Pb205(n,3n)*Pb203*					3.0	10.0	
		&Pb208(n,3n)Pb206(n,2n)Pb205(n,3n)*Pb203*					3.0		
		&Pb208(n,2n)*Pb207*(n,3n)Pb205(n,3n)*Pb203*					2.8		
		&Pb206(n,4n)*Pb203*					1.8	62.0	14.1
		&Pb208(n,3n)Pb206(n,4n)*Pb203*					1.1	9.8	
		&Pb207(n,4n)*Pb204*(n,2n)*Pb203*					0.9	3.5	
		&Pb207(n,2n)Pb206(n,4n)*Pb203*						2.4	
		&Pb207(n,5n)*Pb203*						2.1	32.9
		&Pb208(n,6n)*Pb203*							40.6
		&Pb208(n,5n)Pb204(n,2n)*Pb203*							3.2
Tl202	12.240 d	&Pb204(n,2n)*Pb203*(β^+)Tl203(n,2n)Tl202				72.2	3.6	0.5	
		&Pb206(n,2n)Pb205(n,2n)*Pb204*(n,2n)_ *Pb203*(β^+)Tl203(n,2n)Tl202				23.5			
		&Pb207(n,2n)Pb206(n,2n)Pb205(n,2n)_ *Pb204*(n,2n)*Pb203*(β^+)Tl203(n,2n)Tl202				1.6			
		&Pb206(n,3n)*Pb204*(n,3n)Pb202m(β^+)Tl202					17.7	0.8	
		&Pb207(n,3n)Pb205(n,3n)*Pb203*(β^+)_ Tl203(n,2n)Tl202					14.6	0.3	
		&Pb206(n,3n)*Pb204*(n,2n)*Pb203*(β^+)_ Tl203(n,2n)Tl202					8.0	0.3	
		&Pb208(n,3n)Pb206(n,3n)*Pb204*(n,3n)_ Pb202m(β^+)Tl202					4.8		
		&Pb206(n,3n)*Pb204*(n,t)Tl202					4.4	3.3	2.0
		Pb204(n,3n)Pb202m(β^+)Tl202					4.2	0.6	0.1
		&Pb206(n,4n)*Pb203*(β^+)Tl203(n,2n)Tl202					1.4	21.8	2.1
		Pb206(n,d)Tl205(n,4n)Tl202					1.1	12.6	1.8
		&Pb207(n,4n)*Pb204*(n,t)Tl202					0.2	8.3	2.4
		Pb207(n,t)Tl205(n,4n)Tl202					0.2	6.9	2.0
		Pb208(n,4n)Pb205(n,4n)Pb202m(β^+)Tl202						7.9	0.4
		Pb208(n,4n)Pb205(n,nt)Tl202						4.2	5.8
		Pb208(n,nt)Tl205(n,4n)Tl202						2.8	3.8
		&Pb207(n,5n)*Pb203*(β^+)Tl203(n,2n)Tl202						0.7	4.9
		&Pb208(n,5n)*Pb204*(n,t)Tl202						0.6	14.5
		Pb206(n,5n)Pb202m(β^+)Tl202						0.5	8.9
		Pb206(n,2nt)Tl202						0.3	16.1
		&Pb208(n,6n)*Pb203*(β^+)Tl203(n,2n)Tl202							6.1
		Pb207(n,6n)Pb202m(β^+)Tl202							4.1
Hg203	46.603 d	Pb206(n,α)Hg203	58.1	97.8	99.9	30.9	31.1	8.2	9.3
		Pb204(n,α)Hg201(n,γ)Hg202(n,γ)Hg203	25.5						
		Pb204(n,γ)Pb205(n,α)Hg202(n,γ)Hg203	16.3	2.2					
		Pb207(n,α)Hg204(n,2n)Hg203				34.2	3.7	0.6	0.2
		&Pb208(n,2n)*Pb207*(n,α)Hg204(n,2n)Hg203				13.3	0.3		
		Pb207(n,2n)Pb206(n,α)Hg203				9.0	1.9		0.2
		&Pb204(n,2n)*Pb203*(β^+)Tl203(n,p)Hg203				6.1	0.6		
		&Pb208(n,2n)*Pb207*(n,2n)Pb206(n,α)Hg203				3.5			
		&Pb206(n,2n)Pb205(n,2n)*Pb204*(n,2n)_ *Pb203*(β^+)Tl203(n,p)Hg203				1.0			
		Pb207(n,nα)Hg203				0.3	28.4	29.4	15.1
		&Pb208(n,2n)*Pb207*(n,nα)Hg203				0.1	4.4	3.0	0.8
		Pb208(n,3n)Pb206(n,α)Hg203					17.9	1.3	0.8
		&Pb207(n,3n)Pb205(n,3n)*Pb203*(β^+)_ Tl203(n,p)Hg203					2.3		
	►	Pb208(n,nα)Hg204(n,2n)Hg203					1.7	1.7	0.6

Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	Pb208(n,2nα)Hg203					0.6	31.4	44.4
		Pb206(n,d)Tl205(n,t)Hg203					0.5	2.9	3.1
		&Pb206(n,4n)*Pb203*(β^+)Tl203(n,p)Hg203					0.2	8.3	0.8
		Pb206(n,t)Tl204(n,d)Hg203					0.2	1.6	2.2
		Pb207(n,t)Tl205(n,t)Hg203						1.6	3.4
		Pb208(n,nt)Tl205(n,t)Hg203						0.6	6.6
		&Pb208(n,6n)*Pb203*(β^+)Tl203(n,p)Hg203							2.4
		&Pb207(n,5n)*Pb203*(β^+)Tl203(n,p)Hg203							2.0
		Pb207(n,nt)Tl204(n,d)Hg203							1.8
		Pb208(n,2nt)Tl204(n,d)Hg203							1.4
Po210	138.39 d	Pb208(n,γ)Pb209(β^-)Bi209(n,γ)Bi210_ (β^-)Po210	99.3	100.0	99.9	100.0	99.8	99.8	99.9
		Pb207(n,γ)Pb208(n,γ)Pb209(β^-)Bi209_ (n,γ)Bi210(β^-)Po210	0.7						
Tl204	3.788 y	Pb206(n,α)Hg203(β^-)Tl203(n,γ)Tl204_	85.0	99.6	100.0				
		Pb204(n,α)Hg201(n,γ)Hg202(n,γ)_ Hg203(β^-)Tl203(n,γ)Tl204	9.2						
		Pb204(n,γ)Pb205(n,α)Hg202(n,γ)_ Hg203(β^-)Tl203(n,γ)Tl204	5.8	0.4					
		Pb204(n,p)Tl204				35.0	4.6	1.0	
		Pb208(n,α)Hg205(β^-)Tl205(n,2n)Tl204				20.7	1.8		
		&Pb206(n,2n)Pb205(n,2n)*Pb204*(n,p)Tl204				14.6			
		Pb206(n,2n)Pb205(n,p)Tl205(n,2n)Tl204				10.8			
		Pb206(n,2n)Pb205(n,d)Tl204				9.1	7.7	2.5	
		Pb206(n,d)Tl205(n,2n)Tl204				3.2	4.8	1.7	
		Pb206(n,t)Tl204				0.2	19.8	48.0	36.6
		Pb207(n,3n)Pb205(n,d)Tl204					26.2	3.1	
		&Pb206(n,3n)*Pb204*(n,p)Tl204					12.9	0.6	
		Pb208(n,3n)Pb206(n,t)Tl204					6.8	4.7	2.0
		&Pb208(n,3n)Pb206(n,3n)*Pb204*(n,p)Tl204					2.8		
		Pb207(n,nt)Tl204					2.2	9.1	29.8
		Pb208(n,4n)Pb205(n,d)Tl204					2.1	21.1	2.2
		Pb208(n,2nt)Tl204						0.9	22.2
H3	12.33 y	Pb207(n,X)H3				37.6	21.8	19.9	20.1
		Pb206(n,2n)Pb205(n,X)H3				21.5	1.2	0.7	0.4
		&Pb208(n,2n)*Pb207*(n,X)H3				14.9	1.7	0.6	0.6
		Pb208(n,X)H3				11.2	38.6	40.2	42.0
		Pb206(n,X)H3				7.2	18.7	20.5	20.4
		Pb207(n,2n)Pb206(n,2n)Pb205(n,X)H3				2.1			
		Pb207(n,2n)Pb206(n,X)H3				1.1	0.6		0.3
		Pb204(n,X)H3				0.9	1.3	1.3	1.3
		Pb208(n,3n)Pb206(n,X)H3					5.5	1.7	0.9
		Pb207(n,3n)Pb205(n,X)H3					4.0	0.8	0.4
		&Pb206(n,3n)*Pb204*(n,X)H3					3.1	0.7	0.3
		Pb208(n,4n)Pb205(n,X)H3					0.3	5.8	1.5
		Pb207(n,4n)Pb204(n,X)H3					0.1	1.7	0.4
		&Pb208(n,5n)*Pb204*(n,X)H3							2.8
		&Pb206(n,5n)*Pb202*(n,X)H3							1.7
Pb210	22.16 y	Pb208(n,γ)Pb209(n,γ)Pb210	99.2	100.0	99.9	97.4	96.8	97.5	98.6
		Pb207(n,γ)Pb208(n,γ)Pb209(n,γ)Pb210	0.8						
		Pb208(n,γ)Pb209(β^-)Bi209(n,γ)Bi210m_ (n,p)Pb210				2.1	2.7	2.1	1.1
Bi207	31.76 y	**&**Pb208(n,γ)Pb209(β^-)Bi209(n,2n)_ *Bi208*(n,2n)*Bi207*				99.1			0.7
		Pb208(n,γ)Pb209(β^-)Bi209(n,3n)Bi207				0.9	99.4	99.0	99.3
Hg194	440.01 y	**&**Pb204(n,3n)*Pb202*(n,nα)Hg198(n,3n)_ Hg196(n,3n)Hg194					3.3		
		Pb204(n,nα)Hg200(n,3n)Hg198(n,3n)_ Hg196(n,3n)Hg194						2.6	
		Pb206(n,3n)Pb204(n,3n)Pb202(n,nα)_ Hg198(n,3n)Hg196(n,3n)Hg194						2.2	
		Pb206(n,3n)Pb204(n,nα)Hg200(n,3n)_ Hg198(n,3n)Hg196(n,3n)Hg194						2.1	

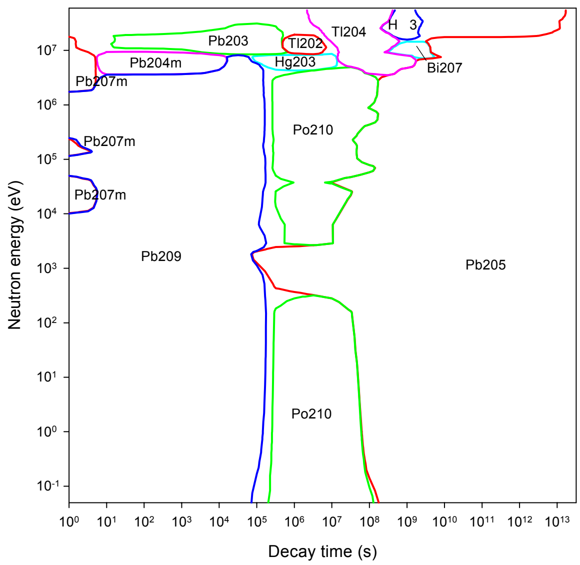
Nuclide	T½	Pathway	210	186	151	42	30	21	6
		Pb207(n,6n)Pb202(n,5n)Pb198(β^+)_ Tl198(β^+)Hg198(n,5n)Hg194							9.8
		Pb208(n,6n)Pb203(β^+)Tl203(n,5n)_ Tl199(β^+)Hg199(n,6n)Hg194							2.0
		Other very long pathways				100.0	96.7	93.1	88.2
Pb202	5.3 10^4 y	**&**Pb204(n,2n)*Pb203*(n,2n)*Pb202*				73.6			
		&Pb206(n,2n)Pb205(n,2n)*Pb204*(n,2n)_ *Pb203*(n,2n)*Pb202*				17.8			
		&Pb206(n,3n)*Pb204*(n,3n)*Pb202*					57.8	4.8	
		&Pb204(n,3n)*Pb202*					23.4	7.8	
		&Pb208(n,3n)Pb206(n,3n)*Pb204*(n,3n)*Pb202*					11.0		
		&Pb207(n,4n)*Pb204*(n,3n)*Pb202*					2.6	12.6	
		&Pb207(n,3n)Pb205(n,4n)*Pb202*					0.9	7.6	
		&Pb206(n,2n)Pb205(n,4n)*Pb202*					0.2	6.2	
		&Pb208(n,4n)Pb205(n,4n)*Pb202*						52.7	1.1
		&Pb206(n,5n)*Pb202*						3.7	60.4
		Pb208(n,5n)Pb204(n,3n)Pb202						0.6	1.5
		&Pb207(n,6n)*Pb202*							27.4
		Pb208(n,3n)Pb206(n,5n)Pb202							2.3
Bi208	3.7 10^5 y	**&**Pb208(n,γ)Pb209(β^-)Bi209(n,2n)*Bi208*				100.0	99.9	99.9	99.9
Bi210m	3.0 10^6 y	Pb208(n,γ)Pb209(β^-)Bi209(n,γ)Bi210m	99.5	100.0	100.0	99.9	99.9	99.9	99.9
		Pb207(n,γ)Pb208(n,γ)Pb209(β^-)Bi209_ (n,γ)Bi210m	0.5						
Pb205	1.5 10^7 y	Pb204(n,γ)Pb205	100.0	100.0	100.0				
		Pb206(n,2n)Pb205				83.9	18.8	9.2	17.0
		Pb207(n,2n)Pb206(n,2n)Pb205				12.6	0.6		
		&Pb208(n,2n)*Pb207*(n,2n)Pb206(n,2n)Pb205				3.4			
		Pb207(n,3n)Pb205					64.3	11.2	18.6
		Pb208(n,3n)Pb206(n,2n)Pb205					5.5		
		Pb208(n,4n)Pb205					5.2	77.7	62.2
		&Pb208(n,2n)*Pb207*(n,3n)Pb205					5.1		

Lead activation characteristics

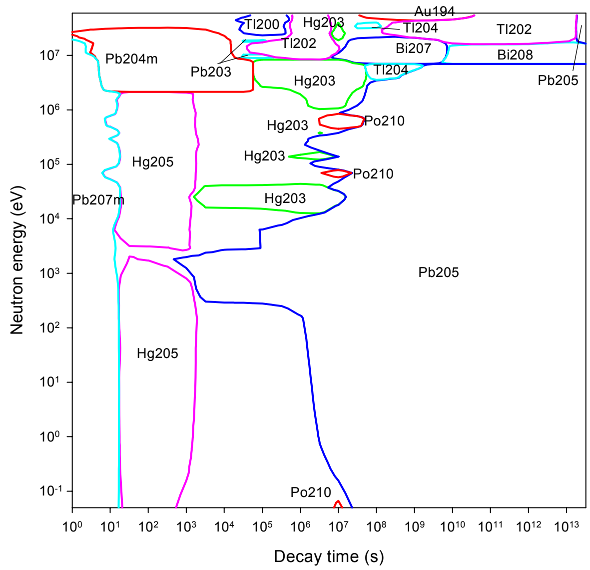


Lead importance diagrams & transmutation

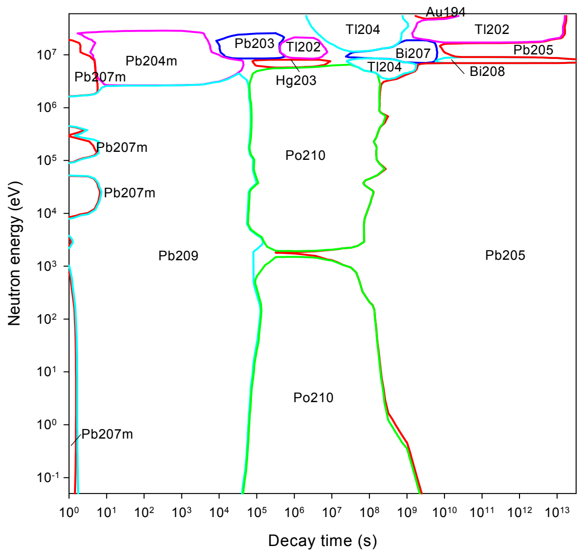
Activity



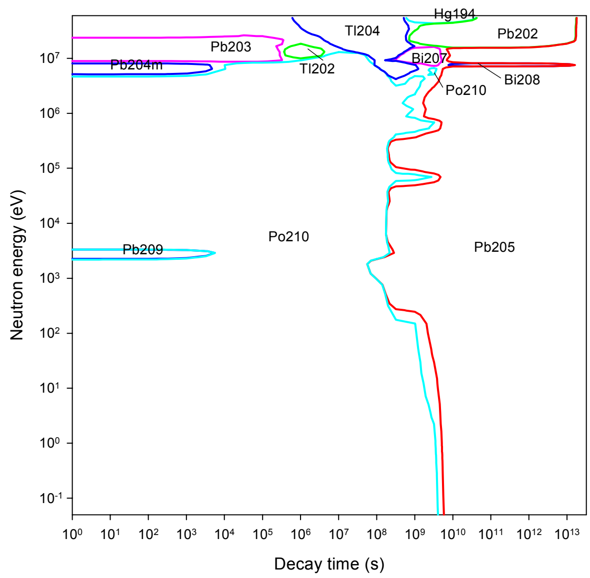
Dose rate



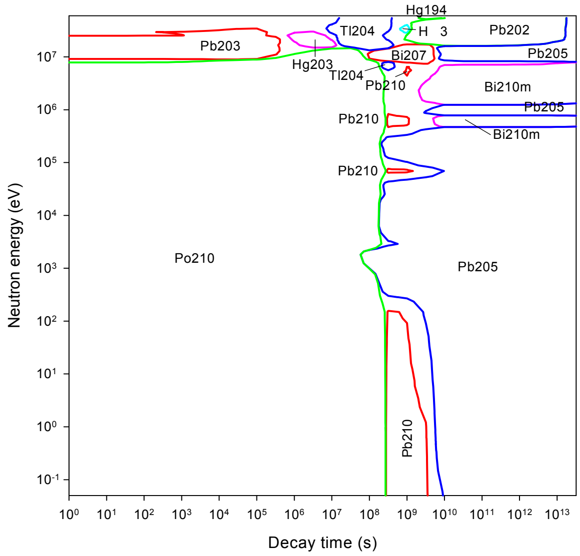
Heat output



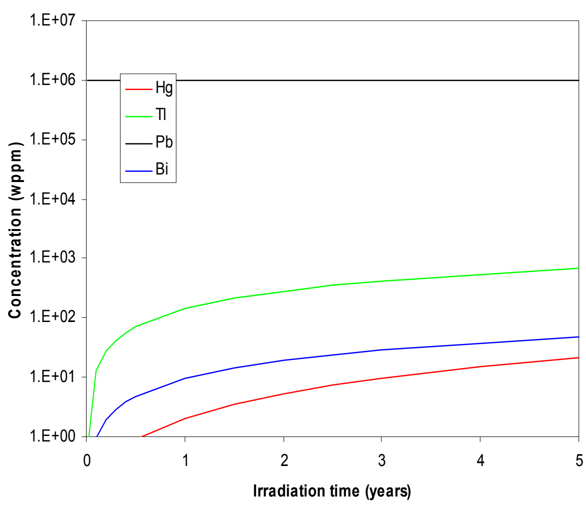
Ingestion dose



Inhalation dose



First wall transmutation



Bismuth

General properties

		Isotopes	Isotopic abundances / %
Atomic number	83	Bi209	100.0 ($T_{1/2}$=1.90 10^{19} y)
Crustal abundance / wppm	8.5 10^{-3}		
Melting point / K	544.6		
Boiling point / K	1837		
Density / kgm^{-3}	9747		
Thermal conductivity / $Wm^{-1}K^{-1}$	7.87		
Electrical resistivity /Ωm	1.068 10^{-6}		
Coefficient of thermal expansion / K^{-1}	1.34 10^{-5}		
Crystal structure	Rhombohedral		
Number of stable isotopes	0 (1)		
Mean atomic weight	208.98038		

Activation properties

Act	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Bq kg^{-1}	1.87E14	4.66E13	3.69E13	6.33E12	3.41E11	7.53E9
Bi208m	74.85					
Po210	11.01	44.14	55.58	54.08		
Bi210	11.01	44.12	33.67			
Bi207	1.57	6.28	7.94	45.23	96.78	
Bi206	0.80	3.19	2.69			
Pb209	0.45	1.77				
Bi208	0.01	0.02	0.03	0.14	2.66	99.71

Heat	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
kW kg^{-1}	5.61E-2	2.07E-2	1.99E-2	3.74E-3	9.30E-5	3.22E-6
Bi208m	62.89					
Po210	31.80	85.92	89.43	79.41		
Bi210	2.28	6.17	3.89			
Bi206	1.44	3.90	2.72			
Bi207	1.39	3.75	3.92	20.37	94.28	
Bi208	0.01	0.02	0.02	0.10	4.16	99.69
Po209	0.01	0.01	0.01	0.08	1.55	

Dose	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv h^{-1}	3.68E4	1.81E3	1.48E3	8.22E2	1.01E2	5.54E0
Bi208m	95.02					
Bi206	2.62	53.32	43.31			
Bi207	2.27	46.18	56.23	99.19	93.36	
Bi208	0.02	0.37	0.45	0.81	6.64	100.0
Pb204m		0.09				

Ing	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	2.47E7	2.47E7	2.46E7	4.12E6	1.83E3	1.07E1
Po210	99.83	99.85	99.89	99.81	0.08	
Bi210	0.11	0.11	0.07			
Bi207	0.02	0.02	0.02	0.09	23.39	
Po209	0.01	0.01	0.01	0.07	75.78	
Bi208					0.69	98.50
Bi210m					0.01	1.51

Inh	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
Sv kg^{-1}	9.08E7	9.05E7	8.93E7	1.48E7	6.27E3	6.64E1
Po210	97.48	97.78	98.67	99.80	0.09	
Bi210	2.11	2.11	1.29			
Bi207	0.02	0.02	0.02	0.11	29.49	
Po209	0.01	0.01	0.01	0.06	69.14	
Bi210m					0.59	54.80
Bi208					0.58	45.20
Pb210					0.11	

Clear	**0**	**10^{-5} y**	**10^{-2} y**	**1 y**	**100 y**	**10^{5} y**
	2.85E11	7.29E10	6.32E10	3.21E10	3.32E9	1.98E7
Bi208m	74.29					
Bi207	10.26	40.13	46.31	89.25	99.28	
Po210	7.21	28.21	32.43	10.67		
Bi210	7.21	28.20	19.65			
Bi206	0.52	2.04	1.57			
Bi208	0.01	0.03	0.04	0.07	0.72	99.93

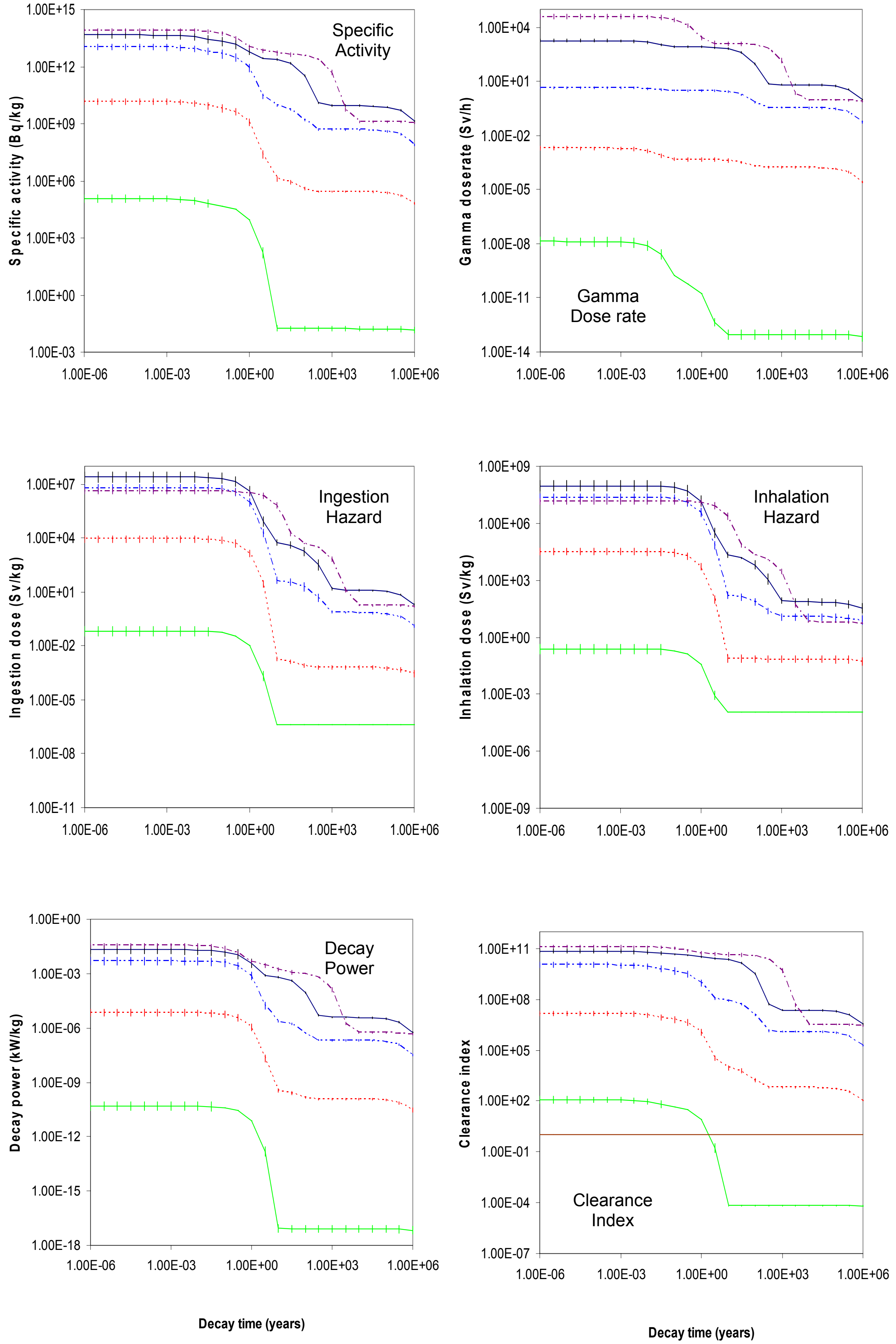
Bismuth

Pathway analysis

Nuclide	T½	Pathway	210	186	151	42	30	21	6
Tl206m	3.76 m	Bi209(n,α)Tl206m	100.0	100.0	100.0	99.0	50.8	17.9	57.7
		Bi209(n,3n)Bi207(β^+)Pb207(n,d)Tl206m					32.6	10.9	2.8
		&Bi209(n,t)*Pb207*(n,d)Tl206m					6.3	30.3	19.7
		Bi209(n,4n)Bi206(β^+)Pb206(n,p)Tl206m					3.0	18.7	1.3
		Bi209(n,3n)Bi207(n,2n)Bi206(β^+)_ Pb206(n,p)Tl206m					1.4	0.1	
		Bi209(n,d)Pb208(n,t)Tl206m					1.1	19.0	17.0
Tl206	4.20 m	**&**Bi209(n,α)*Tl206*	100.0	100.0	100.0	97.4	56.3	13.5	50.5
		Bi209(n,2n)Bi208(n,2n)Bi207(n,2n)_ Bi206(β^+)Pb206(n,p)Tl206				2.1			
		&Bi209(n,3n)Bi207(β^+)Pb207(n,d)*Tl206*					15.9	4.6	2.6
		&Bi209(n,4n)Bi206(β^+)Pb206(n,p)*Tl206*					9.6	57.6	9.1
		&Bi209(n,2n)*Bi208*(n,3n)Bi206(β^+)_ Pb206(n,p)Tl206					5.6	0.4	
		Bi209(n,3n)Bi207(n,2n)Bi206(β^+)_ Pb206(n,p)Tl206					4.5	0.4	
		&Bi209(n,t)*Pb207*(n,d)*Tl206*					3.0	12.8	18.6
		&Bi209(n,d)Pb208(n,t)*Tl206*					1.3	7.5	14.7
		Bi209(n,nt)Pb206(n,p)Tl206					0.3	1.0	2.7
Bi201m	59.10 m	**&**Bi209(n,3n)Bi207(n,3n)Bi205(n,3n)_ *Bi203*(n,3n)Bi201m					90.9		
		Bi209(n,2n)Bi208(n,4n)Bi205(n,3n)_ Bi203(n,3n)Bi201m					1.3		
		Bi209(n,4n)Bi206(n,4n)Bi203(n,3n)Bi201m					0.2	2.7	
		Bi209(n,3n)Bi207(n,4n)Bi204(n,4n)Bi201m						83.2	
		Bi209(n,3n)Bi207(n,5n)Bi203(n,3n)Bi201m						2.5	
		&Bi209(n,2n)*Bi208*(n,5n)Bi204(n,4n)Bi201m						1.8	
		Bi209(n,5n)Bi205(n,5n)Bi201m						0.7	93.2
		Bi209(n,4n)Bi206(n,6n)Bi201m							2.1
		Bi209(n,6n)Bi204(n,4n)Bi201m							1.4
Bi210	5.012 d	Bi209(n,γ)Bi210	100.0	100.0	100.0	99.9	99.8	99.9	99.9
Bi206	6.243 d	**&**Bi209(n,2n)*Bi208*(n,2n)*Bi207*(n,2n)Bi206				99.4	0.2		
		Bi209(n,3n)Bi207(n,2n)Bi206				0.6	29.7	1.5	
		&Bi209(n,2n)*Bi208*(n,3n)Bi206					37.6	1.4	
		Bi209(n,4n)Bi206					32.4	96.7	95.6
Bi205	15.31 d	**&**Bi209(n,2n)*Bi208*(n,2n)Bi207(n,2n)_ Bi206(n,2n)Bi205				99.4			
		Bi209(n,3n)Bi207(n,3n)Bi205					98.0	19.3	
		&Bi209(n,2n)*Bi208*(n,4n)Bi205					1.4	37.6	
		Bi209(n,5n)Bi205						42.9	96.8
Po210	138.39 d	Bi209(n,γ)Bi210(β^-)Po210	100.0	100.0	100.0	99.9	99.9	99.9	100.0
Bi207	31.76 y	**&**Bi209(n,2n)*Bi208*(n,2n)*Bi207*				99.4			
		Bi209(n,3n)Bi207				0.6	99.1	98.5	98.9
Po209	102.0 y	Bi209(n,γ)Bi210(β^-)Po210(n,2n)Po209				99.9	99.8	99.9	99.9
Hg194	440.01 y	Long pathways involving (n,α), (n,nα), β^-				100.0	100.0	100.0	100.0
Pb202	5.3 10^4 y	Bi209(n,2n)Bi208(n,2n)Bi207(n,2n)_ Bi206(β^+)Pb206(n,2n)Pb205(n,2n)_ Pb204(n,2n)Pb203(n,2n)Pb202				20.5			
		&Bi209(n,α)Tl206(β^-)Pb206(n,2n)Pb205_ (n,2n)*Pb204*(n,2n)*Pb203*(n,2n)*Pb202*				6.8			
		&Bi209(n,γ)Bi210(β^-)Po210(α)Pb206(n,2n)_ Pb205(n,2n)*Pb204*(n,2n)*Pb203*(n,2n)*Pb202*				3.8			
		&Bi209(n,4n)Bi206(β^+)Pb206(n,3n)_ *Pb204*(n,3n)*Pb202*					39.5	8.2	
	►	**&**Bi209(n,2n)*Bi208*(n,3n)Bi206(β^+)_ Pb206(n,3n)Pb204(n,3n)Pb202					10.4		

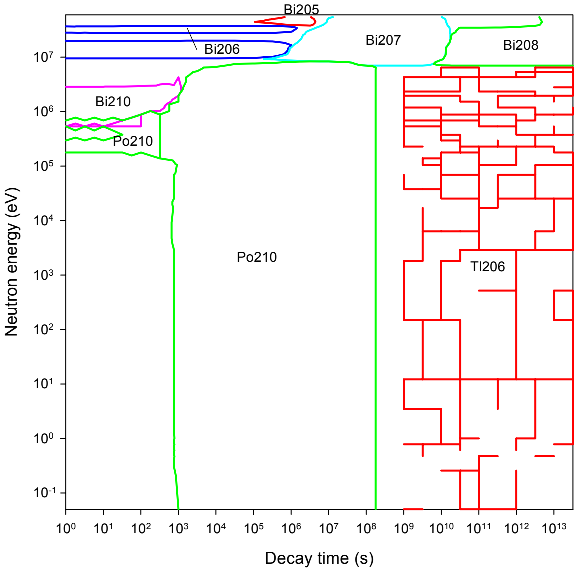
Nuclide	T½	Pathway	210	186	151	42	30	21	6
	◄	&Bi209(n,3n)Bi207(n,2n)Bi206(β^+)_ Pb206(n,3n)*Pb204*(n,3n)*Pb202*					9.0		
		&Bi209(n,3n)Bi207(n,3n)Bi205(β^+)_ Pb205(n,4n)*Pb202*					8.6	4.7	
		&Bi209(n,3n)Bi207(n,3n)Bi205(β^+)_ Pb205(n,2n)*Pb204*(n,3n)*Pb202*					8.6		
		&Bi209(n,3n)Bi207(n,4n)Bi204(β^+)_ *Pb204*(n,3n)*Pb202*					5.5	8.7	
		&Bi209(n,4n)Bi206(β^+)Pb206(n,2n)_ Pb205(n,4n)*Pb202*					0.1	10.4	0.4
		&Bi209(n,5n)Bi205(β^+)*Pb205*(n,4n)*Pb202*						35.7	25.6
		&i209(n,2n)*Bi208*(n,4n)Bi205(β^+)_ Pb205(n,4n)Pb202						9.6	
		&Bi209(n,4n)Bi206(β^+)Pb206(n,5n)*Pb202*						9.4	34.5
		&Bi209(n,d)Pb208(n,4n)Pb205(n,4n)*Pb202*						2.4	
		&Bi209(n,nt)Pb206(n,5n)*Pb202*						0.1	10.3
		&Bi209(n,6n)Bi204(β^+)*Pb204*(n,3n)*Pb202*							12.0
		Bi209(n,3n)Bi207(n,6n)Bi202(β^+)Pb202							5.1
		&Bi209(n,t)*Pb207*(n,6n)*Pb202*							5.0
		Other very long pathways				68.9	18.3	11.1	7.1
Bi208	3.7 10^5 y	&Bi209(n,2n)*Bi208*				100.0	99.9	99.9	99.9
Bi210m	3.0 10^6 y	Bi209(n,γ)Bi210m	100.0	100.0	100.0	99.9	99.9	99.9	99.9

Bismuth activation characteristics

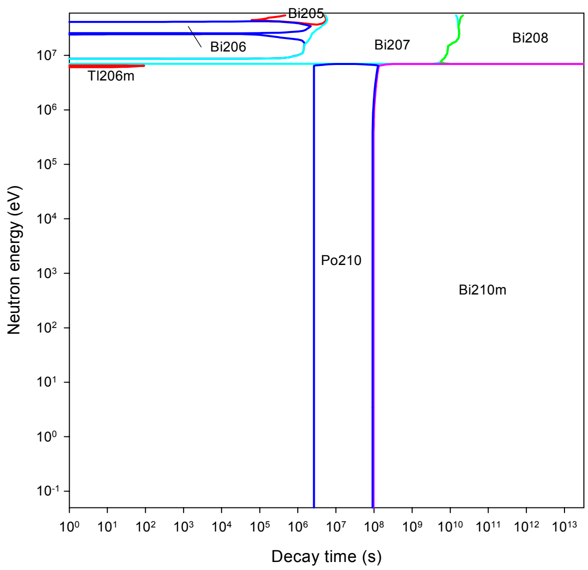


Bismuth importance diagrams & transmutation

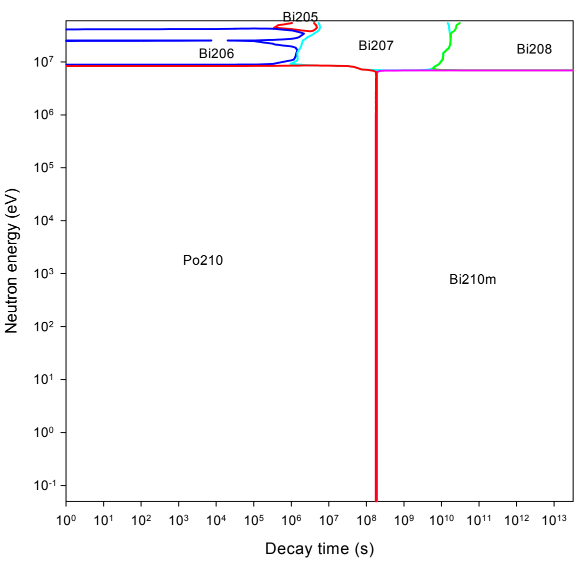
Activity



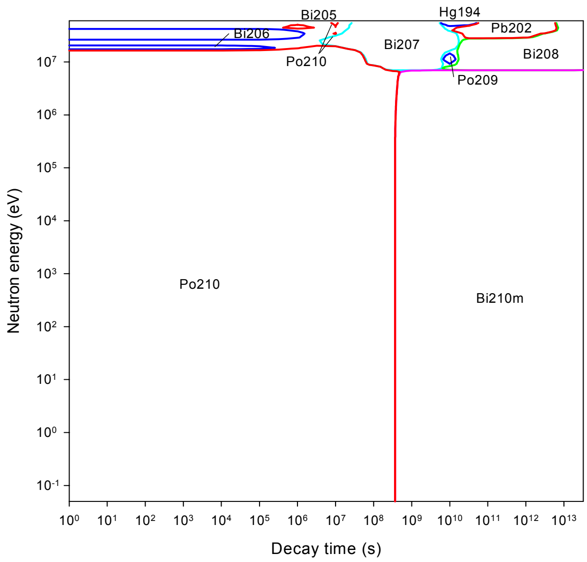
Dose rate



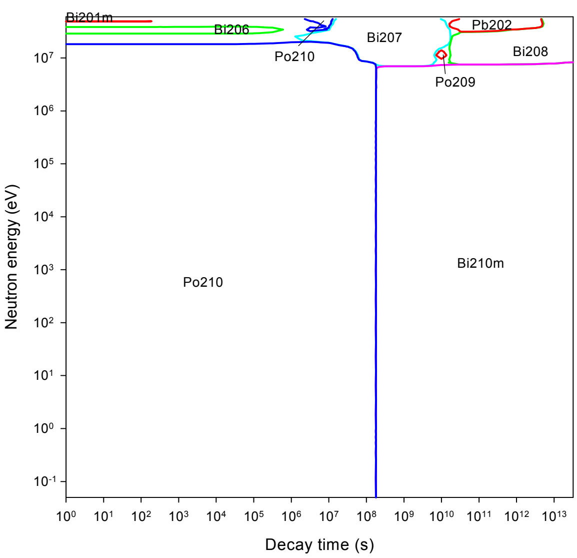
Heat output



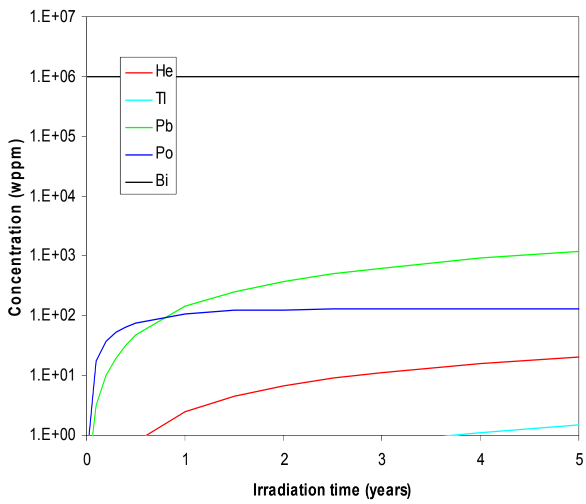
Ingestion dose



Inhalation dose



First wall transmutation



PART 2:
The Summary Tables

Summary of Primary and Secondary nuclides

	Nuclide	T½	Contributing elements: Primary	Contributing elements: Secondary
	H-3	12.330 y	H, He, Li, Be, B, C, N, O, F, Ne, Na, Mg, Al, Si, P, S, Cl, Ar, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Zn, Ga, Ge, As, Se, Br, Kr, Rb, Sr, Y, Zr, Nb, Mo, Ru, Rh, Pd, Ag, Sn, Sb, Te, I, Xe, Cs, La, Ce, Pr, Nd, Tb, Ho, Er, Tm, Yb, Lu, Hf, Ta, W, Re, Os, Ir, Hg, Tl, Pb	Cu, Cd, In, Ba, Sm, Eu, Gd, Dy, Pt, Au, Bi
	He-6	0.808 s	Li, Be, B, C	N, O
	Li-8	0.838 s	Li, Be, B, C, N	O
	Li-9	0.178 s		Be
*	Be-7	53.220 d	C, N, O, F, Ne	B
	Be-10	1.60E+06 y	Be, B, C, N, O, F, Ne, Na, Mg, Al, Si, P	
	Be-11	13.810 s	Be, B, C	N
+	C-10	19.255 s		C, N
*	C-11	20.370 m	B, C, N, O	F, Ne
	C-14	5699.985 y	C, N, O, F, Ne, Na, Mg, Al, Si, P, S	
	C-15	2.449 s	C, N, O	F
	N-13	9.967 m	N, O	C, F, Ne
	N-16	7.130 s	N, O, F	Ne, Na, Mg
	N-17	4.170 s		O, F
+	O-14	1.177 m		O
	O-15	2.041 m	O	F, Ne, Na, Mg
	O-19	26.910 s	O, F, Ne	Na
+	F-17	1.075 m		F, Ne, Na
	F-18	1.829 h	O, F, Ne	Na, Mg, Al, Si
	F-20	11.030 s	F, Ne, Na	Mg, Al
	F-21	4.158 s	Ne	Na, Mg
	F-22	4.230 s		Ne, Na
*	Ne-19	17.220 s	Ne	Mg
	Ne-23	37.200 s	F, Ne, Na	Mg, Al, Si, P
+	Ne-24	3.380 m		Mg, Al, Si, P
+	Na-21	22.490 s		Na, Mg, Al
	Na-22	2.603 y	Ne, Na, Mg, Al, Si, P, S, Cl, Ar, K	Ca
	Na-24	14.957 h	O, F, Ne, Na, Mg, Al, Si, P, S, Cl	Ar, K
	Na-25	59.600 s	Mg	Al, Si
	Na-26	1.080 s		Mg, Al
	Mg-23	11.317 s		Mg, Al, Si
	Mg-27	9.458 m	Mg, Al	Si, P, S
+	Mg-28	20.900 h		Si, P, S, Cl, Ar, K
+	Al-25	7.183 s		Al, Si
	Al-26	7.17E+05 y	Mg, Al, Si, P, S, Cl, Ar, K, Ca	Sc, Ti, V, Cr
	Al-26m	6.345 s		Al, Si, P, S
	Al-28	2.241 m	Al, Si, P, S	Mg, Cl, Ar, K
	Al-29	6.560 m	Si, S	P, Cl
	Al-30	3.650 s		Si, P, S, Cl
+	Si-27	4.170 s		Si, S
	Si-31	2.620 h	Mg, Al, Si, P, S	Cl, Ar, K
	Si-32	132.003 y	Na, Mg, Al, Si, P, S, Cl	
+	P-29	4.140 s		P, S, Cl
	P-30	2.498 m	P, S	Cl, K
	P-32	14.270 d	Na, Mg, Al, Si, P, S, Cl, Ar, K, Ca	Sc
	P-33	25.383 d	S, Cl, Ar, K	Ca
	P-34	12.400 s		S, Cl, Ar, K, Ca
	P-35	47.300 s		Cl
	P-36	5.600 s		Cl, Ar
	S-31	2.572 s		S
	S-35	87.320 d	S, Cl, Ar, K	Si, P, Ca, Sc
	S-37	4.990 m	S, Cl, Ar, Ca	S, K
+	S-38	2.838 h		Ar, K
+	Cl-33	2.511 s		Cl
	Cl-34	1.526 s		Cl, K, Ca
	Cl-34m	32.100 m	Cl	K, Ca

	Nuclide	T½	Contributing elements	
			Primary	Secondary
	Cl-36	3.01E+05 y	Mg, Al, Si, P, S, Cl, Ar, K, Ca, Sc, Ti, V, Cr, Mn	
	Cl-38	37.200 m	S, Cl, Ar, K, Ca	
	Cl-38m	0.715 s		S, Cl, Ar, K, Ca
	Cl-39	55.600 m	Ar, K	Ca
>	Cl-40	1.350 m	Ar	
	Ar-37	35.040 d	Ar, K, Ca	Cl, Sc, Ti
	Ar-39	269.006 y	S, Cl, Ar, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Ni	Cu, Zn
	Ar-41	1.827 h	Cl, Ar, K	S, Ca, Sc, Ti, V, Cr
	Ar-42	33.001 y	Ar, K, Sc, Ti, V, Cr, Mn, Fe	Ca, Fe, Ni
+	K-37	1.226 s		K
	K-38	7.610 m	K, Ca	
	K-38m	0.924 s		K, Ca
	K-40	1.26E+09 y	K, Ca, Sc, Ti, V, Cr	Ar
	K-42	12.359 h	Cl, Ar, K, Ca, Sc, Ti, V, Cr, Mn	S, Fe
	K-43	22.200 h	Ca	K, Sc, Ti
	K-44	22.130 m		Ca, Sc
>	Ca-39	0.860 s	Ca	
	Ca-41	1.03E+05 y	Ca, Sc, Ti, V, Cr	Mn
	Ca-45	163.000 d	K, Ca, Sc, Ti, V, Cr, Mn	Ar
	Ca-47	4.538 d	Ca, Mn	Ti, V, Cr
*	Ca-48	5.30E+19 y	Sc, Ti, Mn	
	Ca-49	8.720 m	Ca	
+	Sc-42m	1.033 m		Sc
+	Sc-43	3.891 h		Sc, Ti
	Sc-44	3.970 h	Sc, Ti, V, Cr, Mn, Fe	Ca, Ni
	Sc-44m	2.442 d	Sc	Ti, V, Cr
	Sc-45m	0.316 s	Sc	Ti
	Sc-46	83.788 d	Ar, K, Ca, Sc, Ti, V, Cr, Mn	Cl
	Sc-46m	18.700 s		Ca, Sc, Ti, V
	Sc-47	3.351 d	Ti, V, Cr	Ca, Sc, Mn
	Sc-48	1.820 d	Ti, V, Mn	Cr
	Sc-49	57.200 m		Ca, Ti, V, Cr
	Sc-50	1.708 m		Ti, V
+	Ti-44	60.000 y		Ti, V, Cr, Mn, Fe, Ni
	Ti-45	3.080 h		Ti, Cr
	Ti-51	5.800 m	Ti, V	Cr
+	V-47	32.600 m		V, Cr
>	V-48	15.974 d	V, Cr	Mn, Fe
	V-49	330.000 d	V, Cr	Mn, Fe
	V-50	1.40E+17 y	V, Cr	
	V-52	3.745 m	Ti, V, Cr, Mn	Fe
	V-53	1.620 m		Cr, Mn, Fe
	V-54	49.800 s		Cr, Mn
	Cr-49	41.900 m		Cr
*	Cr-50	1.80E+17 y	Cr	
	Cr-51	27.703 d	Cr	V, Mn, Fe, Ni
	Cr-55	3.540 m	Cr, Mn	Fe
+	Cr-56	5.940 m		Fe
+	Mn-51	46.200 m		Mn, Fe
	Mn-52	5.595 d		Mn, Fe, Co, Ni
	Mn-52m	21.200 m		Mn, Fe, Ni
	Mn-53	3.68E+06 y	Cr, Mn, Fe, Co, Ni, As	Cu, Zn, Ga, Ge
	Mn-54	312.130 d	Mn, Fe, Co	Cr, Ni, Cu, Zn
	Mn-56	2.582 h	Ti, V, Cr, Mn, Fe	Co, Ni, Cu
	Mn-57	1.423 m		Co, Ni
	Fe-53	8.510 m		Fe, Ni
	Fe-53m	2.580 m		Fe, Ni
	Fe-55	2.735 y	Fe, Co, Ni	Mn, Cu, Zn
	Fe-59	44.495 d	V, Mn, Fe, Co, Ga	Cr, Ni, Cu, Ge, As
	Fe-60	1.50E+06 y	Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As	
+	Co-55	17.530 h		Ni

	Nuclide	$T_{½}$	Contributing elements	
			Primary	Secondary
>	Co-56	77.310 d	Ni	Co, Cu, Zn
	Co-57	271.800 d	Co, Ni	Cu, Zn
	Co-58	70.860 d	Co, Ni, Cu	Zn, Ga
	Co-58m	8.900 h		Co, Ni, Cu, Zn
	Co-60	5.271 y	Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br	
	Co-60m	10.470 m	Co	Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Ga, Ge, As
	Co-61	1.650 h		Fe, Ni, Cu, Zn
	Co-62	1.500 m		Ni, Cu
	Co-62m	13.910 m		Cu
+	Co-63	27.400 s		Cu
	Ni-57	1.496 d		Ni
	Ni-59	7.60E+04 y	Co, Ni, Cu, Zn, Ga, Ge, As	Se, Br
	Ni-63	100.600 y	V, Cr, Mn, Fe, Ni, Cu, Zn, Ga, Ge, As	Ti, Se, Br
	Ni-65	2.520 h	Ni	Cu, Zn
+	Cu-60	23.700 m		Cu, Zn
+	Cu-61	3.333 h		Cu, Zn
	Cu-62	9.750 m	Cu, Zn	Ga
	Cu-64	12.701 h	Ni, Cu, Zn	Ga, Ge
	Cu-66	5.100 m	Cu	Ni, Zn, Ga
<	Cu-67	2.579 d		Zn, Ga, Ge
	Cu-68	31.100 s		Zn, Ga
	Cu-68m	3.750 m		Zn, Ga
+	Zn-61	1.485 m		Zn
+	Zn-62	9.260 h		Zn
<	Zn-63	38.400 m		Cu, Zn
*	Zn-64	2.30E+18 y	Cu, Zn, Ga	
	Zn-65	244.150 d	Cu, Zn, Ga, Ge, As	Ni, Se, Br
	Zn-69	56.400 m	Zn, Ga	Ge
	Zn-69m	13.780 h	Zn, Ga	Ge
>	Zn-71	2.450 m	Ga	Zn, Ga, Ge
	Zn-71m	3.960 h		Ga, Ge
+	Zn-73	23.500 s		Ge
+	Ga-65	15.200 m		Ga
*	Ga-66	9.490 h	Ga	Ge
>	Ga-67	3.261 d	Ga	Ge
	Ga-68	1.128 h	Ga, Ge, As, Se, Br	Kr
	Ga-70	21.140 m	Zn, Ga, Ge	As
	Ga-72	14.100 h	Ga, Ge, As	Zn, Se
	Ga-73	4.860 h		Ge, As
	Ga-74	8.120 m		Ge, As
	Ga-75	2.170 m		Ge
+	Ga-76	32.600 s		Ge
+	Ge-67	18.900 m		Ge
>	Ge-68	270.950 d	Ga, Ge	As, Se, Br
	Ge-69	1.627 d	Ga, Ge	As, Se
	Ge-71	11.430 d	Ga, Ge, As	Zn, Se, Br, Kr
	Ge-73m	0.499 s		Ga, Ge, As
	Ge-75	1.380 h	Ge, As	Se
	Ge-75m	47.700 s		Ge, As
	Ge-77	11.300 h	Ge	As, Se
	Ge-77m	52.900 s		Ge
+	Ge-79m	39.000 s		Se
+	As-71	2.720 d		As, Se
*	As-72	1.083 d	As	Se, Br, Kr
	As-73	80.301 d	As	Ge, Se, Br, Kr
	As-74	17.780 d	Ge, As, Se, Br	Kr
	As-76	1.093 d	Ge, As, Se, Br	
	As-77	1.618 d	Ge, As	Se, Br
	As-78	1.512 h		Se, Br
	As-79	9.010 m		Se
	As-80	15.200 s		Se
+	As-81	33.300 s		Se

	Nuclide	T½	Contributing elements	
			Primary	Secondary
+	As-82	19.100 s		Se
+	As-82m	13.600 s		Se
+	Se-71	4.740 m		As, Se
+	Se-72	8.400 d		As, Se
	Se-73	7.150 h		As, Se, Br
	Se-73m	39.800 m		As, Se
	Se-75	119.640 d	As, Se, Br, Kr	Rb, Sr
	Se-77m	17.360 s	As, Se	Ge, Br, Kr
	Se-79	1.10E+06 y	Zn, Ga, Ge, As, Se, Br, Kr, Y	Rb, Sr
	Se-79m	3.900 m	As	Se, Br
	Se-81	18.450 m	Se	As, Br, Kr
	Se-81m	57.280 m		As, Se, Br, Kr
	Se-83	22.333 m		Se, Kr
>	Se-83m	1.168 m	Se	
+	Br-75	1.612 h		Br
*	Br-76	16.200 h	Br	Kr
+	Br-76m	1.310 s		Br
>	Br-77	2.377 d	Br	Kr
+	Br-77m	4.280 m		Br, Kr
	Br-78	6.460 m	Br, Kr	Se, Rb
	Br-79m	4.864 s	Br	Kr, Rb
	Br-80	17.600 m	Br	As, Se, Kr, Rb
	Br-80m	4.410 h	Br	As, Se, Kr, Rb
	Br-82	1.472 d	As, Se, Br, Kr, Rb	Sr
	Br-82m	6.090 m		Se, Br, Kr, Rb
	Br-83	2.400 h		Se, Kr
	Br-84	31.800 m		Kr, Rb
	Br-84m	6.000 m		Kr, Rb
	Br-85	2.900 m		Kr
	Br-86	55.000 s		Kr
+	Kr-76	14.806 h		Br
	Kr-77	1.240 h		Br, Kr
	Kr-79	1.460 d	Se, Br, Kr	Rb, Sr, Y, Zr, Nb, Mo
	Kr-79m	50.000 s		Br, Kr, Rb
	Kr-81	2.10E+05 y	Ga, Ge, As, Se, Br, Kr, Rb, Sr, Y, Zr, Nb	Mo
	Kr-81m	13.200 s		Br, Kr
	Kr-83m	1.830 h	Se, Br, Kr	As, Rb, Sr, Y, Zr, Nb, Mo
	Kr-85	10.752 y	Ga, Ge, As, Se, Br, Kr, Rb, Sr, Y, Zr, Nb, Mo, Ru	Rh
	Kr-85m	4.480 h	Kr	Se, Br, Rb, Sr, Y
	Kr-87	1.272 h	Kr	Rb
+	Rb-81	4.576 h		Rb, Sr
+	Rb-81m	30.250 m		Rb, Sr
+	Rb-82	1.273 m		Rb, Sr, Y
*	Rb-82m	6.472 h	Rb	Sr, Y
	Rb-83	86.200 d	Kr, Rb	Sr, Y, Zr, Nb, Mo
	Rb-84	33.500 d	Kr, Rb, Sr	Y, Zr, Nb, Mo
	Rb-84m	20.400 m		Kr, Rb, Sr, Y
	Rb-86	18.640 d	Br, Kr, Rb, Sr, Y	As, Se, Zr, Nb, Kr, Rb, Sr, Y
	Rb-86m	1.017 m		Kr, Rb, Sr, Y
	Rb-87	4.75E+10 y	Rb, Sr, Y	
	Rb-88	17.800 m		Rb, Sr, Y
+	Sr-82	25.550 d		Sr, Y
	Sr-83	1.350 d		Sr, Y
	Sr-85	64.849 d	Rb, Sr	Y, Zr, Nb, Mo
	Sr-85m	1.127 h		Sr, Y
	Sr-87m	2.803 h	Sr	Kr, Rb, Y
	Sr-89	50.570 d	Rb, Sr, Y	Zr, Nb, Mo
	Sr-90	28.790 y	Rb, Sr, Y, Zr	Nb, Mo
	Sr-91	9.630 h		Zr
+	Y-84m	40.000 m		Zr
+	Y-85	2.681 h		Y
+	Y-85m	4.861 h		Y

	Nuclide	T½	Contributing elements	
			Primary	Secondary
*	Y-86	14.740 h	Y	Zr, Nb, Mo
+	Y-86m	48.000 m		Y
	Y-87	3.346 d		Y, Zr, Nb, Mo
	Y-87m	13.370 h		Y, Zr, Nb, Mo
	Y-88	106.629 d	Y, Zr, Nb, Mo, Ru	Sr
	Y-89m	15.663 s	Y, Zr	Sr, Nb, Mo, Ru
	Y-90	2.671 d	Rb, Sr, Y, Zr, Nb	Mo, Rh
	Y-90m	3.190 h	Y, Nb	Zr
	Y-91	58.510 d	Y, Zr	Nb, Mo
	Y-91m	49.710 m		Y, Zr
	Y-92	3.540 h		Zr
+	Y-93	10.180 h		Zr
	Y-94	18.700 m		Zr
+	Zr-87	1.680 h		Zr, Nb, Mo
+	Zr-88	83.000 d		Zr, Nb, Mo, Ru
	Zr-89	3.267 d	Zr	Nb, Mo, Ru
	Zr-89m	4.180 m		Zr, Nb
	Zr-90m	0.809 s	Zr, Nb	Mo
	Zr-93	1.53E+06 y	Sr, Y, Zr, Nb	Mo
	Zr-95	64.032 d	Zr	
	Zr-97	16.744 h	Zr	
+	Nb-88m	7.780 m		Mo
+	Nb-89	2.030 h		Nb, Mo
	Nb-90	14.600 h	Nb, Mo	Ru
	Nb-90m	18.820 s		Nb, Mo
	Nb-91	680.016 y	Nb, Mo, Ru	Zr, Rh, Pd
	Nb-91m	60.900 d	Nb, Mo	Ru
	Nb-92	3.50E+07 y	Nb, Mo	Zr
	Nb-92m	10.150 d	Nb, Mo	Ru
	Nb-93m	16.126 y	Rb, Sr, Y, Zr, Nb, Mo, Ru	Rh, Pd, Ag, Cd, In, Sn, Sb
	Nb-94	2.00E+04 y	Zr, Nb, Mo, Ru, Rh, Pd, Ag, Cd, In, Sn, Sb	Y
	Nb-94m	6.260 m	Nb	Mo
	Nb-95	34.991 d	Zr, Nb, Mo	Ru
	Nb-95m	3.608 d		Nb, Mo
	Nb-96	23.350 h	Nb	Zr, Mo
	Nb-97	1.202 h		Zr, Mo
	Nb-97m	52.700 s		Zr
	Nb-98m	51.300 m		Mo
+	Mo-90	5.560 h		Mo
	Mo-91	15.490 m		Mo, Ru
	Mo-91m	1.077 m		Mo
	Mo-93	4000.009 y	Zr, Mo, Ru, Rh, Pd, Ag, Cd, In, Sn, Sb	I
	Mo-93m	6.850 h		Mo, Ru
	Mo-99	2.748 d	Mo	Zr, Ru
	Mo-101	14.610 m	Mo	
+	Tc-92	4.400 m		Ru, Rh, Pd
+	Tc-93	2.750 h		Ru
+	Tc-94	4.883 h		Ru, Rh
+	Tc-94m	52.000 m		Ru
	Tc-95	20.000 h		Ru, Rh
	Tc-95m	61.000 d		Ru
	Tc-96	4.280 d	Ru	Mo, Rh, Pd
	Tc-96m	51.500 m		Ru
	Tc-97	2.60E+06 y	Ru, Rh	Mo, Pd, Ag, Cd, In, Sn, Sb
	Tc-97m	90.200 d	Ru	Mo, Rh
	Tc-98	4.20E+06 y	Mo, Ru, Rh, Pd, Ag, Cd, In, Sn, Sb	I
	Tc-99	2.14E+05 y	Zr, Nb, Mo, Ru, Rh, Pd, Ag, Cd	In, Sn, Sb
	Tc-99m	6.010 h		Zr, Mo, Ru
>	Tc-100	15.800 s	Mo, Ru	Zr, Rh, Pd
	Tc-101	14.200 m		Mo, Ru
	Tc-102	5.280 s		Ru
>	Tc-102m	4.350 m	Ru	Rh, Pd
+	Tc-103	54.200 s		Ru

	Nuclide	T½	Contributing elements	
			Primary	Secondary
	Tc-104	18.300 m		Ru
+	Ru-94	51.800 m		Ru
	Ru-95	1.643 h		Ru
	Ru-97	2.900 d	Ru	Rh, Pd
	Ru-103	39.260 d	Mo, Ru, Rh	Pd, Ag
	Ru-105	4.440 h	Rh	Ru, Pd
	Ru-106	1.020 y	Ru, Rh	Pd
+	Rh-98	8.720 m		Rh, Pd
+	Rh-98m	3.500 m		Rh, Pd
+	Rh-99	16.100 d		Rh, Pd
+	Rh-99m	4.694 h		Rh, Pd
>	Rh-100	20.800 h	Rh, Pd	Ru, Ag, Cd
+	Rh-100m	4.600 m		Rh, Pd, Ag
>	Rh-101	3.300 y	Rh	Ru, Pd, Ag
>	Rh-101m	4.340 d	Rh	Ru, Pd, Ag
	Rh-102	2.902 y	Ru, Rh, Pd, Ag	Cd, In, Sn, Sb
	Rh-102m	208.000 d		Ru, Rh, Pd, Ag
	Rh-103m	56.114 m	Rh	Mo, Ru, Pd, Ag, Cd
	Rh-104	42.300 s	Ru, Rh	Pd, Ag
	Rh-104m	4.340 m	Rh	Ru, Pd, Ag
	Rh-105	1.473 d	Rh	Ru, Pd, Ag
	Rh-105m	40.000 s		Ru, Rh, Pd
	Rh-106	30.000 s	Ru, Rh	Pd
	Rh-106m	2.200 h	Rh	Ru, Pd, Ag
	Rh-107	21.700 m		Pd
	Rh-108	16.800 s		Pd
	Rh-108m	6.000 m		Pd
+	Rh-109	1.333 m		Pd
+	Rh-110	28.500 s		Pd
+	Pd-99	21.400 m		Pd
+	Pd-100	3.630 d		Pd, Ag
	Pd-101	8.470 h		Rh, Pd, Ag
	Pd-103	16.980 d	Pd	Ag, Cd
	Pd-107	6.50E+06 y	Rh, Pd, Ag, Cd, In, Sn, Sb, I	Ru
	Pd-107m	21.300 s		Rh, Pd, Ag
	Pd-109	13.701 h	Pd, Ag	Rh
	Pd-109m	4.690 m		Pd, Ag
+	Pd-110	6.00E+17 y		Ag
	Pd-111	23.400 m		Pd
	Pd-111m	5.500 h	Pd	
+	Ag-102	12.900 m		Cd
+	Ag-103	1.095 h		Ag, Cd
+	Ag-104	1.153 h		Ag, Cd, In
+	Ag-104m	33.500 m		Ag, Cd
>	Ag-105	41.300 d	Ag	Cd, In, Sn
+	Ag-105m	7.230 m		Ag, Cd
	Ag-106	24.000 m		Ag, Cd
	Ag-106m	8.460 d	Ag, Cd	Pd, In, Sn
	Ag-107m	44.300 s	Ag	Cd, In
	Ag-108	2.400 m	Ag	Pd, Cd, In, Sn, Sb, I
	Ag-108m	418.010 y	Rh, Pd, Ag, Cd, In, Sn, Sb, I, Xe, Cs	Te, Ba
	Ag-109m	39.600 s	Ag, Cd	Rh, Pd, In, Sn, Sb
	Ag-110	24.560 s	Pd, Ag	Rh, Cd, In
	Ag-110m	249.780 d	Ru, Rh, Pd, Ag, Cd, In, Sn, Sb	
	Ag-111	7.450 d	Pd, Ag	Rh, Cd, In
	Ag-111m	1.080 m		Pd, Ag, Cd, In
	Ag-112	3.130 h		Pd, Cd, In
	Ag-113	5.370 h		Cd
+	Ag-113m	1.145 m		Cd
	Ag-114	4.600 s		Cd
+	Ag-115	20.000 m		Cd
	Ag-116	2.680 m		Cd
	Cd-105	55.500 m		Cd

	Nuclide	T½	Contributing elements	
			Primary	Secondary
	Cd-107	6.520 h		Ag, Cd, In
*	Cd-108	4.10E+17 y	Ag	Cd
	Cd-109	1.267 y	Ag, Cd	In, Sn, Sb
	Cd-111m	48.540 m	Cd	Pd, Ag, In, Sn
	Cd-113	7.70E+15 y	Cd	Ag
	Cd-113m	14.100 y	Pd, Ag, Cd, In, Sn, Sb	Rh, Te, I, Xe
*	Cd-114	6.00E+17 y	Cd	In
	Cd-115	2.228 d	Cd	Pd, Ag, In, Sn
>	Cd-115m	44.600 d	Cd	Pd, Ag, In, Sn, Sb
+	Cd-116	3.40E+19 y		Cd
	Cd-117	2.490 h		Cd, Sn
	Cd-117m	3.360 h		Cd, Sn
+	In-108	58.000 m		In, Sn
+	In-108m	39.667 m		In, Sn
+	In-109	4.200 h		In, Sn
+	In-110	4.900 h		In, Sn
+	In-110m	1.152 h		In, Sn
	In-111	2.805 d		In, Sn
+	In-111m	7.900 m		In
	In-112	14.700 m		Cd, In, Sn
	In-112m	20.700 m		In, Sn
	In-113m	1.658 h	In, Sn, Sb	Cd
	In-114	1.198 m	In	Cd, Sn, Sb
	In-114m	50.000 d	In	Cd, Sn, Sb
	In-115	4.41E+14 y	Cd, In, Sb	Rh, Pd, Ag
	In-115m	4.486 h	In	Ag, Cd, Sn
	In-116	14.200 s		Ag, Cd, In, Sn
	In-116m	54.600 m	Ag, Cd, In, Sn	Pd, Sb
	In-116n	2.170 s		Ag, Cd, In, Sn
	In-117	43.200 m		Cd, Sn, Sb
	In-117m	1.937 h		Cd, Sn
	In-118	5.000 s		Sn
	In-118m	4.450 m		Sn, Sb
+	In-118n	8.500 s		Sn
	In-119	2.400 m		Sn, Sb
+	In-119m	18.000 m		Sn
	In-120	3.080 s		Sn
	In-120m	46.200 s		Sn, Sb
	In-120n	46.200 s		Sn
+	In-121	23.100 s		Sn
+	In-123	5.980 s		Sn
+	Sn-108	10.300 m		In, Sn, Sb
*	Sn-109	18.000 m	In	Cd, Sn, Sb
+	Sn-110	4.100 h		In, Sn
	Sn-111	35.300 m		In, Sn
	Sn-113	115.090 d	Sn	In, Sb
>	Sn-113m	20.900 m	In, Sn, Sb	Cd, Te, I
	Sn-117m	13.600 d	In, Sn	Cd, Sb
	Sn-119m	293.000 d	In, Sn, Sb	Te, I, Xe
	Sn-121	1.128 d	In, Sn, Sb, Te, I, Xe, Cs	
	Sn-121m	55.001 y	In, Sn, Sb, Te, I, Xe, Cs	
	Sn-123	129.200 d	Sn, Sb	Te, I
	Sn-123m	40.060 m		Sn
*	Sn-124	1.00E+17 y	Sn, Sb	
	Sn-125	9.640 d		Sn
>	Sn-125m	9.520 m	Sn	Te
	Sn-126	2.30E+05 y	Sn, Sb, Te, I	
+	Sn-127	2.100 h		Te
+	Sn-127m	4.130 m		Te
+	Sb-116	15.800 m		Sb, Te
+	Sb-116m	1.005 h		Sb
+	Sb-117	2.800 h		Sb
+	Sb-118	3.600 m		Sb, Te, I, Xe

	Nuclide	$T_{1/2}$	Contributing elements	
			Primary	Secondary
+	Sb-118m	5.000 h		Sn, Sb, Te, I
>	Sb-119	1.596 d	Sb	Te, I
	Sb-120	15.900 m		Sn, Sb, Te, I
>	Sb-120m	5.760 d	Sb	Sn, Te, I, Xe
	Sb-122	2.700 d	Sn, Sb	Te, I, Xe
	Sb-122m	4.190 m		Sn, Sb, I
	Sb-124	60.200 d	Sn, Sb, I	Te, Xe, Cs
	Sb-124m	1.550 m		Sb, Te, I
+	Sb-124n	20.200 m		Te
	Sb-125	2.759 y	Sn, Sb, Te, I, Xe, Cs	In
	Sb-126	12.400 d		Sn, Te, I, Xe, Cs, Ba
	Sb-126m	19.100 m	Sn, Te, I, Xe	Cs, Ba
	Sb-126n	11.000 s		Sn, Te, I
	Sb-127	3.850 d		Te
	Sb-128	9.010 h		Te
	Sb-128m	10.400 m		Te
	Sb-129	4.360 h		Te
+	Sb-129m	17.700 m		Te
	Sb-130	39.500 m		Te
	Sb-130m	6.300 m		Te
+	Te-117	1.033 h		Te
+	Te-118	6.000 d		Sb, Te, I
+	Te-119	16.050 h		Te, I
	Te-119m	4.700 d		Sb, Te, I, Xe
	Te-121	19.160 d	Sb, Te, I, Xe	Sn, Cs
	Te-121m	154.000 d	Sb	Sn, Te, I, Xe, Cs
	Te-123	9.20E+16 y	Sb	
	Te-123m	119.500 d	Sb, Te	Sn, I, Xe, Cs
	Te-125m	57.400 d	Te	Sn, Sb, I, Xe, Cs
	Te-127	9.350 h	Te, I	Xe, Cs
	Te-127m	109.000 d	Te, I	Xe, Cs
	Te-129	1.160 h	Te, I	Cs
	Te-129m	33.600 d	Te, I	Cs
	Te-131	25.000 m		Te
+	Te-131m	1.250 d		Te, Xe
+	Te-133m	55.400 m		Xe
+	I-120m	53.000 m		Xe
+	I-122	3.630 m		I, Xe, Cs
+	I-123	13.223 h		I, Xe
*	I-124	4.176 d	I, Xe	Te, Cs
	I-125	59.407 d	I, Xe	Te, Cs, Ba
	I-126	12.980 d	I	Te, Xe, Cs
	I-128	24.990 m	Te, I	Xe, Cs
	I-129	1.61E+07 y	Sb, Te, I, Xe, Cs, Ba	Sn, La, Ce, Pr, Nd
	I-130	12.360 h	Te, I	Xe, Cs, Ba, La
	I-130m	9.000 m		Te
	I-131	8.023 d	Te	Xe, Cs
	I-132	2.295 h		Xe
	I-133	20.800 h		Xe
+	I-133m	9.000 s		Xe
	I-134	52.500 m		Xe
	I-135	6.570 h		Xe
	I-136	1.390 m		Xe
+	I-136m	45.000 s		Xe
+	Xe-122	20.100 h		Te, I, Xe, Cs
	Xe-123	2.080 h		I, Xe
*	Xe-124	2.00E+14 y	I	Xe
	Xe-125	16.900 h		Te, I, Xe, Cs, Pr
	Xe-125m	56.000 s		I, Xe, Cs
	Xe-127	36.400 d	Te, Xe, Cs, Ba, La, Ce, Pr, Nd	I
	Xe-127m	1.160 m		Xe, Cs
	Xe-129m	8.880 d	I, Xe, Cs	Te, Ba, La, Pr
	Xe-131m	11.930 d	Te, I, Xe, Cs, Ba	La, Pr

	Nuclide	T½	Contributing elements	
			Primary	Secondary
	Xe-133	5.244 d	Xe, Cs, Ba	Te, I, La, Pr
	Xe-133m	2.188 d		Te, Xe, Cs, Ba, La
+	Xe-134	1.10E+16 y		Xe
	Xe-134m	0.290 s	Xe	
	Xe-135	9.140 h	Xe	Ba, La
>	Xe-135m	15.290 m	Xe	Xe, Ba
	Xe-137	3.818 m		Xe
+	Cs-126	1.640 m		Ba
+	Cs-128	3.620 m		Cs, Ba, La, Ce, Pr
	Cs-129	1.342 d		Cs, Ba, La
*	Cs-130	29.210 m	Cs	Xe, Ba, La
+	Cs-130m	3.460 m		Cs
	Cs-131	9.690 d	Cs, Ba	Xe, La, Ce, Pr
	Cs-132	6.530 d	Cs	Xe, Ba, La, Ce, Pr, Nd
	Cs-134	2.065 y	Te, I, Xe, Cs, Ba, La, Ce, Pr	Nd
	Cs-134m	2.908 h		Xe, Cs, Ba, La
	Cs-135	2.30E+06 y	I, Xe, Cs, Ba, La, Ce, Pr, Nd	Te
	Cs-135m	53.000 m		Xe, Cs, Ba, La
	Cs-136	13.030 d	I, Xe, Cs, Ba, La	Te, Ce, Pr, Nd
	Cs-136m	19.000 s		Cs, Ba, La
	Cs-137	30.041 y	Te, I, Xe, Cs, Ba, La, Pr	Ce, Nd
	Cs-138	33.410 m		Ba
+	Ba-128	2.430 d		Ba
	Ba-129	2.380 h		Ba, La, Ce, Pr, Nd
>	Ba-129m	2.140 h	Ce, Pr	Ba, La, Nd, Sm
	Ba-131	11.550 d	Ba	Cs, La, Ce, Pr, Nd
	Ba-131m	14.600 m		Ba, La
	Ba-133	10.540 y	Xe, Cs, Ba, La, Ce, Pr, Nd	
	Ba-133m	1.592 d		Ba, La
	Ba-135m	1.196 d	Ba	Cs, La, Ce
	Ba-136m	0.308 s		Ba, La, Ce
	Ba-137m	2.552 m	Te, I, Xe, Cs, Ba, La, Ce, Pr, Nd	Sb
	Ba-139	1.384 h	Ba	La
+	La-132	4.800 h		La, Ce, Pr, Nd
+	La-133	3.912 h		La, Ce, Pr
+	La-134	6.450 m		La, Ce, Pr, Nd
>	La-135	19.500 h	La	Ce, Pr, Nd
	La-136	9.870 m	La, Ce	Pr, Nd
	La-137	6.00E+04 y	Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho	Er, Tm
	La-138	1.02E+11 y	Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy	Ho
	La-140	1.679 d	Ba, La, Ce, Pr	Nd
+	La-141	3.920 h		Ce
	La-142	1.518 h		Ce
+	Ce-132	3.510 h		Ce
+	Ce-133m	4.900 h		Ce, Pr
+	Ce-134	3.160 d		Ce, Pr, Nd
>	Ce-135	17.700 h	Pr	Ce, Nd
+	Ce-135m	20.000 s		Ce
*	Ce-136	7.00E+13 y	Ce	
	Ce-137	9.000 h	Ce	Pr, Nd
	Ce-137m	1.433 d		Ce, Pr, Nd
	Ce-139	137.641 d	La, Ce, Pr, Nd	Sm
	Ce-139m	56.100 s	Ce	Pr, Nd
	Ce-141	32.500 d	Ba, La, Ce, Pr	Nd
<	Ce-142	5.00E+16 y		Ce, Pr
	Ce-143	1.379 d	Ce	Nd
	Ce-144	285.000 d	Ce, Pr	La, Nd
+	Pr-136	13.100 m		Pr
+	Pr-137	1.280 h		Pr
+	Pr-138	1.450 m		Pr, Sm
*	Pr-138m	2.120 h	Pr	Ce, Sm
>	Pr-139	4.410 h	Pr	Ce, Sm
	Pr-140	3.390 m	Pr, Nd	Ce, Sm

	Nuclide	T½	Contributing elements	
			Primary	Secondary
	Pr-142	19.120 h	Ce, Pr	Ba, La
	Pr-142m	14.600 m		La, Ce, Pr
	Pr-143	13.560 d	Ce, Pr	La
	Pr-144	17.280 m	Ce, Pr	La
+	Nd-138	5.040 h		Nd
+	Nd-139	29.700 m		Nd
*	Nd-139m	5.500 h	Nd	Sm, Eu
>	Nd-140	3.370 d	Nd	Sm, Eu
	Nd-141	2.490 h	Nd	Sm, Eu
	Nd-141m	1.033 m	Nd	Sm
	Nd-144	2.29E+15 y	Pr, Nd	La, Ce
	Nd-147	10.980 d	Pr, Nd	Ce, Sm
	Nd-149	1.728 h	Nd	
	Nd-151	12.440 m	Nd	
+	Pm-140	9.200 s		Sm
+	Pm-140m	5.950 m		Sm
+	Pm-141	20.900 m		Sm
	Pm-142	40.500 s		Sm, Eu, Gd
	Pm-143	266.000 d		Nd, Sm, Eu, Gd
	Pm-144	363.000 d	Nd, Sm	Eu, Gd, Tb
	Pm-145	17.700 y	Nd, Sm	Eu, Gd
	Pm-146	5.531 y	Nd, Sm	Eu
	Pm-147	2.623 y	La, Ce, Pr, Nd	Sm, Eu
	Pm-148	5.368 d		Ce, Pr, Nd, Sm, Eu
	Pm-148m	41.050 d	Pr, Nd	Ce, Sm, Eu
	Pm-149	2.212 d		Pr, Nd, Sm, Eu
	Pm-150	2.680 h		Ce, Pr, Nd, Sm, Eu
	Pm-151	1.183 d		Nd, Sm
	Pm-152m	7.520 m		Sm
	Pm-153	5.250 m		Sm
	Pm-154	1.700 m		Sm
+	Sm-140	14.817 m		Sm
+	Sm-141	10.200 m		Sm
+	Sm-141m	22.600 m		Sm
+	Sm-142	1.208 h		Eu
	Sm-143	8.750 m		Eu
	Sm-143m	1.100 m		Eu
	Sm-145	340.000 d	Sm	Eu, Gd, Tb
	Sm-146	1.00E+08 y	Nd, Sm, Eu	Gd, Tb
	Sm-147	1.06E+11 y	La, Ce, Pr, Nd, Sm, Eu	
	Sm-148	8.00E+15 y		Eu
<	Sm-149	2.00E+15 y		Eu
	Sm-151	90.002 y	La, Pr, Nd, Sm, Eu, Gd, Tb	
	Sm-153	1.928 d	Sm	Pr, Eu, Gd
	Sm-155	22.300 m	Sm	Gd
+	Eu-145	5.930 d		Eu, Gd
+	Eu-146	4.590 d		Eu, Gd, Tb, Dy, Er
+	Eu-147	24.000 d		Eu, Gd, Tb
>	Eu-148	54.500 d	Eu	Sm, Gd, Tb, Dy, Ho, Er
	Eu-149	93.100 d	Eu	Sm, Gd, Tb, Dy
	Eu-150	36.359 y	Nd, Sm, Eu, Gd	Tb, Dy, Ho, Er, Tm
	Eu-150m	12.800 h		Eu, Gd
	Eu-152	13.525 y	Nd, Sm, Eu, Gd	Pr, Tb, Dy, Ho, Er, Tm, Yb
	Eu-152m	9.275 h	Eu	Sm, Gd
	Eu-152n	1.600 h		Eu
	Eu-154	8.593 y	La, Ce, Pr, Nd, Sm, Eu, Gd, Tb	Dy, Ho, Er, Tm, Yb
	Eu-154m	46.400 m		Eu, Gd
	Eu-155	4.753 y	Nd, Sm, Eu, Gd, Tb	La, Ce, Pr, Dy, Ho
	Eu-156	15.190 d	Pr, Nd, Sm, Eu, Gd	La, Ce, Tb, Dy
	Eu-157	15.180 h		Pr, Nd, Sm, Eu, Gd
	Eu-158	45.900 m		Sm, Eu, Gd
	Eu-159	18.100 m		Gd
	Eu-160	38.000 s		Gd

	Nuclide	$T_{½}$	Contributing elements	
			Primary	Secondary
+	Gd-145	23.000 m		Gd
+	Gd-146	48.270 d		Gd, Tb
+	Gd-147	1.588 d		Eu, Gd
	Gd-148	74.602 y	Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm	Yb, Lu, Ta
	Gd-149	9.280 d		Eu, Gd, Tb, Dy
	Gd-150	1.82E+06 y	Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta	
	Gd-151	124.000 d		Sm, Eu, Gd, Tb, Dy, Ho, Er
	Gd-152	1.08E+14 y	Eu, Gd, Dy	
	Gd-153	240.400 d	Eu, Gd, Tb	Sm, Dy, Ho, Er, Tm
	Gd-159	18.479 h	Gd	Nd, Sm, Eu, Tb, Dy
*	Gd-160	1.30E+17 y	Eu, Gd, Tb, Ho, Tm	Dy
	Gd-161	3.660 m	Gd	Dy
+	Tb-151	17.609 h		Dy
+	Tb-152	17.500 h		Tb, Dy, Ho, Er
+	Tb-152m	4.300 m		Dy
+	Tb-153	2.340 d		Tb, Dy, Ho, Er
+	Tb-154	21.500 h		Gd, Tb, Dy, Ho, Er
*	Tb-154m	9.000 h	Gd, Tb, Dy, Ho, Er, Tm	Yb, Lu
+	Tb-154n	22.694 h		Tb, Dy, Ho
>	Tb-155	5.320 d	Tb	Dy, Ho, Er
	Tb-156	5.170 d	Tb, Dy	Gd, Ho, Er
	Tb-156m	1.017 d		Tb
	Tb-156n	5.100 h		Tb
	Tb-157	99.002 y	Gd, Tb, Dy, Ho	Tm, Yb, Lu, Hf
	Tb-158	180.000 y	Gd, Tb, Dy, Ho, Tm	Yb, Lu, Hf
	Tb-158m	10.800 s	Tb	Gd, Dy
	Tb-160	72.300 d	Sm, Eu, Gd, Tb, Dy, Ho, Er	Pr, Tm
	Tb-161	6.890 d	Sm, Eu, Gd, Tb, Dy	Ho
>	Tb-162	7.600 m	Gd, Tb, Ho	Dy, Tm
>	Tb-163	19.500 m	Dy	Tm
	Tb-164	3.000 m		Dy
+	Dy-151	17.900 m		Dy
+	Dy-153	6.400 h		Dy
	Dy-154	3.00E+06 y	Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta	Tb
	Dy-155	9.900 h		Dy, Ho, Er
*	Dy-156	1.00E+18 y	Dy	
	Dy-157	8.140 h	Dy	Ho, Er
	Dy-159	144.400 d	Dy, Ho, Er	Tm, Yb
	Dy-165	2.334 h	Dy	Nd, Sm, Eu, Gd, Tb, Ho, Er
	Dy-165m	1.258 m		Sm, Eu, Gd, Tb, Dy
	Dy-166	3.400 d		Sm, Eu, Gd, Tb, Dy, Er
*	Ho-158	11.000 m	Er	Ho, Tm, Yb
+	Ho-158n	21.333 m		Ho, Er
+	Ho-159	33.050 m		Ho, Er, Tm
>	Ho-160	25.300 m	Er	Ho, Tm, Yb
+	Ho-160m	5.000 h		Ho, Er, Tm
+	Ho-160n	2.900 s		Ho
>	Ho-161	2.480 h	Ho	Er, Tm, Yb
	Ho-161m	6.770 s		Ho
>	Ho-162	15.000 m	Ho, Er, Tm	
	Ho-162m	1.117 h	Ho	Er, Tm
	Ho-163	4570.090 y	Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, W	
	Ho-163m	1.100 s		Ho, Er
	Ho-164	28.600 m	Ho	Er, Tm
	Ho-164m	37.600 m		Ho, Er
	Ho-166	1.117 d	Tb, Dy, Ho	Nd, Sm, Eu, Gd, Er, Tm
	Ho-166m	1200.000 y	Cs, Ba, La, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, W	Ce, Re
	Ho-167	3.100 h	Ho	Eu, Gd, Tb, Dy, Er
	Ho-168	2.990 m		Er
	Ho-169	4.400 m		Er
	Ho-170	2.780 m		Er

	Nuclide	T½	Contributing elements	
			Primary	Secondary
+	Ho-170m	43.000 s		Er
+	Er-158	2.250 h		Er
+	Er-159	36.000 m		Er, Tm
	Er-160	1.191 d		Ho, Er, Tm
	Er-161	3.211 h		Ho, Er, Tm, Yb
*	Er-162	1.40E+14 y	Ho, Er	Tm
	Er-163	1.250 h		Ho, Er, Tm, Yb
	Er-165	10.360 h	Er	Ho, Tm, Yb, Lu
	Er-167m	2.269 s	Dy, Ho, Er	Sm, Eu, Gd, Tb, Tm, Yb, Lu, Hf
	Er-169	9.400 d	Dy, Ho, Er	Eu, Gd, Tb, Tm
	Er-171	7.516 h	Er	Dy, Ho
+	Tm-163	1.810 h		Tm, Yb
+	Tm-164	2.000 m		Tm, Yb
+	Tm-164m	5.100 m		Tm
+	Tm-165	1.253 d		Tm, Yb, Lu
>	Tm-166	7.700 h	Tm, Yb	Lu, Hf
>	Tm-167	9.250 d	Tm	Yb, Lu, Hf
	Tm-168	93.100 d	Er, Tm, Yb, Lu	
	Tm-170	128.600 d	Gd, Tb, Dy, Ho, Er, Tm, Yb	Lu
	Tm-171	1.917 y	Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu	
	Tm-172	2.650 d	Tb, Dy, Ho, Er, Tm, Lu	Gd, Yb
	Tm-173	8.240 h		Yb
	Tm-174	5.400 m		Yb
+	Tm-175	15.167 m		Yb
	Tm-176	1.900 m		Yb
+	Yb-163	11.050 m		Yb
+	Yb-164	1.263 h		Yb
+	Yb-165	9.900 m		Lu
+	Yb-166	2.363 d		Lu
	Yb-167	17.500 m		Lu
*	Yb-168	1.30E+14 y	Tm, Yb	
	Yb-169	32.018 d	Yb	Lu
	Yb-169m	46.000 s		Lu
	Yb-175	4.185 d	Tm, Yb	
	Yb-176m	11.400 s	Yb	
	Yb-177	1.911 h	Yb	
+	Lu-167	51.500 m		Lu, Hf, Ta
+	Lu-168	5.500 m		Lu, Hf
+	Lu-168m	6.700 m		Hf, Ta
+	Lu-169	1.419 d		Lu, Hf, Ta, W
+	Lu-169m	2.667 m		Lu
*	Lu-170	2.002 d	Lu	Yb, Hf, Ta, W
+	Lu-170m	0.670 s		Lu
	Lu-171	8.250 d		Yb, Lu, Hf, Ta, W
+	Lu-171m	1.300 m		Lu, Hf
	Lu-172	6.700 d	Lu, Hf, Ta, W, Re, Os	Yb, Ir, Pt, Au
	Lu-172m	3.700 m		Lu, Hf, Ta, W, Re, Os
>	Lu-173	1.336 y	Yb, Lu, Hf	Ta, W, Re, Os, Ir
	Lu-174	3.559 y	Yb, Lu, Hf	Ta, W, Re, Os
	Lu-174m	142.000 d		Yb, Lu, Hf, Ta
	Lu-176	4.00E+10 y	Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta	
	Lu-176m	3.635 h	Yb, Lu	Er, Tm, Hf, Ta
	Lu-177	6.647 d	Yb, Lu	Tm, Hf, Ta
	Lu-177m	160.300 d	Yb, Lu	Tm, Hf, Ta
	Lu-178	28.400 m	Lu	Tm, Yb, Hf, Ta
	Lu-178m	23.100 m		Lu, Hf, Ta
+	Lu-179	4.590 h		Hf, Ta
	Lu-180	5.700 m		Hf, Ta
+	Hf-169	3.240 m		Hf
+	Hf-170	16.000 h		Hf
*	Hf-171	12.111 h	Hf, Ta	W, Re, Os
*	Hf-172	1.870 y	Hf, Ta, W, Re	Os, Ir

	Nuclide	$T_{½}$	Contributing elements	
			Primary	Secondary
	Hf-173	23.900 h		Hf, Ta, W
	Hf-174	2.00E+15 y		Hf
	Hf-175	70.000 d	Hf, Ta	W, Re
	Hf-177m	1.080 s	Yb, Lu, Hf	Er, Tm, Ta
	Hf-177n	51.400 m		Yb, Lu, Hf
	Hf-178m	4.000 s	Hf	Tm, Yb, Lu, Ta, W, Re, Os
	Hf-178n	31.001 y	Yb, Lu, Hf, Ta, W, Re, Os	Tm
	Hf-179m	18.670 s	Lu, Hf	Tm, Yb, Ta
	Hf-179n	25.100 d	Hf	Tm, Yb, Lu, Ta, W
	Hf-180m	5.500 h		Tm, Yb, Lu, Hf, Ta, W
	Hf-181	42.380 d	Er, Tm, Yb, Lu, Hf	Dy, Ho, Ta, W
	Hf-182	9.00E+06 y	Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, W	Nd, Sm, Eu, Gd, Re, Os, Ir
	Hf-183	1.067 h		Tm, Yb, Lu, Hf, W
+	Ta-174	1.140 h		W
+	Ta-175	10.500 h		Ta, W, Re
*	Ta-176	8.090 h	Ta	W, Re
	Ta-177	2.350 d		Ta, W, Re
	Ta-178	9.290 m		Ta, W, Re
	Ta-178m	2.361 h	Ta	W
	Ta-179	1.610 y	Ta, W, Re	Ir, Pt
	Ta-180	8.080 h	Ta	W
	Ta-180m	1.80E+15 y	Ta	
	Ta-182	114.700 d	Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, W, Re	Ir, Pt, Au
	Ta-182m	0.283 s		Ta
	Ta-183	5.090 d	Hf, Ta	Tm, Yb, Lu
	Ta-184	8.700 h		Tm, Yb, Lu, Hf
+	W-175	35.200 m		Re
+	W-177	2.200 h		Re
	W-178	21.600 d		Re
	W-179	37.050 m		Re
	W-181	120.980 d	W	Re, Ir, Pt
*	W-183	1.10E+17 y	Ta, W	
	W-183m	5.250 s	W	Yb, Lu, Re
	W-185	75.100 d	Hf, Ta, W, Re, Os	Yb, Lu
	W-185m	1.667 m		Re
	W-187	23.850 h	W, Re	
<	W-188	69.780 d		Re
+	Re-179	19.500 m		Os
+	Re-180	2.440 m		Re, Os
+	Re-181	19.900 h		W, Re, Os, Ir
	Re-182	2.667 d		W, Re, Os, Ir, Pt
+	Re-182m	12.700 h		W, Re, Os
>	Re-183	70.000 d	Re	W, Os, Ir, Pt, Au
	Re-184	37.900 d	W, Re, Os	Ir, Pt, Au, Hg
	Re-184m	168.000 d	W, Re	Os, Ir, Pt, Au
	Re-186	3.775 d	Ta, W, Re, Os, Ir, Pt, Au, Hg, Tl	Lu, Hf
	Re-186m	2.00E+05 y	Ta, W, Re, Os, Ir, Pt, Au, Hg, Tl	Lu, Hf
	Re-187	4.35E+10 y	W, Re, Ir, Au	Ta, Os
	Re-188	16.980 h	W, Re	Ta, Ir
	Re-188m	18.600 m		Re
	Re-189	1.013 d		Ir
+	Os-179	6.500 m		Os
+	Os-180	21.500 m		Os
+	Os-181m	1.750 h		Os
+	Os-182	22.100 h		Os, Ir
	Os-183	13.000 h		Os, Ir, Pt
	Os-183m	9.889 h		Os
*	Os-184	5.60E+13 y	Os	
	Os-185	93.800 d	Os, Ir, Pt, Au	Re, Hg, Tl, Pb
	Os-186	2.00E+15 y	Os	Re
	Os-189m	4.806 h	Os	W, Re, Ir, Pt, Au
	Os-190m	9.900 m	Os	Ir, Pt

	Nuclide	T½	Contributing elements	
			Primary	Secondary
	Os-191	15.300 d	Os, Au	Ta, W, Re, Ir, Pt
	Os-191m	13.100 h		W, Re, Os
	Os-192m	5.900 s		Os
	Os-193	1.255 d	Os	Re, Ir
	Os-194	5.989 y	Ta, W, Re, Os, Ir, Pt, Au	Hf
+	Ir-185	13.889 h		Ir, Pt, Au, Hg
+	Ir-186	16.639 h		Ir, Pt, Au, Hg
+	Ir-186m	2.000 h		Ir, Pt
+	Ir-187	10.500 h		Ir, Pt, Au
>	Ir-188	1.729 d	Ir, Pt, Au, Hg	Os, Tl, Pb
>	Ir-189	13.200 d	Ir	Os, Pt, Au, Hg
	Ir-190	12.000 d	Os, Ir, Pt	Au, Hg
	Ir-190m	1.120 h		Os, Ir
	Ir-190n	3.087 h		Ir
	Ir-191m	4.900 s	Os, Au	W, Re, Ir, Pt
>	Ir-191n	5.500 s	Os, Ir	Pt
	Ir-192	73.822 d	Ta, W, Re, Os, Ir, Pt, Au	Hg, Tl, Pb
	Ir-192m	1.440 m		W, Re, Os, Ir
	Ir-192n	241.000 y	Ta, W, Re, Os, Ir, Pt, Au	Hg
>	Ir-193m	10.602 d	Ir, Au	W, Re, Os, Pt
	Ir-194	19.300 h	Ta, W, Re, Os, Ir, Au	Hf, Pt
	Ir-195	2.500 h		Os, Ir
	Ir-195m	3.800 h		Os, Ir, Pt
+	Ir-196	52.000 s		Pt
+	Ir-198	8.000 s		Pt
+	Pt-185	1.183 h		Pt
+	Pt-186	2.080 h		Pt
+	Pt-187	2.350 h		Pt, Au
	Pt-188	10.200 d		Pt, Au, Hg
	Pt-189	10.870 h		Pt, Au, Hg
	Pt-190	6.50E+11 y	Pt, Au, Hg	Ir, Tl
	Pt-191	2.802 d		Ir, Pt, Au, Hg
	Pt-193	50.001 y	Hf, Ta, W, Re, Os, Ir, Pt, Au, Hg, Tl	Lu, Pb
	Pt-193m	4.340 d	Ir, Pt	Re, Os, Au, Hg
	Pt-195m	4.020 d	Ir, Pt	Os, Au, Hg
	Pt-197	19.892 h	Pt	Ir, Au, Hg
	Pt-197m	1.588 h		Ir, Pt
	Pt-199	30.800 m	Pt	
	Pt-199m	13.600 s		Pt
+	Au-190	42.800 m		Hg
+	Au-191	3.180 h		Au, Hg
*	Au-192	4.940 h	Au	Hg, Tl, Pb
+	Au-193	17.650 h		Au, Hg, Tl
+	Au-193m	3.900 s		Au, Hg
	Au-194	1.584 d	Pt, Au, Hg, Tl, Pb	Bi
+	Au-194m	0.600 s		Au
+	Au-194n	0.420 s		Au
	Au-195	186.090 d	Pt, Au, Hg, Tl	Pb, Bi
	Au-195m	30.500 s		Au, Hg
	Au-196	6.183 d	Au, Hg	Pt, Tl, Pb
	Au-196m	8.100 s		Au, Hg
	Au-196n	9.600 h		Au, Hg
	Au-197m	7.740 s	Au	Pt, Hg
	Au-198	2.694 d	Ir, Pt, Au, Hg	Os, Tl, Pb
	Au-199	3.139 d	Ir, Pt, Au	Hg, Tl, Pb
	Au-200	48.400 m		Ir, Pt, Au, Hg, Tl
+	Au-201	26.000 m		Hg
	Au-202	28.800 s		Hg, Tl
	Au-204	39.800 s		Hg
+	Hg-189m	8.700 m		Hg
+	Hg-191	48.333 m		Hg
+	Hg-191m	50.833 m		Hg
+	Hg-192	4.850 h		Hg

	Nuclide	$T_{1/2}$	Contributing elements	
			Primary	Secondary
+	Hg-193	3.800 h		Hg, Tl
+	Hg-193m	11.806 h		Hg
	Hg-194	440.008 y	Pt, Au, Hg, Tl, Pb, Bi	
	Hg-195	9.900 h		Au, Hg, Tl
	Hg-195m	1.736 d		Au, Hg, Tl, Pb
*	Hg-196	2.50E+18 y	Au	Hg
	Hg-197	2.692 d	Hg	Tl, Pb
	Hg-197m	23.900 h		Hg, Tl, Pb
	Hg-199m	42.100 m	Au, Hg	Tl
	Hg-203	46.603 d	Ir, Pt, Au, Hg, Tl, Pb	
	Hg-205	5.200 m	Hg, Pb	
+	Tl-198	5.300 h		Tl, Pb
+	Tl-198m	1.870 h		Tl, Pb
+	Tl-199	7.420 h		Tl, Pb, Bi
>	Tl-200	1.088 d	Tl, Pb	Bi
>	Tl-201	3.041 d	Tl	Pb, Bi
	Tl-202	12.240 d	Hg, Tl, Pb	Bi
	Tl-204	3.788 y	Pt, Au, Hg, Tl, Pb	Ir, Bi
	Tl-206	4.202 m	Tl, Bi	Pb
	Tl-206m	3.760 m	Bi	Tl, Pb
	Tl-207	4.770 m		Pb
	Tl-207m	1.330 s		Pb
<	Tl-208	3.053 m		Pb
+	Pb-198	2.400 h		Pb
+	Pb-199	1.500 h		Pb, Bi
+	Pb-199m	12.200 m		Pb
+	Pb-200	21.500 h		Pb, Bi
	Pb-201	9.400 h		Tl, Pb, Bi
+	Pb-201m	1.017 m		Pb, Bi
	Pb-202	5.30E+04 y	Hg, Tl, Pb, Bi	
+	Pb-202m	3.570 h		Tl, Pb, Bi
	Pb-203	2.162 d	Pb	Tl, Bi
	Pb-203m	6.290 s		Tl, Pb, Bi
	Pb-204	1.40E+17 y	Au	
	Pb-204m	1.125 h	Tl, Pb	Bi
	Pb-205	1.53E+07 y	Ir, Pt, Au, Hg, Tl, Pb	Bi
+	Pb-205m	0.006 s		Bi
	Pb-207m	0.806 s	Pb	Tl, Bi
	Pb-209	3.253 h	Pb	Bi
	Pb-210	22.160 y	Pb	Pb, Bi
+	Bi-199	27.000 m		Bi
+	Bi-200m	31.000 m		Bi
*	Bi-201m	59.100 m	Bi	
+	Bi-202	1.720 h		Bi
+	Bi-203	11.761 h		Bi
+	Bi-204	11.220 h		Bi
>	Bi-205	15.310 d	Bi	
	Bi-206	6.243 d	Bi	
	Bi-207	31.760 y	Pb, Bi	
	Bi-208	3.68E+05 y	Pb, Bi	
	Bi-210	5.012 d	Bi	Pb
	Bi210m	3.00E+06 y	Pb, Bi	
	Bi211	2.170 m		Pb, Bi
	Po208	2.930 y		Pb, Bi
	Po209	102.002 y	Bi	Pb
	Po210	138.388 d	Pb, Bi	

Summary of Major reactions

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
H1(n,γ)**H2**	H3	5	4*	•	
H2(n,γ)H3	H3	5	4*	•	
He3(n,p)H3	H3	5	4	•	
He4(n,2n)**He3**	H3	5	0		
Li6(n,α)H3	H3	5	4	•	
Li7(n,nα)H3	H3	5	5_3	•	•
Li7(n,γ)Li8	Li8	5	4	•	
Li7(n,d)He6	He6	5	2	•	
Be9(n,γ)Be10	H3, Li8, Be10, Be11	5	2	•	
Be9(n,d)Li8	Li8	5	4	•	
Be9(n,t)**Li7**	H3, He6, Li8	5	5_2	•	
Be9(n,α)He6	He6	5	4	•	
Be10(n,γ)Be11	Li8, Be11	5	2*	•	
B10(n,p)Be10	He6, Li8, Be10, Be11	5	2	•	
B10(n,h)Li8	Li8	5	0		
B10(n,α)**Li7**	H3, He6, Li8	5	4	•	
B10(n,2α)H3	H3	5	6	•	•
B11(n,nα)**Li7**	H3, He6	4	0		
B11(n,n2α)H3	H3	5	0		
B11(n,γ)B12	C11	5	2	•	
B11(n,p)Be11	Be11	5	2	•	
B11(n,d)Be10	H3, He6, Li8, Be10	5	2	•	
B11(n,t)**Be9**	H3, He6, Li8	4	5_2	•	•
B11(n,α)Li8	Li8	5	4	•	
B11(n,dα)He6	He6	5	0		
C12(n,2n)C11	H3, He6, Li8, Be10, Be11, C11	5	3	•	
C12(n,2nα)Be7	H3, He6, Be7	5	0		
C12(n,d)**B11**	H3, He6, Li8, Be10, Be11	5	3	•	
C12(n,h)Be10	H3, He6, Li8, Be10	5	0		
C12(n,α)**Be9**	H3, He6, Li8	5	4	•	
C12(n,2p)Be11	Be11	5	0		
C12(n,pα)Li8	Li8	5	0		
C12(n,d2α)H3	H3	5	0		
C12(n,dα)**Li7**	H3, He6	4	0		
C12(n,hα)He6	He6	4	0		
C13(n,3nα)Be7	Be7	4	0		
C13(n,γ)C14	H3, Be11, C14, C15	5	4	•	
C13(n,t)**B11**	He6, Li8, Be10, Be11	5	2	•	
C13(n,α)Be10	He6, Li8, Be10, Be11	5	1	•	
C13(n,t2α)H3	H3	5	0		
C14(n,nα)Be10	Li8, Be10	5	0		
C14(n,γ)C15	C15, N16	5	2	•	
C14(n,α)Be11	Be11	5	0		
N14(n,2n)N13	Li8, Be7, Be10, Be11, C11, N13	5	6	•	•
N14(n,nα)**B10**	H3, Li8, Be10	5	0		
N14(n,nt)C11	Li8, Be10, Be11, C11	5	0		
N14(n,γ)**N15**	N16	5	5_2	•	•
N14(n,p)C14	H3, Li8, Be10, Be11, C14, C15	5	2	•	
N14(n,d)**C13**	H3, Li8, Be7, Be10, Be11, C11	5	0		
N14(n,t)**C12**	H3, Li8, Be7, Be10, Be11, C11	5	5_2	•	•
N14(n,α)**B11**	H3, Li8, Be10, Be11	5	4	•	
N14(n,3α)H3	H3	5	0		
N14(n,pα)Be10	H3, Li8, Be10	5	0		
N14(n,dα)**Be9**	H3, Li8	5	0		
N14(n,ntα)Be7	Be7	5	0		
N14(n,ph)Be11	Be11	5	0		
N15(n,2n)**N14**	H3, Be7, Be10, C14, N13	5	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
N15(n,nα)**B11**	Li8, Be10, Be11	4	0		
N15(n,γ)N16	N16	5	4	•	
N15(n,p)C15	C15	5	2	•	
N15(n,d)C14	Be10, Be11, C14	5	0		
N15(n,t)**C13**	Be7, Be10	4	0		
N15(n,dα)Be10	Be10	5	0		
O16(n,2n)O15	H3, Be7, Be10, C14, C15, N13, O15	5	3	•	
O16(n,nα)**C12**	H3, Be7, Be10, C11	5	1	•	
O16(n,2nα)C11	Be10, C11	5	0		
O16(n,2n2α)Be7	Be7	5	0		
O16(n,nt)N13	Be7, Be10, C11, N13	5	0		
O16(n,p)N16	N16	5	6	•	•
O16(n,d)**N15**	H3, Be10, C14, C15, N13	5	2	•	
O16(n,t)**N14**	H3, Be7, Be10, C11, C14, N13	5	5_2	•	•
O16(n,h)C14	H3, Be7, Be10, C11, C14	5	0		
O16(n,α)**C13**	H3, Be7, Be10, C11	5	4	•	
O16(n,2p)C15	Be10, C15	5	0		
O16(n,dα)**B11**	Be10	4	0		
O16(n,hα)Be10	Be10	5	0		
O17(n,α)C14	H3, Be10, C14, C15, N16	5	4	•	
O17(n,2α)Be10	Be10	5	0		
O18(n,nα)C14	Be10, C14	5	0		
O18(n,γ)O19	O19, F18, F20, Na24	5	4	•	
O18(n,t)N16	N16	4	0		
O18(n,α)C15	C15	4	2	•	
F19(n,2n)F18	H3, Be7, Be10, C14, N16, F18	5	6	•	•
F19(n,nα)**N15**	H3, Be7, Be10, C14	5	0		
F19(n,γ)F20	O19, F20, Na24	5	4	•	
F19(n,p)O19	O19	5	6	•	•
F19(n,α)N16	Be7, Be10, N16	5	4	•	
F19(n,2α)B12	Be7, Be10	4	0		
F19(n,d2α)Be10	Be10	5	0		
F19(n,dα)C14	H3, Be7, Be10, C14	5	0		
F19(n,tα)**C13**	H3, Be7, Be10	4	0		
F19(n,ntα)**C12**	Be7, Be10	4	0		
Ne20(n,2n)Ne19	H3, Be10, C14, O19, F18, Ne19	5	0		
Ne20(n,n2α)**C12**	H3, Be7, Be10	5	0		
Ne20(n,γ)**Ne21**	O19, F20, F21, Na24	5	3	•	
Ne20(n,p)F20	F20	5	0		
Ne20(n,d)**F19**	H3, Be7, Be10, C14, O19, F18	5	0		
Ne20(n,t)F18	H3, Be7, Be10, C14, F18	5	5_0		•
Ne20(n,α)**O17**	H3, Be7, Be10, C14	5	4	•	
Ne20(n,2α)**C13**	H3, Be7, Be10	5	0		
Ne20(n,2p)O19	C14, O19, F18	5	0		
Ne20(n,dα)**N15**	H3, Be7, Be10, C14	5	0		
Ne20(n,hα)C14	Be10, C14	4	0		
Ne21(n,γ)**Ne22**	Na24	5	3	•	
Ne21(n,p)F21	F21	5	0		
Ne21(n,d)F20	F20	4	0		
Ne21(n,α)**O18**	Be10, C14, O19, F20	5	2	•	
Ne21(n,2α)C14	Be10, C14	5	0		
Ne22(n,2n)**Ne21**	H3, Be10, C14, O19, F20, F21	5	0		
Ne22(n,n2α)C14	Be10, C14	4	0		
Ne22(n,γ)Ne23	Ne23, Na22, Na24	5	3	•	
Ne22(n,d)F21	C14, O19, F20, F21	5	0		
Ne22(n,t)F20	F18, F20, Ne19	4	0		
Ne22(n,α)O19	H3, O19, F18	5	0		
Na23(n,2n)Na22	H3, Be10, C14, F20, Na22	5	6	•	•
Na23(n,nα)**F19**	H3, Be10, C14	4	4	•	
Na23(n,n2α)**N15**	H3, Be10, C14	5	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Na23(n,γ)Na24m	Ne23, Na24	5	2	•	
Na23(n,γ)Na24	Ne23, Na24	5	2	•	
Na23(n,p)Ne23	Ne23	5	6*	•	•
Na23(n,d)**Ne22**	H3, Be10, C14, F20, Ne23	4	0		
Na23(n,t)**Ne21**	H3, Be10, C14, F20	4	5_2*	•	•
Na23(n,α)F20	Be10, C14, F20	5	4	•	
Na23(n,d2α)C14	Be10, C14	5	0		
Mg24(n,nα)**Ne20**	H3, Be10, C14	5	0		
Mg24(n,n2α)**O16**	H3, Be10, C14	4	0		
Mg24(n,2n2α)O15	Be10, C14	4	0		
Mg24(n,γ)**Mg25**	Ne23, Na24	4	0		
Mg24(n,p)Na24	Na24	5	0		
Mg24(n,p)Na24m	Na24	4	0		
Mg24(n,d)**Na23**	H3, Be10, C14, Na22	5	0		
Mg24(n,t)Na22	H3, Be10, C14, Na22	5	5_0		•
Mg24(n,α)**Ne21**	H3, Be10, C14	5	0		
Mg24(n,2α)**O17**	H3, Be10, C14	5	0		
Mg24(n,dα)**F19**	H3, Be10, C14	4	0		
Mg25(n,nα)**Ne21**	H3, Be10, C14	4	0		
Mg25(n,p)Na25	Na25	5	6	•	•
Mg25(n,d)Na24	Be10, C14, Na22, Na24	4	0		
Mg25(n,α)**Ne22**	Be10, C14, Ne23, Na24	5	2	•	
Mg26(n,n3α)C14	Be10, C14	4	0		
Mg26(n,γ)Mg27	Mg27, Al26, Si31, Si32, P32	5	4	•	
Mg26(n,d)Na25	H3, Be10, C14, Na24, Na25	5	0		
Mg26(n,t)Na24	Na22, Na24	4	0		
Mg26(n,α)Ne23	H3, Be10, Na22	4	6*	•	•
Al26(n,nα)Na22	Be10, C14, Na22	4	0		
Al27(n,2n)Al26	H3, Be10, C14, Na22, Na24, Al26	5	4/3	•	
Al27(n,nα)**Na23**	H3, Be10, C14, Na22	5	2	•	
Al27(n,n3α)**N15**	Be10, C14	5	0		
Al27(n,2nα)Na22	Be10, C14, Na22	5	5_3		•
Al27(n,n2α)**F19**	Be10, C14	4	0		
Al27(n,γ)Al28	Al28, Si31, Si32, P32	5	4	•	
Al27(n,p)Mg27	Mg27	5	6	•	•
Al27(n,t)**Mg25**	H3, Be10, C14, Na22, Na24	4	6	•	•
Al27(n,α)Na24	Be10, C14, Na22, Na24	5	2	•	
Al27(n,α)Na24m	Be10, C14, Na22, Na24	4	2	•	
Al27(n,dα)**Ne22**	H3, Be10, C14	4	0		
Si28(n,nα)**Mg24**	H3, Be10, C14, Na22, Na24	5	0		
Si28(n,n3α)**O16**	Be10, C14	4	0		
Si28(n,γ)**Si29**	Al29, Si31, Si32, P32	5	4	•	
Si28(n,p)Al28	Al28	5	6	•	•
Si28(n,d)**Al27**	H3, Be10, C14, Na22, Na24, Al26	5	1	•	
Si28(n,t)Al26	H3, Be10, C14, Na22, Na24, Al26	5	0		
Si28(n,α)**Mg25**	H3, Be10, C14, Na22, Na24	4	2	•	
Si28(n,2α)**Ne21**	Be10, C14	5	0		
Si28(n,pα)Na24	Be10, C14, Na22, Na24	5	0		
Si28(n,pα)Na24m	Be10, C14, Na22, Na24	4	0		
Si28(n,tα)Na22	Be10, C14, Na22	5	0		
Si29(n,γ)**Si30**	Si31, Si32, P32, Cl36	5	2	•	
Si29(n,p)Al29	Al29	5	6	•	•
Si29(n,d)Al28	C14, Na22, Na24, Al26, Al28	4	0		
Si29(n,α)**Mg26**	C14, Na22, Na24	4	3	•	
Si29(n,dα)Na24	Na22, Na24	4	0		
Si30(n,γ)Si31	Si31, Si32, P32, Cl36	5	4	•	
Si30(n,d)Al29	C14, Na22, Na24, Al28, Al29	5	0		
Si30(n,t)Al28	Na22, Na24, Al26, Al28	4	0		
Si30(n,α)Mg27	H3, Be10, C14, Na22, Na24, Al26	4	6	•	•
Si31(n,γ)Si32	Si32	5	2	•	

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
P31(n,2n)P30	H3, C14, Na24, Al26, Al28, Al29, P30	5	4	•	
P31(n,nα)**Al27**	H3, Be10, C14, Na22, Na24, Al26	5	0		
P31(n,2nα)Al26	Be10, C14, Na22, Na24, Al26	5	0		
P31(n,n2α)**Na23**	Be10, C14, Na22	4	0		
P31(n,2n2α)Na22	Be10, C14, Na22	4	0		
P31(n,γ)P32	Si31, Si32, P32, S35, Cl36	5	4	•	
P31(n,p)Si31	Si31, Si32	5	6	•	•
P31(n,d)**Si30**	H3, Be10, C14, Na22, Na24, Al26, Al28, Al29	4	0		
P31(n,t)**Si29**	H3, Be10, C14, Na22, Na24, Al26, Al28, Al29	4	5_3		•
P31(n,α)Al28	H3, Be10, C14, Na22, Na24, Al26, Al28	5	6	•	•
P31(n,2α)Na24	Be10, C14, Na22, Na24	5	0		
P31(n,2α)Na24m	Be10, C14, Na22, Na24	4	0		
P31(n,dα)**Mg26**	H3, Be10, C14, Na22, Na24	4	0		
P32(n,p)Si32	Si32	5	0		
P33(n,γ)P34	S35, Cl36	4	0		
S32(n,nα)**Si28**	H3, C14, Na22, Na24, Al26, Al28	5	0		
S32(n,n2α)**Mg24**	C14, Na22, Na24	4	0		
S32(n,γ)**S33**	H3, Si31, Si32, P32, P33, S35, Cl36	5	4	•	
S32(n,p)P32	H3, Al29, Si31, Si32, P32	5	6	•	•
S32(n,d)**P31**	H3, C14, Na22, Na24, Al26, Al28, Al29, Si31, P30	5	0		
S32(n,t)P30	H3, C14, Na22, Na24, Al26, Al28, Al29, P30	5	5_2	•	•
S32(n,h)**Si30**	H3, C14, Na22, Na24, Al26, Al28, Al29	5	0		
S32(n,α)**Si29**	H3, C14, Na22, Na24, Al26, Al28, Al29, Si31, Si32, P32	5	4	•	
S32(n,2α)**Mg25**	C14, Na22, Na24	4	0		
S32(n,2p)Si31	H3, Na22, Na24, Al26, Al28, Al29, Si31, P30	5	0		
S32(n,pα)Al28	C14, Na22, Na24, Al26, Al28	5	0		
S32(n,dα)**Al27**	H3, C14, Na22, Na24, Al26	4	0		
S32(n,tα)Al26	C14, Na22, Na24, Al26	5	0		
S32(n,ph)Al29	Na24, Al28, Al29	4	0		
S33(n,γ)**S34**	S35, Cl36	5	2	•	
S33(n,p)P33	Si32, P33	5	2	•	
S33(n,d)P32	Na22, Al26, Si32, P32	4	0		
S33(n,α)**Si30**	Na22, Na24, Al26, Al28, Al29, Si31, Si32, P32	5	4	•	
S33(n,2p)Si32	Si32	4	0		
S34(n,nα)**Si30**	Na22, Na24, Al26, Al28, Al29	4	0		
S34(n,γ)S35	H3, Si32, P32, P33, S35, S37, Cl36, Cl38, Ar39	5	4	•	
S34(n,d)P33	H3, Na22, Al26, Al29, Si31, Si32, P32, P33	5	0		
S34(n,t)P32	Na22, Al26, Si31, P30, P32	4	0		
S34(n,h)Si32	Si31, Si32	5	0		
S34(n,α)Si31	H3, Na22, Na24, Al26, Al28, Si31, P30	4	6	•	•
S35(n,γ)**S36**	S37	5	0		
S35(n,α)Si32	Si32	5	0		
S36(n,2n)S35	Na22, Al26, Si32, P32, P33, S35, Cl36	5	0		
S36(n,nα)Si32	Si32, P32	4	0		
S36(n,γ)S37	S37, Cl36, Cl38, Ar39	5	2	•	
S36(n,d)P35	P32, S35	4	0		
S36(n,α)Si33	P32, P33	4	0		
Cl35(n,2n)Cl34m	Si32, P32, P33, Cl34m	5	5_2*	•	•
Cl35(n,nα)**P31**	H3, Na22, Na24, Al26	5	0		
Cl35(n,n2α)**Al27**	Na22, Na24, Al26	5	0		
Cl35(n,2n2α)Al26	Na22, Na24, Al26	5	0		
Cl35(n,γ)Cl36	H3, P33, S37, Cl36, Cl38, Ar39, Ar41, K42	5	4	•	
Cl35(n,p)S35	Si32, S35, S37	5	4	•	
Cl35(n,d)**S34**	H3, Na22, Na24, Al26, Si32, P32, P33	4	0		
Cl35(n,t)**S33**	H3, Na22, Na24, Al26, Si32, P32, P33	4	5_3		•
Cl35(n,h)P33	H3, Na22, Na24, Al26, Si32, P32, P33	5	0		
Cl35(n,α)P32	H3, Na22, Na24, Al26, Si32, P32	5	4	•	
Cl35(n,tα)**Si29**	H3, Na22, Na24, Al26	4	0		
Cl35(n,ph)Si32	Si32	4	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Cl36(n,nα)P32	Na22, Al26, Si32, P32	4	0		
Cl36(n,γ)**Cl37**	Cl38, Ar39, Ar41, K42	5	2	•	
Cl36(n,p)**S36**	Si32, P33, S35, S37	5	2	•	
Cl36(n,α)P33	Na22, Al26, Si32, P32, P33, S35	5	0		
Cl37(n,2n)Cl36	H3, Al26, Si32, P32, P33, S35, Cl34m, Cl36	5	0		
Cl37(n,nα)P33	H3, Na24, Al26, Si32, P32, P33	5	0		
Cl37(n,2nα)P32	Na22, Na24, Al26, P32	4	0		
Cl37(n,γ)Cl38	S37, Cl38, Ar39, Ar41, K40, K42	5	4	•	
Cl37(n,γ)Cl38m	S37, Cl38, Ar39, Ar41, K40, K42	5	2	•	
Cl37(n,p)S37	S37	5	6*	•	•
Cl37(n,d)**S36**	H3, Si32, P33, S35	4	0		
Cl37(n,t)S35	H3, Na22, Al26, Si32, P32, P33, S35, Cl34m	5	0		
Cl37(n,dα)Si32	Si32	5	0		
Ar36(n,nα)**S32**	Na22, Al26, P32	4	0		
Ar36(n,n2α)**Si28**	Na22, Al26	4	0		
Ar36(n,γ)Ar37	H3, P32, P33, S35, S37, Cl36, Cl38, Ar37, Ar39	5	2	•	
Ar36(n,p)Cl36	H3, Al26, P32, P33, S35, S37, Cl36	5	2	•	
Ar36(n,d)**Cl35**	H3, Na22, Al26, P32, P33, S35	4	0		
Ar36(n,2α)**Si29**	Na22, Al26	4	0		
Ar36(n,pα)P32	Na22, Al26, P32	5	0		
Ar36(n,dα)**P31**	Na22, Al26	4	0		
Ar37(n,α)**S34**	Al26, P32, P33, S35, S37, Cl36	5	2	•	
Ar37(n,2α)**Si30**	Al26	4	0		
Ar38(n,2n)Ar37	Al26, P32, P33, S35, S37, Cl36, Ar37	5	0		
Ar38(n,nα)**S34**	Na22, Al26, P32, P33	4	0		
Ar38(n,γ)Ar39	S37, Ar39, Ar41, K40, K42	5	2	•	
Ar38(n,p)Cl38m	Cl38	4	0		
Ar38(n,p)Cl38	Cl38	4	0		
Ar38(n,t)Cl36	Al26, P32, P33, S35, Cl36	5	0		
Ar38(n,α)S35	Na22, Al26, P32, S35	4	0		
Ar38(n,2p)S37	S37	4	0		
Ar38(n,dα)P33	Al26, P32, P33	4	0		
Ar38(n,tα)P32	Na22, Al26, P32	4	0		
Ar39(n,2n)**Ar38**	Na22, Al26, P32, P33, S35, S37, Cl36, Cl38, Ar37	5	0		
Ar39(n,3n)Ar37	P32, P33, S37, Cl36, Ar37	4	0		
Ar39(n,nα)S35	Na22, Al26, P32, P33, S35	5	0		
Ar39(n,γ)**Ar40**	Ar41, K42	5	2	•	
Ar39(n,p)Cl39	Cl39	5	0		
Ar39(n,d)Cl38	P33, Cl36, Cl38, Ar37	4	0		
Ar39(n,d)Cl38m	Cl36, Cl38, Ar37	4	0		
Ar39(n,α)**S36**	P32, P33, S35, S37	5	0		
Ar40(n,2n)Ar39	H3, Na22, Al26, P32, P33, S35, S37, Cl36, Cl38, Cl39, Ar37, Ar39	5	0		
Ar40(n,3n)**Ar38**	H3, Na22, Al26, P32, P33, S35, S37, Cl36, Cl38, Ar37	5	0		
Ar40(n,nα)**S36**	H3, Na22, Al26, P32, P33, S35	4	0		
Ar40(n,2nα)S35	H3, Na22, Al26, P32, P33, S35	5	0		
Ar40(n,3nα)**S34**	H3, Na22, Al26, P32, P33	4	0		
Ar40(n,4n)Ar37	H3, Na22, Al26, P32, P33, S35, S37, Cl36, Ar37	5	0		
Ar40(n,γ)Ar41	Ar41, Ar42, K42, Sc46	5	4	•	
Ar40(n,p)Cl40	Cl40	5	2	•	
Ar40(n,d)Cl39	H3, Al26, P32, P33, S35, S37, Cl36, Cl38, Cl39, Ar37, Ar39	5	0		
Ar40(n,t)Cl38	H3, Al26, P32, P33, S35, S37, Cl36, Cl38, Ar37	5	0		
Ar40(n,t)Cl38m	Al26, P32, P33, S35, S37, Cl36, Cl38, Ar37	4	0		
Ar40(n,α)S37	H3, P32, P33, S35, S37, Cl36	5	4	•	
Ar40(n,2nt)Cl36	H3, Na22, Al26, P32, P33, S35, Cl36	5	0		
Ar40(n,ntα)P33	Na22, Al26, P32, P33	4	0		
Ar41(n,γ)Ar42	Ar42	5	2	•	
K39(n,2n)K38	H3, Na22, Al26, P32, P33, S35, S37, Cl36, Cl38,	5	5/4	•	•

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
	Ar37, K38				
K39(n,nα)**Cl35**	H3, Na22, Al26, P32, P33, S35	4	4	•	
K39(n,n2α)**P31**	Na22, Al26	5	0		
K39(n,γ)K40	H3, Cl38, Ar39, Ar41, Ar42, K40, K42, Ca45, Sc46	5	4	•	
K39(n,p)Ar39	H3, Na22, Al26, P32, P33, S35, S37, Cl36, Cl38, Cl39, Ar37, Ar39	5	2	•	
K39(n,d)Ar38	H3, Na22, Al26, P32, P33, S35, S37, Cl36, Cl38, Ar37	5	0		
K39(n,t)Ar37	H3, Na22, Al26, P32, P33, S35, S37, Cl36, Ar37	5	2	•	
K39(n,α)Cl36	H3, Na22, Al26, P32, P33, S35, Cl36, Cl38, Ar37, Ar39	5	4	•	
K39(n,2α)P32	Na22, Al26, P32	5	5_1	•	•
K39(n,2p)Cl38m	Cl36, Cl38, Ar37	4	0		
K39(n,2p)Cl38	P33, Cl36, Cl38, Ar37	5	0		
K39(n,pα)S35	H3, Na22, Al26, P32, P33, S35	5	0		
K39(n,dα)**S34**	H3, Na22, Al26, P32, P33	4	0		
K40(n,nα)Cl36	H3, P32, P33, Cl36	4	0		
K40(n,γ)**K41**	K42, Ca45, Sc46	4	2	•	
K40(n,p)Ar40	S37, Cl39, Ar41, Ar42	5	2	•	
K40(n,α)**Cl37**	P32, S37, Cl36, Cl38, Ar39	5	2	•	
K41(n,2n)K40	H3, P33, S35, Cl36, Cl38, Cl39, Ar39, K38, K40	5	0		
K41(n,nα)**Cl37**	P32, P33, S35, Cl36	4	0		
K41(n,2nα)Cl36	Al26, P32, P33, S35, Cl36	5	0		
K41(n,γ)K42	Ar42, K42, K43, Ca45, Sc46	5	6*	•	•
K41(n,p)Ar41	Ar41, Ar42	5	6*	•	•
K41(n,d)Ar40	S35, Cl38, Cl39, Ar39	4	0		
K41(n,t)Ar39	H3, P33, S35, Cl38, Cl39, Ar37, Ar39	4	0		
K41(n,h)Cl39	Cl39, Ar39	5	5_1	•	•
K42(n,γ)K43	K43, Ca45, Sc46	5	0		
K42(n,p)Ar42	Ar42	5	0		
Ca40(n,2n)Cα39	H3, Al26, P32, S37, Cl36, Cl38, Ar37, Ar39, K38, Ca39	5	4	•	
Ca40(n,n3α)**Si28**	Al26	4	0		
Ca40(n,n2α)**S32**	Al26, P32	4	0		
Ca40(n,γ)Ca41	H3, S37, Ar39, K40, K42, K43, Ca41	5	4	•	
Ca40(n,p)K40	H3, P32, S37, Cl36, Cl38, Ar37, Ar39, K38, K40	5	2	•	
Ca40(n,d)**K39**	H3, Al26, P32, S37, Cl36, Cl38, Ar37, Ar39, K38	5	0		
Ca40(n,t)K38	H3, Al26, P32, S37, Cl36, Cl38, Ar37, K38	5	5_1	•	•
Ca40(n,h)Ar38	H3, Al26, P32, S37, Cl36, Cl38, Ar37	4	5_3		•
Ca40(n,α)Ar37	H3, Al26, P32, S37, Cl36, Cl38, Ar37, Ar39, K40	5	4	•	
Ca40(n,2α)**S33**	H3, Al26, P32	4	0		
Ca40(n,2p)Ar39	H3, Al26, P32, S37, Cl36, Cl38, Ar37, Ar39	5	0		
Ca40(n,pα)Cl36	H3, Al26, P32, Cl36	5	0		
Ca40(n,3p)Cl38	Cl38	4	0		
Ca40(n,3p)Cl38m	Cl38	4	0		
Ca41(n,p)**K41**	K40, K42, K43	5	2	•	
Ca41(n,α)Ar38	S37, Cl36, Ar39, K40	5	2	•	
Ca41(n,dα)Cl36	Cl36	4	0		
Ca42(n,2n)Ca41	H3, Cl36, Ar39, K40, Ca41	5	0		
Ca42(n,γ)**Ca43**	Ca45, Sc46	5	4	•	
Ca42(n,p)K42	K42	5	5_3*		•
Ca42(n,t)K40	Cl36, Ar39, K40	4	0		
Ca42(n,α)Ar39	Cl36, Cl38, Ar39	5	0		
Ca43(n,2n)**Ca42**	Cl36, Ar39, K40, K42, Ca41	4	0		
Ca43(n,3n)Ca41	Cl36, Ar39, K40, Ca41	5	0		
Ca43(n,nα)Ar39	Cl36, Ar39	5	0		
Ca43(n,γ)**Ca44**	Ca45, Ca47, Sc46	5	2	•	
Ca43(n,p)K43	K43	5	2	•	

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Ca43(n,d)K42	Cl36, Ar39, K40, K42, Ca41	4	0		
Ca44(n,2n)**Ca43**	H3, Cl36, Ar39, Ar42, K40, K42, K43, Ca41	5	0		
Ca44(n,4n)Ca41	Cl36, Ca41	5	0		
Ca44(n,γ)Ca45	H3, Ca45, Ca47, Ca48, Sc46, Sc47, Sc48	5	2	•	
Ca44(n,d)K43	Cl36, Ar39, Ar42, K40, K42, K43, Ca41	5	0		
Ca44(n,t)K42	Cl36, K40, K42, Ca41	5	5_0		•
Ca44(n,h)Ar42	Ar42, K42	4	0		
Ca44(n,α)Ar41	Cl36, Cl38, Ar39, K40	5	4	•	
Ca45(n,γ)**Ca46**	Ca47, Ca48, Sc47, Sc48	5	2	•	
Ca45(n,α)Ar42	Ar39, Ar42, K40, K42, Ca41	5	0		
Ca46(n,2n)Ca45	Ar39, Ar42, K42, Ca41, Ca45, Sc44	5	0		
Ca46(n,nα)Ar42	Ar42	4	0		
Ca46(n,γ)Ca47	Ca47, Ca48, Sc47, Sc48	5	2	•	
Ca47(n,γ)Ca48	Ca48	5	0		
Ca48(n,2n)Ca47	Ca45, Ca47, Sc46	5	6	•	•
Ca48(n,3n)**Ca46**	K43, Ca45	5	0		
Ca48(n,4n)Ca45	Ca45	5	0		
Ca48(n,γ)Ca49	Ca49	5	4	•	
Ca48(n,d)K47	Ca47, Sc46	4	0		
Sc45(n,n')Sc45m	Sc45m	5	0		
Sc45(n,2n)Sc44	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Sc44	5	5_2	•	•
Sc45(n,2n)Sc44m	Cl36, Ar39, Ar42, K40, K42, Ca41, Sc44, Sc44m	5	6*	•	•
Sc45(n,nα)**K41**	H3, Cl36, Ar39, K40	5	0		
Sc45(n,2nα)K40	H3, Cl36, Ar39, K40	5	0		
Sc45(n,2n2α)Cl36	Cl36	5	0		
Sc45(n,γ)Sc46	H3, Ca48, Sc46, Sc47, Sc48	5	3	•	
Sc45(n,γ)Sc46m	H3, Ca48, Sc46, Sc47, Sc48	4	3	•	
Sc45(n,p)Ca45	Ar42, Ca45, Ca48, Sc45m	5	4	•	
Sc45(n,d)**Ca44**	H3, Cl36, Ar39, Ar42, K40, K42, Ca41	4	0		
Sc45(n,t)**Ca43**	H3, Cl36, Ar39, Ar42, K40, K42, Ca41	5	0		
Sc45(n,α)K42	H3, Cl36, Ar39, Ar42, K40, K42, Ca41	5	6*	•	•
Sc45(n,2nt)Ca41	Cl36, Ar39, K40, Ca41	5	0		
Sc45(n,tα)Ar39	H3, Cl36, Ar39	5	0		
Sc45(n,ph)Ar42	Ar42	5	0		
Sc46(n,γ)Sc47	Ca48, Sc47, Sc48	5	2	•	
Sc46(n,p)**Ca46**	Ar42, Ca48	5	0		
Sc47(n,γ)Sc48	Sc48	4	0		
Sc48(n,p)Ca48	Ca48	5	0		
Ti46(n,nα)**Ca42**	Cl36, Ar39, K40, K42, Ca41	5	0		
Ti46(n,2nα)Ca41	Cl36, Ar39, K40, Ca41	5	0		
Ti46(n,p)Sc46	H3, Ar42, K42, Sc44, Sc46	5	6	•	•
Ti46(n,d)**Sc45**	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44	4	0		
Ti46(n,t)Sc44	Cl36, Ar39, Ar42, K40, K42, Ca41, Sc44	4	5/5	•	•
Ti46(n,α)**Ca43**	H3, Cl36, Ar39, Ar42, K40, K42, Ca41	5	0		
Ti46(n,2α)Ar39	Cl36, Ar39	5	0		
Ti46(n,pα)K42	Cl36, Ar39, K40, K42, Ca41	4	0		
Ti46(n,tα)K40	Cl36, Ar39, K40	5	0		
Ti47(n,2n)**Ti46**	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44, Sc46	4	0		
Ti47(n,nα)**Ca43**	Cl36, Ar39, Ar42, K40, K42, Ca41	5	0		
Ti47(n,3nα)Ca41	Cl36, Ar39, K40, Ca41	4	0		
Ti47(n,p)Sc47	Sc47	4	6	•	•
Ti47(n,d)Sc46	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44, Sc46	5	0		
Ti47(n,α)**Ca44**	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Ca48, Sc46, Sc47, Sc48	5	0		
Ti48(n,2n)**Ti47**	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44, Sc46, Sc47	4	4	•	
Ti48(n,2n2α)Ar39	Cl36, Ar39	4	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Ti48(n,γ)**Ti49**	Ti51, V52, Mn56	4	4	•	
Ti48(n,p)Sc48	H3, Ca48, Sc48	5	6	•	•
Ti48(n,d)Sc47	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44, Sc46, Sc47	5	5_0*	•	•
Ti48(n,t)Sc46	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44, Sc46	5	5/5	•	•
Ti48(n,α)Ca45	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44	5	4	•	
Ti48(n,tα)K42	Cl36, Ar39, K40, K42, Ca41	4	0		
Ti49(n,2n)**Ti48**	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Ca48, Sc44, Sc46, Sc47, Sc48	4	0		
Ti49(n,nα)Ca45	Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44	5	0		
Ti49(n,γ)**Ti50**	Ti51, V52, Mn56	4	4	•	
Ti49(n,d)Sc48	Ar39, Ar42, K42, Ca45, Ca48, Sc44, Sc46, Sc47, Sc48	4	0		
Ti49(n,h)Ca47	Ca47, Sc47	4	0		
Ti49(n,2α)Ar42	Ar42	4	0		
Ti49(n,2p)Ca48	Ca48	4	0		
Ti50(n,nα)**Ca46**	Cl36, Ar39, Ar42, K42, Ca45, Sc44	4	0		
Ti50(n,n2α)Ar42	Ar42	4	0		
Ti50(n,γ)Ti51	Ti51, V52, Mn56	5	4	•	
Ti50(n,t)Sc48	Sc48	4	0		
Ti50(n,h)Ca48	Ar42, Ca48	5	0		
Ti50(n,α)Ca47	Ar39, Ca41, Ca47, Sc46, Sc47	5	5_2	•	•
V49(n,2n)V48	Ar39, Ar42, K42, Ca45, Sc44, Sc46, Sc47, V48	5	0		
V49(n,α)Sc46	Ar39, Ar42, K40, K42, Ca41, Sc44, Sc46	5	0		
V49(n,α)Sc46m	Ar39, K42, Ca41, Sc44, Sc46	4	0		
V50(n,2n)V49	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Ca47, Ca48, Sc44, Sc46, Sc47, Sc48, V48, V49	5	1	•	
V50(n,3n)V48	Cl36, Ar39, Ar42, K42, Ca41, Ca45, Ca47, Sc44, Sc46, Sc47, Sc48, V48	5	0		
V50(n,nα)Sc46	Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45,	5	0		
V50(n,p)**Ti50**	Ar42, Ca45, Ca47, Ca48, Sc47, Ti51	5	2	•	
V50(n,α)Sc47	Cl36, Ar39, K40, K42, Ca41, Sc44, Sc46, Sc47	5	2	•	
V50(n,dα)Ca45	Cl36, Ar39, Ar42, K40, K42, Ca45, Sc44	4	0		
V51(n,2n)V50	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Ca47, Ca48, Sc44, Sc46, Sc47, Sc48, V48, V49, V50	5	4	•	
V51(n,3n)V49	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Ca47, Ca48, Sc44, Sc46, Sc47, Sc48, V48, V49	5	0		
V51(n,nα)Sc47	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44, Sc46, Sc47	5	6	•	•
V51(n,2nα)Sc46	Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44, Sc46	5	5_3		•
V51(n,3nα)**Sc45**	Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44	4	0		
V51(n,4n)V48	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44, Sc46, Sc47, Sc48, V48	5	5_3		•
V51(n,γ)V52	V52, Mn56, Fe59, Fe60	5	6	•	•
V51(n,p)Ti51	Ti51	5	6	•	•
V51(n,d)**Ti50**	H3, Ar39, Ar42, K40, K42, Ca41, Ca45, Ca47, Ca48, Sc44, Sc46, Sc47, Sc48	4	2	•	
V51(n,t)**Ti49**	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Ca47, Ca48, Sc44, Sc46, Sc47, Sc48	4	6	•	•
V51(n,α)Sc48	Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Ca48, Sc44, Sc46, Sc47, Sc48	5	6	•	•
V51(n,dα)**Ca46**	Cl36, Ar39, Ar42, K42, Ca45	4	0		
V51(n,tα)Ca45	Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44	5	0		
Cr50(n,nα)**Ti46**	Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44, Sc46	5	0		
Cr50(n,γ)Cr51	H3, V52, Cr51	5	4	•	
Cr50(n,p)V50	H3, Ar42, Ca45, Sc46, Sc47, V48, V49, V50	4	4	•	
Cr50(n,d)V49	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45,	5	2	•	

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
	Sc44, Sc46, Sc47, V48, V49				
Cr50(n,t)V48	Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44, Sc46, Sc47, V48	4	5_2	•	•
Cr50(n,α)**Ti47**	Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44, Sc46, Sc47	5	2	•	
Cr50(n,pα)Sc46	Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44, Sc46	4	5_3		•
Cr52(n,2n)Cr51	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Ca47, Ca48, Sc44, Sc46, Sc47, Sc48, V48, V49, V50, Cr50, Cr51	5	6	•	•
Cr52(n,3n)Cr50	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44, Sc46, Sc47, V48, V49, V50, Cr50	4	0		
Cr52(n,nα)**Ti48**	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Ca47, Sc44, Sc46, Sc47	4	1	•	
Cr52(n,3nα)**Ti46**	Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44, Sc46	4	0		
Cr52(n,nt)V49	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Ca47, Ca48, Sc44, Sc46, Sc47, Sc48, V48, V49	5	0		
Cr52(n,γ)**Cr53**	Cr55, Mn56, Fe59, Fe60, Co60	5	4	•	
Cr52(n,p)V52	V52	5	6	•	•
Cr52(n,d)**V51**	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Ca47, Ca48, Sc44, Sc46, Sc47, Sc48, V48, V49, V50	4	2	•	
Cr52(n,t)V50	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44, Sc46, Sc47, Sc48, V48, V49, V50	5	5_3		•
Cr52(n,α)**Ti49**	H3, Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Ca47, Ca48, Sc44, Sc46, Sc47, Sc48	4	2	•	
Cr52(n,2α)Ca45	Cl36, Ar39, Ar42, K40, K42, Ca45, Sc44	4	0		
Cr52(n,dα)Sc47	Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44, Sc46, Sc47	4	5_3		•
Cr52(n,tα)Sc46	Cl36, Ar39, Ar42, K40, K42, Ca41, Ca45, Sc44, Sc46	4	0		
Cr53(n,γ)**Cr54**	Cr55, Mn56, Fe59, Fe60, Co60	5	4	•	
Cr53(n,d)V52	V52, Cr51	4	0		
Cr53(n,α)**Ti50**	Ar39, Ar42, Ca45, Ca47, Ca48, Sc44, Sc46, Sc47, Sc48	5	2	•	
Cr54(n,2n)**Cr53**	H3, Ar42, Ca45, Ca47, Ca48, Sc46, Sc48, V52, Cr51	5	0		
Cr54(n,nα)**Ti50**	Ar39, Ar42, K42, Ca45, Ca47, Ca48, Sc44, Sc46, Sc48	4	0		
Cr54(n,γ)Cr55	Cr55, Mn53, Mn56, Fe59, Fe60, Co60	5	4	•	
Cr54(n,t)V52	Ar39, V52	4	0		
Mn53(n,nα)V49	Cl36, Ar39, Ar42, K42, Ca45, Ca47, Ca48, Sc44, Sc46, Sc48	4	0		
Mn54(n,2n)Mn53	Cl36, Ar39, Ar42, K42, Ca45, Ca47, Ca48, Sc44, Sc46, Sc48, Mn53	5	0		
Mn54(n,α)**V51**	Ar39, Ar42, K42, Ca45, Ca47, Ca48, Sc44, Sc46, Sc48	4	0		
Mn55(n,2n)Mn54	H3, Cl36, Ar39, Ar42, K42, Ca45, Ca47, C a48, Sc44, Sc46, Sc48, V52, Mn53, Mn54	5	6	•	•
Mn55(n,3n)Mn53	H3, Cl36, Ar39, Ar42, K42, Ca45, Ca47, Ca48, Sc44, Sc46, Sc48, V52, Mn53	5	0		
Mn55(n,nα)**V51**	Cl36, Ar39, Ar42, K42, Ca45, Ca47, Ca48, Sc44, Sc46, Sc48	4	0		
Mn55(n,2nα)V50	H3, Cl36, Ar39, Ar42, K42, Ca45, Ca47, C a48, Sc44, Sc46, Sc48	4	0		
Mn55(n,3nα)V49	Cl36, Ar39, Ar42, K42, Ca45, Ca47, Ca48, Sc44, Sc46, Sc48	4	0		
Mn55(n,γ)Mn56	Cr55, Mn56, Fe59, Fe60, Co60, Ni63	5	6	•	•
Mn55(n,p)Cr55	Cr55	5	6	•	•
Mn55(n,t)**Cr53**	H3, Cl36, Ar39, Ar42, K42, Ca45, Ca47, C a48, Sc44, Sc46, Sc48, V52	4	6	•	•
Mn55(n,α)V52	Cl36, Ar39, Ar42, K42, Ca45, Ca47, Ca48, Sc44,	5	6	•	•

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
	Sc46, Sc48, V52				
Mn55(n,2α)Sc48	Cl36, Ar39, Ar42, K42, Ca45, Ca47, Sc44, Sc46, Sc48	4	5_3		•
Mn55(n,dα)**Ti50**	Cl36, Ar39, Ar42, K42, Ca45, Ca47, Ca48, Sc44, Sc46, Sc48	5	0		
Fe54(n,nα)Cr50	Ar39, Ar42, Sc44	5	1	•	
Fe54(n,γ)Fe55	H3, Mn56, Fe55	5	4	•	
Fe54(n,p)Mn54	H3, Ar42, Sc44, Mn53, Mn54	4	6	•	•
Fe54(n,d)Mn53	H3, Ar39, Ar42, Sc44, Mn53	5	2	•	
Fe54(n,dα)V49	Ar39, Ar42, Sc44	4	0		
Fe56(n,2n)Fe55	H3, Ar39, Ar42, Sc44, Mn53, Mn54, Fe55	5	4	•	
Fe56(n,nt)Mn53	H3, Ar39, Ar42, Sc44, Mn53	5	0		
Fe56(n,γ)**Fe57**	Cr55, Mn56, Fe59, Fe60, Co60, Ni63	5	4	•	
Fe56(n,p)Mn56	Mn56	5	6	•	•
Fe56(n,t)Mn54	H3, Ar39, Ar42, Sc44, Mn53, Mn54	5	6	•	•
Fe57(n,3n)Fe55	Mn53, Mn54, Fe55	4	0		
Fe57(n,γ)**Fe58**	Mn56, Fe59, Fe60, Co60, Ni63	5	4	•	
Fe57(n,α)**Cr54**	Cr55	5	2	•	
Fe58(n,γ)Fe59	Mn56, Fe59, Fe60, Co60, Ni63	5	6	•	•
Fe59(n,γ)Fe60	Fe60, Ni63	5	2	•	
Co57(n,2n)Co56	Mn53, Fe55, Co56	5	0		
Co57(n,nα)Mn53	Ar39, Sc44, Mn53	4	0		
Co58(n,2n)Co57	Mn53, Mn54, Fe55, Co56, Co57	5	0		
Co59(n,2n)Co58	H3, Ar39, Sc44, Mn53, Mn54, Fe55, Co57, Co58	4	5_2	•	•
Co59(n,2n)Co58m	H3, Ar39, Sc44, Mn53, Mn54, Fe55, Fe59, Co57, Co58	5	6*	•	•
Co59(n,3n)Co57	H3, Ar39, Sc44, Mn53, Mn54, Fe55, Co57	5	6	•	•
Co59(n,nα)**Mn55**	H3, Ar39, Sc44, Mn53, Mn54	5	0		
Co59(n,2nα)Mn54	H3, Ar39, Sc44, Mn53, Mn54	5	0		
Co59(n,3nα)Mn53	Ar39, Sc44, Mn53	5	0		
Co59(n,γ)Co60	Fe59, Fe60, Co60, Co60m, Ni59, Ni63	5	6	•	•
Co59(n,γ)Co60m	H3, Fe59, Fe60, Co60, Co60m, Ni59, Ni63	5	3*	•	
Co59(n,p)Fe59	Fe59, Fe60	5	6	•	•
Co59(n,t)**Fe57**	H3, Ar39, Sc44, Mn53, Mn54, Fe55	4	6	•	•
Co59(n,α)Mn56	Ar39, Sc44, Mn53, Mn54, Fe55	5	6	•	•
Co59(n,2nt)Fe55	Ar39, Sc44, Mn53, Mn54, Fe55	5	0		
Co60(n,γ)Co61	Fe59, Fe60, Ni63	5	2	•	
Co60(n,p)Fe60	Fe60	5	0		
Ni58(n,nα)**Fe54**	H3, Ar39, Mn53	5	2	•	
Ni58(n,γ)Ni59	H3, Fe60, Co60, Ni59, Ni63	5	2	•	
Ni58(n,p)Co58	H3, Fe60, Co56, Co57, Co58	5	6	•	•
Ni58(n,p)Co58m	H3, Fe60, Co56, Co57, Co58	5	4	•	
Ni58(n,d)Co57	H3, Ar39, Mn53, Fe55, Co56, Co57	5	6	•	•
Ni58(n,t)Co56	H3, Ar39, Mn53, Fe55, Co56	5	6	•	•
Ni58(n,α)Fe55	H3, Ar39, Mn53, Fe55	5	4	•	
Ni58(n,dα)Mn53	H3, Ar39, Mn53	5	0		
Ni59(n,p)**Co59**	Co60	5	4	•	
Ni59(n,α)**Fe56**	Fe60	5	4	•	
Ni60(n,2n)Ni59	H3, Mn53, Fe55, Co57, Co58, Ni59	5	2	•	
Ni60(n,2nα)Fe55	Mn53, Fe55	4	0		
Ni60(n,nt)Co57	Mn53, Fe55, Co57	4	0		
Ni60(n,p)Co60	H3, Fe60, Co58, Co60	4	6	•	•
Ni60(n,p)Co60m	H3, Fe60, Co58, Co60, Co60m	5	6	•	•
Ni60(n,t)Co58	H3, Mn53, Fe55, Co58	4	6	•	•
Ni60(n,t)Co58m	Fe55, Co58	4	0		
Ni61(n,2n)**Ni60**	Co58, Co60, Ni59	4	0		
Ni61(n,3n)Ni59	Mn53, Co58, Ni59	5	0		
Ni61(n,γ)**Ni62**	Ni63, Ni65, Cu64	5	2	•	
Ni61(n,α)**Fe58**	Fe59, Fe60, Co60	5	2	•	
Ni62(n,2n)**Ni61**	H3, Fe60, Co60, Ni59	4	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Ni62(n,γ)Ni63	Ni63, Ni65, Cu64	5	4	•	
Ni62(n,t)Co60	Mn53, Fe59, Fe60, Co60	4	0		
Ni62(n,h)Fe60	Fe60	4	0		
Ni62(n,α)Fe59	Fe59, Co58	5	6*	•	•
Ni63(n,nα)Fe59	Mn53, Fe59	4	0		
Ni63(n,γ)**Ni64**	Ni65	4	2	•	
Ni63(n,α)Fe60	Fe59, Fe60	5	0		
Ni64(n,2n)Ni63	H3, Fe59, Fe60, Co60, Ni59, Ni63, Cu64	5	2	•	
Ni64(n,nα)Fe60	Fe59, Fe60	5	1	•	
Ni64(n,2nα)Fe59	Fe59	5	0		
Ni64(n,γ)Ni65	Ni63, Ni65, Cu64, Cu66	5	4	•	
Ni64(n,d)Co63	Fe59, Ni63, Cu64	4	0		
Cu63(n,2n)Cu62	Fe59, Fe60, Co58, Co60, Ni59, Cu62	5	6	•	•
Cu63(n,nα)**Co59**	Mn53, Fe59, Co58	5	2	•	
Cu63(n,2nα)Co58	Mn53, Co58	5	0		
Cu63(n,2nα)Co58m	Mn53, Co58	4	0		
Cu63(n,γ)Cu64	Fe60, Co60, Ni63, Cu64, Cu66, Zn64, Zn65	5	5_2	•	•
Cu63(n,p)Ni63	Fe60, Ni59, Ni63	5	4	•	
Cu63(n,t)**Ni61**	Fe59, Fe60, Co58, Co60, Ni59	5	5_3		•
Cu63(n,α)Co60	Fe59, Fe60, Co58, Co60, Ni59	5	6	•	•
Cu63(n,α)Co60m	Fe59, Fe60, Co58, Co60, Ni59	4	4	•	
Cu63(n,2nt)Ni59	Mn53, Co58, Ni59	5	0		
Cu65(n,2n)Cu64	Fe59, Fe60, Co58, Co60, Ni59, Ni63, Cu62, Cu64, Zn64, Zn65	5	6	•	•
Cu65(n,nα)Co61	Fe59, Co58, Co60, Ni59	4	6	•	•
Cu65(n,2nα)Co60	Mn53, Fe59, Fe60, Co58, Co60, Ni59	4	0		
Cu65(n,γ)Cu66	Ni63, Cu66, Zn65	5	6	•	•
Cu65(n,d)**Ni64**	Fe59, Fe60, Ni63	4	4	•	
Cu65(n,t)Ni63	Fe59, Fe60, Co60, Ni59, Ni63	5	0		
Cu65(n,dα)Fe60	Fe60	4	0		
Zn64(n,2n)Zn63	H3, Fe60, Co60, Ni59, Ni63, Cu62	4	6	•	•
Zn64(n,nα)**Ni60**	H3, Mn53, Fe59, Fe60, Co60, Ni59	5	2	•	
Zn64(n,2nα)Ni59	H3, Mn53, Ni59	5	0		
Zn64(n,γ)Zn65	H3, Ni63, Cu64, Cu66, Zn65	5	4	•	
Zn64(n,p)Cu64	Fe60, Ni63, Cu64	5	6	•	•
Zn64(n,d)**Cu63**	H3, Fe59, Fe60, Co60, Ni59, Ni63, Cu62, Cu64	5	0		
Zn64(n,t)Cu62	H3, Fe59, Fe60, Co60, Ni59, Cu62	5	6	•	•
Zn64(n,α)**Ni61**	H3, Fe60, Co60, Ni59	5	4	•	
Zn64(n,2p)Ni63	Fe60, Ni63	4	0		
Zn64(n,pα)Co60	Fe60, Co60, Ni59	4	0		
Zn64(n,pα)Co60m	Fe60, Co60, Ni59	4	0		
Zn65(n,2n)Zn64	Co60, Ni59, Zn64	4	0		
Zn65(n,α)**Ni62**	Fe59, Co60, Ni59, Ni63, Cu64	5	0		
Zn66(n,2n)Zn65	H3, Fe59, Fe60, Co60, Ni59, Ni63, Cu62, Cu64, Zn64, Zn65	5	4	•	
Zn66(n,nα)**Ni62**	Fe59, Fe60, Co60, Ni59	5	0		
Zn66(n,t)Cu64	H3, Fe59, Fe60, Co60, Ni59, Ni63, Cu62, Cu64, Zn64	5	0		
Zn66(n,α)Ni63	Fe59, Fe60, Co60, Ni59, Ni63, Cu64, Zn64, Zn65	5	2	•	
Zn66(n,tα)Co60	Fe59, Fe60, Co60	4	0		
Zn67(n,3n)Zn65	Fe59, Fe60, Co60, Ni59, Ni63, Cu64, Zn64, Zn65	5	0		
Zn67(n,nα)Ni63	Fe59, Fe60, Co60, Ni59, Ni63	4	0		
Zn68(n,2n)**Zn67**	H3, Fe59, Fe60, Co60, Ni63, Cu64, Zn64, Zn65	4	1	•	
Zn68(n,2nα)Ni63	Fe59, Fe60, Co60, Ni59, Ni63	4	0		
Zn68(n,4n)Zn65	Mn53, Fe59, Fe60, Co60, Ni59, Ni63, Cu64, Zn65	4	0		
Zn68(n,γ)Zn69	Ni63, Zn69, Ga70	5	4	•	
Zn68(n,γ)Zn69m	Ni63, Zn69, Zn69m, Ga70	5	5_2	•	•
Zn70(n,2n)Zn69	H3, Zn69, Zn69m, Ga68, Ga70	4	2	•	

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Zn70(n,2n)Zn69m	Zn69, Zn69m, Ga68, Ga70	5	4	•	
Zn70(n,γ)Zn71	Zn71, Ga70	5	2	•	
Zn70(n,γ)Zn71m	Ga70	4	2	•	
Zn70(n,d)Cu69	Zn69, Ga70	4	0		
Ga67(n,2n)Ga66	Ga66	5	0		
Ga69(n,2n)Ga68	H3, Fe59, Fe60, Co60, Ni59, Ni63, Zn64, Zn65, Zn69m, Ga68	5	6	•	•
Ga69(n,3n)Ga67	H3, Fe59, Fe60, Co60, Ni59, Ni63, Zn64, Zn65, Ga66, Ga67	5	0		
Ga69(n,nα)**Cu65**	H3, Mn53, Fe59, Fe60, Co60, Ni59, Ni63, Zn64	5	0		
Ga69(n,2nα)Cu64	Mn53, Fe59, Fe60, Co60, Ni59, Ni63, Zn64	5	0		
Ga69(n,3nα)**Cu63**	Mn53, Fe59, Fe60, Co60, Ni59, Ni63	4	0		
Ga69(n,2n2α)Co60	Mn53, Fe59, Fe60, Co60, Ni59	4	0		
Ga69(n,4n)Ga66	Fe59, Fe60, Co60, Ni59, Ni63, Zn64, Zn65, Ga66	5	0		
Ga69(n,γ)Ga70	H3, Zn69, Zn69m, Zn71, Ga70, Ga72, Ge71	5	4	•	
Ga69(n,p)Zn69	Zn69	4	2	•	
Ga69(n,p)Zn69m	Zn69, Zn69m	5	2	•	
Ga69(n,t)**Zn67**	H3, Fe59, Fe60, Co60, Ni59, Ni63, Zn64, Zn65	4	5_3		•
Ga69(n,α)Cu66	Fe59, Fe60, Co60, Ni59, Ni63, Zn64, Zn65	5	4	•	
Ga69(n,2nt)Zn65	Mn53, Fe59, Fe60, Co60, Ni59, Ni63, Zn64, Zn65	5	0		
Ga69(n,tα)Ni63	Mn53, Fe59, Fe60, Co60, Ni59, Ni63	5	0		
Ga71(n,2n)Ga70	H3, Fe59, Fe60, Co60, Ni59, Ni63, Zn64, Zn65, Zn69, Zn69m, Ga66, Ga67, Ga68, Ga70, Ge68, Ge69, Ge71	5	6	•	•
Ga71(n,3n)**Ga69**	H3, Mn53, Fe59, Fe60, Co60, Ni59, Ni63, Zn64, Zn65, Zn69, Zn69m, Ga66, Ga67, Ga68	4	0		
Ga71(n,nα)Cu67	H3, Mn53, Fe59, Fe60, Co60, Ni59, Ni63, Zn64, Zn65	4	4	•	
Ga71(n,4n)Ga68	H3, Fe59, Fe60, Co60, Ni59, Ni63, Zn64, Zn65, Ga68	4	0		
Ga71(n,γ)Ga72	Zn69, Ga72, Ge71, Se79	5	4	•	
Ga71(n,p)Zn71	Zn71	5	2/2	•	
Ga71(n,t)Zn69	Fe60, Co60, Ni63, Zn64, Zn69, Ga66, Ga67, Ga68	4	0		
Ga71(n,t)Zn69m	Fe60, Co60, Ni59, Ni63, Zn64, Zn65, Zn69, Zn69m, Ga66, Ga67, Ga68	5	0		
Ga71(n,5n)Ga67	Fe59, Fe60, Ni59, Ni63, Zn64, Zn65, Ga67	4	0		
Ge68(n,d)Ga67	Ni63, Zn65, Ga66, Ga67	5	0		
Ge68(n,t)Ga66	Fe60, Ni59, Ga66	4	0		
Ge69(n,2n)Ge68	Ni59, Ga66, Ga67, Ge68	5	0		
Ge70(n,2n)Ge69	H3, Fe60, Co60, Ni59, Ni63, Zn65, Zn69m, Ga66, Ga67, Ga68, Ge68, Ge69	5	4	•	
Ge70(n,3n)Ge68	Mn53, Fe60, Co60, Ni59, Ni63, Zn64, Zn65, Ga66, Ga68, Ge68	5	0		
Ge70(n,nα)**Zn66**	H3, Mn53, Fe59, Fe60, Co60, Ni59, Ni63, Zn64, Zn65	5	0		
Ge70(n,2nα)Zn65	Mn53, Fe60, Co60, Ni59, Ni63, Zn65	5	0		
Ge70(n,3nα)Zn64	Mn53, Fe60, Co60, Ni59, Ni63, Zn64	4	0		
Ge70(n,γ)Ge71	H3, Ni63, Zn69, Zn69m, Ga70, Ga72, Ge71	5	4	•	
Ge70(n,p)Ga70	Ga70	4	4	•	
Ge70(n,d)**Ga69**	H3, Fe60, Co60, Ni59, Ni63, Zn65, Zn69m, Ga67, Ga68	4	0		
Ge70(n,t)Ga68	H3, Fe60, Co60, Ni59, Ni63, Zn65, Ga68	5	2	•	
Ge70(n,α)**Zn67**	H3, Fe60, Co60, Ni59, Ni63, Zn65, Zn69, Zn69m, Ga70	4	0		
Ge70(n,2α)Ni63	Mn53, Fe59, Fe60, Co60, Ni59, Ni63	4	0		
Ge70(n,tα)Cu64	Fe60, Co60, Ni59, Ni63	4	0		
Ge71(n,α)**Zn68**	Ni63, Zn69, Zn69m, Ga70	5	0		
Ge72(n,2n)Ge71	H3, Fe60, Co60, Ni63, Zn65, Ga68, Ga70, Ga72, Ge68, Ge69, Ge71	5	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Ge72(n,4n)Ge69	Fe60, Co60, Ni59, Ni63, Zn65, Ga68, Ge69	4	0		
Ge72(n,γ)**Ge73**	Ge75, As76, Se79	4	0		
Ge72(n,p)Ga72	Ga72	5	4	•	
Ge72(n,t)Ga70	H3, Fe60, Co60, Ni59, Ni63, Zn65, Ga68, Ga70, Ge68, Ge69	5	0		
Ge72(n,5n)Ge68	Mn53, Fe60, Ni59, Ni63, Zn65, Ga68, Ge68	4	0		
Ge73(n,3n)Ge71	H3, Fe60, Co60, Ni59, Ni63, Zn65, Ga68, Ga70, Ge69, Ge71	5	0		
Ge73(n,γ)**Ge74**	Ge75, As76, Se79	4	2	•	
Ge73(n,d)Ga72	Fe60, Ni63, Zn65, Ga68, Ga70, Ga72, Ge71	5	0		
Ge74(n,4n)Ge71	H3, Fe60, Co60, Ni63, Zn65, Ga68, Ga70, Ge71	5	0		
Ge74(n,γ)Ge75	H3, Ge75, As76, As77, Se79, Kr81	5	2	•	
Ge74(n,γ)Ge75m	H3, Ge75, As74, As76, Se79, Kr81	4	2	•	
Ge74(n,t)Ga72	H3, Ni63, Zn65, Ga68, Ga70, Ga72, Ge69, Ge71	5	5_0		•
Ge76(n,2n)Ge75	H3, Ga72, Ge75, As74, As76	4	6	•	•
Ge76(n,2n)Ge75m	Ga70, Ga72, Ge75, As74, As76	5	6	•	•
Ge76(n,γ)Ge77	Ge77, As76, As77, Se79, Kr81	5	2	•	
Ge76(n,γ)Ge77m	Ge77, As76, As77, Se79, Kr81	4	2	•	
Ge76(n,d)Ga75	Ge75, As74, As76	4	0		
As73(n,2n)As72	Fe60, Ni63, Zn65, Ga68, Ge71, As72	4	0		
As75(n,2n)As74	H3, Mn53, Fe60, Co60, Ni59, Ni63, Zn65, Ga68, Ga72, Ge71, As72, As73, As74, Se75	5	0		
As75(n,3n)As73	H3, Mn53, Fe60, Co60, Ni59, Ni63, Zn65, Ga68, Ga72, Ge71, As72, As73	5	0		
As75(n,nα)**Ga71**	H3, Mn53, Fe60, Co60, Ni59, Ni63, Zn65, Ga68	4	0		
As75(n,2nα)Ga70	H3, Mn53, Fe60, Co60, Ni59, Ni63, Zn65, Ga68, Ga70	5	0		
As75(n,3nα)**Ga69**	H3, Mn53, Fe60, Co60, Ni59, Ni63, Zn65, Ga68	4	0		
As75(n,4n)As72	H3, Mn53, Fe60, Co60, Ni59, Ni63, Zn65, Ga68, Ga72, Ge71, As72	5	0		
As75(n,γ)As76	H3, Ge75, As76, As77, Se75, Se77m, Se79, Se79m, Br82, Kr81	5	4	•	
As75(n,p)Ge75	Ge75	5	6	•	•
As75(n,p)Ge75m	Ge75	5	6	•	•
As75(n,α)Ga72	Fe60, Co60, Ni63, Zn65, Ga68, Ga72, Ge71	5	6	•	•
As75(n,5n)As71	Fe60, Co60, Ni63, Zn65, Ga68, Ge71	4	0		
As75(n,2nt)Ge71	H3, Mn53, Fe60, Co60, Ni59, Ni63, Zn65, Ga68, Ge71	5	0		
As75(n,4nα)Ga68	Mn53, Fe60, Co60, Ni59, Ni63, Zn65, Ga68	4	0		
As76(n,γ)As77	Ge75, As77, Se79, Se79m, Br82, Kr81	5	0		
Se74(n,2n)Se73	Co60, Zn65, Ga68, Ge71, As72, As73	4	4/4	•	
Se74(n,3n)Se72	Co60, Zn65, Ga68, As72	4	0		
Se74(n,nα)**Ge70**	Fe60, Co60, Ni59, Ni63, Zn65, Ga68	5	0		
Se74(n,γ)Se75	H3, As76, Se75, Se77m	5	2	•	
Se74(n,d)As73	H3, Fe60, Co60, Ni63, Zn65, Ga68, Ga72, Ge71, As72, As73	4	0		
Se74(n,t)As72	Co60, Ga68, Ge71, As72	4	0		
Se74(n,α)Ge71	Fe60, Co60, Ni63, Zn65, Ga68, Ge71	4	0		
Se75(n,γ)**Se76**	Se77m	4	2	•	
Se76(n,2n)Se75	H3, Co60, Ga68, As74, As76, Se75	5	4	•	
Se76(n,γ)**Se77**	Ge75, As77, Se77m, Se79, Se79m, Br82, Kr81	5	2	•	
Se76(n,γ)Se77m	Ge75, As77, Se77m, Se79, Se79m, Br82, Kr81	5	2	•	
Se76(n,p)As76	As76	5	4	•	
Se76(n,t)As74	Ga68, As74	5	0		
Se77(n,3n)Se75	H3, Co60, Ga68, As74, Se75	4	0		
Se77(n,nt)As74	Ga68, As74	4	0		
Se77(n,γ)**Se78**	Se79, Se79m, Br82, Kr81	5	4	•	
Se77(n,p)As77	As77	5	2	•	
Se77(n,d)As76	As74, As76, Se75	5	2	•	
Se77(n,α)**Ge74**	Ga68, Ge75	4	2	•	
Se78(n,2n)Se77m	H3, Ga68, As74, As76, Se75, Se77m	5	6	•	•

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Se78(n,4n)Se75	H3, Co60, Ga68, As74, Se75	5	0		
Se78(n,γ)Se79	Se79, Se79m, Br82	5	2	•	
Se78(n,γ)Se79m	Se79, Se79m, Se81, Br82, Kr81	5	2	•	
Se78(n,t)As76	H3, Ga68, As74, As76, Se75	5	0		
Se79(n,γ)**Se80**	Se81, Br82	4	1	•	
Se80(n,2n)Se79	H3, As74, As76, Se75, Se77m, Se79	5	0*/4*	•	
Se80(n,4n)Se77m	H3, Ga68, As74, As76, Se75, Se77m	5	0		
Se80(n,γ)Se81	Se81, Br82, Kr83m, Kr85	5	4/3	•	
Se80(n,d)As79	As76, Se77m, Se79	4	0		
Se82(n,2n)Se81	H3, Se81, Br82, Kr79, Kr81	4	5_2	•	•
Se82(n,2n)Se81m	As76, Se81, Br82, Kr79, Kr81	5	2	•	
Se82(n,γ)Se83	Br82, Kr79, Kr81, Kr83m, Kr85	5	2	•	
Se82(n,γ)Se83m	Se83m, Br82, Kr79, Kr81, Kr83m, Kr85	5	2	•	
Se82(n,d)As81	Se81, Br82, Kr79	4	0		
Br79(n,n')Br79m	Br79m	5	4	•	
Br79(n,2n)Br78	H3, Ga68, As74, As76, Se75, Se79, Br78	5	6	•	•
Br79(n,3n)Br77	H3, Co60, Ga68, As74, As76, Se75, Br76, Br77	4	0		
Br79(n,3n)Br77m	Ga68, As74, As76, Se75, Br76, Br77	5	0		
Br79(n,nα)**As75**	H3, Co60, Ga68, As74	4	0		
Br79(n,2nα)As74	Co60, Ga68, As74	5	0		
Br79(n,4n)Br76	Ga68, As74, As76, Se75, Br76	4	0		
Br79(n,4n)Br76m	Ga68, As74, As76, Se75, Br76	5	0		
Br79(n,γ)Br80	H3, Se79, Br80, Br82, Kr81, Kr83m, Kr85, Rb86	5	4	•	
Br79(n,γ)Br80m	H3, Se79, Br80, Br80m, Br82, Kr81, Kr83m, Kr85, Rb86	5	4	•	
Br79(n,p)Se79	As76, Se75, Se79	5	0		
Br79(n,p)Se79m	Se79	4	2	•	
Br79(n,α)As76	Co60, Ga68, As74, As76, Se75	5	4	•	
Br79(n,2nt)Se75	Co60, Ga68, As74, Se75	4	0		
Br81(n,2n)Br80	H3, As74, As76, Se75, Se79, Br76, Br77, Br78, Br79m, Br80, Br80m, Kr79, Kr81	4	6/2	•	•
Br81(n,2n)Br80m	As74, Se75, Se79, Br76, Br77, Br78, Br79m, Br80, Br80m, Kr79, Kr81	5	2	•	
Br81(n,3n)Br79m	H3, Ga68, As74, As76, Se75, Se79, Br76, Br77, Br78, Br79m	5	0		
Br81(n,2nα)As76	Co60, Ga68, As74, As76, Se75	4	0		
Br81(n,4n)Br78	H3, Ga68, As74, As76, Se75, Br78	5	0		
Br81(n,γ)Br82	Br82, Kr81, Kr83m, Kr85, Rb86	5	2	•	
Br81(n,γ)Br82m	Br82, Kr81, Kr83m, Kr85, Rb86	5	2	•	
Br81(n,t)Se79	H3, As76, Se75, Se79	5	0		
Br81(n,5n)Br77m	As74, As76, Se75, Br77	4	0		
Br82(n,γ)Br83	Kr83m, Kr85, Rb86	4	0		
Kr78(n,γ)Kr79	H3, Se79, Br82, Kr79, Kr81	5	2/2	•	
Kr78(n,α)Se75	Se75	5	0		
Kr80(n,2n)Kr79	H3, As76, Se75, Se79, Br76, Br77, Br78, Br79m, Kr79	4	2	•	
Kr80(n,2n)Kr79m	Se75, Se79, Br76, Br77, Br78, Kr79	4	2	•	
Kr80(n,2nα)Se75	Se75	4	0		
Kr80(n,γ)Kr81	H3, Se79, Br82, Kr81, Kr83m, Kr85, Rb86	5	2	•	
Kr80(n,γ)Kr81m	H3, Se79, Br82, Kr81, Kr83m, Kr85, Rb86	5	2	•	
Kr80(n,t)Br78	Se75, Br78	4	0		
Kr81(n,α)**Se78**	Se79	5	0		
Kr82(n,2n)Kr81	H3, Se75, Br78, Kr79, Kr81	5	2/2	•	
Kr82(n,3n)**Kr80**	H3, Se75, Br78, Kr79	4	0		
Kr82(n,4n)Kr79m	Se75, Se79, Br78, Kr79	4	0		
Kr82(n,γ)**Kr83**	Kr83m, Kr85, Kr85m, Rb86	4	2	•	
Kr82(n,γ)Kr83m	Kr83m, Kr85, Kr85m, Rb86	5	2	•	
Kr82(n,p)Br82	Br82	4	0		
Kr82(n,p)Br82m	Br82	4	0		
Kr82(n,α)Se79	Se75, Se79	5	0		
Kr83(n,3n)Kr81	H3, Se75, Br78, Kr79, Kr81	5	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Kr83(n,nα)Se79	Se75, Se79	4	0		
Kr83(n,γ)**Kr84**	Kr85, Kr85m, Rb86	5	0		
Kr83(n,d)Br82	Se79, Br78, Br82, Kr79, Kr81	4	0		
Kr84(n,2n)**Kr83**	H3, Se75, Se79, Br78, Br82, Kr79, Kr81, Kr83m	4	0		
Kr84(n,2n)Kr83m	H3, Se79, Br82, Kr79, Kr81, Kr83m	5	0		
Kr84(n,2nα)Se79	Se75, Se79	5	0		
Kr84(n,4n)Kr81	H3, Se75, Se79, Br78, Kr79, Kr81	5	0		
Kr84(n,γ)Kr85	Kr85, Rb86	5	2	•	
Kr84(n,γ)Kr85m	Kr85, Kr85m, Rb83, Rb86	5	2	•	
Kr84(n,d)Br83	Se75, Se79, Br78, Br82, Kr79, Kr81, Kr83m	5	0		
Kr84(n,t)Br82	Se75, Se79, Br78, Br82, Kr79	5	0		
Kr84(n,t)Br82m	Br78, Br82, Kr79	4	0		
Kr86(n,2n)Kr85	H3, Se79, Br82, Kr83m, Kr85, Kr85m, Rb83, Rb84, Rb86	5	0		
Kr86(n,2n)Kr85m	H3, Br82, Kr83m, Kr85, Kr85m, Rb83, Rb84, Rb86	5	2	•	
Kr86(n,γ)Kr87	Kr87, Rb86	5	4	•	
Kr86(n,d)Br85	Kr83m, Kr85, Kr85m, Rb83, Rb84, Rb86	5	0		
Rb83(n,2n)Rb82m	Kr81, Rb82m	5	0		
Rb84(n,2n)Rb83	Kr81, Rb82m, Rb83	4	0		
Rb85(n,2n)Rb84	H3, Se79, Br82, Kr81, Kr85, Rb82m, Rb83, Rb84	5	6	•	•
Rb85(n,2n)Rb84m	H3, Se79, Br82, Kr81, Kr85, Rb82m, Rb83, Rb84	5	4*	•	
Rb85(n,3n)Rb83	H3, Se79, Br82, Kr81, Kr83m, Rb82m, Rb83	5	0		
Rb85(n,4n)Rb82m	Se79, Br82, Kr81, Rb82m	5	0		
Rb85(n,γ)Rb86	H3, Kr85, Rb86, Rb87, Sr89, Sr90, Y90	5	4/4	•	
Rb85(n,p)Kr85	H3, Br82, Kr85	5	0/4	•	
Rb85(n,α)Br82	Se79, Br82, Kr81	5	0		
Rb85(n,α)Br82m	Se79, Br82, Kr81	4	0		
Rb85(n,5n)Rb81m	Kr81	4	0		
Rb85(n,2nt)Kr81	Kr81	4	0		
Rb87(n,2n)Rb86	H3, Kr81, Rb82m, Rb84, Rb86, Sr85	5	4	•	
Rb87(n,2n)Rb86m	H3, Kr81, Rb82m, Rb86, Sr85	5	6	•	•
Rb87(n,γ)Rb88	Sr89, Sr90, Y90, Nb93m	5	4	•	
Rb87(n,t)Kr85	Br82, Kr81, Kr85	5	0		
Sr84(n,γ)Sr85	H3, Kr85, Rb86, Sr85	4	2	•	
Sr84(n,γ)Sr85m	H3, Kr85, Rb86, Rb87, Sr85	5	6	•	•
Sr84(n,α)Kr81	Kr81	5	0		
Sr86(n,2n)Sr85	H3, Se79, Kr81, Kr85, Rb82m, Rb84, Sr85	5	6	•	•
Sr86(n,2nα)Kr81	Kr81	4	0		
Sr86(n,γ)Sr87m	Kr85, Rb87, Sr87m, Sr89, Sr90, Y90	5	5_2	•	•
Sr86(n,p)Rb86	H3, Rb86	4	2/4	•	
Sr87(n,3n)Sr85	H3, Se79, Kr81, Kr85, Rb84, Sr85	4	0		
Sr87(n,p)Rb87	Kr85, Rb86, Rb87	4	2	•	
Sr87(n,α)**Kr84**	Se79, Kr81, Kr85	5	0		
Sr88(n,2n)**Sr87**	H3, Se79, Kr81, Rb84, Rb86, Rb87, Sr85, Sr87m	4	2	•	
Sr88(n,2n)Sr87m	H3, Se79, Kr81, Rb84, Rb86, Rb87, Sr85, Sr87m	5	6	•	•
Sr88(n,4n)Sr85	H3, Se79, Kr81, Kr85, Rb84, Sr85	5	0		
Sr88(n,γ)Sr89	H3, Sr89, Sr90, Y89m, Y90, Y91, Zr93, Nb93m, Nb94	5	4	•	
Sr88(n,d)Rb87	H3, Kr85, Rb84, Rb86, Rb87	5	0		
Sr88(n,t)Rb86	Kr81, Rb84, Rb86, Sr85	4	2	•	
Sr88(n,t)Rb86m	Kr81, Rb84, Rb86, Sr85	5	0		
Sr88(n,α)Kr85	H3, Se79, Kr81, Kr85, Rb84	5	0/4	•	
Sr89(n,γ)Sr90	Sr90, Y90, Y91, Zr93, Nb93m	5	2	•	
Sr90(n,γ)Sr91	Y91, Zr93, Nb93m	5	2	•	
Y87(n,2n)Y86	Y86	5	0		
Y88(n,2n)Y87m	Se79, Kr81, Rb86, Rb87, Y86	5	2	•	
Y88(n,3n)Y86	Se79, Kr81, Y86	5	0		
Y88(n,3n)Y86m	Kr81, Y86	4	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Y89(n,n')Y89m	Y89m	5	6	•	•
Y89(n,2n)Y88	H3, Se79, Kr81, Kr85, Rb86, Rb87, Sr89, Sr90, Y86, Y88	5	6	•	•
Y89(n,nα)**Rb85**	Se79, Kr81, Kr85	4	0		
Y89(n,2nα)Rb84	Se79, Kr81	4	0		
Y89(n,2nα)Rb84m	Se79, Kr81	4	0		
Y89(n,4n)Y86	Se79, Kr81, Kr85, Rb86, Y86	5	0		
Y89(n,4n)Y86m	Kr81, Kr85, Rb86, Y86	4	0		
Y89(n,γ)Y90	Rb87, Sr89, Sr90, Y89m, Y90, Y90m, Y91, Zr93, Nb93m, Nb94	5	4	•	
Y89(n,γ)Y90m	Rb87, Sr90, Y90, Y90m, Y91, Zr93, Nb93m	5	6	•	•
Y89(n,p)Sr89	Rb87, Sr89, Sr90, Y91	5	4	•	
Y89(n,d)**Sr88**	H3, Se79, Kr81, Kr85, Rb86, Rb87	4	2	•	
Y89(n,h)Rb87	Kr85, Rb86, Rb87	5	0		
Y89(n,α)Rb86	Se79, Kr81, Kr85, Rb86	5	5_2	•	•
Y89(n,α)Rb86m	Se79, Kr81, Kr85, Rb86	4	6	•	•
Y90(n,γ)Y91	Sr89, Sr90, Y89m, Y91, Zr93, Nb93m, Nb94	5	0		
Y90(n,γ)Y91m	Sr89, Sr90, Y89m, Y91, Zr93, Nb93m, Nb94	4	0		
Y90(n,α)Rb87	Rb87	5	0		
Zr90(n,n')Zr90m	Zr90m	5	4	•	
Zr90(n,2n)Zr89	Kr81, Kr85, Y88, Y89m, Y90, Zr89	5	6	•	•
Zr90(n,3n)Zr88	Kr81, Kr85, Y88	5	0		
Zr90(n,γ)**Zr91**	Sr89, Sr90, Y89m, Y90, Y91, Zr93, Nb93m	5	4	•	
Zr90(n,p)Y90	Y90	5	4	•	
Zr90(n,p)Y90m	Y90, Y90m	4	6	•	•
Zr90(n,t)Y88	Kr81, Kr85, Y88	4	6	•	•
Zr91(n,2n)Zr90m	H3, Kr85, Y88, Y89m, Y90, Zr89, Zr90m	5	0		
Zr91(n,γ)**Zr92**	Sr90, Y90, Y91, Zr93, Nb93m, Nb94	5	4	•	
Zr91(n,p)Y91m	Y91	4	4	•	
Zr91(n,p)Y91	Y91	4	2	•	
Zr91(n,d)Y90m	Y90, Y90m	4	0		
Zr91(n,α)**Sr88**	Kr85, Sr89, Sr90, Y89m, Y90, Y91, Nb94	5	0		
Zr92(n,2n)**Zr91**	H3, Kr85, Y88, Y89m, Y90, Y90m, Y91, Zr89, Zr90m	5	0		
Zr92(n,3n)Zr90m	H3, Kr81, Kr85, Y88, Y89m, Y90, Y90m, Zr89, Zr90m	4	0		
Zr92(n,4n)Zr89	Kr85, Y89m, Zr89	4	0		
Zr92(n,γ)Zr93	Sr90, Y90, Y91, Zr93, Nb93m, Nb94	5	4	•	
Zr92(n,d)Y91	Y91, Zr90m	4	0		
Zr92(n,d)Y91m	Y90m, Y91, Zr90m	4	0		
Zr92(n,t)Y90m	Y90, Y90m	4	0		
Zr93(n,α)Sr90	Sr90, Y90, Y91, Nb94	5	0		
Zr94(n,2n)Zr93	H3, Sr90, Y91, Zr90m, Zr93, Nb93m	5	0		
Zr94(n,nα)Sr90	Kr85, Sr90, Y90	5	0		
Zr94(n,nt)Y91m	Y91	4	0		
Zr94(n,γ)Zr95	Zr95, Nb93m, Nb94, Nb95, Nb96, Mo93, Tc99	5	6	•	•
Zr94(n,5n)Zr90m	Zr90m	4	0		
Zr96(n,2n)Zr95	H3, Zr93, Zr95, Nb93m, Nb94, Nb95, Mo93	5	6	•	•
Zr96(n,4n)Zr93	Y91, Zr93	4	0		
Zr96(n,γ)Zr97	Zr97, Nb94, Mo93, Tc99	5	5_2	•	•
Zr96(n,d)Y95	Zr95, Nb93m, Nb94, Nb95, Mo93	4	0		
Nb91(n,2n)Nb90	Kr81, Kr85, Y88, Y90, Y90m, Zr90m, Nb90	5	0		
Nb91(n,d)Zr90m	Y88, Y90, Y90m, Zr90m	4	0		
Nb91(n,α)Y88	Kr81, Kr85, Y88	4	0		
Nb92(n,2n)Nb91	Kr81, Kr85, Y88, Zr90m, Nb90, Nb91, Nb91m	5	0		
Nb92(n,2n)Nb91m	Kr85, Y88, Zr90m, Nb90, Nb91, Nb91m	5	0		
Nb93(n,n')Nb93m	H3, Y88, Y90, Y90m, Zr90m, Zr93, Nb90, Nb91, Nb91m, Nb92, Nb92m, Nb93m, Nb94, Nb94m, Nb95, Nb96	5	4	•	
Nb93(n,2n)Nb92	H3, Kr81, Kr85, Y88, Y90, Y90m, Zr90m, Nb90, Nb91, Nb91m, Nb92, Nb92m	5	4	•	

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Nb93(n,2n)Nb92m	H3, Kr85, Y88, Y90, Y90m, Zr90m, Nb90, Nb91, Nb91m, Nb92m	5	6	•	•
Nb93(n,3n)Nb91	H3, Kr81, Kr85, Y88, Y90, Y90m, Zr90m, Nb90, Nb91, Nb91m	5	0		
Nb93(n,3n)Nb91m	H3, Kr81, Kr85, Y88, Y90, Y90m, Zr90m, Nb90, Nb91, Nb91m	5	5_4	•	•
Nb93(n,nα)**Y89**	H3, Kr81, Kr85, Y88	4	0		
Nb93(n,nα)Y89m	H3, Kr81, Kr85, Y88	4	6	•	•
Nb93(n,2nα)Y88	Kr81, Kr85, Y88	5	0		
Nb93(n,3nα)Y87m	Kr81, Kr85	4	0		
Nb93(n,nt)Zr90m	H3, Kr81, Kr85, Y88, Y90, Y90m, Zr90m	5	0		
Nb93(n,4n)Nb90	H3, Kr81, Kr85, Y88, Y90, Y90m, Zr90m, Nb90	5	5_3		•
Nb93(n,γ)Nb94	H3, Zr93, Nb93m, Nb94, Nb94m, Nb95, Nb96, Tc99	4	4	•	
Nb93(n,γ)Nb94m	H3, Zr93, Nb93m, Nb94, Nb94m, Nb95, Nb96, Tc99	5	6	•	•
Nb93(n,p)Zr93	H3, Kr85, Y90, Y90m, Zr90m, Zr93, Nb93m, Nb95, Nb96	5	2	•	
Nb93(n,t)**Zr91**	H3, Kr81, Kr85, Y88, Y90, Y90m, Zr90m	4	6*	•	•
Nb93(n,α)Y90	Kr81, Kr85, Y88, Y90, Y90m, Zr90m	5	6	•	•
Nb93(n,α)Y90m	Kr81, Y88, Y90, Y90m, Zr90m	5	6	•	•
Nb93m(n,γ)Nb94	Y91, Nb94, Nb95	4	0		
Nb93m(n,γ)Nb94m	Y91, Nb94, Nb94m, Nb95, Nb96	5	0		
Nb94(n,2n)Nb93m	Nb93m	4	0		
Nb94(n,γ)Nb95	Zr93, Nb93m, Nb95, Nb96, Tc99	5	2/2	•	
Nb95(n,2n)Nb94	Nb93m, Nb94	4	0		
Nb95(n,2n)Nb94m	Nb93m, Nb94	4	0		
Nb95(n,3n)Nb93m	Nb93m	4	0		
Nb95(n,γ)Nb96	Zr93, Nb93m, Nb96, Tc99	5	4	•	
Mo92(n,2n)Mo91	H3, Kr85, Y88, Nb90, Nb91, Nb91m	4	5_2	•	•
Mo92(n,2n)Mo91m	Kr85, Y88, Nb90, Nb91, Nb91m	4	5_2*	•	•
Mo92(n,nα)Zr88	Kr85, Y88	5	6*	•	•
Mo92(n,γ)Mo93	H3, Nb93m, Nb94, Nb95, Mo93	5	1/3	•	
Mo92(n,p)Nb92	H3, Y88, Nb90, Nb91, Nb91m, Nb92, Nb92m	5	5_1	•	•
Mo92(n,p)Nb92m	Kr85, Nb92m	5	6	•	•
Mo92(n,d)Nb91	H3, Kr85, Y88, Nb90, Nb91, Nb91m	5	1	•	
Mo92(n,d)Nb91m	Kr85, Y88, Nb90, Nb91, Nb91m	5	6	•	•
Mo92(n,t)Nb90	H3, Kr85, Y88, Nb90	5	5_4	•	•
Mo92(n,α)Zr89	H3, Kr85, Y88	4	6	•	•
Mo93(n,p)Nb93m	Nb93m	4	0		
Mo94(n,2n)Mo93	H3, Kr85, Y88, Nb90, Nb91, Nb91m, Nb92, Nb92m, Nb93m, Mo93	5	2/4	•	
Mo94(n,nt)Nb91m	Y88, Nb90, Nb91, Nb91m	4	0		
Mo94(n,p)Nb94	H3, Nb92, Nb92m, Nb93m, Nb94	4	1	•	
Mo94(n,p)Nb94m	H3, Nb92, Nb92m, Nb93m, Nb94	4	3	•	
Mo94(n,d)Nb93m	Nb91m, Nb92, Nb92m, Nb93m	5	0		
Mo94(n,t)Nb92	Kr85, Y88, Nb90, Nb91m, Nb92, Nb92m	5	0		
Mo94(n,t)Nb92m	Y88, Nb92m	4	0		
Mo95(n,2n)**Mo94**	H3, Kr85, Y88, Nb90, Nb91, Nb91m, Nb92, Nb92m, Nb93m, Nb94, Mo93	5	0		
Mo95(n,3n)Mo93	H3, Kr85, Y88, Nb90, Nb91, Nb91m, Nb92, Nb92m, Nb93m, Mo93	5	0/5		•
Mo95(n,nt)Nb92	H3, Kr85, Y88, Nb90, Nb91, Nb92, Nb92m	4	0		
Mo95(n,nt)Nb92m	Y88, Nb92m	4	0		
Mo95(n,γ)**Mo96**	Zr93, Nb93m, Nb95, Nb96, Mo99, Tc99, Tc100	5	4	•	
Mo95(n,p)Nb95	Nb94, Nb95	5	5_2	•	•
Mo95(n,d)Nb94	H3, Y88, Nb90, Nb92, Nb92m, Nb93m, Nb94	4	0		
Mo95(n,d)Nb94m	H3, Nb90, Nb92, Nb92m, Nb93m, Nb94	4	0		
Mo95(n,t)Nb93m	Nb90, Nb91m, Nb92, Nb92m, Nb93m	5	0		
Mo95(n,α)**Zr92**	Kr85, Zr93, Nb93m	4	0		
Mo96(n,nt)Nb93m	Nb92m, Nb93m	4	0		
Mo96(n,4n)Mo93	H3, Kr85, Y88, Nb90, Nb91, Nb91m, Nb92,	4	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
	Nb92m, Nb93m, Mo93				
Mo96(n,γ)**Mo97**	Nb95, Mo99, Tc99, Tc100	5	4	•	
Mo96(n,d)Nb95	H3, Nb92, Nb92m, Nb93m, Nb94, Nb95, Mo93	4	6	•	•
Mo96(n,t)Nb94	H3, Y88, Nb90, Nb91m, Nb92, Nb92m, Nb93m, Nb94	4	0		
Mo96(n,α)Zr93	Zr93, Nb93m	5	2	•	
Mo96(n,2nt)Nb92	H3, Kr85, Y88, Nb90, Nb92, Nb92m	4	0		
Mo97(n,γ)Mo98	Mo99, Tc99, Tc100	5	4	•	
Mo98(n,nt)Nb95	H3, Nb91, Nb92, Nb92m, Nb93m, Nb95, Mo93	4	0		
Mo98(n,γ)Mo99	Mo99, Tc98, Tc99, Tc100, Ru103	5	6	•	•
Mo100(n,2n)Mo99	H3, Nb95, Mo99, Tc98, Tc99, Tc100	5	6	•	•
Mo100(n,γ)Mo101	Mo101, Tc98, Tc100, Ru103	5	6	•	•
Mo100(n,d)Nb99	Mo99, Tc98, Tc99, Tc100	4	0		
Tc97(n,2n)Tc96	Nb94, Mo93, Tc96	4	0		
Tc97(n,γ)Tc98	H3, Tc98, Tc99, Tc100	5	0		
Tc97(n,α)Nb94	Nb93m, Nb94	4	0		
Tc97(n,α)Nb94m	Nb93m, Nb94	5	0		
Tc98(n,2n)Tc97	Nb94, Mo93, Tc96, Tc97, Tc97m	4	0		
Tc98(n,γ)Tc99	Tc99, Tc100	5	0		
Tc98(n,γ)Tc99m	Tc99, Tc100	4	0		
Tc99(n,2n)Tc98	Nb94, Nb95, Mo93, Tc96, Tc97, Tc97m, Tc98	5	2	•	
Tc99(n,3n)Tc97	Nb94, Mo93, Tc96, Tc97	4	0		
Tc99(n,γ)Tc100	Tc100, Ru103	5	4	•	
Ru96(n,2n)Ru95	H3, Kr85, Y88, Nb91, Nb93m, Nb94, Mo93	4	6	•	•
Ru96(n,nα)Mo92	Kr85, Y88, Nb91	5	0		
Ru96(n,2nα)Mo91	Kr85, Y88, Nb91	4	0		
Ru96(n,nt)Tc93	H3, Kr85, Y88, Nb91, Nb93m, Mo93	4	0		
Ru96(n,γ)Ru97	H3, Nb94, Tc97, Tc97m, Tc98, Tc99, Tc100, Ru97	5	4	•	
Ru96(n,p)Tc96m	Nb93m, Nb94, Mo93, Tc96	4	0		
Ru96(n,d)Tc95	H3, Kr85, Y88, Nb91, Nb93m, Nb94, Mo93	4	0		
Ru96(n,α)Mo93	Kr85, Y88, Nb91, Nb93m, Nb94, Mo93	5	0		
Ru96(n,dα)Nb91	Kr85, Y88, Nb91	4	0		
Ru98(n,2n)Ru97	H3, Nb91, Nb93m, Nb94, Mo93, Tc96, Tc97, Tc97m, Ru97	5	2	•	
Ru98(n,nα)**Mo94**	Kr85, Y88, Nb91, Nb93m, Nb94, Mo93	5	0		
Ru98(n,p)Tc98	H3, Nb94, Tc96, Tc97, Tc97m, Tc98	4	0		
Ru98(n,d)Tc97m	Nb94, Tc96, Tc97, Tc97m	4	0		
Ru99(n,2n)**Ru98**	H3, Y88, Nb91, Nb93m, Nb94, Mo93, Tc96, Tc97, Tc97m, Tc98, Ru97	5	0		
Ru99(n,3n)Ru97	H3, Kr85, Y88, Nb91, Nb93m, Nb94, Mo93, Tc96, Tc97, Tc97m, Ru97	5	0		
Ru99(n,nt)Tc96	H3, Y88, Nb93m, Nb94, Mo93, Tc96	4	0		
Ru99(n,p)Tc99	H3, Nb94, Tc96, Tc97, Tc97m, Tc98, Tc99	4	0/4	•	
Ru99(n,d)Tc98	H3, Nb91, Nb93m, Nb94, Tc96, Tc97, Tc97m, Tc98	5	0		
Ru99(n,t)Tc97m	Nb93m, Tc96, Tc97, Tc97m	4	0		
Ru99(n,α)**Mo96**	Nb93m, Nb94, Mo93, Tc99	5	0		
Ru100(n,nt)Tc97m	Tc97, Tc97m	4	0		
Ru100(n,4n)Ru97	H3, Kr85, Y88, Nb91, Nb93m, Nb94, Mo93, Tc96, Tc97, Tc97m, Ru97	4	0		
Ru100(n,p)Tc100	Tc100	5	6*	•	•
Ru100(n,d)Tc99	H3, Nb93m, Nb94, Tc96, Tc97, Tc97m, Tc98, Tc99	4	0		
Ru100(n,t)Tc98	H3, Nb91, Nb93m, Nb94, Tc96, Tc97, Tc97m, Tc98	4	0		
Ru101(n,3n)**Ru99**	H3, Nb93m, Nb94, Mo93, Tc96, Tc97, Tc97m, Tc98, Tc99, Ru97	4	0		
Ru101(n,nt)Tc98	H3, Nb91, Nb93m, Nb94, Tc96, Tc97, Tc97m, Tc98	4	0		
Ru101(n,γ)**Ru102**	Ru103, Rh103m, Rh104	5	4	•	
Ru101(n,d)Tc100	Tc96, Tc97, Tc97m, Tc98, Tc99, Tc100, Ru97	4	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Ru101(n,t)Tc99	H3, Nb93m, Nb94, Tc96, Tc97, Tc97m, Tc98	4	0		
Ru101(n,α)Mo98	Nb94, Tc99	5	2	•	
Ru101(n,5n)Ru97	H3, Kr85, Y88, Nb91, Nb93m, Nb94, Mo93, Tc96, Tc97, Tc97m, Ru97	4	0		
Ru102(n,nt)Tc99	H3, Nb93m, Nb94, Tc96, Tc97, Tc97m, Tc98, Tc99	4	0		
Ru102(n,γ)Ru103	Ru103, Ru106, Rh102, Rh103m, Rh104, Rh106, Ag110m	5	4	•	
Ru102(n,p)Tc102m	Tc102m	5	6	•	•
Ru102(n,t)Tc100	H3, Nb94, Tc96, Tc97, Tc97m, Tc98, Tc99, Tc100, Ru97	5	0		
Ru102(n,2nt)Tc98	H3, Nb91, Nb93m, Nb94, Tc96, Tc97, Tc97m, Tc98	4	0		
Ru104(n,2n)Ru103	H3, Tc96, Tc97m, Tc98, Tc99, Tc100, Ru103, Rh102, Rh104	5	4	•	
Ru104(n,γ)Ru105	Ru103, Ru105, Ru106, Rh102, Rh103m, Rh104, Rh105, Rh106, Rh106m, Pd107, Ag110m	5	4	•	
Ru104(n,d)Tc103	Ru103, Rh102, Rh104	4	0		
Ru104(n,t)Tc102m	Tc100, Tc102m	5	0		
Ru105(n,γ)Ru106	Ru106, Rh106	5	2	•	
Rh101(n,2n)Rh100	Mo93, Rh100	4	0		
Rh101(n,2n)Rh100m	Rh100	4	0		
Rh102(n,2n)Rh101	Nb94, Mo93, Tc97, Tc98, Rh100, Rh101, Rh101m	5	0		
Rh102(n,2n)Rh101m	Nb94, Mo93, Tc97, Tc98, Tc99, Rh100, Rh101, Rh101m	5	0		
Rh102(n,3n)Rh100m	Mo93, Tc98, Tc99, Rh100	4	0		
Rh102(n,nα)Tc98	Nb94, Mo93, Tc97, Tc98	4	0		
Rh102(n,α)Tc99	Nb94, Mo93, Tc97, Tc98, Tc99	4	0		
Rh103(n,n')Rh103m	Rh103m	5	5_2	•	•
Rh103(n,2n)Rh102	H3, Nb94, Mo93, Tc97, Tc98, Tc99, Ru103, Rh100, Rh101, Rh101m, Rh102	5	5/4	•	•
Rh103(n,3n)Rh101	H3, Nb94, Mo93, Tc97, Tc98, Tc99, Rh100, Rh101, Rh101m	5	0		
Rh103(n,3n)Rh101m	H3, Nb94, Mo93, Tc97, Tc98, Tc99, Rh100, Rh101, Rh101m	5	5_2	•	•
Rh103(n,nα)Tc99	H3, Nb94, Mo93, Tc97, Tc98, Tc99	5	0		
Rh103(n,2nα)Tc98	Nb94, Mo93, Tc97, Tc98	5	0		
Rh103(n,3nα)Tc97	Nb94, Mo93, Tc97	4	0		
Rh103(n,2n2α)Nb94	Nb94	4	0		
Rh103(n,4n)Rh100	H3, Nb94, Mo93, Tc97, Tc98, Tc99, Rh100	4	5_3		•
Rh103(n,4n)Rh100m	Nb94, Mo93, Tc97, Tc98, Tc99, Rh100	5	0		
Rh103(n,γ)Rh104	Tc99, Ru103, Ru105, Ru106, Rh103m, Rh104, Rh104m, Rh105, Rh106, Rh106m, Pd107, Ag108m, Ag110m	5	5_2	•	•
Rh103(n,γ)Rh104m	Tc99, Ru103, Ru105, Ru106, Rh103m, Rh104, Rh104m, Rh105, Rh106, Rh106m, Pd107, Ag108m, Ag110m	5	4*	•	
Rh103(n,p)Ru103	Ru103, Ru105, Ru106, Rh103m, Rh105	5	5_2	•	•
Rh105(n,γ)Rh106	Rh106, Ag110m	5	1	•	
Rh105(n,γ)Rh106m	Rh106m, Ag110m	5	1	•	
Pd102(n,2n)Pd101	H3, Nb94, Tc97, Tc98, Tc99, Rh100, Rh101, Rh101m	4	4	•	
Pd102(n,3n)Pd100	Nb94, Mo93, Tc98, Tc99, Rh100	4	0		
Pd102(n,nα)**Ru98**	Nb94, Mo93, Tc97, Tc98	5	0		
Pd102(n,γ)Pd103	H3, Tc99, Pd103	5	2	•	
Pd102(n,α)**Ru99**	Nb94, Mo93, Tc97, Tc98, Tc99	5	0		
Pd104(n,2n)Pd103	H3, Nb94, Mo93, Tc98, Tc99, Rh100, Rh102, Pd103	5	0		
Pd104(n,3n)**Pd102**	H3, Nb94, Mo93, Tc98, Tc99, Rh100, Rh102	4	0		
Pd104(n,γ)**Pd105**	Ru103, Rh103m, Rh105, Rh106, Rh106m, Pd107, Ag108m, Ag110m	5	4	•	

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Pd104(n,t)Rh102	Nb94, Mo93, Tc98, Tc99, Rh100, Rh102	4	0		
Pd104(n,α)**Ru101**	Mo93, Tc98, Tc99, Ru103, Rh103m	5	0		
Pd104(n,5n)Pd100	Nb94, Mo93, Tc98, Tc99, Rh100	4	0		
Pd105(n,2n)**Pd104**	H3, Mo93, Tc98, Tc99, Rh100, Rh102, Rh104, Pd103	4	0		
Pd105(n,3n)Pd103	H3, Nb94, Mo93, Tc98, Tc99, Rh100, Rh102, Pd103	5	0		
Pd105(n,nt)Rh102	Nb94, Tc98, Tc99, Rh100, Rh102	4	0		
Pd105(n,γ)**Pd106**	Rh106, Rh106m, Pd107, Ag108m, Ag110m	5	4	•	
Pd105(n,α)**Ru102**	Tc98, Tc99, Ru103, Rh103m	5	2	•	
Pd106(n,4n)Pd103	H3, Nb94, Mo93, Tc98, Tc99, Rh100, Rh102, Pd103	4	0		
Pd106(n,γ)Pd107	Pd107, Pd109, Ag108m, Ag110m	5	2	•	
Pd106(n,γ)Pd107m	Pd107, Ag108m, Ag110m	4	2	•	
Pd106(n,p)Rh106	Rh106	5	1	•	
Pd106(n,p)Rh106m	Rh106m	5	6	•	•
Pd107(n,γ)**Pd108**	Pd109, Ag110m	5	4	•	
Pd108(n,2n)Pd107	H3, Pd103, Pd107	5	0		
Pd108(n,2n)Pd107m	H3, Pd103, Pd107	4	5_2*	•	•
Pd108(n,γ)Pd109	H3, Pd109, Ag109m, Ag110, Ag110m, Ag111, Cd113m	5	2/3	•	
Pd108(n,d)Rh107	H3, Pd103, Pd107	4	0		
Pd110(n,2n)Pd109	H3, Pd109, Ag108m, Ag110, Ag110m	5	6	•	•
Pd110(n,2n)Pd109m	H3, Pd109, Ag108m, Ag110, Ag110m	4	6	•	•
Pd110(n,4n)Pd107m	H3, Pd103, Pd107	4	0		
Pd110(n,γ)Pd111	Ag110, Ag110m, Ag111, Cd113m	5	4	•	
Pd110(n,γ)Pd111m	Pd111m, Ag110, Ag110m, Ag111, Cd113m	5	4	•	
Pd110(n,d)Rh109	Pd109, Ag108m, Ag110, Ag110m	4	0		
Ag106m(n,2n)Ag105m	Ag105	5	0		
Ag107(n,n')Ag107m	Ag107m	5	4	•	
Ag107(n,2n)Ag106	H3, Nb94, Mo93, Tc98, Tc99, Rh102, Pd107, Ag105	4	6/4	•	•
Ag107(n,2n)Ag106m	H3, Nb94, Mo93, Tc98, Tc99, Rh102, Ag105, Ag106m	5	4	•	
Ag107(n,3n)Ag105m	H3, Nb94, Mo93, Tc98, Tc99, Rh102, Ag105	5	0		
Ag107(n,nα)Rh103m	H3, Nb94, Mo93, Tc98, Tc99, Rh102	4	0		
Ag107(n,2nα)Rh102	Nb94, Mo93, Tc98, Tc99, Rh102	5	0		
Ag107(n,γ)Ag108	Pd107, Pd109, Ag108, Ag109m, Ag110, Ag110m, Ag111, Cd108, Cd109, Cd113m, In116m	5	4	•	
Ag107(n,γ)Ag108m	H3, Pd107, Pd109, Ag108m, Ag109m, Ag110, Ag110m, Ag111	5	2	•	
Ag107(n,p)Pd107	Pd107	5	0		
Ag107(n,p)Pd107m	Pd107	4	4	•	
Ag108m(n,2n)Ag107m	Pd107, Ag106m, Ag107m	4	0		
Ag108m(n,γ)Ag109m	Ag109m, Ag110, Ag110m, Ag111	4	0		
Ag109(n,n')Ag109m	Ag109m	5	4	•	
Ag109(n,2n)Ag108	H3, Tc98, Rh102, Pd107, Ag106m, Ag107m, Ag108, Ag108m, Cd108, Cd109	5	6/4	•	•
Ag109(n,2n)Ag108m	H3, Tc98, Rh102, Pd107, Ag105, Ag106m, Ag107m, Ag108, Ag108m, Cd108, Cd109	5	4	•	
Ag109(n,3n)Ag107m	H3, Nb94, Tc98, Tc99, Rh102, Pd107, Ag105, Ag106m, Ag107m	5	0		
Ag109(n,4n)Ag106m	H3, Nb94, Mo93, Tc98, Tc99, Rh102, Ag106m	5	0		
Ag109(n,γ)Ag110	Ag110, Ag110m, Ag111, Cd109, Cd113m, In116m	5	4	•	
Ag109(n,γ)Ag110m	H3, Pd107, Ag110, Ag110m, Ag111, Cd109, Cd113m, In116m	5	4	•	
Ag109(n,p)Pd109	Pd109, Ag109m	5	2	•	
Ag109(n,p)Pd109m	Pd109, Ag109m	5	4	•	
Ag109(n,t)Pd107	Pd107	4	0		
Ag109(n,t)Pd107m	Pd107	5	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Ag109(n,5n)Ag105m	Nb94, Mo93, Tc98, Tc99, Rh102, Ag105	4	0		
Ag110m(n,γ)Ag111	Ag111, Cd113m	5	0		
Ag110m(n,γ)Ag111m	Ag111, Cd113m, In116m	5	0		
Ag110m(n,α)Rh107	Pd107	5	0		
Cd106(n,2n)Cd105	Nb94, Tc98, Tc99, Ag105	4	4	•	
Cd106(n,nα)**Pd102**	Nb94, Mo93, Tc98, Tc99	5	0		
Cd106(n,2nα)Pd101	Nb94, Mo93, Tc98, Tc99	4	0		
Cd106(n,γ)Cd107	Ag108m, Ag109m	5	4	•	
Cd106(n,p)Ag106m	Ag106m	4	2	•	
Cd106(n,α)Pd103	Nb94, Mo93, Tc98, Tc99, Rh102	4	2	•	
Cd108(n,2n)Cd107	Tc98, Pd107, Ag106m, Ag107m	5	2	•	
Cd108(n,γ)Cd109	Pd107, Ag109m, Ag110, Ag110m, Ag111, Cd109, Cd111m, Cd113m, In116m	5	4	•	
Cd109(n,α)**Pd106**	Pd107	5	2	•	
Cd110(n,2n)Cd109	Pd107, Ag106m, Ag108m, Ag109m, Ag110m, Cd109	5	2	•	
Cd110(n,γ)**Cd111**	Ag111, Cd113, Cd113m, Cd115, Cd115m, In115, In116m	5	5_2	•	•
Cd110(n,γ)Cd111m	Ag111, Cd111m, Cd113m, In116m	5	3	•	
Cd110(n,p)Ag110m	Ag106m, Ag108m, Ag110m, Ag111	5	4	•	
Cd110(n,t)Ag108m	Tc98, Tc99, Pd107, Ag106m, Ag108m	5	0		
Cd110(n,α)Pd107	Pd107	4	0		
Cd110(n,α)Pd107m	Pd107	4	0		
Cd110(n,2nt)Ag106m	Mo93, Tc98, Tc99, Ag106m	4	0		
Cd111(n,2n)**Cd110**	Pd107, Ag106m, Ag108m, Ag109m, Ag110, Ag110m, Cd109	4	0		
Cd111(n,3n)Cd109	Pd107, Ag106m, Ag108m, Ag109m, Cd109	5	0		
Cd111(n,nα)Pd107m	Pd107	4	0		
Cd111(n,nt)Ag108m	Tc99, Pd107, Ag106m, Ag108m	4	0		
Cd111(n,γ)**Cd112**	Cd113, Cd113m, Cd114, Cd115, Cd115m, In115, In116m	5	4	•	
Cd111(n,d)Ag110m	Pd107, Ag106m, Ag108m, Ag110, Ag110m	4	0		
Cd111(n,α)**Pd108**	Pd107, Ag110m	4	0		
Cd112(n,2n)Cd111m	Pd107, Ag106m, Ag108m, Ag109m, Ag110m, Cd109, Cd111m	5	6	•	•
Cd112(n,2nα)Pd107m	Pd107	4	0		
Cd112(n,4n)Cd109	Tc98, Tc99, Pd107, Ag106m, Ag108m, Ag109m, Cd109	4	0		
Cd112(n,γ)Cd113	Cd113, Cd113m, Cd114, Cd115, Cd115m, In115, In116m	5	2	•	
Cd112(n,γ)Cd113m	Cd113m, Cd114, Cd115, Cd115m, In115, In116m	5	2	•	
Cd112(n,t)Ag110m	Pd107, Ag106m, Ag108m, Ag110m	4	0		
Cd112(n,2nt)Ag108m	Tc99, Pd107, Ag106m, Ag108m	4	0		
Cd113(n,3n)Cd111m	Pd107, Ag106m, Ag108m, Ag109m, Ag110m, Cd109, Cd111m	4	0		
Cd113(n,γ)Cd114	Cd114, Cd115, Cd115m, In115, In116m	5	4	•	
Cd113(n,5n)Cd109	Tc98, Pd107, Ag106m, Ag108m, Ag109m, Cd109	4	0		
Cd114(n,2n)Cd113	Pd107, Ag110m, Cd109, Cd111m, Cd113, Cd113m	4	0		
Cd114(n,2n)Cd113m	Pd107, Ag110m, Cd109, Cd111m, Cd113m	5	2	•	
Cd114(n,4n)Cd111m	Pd107, Ag106m, Ag108m, Ag110m, Cd109, Cd111m	5	0		
Cd114(n,γ)Cd115	Cd113m, Cd115, In115, In115m, In116m	5	4	•	
Cd114(n,γ)Cd115m	Cd115m, In115, In116m	5	2	•	
Cd116(n,2n)Cd115	Cd115, In115, In116m	5	4	•	
Cd116(n,2n)Cd115m	Cd113m, Cd115m, In113m, In115, In116m	5	2	•	
Cd116(n,4n)Cd113m	Pd107, Ag110m, Cd109, Cd113m	4	0		
Cd116(n,d)Ag115	Cd115, In115, In116m	4	0		
In113(n,2n)In112m	Pd107, Ag108m, Ag110m, Sn109	4	5_2	•	•
In113(n,2nα)Ag108m	Tc98, Pd107, Ag108m	4	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
In113(n,γ)In114	Cd113m, In114, In115m	5	1	•	
In113(n,γ)In114m	H3, Ag110m, Cd113m, In114, In114m, In115, In115m, In116m	5	4	•	
In113(n,α)Ag110m	Pd107, Ag108m, Ag110m	5	0		
In114m(n,γ)In115	In115, In116m	5	0		
In114m(n,γ)In115m	Cd113m, In115, In115m, In116m	5	0		
In114m(n,α)Ag111	Ag110m, Cd113m	4	0		
In115(n,n')In115m	In113m, In115m, Sn113m	5	4	•	
In115(n,2n)In114m	Pd107, Ag108m, Ag110m, Cd113m, In113m, In114, In114m, Sn113m	5	4	•	
In115(n,3n)**In113**	Tc98, Pd107, Ag108m, Ag110m, Cd113m, In113m	4	0		
In115(n,3n)In113m	Pd107, Ag108m, Ag110m, In113m	5	0		
In115(n,2nα)Ag110m	Pd107, Ag108m, Ag110m	5	0		
In115(n,4n)In112m	Pd107, Ag108m, Ag110m, Sn109	5	0		
In115(n,γ)In116	Sn117m, Sn119m, Sn121, Sn121m	4	5_2	•	•
In115(n,γ)In116m	In116m, Sn117m, Sn119m, Sn121, Sn121m	5	5_1	•	•
In115(n,γ)In116n	In116m, Sn117m, Sn119m, Sn121, Sn121m	5	2	•	
In115(n,t)Cd113m	Pd107, Ag108m, Ag110m, Cd113m	5	0		
In115(n,4nα)Ag108m	Pd107, Ag108m	4	0		
Sn112(n,2n)Sn111	H3, Pd107, Ag108m, Ag110m	4	6	•	•
Sn112(n,4n)Sn109	Ag108m, Sn109	5	0		
Sn112(n,γ)Sn113	H3, Cd113m, In113m, In116m, Sn113	5	1	•	
Sn112(n,γ)Sn113m	H3, Cd113m, In113m, In116m, Sn113, Sn113m	5	2	•	
Sn112(n,α)Cd109	Pd107, Ag108m, Ag110m, Cd113m	5	2	•	
Sn113(n,α)**Cd110**	Pd107, Cd113m	4	0		
Sn114(n,2n)Sn113	H3, Pd107, Ag108m, Ag110m, Cd113m, In113m, Sn113, Sn113m	4	5_2	•	•
Sn114(n,2n)Sn113m	H3, Pd107, Ag108m, Ag110m, In113m, Sn113, Sn113m	5	2	•	
Sn114(n,γ)**Sn115**	Cd113m	4	4	•	
Sn115(n,2n)**Sn114**	Ag110m, In113m, Sn113, Sn113m	4	0		
Sn115(n,3n)Sn113m	Ag108m, Ag110m, In113m, Sn113, Sn113m	4	0		
Sn115(n,α)**Cd112**	Cd113m	5	2	•	
Sn116(n,2n)**Sn115**	H3, Pd107, Ag108m, Ag110m, In113m, Sn113, Sn113m	4	0		
Sn116(n,3n)**Sn114**	H3, Pd107, Ag108m, Ag110m, In113m, Sn113, Sn113m	4	0		
Sn116(n,4n)Sn113m	Ag108m, Ag110m, In113m, Sn113, Sn113m	4	0		
Sn116(n,γ)**Sn117**	Sn117m, Sn119m, Sn121, Sn121m	5	4	•	
Sn116(n,γ)**Sn117**m	Sn117m, Sn119m, Sn121, Sn121m	5	4	•	
Sn116(n,p)In116m	In116m	5	6	•	•
Sn116(n,p)In116n	In116m	4	2	•	
Sn116(n,α)Cd113m	Pd107, Ag108m, Ag110m, Cd113m	5	0		
Sn117(n,3n)**Sn115**	H3, Pd107, Ag108m, Ag110m, In113m, In115, Sn113, Sn113m	4	0		
Sn117(n,nα)Cd113m	Pd107, Ag108m, Ag110m, Cd113m	4	0		
Sn117(n,γ)**Sn118**	Sn119m, Sn121, Sn121m	5	4	•	
Sn117(n,5n)Sn113m	Ag108m, Ag110m, In113m, Sn113, Sn113m	5	0		
Sn118(n,2n)Sn117m	H3, Ag110m, Cd113m, In113m, In115, In116m, Sn113, Sn113m, Sn117m	5	5_2*	•	•
Sn118(n,2nα)Cd113m	Pd107, Ag108m, Ag110m, Cd113m	4	0		
Sn118(n,γ)**Sn119**	Sn119m, Sn121, Sn121m	5	4	•	
Sn118(n,γ)Sn119m	Sn119m, Sn121, Sn121m	5	2	•	
Sn118(n,t)In116m	In113m, In116m, Sn113, Sn113m	4	0		
Sn118(n,t)In116n	In116m, Sn113m	4	0		
Sn119(n,n')Sn119m	In115, Sn117m, Sn119m	4	0		
Sn119(n,3n)**Sn117**	H3, Cd113m, In113m, In115, In116m, Sn113, Sn113m, Sn117m	4	0		
Sn119(n,3n)Sn117m	H3, Cd113m, In113m, In115, In116m, Sn113, Sn113m, Sn117m	4	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Sn119(n,nα)Cd115	Ag110m, Cd113m, In113m, In115, Sn113m	4	0		
Sn119(n,nα)Cd115m	Ag110m, Cd113m, In113m, In115	4	0		
Sn119(n,3nα)Cd113m	Pd107, Ag110m, Cd113m	4	0		
Sn119(n,γ)**Sn120**	H3, Sn121, Sn121m, Sb122, Sb124	5	4	•	
Sn120(n,2n)Sn119m	H3, Cd113m, In115, In116m, Sn117m, Sn119m	5	6	•	•
Sn120(n,4n)Sn117m	H3, Ag108m, Ag110m, Cd113m, In113m, In115, In116m, Sn113, Sn113m, Sn117m	5	0		
Sn120(n,γ)Sn121	H3, Sn121, Sb122, Sb124	5	4	•	
Sn120(n,γ)Sn121m	Sn121, Sn121m	5	2	•	
Sn122(n,2n)Sn121	H3, Sn121	5	0		
Sn122(n,2n)Sn121m	H3, Sn121, Sn121m	5	2	•	
Sn122(n,4n)Sn119m	H3, Sn117m, Sn119m	4	0		
Sn122(n,γ)Sn123	Sn123, Sn124, Sn126, Sb124	5	2	•	
Sn122(n,γ)Sn123m	Sb124, Sb125, Sb126m	5	3	•	
Sn122(n,d)In121	Sn121, Sn121m	4	0		
Sn123(n,γ)Sn124	Sn124, Sn126	5	0		
Sn124(n,2n)Sn123	H3, Sn121, Sn121m, Sn123, Sb122, Sb124	5	6/6	•	•
Sn124(n,2n)Sn123m	H3, Sb122, Sb124	4	6	•	•
Sn124(n,nt)In121	Sn121	4	0		
Sn124(n,4n)Sn121	Sn121, Sb122	4	0		
Sn124(n,4n)Sn121m	H3, Sn121, Sn121m	5	0		
Sn124(n,γ)Sn125	Sn126, Sb124, Sb125, Sb126m	5	2	•	
Sn124(n,γ)Sn125m	Sn125m, Sb124, Sb125, Sb126m	5	4	•	
Sn125(n,γ)Sn126	Sn126	5	0		
Sb120m(n,2n)Sb119	In115, Sb119	5	0		
Sb121(n,2n)Sb120	H3, Cd113m, In113m, In115, Sn113m, Sn119m, Sn121, Sn121m	5	6/4	•	•
Sb121(n,2n)Sb120m	H3, Cd113m, In113m, In115, Sn113m, Sn119m, Sn121, Sn121m, Sb119, Sb120m	5	4	•	
Sb121(n,3n)Sb119	H3, Pd107, Cd113m, In113m, In115, Sn113m, Sn119m, Sb119	5	0		
Sb121(n,3nα)In115	Ag108m, Ag110m, Cd113m, In113m, In115	4	0		
Sb121(n,4n)Sb118	H3, Pd107, Ag110m, Cd113m, In113m, In115, Sn113m	4	0		
Sb121(n,γ)Sb122	H3, Sn119m, Sn121, Sn121m, Sn123, Sn124, Sn126, Sb122, Sb124, Sb125, Sb126m, Te121, Te121m, Te123, Te123m, I129	5	3/3	•	
Sb121(n,p)Sn121	Sn121	4	2	•	
Sb121(n,p)Sn121m	Sn119m, Sn121, Sn121m	5	0		
Sb121(n,t)Sn119m	Cd113m, In113m, In115, Sn113m, Sn119m	5	0		
Sb121(n,5n)Sb117	H3, Cd113m, In113m, In115, Sn113m	5	0		
Sb122(n,γ)**Sb123**	Sb124, Sb125, Sb126m	5	0		
Sb123(n,2n)Sb122	H3, Sn113m, Sn119m, Sn121, Sn121m, Sn123, Sb119, Sb120m, Sb122, Te121, Te121m, Te123, Te123m	5	1	•	
Sb123(n,2n)Sb122m	Sn119m, Sn121, Sn121m, Sb119, Sb122, Te121, Te121m, Te123, Te123m	4	2	•	
Sb123(n,4n)Sb120m	Cd113m, In113m, In115, Sn113m, Sn119m, Sb120m	4	0		
Sb123(n,γ)Sb124	Sn121, Sn121m, Sn124, Sn126, Sb124, Sb125, Sb126m, Te123, Te123m, I129	5	4/2/2	•	
Sb123(n,γ)Sb124m	Sn121, Sn121m, Sn124, Sn126, Sb124, Sb125, Te123, Te123m, I129	4	2	•	
Sb123(n,p)Sn123	Sn121, Sn121m, Sn123, Sn124, Sn126	5	1/2	•	
Sb123(n,t)Sn121	Sn121	5	0		
Sb123(n,t)Sn121m	Cd113m, In113m, In115, Sn113m, Sn119m, Sn121, Sn121m	5	0		
Sb123(n,5n)Sb119	H3, Cd113m, In113m, In115, Sn113m, Sn119m, Sb119	5	0		
Sb124(n,γ)Sb125	Sn126, Sb125, Sb126m, I129	5	2	•	
Sb125(n,γ)Sb126m	Sn126, Sb126m, I129	4	0		
Sb125(n,γ)Sb126n	Sb126m, I129	5	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Sb125(n,p)Sn125	Sn126	4	0		
Sb126(n,p)Sn126	Sn126	5	0		
Te120(n,γ)Te121m	H3, Sb125, Sb126m, Te121	5	2	•	
Te120(n,γ)Te121	H3, Sb125, Sb126m, Te121	5	2	•	
Te122(n,2n)Te121m	H3, Sn113m, Sn121, Sn121m, Sb119, Te121, Te121m	5	4	•	
Te122(n,2n)Te121	H3, Sn121, Sn121m, Sb119, Sb120m, Te121	4	4	•	
Te122(n,γ)Te123m	Sn121, Sn121m, Te123, Te123m, Te125m	5	1	•	
Te122(n,γ)Te123	Sn121, Sn121m, Te123, Te123m, Te125m, I129	5	2	•	
Te122(n,α)Sn119m	Sn119m	5	0		
Te123(n,2n)**Te122**	Sn121, Sn121m, Te121	4	0		
Te123(n,α)**Sn120**	Sn121, Sn121m	5	2	•	
Te123m(n,α)**Sn120**	Sn121, Sn121m	5	0		
Te124(n,2n)Te123m	H3, Te121, Te123, Te123m, Te125m	5	4	•	
Te124(n,4n)Te121m	H3, Sn121, Te121	4	0		
Te124(n,4n)Te121	Sn121, Te121	4	0		
Te124(n,γ)Te125m	Te125m	5	2	•	
Te124(n,α)Sn121	Sn121	4	1	•	
Te124(n,α)Sn121m	Sn121, Sn121m	5	0		
Te125(n,2n)**Te124**	H3, Sn121, Sn121m, Sb124, Te121, Te123m, Te125m	4	0		
Te125(n,3n)Te123m	H3, Sn121, Te121, Te123m, Te125m	5	0		
Te125(n,nα)Sn121	Sn121	5	0		
Te125(n,nα)Sn121m	Sn121, Sn121m	5	0		
Te125(n,γ)**Te126**	H3, Te127, Te127m, I128, I129	4	4	•	
Te125(n,p)Sb125	Sb125	4	0		
Te125(n,d)Sb124m	Sb124	4	0		
Te125(n,α)**Sn122**	Sn121, Sn121m, Sb124, Sb125, Sb126m	5	0		
Te125(n,5n)Te121m	H3, Sn121, Te121	4	0		
Te126(n,2n)Te125m	H3, Sn121, Sn121m, Sb124, Sb125, Te121, Te123m, Te125m	5	2	•	
Te126(n,2nα)Sn121	Sn121	4	0		
Te126(n,2nα)Sn121m	Sn121, Sn121m	4	0		
Te126(n,4n)Te123m	H3, Sn121, Sn121m, Te121, Te123m, Te125m	5	0		
Te126(n,γ)Te127	H3, Te127, Te129, Te129m, I128, I129, Xe131m	5	4	•	
Te126(n,γ)Te127m	H3, Sn126, Te127, Te127m, Te129, Te129m, I128, I129, I130	5	2	•	
Te126(n,p)Sb126n	Sn126, Sb126m	4	2	•	
Te126(n,p)Sb126	Sn126, Sb125	5	2	•	
Te126(n,p)Sb126m	Sn126, Sb126m	5	2	•	
Te126(n,d)Sb125	Sn121, Sn121m, Sb125, Te121, Te123m, Te125m	5	0		
Te127m(n,γ)Te128	Sn126, Te129, Te129m, I129, I130	4	2	•	
Te127m(n,2p)Sn126	Sn126	5	0		
Te128(n,2n)Te127m	H3, Sn121, Sn121m, Sb125, Sb126m, Te123m, Te125m, Te127, Te127m, I128, Xe127	5	2	•	
Te128(n,2n)Te127	H3, Sb126m, Te127	4	4	•	
Te128(n,3n)**Te126**	H3, Sn121, Sn121m, Sb125, Sb126m, Te121, Te123m, Te125m	4	0		
Te128(n,nt)Sb125	H3, Sn121, Sn121m, Sb125, Te121, Te123m, Te125m	5	0		
Te128(n,4n)Te125m	H3, Sn121, Sn121m, Sb125, Te121, Te123m, Te125m	4	0		
Te128(n,γ)Te129	Sn126, Te129, I129, I130, Xe131m, Cs134, Cs137	5	4	•	
Te128(n,γ)Te129m	Sn126, Te129, Te129m, I129, I130, Xe131m	5	2	•	
Te128(n,t)Sb126m	Sn121, Sn121m, Sb125, Sb126m, Te123m, Te125m	4	0		
Te128(n,t)Sb126n	Sb125, Sb126m, Te123m, Te125m	4	0		
Te128(n,h)Sn126	Sn121, Sn126	5	0		
Te128(n,4nα)Sn121m	Sn121, Sn121m	4	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Te129m(n,α)Sn126	Sn126	5	0		
Te130(n,2n)Te129m	H3, Sn126, Sb125, Sb126m, Te127, Te127m, Te129, Te129m, I128, I129, I130, Xe127	5	4	•	
Te130(n,2n)Te129	H3, Sb125, Sb126m, Te129, I128, I129, I130, Xe127	4	6	•	•
Te130(n,nα)Sn126	Sn121, Sn121m, Sn126, Sb125	5	0		
Te130(n,4n)Te127m	H3, Sn121, Sn121m, Sb125, Te121, Te123m, Te125m, Te127, Te127m, I128, Xe127	5	0		
Te130(n,γ)Te131	I128, I130, I131, Xe127, Xe131m, Cs134, Cs137, Ba137m	5	2	•	
Te130(n,γ)Te131m	I130, I131, Xe127, Xe131m, Cs134, Cs137, Ba137m	4	4	•	
Te130(n,d)Sb129	H3, Te129, Te129m, I128, I129, I130, Xe127	4	0		
Te130(n,6n)Te125m	H3, Sn121, Sn121m, Te121, Te123m, Te125m	4	0		
I125(n,2n)I124	Sn121, Sn121m, Te121, I124	5	0		
I125(n,γ)I126	H3, Sn121m, Sb125, Sb126m, I129, Xe127	5	2	•	
I126(n,γ)**I127**	I129	5	2	•	
I126(n,α)**Sb123**	Sn121m, Sb125, Sb126m, Te121	5	0		
I127(n,2n)I126	H3, Sn121, Sn121m, Sn126, Sb124, Sb125, Sb126m, Te121, Te127, Te127m, I124, I125, I126, Xe124, Xe127	5	6	•	•
I127(n,3n)I125	H3, Sn121, Sn121m, Sb124, Sb125, Te121, I124, I125	5	2	•	
I127(n,4n)I124	H3, Sn121, Sn121m, Sb124, Te121, I124	5	0		
I127(n,γ)I128	H3, Sn126, Sb124, Sb125, Sb126m, Te127, Te127m, Te129, Te129m, I128, I129, I130, Xe127, Xe129m, Xe131m, Cs134, Cs135, Cs136, Cs137	5	5_2	•	•
I127(n,p)Te127	Te127	5	2	•	
I127(n,p)Te127m	Sn126, Sb126m, Te127, Te127m, Te129, Te129m	5	2	•	
I127(n,d)**Te126**	H3, Sn121, Sn121m, Sn126, Sb124, Sb125, Sb126m, Te121	4	0		
I127(n,h)Sb125	Sn121, Sb125	5	5_3		•
I127(n,α)Sb124	Sn121, Sn121m, Sb124, Sb125, Sb126m, Te121	5	5_0		•
I127(n,α)Sb124m	Sn121, Sn121m, Sb124, Sb125, Te121	4	2	•	
I128(n,α)Sb125	Sb124, Sb125, Sb126m	5	0		
I129(n,2n)I128	Sn121, Sn121m, Sb125, I128, Xe127	4	2	•	
I129(n,nα)Sb125	Sn121, Sn121m, Sb125	5	0		
I129(n,γ)I130	I130, Xe127, Xe131m, Cs134, Cs137	4	2	•	
I129(n,γ)I130m	I130, Xe131m, Cs134	5	2	•	
Xe124(n,2n)Xe123	Te121	4	2	•	
Xe124(n,γ)Xe125	H3, Sn121, Sn121m, Sb125, Sb126m, I125, I129, Xe127	5	2/2	•	
Xe124(n,p)I124	Sn121, Sn121m, I124	5	0		
Xe124(n,α)Te121	Sn121, Sn121m, Sb125, Sb126m, Te121	5	0		
Xe124(n,α)Te121m	Sn121, Sn121m, Sb125, Te121	4	0		
Xe125(n,2n)Xe124	Xe124	5	0		
Xe125(n,α)**Te122**	Sn121, Sn121m	5	2	•	
Xe126(n,2n)Xe125	Sn121, Sn121m, Sb125, Te121, I124, I125, Xe124	5	2	•	
Xe126(n,2n)Xe125m	Sn121, Sn121m, Sb125, Te121, I124, I125, Xe124	4	2	•	
Xe126(n,3n)Xe124	Te121, I124, Xe124	5	0		
Xe126(n,γ)Xe127	Sn121, Sn121m, Sb125, Sb126m, I129, Xe127	5	2/2	•	
Xe126(n,α)Te123	Sn121, Sn121m, Te121	5	0		
Xe126(n,α)Te123m	Sn121, Sn121m, Te121	4	0		
Xe127(n,α)**Te124**	Sn121, Sn121m	4	2	•	
Xe128(n,2n)Xe127	H3, Sn121, Sn121m, Sb125, Sb126m, I124, I125, Xe127	5	2/2	•	
Xe128(n,γ)**Xe129**	Te127, Te127m, I129, I130, Xe129m, Xe131m, Cs134, Cs135, Cs136, Cs137	5	2	•	

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Xe128(n,γ)Xe129m	Te127, I129, I130, Xe129m, Xe131m, Cs134, Cs135, Cs136	5	2	•	
Xe128(n,α)**Te125**	Sn121, Sn121m, Sb124, Sb125, Te127, Te127m	5	0		
Xe129(n,n')Xe129m	Xe129m	4	0		
Xe129(n,2n)**Xe128**	H3, Sn121, Sn121m, Sb125, Sb126m, Te121, I124, I125, Xe127	5	0		
Xe129(n,3n)Xe127	H3, Sn121, Sn121m, Sb125, Sb126m, Te121, I124, I125, Xe127	4	0		
Xe129(n,3n)Xe127m	H3, Sn121, Sn121m, Sb125, Sb126m, Te121, I124, I125, Xe127	5	0		
Xe129(n,nt)I126	Sn121, Sn121m, Sb125, Sb126m, Te121, I124, I125	4	0		
Xe129(n,γ)**Xe130**	I130, Xe131m, Xe133, Xe134m, Cs134, Cs135, Cs136, Cs137	5	2	•	
Xe129(n,p)I129	Sb125, Sb126m, I129, I130	5	0		
Xe129(n,α)**Te126**	Sn121, Sn121m, Sb125, Sb126m, Te127, Te127m	5	0		
Xe129(n,5n)Xe125m	Sn121, Sn121m, Sb125, Te121, I124, I125	5	0		
Xe130(n,2n)Xe129m	H3, Sn121, Sn121m, I125, I129, Xe127, Xe129m	5	1	•	
Xe130(n,4n)Xe127m	Sn121, Sn121m, Sb125, Sb126m, I124, I125, Xe127	4	0		
Xe130(n,γ)**Xe131**	Xe131m, Xe133, Xe134m, Cs134, Cs135, Cs136, Cs137	5	2	•	
Xe130(n,γ)Xe131m	Xe131m, Xe133, Xe134m, Cs134, Cs135, Cs136	5	2	•	
Xe131(n,n')Xe131m	Xe131m	4	0		
Xe131(n,2n)**Xe130**	H3, Sn121, Sn121m, Sb125, Sb126m, I124, I125, I129, Xe127, Xe129m	5	0		
Xe131(n,3n)Xe129m	H3, Sn121, Sn121m, Sb125, Sb126m, Te121, I124, I125, I129, Xe127, Xe129m	5	0		
Xe131(n,γ)**Xe132**	Xe133, Xe134m, Xe135, Xe135m, Cs134, Cs135, Cs136, Cs137, Ba137m	5	2	•	
Xe131(n,t)I129	H3, Sn121, Sn121m, Sb125, Sb126m, Te121, I124, I125, I129	5	0		
Xe131(n,α)Te128	Sn121, Sn121m, Sb125, Sb126m, I129	5	0		
Xe131(n,5n)Xe127m	Sn121, Sn121m, Sb125, Sb126m, I124, I125, Xe127	4	0		
Xe132(n,2n)**Xe131**	H3, Sn121, Sn121m, Sb125, I129, Xe127, Xe129m, Xe131m	4	0		
Xe132(n,2n)Xe131m	H3, Sb125, Sb126m, I125, I129, Xe127, Xe129m, Xe131m	5	2	•	
Xe132(n,nt)I129	H3, Sn121, Sn121m, Sb125, Sb126m, Te121, I124, I125, I129	4	0		
Xe132(n,4n)Xe129m	H3, Sn121, Sn121m, Sb125, Sb126m, Te121, I124, I125, I129, Xe127, Xe129m	5	0		
Xe132(n,γ)Xe133	Xe133, Xe134m, Xe135, Xe135m, Cs134, Cs135, Cs136, Cs137, Ba137m	5	2	•	
Xe132(n,γ)Xe133m	Xe133, Xe134m, Cs134, Cs135, Cs136, Cs137, Ba137m	5	2	•	
Xe132(n,α)Te129	Sb125, Sb126m, I129, Xe127	4	0		
Xe133(n,γ)Xe134m	Xe134m, Cs137	5	0		
Xe133m(n,γ)Xe134m	Xe134m	5	0		
Xe134(n,n')Xe134m	Xe134m	5	0		
Xe134(n,2n)Xe133	H3, Xe131m, Xe133	5	2	•	
Xe134(n,2n)Xe133m	Xe133	4	2	•	
Xe134(n,4n)Xe131m	H3, Sb125, Sb126m, I125, I129, Xe127, Xe129m, Xe131m	4	0		
Xe134(n,γ)Xe135	Xe135, Cs134, Cs135, Cs136, Cs137, Ba137m	5	2	•	
Xe134(n,γ)Xe135m	Xe135, Xe135m, Cs135, Cs136	5	2	•	
Xe134(n,d)I133	Xe133	4	0		
Xe136(n,2n)Xe135	H3, Xe134m, Xe135, Cs134, Cs135, Cs136, Ba133	5	2	•	
Xe136(n,2n)Xe135m	Xe134m, Xe135, Xe135m, Cs134, Cs135,	5	2	•	

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
	Cs136, Ba133				
Xe136(n,3n)Xe134m	H3, Xe133, Xe134m	5	0		
Xe136(n,4n)Xe133m	I129, Xe133, Cs134, Ba133	5	0		
Xe136(n,γ)Xe137	Cs134, Cs136, Cs137, Ba133, Ba137m	5	2	•	
Xe136(n,d)I135	Xe135, Xe135m, Cs134, Cs135, Cs136, Ba133	5	0		
Cs131(n,2n)Cs130	Cs130, Ba129m	5	0		
Cs131(n,γ)Cs132	I129, Xe131m, Xe133, Cs134, Cs136, Cs137	5	0		
Cs132(n,2n)Cs131	Xe127, Xe129m, Cs130, Cs131	4	0		
Cs132(n,3n)Cs130	Cs130	4	0		
Cs132(n,α)I129	Sb125, I129, Xe127, Xe131m	5	2	•	
Cs133(n,2n)Cs132	H3, Sn121, Sn121m, Sb125, I129, Xe127, Xe129m, Xe131m, Cs130, Cs131, Cs132, Ba133	5	6	•	•
Cs133(n,3n)Cs131	H3, Sn121, Sn121m, Sb125, I129, Xe127, Xe129m, Xe131m, Cs130, Cs131	5	1	•	
Cs133(n,nα)I129	Sn121, Sn121m, Sb125, I129, Xe127	5	0		
Cs133(n,4n)Cs130	H3, Sn121, Sn121m, Sb125, I129, Xe127, Xe129m, Cs130	4	0		
Cs133(n,4n)Cs130m	Sn121, Sn121m, Sb125, I129, Xe127, Xe129m, Cs130	5	0		
Cs133(n,γ)Cs134	H3, I129, Xe131m, Xe133, Cs134, Cs135, Cs136, Cs137, Ba133, Ba135m, Ba137m	5	4	•	
Cs133(n,γ)Cs134m	H3, I129, Xe131m, Xe133, Cs134, Cs135, Cs136, Cs137, Ba133, Ba137m	4	3	•	
Cs133(n,p)Xe133	Xe133	5	2	•	
Cs133(n,p)Xe133m	Xe133	5	2	•	
Cs133(n,t)Xe131m	Sn121, Sn121m, Sb125, I129, Xe127, Xe129m, Xe131m	5	0		
Cs133(n,5n)Cs129	H3, Sn121, Sn121m, I129, Xe127, Xe129m	4	0		
Cs133(n,2nt)Xe129m	Sn121, Sn121m, Xe127, Xe129m	5	0		
Cs133(n,4nα)I126	Sn121, Sn121m, Sb125	4	0		
Cs134(n,γ)Cs135	Xe133, Cs135, Cs136, Cs137, Ba137m	5	2/0	•	
Cs134(n,α)I131	I129, Xe131m, Xe133	5	0		
Cs135(n,2n)Cs134	Xe127, Cs134, Ba133	4	0		
Cs135(n,γ)Cs136	Xe133, Cs134, Cs136, Cs137, Ba133, Ba137m	5	2/0	•	
Cs136(n,γ)Cs137	Cs136, Cs137, Ba137m	5	0		
Cs136(n,α)I133	Xe133, Cs134	5	0		
Cs137(n,2n)Cs136	Cs136, Ba133	4	0		
Ba130(n,2n)Ba129	I129, Xe127	4	0		
Ba130(n,2n)Ba129m	I129, Xe127, Ba129m	4	2	•	
Ba130(n,γ)Ba131	I129, Xe131m, Xe133, Cs131, Cs134, Cs136, Cs137, Ba131, Ba133	5	2	•	
Ba130(n,γ)Ba131m	I129, Xe131m, Xe133, Cs131, Cs136, Ba131, Ba133	4	2	•	
Ba130(n,α)Xe127	Xe127, Xe131m	5	0		
Ba131(n,2n)**Ba130**	Cs130, Ba129m	4	0		
Ba132(n,2n)Ba131	I129, Xe129m, Xe131m, Cs130, Cs131, Ba129m, Ba131	4	6	•	•
Ba132(n,2n)Ba131m	I129, Xe127, Xe131m, Cs130, Cs131, Ba129 m, Ba131	4	4	•	
Ba132(n,γ)Ba133	Xe131m, Cs134, Cs135, Cs136, Cs137, Ba133, Ba135m	5	2/2	•	
Ba133(n,3n)Ba131m	I129, Xe131m, Cs131, Ba129m, Ba131	4	0		
Ba133(n,α)**Xe130**	Xe131m	5	0		
Ba134(n,2n)Ba133	I129, Xe127, Xe131m, Xe133, Cs131, Ba129m, Ba131, Ba133	4	3	•	
Ba134(n,2n)Ba133m	I129, Xe127, Xe131m, Xe133, Cs131, Ba129m, Ba131, Ba133	4	6	•	•
Ba134(n,4n)Ba131m	I129, Xe127, Xe131m, Cs131, Ba131	4	0		
Ba134(n,γ)**Ba135**	Xe133, Ba137m	5	5_2	•	•
Ba134(n,γ)Ba135m	Xe133, Ba135m, Ba137m	5	4	•	
Ba134(n,p)Cs134	Cs134	4	2/0	•	
Ba134(n,α)Xe131m	I129, Xe127, Xe131m	4	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Ba135(n,2n)**Ba134**	I129, Xe127, Xe131m, Xe133, Cs131, Cs134, Ba129m, Ba131, Ba133	4	0		
Ba135(n,3n)Ba133	I129, Xe127, Xe131m, Xe133, Cs131, Ba129m, Ba131, Ba133	4	0		
Ba135(n,3n)Ba133m	I129, Xe127, Xe131m, Xe133, Cs131, Ba129m, Ba131, Ba133	4	0		
Ba135(n,nα)Xe131m	I129, Xe127, Xe131m	4	0		
Ba135(n,d)Cs134	I129, Xe131m, Xe133, Cs131, Cs134, Ba131	4	0		
Ba135(n,α)**Xe132**	I129, Xe131m, Xe133	5	0		
Ba135(n,5n)Ba131m	I129, Xe127, Xe131m, Cs131, Ba131	4	0		
Ba136(n,2n)Ba135m	I129, Xe131m, Cs131, Cs134, Cs135, Ba131, Ba133, Ba135m	5	6	•	•
Ba136(n,4n)Ba133	I129, Xe127, Xe131m, Cs131, Ba129m, Ba131, Ba133	4	0		
Ba136(n,4n)Ba133m	I129, Xe127, Xe131m, Cs131, Ba129m, Ba13	4	0		
Ba136(n,γ)Ba137m	Ba137m	5	2	•	
Ba136(n,p)Cs136	Cs136	4	1/0	•	
Ba136(n,α)Xe133	I129, Xe131m, Xe133, Cs134	4	0/1	•	
Ba137(n,3n)Ba135m	I129, Xe127, Xe131m, Cs131, Cs134, Cs135, Ba131, Ba133, Ba135m	4	0		
Ba137(n,nα)Xe133m	I129, Xe131m, Xe133, Cs131	4	0		
Ba137(n,p)Cs137	Cs135, Cs136, Cs137	5	2	•	
Ba137(n,d)Cs136	Xe131m, Cs136, Ba135m	4	0		
Ba138(n,2n)Ba137m	I129, Xe131m, Xe133, Cs131, Cs134, Cs135, Cs136, Cs137, Ba131, Ba133, Ba135m, Ba137m	5	6	•	•
Ba138(n,2nα)Xe133m	I129, Xe131m, Xe133, Cs131	5	0		
Ba138(n,nt)Cs135	I129, Xe127, Xe131m, Xe133, Cs131, Cs134, Cs135	5	0		
Ba138(n,4n)Ba135m	I129, Xe127, Xe131m, Xe133, Cs131, Cs134, Cs135, Ba131, Ba133, Ba135m	5	0		
Ba138(n,γ)Ba139	Cs137, Ba139, La137, La138, La140, Ce141	5	6*	•	•
Ba138(n,d)Cs137	I129, Xe131m, Xe133, Cs131, Cs134, Cs135, Cs136, Cs137, Ba137m	5	0		
Ba138(n,t)Cs136	Xe131m, Xe133, Cs131, Cs134, Cs136, Ba131, Ba133	5	0		
Ba138(n,α)Xe135	I129, Cs131, Cs134, Cs135	4	2	•	
Ba138(n,α)Xe135m	I129, Xe133, Cs131, Cs134, Cs135	4	4	•	
Ba138(n,2nt)Cs134	I129, Xe131m, Xe133, Cs131, Cs134, Ba131	4	0		
Ba138(n,4nα)Xe131m	I129, Xe127, Xe131m	4	0		
La137(n,2n)La136	Cs134, Cs135, Cs136, Ba133, Ba137m, La136	5	0		
La137(n,2n)La136m	Cs134, Cs135, Cs136, Ba133, La136	4	0		
La137(n,3n)La135	Xe127, Cs134, Cs135, Ba129m, Ba133, La135	5	0		
La137(n,γ)La138	H3, Cs135, Ba137m, La138, La140	5	0		
La137(n,α)Cs134	Cs134, Cs135, Ba133	4	0		
La137(n,5n)La133	Xe127, Ba129m, Ba133	5	0		
La138(n,2n)La137	H3, Xe127, Cs134, Cs135, Cs136, Cs137, Ba133, Ba137m, La136, La137	5	0		
La138(n,3n)La136	Cs134, Cs135, Cs136, Ba133, La136	4	0		
La138(n,4n)La135	Xe127, Cs134, Cs135, Ba129m, Ba133, La135	4	0		
La138(n,γ)**La139**	Cs137, Ba137m, La140, Ce141	5	2	•	
La138(n,d)Ba137m	Cs135, Cs136, Cs137, Ba137m	4	0		
La138(n,α)Cs135	Cs134, Cs135, Cs136, Cs137, Ba129m, Ba133, Ba137m	5	0		
La139(n,2n)La138	H3, Xe127, Cs134, Cs135, Cs136, Cs137, Ba129m, Ba133, Ba137m, La135, La136, La137, La138	5	0		
La139(n,3n)La137	H3, Xe127, Cs134, Cs135, Cs136, Cs137, Ba133, Ba137m, La135, La136, La137	5	0		
La139(n,nα)Cs135	Xe127, Cs134, Cs135, Ba133	5	0		
La139(n,2nα)Cs134	Xe127, Cs134	4	0		
La139(n,2nα)Cs134m	Cs134	4	0		
La139(n,4n)La136	H3, Xe127, Cs134, Cs135, Cs136, Ba133, La136	5	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
La139(n,4n)La136m	Xe127, Cs134, Cs135, Cs136, Ba133, La136	4	0		
La139(n,γ)La140	Cs137, Ba137m, La135, La138, La140, Ce139, Ce141, Pm147	5	6*	•	•
La139(n,d)**Ba138**	H3, Cs134, Cs135, Cs136, Cs137, Ba133, Ba137m	5	0		
La139(n,t)Ba137m	Xe127, Cs134, Cs135, Cs136, Cs137, Ba133, Ba137m	5	2	•	
La139(n,h)Cs137	Cs134, Cs135, Cs136, Cs137	5	5_3		•
La139(n,α)Cs136	Cs134, Cs135, Cs136, Cs137, Ba133	5	6	•	•
La139(n,5n)La135	H3, Xe127, Cs134, Cs135, Ba133, La135	5	0		
La140(n,γ)La141	La138, Ce139, Ce141, Pm147	5	2	•	
La140(n,α)Cs137	Cs137, Ba137m	5	0		
La141(n,γ)La142	Pm147	4	0		
Ce136(n,2n)Ce135	Cs134, Cs135, Ba129m, Ba133, La135, Ce135	5	0		
Ce136(n,nα)**Ba132**	Ba129m	4	0		
Ce136(n,4n)Ce133m	Ba129m, Ba133	4	0		
Ce136(n,γ)Ce137	H3, Cs134, Cs135, Ba137m, La137, La138, La140, Ce137, Ce139, Ce139m	5	2/2	•	
Ce136(n,α)Ba133	Cs134, Cs135, Ba129m, Ba133, Ba137m	5	0		
Ce137m(n,2n)Ce136	La135, Ce135	4	0		
Ce138(n,2n)Ce137m	H3, Cs134, Cs135, Ba137m, La135, La136, La137, Ce135, Ce137	5	4	•	
Ce138(n,3n)Ce136	H3, Cs134, Ba129m, Ba133, La136, Ce135, Ce136	5	0		
Ce138(n,4n)Ce135	Cs134, Cs135, Ba129m, Ba133, Ce135	4	0		
Ce138(n,γ)Ce139	Ba137m, La140, Ce139	5	2	•	
Ce138(n,γ)Ce139m	La140, Ce139, Ce139m	5	2	•	
Ce139(n,2n)**Ce138**	Cs134, Ba133, La135, La136, La137, Ce135, Ce136, Ce137	4	0		
Ce139(n,α)**Ba136**	Ba133, Ba137m	5	0		
Ce140(n,2n)Ce139	H3, Cs134, Cs135, Cs137, Ba129m, Ba133, Ba137m, La135, La136, La137, La138, La140, Ce135, Ce136, Ce137, Ce139, Ce139m	5	2	•	
Ce140(n,2n)Ce139m	H3, Cs134, Cs135, Ba133, Ba137m, La135, La136, La137, La138, La140, Ce135, Ce136, Ce137, Ce139, Ce139m	5	6	•	•
Ce140(n,3n)**Ce138**	H3, Cs134, Cs135, Ba129m, Ba133, Ba137m, La136, La137, La138, Ce135, Ce136, Ce137	5	0		
Ce140(n,4n)Ce137	H3, Cs134, Cs135, Ba129m, Ba133, Ba137m, La136, La137, Ce137	4	0		
Ce140(n,4n)Ce137m	Cs134, Cs135, Ba129m, Ba133, Ba137m, La136, La137, Ce137	5	0		
Ce140(n,γ)Ce141	Cs135, La138, Ce139, Ce141, Ce143, Ce144, Pr142, Pr143, Pr144, Pm147, Sm147	5	4	•	
Ce140(n,p)La140	Cs137, La140	5	4	•	
Ce140(n,t)La138	H3, Cs134, Cs135, Ba129m, Ba133, Ba137m, La136, La137, La138	5	0		
Ce140(n,α)**Ba137**	Cs134, Cs135, Cs137, Ba133, Ba137m	4	0		
Ce140(n,α)Ba137m	Cs134, Cs135, Cs137, Ba129m, Ba133, Ba137m	5	6	•	•
Ce140(n,5n)Ce136	H3, Cs134, Cs135, Ba129m, Ba133, La136, Ce135, Ce136	5	0		
Ce140(n,2nt)La136	Cs134, Cs135, Ba129m, Ba133, La136	4	0		
Ce142(n,2n)Ce141	H3, Ba137m, La140, Ce139, Ce139m, Ce141, Pr142	5	4	•	
Ce142(n,4n)Ce139m	Cs134, Cs135, Ba137m, La136, La137, La138, Ce136, Ce139, Ce139m	4	0		
Ce142(n,γ)Ce143	Ce143, Ce144, Pr142, Pr143, Pr144, Pm147, Sm147	5	4	•	
Ce142(n,d)La141	Ce141, Pr142	4	0		
Ce142(n,t)La140	La140	4	0		
Ce143(n,γ)Ce144	Ce144, Pr144, Pm147, Sm147	5	2	•	
Pr141(n,2n)Pr140	H3, Cs134, Cs135, Cs137, Ba129m, Ba133,	5	5_2	•	•

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
	Ba137m, La137, La138, La140, Ce135, Ce139, Ce139m, Ce141, Pr140				
Pr141(n,3n)Pr139	H3, Cs134, Cs135, Cs137, Ba129m, Ba133, Ba137m, La137, La138, La140, Ce135, Ce139, Pr139	5	4	•	
Pr141(n,4n)Pr138	H3, Cs134, Cs135, Ba129m, Ba133, La137, La138, Ce135	4	0		
Pr141(n,4n)Pr138m	H3, Cs134, Cs135, Ba129m, Ba133, La137, La138, Ce135, Pr138m	5	0		
Pr141(n,γ)Pr142	H3, Cs137, Ba137m, La140, Ce139, Ce141, Ce144, Pr138m, Pr139, Pr142, Pr143, Pr144, Nd144, Nd147, Pm147, Pm148m, Sm147	5	2	•	
Pr141(n,γ)Pr142m	H3, Cs137, Ba137m, La140, Ce139, Ce141, Ce144, Pr138m, Pr139, Pr142, Pr143, Pr144, Nd144, Nd147, Pm147, Pm148m, Sm147	5	2	•	
Pr141(n,p)Ce141	La140, Ce141, Ce144, Pr143	5	4	•	
Pr141(n,d)**Ce140**	H3, Cs135, Cs137, Ba129m, Ba133, Ba137m, La137, La138, La140, Ce135, Ce139	4	0		
Pr141(n,α)La138	H3, Cs134, Cs135, Cs137, Ba129m, Ba133, Ba137m, La137, La138, La140, Ce141	5	2	•	
Pr141(n,5n)Pr137	Cs134, Cs135, Ba129m, Ba133, Ba137m, La137	5	0		
Pr142(n,γ)Pr143	La140, Ce141, Pr143, Pr144, Nd144, Nd147, Pm147, Pm148m, Sm147	5	2	•	
Pr142(n,α)**La139**	Cs137, Ba137m, La140, Ce141	5	0		
Pr143(n,γ)Pr144	Pr144, Nd147, Pm147, Sm147	4	0		
Pr143(n,γ)Pr144m	Pr144, Nd144, Nd147, Pm147, Pm148m, Sm147	5	0		
Nd140(n,2n)Nd139m	Pr139, Nd139m	5	0		
Nd140(n,t)Pr138m	Pr138m	5	0		
Nd141(n,2n)Nd140	Pr138m, Pr139, Nd139m, Nd140	5	0		
Nd142(n,2n)Nd141	H3, La137, La138, Ce139, Pr138m, Pr139, Pr140, Nd139m, Nd140, Nd141	5	2	•	
Nd142(n,2n)Nd141m	H3, La137, La138, Ce139, Pr138m, Pr139, Pr140, Nd139m, Nd140, Nd141, Nd141m	5	6	•	•
Nd142(n,3n)Nd140	H3, La137, La138, Ce139, Pr138m, Pr140, Nd139m, Nd140	5	0		
Nd142(n,4n)Nd139m	H3, La137, La138, Ce139, Nd139m	5	0		
Nd142(n,γ)**Nd143**	Cs135, Ba137m, La138, Ce141, Pr143, Pr144, Nd144, Nd147, Pm147, Pm148m, Sm147	5	4	•	
Nd142(n,α)Ce139	Cs135, Cs137, Ba137m, La137, La138, La140, Ce139, Ce141	5	2	•	
Nd142(n,α)Ce139m	Cs137, Ba137m, La137, La138, La140, Ce139	4	1	•	
Nd143(n,3n)Nd141m	H3, La137, La138, Ce139, Pr140, Nd139m, Nd141, Nd141m	4	0		
Nd143(n,γ)Nd144	Cs135, La138, Ce141, Pr144, Nd144, Nd147, Pm147, Pm148m, Sm147, Sm151, Eu152	5	4	•	
Nd143(n,p)Pr143	Pr143, Pr144	4	2	•	
Nd143(n,α)**Ce140**	Cs135, Ba137m, La137, La138, Ce139, Ce141	4	4	•	
Nd143(n,5n)Nd139m	La137, La138, Ce139, Nd139m	4	0		
Nd144(n,4n)Nd141m	H3, La137, La138, Ce139, Pr140, Nd141, Nd141m	4	0		
Nd144(n,γ)**Nd145**	Nd147, Nd149, Pm147, Pm148m, Sm147, Sm151, Eu152	5	4	•	
Nd144(n,p)Pr144	Pr144	4	2/2	•	
Nd144(n,α)Ce141	Cs135, La137, La138, Ce139, Ce141, Pr140	5	2	•	
Nd144(n,5n)Nd140	H3, La137, La138, Ce139, Pr140, Nd140	4	0		
Nd145(n,γ)**Nd146**	H3, Nd147, Nd149, Pm147, Pm148m, Sm147, Sm151, Eu152, Eu154	5	4	•	
Nd146(n,γ)Nd147	H3, Nd147, Nd149, Pm144, Pm145, Pm146, Pm147, Pm148m, Sm146, Sm147, Sm151, Eu152	5	4	•	
Nd148(n,2n)Nd147	H3, Nd147, Pm144, Pm145, Pm146, Pm147, Pm148m, Sm146, Sm147	5	4	•	
Nd148(n,γ)Nd149	Nd149, Pm148m, Sm146, Sm151, Eu152,	5	4	•	

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
	Eu154, Eu155, Eu156				
Nd150(n,2n)Nd149	H3, Nd149, Pm144, Pm145, Pm146, Pm147, Pm148m, Sm146, Sm147	5	5_2	•	•
Nd150(n,4n)Nd147	H3, Nd147, Pm144, Pm145, Pm146, Pm147, Pm148m, Sm146, Sm147	5	0		
Nd150(n,γ)Nd151	H3, Nd151, Pm148m, Sm146, Sm151, Eu150, Eu152, Eu154, Eu155, Eu156	5	4	•	
Nd150(n,d)Pr149	Nd149, Pm144, Pm145, Pm146, Pm148m, Sm146, Sm147	4	0		
Pm145(n,2n)Pm144	Pm144	5	0		
Pm145(n,γ)Pm146	Pm146, Sm146, Sm147	5	0		
Pm146(n,2n)Pm145	La137, La138, Pm144, Pm145	5	0		
Pm147(n,2n)Pm146	La137, La138, Pm144, Pm145, Pm146, Sm146	5	0		
Pm147(n,3n)Pm145	La137, La138, Pm144, Pm145	4	0		
Pm147(n,4n)Pm144	Pm144	5	0		
Pm147(n,γ)Pm148m	Pm148m, Sm151	5	2	•	
Pm149(n,2n)Pm148m	Pm148m	4	0		
Sm144(n,γ)Sm145	Pm145, Pm146, Sm145, Sm146, Sm147	5	4	•	
Sm144(n,α)Nd141	La137, La138	5	0		
Sm145(n,γ)Sm146	Sm146, Sm147	5	2	•	
Sm146(n,2n)Sm145	Pm144, Pm145, Sm145	5	0		
Sm146(n,p)Pm146	Pm144, Pm145, Pm146	4	0		
Sm147(n,2n)Sm146	La138, Pm144, Pm145, Pm146, Sm145, Sm146	5	0		
Sm147(n,3n)Sm145	La137, La138, Pm144, Pm145, Sm145	5	0		
Sm147(n,nt)Pm144	La137, La138, Pm144	4	0		
Sm147(n,γ)Sm148	Sm151, Sm153, Eu152, Eu154, Eu155, Eu156	4	4	•	
Sm147(n,d)Pm146	Pm144, Pm145, Pm146, Sm146	5	0		
Sm148(n,2n)Sm147	Pm144, Pm145, Pm146, Sm145, Sm146, Sm147	4	4	•	
Sm148(n,3n)Sm146	La138, Pm144, Pm145, Pm146, Sm145, Sm146	5	0		
Sm148(n,4n)Sm145	La138, Pm144, Pm145, Sm145	4	0		
Sm148(n,γ)Sm149	Sm151, Sm153, Eu152, Eu154, Eu155, Eu156	4	4	•	
Sm148(n,p)Pm148m	Pm148m	4	2	•	
Sm148(n,t)Pm146	Pm144, Pm146, Sm146	4	0		
Sm148(n,2nt)Pm144	Pm144	4	0		
Sm149(n,2n)Sm148	Pm144, Pm145, Pm146, Pm148m, Sm145, Sm146, Sm147	4	0		
Sm149(n,3n)Sm147	Pm144, Pm145, Pm146, Sm145, Sm146, Sm147	5	0		
Sm149(n,nt)Pm146	Pm144, Pm146, Sm146	4	0		
Sm149(n,4n)Sm146	La138, Pm144, Pm145, Pm146, Sm145, Sm146	5	0		
Sm149(n,γ)**Sm150**	Sm147, Sm151, Sm153, Eu152, Eu154, Eu155, Eu156	5	4	•	
Sm149(n,d)Pm148m	Pm148m, Sm145, Sm146	5	0		
Sm149(n,α)**Nd146**	Sm147	5	4	•	
Sm149(n,5n)Sm145	La138, Pm144, Pm145, Sm145	4	0		
Sm150(n,γ)Sm151	Sm151, Sm153, Sm155, Eu152, Eu154, Eu155, Eu156, Gd152	5	4	•	
Sm150(n,α)Nd147	Pm146, Sm146, Sm147	5	3	•	
Sm150(n,5n)Sm146	La138, Pm144, Pm145, Pm146, Sm145, Sm146	4	0		
Sm151(n,γ)**Sm152**	Sm153, Sm155, Eu154, Eu155, Eu156	5	2	•	
Sm152(n,2n)Sm151	Pm146, Sm145, Sm146, Sm147, Sm151, Eu150, Gd148, Gd150	5	4	•	
Sm152(n,γ)Sm153	Sm153, Sm155, Eu150, Eu152, Eu154, Eu155, Eu156, Gd148, Gd150, Tb160, Tb161	5	4*	•	
Sm153(n,γ)**Sm154**	Sm155, Eu155, Eu156, Tb160, Tb161	4	2	•	
Sm154(n,2n)Sm153	Pm146, Sm153, Eu150, Eu152, Eu154, Gd148, Gd150	5	6	•	•
Sm154(n,4n)Sm151	Pm145, Pm146, Sm145, Sm146, Sm147, Sm151, Eu150, Gd148, Gd150	5	0		
Sm154(n,γ)Sm155	Sm155, Eu150, Eu152, Eu154, Eu155, Eu156, Gd148, Gd150, Tb160, Tb161	5	4	•	
Sm154(n,d)Pm153	Sm153, Eu150, Eu152, Eu154, Gd148, Gd150	4	0		
Eu149(n,2n)Eu148	Sm146, Sm147, Eu148	5	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Eu150(n,2n)Eu149	La137, La138, Sm146, Sm147, Eu148, Eu149	5	0		
Eu150(n,3n)Eu148	Sm146, Sm147, Eu148	4	0		
Eu151(n,2n)Eu150	La137, La138, Sm146, Sm147, Eu148, Eu149, Eu150, Gd148, Gd150	5	4	•	
Eu151(n,2n)Eu150m	Sm146, Sm147, Eu148, Eu149, Gd148, Gd150	5	4	•	
Eu151(n,3n)Eu149	Sm146, Sm147, Eu148, Eu149	5	4	•	
Eu151(n,4n)Eu148	Sm146, Sm147, Eu148	5	0		
Eu151(n,γ)Eu152	H3, Sm147, Sm151, Eu152, Eu154, Eu155, Eu156, Gd152, Gd153, Gd160, Tb160, Tb161	5	2/5/2	•	
Eu151(n,γ)Eu152m	H3, Sm147, Sm151, Eu152m, Eu154, Eu155, Eu156, Gd152, Gd153, Gd160, Tb160, Tb161	5	5_2	•	•
Eu151(n,p)Sm151	Sm147, Sm151	4	0		
Eu151(n,5n)Eu147	Sm146, Sm147	5	0		
Eu151(n,6n)Eu146	Sm146	5	0		
Eu152(n,2n)**Eu151**	Sm146, Sm147, Sm151, Eu148, Eu149, Eu150, Gd148, Gd150	4	0		
Eu152(n,γ)**Eu153**	Sm151, Eu154, Eu155, Eu156, Gd160, Tb160, Tb161	4	4	•	
Eu152(n,α)Pm149	Sm147, Sm151	4	0		
Eu153(n,2n)Eu152	Sm146, Sm147, Sm151, Eu148, Eu149, Eu150, Eu152, Eu152m, Gd148, Gd150, Gd152, Gd153	5	4/4/4	•	
Eu153(n,2n)Eu152m	Sm151, Eu150, Eu152m, Gd148, Gd150, Gd152, Gd153	5	4	•	
Eu153(n,4n)Eu150	Sm146, Sm147, Eu148, Eu149, Eu150, Gd148, Gd150	5	0		
Eu153(n,4n)Eu150m	Sm146, Sm147, Gd148, Gd150	5	0		
Eu153(n,γ)Eu154	Sm151, Eu154, Eu155, Eu156, Gd152, Gd153, Gd160, Tb160, Tb161	5	4/0	•	
Eu153(n,t)Sm151	Sm146, Sm147, Sm151	5	0		
Eu153(n,5n)Eu149	Sm146, Sm147, Eu149	5	0		
Eu153(n,6n)Eu148	Sm146, Sm147, Eu148	5	0		
Eu154(n,γ)Eu155	Eu155, Eu156, Gd160, Tb160, Tb161	5	4	•	
Eu155(n,2n)Eu154	Sm151, Eu154, Gd148, Gd150, Gd153	4	0		
Eu155(n,γ)Eu156	Eu156, Gd160, Tb160, Tb161	5	4	•	
Eu156(n,γ)Eu157	Gd160, Tb160, Tb161	5	0		
Eu156(n,α)Pm153	Eu154, Eu155, Gd150	4	0		
Gd149(n,2n)Gd148	Sm147, Gd148	5	0		
Gd150(n,2n)Gd149	Sm146, Sm147, Eu148, Eu149, Gd148	5	0		
Gd150(n,3n)Gd148	Gd148	5	0		
Gd150(n,nα)Sm146	Sm146	4	0		
Gd151(n,2n)Gd150	Gd148, Gd150	5	0		
Gd152(n,2n)Gd151	La138, Sm151, Eu150, Gd148, Gd150	5	2	•	
Gd152(n,3n)Gd150	Eu150, Gd148, Gd150	4	0		
Gd152(n,γ)Gd153	Sm147, Sm151, Eu152, Eu154, Eu155, Eu156, Gd153, Gd160, Tb160, Tb161	5	4	•	
Gd152(n,α)Sm149	La137, La138, Sm147, Sm151, Eu152	5	2	•	
Gd152(n,5n)Gd148	Gd148	4	0		
Gd153(n,2n)Gd152	Eu150, Gd148, Gd150, Gd152	4	0		
Gd153(n,4n)Gd150	Eu150, Gd148, Gd150	4	0		
Gd153(n,γ)**Gd154**	Sm151, Eu152, Gd152, Gd160, Tb160, Tb161	5	2	•	
Gd153(n,α)**Sm150**	Sm147, Sm151, Eu152, Gd152	4	2	•	
Gd154(n,2n)Gd153	Sm151, Eu150, Eu152, Eu154, Gd148, Gd150, Gd152, Gd153	5	2	•	
Gd154(n,3n)Gd152	Eu150, Eu152, Gd148, Gd150, Gd152	4	0		
Gd154(n,p)Eu154	Eu152, Eu154	4	0		
Gd154(n,α)Sm151	Sm151, Eu152, Gd152	5	2	•	
Gd155(n,2n)**Gd154**	Sm151, Eu150, Eu152, Eu154, Gd148, Gd150, Gd152, Gd153	5	4	•	
Gd155(n,3n)Gd153	Sm151, Eu150, Eu152, Gd148, Gd150, Gd152, Gd153	5	0		
Gd155(n,nα)Sm151	Sm151	5	0		
Gd155(n,nt)Eu152	Sm151, Eu150, Eu152	4	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Gd155(n,4n)Gd152	Eu150, Eu152, Gd148, Gd150, Gd152	5	0		
Gd155(n,γ)**Gd156**	Gd159, Gd160, Tb160, Tb161, Tb162	4	4	•	
Gd155(n,p)Eu155	Eu150, Eu152, Eu154, Eu155	5	0		
Gd155(n,d)Eu154	Sm151, Eu150, Eu152, Eu154	4	0		
Gd155(n,6n)Gd150	Eu150, Gd148, Gd150	5	0		
Gd156(n,2n)**Gd155**	Sm151, Eu150, Eu152, Eu154, Eu155, Gd148, Gd150, Gd152, Gd153	4	4	•	
Gd156(n,3n)**Gd154**	Sm151, Eu150, Eu152, Eu154, Gd148, Gd150, Gd152, Gd153	4	0		
Gd156(n,2nα)Sm151	Sm151	4	0		
Gd156(n,4n)Gd153	Sm151, Eu150, Eu152, Gd148, Gd150, Gd152, Gd153	5	0		
Gd156(n,γ)**Gd157**	Eu155, Gd159, Gd160, Tb160, Tb161, Tb162	5	4	•	
Gd156(n,p)Eu156	Eu155, Eu156	5	2	•	
Gd156(n,d)Eu155	Sm151, Eu150, Eu152, Eu154, Eu155, Gd150, Gd152	5	0		
Gd156(n,t)Eu154	Sm151, Eu150, Eu152, Eu154, Gd150	4	0		
Gd156(n,α)Sm153	Sm151, Eu150, Eu152, Eu154, Eu155, Gd150	5	2	•	
Gd156(n,5n)Gd152	Eu150, Eu152, Gd148, Gd150, Gd152	4	0		
Gd157(n,3nα)Sm151	Sm151	4	0		
Gd157(n,γ)**Gd158**	Eu155, Gd159, Gd160, Tb160, Tb161, Tb162, Ho166m	5	4	•	
Gd157(n,d)Eu156	Sm151, Eu150, Eu156, Gd152, Gd153	4	0		
Gd157(n,t)Eu155	Sm151, Eu150, Eu152, Eu154, Eu155, Gd150	4	0		
Gd157(n,α)**Sm154**	Sm151, Eu155	5	2	•	
Gd157(n,5n)Gd153	Sm151, Eu150, Eu152, Gd148, Gd150, Gd152, Gd153	4	0		
Gd157(n,6n)Gd152	Eu150, Eu152, Gd148, Gd150, Gd152	4	0		
Gd158(n,nt)Eu155	Sm151, Eu150, Eu152, Eu155, Gd150	4	0		
Gd158(n,γ)Gd159	Gd159, Gd160, Tb154m, Tb157, Tb158, Tb160, Tb161, Tb162, Ho166m	5	4	•	
Gd158(n,t)Eu156	Sm151, Eu150, Eu152, Eu156, Gd152, Gd153	4	0		
Gd158(n,α)Sm155	Eu150, Eu152, Eu154, Eu155	4	5_2	•	•
Gd158(n,6n)Gd153	Sm151, Eu150, Eu152, Gd148, Gd150, Gd152, Gd153	4	0		
Gd159(n,γ)Gd160	Gd160	5	0		
Gd160(n,2n)Gd159	Eu155, Eu156, Gd159, Tb154m, Tb157, Tb158, Tb160	5	5_2	•	•
Gd160(n,γ)Gd161	Gd161, Tb157, Tb160, Tb161, Tb162, Ho166m	5	6	•	•
Gd160(n,d)Eu159	Gd159, Tb154m, Tb157, Tb158, Tb160	4	0		
Gd160(n,2nt)Eu156	Eu156, Gd152	4	0		
Tb155(n,2n)Tb154m	Gd152, Tb154m	5	0		
Tb156(n,2n)Tb155	Sm151, Gd153, Tb154m, Tb155	4	0		
Tb157(n,2n)Tb156	Sm151, Eu154, Eu155, Gd148, Gd150, Gd152, Gd153, Tb154m, Tb155, Tb156	4	0		
Tb157(n,2n)Tb156m	Sm151, Eu154, Gd150, Gd153, Tb154m, Tb15	4	0		
Tb157(n,3n)Tb155	Sm151, Eu154, Eu155, Gd148, Gd150, Gd152, Gd153, Tb154m, Tb155	5	0		
Tb157(n,4n)Tb154m	Sm151, Gd148, Gd150, Gd152, Gd153, Tb154m	5	0		
Tb157(n,γ)Tb158	Tb158, Tb160, Tb161	5	0		
Tb157(n,γ)Tb158m	Tb158, Tb160, Tb161	4	0		
Tb157(n,α)Eu154	Sm151, Eu154, Gd148, Gd150, Gd153	4	0		
Tb157(n,5n)Tb153	Sm151, Gd148, Gd150, Gd152, Gd153	4	0		
Tb158(n,2n)Tb157	H3, Sm151, Eu154, Gd148, Gd150, Gd153, Tb154m, Tb155, Tb156, Tb157	5	0		
Tb158(n,3n)Tb156	Sm151, Eu154, Eu155, Gd148, Gd150, Gd153, Tb154m, Tb156	4	0		
Tb158(n,4n)Tb155	Sm151, Eu154, Gd148, Gd150, Gd152, Gd153, Tb154m, Tb155	4	0		
Tb158(n,γ)**Tb159**	Tb160, Tb161	5	0		
Tb158(n,α)Eu155	Sm151, Eu154, Eu155, Gd150, Gd153	5	0		
Tb159(n,2n)Tb158	H3, Sm151, Eu154, Eu155, Gd148, Gd150,	5	4	•	

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
	Gd153, Tb154m, Tb155, Tb156, Tb157, Tb158, Tb158m				
Tb159(n,2n)Tb158m	H3, Sm151, Eu154, Eu155, Gd148, Gd150, Gd153, Tb154m, Tb155, Tb156, Tb157, Tb158, Tb158m	5	5_4	•	•
Tb159(n,3n)Tb157	H3, Sm151, Eu154, Eu155, Gd148, Gd150, Gd153, Tb154m, Tb155, Tb156, Tb157	5	0		
Tb159(n,nα)Eu155	Sm151, Eu154, Eu155, Gd148, Gd150, Gd152, Gd153	5	0		
Tb159(n,2nα)Eu154	Sm151, Eu154, Gd148, Gd150	4	0		
Tb159(n,4n)Tb156	H3, Sm151, Eu154, Eu155, Gd148, Gd150, Gd152, Gd153, Tb154m, Tb156	5	0		
Tb159(n,γ)Tb160	Eu155, Gd160, Tb160, Tb161, Tb162, Ho166, Ho166m	5	4	•	
Tb159(n,α)Eu156	Sm151, Eu154, Eu155, Eu156, Gd148, Gd150, Gd153	5	6*	•	•
Tb159(n,5n)Tb155	H3, Sm151, Eu154, Eu155, Gd148, Gd150, Gd152, Gd153, Tb155	5	0		
Tb159(n,6n)Tb154m	Sm151, Eu154, Gd148, Gd150, Gd153, Tb154	5	0		
Tb160(n,γ)Tb161	Eu155, Gd160, Tb161, Tb162, Ho166, Ho166m	5	2	•	
Tb160(n,p)Gd160	Gd160, Tb161	5	0		
Tb160(n,α)Eu157	Eu155	4	0		
Tb161(n,γ)Tb162	Gd160, Tb162, Ho166, Ho166m	5	0		
Dy154(n,3n)Dy152	Gd148, Gd150, Gd152	4	0		
Dy155(n,2n)Dy154	Gd148, Gd150, Dy154	5	0		
Dy156(n,2n)Dy155	Gd148, Gd150, Gd152, Tb154m, Dy154	5	6	•	•
Dy156(n,3n)Dy154	Gd148, Gd150, Gd152, Tb154m, Dy154	4	0		
Dy156(n,nα)Gd152	Gd148, Gd150, Gd152	4	0		
Dy156(n,γ)Dy157	Tb157, Tb158, Tb160, Tb161, Dy157, Dy159	5	4	•	
Dy156(n,α)Gd153	Gd148, Gd150, Gd152	5	2	•	
Dy156(n,5n)Dy152	Gd148, Gd150, Gd152	4	0		
Dy157(n,2n)Dy156	Tb154m, Dy154	4	0		
Dy158(n,2n)Dy157	Gd152, Tb154m, Tb156, Tb157, Dy154, Dy157	5	6	•	•
Dy158(n,3n)Dy156	Gd148, Gd150, Gd152, Tb154m, Tb156, Dy154, Dy156	4	0		
Dy158(n,4n)Dy155	Gd148, Gd150, Gd152	4	0		
Dy158(n,γ)Dy159	Tb160, Tb161, Dy159, Dy165, Ho166, Ho166m	5	4	•	
Dy158(n,5n)Dy154	Gd148, Gd150, Gd152, Dy154	4	0		
Dy159(n,2n)**Dy158**	Gd148, Tb154m, Tb156, Tb157, Dy154, Dy156, Dy157	4	0		
Dy159(n,3n)Dy157	Tb154m, Tb156, Tb157, Dy157	4	0		
Dy159(n,4n)Dy156	Gd148, Gd150, Gd152, Tb154m, Dy154, Dy156	4	0		
Dy160(n,2n)Dy159	Gd150, Tb154m, Tb156, Tb157, Tb158, Tb160, Dy154, Dy156, Dy157, Dy159	5	2	•	
Dy160(n,4n)Dy157	Gd148, Gd150, Gd152, Tb154m, Tb156, Tb157, Dy154, Dy157	4	0		
Dy160(n,γ)**Dy161**	Eu155, Gd160, Tb161, Tb162, Tb163, Dy165, Ho166, Ho166m	5	4	•	
Dy160(n,p)Tb160	Tb160	4	2	•	
Dy160(n,α)**Gd157**	Eu155, Gd152	5	2	•	
Dy161(n,2n)**Dy160**	Gd148, Gd150, Gd152, Tb154m, Tb156, Tb157, Tb158, Tb160, Dy154, Dy156, Dy157, Dy159	5	0		
Dy161(n,3n)Dy159	Gd148, Gd150, Gd152, Tb154m, Tb156, Tb157, Tb158, Tb160, Dy154, Dy156, Dy157, Dy159	5	0		
Dy161(n,nt)Tb158	Gd148, Gd150, Gd152, Tb154m, Tb156, Tb158	4	0		
Dy161(n,4n)**Dy158**	Gd148, Gd150, Gd152, Tb154m, Tb156, Tb157, Tb158, Dy154, Dy156, Dy157	4	0		
Dy161(n,γ)**Dy162**	Gd160, Tb162, Tb163, Dy165, Ho166, Ho166m, Er167m, Tm170	5	4	•	
Dy161(n,p)Tb161	Tb160, Tb161, Tb162	5	2	•	
Dy161(n,d)Tb160	Tb154m, Tb156, Tb157, Tb158, Tb160, Dy156, Dy157, Dy159	5	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Dy161(n,5n)Dy157	Gd148, Gd150, Gd152, Tb154m, Tb156, Tb157, Dy157	5	0		
Dy161(n,6n)Dy156	Gd148, Gd150, Gd152, Tb154m, Tb156, Dy154, Dy156	5	0		
Dy162(n,2n)**Dy161**	Gd152, Tb154m, Tb156, Tb157, Tb158, Tb160, Tb161, Dy154, Dy156, Dy157, Dy159	4	0		
Dy162(n,4n)Dy159	Gd148, Gd150, Gd152, Tb154m, Tb156, Tb157, Tb158, Dy154, Dy156, Dy157, Dy159	5	0		
Dy162(n,γ)**Dy163**	Gd160, Tb163, Dy165, Ho166, Ho166m, Er167m, Tm170, Tm171	5	4	•	
Dy162(n,p)Tb162	Tb162	5	6	•	•
Dy162(n,d)Tb161	Tb157, Tb158, Tb160, Tb161, Dy156, Dy157, Dy159	5	0		
Dy162(n,t)Tb160	Tb154m, Tb156, Tb157, Tb158, Tb160, Dy156, Dy157	4	5_0		•
Dy162(n,α)Gd159	Tb156, Tb157, Tb158, Tb160	5	2	•	
Dy162(n,5n)**Dy158**	Gd148, Gd150, Gd152, Tb154m, Tb156, Tb157, Tb158, Dy154, Dy156, Dy157	4	0		
Dy162(n,6n)Dy157	Gd148, Gd150, Gd152, Tb154m, Tb156, Tb157, Dy157	4	0		
Dy162(n,2nt)Tb158	Gd148, Gd150, Tb154m, Tb156, Tb158	4	0		
Dy163(n,nt)Tb160	Tb154m, Tb156, Tb157, Tb158, Tb160, Dy156	4	0		
Dy163(n,4n)**Dy160**	Gd148, Gd150, Gd152, Tb154m, Tb156, Tb157, Tb158, Tb160, Dy154, Dy156, Dy157, Dy159	4	0		
Dy163(n,γ)**Dy164**	Tb163, Dy165, Ho166, Ho166m, Er167m, Er169, Tm170, Tm171, Tm172	5	4	•	
Dy163(n,p)Tb163	Tb163	5	6	•	•
Dy163(n,t)Tb161	Tb157, Tb158, Tb160, Tb161, Dy156, Dy159	4	0		
Dy163(n,α)Gd160	Gd160, Tb157, Tb158	5	2	•	
Dy163(n,5n)Dy159	Gd148, Gd150, Gd152, Tb154m, Tb156, Tb157, Tb158, Dy154, Dy156, Dy159	4	0		
Dy163(n,6n)**Dy158**	Gd148, Gd150, Gd152, Tb154m, Tb156, Tb157, Tb158, Dy154, Dy156, Dy157	4	0		
Dy164(n,2n)**Dy163**	Gd160, Tb154m, Tb156, Tb157, Tb158, Tb160, Tb161, Tb162, Tb163, Dy157, Dy159	5	0		
Dy164(n,nα)Gd160	Gd160, Tb157, Tb158	4	0		
Dy164(n,nt)Tb161	Tb157, Tb158, Tb161, Dy156	4	0		
Dy164(n,γ)Dy165	Tb163, Dy165, Ho163, Ho166, Ho166m, Er167m, Er169, Tm170, Tm171, Tm172	5	5_2	•	•
Dy164(n,γ)Dy165m	Tb163, Dy165, Ho163, Ho166, Ho166m, Er167m, Er169, Tm170, Tm171, Tm172	5	6	•	•
Dy164(n,d)Tb163	Tb163	5	0		
Dy164(n,6n)Dy159	Gd148, Gd150, Gd152, Tb154m, Tb156, Tb157, Tb158, Dy154, Dy156, Dy159	4	0		
Ho163(n,2n)Ho162	Tb157, Tb158, Tb160, Tb162, Dy154, Dy159, Ho162	5	0		
Ho163(n,2n)Ho162m	Tb157, Tb158, Tb160, Tb162, Dy154, Dy159, Ho162, Ho162m	5	0		
Ho163(n,3n)Ho161	Tb157, Tb158, Tb160, Dy154, Dy159, Ho161	5	0		
Ho163(n,2nα)Tb158	Tb154m, Tb157, Tb158	4	0		
Ho163(n,4n)Ho160	Tb154m, Tb157, Tb158, Tb160, Dy154, Dy159, Ho160	5	0		
Ho163(n,γ)Ho164	Ho166m, Er165	5	2/0	•	
Ho163(n,α)Tb160	Tb157, Tb158, Tb160, Dy154, Dy159	5	0		
Ho163(n,5n)Ho159	Tb154m, Tb157, Tb158, Dy154, Dy159	4	0		
Ho165(n,2n)Ho164	H3, Gd160, Tb154m, Tb157, Tb158, Tb160, Tb162, Dy154, Dy159, Ho161, Ho162, Ho162m, Ho163, Ho164, Er162	5	6	•	•
Ho165(n,2n)Ho164m	Gd160, Tb157, Tb158, Tb160, Tb162, Dy154, Dy159, Ho162, Ho162m, Ho163, Ho164, Er162	4	6*	•	•
Ho165(n,3n)Ho163	H3, Tb154m, Tb157, Tb158, Tb160, Tb162, Dy154, Dy159, Ho160, Ho161, Ho162, Ho162m, Ho163	5	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Ho165(n,2nα)Tb160	Gd160, Tb154m, Tb157, Tb158, Tb160, Dy154, Dy159	4	0		
Ho165(n,4n)Ho162	H3, Gd160, Tb154m, Tb157, Tb158, Tb160, Tb162, Dy154, Dy159, Ho162	4	0		
Ho165(n,4n)Ho162m	H3, Gd160, Tb154m, Tb157, Tb158, Tb160, Tb162, Dy154, Dy159, Ho162, Ho162m	5	0		
Ho165(n,γ)Ho166	Gd160, Tb163, Ho166, Ho167, Er162, Er167m, Er169, Tm170, Tm171, Tm172	5	4	•	
Ho165(n,γ)Ho166m	Tb163, Ho166, Ho166m, Ho167, Er167m, Er169, Tm170, Tm171	5	2	•	
Ho165(n,d)**Dy164**	H3, Gd160, Tb154m, Tb157, Tb158, Tb160, Tb162, Dy154, Dy159	4	0		
Ho165(n,α)Tb162	Gd160, Tb157, Tb158, Tb160, Tb162, Dy154, Dy159	5	6*	•	•
Ho165(n,5n)Ho161	H3, Gd160, Tb154m, Tb157, Tb158, Tb160, Dy154, Dy159, Ho161	5	0		
Ho165(n,4nα)Tb158	Tb154m, Tb157, Tb158	4	0		
Ho166m(n,γ)Ho167	Ho167, Er167m, Er169, Tm170, Tm171	5	2	•	
Ho166m(n,α)Tb163	Gd160, Tb158, Tb163	5	0		
Er160(n,3n)Er158	Ho158	4	0		
Er160(n,t)Ho158	Ho158	5	0		
Er160(n,t)Ho158m	Ho158	4	0		
Er161(n,2n)Er160	Dy154, Ho158, Ho160	5	0		
Er162(n,2n)Er161	Tb160, Dy154, Dy159, Ho158, Ho160, Ho161	5	6*	•	•
Er162(n,3n)Er160	Tb160, Dy154, Dy159, Ho158, Ho160	4	0		
Er162(n,nα)**Dy158**	Gd150, Tb154m, Dy154	4	0		
Er162(n,γ)Er163	Tb160, Ho163, Ho166m, Er165	5	2	•	
Er162(n,α)Dy159	Tb154m, Tb160, Dy154, Dy159	5	2	•	
Er162(n,5n)Er158	Tb154m, Dy154, Ho158	4	0		
Er164(n,2n)Er163	H3, Tb157, Tb158, Tb160, Dy159, Ho160, Ho161, Ho162, Ho162m, Ho163	5	5_2*	•	•
Er164(n,3n)Er162	H3, Gd150, Tb154m, Tb160, Dy154, Dy159, Ho158, Ho160, Ho161, Ho162, Er162	5	0		
Er164(n,γ)Er165	Ho166m, Er165, Er167m, Tm170	5	3	•	
Er166(n,2n)Er165	H3, Gd160, Tb154m, Tb158, Tb160, Dy154, Dy159, Ho160, Ho162, Ho163, Ho166m, Er162, Er165	5	5_2*	•	•
Er166(n,3n)**Er164**	H3, Tb154m, Tb158, Tb160, Dy154, Dy159, Ho158, Ho160, Ho162, Ho163, Er162	5	0		
Er166(n,4n)Er163	H3, Gd160, Tb154m, Tb158, Tb160, Dy154, Dy159, Ho158, Ho160, Ho162, Ho163	5	0		
Er166(n,γ)**Er167**	Ho167, Er167m, Er169, Tm170, Tm171, Tm172	5	2	•	
Er166(n,γ)Er167m	Ho167, Er167m, Er169, Tm170, Tm171, Tm172	5	2	•	
Er166(n,p)Ho166m	Ho166m, Ho167	5	0		
Er166(n,α)**Dy163**	Gd160, Tb154m, Tb158, Tb160, Dy154, Dy159	5	2	•	
Er166(n,5n)Er162	H3, Tb154m, Tb160, Dy154, Dy159, Ho158, Ho160, Ho162, Er162	5	0		
Er166(n,6n)Er161	H3, Gd160, Tb154m, Tb158, Tb160, Dy154, Dy159	4	0		
Er167(n,3n)Er165	H3, Gd160, Tb158, Tb160, Dy154, Dy159, Ho160, Ho162, Ho163, Er162, Er165	5	0		
Er167(n,γ)**Er168**	Ho166m, Er169, Er171, Tm170, Tm171, Tm172, Lu176	5	4	•	
Er167(n,d)Ho166m	H3, Tb158, Tb160, Ho160, Ho162, Ho163, Ho166m	5	0		
Er167(n,5n)Er163	H3, Tb154m, Tb158, Tb160, Dy154, Dy159, Ho158, Ho160, Ho162, Ho163	4	0		
Er167(n,6n)Er162	H3, Tb154m, Tb160, Dy154, Dy159, Ho158, Ho160, Ho162, Er162	4	0		
Er168(n,2n)Er167m	H3, Gd160, Ho166m, Er162, Er165, Er167m	5	2	•	
Er168(n,4n)Er165	H3, Gd160, Tb154m, Tb158, Tb160, Dy154, Dy159, Ho160, Ho162, Ho163, Er165	5	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Er168(n,γ)Er169	Ho166m, Er169, Er171, Tm168, Tm170, Tm171, Tm172, Lu176	5	4	•	
Er168(n,t)Ho166m	H3, Tb160, Ho160, Ho162, Ho163, Ho166m	4	0		
Er168(n,α)Dy165	Gd160, Ho163, Ho166m	4	1	•	
Er168(n,α)Dy165m	Gd160, Ho166m	4	2	•	
Er168(n,6n)Er163	H3, Tb154m, Tb158, Tb160, Dy154, Dy159, Ho158, Ho160, Ho162, Ho163	4	0		
Er170(n,2n)Er169	H3, Ho166m, Er167m, Er169, Tm168, Tm170	5	2	•	
Er170(n,4n)Er167m	Er167m	4	0		
Er170(n,γ)Er171	Er171, Tm168, Tm170, Tm171, Tm172, Lu176	5	4	•	
Er170(n,d)Ho169	Er167m, Er169, Tm168, Tm170	4	6*	•	•
Er170(n,6n)Er165	H3, Tb154m, Tb160, Dy154, Dy159, Ho160, Ho162, Er165	4	0		
Tm167(n,2n)Tm166	Tm166	5	0		
Tm168(n,2n)Tm167	Gd160, Tb158, Ho163, Er167m, Tm166, Tm167	5	0		
Tm168(n,3n)Tm166	Tm166	5	0		
Tm169(n,2n)Tm168	H3, Gd160, Tb158, Dy154, Ho162, Ho163, Ho166m, Er167m, Tm166, Tm167, Tm168, Yb168	5	6	•	•
Tm169(n,3n)Tm167	H3, Gd160, Tb158, Ho162, Ho163, Ho166m, Er167m, Tm166, Tm167	5	4	•	
Tm169(n,2nα)Ho164	Gd160, Tb154m, Tb158, Dy154	4	0		
Tm169(n,2nα)Ho164m	Gd160, Tb158, Dy154, Ho163	4	0		
Tm169(n,3nα)Ho163	H3, Tb154m, Tb158, Dy154, Ho162, Ho163	4	0		
Tm169(n,4n)Tm166	H3, Gd160, Tb154m, Tb158, Dy154, Ho162, Ho163, Ho166m, Tm166	5	0		
Tm169(n,γ)Tm170	Tm170, Tm171, Tm172, Yb168, Yb175, Lu176	5	4	•	
Tm169(n,α)Ho166	Gd160, Tb158, Ho163	5	2	•	
Tm169(n,α)Ho166m	Gd160, Tb158, Ho162, Ho163, Ho166m	5	2	•	
Tm169(n,5n)Tm165	H3, Gd160, Tb154m, Tb158, Ho162, Ho163, Ho166m	4	0		
Tm170(n,γ)Tm171	Tm171, Tm172, Yb175, Lu176	5	4	•	
Tm171(n,2n)Tm170	Ho166m, Tm168, Tm170	4	0		
Tm171(n,γ)Tm172	Tm172, Yb175, Lu176	5	4	•	
Yb168(n,2n)Yb167	Ho163, Ho166m, Tm166, Tm167	5	6	•	•
Yb168(n,3n)Yb166	Ho163, Ho166m, Tm166	4	0		
Yb168(n,nα)**Er164**	Ho163	4	0		
Yb168(n,γ)Yb169	H3, Ho166m, Tm170, Tm171, Yb169	5	1	•	
Yb168(n,γ)Yb169m	H3, Ho166m, Tm170, Tm171, Yb169	5	0		
Yb168(n,α)Er165	Ho163, Ho166m	5	2	•	
Yb170(n,2n)Yb169	H3, Ho163, Ho166m, Tm166, Tm168, Tm170, Yb168, Yb169	4	0		
Yb170(n,3n)Yb168	H3, Ho163, Ho166m, Tm166, Tm168, Yb168	5	0		
Yb170(n,4n)Yb167	Ho163, Ho166m	4	0		
Yb170(n,γ)**Yb171**	Tm171, Tm172, Yb175, Lu176	4	4	•	
Yb170(n,p)Tm170	Tm170	4	0		
Yb171(n,2n)**Yb170**	H3, Ho163, Ho166m, Tm166, Tm168, Tm170, Yb168, Yb169	4	0		
Yb171(n,3n)Yb169	H3, Ho163, Ho166m, Tm166, Tm168, Yb168, Yb169	4	0		
Yb171(n,nt)Tm168	Ho163, Ho166m, Tm168	4	0		
Yb171(n,4n)Yb168	H3, Ho163, Ho166m, Tm166, Tm168, Yb168	5	0		
Yb171(n,γ)**Yb172**	Ho166m, Tm170, Tm171, Tm172, Yb175, Yb176m, Lu176, Lu176m, Lu177, Lu177m, Hf177m	4	4	•	
Yb171(n,p)Tm171	Tm168, Tm170, Tm171, Tm172	4	0		
Yb171(n,d)Tm170	Ho166m, Tm166, Tm168, Tm170, Yb168	4	0		
Yb171(n,α)**Er168**	Ho166m	4	2	•	
Yb171(n,5n)Yb167	Ho163, Ho166m	4	0		
Yb171(n,6n)Yb166	H3, Ho163, Ho166m, Tm166	4	0		
Yb172(n,3n)**Yb170**	H3, Ho163, Ho166m, Tm166, Tm168, Tm170, Yb168, Yb169	4	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Yb172(n,4n)Yb169	H3, Ho163, Ho166m, Tm166, Tm168, Yb169	4	0		
Yb172(n,γ)**Yb173**	Tm171, Yb175, Yb176m, Lu176, Lu176m, Lu177, Lu177m, Hf177m	5	4	•	
Yb172(n,d)Tm171	Ho166m, Tm166, Tm168, Tm170, Tm171, Yb168, Yb169	5	0		
Yb172(n,t)Tm170	H3, Ho166m, Tm166, Tm168, Tm170, Yb168	4	0		
Yb172(n,α)Er169	Ho166m, Tm168, Tm170, Tm171	5	2	•	
Yb172(n,5n)Yb168	H3, Ho163, Ho166m, Tm166, Tm168, Yb168	4	0		
Yb172(n,6n)Yb167	Ho163, Ho166m	4	0		
Yb172(n,2nt)Tm168	Ho163, Ho166m, Tm168	4	0		
Yb173(n,nt)Tm170	Ho166m, Tm166, Tm168, Tm170	4	0		
Yb173(n,γ)**Yb174**	Tm171, Yb175, Yb176m, Yb177, Lu176, Lu176m, Lu177, Lu177m, Hf177m, Hf181, Hf182, Ta182	5	4	•	
Yb173(n,d)Tm172	Tm166, Tm168, Tm170, Tm172, Yb168	5	0		
Yb173(n,t)Tm171	Ho166m, Tm166, Tm168, Tm170, Tm171, Yb168	4	0		
Yb173(n,α)**Er170**	Ho166m, Tm168, Tm171	5	2	•	
Yb173(n,6n)Yb168	H3, Ho163, Ho166m, Tm166, Tm168, Yb168	4	0		
Yb174(n,nt)Tm171	H3, Ho166m, Tm166, Tm168, Tm170, Tm171	4	0		
Yb174(n,γ)Yb175	Yb175, Yb176m, Yb177, Lu173, Lu174, Lu176, Lu176m, Lu177, Lu177m, Hf177m, Hf178n, Hf181, Hf182, Ta182	5	4	•	
Yb174(n,α)Er171	Ho166m, Tm168, Tm170, Tm171	4	6	•	•
Yb174(n,6n)Yb169	H3, Ho163, Ho166m, Tm166, Tm168, Yb169	4	0		
Yb174(n,2nt)Tm170	Ho166m, Tm166, Tm168, Tm170	4	0		
Yb175(n,γ)Yb176m	Yb176m	5	2	•	
Yb176(n,n')Yb176m	Yb176m	5	0		
Yb176(n,2n)Yb175	H3, Tm171, Yb175, Lu172, Lu173, Lu174, Lu176, Lu176m, Lu177m	5	2	•	
Yb176(n,γ)Yb177	Yb177, Lu173, Lu176, Lu176m, Lu177, Lu177m, Hf177m, Hf178n, Hf181, Hf182, Ta182	5	4	•	
Yb176(n,γ)Yb177m	Yb177, Lu176, Lu176m, Lu177, Lu177m, Hf177m, Hf178n, Hf181, Hf182, Ta182	5	0		
Yb176(n,d)Tm175	Yb175, Lu173, Lu174, Lu176, Lu176m	4	0		
Lu173(n,2n)Lu172	Ho166m, Tm168, Tm171, Tm172, Lu170, Lu172	4	0		
Lu173(n,4n)Lu170	Tm168, Lu170	5	0		
Lu173(n,4n)Lu170m	Tm168, Lu170	4	0		
Lu174(n,2n)Lu173	H3, Ho166m, Tm168, Tm171, Tm172, Lu170, Lu172, Lu173	5	0		
Lu174(n,α)Tm171	Ho166m, Tm168, Tm171	4	0		
Lu175(n,2n)Lu174	H3, Ho166m, Tm168, Tm171, Tm172, Lu170, Lu172, Lu173, Lu174	5	5/4	•	•
Lu175(n,2n)Lu174m	H3, Ho166m, Tm168, Tm171, Tm172, Lu170, Lu172, Lu173, Lu174	4	4	•	
Lu175(n,3n)Lu173	H3, Ho166m, Tm168, Tm171, Tm172, Lu170, Lu172, Lu173	5	5_2*	•	•
Lu175(n,nα)Tm171	Ho166m, Tm168, Tm171	5	0		
Lu175(n,4n)Lu172	H3, Ho166m, Tm168, Tm171, Tm172, Lu170, Lu172	5	5_3		•
Lu175(n,4n)Lu172m	Ho166m, Tm168, Tm171, Tm172, Lu170, Lu172	4	0		
Lu175(n,γ)Lu176	Tm171, Lu176, Lu176m, Lu177, Lu177m, Lu178, Hf177m, Hf178m, Hf178n, Hf179m, Hf181, Hf182, Ta182	5	2	•	
Lu175(n,γ)Lu176m	Tm171, Lu176m, Lu177, Hf177m, Hf178m, Hf178n, Hf179m, Hf181, Hf182, Ta182	5	6	•	•
Lu175(n,α)Tm172	Ho166m, Tm168, Tm171, Tm172	5	2	•	
Lu175(n,6n)Lu170	H3, Ho166m, Tm168, Lu170	5	0		
Lu175(n,6n)Lu170m	Tm168, Lu170	4	0		
Lu175(n,4nα)Tm168	Ho166m, Tm168	4	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Lu176(n,n')Lu176m	Lu176m, Hf177m, Hf178n, Hf179m	5	0		
Lu176(n,γ)Lu177	Tm171, Lu177, Lu177m, Lu178, Hf177m, Hf178m, Hf178n, Hf179m, Hf181, Hf182, Ta182	5	4	•	
Lu176(n,γ)Lu177m	Lu177, Lu177m, Lu178, Hf177m, Hf178n, Hf179m, Hf181	5	2	•	
Lu176(n,α)Tm173	Tm171	4	2	•	
Lu177(n,n')Lu177m	Lu177m	5	0		
Lu177(n,γ)Lu178	Lu178, Hf178n, Hf179m, Hf181, Hf182, Ta182	5	0		
Hf172(n,2n)Hf171	Hf171	5	0		
Hf173(n,2n)Hf172	Hf171, Hf172	5	0		
Hf174(n,2n)Hf173	Ho166m, Lu172, Lu173, Hf171, Hf172	5	6	•	•
Hf174(n,3n)Hf172	Ho166m, Lu172, Hf171, Hf172	4	0		
Hf174(n,4n)Hf171	Hf171	5	0		
Hf174(n,γ)Hf175	H3, Ho166m, Lu176, Hf175, Hf177m, Hf178m, Hf178n, Hf179m, Hf179n	5	4	•	
Hf174(n,α)**Yb171**	Ho166m	4	0		
Hf175(n,4n)Hf172	Lu172, Hf171, Hf172	4	0		
Hf176(n,2n)Hf175	H3, Ho166m, Lu172, Lu173, Lu174, Lu176, Hf171, Hf172, Hf175	5	6	•	•
Hf176(n,3n)Hf174	H3, Ho166m, Lu172, Lu173, Lu174, Hf171, Hf172	4	0		
Hf176(n,4n)Hf173	Ho166m, Lu172, Lu173	4	0		
Hf176(n,γ)**Hf177**	Tm171, Hf177m, Hf178m, Hf178n, Hf179m, Hf179n, Hf181, Hf182, Ta182, Ta183, W185	5	4	•	
Hf176(n,γ)Hf177m	Hf177m	5	0		
Hf176(n,p)Lu176	Lu174, Lu176	4	0		
Hf176(n,α)**Yb173**	Ho166m, Tm171	5	0		
Hf176(n,5n)Hf172	H3, Lu172, Hf171, Hf172	5	0		
Hf176(n,6n)Hf171	Hf171	5	0		
Hf177(n,n')Hf177m	Hf177m	5	0		
Hf177(n,2n)**Hf176**	H3, Ho166m, Lu172, Lu173, Lu174, Lu176, Hf171, Hf172, Hf175	4	0		
Hf177(n,3n)Hf175	H3, Ho166m, Lu172, Lu173, Lu174, Hf171, Hf172, Hf175	4	0		
Hf177(n,nt)Lu174	Lu174	4	0		
Hf177(n,4n)Hf174	H3, Ho166m, Lu172, Lu173, Lu174, Hf171, Hf172	5	0		
Hf177(n,γ)**Hf178**	Lu178, Hf178n, Hf179m, Hf179n, Hf181, Hf182, Ta182, Ta183, W185	5	4/2/2	•	
Hf177(n,γ)Hf178m	Lu178, Hf178m, Hf178n, Hf179m, Hf181	5	2	•	
Hf177(n,γ)Hf178n	Hf178n	5	2	•	
Hf177(n,p)Lu177m	Lu177m	4	0		
Hf177(n,d)Lu176	Lu172, Lu173, Lu174, Lu176, Lu176m	5	0		
Hf177(n,α)**Yb174**	Tm171	4	2	•	
Hf177(n,5n)Hf173	H3, Lu172, Lu173	4	0		
Hf177(n,6n)Hf172	H3, Lu172, Hf171, Hf172	4	0		
Hf178(n,n')Hf178n	H3, Lu176, Hf177m, Hf178m, Hf178n, Hf179m	5	0		
Hf178(n,n')Hf178m	Hf178m	4	0		
Hf178(n,2n)Hf177m	H3, Lu176, Hf175, Hf177m	4	0		
Hf178(n,4n)Hf175	H3, Ho166m, Lu172, Lu173, Lu174, Hf171, Hf172, Hf175	5	0		
Hf178(n,γ)**Hf179**	Hf179m, Hf181, Hf182, Ta180m, Ta182, Ta183, W185	5	2/2/2	•	
Hf178(n,γ)Hf179m	Hf179m, Hf181, Hf182, Ta180m, Ta182, Ta183, W185	5	2	•	
Hf178(n,γ)Hf179n	Hf179n, Hf181	5	2	•	
Hf178(n,t)Lu176	H3, Lu172, Lu173, Lu174, Lu176	4	0		
Hf178(n,α)Yb175	Lu172, Lu173, Lu174, Lu176	5	4	•	
Hf178(n,5n)Hf174	H3, Lu172, Lu173, Lu174, Hf171, Hf172	4	0		
Hf178(n,6n)Hf173	H3, Lu172, Lu173	4	0		
Hf179(n,n')Hf179n	Hf179n	5	3	•	

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Hf179(n,2n)Hf178m	H3, Lu172, Lu173, Lu176, Hf175, Hf177m, Hf178m, Hf178n	5	2	•	
Hf179(n,2n)Hf178n	H3, Hf178n	4	4	•	
Hf179(n,3n)Hf177m	Lu176, Hf175, Hf177m	4	0		
Hf179(n,4n)**Hf176**	H3, Lu172, Lu173, Lu174, Lu176, Hf171, Hf172, Hf175	4	0		
Hf179(n,γ)**Hf180**	Hf181, Hf182, Ta182, Ta183, W185	5	4	•	
Hf179(n,γ)Hf180m	Hf181, Hf182, Ta180m, Ta182, Ta183, W185	4	2	•	
Hf180(n,2n)**Hf179**	H3, Lu172, Lu176, Hf175, Hf177m, Hf178m, Hf178n, Hf179m, Hf179n	4	0/6/2	•	•
Hf180(n,2n)Hf179m	H3, Hf175, Hf177m, Hf178m, Hf178n, Hf179m, Hf179n	5	6	•	•
Hf180(n,2n)Hf179n	Hf178m, Hf178n, Hf179n	4	2	•	
Hf180(n,3n)Hf178m	H3, Lu176, Hf175, Hf177m, Hf178m, Hf178n	4	0		
Hf180(n,4n)Hf177m	Lu173, Lu176, Hf175, Hf177m	4	0		
Hf180(n,γ)Hf181	Hf181, Hf182, Ta182, Ta183, W185	5	5_2	•	•
Hf180(n,6n)Hf175	H3, Lu172, Lu173, Lu174, Hf171, Hf175	5	0		
Hf180(n,2nt)Lu176	Lu172, Lu174, Lu176	4	0		
Hf181(n,γ)Hf182	Hf182, Ta183, W185	5	2/0	•	
Ta177(n,2n)Ta176	Ta176	5	0		
Ta179(n,2n)Ta178m	Lu172, Lu176, Hf172, Hf175, Hf178n, Ta178m	5	0		
Ta179(n,3n)Ta177	Lu172, Lu176, Hf171, Hf172, Hf175, Ta176	5	0		
Ta179(n,4n)Ta176	Lu172, Lu176, Hf171, Hf172, Hf175, Ta176	5	0		
Ta179(n,α)Lu176	Lu172, Lu176	4	0		
Ta180m(n,n')Ta180	Ta180	5	0		
Ta180m(n,2n)Ta179	H3, Lu172, Lu176, Hf172, Hf175, Hf178n, Ta176, Ta178m, Ta179	5	0		
Ta180m(n,3n)Ta178m	Lu172, Lu176, Hf172, Hf175, Hf178n, Ta178m	4	0		
Ta180m(n,nα)Lu176	Lu172, Lu176	4	0		
Ta180m(n,α)Lu177	Lu176, Hf172, Hf175, Hf178n	5	0		
Ta181(n,2n)Ta180	H3, Lu172, Lu176, Hf171, Hf172, Hf175, Hf178n, Hf182, Ta176, Ta178m, Ta179, Ta180	5	6/4	•	•
Ta181(n,2n)Ta180m	H3, Lu172, Lu176, Hf171, Hf172, Hf175, Hf178n, Ta176, Ta178m, Ta179, Ta180, Ta180m	5	4	•	
Ta181(n,3n)Ta179	H3, Lu172, Lu176, Hf171, Hf172, Hf175, Hf178n, Ta176, Ta178m, Ta179	5	4	•	
Ta181(n,2nα)Lu176	Lu172, Lu176	5	0		
Ta181(n,4n)Ta178	H3, Lu172, Lu176, Hf171, Hf172, Hf175, Hf178n	5	0		
Ta181(n,4n)Ta178m	H3, Lu172, Lu176, Hf171, Hf172, Hf175, Hf178n, Ta178m	5	5_0		•
Ta181(n,γ)Ta182	Hf182, Ta180m, Ta182, Ta183, W183, W185, Re186, Re186m	5	6	•	•
Ta181(n,γ)Ta182m	Hf182, Ta182, Ta183, W183, W185, Re186, Re186m	5	2	•	
Ta181(n,α)Lu178	Lu172, Lu176, Hf171, Hf172, Hf175, Hf178n, Hf182, Ta180m	5	5/6	•	•
Ta181(n,α)Lu178m	Lu172, Lu176, Hf171, Hf172, Hf175, Hf178n, Hf182, Ta180m	4	6	•	•
Ta181(n,5n)Ta177	H3, Lu172, Lu176, Hf171, Hf172, Hf175	4	0		
Ta181(n,6n)Ta176	H3, Lu172, Lu176, Hf171, Hf172, Hf175, Ta176	5	0		
Ta182(n,γ)Ta183	Hf182, Ta180m, Ta183, W183, W185, Re186, Re186m	5	4	•	
Ta182(n,p)Hf182	Hf182	4	0		
Ta182(n,α)Lu179	Hf182, Ta180m	4	0		
W180(n,γ)W181	Hf178n, Ta182, W181, W183	5	4	•	
W181(n,α)Hf178n	Hf178n	5	0		
W182(n,2n)W181	H3, Hf172, Hf178n, Ta179, Ta182, W181	5	6	•	•
W182(n,nα)Hf178n	Hf172, Hf178n	5	2	•	
W182(n,4n)W179	Hf172, Hf178n, Ta179	5	0		
W182(n,γ)W183	Hf182, Ta183, W183, W185, Re186, Re186m,	5	4/0	•	

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
	Re187				
W182(n,γ)W183m	Hf182, Ta183, W183, W183m, W185, Re186, Re186m	5	0		
W182(n,p)Ta182	Hf182, Ta182	5	6	•	•
W182(n,6n)W177	Hf172	4	0		
W183(n,2n)**W182**	Hf172, Hf178n, Ta179, Ta182, W181	4	4	•	
W183(n,3n)W181	H3, Hf172, Hf178n, Ta179, W181	4	0		
W183(n,γ)W184	Hf182, W185, W187, Re186, Re186m, Re187, Re188	5	4	•	
W183(n,d)Ta182m	Ta182	4	0		
W183(n,α)**Hf180**	Hf178n, Hf182	5	0		
W183(n,α)Hf180m	Ta180m	4	6*	•	•
W184(n,2n)W183	H3, Hf178n, Ta179, Ta182, W183, W183m	4	0		
W184(n,2n)W183m	H3, Hf178n, Ta182, W183, W183m	5	2	•	
W184(n,4n)W181	Ta179, W181	5	0		
W184(n,γ)W185	Hf182, W183, W183m, W185, W187, Re186, Re186m, Re187, Re188, Os194, Ir192	5	4/2	•	
W184(n,t)Ta182m	Ta182	4	0		
W184(n,6n)W179	Ta179	4	0		
W185(n,α)Hf182	Hf182	5	0		
W186(n,2n)W185	H3, Hf182, Ta182, W183, W185, Re184, Re184m, Re186, Re186m	5	6	•	•
W186(n,2n)W185m	Ta182, W183, W185, Re184, Re184m, Re186, Re186m	4	6	•	•
W186(n,nα)Hf182	Hf182	5	0/5	•	•
W186(n,4n)W183m	Ta179, W183, W183m	5	0		
W186(n,γ)W187	W185, W187, Re184, Re184m, Re186, Re186m, Re187, Re188, Os194, Ir192, Ir192n, Ir194, Pt193	5	6	•	•
W186(n,d)Ta185	W185, Re184, Re184m, Re186, Re186m	4	5_2	•	•
W186(n,6n)W181	Hf172, Hf178n, W181	4	0		
Re184(n,2n)Re183	Hf178n, Ta179, Re183	4	0		
Re184m(n,2n)Re183	Hf178n, Ta179, Re183	4	0		
Re185(n,2n)Re184	H3, Hf178n, Ta179, Ta182, W183, W185, Re183, Re184	5	5/6	•	•
Re185(n,2n)Re184m	H3, Hf178n, Ta179, Ta182, Re183, Re184, Re184m	5	6	•	•
Re185(n,3n)Re183	H3, Hf178n, Ta179, Ta182, W183, Re183	5	5_3*		•
Re185(n,4n)Re182	H3, Hf178n, Ta179, Ta182	4	0		
Re185(n,4n)Re182m	H3, Hf178n, Ta179, Ta182	5	0		
Re185(n,γ)Re186	Hf178n, W183, W183m, W187, Re186, Re187, Re188, Os186, Os194, Ir192, Ir194, Pt193	5	4	•	
Re185(n,γ)Re186m	Re186m, Re187	5	2	•	
Re185(n,α)Ta182	Hf178n, Ta179, Ta182	5	0		
Re185(n,α)Ta182m	Hf178n, Ta179, Ta182	4	0		
Re186(n,γ)Re187	Re187, Re188, Os194, Ir192	5	2	•	
Re187(n,2n)Re186	H3, Hf178n, Ta182, W185, W187, Re183, Re184, Re184m, Re186, Os185	5	6/4	•	•
Re187(n,2n)Re186m	H3, Hf178n, Ta182, W185, Re183, Re184, Re184m, Re186, Re186m	5	4	•	
Re187(n,3n)**Re185**	H3, Hf178n, Ta179, Ta182, W185, Re183, Re184, Re184m	4	0		
Re187(n,4n)Re184	H3, Hf178n, Ta179, Ta182, Re184	5	0		
Re187(n,4n)Re184m	H3, Hf178n, Ta179, Ta182, Re183, Re184, Re184m	5	0		
Re187(n,γ)Re188	Ta182, W185, W187, Re186, Re186m, Re188, Os194, Ir192, Ir192n, Ir194, Pt193	5	6	•	•
Re187(n,γ)Re188m	W185, Re188, Os194, Ir192, Ir192n, Ir194, Pt193	4	6*	•	•
Re187(n,p)W187	W187	5	6*	•	•
Re187(n,t)W185	H3, W185	4	5_3		•
Re187(n,t)W185m	H3, W185	5	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Re187(n,5n)Re183	H3, Hf178n, Ta179, Ta182, Re183	5	0		
Re187(n,6n)Re182m	H3, Hf178n, Ta179, Ta182	4	0		
Os184(n,γ)Os185	H3, Re186, Re186m, Os185	5	2	•	
Os185(n,2n)Os184	Os184	4	0		
Os186(n,2n)Os185	H3, Ta182, W185, Re183, Re184, Re184m, Re186, Re186m, Os184, Os185	5	2	•	
Os186(n,3n)Os184	Re184, Os184	4	0		
Os186(n,p)Re186	W185, Re186	4	2	•	
Os186(n,p)Re186m	Re184, Re186m	4	0		
Os187(n,2n)Os186	H3, W185, Re184, Re186, Re186m, Os184, Os185, Os186	4	0		
Os187(n,3n)Os185	W185, Re184, Os184, Os185	5	0		
Os187(n,4n)Os184	Re184, Os184	4	0		
Os187(n,γ)**Os188**	W185, Re186, Re186m, Re187, Os186, Os189m, Os190m, Os191, Os194, Ir191m, Ir192, Ir192n, Ir194, Pt193	5	4	•	
Os187(n,d)Re186	Re186, Os186	4	0		
Os187(n,d)Re186m	Re184, Re186m	4	0		
Os188(n,2n)**Os187**	H3, W185, Re184, Re186, Re186m, Os184, Os185, Os186	4	0		
Os188(n,3n)Os186	H3, W185, Re184, Re186, Re186m, Os184, Os185, Os186	4	0		
Os188(n,4n)Os185	H3, W185, Re184, Os184, Os185	5	0		
Os188(n,γ)**Os189**	Os190m, Os191, Os194, Ir191m, Ir192, Ir192n, Ir194, Pt193	4	0		
Os188(n,γ)Os189m	Os189m, Os190m, Os191, Os194, Ir191m, Ir192, Ir192n, Ir194, Pt193	5	0		
Os188(n,d)Re187	W185, Re184, Re186, Re186m, Re187	4	0		
Os188(n,t)Re186	Re186, Os184, Os186	4	0		
Os188(n,t)Re186m	W185, Re184, Re186, Re186m	4	0		
Os188(n,α)W185	Ta182, W185, W187, Re184, Re186, Re186m, Re187, Os186	4	0		
Os188(n,α)W185m	W185, Re184, Re186, Re186m, Re187, Os186	5	0		
Os188(n,5n)Os184	H3, Re184, Os184	4	0		
Os189(n,2n)**Os188**	H3, W185, Re184, Re186, Re186m, Re187, Os184, Os185, Os186	4	0		
Os189(n,3n)**Os187**	H3, W185, Re184, Re186, Re186m, Re187, Os184, Os185, Os186	5	0		
Os189(n,nα)W185	W185, Re184	4	0		
Os189(n,nt)Re186	Re184, Re186, Os186	4	0		
Os189(n,nt)Re186m	W185, Re184, Re186, Re186m	4	0		
Os189(n,4n)Os186	H3, Re184, Re186, Re186m, Os184, Os185, Os186	4	0		
Os189(n,γ)**Os190**	H3, Re187, Os191, Os193, Os194, Ir191m, Ir192, Ir192n, Ir194, Pt193	4	4	•	
Os189(n,γ)Os190m	Os190m, Ir192n	5	2	•	
Os189(n,5n)Os185	H3, W185, Re184, Os184, Os185	4	0		
Os189(n,6n)Os184	H3, Re184, Os184	4	0		
Os190(n,n')Os190m	Os190m	4	5_2	•	•
Os190(n,2n)Os189m	H3, W185, Re186, Re186m, Re187, Os184, Os185, Os186, Os189m	5	0		
Os190(n,2nα)W185	W185, Re184	4	0		
Os190(n,4n)**Os187**	H3, W185, Re184, Re186, Re186m, Re187, Os184, Os185, Os186	4	0		
Os190(n,γ)Os191	H3, Os191, Os193, Os194, Ir190, Ir191m, Ir191n, Ir192, Ir192n, Ir194, Pt193	4	2	•	
Os190(n,γ)Os191m	H3, Os191, Os193, Os194, Ir190, Ir191m, Ir191n, Ir192, Ir192n, Ir194, Pt193	5	2	•	
Os190(n,α)W187	Re184, Re186, Re186m, Re187, Os185	5	4	•	
Os190(n,5n)Os186	H3, Re184, Re186, Re186m, Os184, Os185, Os186	4	0		
Os190(n,6n)Os185	H3, W185, Re184, Os184, Os185	4	0		
Os190(n,2nt)Re186	Re186, Os186	4	0		

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Os190(n,2nt)Re186m	W185, Re184, Re186, Re186m	4	0		
Os191(n,γ)**Os192**	Os193, Os194, Ir194	4	0		
Os192(n,n')Os192m	Ir190, Ir192, Ir192n, Pt193	5	2	•	
Os192(n,2n)Os191	H3, Os189m, Os190m, Os191, Ir190, Ir191m, Ir191n, Ir192, Ir192n, Pt193	5	2	•	
Os192(n,2n)Os191m	H3, Os190m, Os191, Ir190, Ir191m, Ir191n, Ir192, Ir192n, Pt193	4	2	•	
Os192(n,3n)Os190m	W185, Os189m, Os190m	5	4	•	
Os192(n,4n)Os189m	H3, W185, Re184, Re186, Re186m, Os184, Os185, Os186, Os189m	5	0		
Os192(n,γ)Os193	Os193, Os194, Ir190, Ir191m, Ir192, Ir192n, Ir193m, Ir194, Pt193	5	4	•	
Os192(n,d)Re191	Re186, Re186m, Os190m, Os191, Ir190, Ir191m, Ir191n, Ir192	5	0		
Os192(n,4nα)W185	W185, Re184	4	0		
Os193(n,γ)Os194	Os194	5	2	•	
Ir189(n,2n)Ir188	Os185, Ir188	5	0		
Ir190(n,2n)Ir189	Ir188, Ir189	5	0		
Ir191(n,n')Ir191n	Ir191m, Ir191n	5	0		
Ir191(n,2n)Ir190	H3, Re186, Re186m, Re187, Os185, Os190m, Ir188, Ir189, Ir190	5	2/4/4*	•	
Ir191(n,2n)Ir190n	Re186, Re186m, Re187, Os190m, Ir188, Ir189, Ir190	4	6	•	•
Ir191(n,3n)Ir189	H3, Re186, Re186m, Re187, Os185, Os189m, Ir188, Ir189	5	4	•	
Ir191(n,nα)Re187	Re186, Re186m, Re187, Os185	5	0		
Ir191(n,2nα)Re186	Re186, Os185	4	0		
Ir191(n,2nα)Re186m	Re186, Re186m	5	0		
Ir191(n,4n)Ir188	H3, Re186, Re186m, Re187, Os185, Ir188	5	0		
Ir191(n,γ)Ir192	H3, Re187, Os194, Ir192, Ir192n, Ir193m, Ir194, Pt193, Pt193m, Pt195m, Au198, Au199	4	2/2/2	•	
Ir191(n,γ)Ir192m	H3, Re187, Os194, Ir192, Ir192n, Ir193m, Ir194, Pt193, Pt193m, Pt195m, Au198, Au199	5	2	•	
Ir191(n,γ)Ir192n	Ir192n, Ir193m	5	2	•	
Ir191(n,α)Re188	Re186, Re186m, Re187, Os185	5	0		
Ir192(n,γ)Ir193m	Ir193m, Ir194, Pt195m, Au198, Au199	5	4	•	
Ir193(n,n')Ir193m	Ir193m	5	4	•	
Ir193(n,2n)Ir192	H3, Re186, Re186m, Re187, Os194, Ir188, Ir189, Ir190, Ir191m, Ir191n, Ir192, Pt190, Pt193, Pt193m	5	0/5/2	•	•
Ir193(n,2n)Ir192m	H3, Re186, Re187, Os194, Ir188, Ir189, Ir190, Ir191m, Ir191n, Ir192, Pt190, Pt193, Pt193m	4	5_2	•	•
Ir193(n,2n)Ir192n	H3, Re186, Re186m, Re187, Os185, Ir188, Ir189, Ir190, Ir191m, Ir191n, Ir192, Ir192n, Pt193, Pt193m	5	2	•	
Ir193(n,3nα)Re187	Re186, Re186m, Re187	4	0		
Ir193(n,4n)Ir190	H3, Re186, Re186m, Re187, Os185, Ir188, Ir190	5	0		
Ir193(n,γ)Ir194	Os194, Ir194, Pt193, Pt193m, Pt195m, Au198, Au199	5	4	•	
Ir193(n,γ)Ir194m	Os194, Ir194, Pt193, Pt193m, Pt195m, Au198, Au199	5	0		
Ir193(n,p)Os193	Os194	5	4	•	
Ir193(n,α)Re190	Re187	4	2/4	•	
Ir193(n,5n)Ir189	H3, Re186, Re186m, Re187, Os185, Ir189	5	0		
Ir193(n,6n)Ir188	H3, Re186, Re186m, Re187, Os185, Ir188	5	0		
Ir193(n,4nα)Re186m	Re186m	4	0		
Ir194(n,γ)Ir195	Ir192n, Au198, Au199	4	2	•	
Pt190(n,2n)Pt189	Re186, Re186m, Os185, Ir188, Ir189	5	0		
Pt190(n,3n)Pt188	Re186, Re186m, Os185, Ir188	5	0		
Pt190(n,γ)Pt191	Re186, Re186m, Ir192, Ir192n, Pt193	5	2	•	
Pt190(n,α)**Os187**	Re186, Re186m, Os185	5	2	•	
Pt192(n,2n)Pt191	H3, Re186, Re186m, Re187, Os185, Ir188,	4	2	•	

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
	Ir189, Ir190, Ir191m, Ir191n, Pt190				
Pt192(n,3n)Pt190	Re186, Re186m, Os185, Ir188, Ir189, Ir190, Pt190	5	0		
Pt192(n,γ)Pt193	Ir194, Pt193, Pt193m, Pt195m, Au198, Au199	5	2	•	
Pt192(n,γ)Pt193m	Pt193, Pt193m, Pt195m, Au198, Au199	5	2	•	
Pt193(n,2n)**Pt192**	Re186, Re186m, Os185, Ir188, Ir190, Ir191m, Ir192, Pt190	4	0		
Pt193(n,4n)Pt190	Os185, Ir188, Ir190, Pt190	4	0		
Pt193(n,d)Ir192	Ir190, Ir192	4	0		
Pt194(n,2n)Pt193	Re186, Re186m, Os185, Ir188, Ir190, Ir191m, Ir192, Ir192n, Ir193m, Pt190, Pt193, Pt193m	4	0		
Pt194(n,2n)Pt193m	Re186, Re186m, Os185, Ir188, Ir190, Ir191m, Ir192, Ir192n, Ir193m, Pt190, Pt193, Pt193m	5	0		
Pt194(n,3n)**Pt192**	Re186, Re186m, Os185, Ir188, Ir190, Ir191m, Ir192, Ir192n, Pt190	5	0		
Pt194(n,4n)Pt191	Re186, Re186m, Os185, Ir188, Ir190, Ir191m	5	0		
Pt194(n,γ)**Pt195**	Ir192n, Pt195m, Pt197, Au197m, Au198, Au199	5	4	•	
Pt194(n,γ)Pt195m	Ir192n, Pt195m, Pt197, Au197m, Au198, Au199	5	2	•	
Pt194(n,p)Ir194	Os194, Ir194	4	4/2	•	
Pt194(n,d)Ir193m	Re186, Re186m, Os185, Ir188, Ir190, Ir192, Ir192n, Ir193m	4	0		
Pt194(n,t)Ir192	Ir188, Ir190, Ir192, Ir192n, Pt190	4	0		
Pt194(n,t)Ir192n	Ir192n	4	0		
Pt194(n,α)Os191	Re186, Re186m, Os191, Ir188, Ir190, Ir191m, Ir192, Ir192n, Ir193m, Pt193	5	0		
Pt194(n,α)Os191m	Re186, Re186m, Os191, Ir190, Ir191m, Ir192, Ir192n, Ir193m	5	0		
Pt194(n,5n)Pt190	Re186, Re186m, Os185, Ir188, Ir190, Pt190	5	0		
Pt194(n,6n)Pt189	Re186, Re186m, Os185	4	0		
Pt194(n,2nt)Ir190	Re186, Re186m, Os185, Ir190	4	0		
Pt195(n,n')Pt195m	Pt195m	4	0		
Pt195(n,2n)**Pt194**	Re186, Re186m, Os185, Ir188, Ir190, Ir191m, Ir192, Ir192n, Ir193m, Ir194, Pt190, Pt193, Pt193m	4	0		
Pt195(n,3n)Pt193m	Re186, Re186m, Os185, Ir188, Ir190, Ir191m, Ir192, Ir192n, Ir193m, Pt190, Pt193, Pt193m	5	0		
Pt195(n,nα)Os191	Re186, Re186m, Ir188, Ir190, Ir191m	4	0		
Pt195(n,nt)Ir192	Ir188, Ir190, Ir192, Pt190	4	0		
Pt195(n,nt)Ir192n	Ir192n	4	0		
Pt195(n,4n)**Pt192**	Re186, Re186m, Os185, Ir188, Ir190, Ir191m, Ir192, Ir192n, Pt190	4	0		
Pt195(n,γ)**Pt196**	Os194, Pt197, Au197m, Au198, Au199, Hg203, Tl204	5	4	•	
Pt195(n,d)Ir194m	Ir190, Ir192, Ir192n, Ir194, Pt190	4	0		
Pt195(n,α)**Os192**	Os194, Ir190, Ir191m, Ir193m	5	0		
Pt195(n,α)Os192m	Os194, Ir191m, Ir192n, Ir193m	5	0		
Pt195(n,6n)Pt190	Re186, Re186m, Os185, Ir188, Ir190, Pt190	4	0		
Pt196(n,2n)**Pt195**	Ir191m, Ir192, Ir192n, Ir193m, Ir194, Pt190, Pt193, Pt193m	4	0		
Pt196(n,2n)Pt195m	Ir191m, Ir192, Ir192n, Ir193m, Ir194, Pt190, Pt193, Pt193m, Pt195m	5	0		
Pt196(n,4n)Pt193m	Re186, Re186m, Os185, Ir188, Ir190, Ir191m, Ir192, Ir192n, Pt190, Pt193, Pt193m	5	0		
Pt196(n,γ)Pt197	Os194, Pt197, Au194, Au195, Au198, Au199	5	4	•	
Pt196(n,γ)Pt197m	Os194, Pt197, Au194, Au195, Au197m, Au198, Au199, Hg194, Hg203, Tl204	5	4	•	
Pt196(n,h)Os194	Os194	4	0		
Pt196(n,α)Os193	Os194, Ir190, Ir191m, Ir192, Ir192n, Ir193m, Pt190	5	2	•	
Pt197(n,α)Os194	Os194	5	0		
Pt198(n,2n)Pt197	Os194, Pt197, Au194, Au195, Au198, Hg194	5	2	•	
Pt198(n,2n)Pt197m	Os194, Pt197, Au194, Au195, Au198, Hg194	5	6	•	•

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Pt198(n,nα)Os194	Os194	5	0		
Pt198(n,4n)Pt195m	Ir190, Ir192, Ir192n, Pt190, Pt193m, Pt195m	4	0		
Pt198(n,γ)Pt199	Pt199, Au198, Au199, Hg194, Hg203, Tl204, Pb205	5	4	•	
Pt198(n,γ)Pt199m	Pt199, Au198, Au199, Hg194, Hg203, Tl204, Pb205	4	2	•	
Au195(n,2n)Au194m	Ir193m, Pt190, Pt193, Au192, Au194	4	0		
Au195(n,4n)Au192	Pt190, Au192	4	0		
Au195(n,4n)Au192m	Pt190, Au192	4	0		
Au197(n,n')Au197m	Au197m	5	5_2	•	•
Au197(n,2n)Au196	Ir191m, Ir192, Ir192n, Ir193m, Ir194, Pt190, Pt193, Au192, Au194, Au195, Au196, Hg194, Hg196	5	6	•	•
Au197(n,3n)Au195	Ir191m, Ir192, Ir192n, Ir193m, Ir194, Pt190, Pt193, Au192, Au194, Au195	4	6	•	•
Au197(n,3n)Au195m	Ir191m, Ir192, Ir192n, Ir193m, Ir194, Pt190, Pt193, Au192, Au194, Au195	5	5_3		•
Au197(n,nα)Ir193m	Ir191m, Ir192, Ir192n, Ir193m, Pt190	5	0		
Au197(n,2nα)Ir192	Ir192, Ir192n, Pt190	4	0		
Au197(n,2nα)Ir192n	Ir192n	4	0		
Au197(n,4n)Au194m	Ir191m, Ir192, Ir192n, Ir193m, Ir194, Pt190, Pt193, Au192, Au194	5	0		
Au197(n,4n)Au194n	Ir191m, Ir192, Ir192n, Ir193m, Ir194, Pt190, Pt193, Au194	4	0		
Au197(n,γ)Au198	Ir192n, Ir193m, Au197m, Au198, Au199, Hg194, Hg199m, Hg203, Tl204, Pb204, Pb205	5	6	•	•
Au197(n,α)Ir194	Os191, Ir191m, Ir192, Ir192n, Ir193m, Ir194, Pt190, Pt193, Au197m	5	6/6	•	•
Au197(n,5n)Au193m	Ir191m, Ir192, Ir192n, Ir193m, Pt190, Pt193	5	0		
Au197(n,6n)Au192	Ir191m, Ir192, Pt190, Au192	4	0		
Au197(n,6n)Au192m	Ir191m, Ir192, Ir192n, Pt190, Au192	5	0		
Au198(n,γ)Au199	Au197m, Au199, Hg203, Tl204, Pb204, Pb205	5	2/2	•	
Au198(n,α)Ir195	Ir192n, Ir193m, Au197m	5	0		
Hg194(n,3n)Hg192	Pt190, Au192	5	0		
Hg194(n,5n)Hg190	Pt190	4	0		
Hg195m(n,2n)Hg194	Pt190, Au192, Hg194	5	0		
Hg196(n,2n)Hg195m	Ir192, Pt190, Pt193, Au192, Au194, Au195, Hg194	5	2	•	
Hg196(n,3n)Hg194	Pt190, Pt193, Au192, Au194, Hg194	5	0		
Hg196(n,4n)Hg193	Pt190, Pt193	4	0		
Hg196(n,γ)Hg197	Au198, Hg197, Hg199m	5	4/2	•	
Hg196(n,α)Pt193	Ir192, Ir192n, Pt190, Pt193	5	0		
Hg198(n,2n)Hg197	H3, Pt193, Au194, Au195, Au196, Au198, Hg194, Hg197	4	4	•	
Hg198(n,2n)Hg197m	Pt193, Au194, Au195, Au196, Au198, Hg194, Hg197	4	4	•	
Hg198(n,3n)Hg196	H3, Pt190, Pt193, Au194, Au195, Au196, Hg194	5	0		
Hg198(n,4n)Hg195m	H3, Pt190, Pt193, Au194, Au195	4	0		
Hg198(n,γ)**Hg199**	Au197m, Au199, Hg199m, Hg203, Tl204, Pb204, Pb205	5	5_2	•	•
Hg198(n,γ)Hg199m	Au197m, Au199, Hg199m, Hg203, Tl204, Pb204, Pb205	5	2	•	
Hg198(n,p)Au198	Au198	5	0		
Hg198(n,α)**Pt195**	Ir192n, Ir193m, Pt190, Pt193, Au197m	5	0		
Hg198(n,5n)Hg194	H3, Pt190, Pt193, Au194, Hg194	5	0		
Hg199(n,2n)**Hg198**	H3, Pt190, Pt193, Au194, Au195, Au196, Au198, Hg194, Hg197	4	0		
Hg199(n,3n)Hg197	H3, Pt190, Pt193, Au194, Au195, Au196, Hg197	4	0		
Hg199(n,3n)Hg197m	H3, Pt193, Au194, Au195, Au196, Hg197	4	0		
Hg199(n,4n)Hg196	H3, Pt190, Pt193, Au194, Au195, Au196, Hg194	5	0		
Hg199(n,γ)**Hg200**	Hg203, Tl204, Pb204, Pb205	5	4	•	
Hg199(n,p)Au199	Au199	4	2	•	

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
Hg199(n,d)Au198	Au195, Au196, Au198, Hg194	4	0		
Hg199(n,α)**Pt196**	Pt190, Pt193, Au197m	5	0		
Hg199(n,5n)Hg195m	H3, Pt190, Pt193, Au194, Au195	4	0		
Hg199(n,6n)Hg194	H3, Pt190, Pt193, Au194, Hg194	4	0		
Hg200(n,2n)Hg199m	H3, Au194, Au195, Au196, Au198, Hg194, Hg197, Hg199m	5	6	•	•
Hg200(n,4n)Hg197	H3, Pt190, Pt193, Au194, Au195, Au196, Hg194, Hg197	4	0		
Hg200(n,4n)Hg197m	H3, Pt193, Au194, Au195, Au196, Hg194, Hg197	4	0		
Hg200(n,γ)**Hg201**	Hg203, Tl204, Pb204, Pb205	5	4	•	
Hg200(n,t)Au198	H3, Pt193, Au194, Au195, Au196, Au198, Hg194	4	0		
Hg201(n,3n)Hg199m	H3, Au194, Au195, Au196, Au198, Hg194, Hg197, Hg199m	5	0		
Hg201(n,4n)**Hg198**	H3, Pt190, Pt193, Au194, Au195, Au196, Au198, Hg194, Hg197	4	0		
Hg201(n,γ)**Hg202**	Hg203, Tl204, Pb204, Pb205	5	4	•	
Hg202(n,4n)Hg199m	H3, Au194, Au195, Au196, Au198, Hg194, Hg197, Hg199m	5	0		
Hg202(n,γ)Hg203	Hg203, Hg205, Tl202, Tl204, Pb202, Pb204, Pb205	5	4	•	
Hg204(n,2n)Hg203	H3, Hg199m, Hg203, Tl200, Tl202, Tl204, Pb202, Pb205	5	4	•	
Hg204(n,γ)Hg205	Hg205, Tl202, Tl204, Pb202, Pb205	5	4	•	
Hg204(n,d)Au203	Hg203, Tl202, Tl204, Pb202	4	0		
Tl201(n,2n)Tl200	Hg194, Tl200	5	0		
Tl202(n,2n)Tl201	Tl200, Tl201	5	0		
Tl203(n,2n)Tl202	H3, Au194, Au195, Hg194, Hg203, Tl200, Tl201, Tl202	5	6	•	•
Tl203(n,3n)Tl201	H3, Au194, Au195, Hg194, Hg199m, Tl200,	5	4	•	
Tl203(n,4n)Tl200	H3, Au194, Au195, Hg194, Tl200	5	0		
Tl203(n,γ)Tl204	Hg203, Hg205, Tl204, Tl206, Pb202, Pb204, Pb204m, Pb205	5	4	•	
Tl203(n,p)Hg203	Hg203	4	2	•	
Tl203(n,α)Au200	Hg194, Hg203	5	2/2	•	
Tl203(n,5n)Tl199	H3, Au194, Au195, Hg194	4	0		
Tl205(n,2n)Tl204	H3, Au195, Hg194, Hg203, Tl200, Tl201, Tl202, Tl204, Pb202, Pb204m, Pb205	5	4	•	
Tl205(n,3n)**Tl203**	H3, Au195, Hg194, Hg203, Tl200, Tl201, Tl202	4	0		
Tl205(n,4n)Tl202	H3, Au194, Au195, Hg194, Tl200, Tl202	5	0		
Tl205(n,γ)Tl206	Hg203, Tl206, Pb202, Pb204m, Pb205	5	6	•	•
Tl205(n,t)Hg203	Hg194, Hg203	5	6	•	•
Tl205(n,5n)Tl201	H3, Au194, Au195, Hg194, Tl201	5	0		
Tl205(n,6n)Tl200	H3, Au194, Au195, Hg194, Tl200	5	0		
Pb202(n,3n)Pb200	Tl200	4	0		
Pb202(n,5n)Pb198	Hg194	4	0		
Pb203(n,2n)Pb202	Tl200, Pb202	4	0		
Pb204(n,n')Pb204m	Pb204m	5	6	•	•
Pb204(n,2n)Pb203	H3, Hg203, Tl200, Tl202, Tl204, Pb202, Pb203	4	6	•	•
Pb204(n,2n)Pb203m	Hg203, Tl200, Tl202, Tl204, Pb202, Pb203	4	5_2	•	•
Pb204(n,3n)Pb202	H3, Hg194, Tl200, Tl202, Pb202	5	0/4	•	
Pb204(n,γ)Pb205	Hg203, Tl204, Pb205	5	4	•	
Pb204(n,p)Tl204	Tl202, Tl204	4	0		
Pb204(n,α)**Hg201**	Hg194, Hg203, Tl204	4	0		
Pb204(n,5n)Pb200	Hg194, Tl200	4	0		
Pb205(n,2n)Pb204	H3, Hg203, Tl200, Tl202, Tl204, Pb202, Pb203, Pb204m	4	0		
Pb205(n,2n)Pb204m	Tl200, Tl202, Tl204, Pb202, Pb203, Pb204m	5	0		
Pb205(n,4n)Pb202	Hg194, Tl200, Tl202, Pb202	4	0		
Pb205(n,d)Tl204	Hg203, Tl202, Tl204, Pb202	4	0		
Pb206(n,2n)Pb205	H3, Hg203, Tl200, Tl202, Tl204, Pb202, Pb203,	5	4	•	

Reaction	Daughter nuclide	Imp	Score	Exp data	
				Diff	Int
	Pb204m, Pb205				
Pb206(n,3n)Pb204	H3, Hg194, Hg203, Tl200, Tl202, Tl204, Pb202, Pb203, Pb204m	4	0		
Pb206(n,3n)Pb204m	H3, Hg203, Tl200, Tl202, Tl204, Pb202, Pb203, Pb204m	5	4	•	
Pb206(n,4n)Pb203	H3, Hg194, Hg203, Tl200, Tl202, Pb203	4	0		
Pb206(n,4n)Pb203m	H3, Hg203, Tl200, Tl202, Pb203	4	0		
Pb206(n,γ)Pb207m	Pb207m	5	2	•	
Pb206(n,p)Tl206	Tl206	5	5_2	•	•
Pb206(n,t)Tl204	H3, Hg194, Hg203, Tl200, Tl202, Tl204, Pb202	4	0		
Pb206(n,α)Hg203	Hg203, Tl200, Tl202, Tl204	5	6	•	•
Pb206(n,5n)Pb202	H3, Hg194, Tl200, Tl202, Pb202	4	0		
Pb207(n,3n)Pb205	H3, Hg194, Hg203, Tl200, Tl202, Tl204, Pb202, Pb203, Pb204m, Pb205	5	0		
Pb207(n,nα)Hg203	Hg203, Tl200, Tl202	4	0		
Pb207(n,nt)Tl204	H3, Hg194, Hg203, Tl200, Tl202, Tl204	4	0		
Pb207(n,4n)Pb204m	Hg194, Tl200, Tl202, Tl204, Pb202, Pb203, Pb204m	5	0		
Pb207(n,d)Tl206m	Tl206, Tl206m	4	0		
Pb207(n,α)**Hg204**	Hg203, Tl200, Tl202	4	2	•	
Pb207(n,6n)Pb202	H3, Hg194, Tl200, Tl202, Pb202	4	0		
Pb208(n,2n)Pb207m	H3, Hg203, Hg205, Tl202, Tl204, Tl206, T	5	4	•	
Pb208(n,3n)**Pb206**	H3, Hg203, Hg205, Tl200, Tl202, Tl204, Tl206, Tl206m, Pb202, Pb203, Pb204m, Pb205	4	0		
Pb208(n,2nα)Hg203	Hg203, Tl200, Tl202	4	0		
Pb208(n,4n)Pb205	H3, Hg194, Hg203, Tl200, Tl202, Tl204, Pb202, Pb203, Pb204m, Pb205	5	0		
Pb208(n,γ)Pb209	H3, Pb209, Pb210, Bi207, Bi208, Bi210m, Po210	5	4	•	
Pb208(n,α)Hg205	Hg203, Hg205, Tl202, Tl204	5	4	•	
Pb208(n,5n)Pb204	H3, Hg194, Tl200, Tl202, Pb202, Pb203	4	0		
Pb208(n,5n)Pb204m	H3, Hg194, Tl200, Tl202, Pb204m	5	0		
Pb208(n,6n)Pb203	H3, Hg194, Hg203, Tl200, Tl202, Pb203	4	0		
Pb208(n,2nt)Tl204	Hg194, Hg203, Tl200, Tl202, Tl204	4	0		
Pb209(n,γ)Pb210	Pb210	5	0		
Bi203(n,3n)Bi201m	Bi201m	5	0		
Bi204(n,4n)Bi201m	Bi201m	5	0		
Bi205(n,3n)Bi203	Bi201m	5	0		
Bi205(n,5n)Bi201m	Bi201m	5	0		
Bi206(n,2n)Bi205	Pb202, Bi205	5	0		
Bi207(n,2n)Bi206	Tl206, Tl206m, Pb202, Bi201m, Bi205, Bi206	5	0		
Bi207(n,3n)Bi205	Pb202, Bi201m, Bi205	5	0		
Bi207(n,4n)Bi204	Pb202, Bi201m	5	0		
Bi208(n,2n)Bi207	Tl206, Tl206m, Pb202, Bi201m, Bi205, Bi206, Bi207	5	0		
Bi208(n,3n)Bi206	Tl206, Tl206m, Pb202, Bi201m, Bi206	4	0		
Bi208(n,4n)Bi205	Pb202, Bi201m, Bi205	4	0		
Bi209(n,2n)Bi208	Tl206, Tl206m, Pb202, Bi201m, Bi205, Bi206, Bi207, Bi208	5	0/4	•	
Bi209(n,3n)Bi207	Tl206, Tl206m, Pb202, Bi201m, Bi205, Bi206, Bi207	5	6	•	•
Bi209(n,4n)Bi206	Tl206, Tl206m, Pb202, Bi201m, Bi206	5	6	•	•
Bi209(n,γ)Bi210	Pb202, Pb210, Bi210, Po209, Po210	5	4	•	
Bi209(n,γ)Bi210m	Pb210, Bi210m	5	2	•	
Bi209(n,α)Tl206	Tl206, Pb202	5	6	•	•
Bi209(n,α)Tl206m	Tl206, Tl206m	5	4*	•	
Bi209(n,5n)Bi205	Pb202, Bi201m, Bi205	5	4	•	
Po210(n,2n)Po209	Pb202, Po209	5	0		

Summary of reaction types

Reaction↓	Importance→	5	4	3	2	1	Total
(n,n′)		22	6	4	9	15	56
(n,2n)		245	120	65	55	75	560
(n,3n)		86	66	69	55	120	396
(n,4n)		82	74	38	44	88	326
(n,5n)		24	45	38	25	75	207
(n,6n)		12	29	16	15	50	122
(n,7n)		0	0	0	1	4	5
(n,γ)		379	53	23	19	49	523
(n,p)		102	50	21	11	37	221
(n,d)	**(n,n′p)**	50	80	52	41	94	317
(n,t)	**(n,n′d)**+**(n,2np)**	54	66	44	38	106	308
(n,h)	(n,pd)+(n,n′2p)	12	5	9	11	28	65
(n,α)	**(n,n′h)**+(n,n′pd)+(n,pt)+(n,2n2p)	170	66	38	43	66	383
(n,n′t)	(n,2nd)+(n,3np)	7	34	41	55	105	242
(n,n′α)	(n,2nh)+(n,3n2p)	53	49	42	46	91	281
(n,2nt)	(n,3nd)+(n,4np)	7	18	36	35	79	175
(n,2nα)	(n,3nh)+(n,4n2p)	25	31	34	34	110	234
(n,3nt)	(n,4nd)+(n,5np)	0	0	0	2	28	30
(n,3nα)	(n,4nh)+(n,5n2p)	1	16	16	18	83	134
(n,4nα)		0	9	5	10	38	62
(n,5nα)		0	0	0	0	2	2
(n,2p)		7	5	4	1	9	26
(n,2α)		9	10	6	7	19	51
(n,n′2α)	(n,3n2pα)	5	8	9	9	28	59
(n,2n2α)		3	5	8	4	26	46
(n,3n2α)		0	0	0	0	1	1
(n,ph)		2	2	1	1	6	12
(n,pα)	(n,n′ph)+(n,dh)	7	5	4	10	18	44
(n,dα)	(n,n′pα)+(n,n′dh)	8	17	5	8	26	64
(n,tα)	(n,n′dα)+(n,2npα)+(n,n′th)	7	7	10	15	39	78
(n,hα)		1	2	3	0	5	11
(n,n′tα)	(n,3npα)	1	2	0	2	20	25
(n,d2α)		3	0	1	0	5	9
(n,t2α)	(n,n′d2α)	1	0	0	1	1	3
(n,3p)		0	2	0	0	1	3
(n,3α)		1	0	2	3	6	12
(n,n′3α)		1	3	1	2	5	12
Standard		**1316**	**744**	**519**	**506**	**1141**	**4226**
Exotic		**71**	**141**	**126**	**124**	**417**	**879**
Total		**1387**	**885**	**645**	**630**	**1558**	**5105**