

Fission Products Per Tonne of Fuel

used for 50.68 GWth-day LWR burnup at power of 36.54 MWth and $3.14 \times 10^{14} N/cm^2/s$ neutron flux,
after ten years' storage, as calculated by ORIGEN2 version 2.1 on 9 October 2013.
Radiotoxicity in Sieverts computed for adult ingestion using dose factors from ICRP publication 119

Isotope ‡	Decay From	Mass grams	Moles	Radioactivity		Decay To	Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity †	
				GBq	GBq/gm				Watts	Watts/gm	Sv	Sv/gm
⁸⁶ Sr ⁸⁷ Sr ⁸⁸ Sr ⁸⁹ Sr ⁹⁰ Sr E ₃₈ Sr	⁸⁷ Rb ₃₇ Rb	923.6 mg 7.616 mg 519.2 gm ≤ 1 pg 615.2 gm 1.135 kg	10.75 mM 87.63 μM 5.906 M ≤ 1 pM 6.843 M 12.76 M									
				4.804 μBq 3.107 PBq 3.107 PBq	1.076 PBq 5.050 TBq 2.737 TBq	β ⁸⁹ Y β ⁹⁰ Y	50.57 d 28.79 y	582.9 keV 195.8 keV	≤ 1 pW 97.44 W 97.44 W	100.5 W 158.4 mW 85.83 mW	≤ 1 pSv 87.00 MSv 87.00 MSv	2.798 MSv 141.4 kSv 76.63 kSv
¹³³ Cs ¹³⁴ Cs ¹³⁵ Cs ¹³⁷ Cs E ₅₅ Cs		1.616 kg 8.139 gm 619.6 gm 1.436 kg 3.680 kg	12.16 M 60.78 mM 4.593 M 10.49 M 27.30 M	390.1 TBq 26.41 GBq 4.626 PBq 5.016 PBq	47.93 TBq 0.0003% → 42.62 MBq 3.221 TBq 5.601% → 1.363 TBq	β ¹³⁴ Ba ϵ ¹³⁴ Xe β ¹³⁵ Ba β ^{137m} Ba β ¹³⁷ Ba	2.065 y 2.300 My 30.04 y	1.715 MeV 56.30 keV 186.6 keV	107.2 W 238.2 μW 138.3 W 245.5 W	13.17 W 384.4 nW 96.31 mW 66.72 mW	7.412 MSv 52.82 Sv 60.14 MSv 67.55 MSv	910.7 kSv 85.25 mSv 41.88 kSv 18.36 kSv
⁸⁹ Y ⁹⁰ Y ⁹¹ Y E ₃₉ Y	⁸⁹ Sr ⁹⁰ Sr ₃₈ Sr	676.0 gm 154.3 mg ≤ 1 pg 676.2 gm	7.604 M 1.716 mM ≤ 1 pM 7.605 M	3.108 PBq 6.162 mBq 3.108 PBq	20.14 PBq 907.8 TBq 4.597 TBq	β ⁹⁰ Zr β ⁹¹ Zr	2.671 d 58.51 d	934.7 keV 606.0 keV	465.4 W ≤ 1 pW 465.4 W	3.016 kW 88.13 W 688.3 mW	8.392 MSv 14.79 pSv 8.392 MSv	54.38 MSv 2.179 MSv 12.41 kSv
¹⁵⁰ Eu ¹⁵¹ Eu ¹⁵² Eu ¹⁵³ Eu ¹⁵⁴ Eu ¹⁵⁵ Eu E ₆₃ Eu	¹⁵¹ Sm ₆₂ Sm ¹⁵³ Gd ₆₄ Gd	375.0 ng 1.710 gm 37.85 mg 195.8 gm 29.45 gm 6.383 gm 233.4 gm	2.501 nM 11.43 mM 249.1 μM 1.280 M 191.3 mM 41.20 mM 1.525 M	919.3 kBq 88.93 μBq 242.3 GBq 294.3 TBq 109.9 TBq 404.4 TBq	2.451 TBq 52.00 μBq 6.402 TBq 27.9% → 9.993 TBq 0.02% → 17.22 TBq 1.733 TBq	ϵ ¹⁵⁰ Sm α ¹⁴⁷ Pm ϵ ¹⁵² Sm β ¹⁵² Gd β ¹⁵⁴ Gd ϵ ¹⁵⁴ Sm β ¹⁵⁵ Gd	36.36 y 1.700 Ey 13.52 y 8.593 y 4.753 y	1.539 MeV 1.905 MeV 1.276 MeV 1.509 MeV 122.7 keV	226.7 nW ≤ 1 pW 49.53 mW 71.14 W 2.160 W 73.35 W	604.5 mW ≤ 1 pW 1.309 W 2.416 W 338.4 mW 314.3 mW	1.195 mSv 339.2 Sv 588.6 kSv 35.17 kSv 624.1 kSv	3.187 kSv 8.962 kSv 19.99 kSv 5.510 kSv 2.674 kSv
⁹⁹ Ru ¹⁰⁰ Ru ¹⁰¹ Ru ¹⁰² Ru ¹⁰³ Ru	⁹⁹ Tc ₄₃ Tc ¹⁰⁰ Mo ₄₂ Mo ¹⁰² Rh ₄₅ Rh	43.95 mg 218.3 gm 1.166 kg 1.217 kg ≤ 1 pg	444.4 μM 2.185 M 11.56 M 11.94 M ≤ 1 pM	6.355 pBq	1.195 PBq 1.198% →	β ^{103m} Rh β ¹⁰³ Rh	39.26 d	564.3 keV	≤ 1 pW	108.0 W	≤ 1 pSv	872.2 kSv

‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas; †Radiotoxicity of daughters is included in parents.

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				GBq	GBq/gm				Watts	Watts/gm	Sv	Sv/gm
¹⁰⁴ Ru ¹⁰⁶ Ru A ₄₄ Ru		863.0 gm 231.6 mg 3.465 kg	8.306 M 2.187 mM 33.99 M									
				28.70 TBq	123.9 TBq	β ¹⁰⁶ Rh	1.020 y	10.03 keV	46.10 mW	199.1 mW	200.9 kSv	867.4 kSv
				28.70 TBq	8.284 GBq				46.10 mW	13.31 μ W	200.9 kSv	57.99 Sv
¹⁴⁶ Pm ¹⁴⁷ Pm ¹⁴⁸ Pm ^{148m} Pm E ₆₁ Pm	¹⁵¹ Eu ^{148m} Pm ₆₁ Pm	2.661 mg 11.02 gm ≤ 1 pg ≤ 1 pg	18.24 μ M 75.01 mM ≤ 1 pM ≤ 1 pM	43.86 GBq 378.2 TBq ≤ 1 pBq 2.956 pBq	16.48 TBq 34.32 TBq 6.083 PBq 791.0 TBq 5% \rightarrow 34.32 TBq	ϵ ¹⁴⁶ Nd β ¹⁴⁶ Sm β ¹⁴⁷ Sm β ¹⁴⁸ Sm β ¹⁴⁸ Sm γ ¹⁴⁸ Pm	5.531 y 2.623 y 5.368 d 41.05 d	850.6 keV 60.52 keV 1.299 MeV 2.139 MeV	5.977 mW 3.667 W ≤ 1 pW ≤ 1 pW	2.246 W 332.8 mW 1.266 kW 271.1 W	39.47 Sv 98.33 kSv ≤ 1 pSv ≤ 1 pSv	14.83 kSv 8.923 kSv 16.42 MSv 1.345 MSv
		11.02 gm	75.03 mM	378.2 TBq	34.32 TBq				3.673 W	333.2 mW	98.37 kSv	8.924 kSv
¹²¹ Sb ¹²³ Sb ¹²⁴ Sb ¹²⁵ Sb ¹²⁶ Sb ^{126m} Sb E ₅₁ Sb	^{121m} Sn ¹²³ Sn ₅₀ Sn	12.20 gm 15.25 gm ≤ 1 pg 1.610 gm	100.9 mM 124.1 mM ≤ 1 pM 12.89 mM									
				45.23 μ Bq	648.0 TBq	β ¹²⁴ Te	60.20 d	2.238 MeV	≤ 1 pW	232.4 W	≤ 1 pSv	1.620 MSv
				61.55 TBq	38.23 TBq	β ¹²⁵ Te	2.759 y	527.4 keV	5.200 W	3.230 W	67.71 kSv	42.05 kSv
					22.377% \rightarrow	β ^{125m} Te						
						β ¹²⁶ Te	12.40 d	3.116 MeV	3.120 mW	1.545 kW	15.00 Sv	7.431 MSv
						β ¹²⁶ Te	19.10 m	2.148 MeV	15.36 mW	1.001 MW	1.607 Sv	104.7 MSv
					14% \rightarrow	γ ¹²⁶ Sb						
		29.06 gm	237.9 mM	61.60 TBq	2.120 TBq				5.218 W	179.6 mW	67.72 kSv	2.330 kSv
¹⁰⁸ Cd ¹⁰⁹ Cd ¹¹⁰ Cd ¹¹¹ Cd ¹¹² Cd ¹¹³ Cd ^{113m} Cd ¹¹⁴ Cd ^{115m} Cd ¹¹⁶ Cd A ₄₈ Cd	¹⁰⁸ Ag ¹¹⁰ Pd ^{113m} Cd ¹¹⁴ In	694.2 μ g 4.558 ng 77.24 gm 45.72 gm 26.97 gm 212.2 mg 276.1 mg	6.434 μ M 41.85 pM 702.8 mM 412.3 mM 241.0 mM 1.879 mM 2.445 mM	207.6 nBq 435.6 kBq	299.0 μ Bq 95.57 TBq	2ϵ ¹⁰⁸ Pd ϵ ^{109m} Ag	410.0 Py 1.267 y	272.0 keV 19.60 keV	≤ 1 pW 1.368 nW	≤ 1 pW 300.1 mW	871.2 μ Sv	191.1 kSv
						β ¹¹³ In	7.700 Py	93.30 keV	≤ 1 pW	≤ 1 pW	80.72 pSv	380.4 pSv
						β ¹¹³ In	14.10 y	283.8 keV	100.8 mW	365.1 mW	50.99 kSv	184.7 kSv
					0.14% \rightarrow	γ ¹¹³ Cd						
						2β ¹¹⁴ Sn	600.0 Py	536.0 keV	≤ 1 pW	≤ 1 pW		
						β ¹¹⁵ In	44.60 d	629.1 keV	≤ 1 pW	95.03 W	≤ 1 pSv	3.111 MSv
						2β ¹¹⁶ Sn	34.00 Ey	2.804 MeV	≤ 1 pW	≤ 1 pW		
									100.8 mW	509.2 μ W	50.99 kSv	257.6 Sv
¹⁴⁰ Ce ¹⁴¹ Ce ¹⁴² Ce ¹⁴⁴ Ce E ₅₈ Ce	¹⁴⁴ Nd ₆₀ Nd	1.896 kg ≤ 1 pg 1.711 kg 55.20 mg	13.55 M ≤ 1 pM 12.06 M 383.6 μ M	≤ 1 pBq	1.055 PBq 1.864 mBq 118.1 TBq	β ¹⁴¹ Pr 2β ¹⁴² Nd β ¹⁴⁴ Pr β ^{144m} Pr	32.50 d 50.00 Py 285.0 d	246.9 keV 1.417 MeV 111.9 keV	≤ 1 pW ≤ 1 pW 116.9 mW	41.72 W ≤ 1 pW 2.118 W	≤ 1 pSv	748.9 kSv 614.3 kSv
		3.607 kg	25.61 M	6.521 TBq	1.808 GBq				116.9 mW	32.41 μ W	33.91 kSv	9.401 Sv

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				GBq	GBq/gm				Watts	Watts/gm	Sv	Sv/gm	
¹²² Te	^{123m} ₅₂ Te	1.243 gm	10.20 mM										
¹²³ Te		21.28 mg	173.1 μM	229.1 mBq	10.77 Bq	ε ¹²³ ₅₁ Sb	92.00 Py	17.09 keV	≤ 1 pW	≤ 1 pW	1.008 nSv	47.37 nSv	
^{123m} Te		2.644 pg	≤ 1 pM	868.3 Bq	328.4 TBq	γ ¹²³ ₅₂ Te	119.5 d	245.6 keV	34.17 pW	12.92 W	1.216 μSv	459.8 kSv	
¹²⁴ Te		¹²⁴ ₅₀ Sn	963.7 mg	7.778 mM									
¹²⁵ Te		¹²⁵ ₅₁ Sb	27.45 gm	219.8 mM									
^{125m} Te		¹²⁵ ₅₁ Sb	22.52 mg	180.3 μM	15.02 TBq	667.0 TBq	γ ¹²⁵ ₅₂ Te	57.40 d	141.8 keV	341.1 mW	15.15 W	13.07 kSv	580.3 kSv
¹²⁶ Te		¹²⁶ ₅₁ Sb	1.322 gm	10.50 mM									
¹²⁷ Te		^{127m} ₅₂ Te	≤ 1 pg	≤ 1 pM	48.93 kBq	97.70 PBq	β ¹²⁷ ₅₃ I	9.350 h	227.7 keV	1.785 nW	3.564 kW	8.318 μSv	16.61 MSv
^{127m} Te			143.0 pg	1.127 pM	49.96 kBq	349.4 TBq	γ ¹²⁷ ₅₂ Te	109.0 d	90.71 keV	726.0 pW	5.077 W	114.9 μSv	803.6 kSv
¹²⁸ Te			170.8 gm	1.335 M	8.029 nBq	47.01 pBq	2β ¹²⁸ ₅₄ Xe	≥ 10 ²¹ y	867.2 keV	≤ 1 pW	≤ 1 pW		
^{129m} Te		≤ 1 pg	≤ 1 pM	≤ 1 pBq	1.115 PBq	γ ¹²⁹ ₅₂ Te	33.60 d	295.7 keV	≤ 1 pW	52.85 W	≤ 1 pSv	3.346 MSv	
¹³⁰ Te		547.3 gm	4.213 M	70.54 nBq	128.9 pBq	2β ¹³⁰ ₅₄ Xe	≥ 10 ²¹ y	2.528 MeV	≤ 1 pW	≤ 1 pW			
E ₅₂ Te		749.1 gm	5.797 M	15.02 TBq	20.05 GBq				341.1 mW	455.3 μW	13.07 kSv	17.44 Sv	
¹⁴⁶ Sm	¹⁴⁶ ₆₁ Pm	12.68 mg	86.90 μM	16.43 kBq	1.296 MBq	α ¹⁴² ₆₀ Nd	100.0 My	2.538 MeV	6.681 nW	526.9 nW	887.2 μSv	69.97 mSv	
¹⁴⁷ Sm	¹⁴⁷ ₆₁ Pm	232.8 gm	1.585 M	195.9 kBq	841.5 Bq	α ¹⁴³ ₆₀ Nd	106.0 Gy	2.309 MeV	72.47 nW	311.3 pW	9.599 mSv	41.23 μSv	
¹⁴⁸ Sm	¹⁴⁸ ₆₀ Nd	309.5 gm	2.092 M	3.459 Bq	11.18 mBq	α ¹⁴⁴ ₆₀ Nd	7.000 Py	2.014 MeV	1.116 pW	≤ 1 pW			
¹⁴⁹ Sm		4.616 gm	31.00 mM	205.0 mBq	44.41 mBq	α ¹⁴⁵ ₆₀ Nd	2.000 Py	1.870 MeV	≤ 1 pW	≤ 1 pW			
¹⁵⁰ Sm	¹⁵⁰ ₆₀ Nd	478.3 gm	3.190 M										
¹⁵¹ Sm		21.13 gm	140.0 mM	20.58 TBq	974.0 GBq	β ¹⁵¹ ₆₃ Eu	90.00 y	19.78 keV	65.21 mW	3.086 mW	2.017 kSv	95.45 Sv	
¹⁵² Sm	¹⁵² ₆₃ Eu	178.3 gm	1.174 M										
¹⁵⁴ Sm	¹⁵⁴ ₆₃ Eu	59.76 gm	388.2 mM										
E ₆₂ Sm		1.284 kg	8.600 M	20.58 TBq	16.02 GBq				65.21 mW	50.77 μW	2.017 kSv	1.570 Sv	
G ₁ ³ H		49.11 mg	16.28 mM	17.55 TBq	357.4 TBq	β ³ ₂ He	12.33 y	5.676 keV	15.96 mW	325.0 mW	737.1 Sv	15.01 kSv	
⁹⁸ Tc	A ₄₃ Tc	10.77 mg	110.0 μM	346.5 kBq	32.17 MBq	β ⁹⁸ ₄₄ Ru	4.200 My	1.532 MeV	85.02 nW	7.894 μW	693.0 μSv	64.35 mSv	
⁹⁹ Tc		1.136 kg	11.49 M	712.8 GBq	627.5 MBq	β ⁹⁹ ₄₄ Ru	214.0 ky	84.59 keV	9.660 mW	8.504 μW	456.2 Sv	401.6 mSv	
^{99m} Tc		1.136 kg	11.49 M	712.8 GBq	627.5 MBq				9.660 mW	8.504 μW	456.2 Sv	401.6 mSv	
¹⁴¹ Pr	¹⁴⁴ ₅₈ Ce	1.689 kg	11.99 M										
¹⁴⁴ Pr		2.331 μg	16.20 nM	6.521 TBq	2.798 EBq	β ¹⁴⁴ ₆₀ Nd	17.28 m	1.240 MeV	1.295 W	555.6 kW	326.0 Sv	139.9 MSv	
^{144m} Pr		11.65 ng	80.95 pM	78.24 GBq	6.716 EBq	γ ¹⁴⁴ ₅₉ Pr	6.900 m	57.70 keV	723.3 μW	62.09 kW			
E ₅₉ Pr		1.689 kg	11.99 M	6.599 TBq	3.907 GBq	β ¹⁴⁴ ₆₀ Nd			1.296 W	767.2 μW	326.0 Sv	193.0 mSv	
¹¹⁴ Sn	¹¹⁴ ₄₈ Cd	3.852 mg	33.82 μM										
¹¹⁵ Sn	¹¹⁵ ₄₉ In	490.4 mg	4.268 mM										
¹¹⁶ Sn	¹¹⁶ ₄₈ Cd	12.26 gm	105.8 mM										
¹¹⁷ Sn		12.64 gm	108.1 mM										

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				GBq	GBq/gm				Watts	Watts/gm	Sv	Sv/gm
¹¹⁸ Sn ¹¹⁹ Sn ^{119m} Sn ¹²⁰ Sn ^{121m} Sn	^{119m} ₅₀ Sn	12.81 gm	108.7 mM	363.7 MBq	165.8 TBq	γ ¹¹⁹ ₅₀ Sn	293.0 d	87.17 keV	5.079 μ W	2.316 W	123.7 mSv	56.39 kSv
12.76 gm		107.3 mM										
2.193 μ g		18.44 nM										
12.99 gm		108.3 mM										
4.782 mg		39.55 μ M										
¹²² Sn ¹²³ Sn ¹²⁴ Sn ¹²⁶ Sn		14.26 gm	117.0 mM	10.47 GBq	2.189 TBq 22.4% \rightarrow	γ ¹²¹ ₅₀ Sn β ¹²¹ ₅₁ Sb	55.00 y	337.9 keV	566.7 μ W	118.5 mW	3.979 Sv	832.0 Sv
¹²² Sn		14.26 gm	117.0 mM									
¹²³ Sn		1.506 ng	12.25 pM									
¹²⁴ Sn		19.24 gm	155.3 mM									
¹²⁶ Sn	42.49 gm	337.5 mM	44.63 GBq	1.050 GBq	33.068% \rightarrow	β ¹²³ ₅₁ Sb 2β ¹²⁴ ₅₂ Te β ^{126m} ₅₁ Sb β ^{126m} ₅₁ Sb	230.0 ky	210.4 keV	1.504 mW	35.40 μ W	209.8 Sv	4.937 Sv
E ₅₀ Sn		139.9 gm	1.152 M	55.46 GBq	396.3 MBq				2.076 mW	14.83 μ W	213.9 Sv	1.528 Sv
¹²⁷ I ¹²⁹ I E ₅₃ I	¹²⁷ ₅₂ Te ^{129m} ₅₂ Te	84.19 gm 273.4 gm 357.6 gm	663.4 mM 2.121 M 2.784 M	1.787 GBq 1.787 GBq	6.536 MBq 4.997 MBq	β ¹²⁹ ₅₄ Xe	16.10 My	78.00 keV	22.33 μ W 22.33 μ W	81.68 nW 62.45 nW	196.6 Sv 196.6 Sv	719.0 mSv 549.7 mSv
⁹⁰ Zr ⁹¹ Zr ⁹² Zr ⁹³ Zr ⁹⁴ Zr ⁹⁵ Zr ⁹⁶ Zr A ₄₀ Zr	⁹⁰ ₃₉ Y ⁹¹ ₃₉ Y ⁹¹ ₃₉ Y	207.2 gm 876.9 gm 956.3 gm 1.073 kg 1.125 kg \leq 1 pg 1.211 kg 5.449 kg	2.305 M 9.646 M 10.41 M 11.55 M 11.98 M \leq 1 pM 12.63 M 58.51 M	 99.82 GBq 26.41 Bq 374.5 mBq 4.282 mBq 99.82 GBq	 93.03 MBq 2.5% \rightarrow 23.48 mBq 794.9 TBq 1.08% \rightarrow 3.536 μ Bq 18.32 MBq	β ^{93m} ₄₁ Nb β ⁹³ ₄₁ Nb 2β ⁹⁴ ₄₂ Mo β ⁹⁵ ₄₁ Nb β ^{95m} ₄₁ Nb 2β ⁹⁶ ₄₂ Mo	1.530 My 6.000 Py 64.03 d 39.00 Ey	19.59 keV 1.144 MeV 854.7 keV 3.350 MeV	313.3 μ W 4.839 pW \leq 1 pW \leq 1 pW 313.3 μ W	292.0 nW \leq 1 pW 108.9 W \leq 1 pW 57.49 nW	109.8 Sv 355.8 pSv 109.8 Sv	102.3 mSv 755.2 kSv 20.15 mSv
⁷⁶ Se ⁷⁷ Se ⁷⁸ Se ⁷⁹ Se ⁸⁰ Se ⁸² Se E ₃₄ Se	⁷⁶ ₃₂ Ge	12.23 mg 1.515 gm 3.687 gm 8.869 gm 20.17 gm 50.43 gm 84.68 gm	161.1 μ M 19.70 mM 47.32 mM 112.4 mM 252.4 mM 615.6 mM 1.048 M	 22.88 GBq 67.30 μ Bq 22.88 GBq	 2.580 GBq 1.334 μ Bq 270.2 MBq	β ⁷⁹ ₃₅ Br 2β ⁸² ₃₆ Kr	377.0 ky 121.0 Ey	41.99 keV 2.995 MeV	153.9 μ W 153.9 μ W	17.35 μ W \leq 1 pW 1.817 μ W	66.35 Sv 66.35 Sv	7.481 Sv 783.5 mSv
¹⁰⁷ Ag ¹⁰⁸ Ag ^{108m} Ag	¹⁰⁷ ₄₆ Pd ^{108m} ₄₇ Ag	438.3 μ g \leq 1 pg 1.817 μ g	4.100 μ M \leq 1 pM 16.84 nM	156.0 kBq 1.753 MBq	27.19 EBq 2.9% \rightarrow 964.8 GBq 8.7% \rightarrow	β ¹⁰⁸ ₄₈ Cd ϵ ¹⁰⁸ ₄₆ Pd ϵ ¹⁰⁸ ₄₆ Pd γ ¹⁰⁸ ₄₇ Ag	2.400 m 418.0 y	628.2 keV 1.634 MeV	15.70 nW 458.8 nW	2.737 MW 252.5 mW	 4.032 mSv	 2.219 kSv

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				GBq	GBq/gm				Watts	Watts/gm	Sv	Sv/gm
¹⁰⁹ Ag	^{109m} Ag	115.4 gm	1.060 M									
^{109m} Ag	¹⁰⁹ Cd	≤ 1 pg	≤ 1 pM	435.6 kBq	96.76 EBq	γ ¹⁰⁹ Ag	39.70 s	86.97 keV	6.069 nW	1.348 MW		
¹¹⁰ Ag	^{110m} Ag	≤ 1 pg	≤ 1 pM	144.3 MBq	154.4 EBq	β ¹¹⁰ Cd	24.56 s	1.212 MeV	28.01 μW	29.97 MW		
^{110m} Ag		61.68 μg	561.2 nM	10.85 GBq	175.9 TBq	ε ¹¹⁰ Pd					30.38 Sv	492.5 kSv
						β ¹¹⁰ Cd	249.8 d	2.816 MeV	4.894 mW	79.35 W		
						γ ¹¹⁰ Ag						
E ₄₇ Ag		115.4 gm	1.060 M	11.00 GBq	95.29 MBq				4.922 mW	42.66 μW	30.38 Sv	263.3 mSv
¹⁰² Rh		141.1 μg	1.385 μM	6.314 GBq	44.75 TBq	ε ¹⁰² Ru	2.902 y	2.151 MeV	2.176 mW	15.42 W	7.577 Sv	53.70 kSv
¹⁰³ Rh	¹⁰³ Ru	611.3 gm	5.940 M									
^{103m} Rh	¹⁰³ Ru	≤ 1 pg	≤ 1 pM	5.729 pBq	1.204 EBq	γ ¹⁰³ Rh	56.11 m	38.82 keV	≤ 1 pW	7.490 kW	≤ 1 pSv	4.576 MSv
¹⁰⁶ Rh	¹⁰⁶ Ru	217.7 ng	2.056 nM	28.70 TBq	131.8 EBq	β ¹⁰⁶ Pd	30.00 s	1.617 MeV	7.437 W	34.16 MW		
A ₄₅ Rh		611.3 gm	5.940 M	28.71 TBq	46.96 GBq				7.439 W	12.17 mW	7.577 Sv	12.39 mSv
⁹³ Nb	⁹³ Zr	1.725 mg	18.57 μM									
^{93m} Nb	⁹³ Zr	4.153 mg	44.70 μM	43.45 GBq	10.46 TBq	γ ⁹³ Nb	16.13 y	29.90 keV	208.1 μW	50.11 mW	5.214 Sv	1.255 kSv
⁹⁴ Nb		1.182 mg	12.59 μM	8.198 MBq	6.936 GBq	β ⁹⁴ Mo	19.99 ky	1.718 MeV	2.257 μW	1.909 mW	13.94 mSv	11.79 Sv
⁹⁵ Nb	⁹⁵ Zr	≤ 1 pg	≤ 1 pM	832.0 mBq	1.448 PBq	β ⁹⁵ Mo	34.99 d	808.8 keV	≤ 1 pW	187.6 W	482.6 pSv	839.8 kSv
^{95m} Nb	⁹⁵ Zr	≤ 1 pg	≤ 1 pM	2.780 mBq	14.10 PBq	γ ⁹⁵ Nb	3.608 d	234.4 keV	≤ 1 pW	529.7 W	1.557 pSv	7.899 MSv
						β ⁹⁵ Mo						
A ₄₁ Nb		7.060 mg	75.85 μM	43.46 GBq	6.156 TBq				210.4 μW	29.80 mW	5.228 Sv	740.5 Sv
¹⁶⁵ Ho		285.7 mg	1.732 mM									
^{166m} Ho		3.505 mg	21.12 μM	232.9 MBq	66.45 GBq	β ¹⁶⁶ Er	1.200 ky	1.868 MeV	69.71 μW	19.89 mW	465.8 mSv	132.9 Sv
E ₆₇ Ho		289.2 mg	1.753 mM	232.9 MBq	805.3 MBq				69.71 μW	241.0 μW	465.8 mSv	1.611 Sv
¹⁰⁴ Pd		463.0 gm	4.456 M									
¹⁰⁵ Pd		609.7 gm	5.812 M									
¹⁰⁶ Pd	¹⁰⁶ Rh	593.8 gm	5.607 M									
¹⁰⁷ Pd		361.2 gm	3.379 M	6.876 GBq	19.04 MBq	β ¹⁰⁷ Ag	6.500 My	10.00 keV	11.02 μW	30.51 nW	254.4 mSv	704.4 μSv
¹⁰⁸ Pd	¹⁰⁸ Ag	248.7 gm	2.305 M									
¹¹⁰ Pd	¹¹⁰ Ag	82.30 gm	748.8 mM	16.51 mBq	200.6 μBq	2β ¹¹⁰ Cd	600.0 Py	2.000 MeV	≤ 1 pW	≤ 1 pW		
A ₄₆ Pd		2.359 kg	22.31 M	6.876 GBq	2.915 MBq				11.02 μW	4.672 nW	254.4 mSv	107.9 μSv
¹⁵² Gd	¹⁵² Eu	80.72 mg	531.3 μM	65.10 mBq	806.5 mBq	α ¹⁴⁸ Sm	108.0 Ty	2.197 MeV	≤ 1 pW	≤ 1 pW	2.669 nSv	33.07 nSv
¹⁵³ Gd		193.4 ng	1.265 nM	25.25 MBq	130.6 TBq	ε ¹⁵³ Eu	240.4 d	152.4 keV	616.4 nW	3.187 W	6.817 mSv	35.25 kSv
¹⁵⁴ Gd	¹⁵⁴ Eu	42.53 gm	276.3 mM									
¹⁵⁵ Gd	¹⁵⁵ Eu	19.66 gm	126.9 mM									
¹⁵⁶ Gd		125.8 gm	806.8 mM									
¹⁵⁷ Gd		196.7 mg	1.253 mM									
¹⁵⁸ Gd		33.19 gm	210.2 mM									
¹⁶⁰ Gd		2.102 gm	13.14 mM	1.337 mBq	636.2 μBq	2β ¹⁶⁰ Dy	130.0 Py	1.729 MeV	≤ 1 pW	≤ 1 pW		

‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas; †Radiotoxicity of daughters is included in parents.

Isotope ‡	Decay From	Mass grams	Moles	Radioactivity		Decay To	Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity †	
				GBq	GBq/gm				Watts	Watts/gm	Sv	Sv/gm
E ₆₄ Gd		223.6 gm	1.435 M	25.25 MBq	112.9 kBq				616.4 nW	2.757 nW	6.818 mSv	30.50 μ Sv
E ¹⁴ C		40.17 μ g	2.869 μ M	6.628 MBq	165.0 GBq	β ¹⁴ N	5.700 ky	49.47 keV	52.53 nW	1.308 mW	3.844 mSv	95.70 Sv
⁸⁵ Rb ⁸⁷ Rb E ₃₇ Rb	⁸⁵ Kr ³⁶ Kr	162.7 gm 361.8 gm 524.5 gm	1.916 M 4.163 M 6.079 M	1.172 MBq 1.172 MBq	3.239 kBq 2.235 kBq	β ⁸⁷ Sr	48.10 Gy	141.0 keV	26.47 nW 26.47 nW	73.16 pW 50.47 pW	1.758 mSv 1.758 mSv	4.859 μ Sv 3.352 μ Sv
¹⁶⁹ Tm ¹⁷⁰ Tm		95.30 μ g ≤ 1 pg	564.1 nM ≤ 1 pM	9.926 Bq	221.2 TBq 0.131% \rightarrow	β ¹⁷⁰ Yb ϵ ¹⁷⁰ Er	128.6 d	334.6 keV	≤ 1 pW	11.86 W	12.90 nSv	287.5 kSv
¹⁷¹ Tm E ₆₉ Tm		49.01 ng 95.35 μ g	286.7 pM 564.4 nM	1.976 MBq 1.976 MBq	40.32 TBq 20.72 GBq	β ¹⁷¹ Yb	1.917 y	26.15 keV	8.278 nW 8.279 nW	168.9 mW 86.82 μ W	217.4 μ Sv 217.4 μ Sv	4.435 kSv 2.280 Sv
⁹ Be ¹⁰ Be E ₄ Be		29.79 μ g 198.9 μ g 228.7 μ g	3.306 μ M 19.86 μ M 23.17 μ M	164.6 kBq 164.6 kBq	827.6 MBq 719.8 MBq	β ¹⁰ B	1.600 My	202.4 keV	5.338 nW 5.338 nW	26.84 μ W 23.34 μ W	181.1 μ Sv 181.1 μ Sv	910.3 mSv 791.7 mSv
¹¹³ In ¹¹⁴ In ^{114m} In	¹¹³ Cd ^{114m} In ⁴⁹ In	195.4 mg ≤ 1 pg ≤ 1 pg	1.731 mM ≤ 1 pM ≤ 1 pM	13.55 pBq 14.16 pBq	50.96 EBq 0.5% \rightarrow 856.6 TBq 3.5% \rightarrow	β ¹¹⁴ Sn ϵ ¹¹⁴ Cd γ ¹¹⁴ In	1.198 m 50.00 d	803.4 keV 239.3 keV	≤ 1 pW ≤ 1 pW	6.559 MW 32.84 W	 ≤ 1 pSv	 3.512 MSv
¹¹⁵ In E ₄₉ In	^{115m} Cd ⁴⁸ Cd	2.697 gm 2.892 gm	23.47 mM 25.20 mM	621.4 mBq 621.4 mBq	230.4 mBq 214.8 mBq	β ¹¹⁵ Sn	441.0 Ty	241.9 keV	≤ 1 pW ≤ 1 pW	≤ 1 pW ≤ 1 pW	19.88 nSv 19.88 nSv	7.373 nSv 6.875 nSv
¹³⁸ La ¹³⁹ La E ₅₇ La		7.637 mg 1.849 kg 1.849 kg	55.38 μ M 13.31 M 13.31 M	5.426 Bq 5.426 Bq	710.5 Bq 2.935 mBq	ϵ ¹³⁸ Ba	102.0 Gy	1.237 MeV	1.075 pW 1.075 pW	140.8 pW ≤ 1 pW	5.969 nSv 5.969 nSv	781.5 nSv 3.228 pSv
¹⁵⁹ Tb ¹⁶⁰ Tb E ₆₅ Tb		4.337 gm ≤ 1 pg 4.337 gm	27.29 mM ≤ 1 pM 27.29 mM	41.75 mBq 41.75 mBq	418.1 TBq 9.626 mBq	β ¹⁶⁰ Dy	72.30 d	1.373 MeV	≤ 1 pW ≤ 1 pW	91.97 W ≤ 1 pW	66.80 pSv 66.80 pSv	668.9 kSv 15.40 pSv
⁶ Li ⁷ Li E ₃ Li		241.9 μ g 15.49 μ g 257.4 μ g	40.22 μ M 2.208 μ M 42.42 μ M									
⁶⁶ Zn ⁶⁷ Zn ⁶⁸ Zn ⁷⁰ Zn E ₃₀ Zn		53.48 ng 2.226 ng 2.128 mg 7.588 mg 9.716 mg	811.2 pM 33.26 pM 31.33 μ M 108.5 μ M 139.8 μ M									
⁶⁹ Ga ⁷¹ Ga		5.671 μ g 2.257 μ g	82.28 nM 31.82 nM									

‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas; †Radiotoxicity of daughters is included in parents.

Isotope ‡	Decay From	Mass grams	Moles	Radioactivity		Decay To	Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity †	
				GBq	GBq/gm				Watts	Watts/gm	Sv	Sv/gm
E ₃₁ Ga		7.928 μg	114.1 nM									
⁷⁰ Ge		33.14 ng	473.9 pM									
⁷² Ge		33.04 mg	459.4 μM									
⁷³ Ge		66.60 mg	913.3 μM									
⁷⁴ Ge		147.3 mg	1.993 mM									
⁷⁶ Ge		748.2 mg	9.855 mM	82.50 nBq	110.3 nBq	2β ⁷⁶ Se	≥ 10 ²¹ y	2.039 MeV	≤ 1 pW	≤ 1 pW		
E ₃₂ Ge		995.1 mg	13.22 mM	82.50 nBq	82.91 nBq				≤ 1 pW	≤ 1 pW		
E ⁷⁵ ₃₃ As		298.2 mg	3.980 mM									
⁷⁹ Br	⁷⁹ Se	1.133 mg	14.36 μM									
⁸¹ Br	⁸¹ Kr	31.96 gm	395.0 mM									
E ₃₅ Br	⁸¹ Kr	31.96 gm	395.0 mM									
⁸⁰ Kr	⁸² Se	358.8 μg	4.490 μM									
⁸¹ Kr		42.36 μg	523.5 nM	32.98 kBq	778.6 MBq	ε ⁸¹ Br	210.0 ky	20.80 keV	109.9 pW	2.594 μW		
⁸² Kr		2.022 gm	24.68 mM									
⁸³ Kr		57.85 gm	697.7 mM									
⁸⁴ Kr		172.8 gm	2.059 M									
⁸⁵ Kr		18.02 gm	212.2 mM	261.8 TBq	14.53 TBq	β ⁸⁵ Rb	10.75 y	252.7 keV	10.60 W	588.2 mW		
⁸⁶ Kr	282.3 gm	3.286 M										
G ₃₆ Kr		533.0 gm	6.280 M	261.8 TBq	491.2 GBq				10.60 W	19.89 mW		
⁹⁵ Mo	⁹⁵ Nb	1.116 kg	11.76 M									
⁹⁶ Mo	⁹⁶ Zr	80.49 gm	839.3 mM									
⁹⁷ Mo		1.202 kg	12.40 M									
⁹⁸ Mo		1.238 kg	12.64 M	1.673 kBq	1.351 Bq	2β ⁹⁸ Ru	100.0 Ty	112.0 keV	30.01 pW	≤ 1 pW		
¹⁰⁰ Mo		1.423 kg	14.24 M	19.03 mBq	13.37 μBq	2β ¹⁰⁰ Ru	9.900 Ey	3.034 MeV	≤ 1 pW	≤ 1 pW		
A ₄₂ Mo		5.059 kg	51.89 M	1.673 kBq	330.6 mBq				30.02 pW	≤ 1 pW		
¹²⁷ Xe	¹²⁸ Te	≤ 1 pg	≤ 1 pM	≤ 1 pBq	1.045 PBq	ε ¹²⁷ I	36.40 d	309.1 keV	≤ 1 pW	51.75 W		
¹²⁸ Xe		7.057 gm	55.17 mM									
¹²⁹ Xe		¹²⁹ I	52.40 mg	406.5 μM								
¹³⁰ Xe		¹³⁰ Te	23.11 gm	177.9 mM								
¹³¹ Xe			566.1 gm	4.325 M								
¹³² Xe			1.753 kg	13.29 M								
¹³⁴ Xe	¹³⁴ Cs	2.246 kg	16.77 M	20.17 Bq	8.980 mBq	2β ¹³⁴ Ba	11.00 Py	830.0 keV	2.682 pW	≤ 1 pW		
¹³⁶ Xe		3.429 kg	25.23 M	1.589 mBq	463.5 nBq	2β ¹³⁶ Ba	210.0 Ey	2.467 MeV	≤ 1 pW	≤ 1 pW		
G ₅₄ Xe		8.024 kg	59.85 M	20.17 Bq	2.514 mBq				2.683 pW	≤ 1 pW		
¹³² Ba	¹³⁴ Xe	3.142 mg	23.82 μM									
¹³⁴ Ba		334.3 gm	2.497 M									

‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas; †Radiotoxicity of daughters is included in parents.

Isotope ‡	Decay From	Mass grams	Moles	Radioactivity		Decay To	Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity †	
				GBq	GBq/gm				Watts	Watts/gm	Sv	Sv/gm
¹³⁵ Ba ¹³⁶ Ba ¹³⁷ Ba ^{137m} Ba ¹³⁸ Ba E ₅₆ Ba	¹³⁵ Cs ¹³⁶ Xe ¹³⁷ Cs ¹³⁷ Cs ¹³⁸ La ¹³⁸ La	1.050 gm 42.80 gm 453.5 gm 219.7 μg 1.944 kg 2.776 kg	7.783 mM 314.9 mM 3.312 M 1.605 μM 14.10 M 20.23 M									
¹⁴² Nd ¹⁴³ Nd ¹⁴⁴ Nd ¹⁴⁵ Nd ¹⁴⁶ Nd ¹⁴⁸ Nd ¹⁵⁰ Nd E ₆₀ Nd	¹⁴² Ce ¹⁴⁷ Sm ¹⁴⁴ Pr ¹⁴⁹ Sm ¹⁴⁶ Pm ¹⁴⁶ Pm	51.65 gm 1.116 kg 2.072 kg 975.8 gm 1.091 kg 563.2 gm 273.6 gm 6.143 kg	364.0 mM 7.809 M 14.40 M 6.734 M 7.477 M 3.808 M 1.825 M 42.41 M									
¹⁶⁰ Dy ¹⁶¹ Dy ¹⁶² Dy ¹⁶³ Dy ¹⁶⁴ Dy E ₆₆ Dy	¹⁶⁰ Gd	612.8 mg 712.4 mg 572.7 mg 537.5 mg 133.0 mg 2.568 gm	3.832 mM 4.427 mM 3.537 mM 3.299 mM 811.3 μM 15.91 mM									
¹⁶⁶ Er ¹⁶⁷ Er ¹⁶⁸ Er ¹⁷⁰ Er E ₆₈ Er	^{166m} Ho ¹⁷⁰ Tm ¹⁶⁹ Tm	88.56 mg 5.663 mg 11.31 mg 59.35 ng 105.5 mg	533.7 μM 33.92 μM 67.35 μM 349.3 pM 635.0 μM									
¹⁷⁰ Yb ¹⁷¹ Yb ¹⁷² Yb E ₇₀ Yb	¹⁷⁰ Tm ¹⁷¹ Tm ¹⁷¹ Tm	39.44 μg 3.377 μg 143.9 ng 42.96 μg	232.1 nM 19.76 nM 836.9 pM 252.7 nM									
Total		52.18 kg	443.5 M	16.84 PBq	322.7 GBq				1.375 kW	26.35 mW	155.5 MSv	2.981 kSv

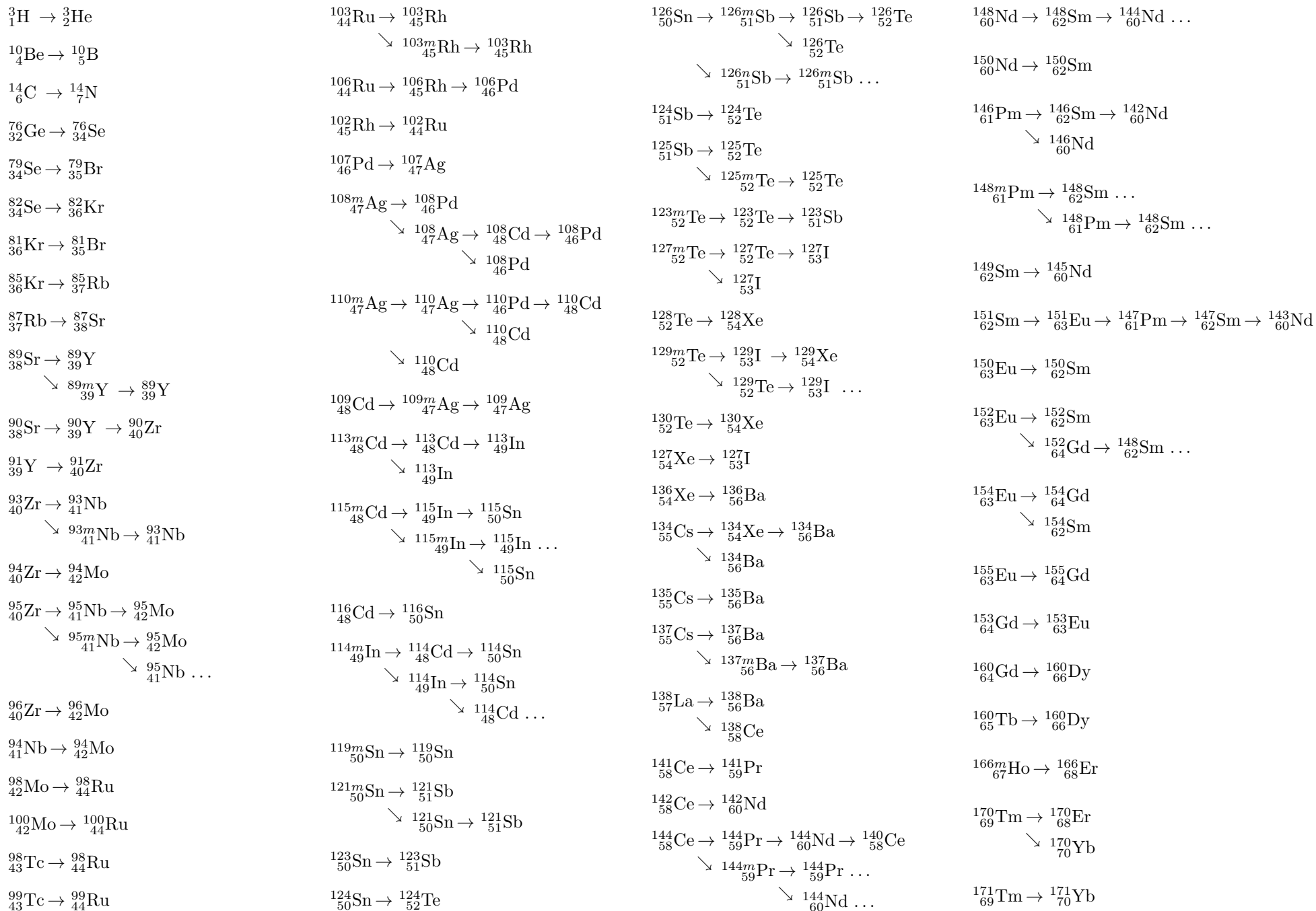
ICRP Publication 119 does not report dose factors for isotopes with half lives less than ten minutes or greater than 10⁹ years.

Total radiotoxicity is not the sum of the “Sv” column because ICRP Publication 119 includes radiotoxicity of daughter in radiotoxicity of parent.

Dose factors for gases are given as Sv/day per Bq/m³. Radiotoxicity is not computed for gases.

‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas; †Radiotoxicity of daughters is included in parents.

Decay Chains



Actinides and Daughters Per Tonne of Fuel

used for 50.68 GWth-day LWR burnup at power of 36.54 MWth and $3.14 \times 10^{14} N/cm^2/s$ neutron flux,
after ten years' storage, as calculated by ORIGEN2 version 2.1 on 9 October 2013.

Radiotoxicity in Sieverts computed for adult ingestion using dose factors from ICRP publication 119

Isotope ‡	Decay From	Mass grams	Moles	Radioactivity		Decay To	Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity †	
				GBq	GBq/gm				Watts	Watts/gm	Sv	Sv/gm
²³⁶ Pu	²³⁶ ₉₃ Np	5.150 ng	21.82 pM	101.3 kBq	19.67 TBq	α ²³² ₉₂ U	2.858 y	5.870 MeV	95.27 nW	18.50 W	8.813 mSv	1.711 MSv
²³⁷ Pu	²⁴¹ ₉₆ Cm	≤ 1 pg	≤ 1 pM	≤ 1 pBq	447.4 TBq	ϵ ²³⁷ ₉₃ Np	45.30 d	62.18 keV	≤ 1 pW	4.457 W	≤ 1 pSv	44.74 kSv
					0.004% →	α ²³³ ₉₂ U						
²³⁸ Pu	²³⁸ ₉₃ Np	300.4 gm	1.262 M	190.4 TBq	633.8 GBq	α ²³⁴ ₉₂ U	87.70 y	5.590 MeV	170.5 W	567.6 mW	43.79 MSv	145.8 kSv
²³⁹ Pu	²³⁹ ₉₃ Np	6.183 kg	25.86 M	14.23 TBq	2.301 GBq	α ^{235m} ₉₂ U	24.11 ky	5.198 MeV	11.85 W	1.917 mW	3.557 MSv	575.4 Sv
					0.06% →	α ²³⁵ ₉₂ U						
²⁴⁰ Pu	^{240m} ₉₃ Np	2.957 kg	12.32 M	24.94 TBq	8.434 GBq	α ²³⁶ ₉₂ U	6.563 ky	5.253 MeV	20.99 W	7.098 mW	6.235 MSv	2.109 kSv
²⁴¹ Pu	²⁴³ ₉₆ Cm	1.109 kg	4.601 M	4.230 PBq	3.814 TBq	β ²⁴¹ ₉₅ Am	14.33 y	5.227 keV	3.542 W	3.194 mW	20.30 MSv	18.31 kSv
					0.002% →	α ²³⁷ ₉₂ U						
²⁴² Pu	²⁴² ₉₅ Am	873.8 gm	3.610 M	123.5 GBq	141.3 MBq	α ²³⁸ ₉₂ U	373.5 ky	4.982 MeV	98.57 mW	112.8 μ W	29.64 kSv	33.92 Sv
²⁴³ Pu	²⁴⁷ ₉₆ Cm	≤ 1 pg	≤ 1 pM	33.76 kBq	96.35 PBq	β ²⁴³ ₉₅ Am	4.956 h	194.7 keV	1.053 nW	3.005 kW	2.870 μ Sv	8.189 MSv
²⁴⁴ Pu	²⁴⁸ ₉₆ Cm	31.02 mg	127.1 μ M	20.37 kBq	656.7 kBq	α ²⁴⁰ ₉₂ U	80.00 My	4.891 MeV	15.96 nW	514.5 nW	4.889 mSv	157.6 mSv
²⁴⁶ Pu	²⁵⁰ ₉₆ Cm	≤ 1 pg	≤ 1 pM	3.610 mBq	1.811 PBq	β ^{246m} ₉₅ Am	10.85 d	142.0 keV	≤ 1 pW	41.19 W	11.91 pSv	5.977 MSv
C ⁹⁴ Pu		11.42 kg	47.66 M	4.460 PBq	390.4 GBq				207.0 W	18.12 mW	73.92 MSv	6.471 kSv
²⁴¹ Cm		≤ 1 pg	≤ 1 pM	≤ 1 pBq	557.3 TBq	ϵ ²⁴¹ ₉₅ Am	32.80 d	693.0 keV	≤ 1 pW	61.88 W	≤ 1 pSv	507.2 kSv
					1% →	α ²³⁷ ₉₄ Pu						
²⁴² Cm	²⁴² ₉₅ Am	1.843 mg	7.614 μ M	225.6 GBq	122.4 TBq	α ²³⁸ ₉₄ Pu	162.9 d	6.214 MeV	224.6 mW	121.9 W	2.707 kSv	1.469 MSv
²⁴³ Cm		585.7 mg	2.410 mM	1.120 TBq	1.912 TBq	α ²³⁹ ₉₄ Pu	30.00 y	6.186 MeV	1.110 W	1.895 W	168.0 kSv	286.8 kSv
					0.24% →	ϵ ²⁴³ ₉₅ Am						
²⁴⁴ Cm		57.94 gm	237.4 mM	173.6 TBq	2.996 TBq	α ²⁴⁰ ₉₄ Pu	18.00 y	5.897 MeV	164.0 W	2.831 W	20.83 MSv	359.5 kSv
²⁴⁵ Cm	²⁴⁵ ₉₅ Am	5.615 gm	22.91 mM	35.70 GBq	6.358 GBq	α ²⁴¹ ₉₄ Pu	8.500 ky	5.597 MeV	32.01 mW	5.701 mW	7.497 kSv	1.335 kSv
²⁴⁶ Cm	²⁴⁶ ₉₅ Am	716.6 mg	2.912 mM	8.150 GBq	11.37 GBq	α ²⁴² ₉₄ Pu	4.730 ky	5.521 MeV	7.209 mW	10.06 mW	1.711 kSv	2.388 kSv
²⁴⁷ Cm	²⁵¹ ₉₈ Cf	9.829 mg	39.78 μ M	33.76 kBq	3.435 MBq	α ²⁴³ ₉₄ Pu	16.00 My	5.390 MeV	29.15 nW	2.966 μ W	6.414 mSv	652.6 mSv
²⁴⁸ Cm	²⁵² ₉₈ Cf	760.1 μ g	3.064 μ M	119.7 kBq	157.5 MBq	α ²⁴⁴ ₉₄ Pu	340.0 ky	20.98 MeV	402.4 nW	529.4 μ W	92.17 mSv	121.3 Sv
²⁵⁰ Cm	²⁵⁴ ₉₈ Cf	4.745 pg	≤ 1 pM	14.44 mBq	3.043 GBq	SF	8.000 ky	123.2 MeV	≤ 1 pW	60.08 mW	63.54 nSv	13.39 kSv
					3% →	α ²⁴⁶ ₉₄ Pu						
C ⁹⁶ Cm		64.87 gm	265.7 mM	175.0 TBq	2.698 TBq				165.4 W	2.549 W	21.01 MSv	323.9 kSv
²⁴¹ Am	²⁴¹ ₉₄ Pu	738.5 gm	3.064 M	93.86 TBq	127.1 GBq	α ²³⁷ ₉₃ Np	432.8 y	5.602 MeV	84.23 W	114.1 mW	18.77 MSv	25.42 kSv
²⁴² Am	^{242m} ₉₅ Am	9.073 μ g	37.48 nM	271.6 GBq	29.93 PBq	β ²⁴² ₉₆ Cm	16.04 h	191.4 keV	8.329 mW	918.0 W	81.48 Sv	8.980 MSv
					16.8% →	ϵ ²⁴² ₉₄ Pu						
^{242m} Am		758.5 mg	3.134 mM	272.9 GBq	359.8 GBq	γ ²⁴² ₉₅ Am	141.0 y	66.63 keV	2.913 mW	3.840 mW	51.85 kSv	68.36 kSv
					0.463% →	α ²³⁸ ₉₃ Np						
²⁴³ Am	²⁴³ ₉₄ Pu	196.9 gm	810.1 mM	1.453 TBq	7.379 GBq	α ²³⁹ ₉₃ Np	7.365 ky	5.421 MeV	1.262 W	6.409 mW	290.6 kSv	1.476 kSv

‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas; †Radiotoxicity of daughters is included in parents.

Isotope ‡	Decay From	Mass grams	Moles	Radioactivity		Decay To	Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity †	
				GBq	GBq/gm				Watts	Watts/gm	Sv	Sv/gm
²⁴⁵ Am ²⁴⁶ Am C ₉₅ Am	²⁴⁹ Bk ₉₇	≤ 1 pg ≤ 1 pg 936.2 gm	≤ 1 pM ≤ 1 pM 3.877 M	2.953 Bq 3.610 mBq 95.86 TBq	228.7 PBq 1.132 EBq 102.4 GBq	β ²⁴⁵ ₉₆ Cm β ²⁴⁶ ₉₆ Cm	2.050 h 39.00 m	313.1 keV 1.361 MeV	≤ 1 pW ≤ 1 pW 85.50 W	11.47 kW 246.9 kW 91.33 mW	183.1 pSv ≤ 1 pSv 19.11 MSv	14.18 MSv 65.66 MSv 20.42 kSv
²³² U ²³³ U ²³⁴ U ²³⁵ U ²³⁶ U ²³⁷ U ²³⁸ U ²⁴⁰ U C ₉₂ U	²³⁶ Pu ₉₄ ²³³ Pa ₉₁ ²³⁴ Pa ₉₁ ²³⁹ Pu ₉₄ ²³⁶ Np ₉₃ ²⁴¹ Pu ₉₄ ²⁴² Pu ₉₄ ²⁴⁴ Pu ₉₄	402.3 μg 4.079 mg 193.1 gm 7.418 kg 5.526 kg 34.33 μg 921.7 kg ≤ 1 pg 934.8 kg	1.734 μM 17.50 μM 825.1 mM 31.56 M 23.41 M 144.8 nM 3.872 kM ≤ 1 pM 3.928 kM	318.8 MBq 1.462 MBq 44.67 GBq 593.6 MBq 13.23 GBq 103.7 GBq 11.47 GBq 20.34 kBq 174.0 GBq	792.4 GBq 358.4 MBq 231.3 MBq 80.02 kBq 2.394 MBq 3.021 PBq 12.44 kBq 34.28 PBq 186.1 kBq	α ²²⁸ ₉₀ Th α ²²⁹ ₉₀ Th α ²³⁰ ₉₀ Th α ²³¹ ₉₀ Th α ²³² ₉₀ Th β ²³⁷ ₉₃ Np α ²³⁴ ₉₀ Th β ²⁴⁰ ₉₃ Np	69.80 y 159.3 ky 245.7 ky 703.8 My 23.70 My 6.750 d 4.468 Gy 14.10 h	5.414 MeV 4.901 MeV 4.859 MeV 4.418 MeV 4.571 MeV 319.3 keV 4.279 MeV 138.4 keV	276.5 μW 1.148 μW 34.77 mW 420.1 μW 9.688 mW 5.304 mW 7.863 mW 450.9 pW 58.32 mW	687.3 mW 281.4 μW 180.1 μW 56.63 nW 1.753 μW 154.5 W 8.531 nW 760.0 W 62.39 nW	105.2 Sv 74.56 mSv 2.189 kSv 27.90 Sv 621.8 Sv 78.81 Sv 516.2 Sv 22.37 μSv 3.539 kSv	261.5 kSv 18.28 Sv 11.34 Sv 3.761 mSv 112.5 mSv 2.296 MSv 560.0 μSv 37.71 MSv 3.785 mSv
²³⁶ Np ²³⁷ Np ²³⁸ Np ²³⁹ Np ^{240m} Np C ₉₃ Np	 ²³⁷ U ₉₂ ^{242m} Am ₉₅ ²⁴³ Am ₉₅	2.483 mg 654.6 gm 142.2 ng 169.2 μg ≤ 1 pg 654.6 gm	10.52 μM 2.761 M 597.4 pM 707.8 nM ≤ 1 pM 2.761 M	1.211 MBq 17.08 GBq 1.365 GBq 1.453 TBq 20.34 kBq 1.471 TBq	487.7 MBq 11.8% → 26.09 MBq 9.599 PBq 8.587 PBq 3.919 EBq 2.248 GBq	ϵ ²³⁶ ₉₂ U β ²³⁶ ₉₄ Pu α ²³³ ₉₁ Pa β ²³⁸ ₉₄ Pu β ²³⁹ ₉₄ Pu β ²⁴⁰ ₉₄ Pu	152.0 ky 2.140 My 2.117 d 2.355 d 7.400 m	340.2 keV 5.157 MeV 807.6 keV 407.7 keV 977.4 keV	66.00 nW 14.11 mW 176.6 μW 94.91 mW 3.185 nW 109.2 mW	26.58 μW 21.56 μW 1.242 kW 560.9 W 613.7 kW 166.8 μW	20.59 mSv 1.879 kSv 1.242 Sv 1.162 kSv 3.042 kSv	8.291 Sv 2.870 Sv 8.735 MSv 6.870 MSv 4.648 Sv
²²⁷ Th ²²⁸ Th ²²⁹ Th ²³⁰ Th ²³¹ Th ²³² Th ²³⁴ Th C ₉₀ Th	²²⁷ Ac ₈₉ ²²⁸ Ac ₈₉ ²³³ U ₉₂ ²³⁴ U ₉₂ ²³⁵ U ₉₂ ²³⁶ U ₉₂ ²³⁸ U ₉₂	239.9 pg 10.55 μg 998.6 ng 6.672 mg 30.16 ng 1.981 mg 13.38 μg 8.678 mg	1.057 pM 46.27 nM 4.360 nM 29.00 μM 130.5 pM 8.537 μM 57.17 nM 37.65 μM	273.1 kBq 320.2 MBq 7.865 kBq 4.985 MBq 593.6 MBq 8.042 Bq 11.47 GBq 12.39 GBq	1.138 PBq 30.35 TBq 7.876 GBq 747.2 MBq 19.68 PBq 4.060 kBq 857.2 TBq 1.428 TBq	α ²²³ ₈₈ Ra α ²²⁴ ₈₈ Ra α ²²⁵ ₈₈ Ra α ²²⁶ ₈₈ Ra β ²³¹ ₉₁ Pa α ²²⁸ ₈₈ Ra β ^{234m} ₉₁ Pa	18.72 d 1.913 y 7.340 ky 75.40 ky 1.063 d 14.05 Gy 24.09 d	6.155 MeV 5.517 MeV 5.159 MeV 4.774 MeV 94.65 keV 4.083 MeV 68.41 keV	269.3 nW 283.0 μW 6.501 nW 3.813 μW 9.001 μW 5.261 pW 125.7 μW 421.8 μW	1.123 kW 26.82 W 6.510 mW 571.5 μW 298.4 W 2.656 nW 9.395 W 48.60 mW	2.403 mSv 23.05 Sv 3.854 mSv 1.047 Sv 201.8 mSv 1.850 μSv 39.00 Sv 63.31 Sv	10.02 MSv 2.185 MSv 3.859 kSv 156.9 Sv 6.692 MSv 933.7 μSv 2.915 MSv 7.295 kSv
²²³ Ra ²²⁴ Ra ²²⁵ Ra ²²⁶ Ra ²²⁸ Ra E ₈₈ Ra	²²³ Fr ₈₇ ²²⁸ Th ₉₀ ²²⁹ Th ₉₀ ²³⁰ Th ₉₀ ²³² Th ₉₀	146.0 pg 54.39 ng 5.418 pg 395.2 ng ≤ 1 pg 449.7 ng	≤ 1 pM 242.8 pM ≤ 1 pM 1.748 nM ≤ 1 pM 1.992 nM	276.9 kBq 320.8 MBq 7.865 kBq 14.47 kBq 3.506 Bq 321.1 MBq	1.897 PBq 5.898 PBq 1.452 PBq 36.61 GBq 8.663 TBq 714.0 TBq	α ²¹⁹ ₈₆ Rn α ²²⁰ ₈₆ Rn β ²²⁵ ₈₉ Ac α ²²² ₈₆ Rn β ²²⁸ ₈₉ Ac	11.43 d 3.640 d 14.80 d 1.600 ky 5.750 y	6.005 MeV 5.789 MeV 118.3 keV 4.870 MeV 13.00 keV	266.4 nW 297.5 μW 149.0 pW 11.29 nW ≤ 1 pW 297.8 μW	1.825 kW 5.470 kW 27.50 W 28.57 mW 18.04 mW 662.1 W	27.69 mSv 20.85 Sv 778.6 μSv 4.052 mSv 2.419 μSv 20.88 Sv	189.7 MSv 383.4 MSv 143.7 MSv 10.25 kSv 5.978 MSv 46.44 MSv
²³¹ Pa ²³³ Pa ²³⁴ Pa ^{234m} Pa	²³¹ Th ₉₀ ²³⁷ Np ₉₃ ^{234m} Pa ₉₁ ²³⁴ Th ₉₀	564.8 μg 22.23 μg 201.5 pg 451.2 pg	2.445 μM 95.39 nM ≤ 1 pM 1.928 pM	987.8 kBq 17.08 GBq 14.92 MBq 11.47 GBq	1.749 GBq 768.3 TBq 74.04 PBq 25.42 EBq	α ²²⁷ ₈₉ Ac β ²³³ ₉₂ U β ²³⁴ ₉₂ U β ²³⁴ ₉₂ U	32.76 ky 27.00 d 6.780 h 1.170 m	5.081 MeV 383.0 keV 2.421 MeV 833.7 keV	804.1 nW 1.048 mW 5.788 μW 1.532 mW	1.424 mW 47.14 W 28.72 kW 3.395 MW	701.3 mSv 14.86 Sv 7.609 mSv	1.242 kSv 668.4 kSv 37.76 MSv

‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas; †Radiotoxicity of daughters is included in parents.

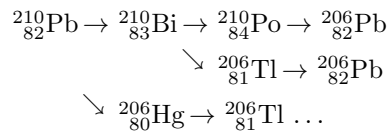
Isotope ‡	Decay From	Mass grams	Moles	Radioactivity		Decay To	Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity †	
				GBq	GBq/gm				Watts	Watts/gm	Sv	Sv/gm
C $_{91}\text{Pa}$		587.0 μg	2.540 μM	28.57 GBq	0.15% \rightarrow 48.66 TBq	γ $^{234}_{91}\text{Pa}$			2.587 mW	4.406 W	15.57 Sv	26.52 kSv
^{206}Pb	$^{210}_{84}\text{Po}$	71.93 pg	≤ 1 pM									
^{207}Pb	$^{207}_{81}\text{Tl}$	17.43 ng	84.21 pM									
^{208}Pb	$^{208}_{81}\text{Tl}$	30.50 μg	146.7 nM									
^{209}Pb	$^{209}_{81}\text{Tl}$	≤ 1 pg	≤ 1 pM	7.865 kBq	168.2 PBq	β $^{209}_{83}\text{Bi}$	3.253 h	194.0 keV	244.4 pW	5.228 kW	448.3 nSv	9.589 MSv
^{210}Pb		685.2 pg	3.263 pM	1.937 kBq	2.827 TBq	β $^{210}_{83}\text{Bi}$	22.16 y	39.06 keV	12.12 pW	17.69 mW	1.337 mSv	1.951 MSv
^{211}Pb	$^{215}_{84}\text{Po}$	≤ 1 pg	≤ 1 pM	276.9 kBq	914.2 PBq	β $^{211}_{83}\text{Bi}$	36.10 m	505.4 keV	22.42 nW	74.02 kW	49.84 μSv	164.5 MSv
^{212}Pb	$^{216}_{84}\text{Po}$	6.236 ng	29.42 pM	320.8 MBq	51.44 PBq	β $^{212}_{83}\text{Bi}$	10.64 h	321.1 keV	16.50 μW	2.646 kW	1.925 Sv	308.7 MSv
^{214}Pb	$^{218}_{84}\text{Po}$	≤ 1 pg	≤ 1 pM	14.47 kBq	1.214 EBq	β $^{214}_{83}\text{Bi}$	26.80 m	537.5 keV	1.246 nW	104.5 kW	2.026 μSv	169.9 MSv
A $_{82}\text{Pb}$		30.52 μg	146.8 nM	321.1 MBq	10.52 TBq				16.52 μW	541.3 mW	1.926 Sv	63.10 kSv
^{249}Cf	$^{249}_{97}\text{Bk}$	10.48 μg	42.08 nM	1.590 MBq	151.7 GBq	α $^{245}_{96}\text{Cm}$	351.0 y	7.804 MeV	1.988 μW	189.7 mW	556.5 mSv	53.10 kSv
^{250}Cf	$^{250}_{97}\text{Bk}$	1.206 μg	4.823 nM	4.882 MBq	4.048 TBq	α $^{246}_{96}\text{Cm}$	13.08 y	6.264 MeV	4.899 μW	4.062 W	781.1 mSv	647.7 kSv
^{251}Cf		976.6 ng	3.890 nM	57.33 kBq	58.70 GBq	α $^{247}_{96}\text{Cm}$	898.0 y	6.028 MeV	55.36 nW	56.69 mW	20.64 mSv	21.13 kSv
^{252}Cf		47.81 ng	189.7 pM	951.9 kBq	19.91 TBq	α $^{248}_{96}\text{Cm}$	2.645 y	12.04 MeV	1.836 μW	38.40 W	85.67 mSv	1.792 MSv
^{254}Cf		≤ 1 pg	≤ 1 pM	≤ 1 pBq	314.7 TBq	SF	60.50 d	199.3 MeV	≤ 1 pW	10.05 kW	≤ 1 pSv	125.9 MSv
C $_{98}\text{Cf}$		12.71 μg	50.98 nM	7.481 MBq	0.309% \rightarrow 588.6 GBq	α $^{250}_{96}\text{Cm}$			8.778 μW	690.6 mW	1.444 Sv	113.6 kSv
^{225}Ac	$^{225}_{88}\text{Ra}$	3.660 pg	≤ 1 pM	7.865 kBq	2.149 PBq	α $^{221}_{87}\text{Fr}$	10.00 d	5.891 MeV	7.423 nW	2.028 kW	188.8 μSv	51.57 MSv
^{227}Ac	$^{231}_{91}\text{Pa}$	103.2 ng	454.6 pM	276.4 kBq	2.678 TBq	β $^{227}_{90}\text{Th}$	21.77 y	81.68 keV	3.617 nW	35.05 mW	304.0 mSv	2.946 MSv
^{228}Ac	$^{228}_{88}\text{Ra}$	≤ 1 pg	≤ 1 pM	3.507 Bq	83.03 PBq	α $^{223}_{87}\text{Fr}$						
E $_{89}\text{Ac}$		103.2 ng	454.6 pM	284.3 kBq	2.754 TBq	β $^{228}_{90}\text{Th}$	6.150 h	1.458 MeV	≤ 1 pW	19.39 kW	1.508 nSv	35.70 MSv
^{208}Bi		≤ 1 pg	≤ 1 pM	119.3 nBq	172.9 MBq	ϵ $^{208}_{82}\text{Pb}$	368.0 ky	2.653 MeV	≤ 1 pW	73.51 μW		
^{209}Bi	$^{209}_{82}\text{Pb}$	1.009 ng	4.828 pM	≤ 1 pBq	3.331 μBq	α $^{205}_{81}\text{Tl}$	19.00 Ey	3.137 MeV	≤ 1 pW	≤ 1 pW		
^{210}Bi	$^{210}_{82}\text{Pb}$	≤ 1 pg	≤ 1 pM	1.937 kBq	4.593 PBq	β $^{210}_{84}\text{Po}$	5.012 d	389.0 keV	120.7 pW	286.2 W	2.518 μSv	5.971 MSv
^{210m}Bi		≤ 1 pg	≤ 1 pM	90.34 nBq	21.01 MBq	α $^{206}_{81}\text{Tl}$	3.000 My	5.295 MeV	≤ 1 pW	17.82 μW	≤ 1 pSv	315.1 mSv
^{211}Bi	$^{211}_{82}\text{Pb}$	≤ 1 pg	≤ 1 pM	276.9 kBq	15.50 EBq	α $^{207}_{81}\text{Tl}$	2.170 m	6.727 MeV	298.4 nW	16.70 MW		
^{212}Bi	$^{212}_{82}\text{Pb}$	591.5 pg	2.790 pM	320.8 MBq	542.3 PBq	β $^{211}_{81}\text{Po}$						
					0.273% \rightarrow	β $^{212}_{84}\text{Po}$	1.009 h	2.868 MeV	147.4 μW	249.2 kW	83.41 mSv	141.0 MSv
					0.014% \rightarrow	β α $^{208}_{82}\text{Pb}$						
					35.93% \rightarrow	α $^{208}_{81}\text{Tl}$						
^{213}Bi	$^{217}_{85}\text{At}$	≤ 1 pg	≤ 1 pM	7.865 kBq	716.3 PBq	β $^{213}_{84}\text{Po}$	45.59 m	709.0 keV	893.3 pW	81.36 kW	1.573 μSv	143.3 MSv
					2.16% \rightarrow	α $^{209}_{81}\text{Tl}$						
^{214}Bi	$^{214}_{82}\text{Pb}$	≤ 1 pg	≤ 1 pM	14.47 kBq	1.635 EBq	β $^{214}_{84}\text{Po}$	19.90 m	2.161 MeV	5.009 nW	566.1 kW	1.592 μSv	179.9 MSv
A $_{83}\text{Bi}$		1.601 ng	7.621 pM	321.1 MBq	200.6 PBq				147.7 μW	92.26 kW	83.41 mSv	52.10 MSv
^{210}Po	$^{210}_{83}\text{Bi}$	10.40 pg	≤ 1 pM	1.730 kBq	166.3 TBq	α $^{206}_{82}\text{Pb}$	138.4 d	5.405 MeV	1.498 nW	144.0 W	2.076 mSv	199.6 MSv

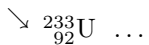
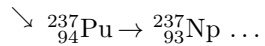
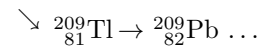
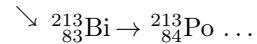
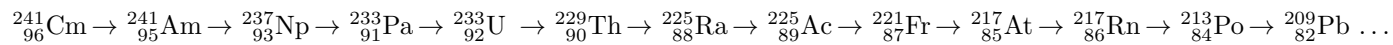
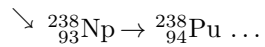
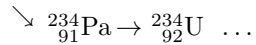
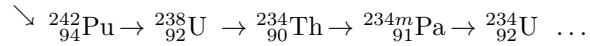
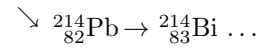
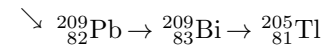
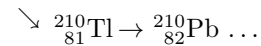
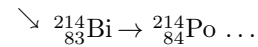
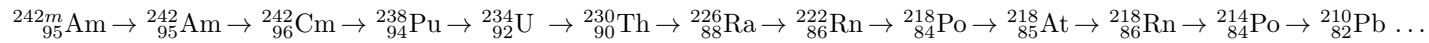
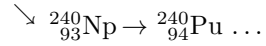
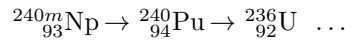
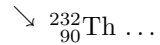
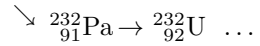
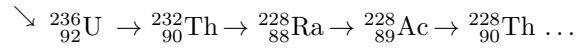
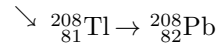
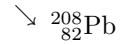
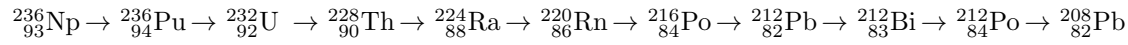
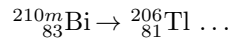
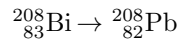
‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas; †Radiotoxicity of daughters is included in parents.

Isotope ‡	Decay From	Mass grams	Moles	Radioactivity		Decay To	Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity †	
				GBq	GBq/gm				Watts	Watts/gm	Sv	Sv/gm
²¹¹ Po	²¹¹ Bi	≤ 1 pg	≤ 1 pM	775.4 Bq	3.536×10 ¹²	α ²⁰⁷ Pb	516.0 ms	7.589 MeV	942.7 pW	4.299 GW		
²¹⁵ Po	²¹⁹ Rn	≤ 1 pg	≤ 1 pM	276.9 kBq	1.091×10 ¹⁵	α ²¹¹ Pb	1.780 ms	7.529 MeV	334.0 nW	1.317×10 ¹²		
²¹⁶ Po	²²⁰ Rn	≤ 1 pg	≤ 1 pM	320.8 MBq	1.289×10 ¹³	α ²¹² Pb	150.0 ms	6.904 MeV	354.8 μW	14.26 GW		
²¹⁸ Po	²²² Rn	≤ 1 pg	≤ 1 pM	14.47 kBq	10.47 EBq	α ²¹⁴ Pb	3.098 m	6.113 MeV	14.17 nW	10.25 MW		
A ⁸⁴ Po		10.43 pg	≤ 1 pM	321.1 MBq	30.80 EBq				355.2 μW	34.06 MW	2.076 mSv	199.1 MSv
²⁴⁹ Bk		3.356 ng	13.47 pM	203.6 kBq	60.67 TBq	β ²⁴⁹ Cf	320.0 d	125.0 keV	4.077 nW	1.215 W	197.5 μSv	58.85 kSv
²⁵⁰ Bk	²⁵⁴ Es	≤ 1 pg	≤ 1 pM	1.108 Bq	144.0 PBq	α ²⁴⁵ Am						
C ⁹⁷ Bk		3.356 ng	13.47 pM	203.6 kBq	60.67 TBq	β ²⁵⁰ Cf	3.217 h	1.172 MeV	≤ 1 pW	27.04 kW	155.1 pSv	20.16 MSv
									4.077 nW	1.215 W	197.5 μSv	58.85 kSv
²²¹ Fr	²²⁵ Ac	≤ 1 pg	≤ 1 pM	7.865 kBq	6.565 EBq	α ²¹⁷ At	4.900 m	6.509 MeV	8.201 nW	6.846 MW		
²²³ Fr	²²⁷ Ac	≤ 1 pg	≤ 1 pM	3.816 kBq	1.432 EBq	β ²²³ Ra	21.80 m	437.9 keV	267.7 pW	100.5 kW	9.158 μSv	3.438 GSv
C ⁸⁷ Fr		≤ 1 pg	≤ 1 pM	11.68 kBq	3.025 EBq				8.469 nW	2.193 MW	9.158 μSv	2.371 GSv
C ⁹⁹ Es		≤ 1 pg	≤ 1 pM	1.106 Bq	69.04 TBq	α ²⁵⁰ Bk	275.7 d	6.620 MeV	1.173 pW	73.22 W	30.97 nSv	1.933 MSv
²⁵⁰ Sf		45.96 μg										
G ² He		2.317 gm	578.9 mM									
²⁰⁷ Tl	²¹¹ Bi	≤ 1 pg	≤ 1 pM	276.1 kBq	7.051 EBq	β ²⁰⁷ Pb	4.770 m	495.3 keV	21.91 nW	559.5 kW		
²⁰⁸ Tl	²¹² Bi	10.57 pg	≤ 1 pM	115.2 MBq	10.90 EBq	β ²⁰⁸ Pb	3.053 m	3.971 MeV	73.29 μW	6.934 MW		
²⁰⁹ Tl	²¹³ Bi	≤ 1 pg	≤ 1 pM	169.9 Bq	15.14 EBq	β ²⁰⁹ Pb	2.200 m	2.802 MeV	76.26 pW	6.797 MW		
A ⁸¹ Tl		10.61 pg	≤ 1 pM	115.5 MBq	10.88 EBq				73.31 μW	6.910 MW		
A ⁸⁵ At	²²¹ Fr	≤ 1 pg	≤ 1 pM	7.865 kBq	5.958×10 ¹³	α ²¹³ Bi	32.30 ms	7.197 MeV	9.068 nW	68.70 GW		
²¹⁹ Rn	²²³ Ra	≤ 1 pg	≤ 1 pM	276.9 kBq	481.7 EBq	α ²¹⁵ Po	3.960 s	6.997 MeV	310.4 nW	540.0 MW		
²²⁰ Rn	²²⁴ Ra	9.394 pg	≤ 1 pM	320.8 MBq	34.15 EBq	α ²¹⁶ Po	55.80 s	6.403 MeV	329.1 μW	35.03 MW		
²²² Rn	²²⁶ Ra	2.541 pg	≤ 1 pM	14.47 kBq	5.695 PBq	α ²¹⁸ Po	3.823 d	5.586 MeV	12.95 nW	5.096 kW		
G ⁸⁶ Rn		11.94 pg	≤ 1 pM	321.1 MBq	26.90 EBq				329.4 μW	27.60 MW		
Total		947.9 kg	3.983 kM	4.730 PBq	4.990 GBq				458.1 W	483.3 μW	21.05 MSv	22.21 Sv

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Total radiotoxicity is not the sum of the “Sv” column because ICRP Publication 119 includes radiotoxicity of daughter in radiotoxicity of parent.
Dose factors for gases are given as Sv/day per Bq/m³. Radiotoxicity is not computed for gases.
‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas; †Radiotoxicity of daughters is included in parents.

Decay Chains





Activation Products Per Tonne of Fuel

used for 50.68 GWth-day LWR burnup at power of 36.54 MWth and $3.14 \times 10^{14} N/cm^2/s$ neutron flux,
after ten years' storage, as calculated by ORIGEN2 version 2.1 on 9 October 2013.

Radiotoxicity in Sieverts computed for adult ingestion using dose factors from ICRP publication 119

Isotope ‡	Decay From	Mass grams	Moles	Radioactivity		Decay To	Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity †	
				GBq	GBq/gm				Watts	Watts/gm	Sv	Sv/gm
⁹⁰ Zr	⁹⁰ Y	120.7 kg	1.343 kM									
⁹¹ Zr	⁹¹ Y	26.41 kg	290.5 M									
⁹² Zr	⁹² Y	41.10 kg	447.2 M									
⁹³ Zr	⁹³ Y	160.7 gm	1.730 M	14.95 GBq	93.03 MBq	β ^{93m} Nb	1.530 My	19.59 keV	46.93 μ W	292.0 nW	16.44 Sv	102.3 mSv
					2.5% \rightarrow	β ⁹³ Nb						
⁹⁴ Zr		42.60 kg	453.6 M	1.000 kBq	23.48 mBq	2β ⁹⁴ Mo	6.000 Py	1.144 MeV	183.2 pW	≤ 1 pW		
⁹⁵ Zr		≤ 1 pg	≤ 1 pM	12.72 mBq	795.5 TBq	β ⁹⁵ Nb	64.03 d	854.3 keV	≤ 1 pW	108.9 W	12.08 pSv	755.7 kSv
					1.08% \rightarrow	β ^{95m} Nb						
⁹⁶ Zr		6.957 kg	72.54 M	24.60 mBq	3.536 μ Bq	2β ⁹⁶ Mo	39.00 Ey	3.350 MeV	≤ 1 pW	≤ 1 pW		
A ₄₀ Zr		237.9 kg	2.608 kM	14.95 GBq	62.83 kBq				46.93 μ W	197.2 pW	16.44 Sv	69.12 μ Sv
⁸⁷ Sr		3.321 mg	38.21 μ M									
⁸⁸ Sr		325.3 mg	3.701 mM									
⁸⁹ Sr		≤ 1 pg	≤ 1 pM	283.5 pBq	1.076 PBq	β ⁸⁹ Y	50.57 d	583.0 keV	≤ 1 pW	100.5 W	≤ 1 pSv	2.797 MSv
⁹⁰ Sr		26.93 μ g	299.5 nM	136.0 MBq	5.050 TBq	β ⁹⁰ Y	28.79 y	195.8 keV	4.266 μ W	158.4 mW	3.808 Sv	141.4 kSv
E ₃₈ Sr		328.6 mg	3.739 mM	136.0 MBq	413.8 MBq				4.266 μ W	12.98 μ W	3.808 Sv	11.59 Sv
⁹³ Nb	⁹³ Zr	245.6 μ g	2.644 μ M									
^{93m} Nb	⁹³ Zr	610.9 μ g	6.575 μ M	6.395 GBq	10.47 TBq	γ ⁹³ Nb	16.13 y	29.88 keV	30.61 μ W	50.11 mW	767.4 mSv	1.256 kSv
⁹⁴ Nb	⁹⁴ Zr	63.41 ng	675.2 pM	439.7 Bq	6.934 GBq	β ⁹⁴ Mo	19.99 ky	1.719 MeV	121.1 pW	1.910 mW	747.5 nSv	11.79 Sv
⁹⁵ Nb	⁹⁵ Zr	≤ 1 pg	≤ 1 pM	28.24 mBq	1.448 PBq	β ⁹⁵ Mo	34.99 d	809.0 keV	≤ 1 pW	187.7 W	16.38 pSv	840.0 kSv
^{95m} Nb	⁹⁵ Zr	≤ 1 pg	≤ 1 pM	94.34 μ Bq	14.10 PBq	γ ⁹⁵ Nb	3.608 d	234.4 keV	≤ 1 pW	529.4 W	≤ 1 pSv	7.896 MSv
					5.6% \rightarrow	β ⁹⁵ Mo						
A ₄₁ Nb		856.6 μ g	9.220 μ M	6.395 GBq	7.466 TBq				30.61 μ W	35.74 mW	767.4 mSv	895.9 Sv
⁸⁹ Y	⁸⁹ Sr	24.79 mg	278.8 μ M									
⁹⁰ Y	⁹⁰ Sr	6.754 ng	75.12 pM	136.0 MBq	20.14 PBq	β ⁹⁰ Zr	2.671 d	935.4 keV	20.38 μ W	3.017 kW	367.2 mSv	54.37 MSv
⁹¹ Y	⁹¹ Sr	≤ 1 pg	≤ 1 pM	686.2 nBq	907.9 TBq	β ⁹¹ Zr	58.51 d	605.8 keV	≤ 1 pW	88.12 W	≤ 1 pSv	2.179 MSv
E ₃₉ Y		24.79 mg	278.8 μ M	136.0 MBq	5.486 GBq				20.38 μ W	822.1 μ W	367.2 mSv	14.81 Sv
⁹⁸ Tc		4.887 ng	49.91 pM	157.2 mBq	32.17 MBq	β ⁹⁸ Ru	4.200 My	1.532 MeV	≤ 1 pW	7.892 μ W	314.4 pSv	64.33 mSv
⁹⁹ Tc		1.152 mg	11.65 μ M	722.8 kBq	627.4 MBq	β ⁹⁹ Ru	214.0 ky	84.60 keV	9.796 nW	8.503 μ W	462.6 μ Sv	401.6 mSv
A ₄₃ Tc		1.152 mg	11.65 μ M	722.8 kBq	627.4 MBq				9.796 nW	8.503 μ W	462.6 μ Sv	401.6 mSv
¹ H		12.73 mg	12.63 mM									
² H		10.72 μ g	5.322 μ M									
³ H		4.054 pg	1.344 pM	1.449 kBq	357.4 TBq	β ³ He	12.33 y	5.678 keV	1.318 pW	325.1 mW	60.86 nSv	15.01 kSv

‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas; †Radiotoxicity of daughters is included in parents.

Isotope ‡	Decay From	Mass grams	Moles	Radioactivity		Decay To	Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity †	
				GBq	GBq/gm				Watts	Watts/gm	Sv	Sv/gm
G ₁ H		12.74 mg	12.64 mM	1.449 kBq	113.7 kBq				1.318 pW	103.4 pW	60.86 nSv	4.777 μSv
¹⁰² Rh ¹⁰³ Rh A ₄₅ Rh		≤ 1 pg 1.108 pg 1.108 pg	≤ 1 pM ≤ 1 pM ≤ 1 pM	2.251 μBq 2.251 μBq	44.76 TBq 2.032 MBq	ε ¹⁰² Ru	2.902 y	2.151 MeV	≤ 1 pW ≤ 1 pW	15.42 W 700.1 nW	≤ 1 pSv ≤ 1 pSv	53.71 kSv 2.438 mSv
³ He ⁴ He G ₂ He	³ H ¹ H	3.120 pg 16.30 mg 16.30 mg	1.034 pM 4.072 mM 4.072 mM									
⁹⁴ Mo ⁹⁵ Mo ⁹⁶ Mo ⁹⁷ Mo ⁹⁸ Mo ¹⁰⁰ Mo A ₄₂ Mo	⁹⁴ Zr ⁴⁰ Zr ⁹⁵ Nb ⁴¹ Nb ⁹⁶ Zr ⁴⁰ Zr	23.39 pg 29.03 gm 1.824 gm 48.80 gm 616.9 mg 1.234 μg 80.27 gm	≤ 1 pM 305.9 mM 19.02 mM 503.6 mM 6.301 mM 12.35 nM 834.8 mM									
				833.5 mBq 16.50 pBq 833.5 mBq	1.351 Bq 13.37 μBq 10.38 mBq	2β ⁹⁸ Ru 2β ¹⁰⁰ Ru	100.0 Ty 9.900 Ey	112.0 keV 3.034 MeV	≤ 1 pW ≤ 1 pW ≤ 1 pW	≤ 1 pW ≤ 1 pW ≤ 1 pW		
⁹⁸ Ru ⁹⁹ Ru ¹⁰⁰ Ru ¹⁰¹ Ru ¹⁰² Ru ¹⁰⁴ Ru A ₄₄ Ru	⁹⁸ Mo ⁴² Mo ⁹⁹ Tc ⁴³ Tc ¹⁰⁰ Mo ⁴² Mo ¹⁰² Rh ⁴⁵ Rh	≤ 1 pg 40.54 ng 99.42 μg 500.4 ng 9.511 ng ≤ 1 pg 99.97 μg	≤ 1 pM 409.9 pM 995.2 nM 4.959 nM 93.33 pM ≤ 1 pM 1.001 μM									
¹⁰⁴ Pd ¹⁰⁵ Pd ¹⁰⁶ Pd A ₄₆ Pd		≤ 1 pg ≤ 1 pg ≤ 1 pg ≤ 1 pg	≤ 1 pM ≤ 1 pM ≤ 1 pM ≤ 1 pM									
Total		238.0 kg	2.609 kM	21.62 GBq	90.84 kBq				102.2 μW	429.4 pW	20.25 Sv	85.10 μSv

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Decay Chains

