

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 fifty 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 ⁹⁰ Sr E ₃₈ Sr	⁸⁷ Rb ₃₇	923.6 mg 7.616 mg 519.2 gm 237.4 gm 757.5 gm	10.75 mM 87.63 μM 5.906 M 2.640 M 8.558 M									
				1.199 PBq 1.199 PBq	5.051 TBq 1.583 TBq	β ⁹⁰ Y ₃₉	28.79 y	195.8 keV	37.61 W 37.61 W	158.4 mW 49.65 mW	33.57 MSv 33.57 MSv	141.4 kSv 44.32 kSv
¹³³ Cs ¹³⁴ Cs ¹³⁵ Cs ¹³⁷ Cs E ₅₅ Cs		1.616 kg 11.77 μg 619.6 gm 570.0 gm 2.806 kg	12.16 M 87.90 nM 4.593 M 4.163 M 20.92 M	564.0 MBq 26.41 GBq 1.836 PBq 1.836 PBq	47.92 TBq 0.0003% → 42.62 MBq 3.221 TBq 654.4 GBq	β ¹³⁴ Ba ₅₆ ϵ ¹³⁴ Xe ₅₄ β ¹³⁵ Ba ₅₆ β ^{137m} Ba ₅₆ β ¹³⁷ Ba ₅₆	2.065 y 2.300 My 30.04 y	1.717 MeV 56.30 keV 186.5 keV	155.1 μW 238.2 μW 54.86 W 54.86 W	13.18 W 384.4 nW 96.25 mW 19.55 mW	10.72 Sv 52.82 Sv 23.87 MSv 23.87 MSv	910.5 kSv 85.25 mSv 41.87 kSv 8.507 kSv
⁸⁹ Y ⁹⁰ Y E ₃₉ Y	⁹⁰ Sr ₃₈	676.0 gm 59.54 mg 676.1 gm	7.604 M 662.2 μM 7.604 M	1.199 PBq 1.199 PBq	20.14 PBq 1.774 TBq	β ⁹⁰ Zr ₄₀	2.671 d	935.0 keV	179.6 W 179.6 W	3.016 kW 265.7 mW	3.237 MSv 3.237 MSv	54.37 MSv 4.788 kSv
¹⁵⁰ Eu ¹⁵¹ Eu ¹⁵² Eu ¹⁵³ Eu ¹⁵⁴ Eu ¹⁵⁵ Eu E ₆₃ Eu	¹⁵¹ Sm ₆₂ ¹⁵³ Gd ₆₄	173.6 ng 7.313 gm 4.929 mg 195.8 gm 1.172 gm 23.82 mg 204.3 gm	1.158 nM 48.88 mM 32.44 μM 1.280 M 7.614 mM 153.8 μM 1.337 M	425.6 kBq 380.3 μBq 31.56 GBq 11.71 TBq 410.1 GBq 12.15 TBq	2.452 TBq 52.00 μBq 6.403 TBq 27.9% → 9.991 TBq 0.02% → 17.22 TBq 59.48 GBq	ϵ ¹⁵⁰ Sm ₆₂ α ¹⁴⁷ Pm ₆₁ ϵ ¹⁵² Sm ₆₂ β ¹⁵² Gd ₆₄ β ¹⁵⁴ Gd ₆₄ ϵ ¹⁵⁴ Sm ₆₂ β ¹⁵⁵ Gd ₆₄	36.36 y 1.700 Ey 13.52 y 8.593 y 4.753 y	1.540 MeV 1.905 MeV 1.275 MeV 1.509 MeV 122.7 keV	105.0 nW ≤ 1 pW 6.449 mW 2.831 W 2.416 W 8.061 mW 2.846 W	604.8 mW ≤ 1 pW 1.308 W 2.416 W 338.4 mW 13.93 mW	553.3 μSv 44.18 Sv 23.42 kSv 19.98 kSv 131.2 Sv 23.60 kSv	3.187 kSv 8.964 kSv 19.98 kSv 5.509 kSv 115.5 Sv
¹⁰⁸ Cd ¹⁰⁹ Cd ¹¹⁰ Cd ¹¹¹ Cd ¹¹² Cd ¹¹³ Cd ^{113m} Cd	¹⁰⁸ Ag ₄₇ ¹¹⁰ Pd ₄₆ ^{113m} Cd ₄₈	694.2 μg ≤ 1 pg 77.24 gm 45.72 gm 26.97 gm 212.4 mg 41.28 mg	6.434 μM ≤ 1 pM 702.8 mM 412.3 mM 241.0 mM 1.881 mM 365.6 μM	207.6 nBq 144.8 μBq 3.232 mBq 331.5 GBq	299.0 μBq 95.58 TBq 15.22 mBq 8.031 TBq 0.14% →	2 ϵ ¹⁰⁸ Pd ₄₆ ϵ ^{109m} Ag ₄₇ β ¹¹³ In ₄₉ β ¹¹³ In ₄₉ γ ¹¹³ Cd ₄₈	410.0 Py 1.267 y 7.700 Py 14.10 y	272.0 keV 19.60 keV 93.30 keV 283.9 keV	≤ 1 pW ≤ 1 pW ≤ 1 pW 15.08 mW	≤ 1 pW 300.1 mW ≤ 1 pW 365.3 mW	≤ 1 pSv 80.79 pSv 7.625 kSv	191.2 kSv 380.4 pSv 184.7 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
¹¹⁴ Cd ¹¹⁶ Cd A ₄₈ Cd		34.99 gm 12.55 gm 197.7 gm	307.2 mM 108.3 mM 1.774 M	6.772 mBq 42.12 μBq 331.5 GBq	193.5 μBq 3.357 μBq 1.677 GBq	2β ¹¹⁴ ₅₀ Sn 2β ¹¹⁶ ₅₀ Sn	600.0 Py 34.00 Ey	536.0 keV 2.804 MeV	≤ 1 pW ≤ 1 pW 15.08 mW	≤ 1 pW ≤ 1 pW 76.27 μW	7.625 kSv	38.56 Sv
¹⁴⁶ Sm ¹⁴⁷ Sm ¹⁴⁸ Sm ¹⁴⁹ Sm ¹⁵⁰ Sm ¹⁵¹ Sm ¹⁵² Sm ¹⁵⁴ Sm E ₆₂ Sm	¹⁴⁶ ₆₁ Pm ¹⁴⁷ ₆₁ Pm ¹⁴⁸ ₆₀ Nd ¹⁵⁰ ₆₀ Nd ¹⁵² ₆₃ Eu ¹⁵⁴ ₆₃ Eu	13.66 mg 243.8 gm 309.5 gm 4.616 gm 478.3 gm 15.53 gm 178.3 gm 59.76 gm 1.290 kg	93.62 μM 1.659 M 2.092 M 31.00 mM 3.190 M 102.9 mM 1.174 M 388.2 mM 8.638 M	17.69 kBq 205.1 kBq 3.459 Bq 205.0 mBq 15.13 TBq 974.2 GBq 15.13 TBq	1.295 MBq 841.3 Bq 11.18 mBq 44.41 mBq 974.2 GBq 11.73 GBq	α ¹⁴² ₆₀ Nd α ¹⁴³ ₆₀ Nd α ¹⁴⁴ ₆₀ Nd α ¹⁴⁵ ₆₀ Nd β ¹⁵¹ ₆₃ Eu	100.0 My 106.0 Gy 7.000 Py 2.000 Py 90.00 y	2.539 MeV 2.310 MeV 2.014 MeV 1.870 MeV 19.77 keV	7.197 nW 75.90 nW 1.116 pW ≤ 1 pW 47.92 mW 47.92 mW	526.9 nW 311.3 pW ≤ 1 pW ≤ 1 pW 3.086 mW 37.15 μW	955.3 μSv 10.05 mSv 1.483 kSv 1.483 kSv	69.93 mSv 41.22 μSv 95.48 Sv 1.150 Sv
⁹⁸ Tc ⁹⁹ Tc A ₄₃ Tc		10.77 mg 1.136 kg 1.136 kg	110.0 μM 11.49 M 11.49 M	346.5 kBq 712.8 GBq 712.8 GBq	32.17 MBq 627.5 MBq 627.5 MBq	β ⁹⁸ ₄₄ Ru β ⁹⁹ ₄₄ Ru	4.200 My 214.0 ky	1.532 MeV 84.58 keV	85.02 nW 9.659 mW 9.659 mW	7.894 μW 8.503 μW 8.503 μW	693.0 μSv 456.2 Sv 456.2 Sv	64.35 mSv 401.6 mSv 401.6 mSv
¹¹⁴ Sn ¹¹⁵ Sn ¹¹⁶ Sn ¹¹⁷ Sn ¹¹⁸ Sn ¹¹⁹ Sn ^{119m} Sn ¹²⁰ Sn ^{121m} Sn ¹²² Sn ¹²⁴ Sn ¹²⁶ Sn E ₅₀ Sn	¹¹⁴ ₄₈ Cd ¹¹⁵ ₄₉ In ¹¹⁶ ₄₈ Cd ^{119m} ₅₀ Sn	3.852 mg 490.4 mg 12.26 gm 12.64 gm 12.81 gm 12.76 gm ≤ 1 pg 12.99 gm 2.746 mg 14.26 gm 19.24 gm 42.48 gm 139.9 gm	33.82 μM 4.268 mM 105.8 mM 108.1 mM 108.7 mM 107.3 mM ≤ 1 pM 108.3 mM 22.71 μM 117.0 mM 155.3 mM 337.4 mM 1.152 M	 408.6 pBq 6.010 GBq 20.54 mBq 44.63 GBq 50.64 GBq	 165.8 TBq 2.189 TBq 22.4% → 1.068 mBq 1.051 GBq 33.068% → 361.9 MBq	 γ ¹¹⁹ ₅₀ Sn γ ¹²¹ ₅₀ Sn β ¹²¹ ₅₁ Sb 2β ¹²⁴ ₅₂ Te β ^{126m} ₅₁ Sb β ^{126m} ₅₁ Sb	 293.0 d 55.00 y 100.0 Py 230.0 ky	 87.15 keV 338.0 keV 2.287 MeV 210.4 keV	≤ 1 pW 325.4 μW ≤ 1 pW 1.504 mW 1.829 mW	2.315 W 118.5 mW ≤ 1 pW 35.40 μW 13.07 μW	≤ 1 pSv 2.284 Sv 209.8 Sv 212.0 Sv	56.38 kSv 831.7 Sv 4.938 Sv 1.515 Sv
¹²⁷ I ¹²⁹ I E ₅₃ I		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 μW 22.33 μW	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	⁹⁰ ₃₉ Y	585.1 gm 876.9 gm 956.3 gm 1.073 kg	6.508 M 9.646 M 10.41 M 11.55 M	99.82 GBq	93.03 MBq	β ^{93m} ₄₁ Nb	1.530 My	19.59 keV	313.3 μW	292.0 nW	109.8 Sv	102.3 mSv

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				GBq	GBq/gm				Watts	Watts/gm	Sv	Sv/gm
⁹⁴ Zr ⁹⁶ Zr A ₄₀ Zr		1.125 kg 1.211 kg 5.827 kg	11.98 M 12.63 M 62.72 M	26.41 Bq 4.282 mBq 99.82 GBq	2.5% → 23.48 mBq 3.536 μBq 17.13 MBq	β ⁹³ Nb 2β ⁹⁴ Mo 2β ⁹⁶ Mo	6.000 Py 39.00 Ey	1.144 MeV 3.350 MeV	4.839 pW ≤ 1 pW 313.3 μW	≤ 1 pW ≤ 1 pW 53.76 nW	109.8 Sv	18.84 mSv
G ₁ H		5.201 mg	1.724 mM	1.858 TBq	357.2 TBq	β ³ He	12.33 y	5.678 keV	1.690 mW	324.9 mW	78.04 Sv	15.00 kSv
⁷⁶ Se ⁷⁷ Se ⁷⁸ Se ⁷⁹ Se ⁸⁰ Se ⁸² Se E ₃₄ Se	⁷⁶ Ge ³² Ge	12.23 mg 1.515 gm 3.687 gm 8.865 gm 20.17 gm 50.43 gm 84.68 gm	161.1 μM 19.70 mM 47.32 mM 112.3 mM 252.4 mM 615.6 mM 1.048 M									
				22.86 GBq	2.579 GBq	β ⁷⁹ Br	377.0 ky	42.00 keV	153.8 μW	17.35 μW	66.29 Sv	7.478 Sv
				67.30 μBq	1.334 μBq	2β ⁸² Kr	121.0 Ey	2.995 MeV	≤ 1 pW 153.8 μW	≤ 1 pW 1.816 μW	66.29 Sv	782.9 mSv
^{121m} Sb ¹²³ Sb ¹²⁵ Sb ^{126m} Sb ^{126m} Sb E ₅₁ Sb	^{121m} Sn ₅₀ Sn ¹²³ Te ₅₂ Te	12.21 gm 15.25 gm 72.39 μg 2.018 μg 15.35 ng 27.46 gm	101.0 mM 124.1 mM 579.6 nM 16.03 nM 121.9 pM 225.1 mM									
				2.768 GBq	38.24 TBq 22.377% →	β ¹²⁵ Te β ^{125m} Te	2.759 y	527.2 keV	233.8 μW	3.230 W	3.045 Sv	42.06 kSv
				6.247 GBq	3.096 PBq	β ¹²⁶ Te	12.40 d	3.117 MeV	3.119 mW	1.546 kW	14.99 Sv	7.430 MSv
				44.63 GBq	2.907 EBq	β ¹²⁶ Te	19.10 m	2.147 MeV	15.35 mW	1.000 MW	1.607 Sv	104.7 MSv
				53.65 GBq	1.954 GBq	γ ¹²⁶ Sb	14% →		18.70 mW	681.1 μW	19.64 Sv	715.4 mSv
⁹³ Nb ^{93m} Nb ⁹⁴ Nb A ₄₁ Nb	⁹³ Zr ₄₀ Zr ⁹³ Zr ₄₀ Zr	16.90 mg 8.422 mg 1.180 mg 26.50 mg	181.9 μM 90.65 μM 12.57 μM 285.1 μM	88.12 GBq 8.187 MBq 88.13 GBq	10.46 TBq 6.938 GBq 3.325 TBq	γ ⁹³ Nb β ⁹⁴ Mo	16.13 y 19.99 ky	29.89 keV 1.719 MeV	421.9 μW 2.254 μW 424.2 μW	50.09 mW 1.910 mW 16.00 mW	10.57 Sv 13.92 mSv 10.59 Sv	1.256 kSv 11.79 Sv 399.5 Sv
¹⁴⁶ Pm ¹⁴⁷ Pm E ₆₁ Pm	 ¹⁵¹ Eu ₆₃ Eu	17.21 μg 283.5 μg 300.7 μg	117.9 nM 1.930 μM 2.048 μM	283.6 MBq 9.730 GBq 10.01 GBq	16.48 TBq 34.32 TBq 33.30 TBq	ϵ ¹⁴⁶ Nd β ¹⁴⁶ Sm β ¹⁴⁷ Sm	5.531 y 2.623 y	850.7 keV 60.49 keV	38.65 μW 94.29 μW 132.9 μW	2.246 W 332.6 mW 442.1 mW	255.2 mSv 2.530 Sv 2.785 Sv	14.83 kSv 8.923 kSv 9.262 kSv
¹²² Te ¹²³ Te ¹²⁴ Te ¹²⁵ Te ^{125m} Te ¹²⁶ Te ¹²⁸ Te ¹³⁰ Te	 ¹²⁴ Sn ₅₀ Sn ¹²⁵ Sb ₅₁ Sb ¹²⁵ Sb ₅₁ Sb ¹²⁶ Sb ₅₁ Sb	1.243 gm 21.28 mg 963.7 mg 29.08 gm 1.013 μg 1.334 gm 170.8 gm 547.3 gm	10.20 mM 173.1 μM 7.778 mM 232.8 mM 8.110 nM 10.60 mM 1.335 M 4.213 M	229.1 mBq 10.77 Bq	10.77 Bq	ϵ ¹²³ Sb γ ¹²⁵ Te 2β ¹²⁸ Xe 2β ¹³⁰ Xe	92.00 Py 57.40 d ≥ 10 ²¹ y ≥ 10 ²¹ y	17.09 keV 141.8 keV 867.2 keV 2.528 MeV	≤ 1 pW 15.34 μW ≤ 1 pW ≤ 1 pW	≤ 1 pW 15.14 W ≤ 1 pW ≤ 1 pW	1.008 nSv 587.3 mSv ≤ 1 pW ≤ 1 pW	47.37 nSv 579.8 kSv ≤ 1 pW ≤ 1 pW

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				GBq	GBq/gm				Watts	Watts/gm	Sv	Sv/gm
E $_{52}\text{Te}$		750.7 gm	5.810 M	675.1 MBq	899.2 kBq				15.34 μW	20.43 nW	587.3 mSv	782.3 μSv
^{165}Ho ^{166m}Ho E $_{67}\text{Ho}$		285.7 mg 3.425 mg 289.1 mg	1.732 mM 20.64 μM 1.753 mM	227.5 MBq 66.42 GBq 227.5 MBq	899.2 kBq 786.9 MBq	β ^{166}Er	1.200 ky	1.869 MeV	68.12 μW 68.12 μW	19.89 mW 235.6 μW	455.0 mSv 455.0 mSv	132.8 Sv 1.574 Sv
^{104}Pd ^{105}Pd ^{106}Pd ^{107}Pd ^{108}Pd ^{110}Pd A $_{46}\text{Pd}$	^{106}Rh ^{108}Ag ^{110}Ag	463.0 gm 609.7 gm 594.1 gm 361.2 gm 248.7 gm 82.30 gm 2.359 kg	4.456 M 5.812 M 5.610 M 3.379 M 2.305 M 748.8 mM 22.31 M	6.876 GBq 19.04 MBq 16.51 mBq 6.876 GBq	899.2 kBq 786.9 MBq 200.6 μBq 2.915 MBq	β ^{107}Ag 2β ^{110}Cd	6.500 My 600.0 Py	10.00 keV 2.000 MeV	11.02 μW ≤ 1 pW 11.02 μW	30.51 nW ≤ 1 pW 4.671 nW	254.4 mSv 254.4 mSv	704.4 μSv 107.8 μSv
E $^{14}_6\text{C}$		39.98 μg	2.855 μM	6.599 MBq	165.1 GBq	β $^{14}_7\text{N}$	5.700 ky	49.44 keV	52.27 nW	1.307 mW	3.827 mSv	95.73 Sv
^{107}Ag ^{108}Ag ^{108m}Ag ^{109}Ag ^{109m}Ag ^{110}Ag ^{110m}Ag E $_{47}\text{Ag}$	^{107}Pd ^{108m}Ag ^{109m}Ag ^{109}Cd ^{110m}Ag	1.980 mg ≤ 1 pg 1.461 μg 115.4 gm ≤ 1 pg ≤ 1 pg ≤ 1 pg	18.52 μM ≤ 1 pM 13.54 nM 1.060 M ≤ 1 pM ≤ 1 pM ≤ 1 pM	125.4 kBq 1.409 MBq 144.8 μBq 362.1 pBq 27.23 nBq	27.19 EBq 2.9% \rightarrow 964.4 GBq 8.7% \rightarrow 96.79 EBq 154.3 EBq 0.3% \rightarrow 175.9 TBq 1.36% \rightarrow 13.30 kBq	β ^{108}Cd ϵ ^{108}Pd ϵ ^{108}Pd γ ^{108}Ag γ ^{109}Ag β ^{110}Cd ϵ ^{110}Pd β ^{110}Cd γ ^{110}Ag	2.400 m 418.0 y 39.70 s 24.56 s 249.8 d	628.2 keV 1.634 MeV 86.95 keV 1.212 MeV 2.815 MeV	12.62 nW 368.8 nW ≤ 1 pW ≤ 1 pW ≤ 1 pW	2.736 MW 252.4 mW 1.348 MW 29.97 MW 79.33 W	3.241 mSv 3.241 mSv ≤ 1 pSv	2.218 kSv 2.218 kSv 492.5 kSv
^{85}Rb ^{87}Rb E $_{37}\text{Rb}$	^{85}Kr	179.4 gm 361.8 gm 541.2 gm	2.113 M 4.163 M 6.276 M	1.172 MBq 1.172 MBq	3.239 kBq 2.166 kBq	β ^{87}Sr	48.10 Gy	141.0 keV	26.47 nW 26.47 nW	73.16 pW 48.91 pW	1.758 mSv 1.758 mSv	4.859 μSv 3.248 μSv
^{102}Rh ^{103}Rh ^{106}Rh A $_{45}\text{Rh}$	^{106}Ru	9.937 ng 611.3 gm ≤ 1 pg 611.3 gm	97.51 pM 5.940 M ≤ 1 pM 5.940 M	444.5 kBq 32.41 Bq 444.5 kBq	44.73 TBq 131.8 EBq 727.2 Bq	ϵ ^{102}Ru β ^{106}Pd	2.902 y 30.00 s	2.153 MeV 1.618 MeV	153.3 nW 8.400 pW 153.3 nW	15.43 W 34.16 MW 250.8 pW	533.4 μSv 533.4 μSv	53.68 kSv 872.6 nSv
^9Be ^{10}Be E $_{4}\text{Be}$		29.79 μg 198.9 μg 228.7 μg	3.306 μM 19.86 μM 23.17 μM	164.6 kBq 164.6 kBq	827.6 MBq 719.8 MBq	β $^{10}_5\text{B}$	1.600 My	202.4 keV	5.338 nW 5.338 nW	26.84 μW 23.34 μW	181.1 μSv 181.1 μSv	910.3 mSv 791.7 mSv
^{99}Ru ^{100}Ru	^{99}Tc ^{100}Mo	191.8 mg 218.3 gm	1.939 mM 2.185 M									

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				GBq	GBq/gm				Watts	Watts/gm	Sv	Sv/gm
¹⁰¹ Ru ¹⁰² Ru ¹⁰⁴ Ru ¹⁰⁶ Ru A ₄₄ Ru	¹⁰² Rh ₄₅	1.166 kg 1.217 kg 863.0 gm ≤ 1 pg 3.464 kg	11.56 M 11.94 M 8.306 M ≤ 1 pM 33.99 M			β ¹⁰⁶ Rh ₄₅	1.020 y	10.03 keV	≤ 1 pW ≤ 1 pW	199.0 mW ≤ 1 pW	226.9 nSv 226.9 nSv	867.2 kSv 65.48 pSv
¹¹³ In ¹¹⁵ In E ₄₉ In	¹¹³ Cd ₄₈	430.0 mg 2.697 gm 3.127 gm	3.809 mM 23.47 mM 27.28 mM	621.4 mBq 621.4 mBq	230.4 mBq 198.7 mBq	β ¹¹⁵ Sn ₅₀	441.0 Ty	241.9 keV	≤ 1 pW ≤ 1 pW	≤ 1 pW ≤ 1 pW	19.88 nSv 19.88 nSv	7.373 nSv 6.359 nSv
¹³⁸ La ¹³⁹ La E ₅₇ La		7.637 mg 1.849 kg 1.849 kg	55.38 μM 13.31 M 13.31 M	5.426 Bq 5.426 Bq	710.5 Bq 2.935 mBq	ϵ ¹³⁸ Ba ₅₆	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
¹⁵² Gd ¹⁵³ Gd ¹⁵⁴ Gd ¹⁵⁵ Gd ¹⁵⁶ Gd ¹⁵⁷ Gd ¹⁵⁸ Gd ¹⁶⁰ Gd E ₆₄ Gd	¹⁵² Eu ₆₃ ¹⁵⁴ Eu ₆₃ ¹⁵⁵ Eu ₆₃	89.89 mg ≤ 1 pg 70.81 gm 26.02 gm 125.8 gm 196.7 mg 33.19 gm 2.102 gm 258.2 gm	591.7 μM ≤ 1 pM 460.0 mM 168.0 mM 806.8 mM 1.253 mM 210.2 mM 13.14 mM 1.660 M	72.47 mBq 16.97 pBq 1.337 mBq 73.81 mBq	806.2 mBq 130.6 TBq 636.2 μBq 285.8 μBq	α ¹⁴⁸ Sm ₆₂ ϵ ¹⁵³ Eu ₆₃ 2β ¹⁶⁰ Dy ₆₆	108.0 Ty 240.4 d 130.0 Py	2.198 MeV 152.3 keV 1.729 MeV	≤ 1 pW ≤ 1 pW ≤ 1 pW ≤ 1 pW	≤ 1 pW 3.188 W ≤ 1 pW ≤ 1 pW	2.971 nSv ≤ 1 pSv 2.971 nSv	33.05 nSv 35.27 kSv 11.51 pSv
¹⁶⁹ Tm ¹⁷¹ Tm E ₆₉ Tm		95.30 μg ≤ 1 pg 95.30 μg	564.1 nM ≤ 1 pM 564.1 nM	1.057 Bq 1.057 Bq	40.30 TBq 11.09 kBq	β ¹⁷¹ Yb ₇₀	1.917 y	26.16 keV	≤ 1 pW ≤ 1 pW	168.9 mW 46.48 pW	116.3 pSv 116.3 pSv	4.433 kSv 1.220 μSv
¹⁴⁰ Ce ¹⁴² Ce ¹⁴⁴ Ce E ₅₈ Ce	¹⁴⁴ Nd ₆₀	1.896 kg 1.711 kg ≤ 1 pg 3.607 kg	13.55 M 12.06 M ≤ 1 pM 25.61 M	3.190 Bq 2.200 mBq 3.192 Bq	1.864 mBq 118.2 TBq 884.9 μBq	2β ¹⁴² Nd ₆₀ β ¹⁴⁴ Pr ₅₉ β ^{144m} Pr ₅₉	50.00 Py 285.0 d	1.417 MeV 111.8 keV	≤ 1 pW ≤ 1 pW ≤ 1 pW	≤ 1 pW 2.117 W ≤ 1 pW	11.44 pSv 11.44 pSv	614.4 kSv ≤ 1 pSv
¹⁴¹ Pr ¹⁴⁴ Pr ^{144m} Pr E ₅₉ Pr	¹⁴⁴ Ce ₅₈ ¹⁴⁴ Ce ₅₈	1.689 kg ≤ 1 pg ≤ 1 pg 1.689 kg	11.99 M ≤ 1 pM ≤ 1 pM 11.99 M	2.200 mBq 26.39 μBq 2.226 mBq	2.798 EBq 6.715 EBq 1.318 μBq	β ¹⁴⁴ Nd ₆₀ γ ¹⁴⁴ Pr ₅₉ β ¹⁴⁴ Nd ₆₀	17.28 m 6.900 m	1.239 MeV 57.71 keV	≤ 1 pW ≤ 1 pW ≤ 1 pW	555.5 kW 62.09 kW ≤ 1 pW	≤ 1 pSv ≤ 1 pSv ≤ 1 pSv	139.9 MSv ≤ 1 pSv
⁶ Li ⁷ Li E ₃ Li		241.9 μg 15.49 μg 257.4 μg	40.22 μM 2.208 μM 42.42 μM									

‡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
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 μM 108.5 μM 139.8 μM									
⁶⁹ Ga ⁷¹ Ga E ₃₁ Ga		5.671 μg 2.257 μg 7.928 μg	82.28 nM 31.82 nM 114.1 nM									
⁷⁰ Ge ⁷² Ge ⁷³ Ge ⁷⁴ Ge ⁷⁶ Ge E ₃₂ Ge		33.14 ng 33.04 mg 66.60 mg 147.3 mg 748.2 mg 995.1 mg	473.9 pM 459.4 μM 913.3 μM 1.993 mM 9.855 mM 13.22 mM									
E ₃₂ Ge				82.50 nBq 82.50 nBq	110.3 nBq 82.91 nBq	2β ⁷⁶ Se	≥ 10 ²¹ y	2.039 MeV	≤ 1 pW ≤ 1 pW	≤ 1 pW ≤ 1 pW		
E ₃₃ As		298.2 mg	3.980 mM									
⁷⁹ Br ⁸¹ Br E ₃₅ Br	⁷⁹ Se ⁸¹ Kr ⁸¹ Kr	4.918 mg 31.96 gm 31.96 gm	62.32 μM 395.0 mM 395.0 mM									
⁸⁰ Kr ⁸¹ Kr ⁸² Kr ⁸³ Kr ⁸⁴ Kr ⁸⁵ Kr ⁸⁶ Kr G ₃₆ Kr	⁸² Se ⁸⁴ Se	358.8 μg 42.35 μg 2.022 gm 57.85 gm 172.8 gm 1.357 gm 282.3 gm 516.3 gm	4.490 μM 523.4 nM 24.68 mM 697.7 mM 2.059 M 15.98 mM 3.286 M 6.084 M		32.98 kBq 778.7 MBq	ε ⁸¹ Br	210.0 ky	20.80 keV	109.9 pW	2.595 μW		
				19.71 TBq	14.52 TBq	β ⁸⁵ Rb	10.75 y	252.7 keV	797.8 mW	587.9 mW		
				19.71 TBq	38.17 GBq				797.8 mW	1.545 mW		
⁹⁵ Mo ⁹⁶ Mo ⁹⁷ Mo ⁹⁸ Mo ¹⁰⁰ Mo A ₄₂ Mo	⁹⁶ Zr ⁹⁶ Zr	1.116 kg 80.49 gm 1.202 kg 1.238 kg 1.423 kg 5.059 kg	11.76 M 839.3 mM 12.40 M 12.64 M 14.24 M 51.89 M									
				1.673 kBq 19.03 mBq 1.673 kBq	1.351 Bq 13.37 μBq 330.6 mBq	2β ⁹⁸ Ru 2β ¹⁰⁰ Ru	100.0 Ty 9.900 Ey	112.0 keV 3.034 MeV	30.01 pW ≤ 1 pW 30.02 pW	≤ 1 pW ≤ 1 pW ≤ 1 pW		
¹²⁸ Xe ¹²⁹ Xe ¹³⁰ Xe ¹³¹ Xe	¹²⁸ Te ¹²⁹ I ¹³⁰ Te ¹³¹ Te	7.057 gm 52.88 mg 23.11 gm 566.1 gm	55.17 mM 410.2 μM 177.9 mM 4.325 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
¹³² Xe ¹³⁴ Xe ¹³⁶ Xe G ₅₄ Xe	¹³⁴ Cs	1.753 kg 2.246 kg 3.429 kg 8.024 kg	13.29 M 16.77 M 25.23 M 59.85 M	20.17 Bq 1.589 mBq 20.17 Bq	8.980 mBq 463.5 nBq 2.514 mBq	2β ¹³⁴ Ba 2β ¹³⁶ Ba	11.00 Py 210.0 Ey	830.0 keV 2.467 MeV	2.682 pW ≤ 1 pW 2.683 pW	≤ 1 pW ≤ 1 pW ≤ 1 pW		
¹³² Ba ¹³⁴ Ba ¹³⁵ Ba ¹³⁶ Ba ¹³⁷ Ba ^{137m} Ba ¹³⁸ Ba E ₅₆ Ba	¹³⁴ Xe ¹³⁵ Cs ¹³⁶ Xe ¹³⁷ Cs ¹³⁷ Cs ¹³⁸ La	3.142 mg 342.5 gm 1.057 gm 42.80 gm 1.320 kg 87.20 μg 1.944 kg 3.650 kg	23.82 μM 2.558 M 7.835 mM 314.9 mM 9.642 M 636.9 nM 14.10 M 26.62 M	1.737 PBq 1.737 PBq	19.92 EBq 475.8 GBq	γ ¹³⁷ Ba	2.552 m	661.9 keV	184.2 W 184.2 W	2.112 MW 50.46 mW		
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	83.17 Bq 18.65 mBq 1.150 mBq 83.19 Bq	40.14 mBq 33.12 μBq 4.201 μBq 13.54 mBq	α ¹⁴⁰ Ce 2β ¹⁴⁸ Sm 2β ¹⁵⁰ Sm	2.290 Py 2.700 Ey 21.00 Ey	1.905 MeV 1.929 MeV 3.368 MeV	25.38 pW ≤ 1 pW ≤ 1 pW 25.39 pW	≤ 1 pW ≤ 1 pW ≤ 1 pW ≤ 1 pW		
E ¹⁵⁹ Tb ₆₅ Tb		4.337 gm	27.29 mM									
¹⁶⁰ Dy ¹⁶¹ Dy ¹⁶² Dy ¹⁶³ Dy ¹⁶⁴ Dy E ₆₆ Dy	¹⁶⁰ Gd ₆₄ 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 ₆₇ Ho	88.64 mg 5.663 mg 11.31 mg 59.35 ng 105.6 mg	534.2 μM 33.92 μM 67.35 μM 349.3 pM 635.5 μM									
¹⁷⁰ Yb ¹⁷¹ Yb ¹⁷² Yb E ₇₀ Yb	¹⁷¹ Tm ₆₉ Tm	39.44 μg 3.426 μg 143.9 ng 43.01 μg	232.1 nM 20.04 nM 836.9 pM 253.0 nM									

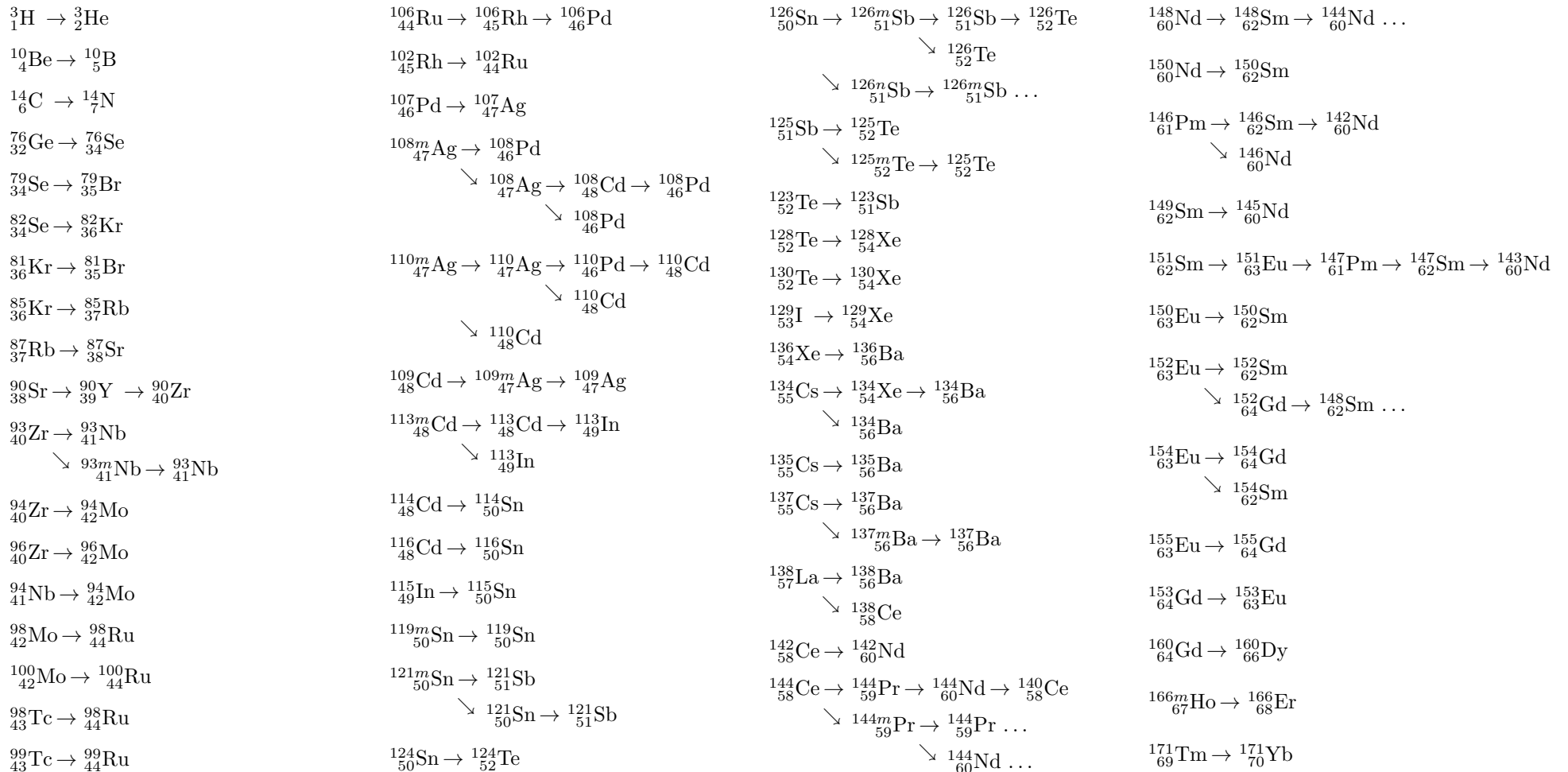
‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas; †Radiotoxicity of daughters is included in parents.

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
Total		52.18 kg	443.5 M	6.022 PBq	115.4 GBq				460.1 W	8.818 mW	57.47 MSv	1.101 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 fifty 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	5.542 ng	23.48 pM	109.0 kBq	19.67 TBq	α ²³² ₉₂ U	2.858 y	5.870 MeV	102.5 nW	18.50 W	9.483 mSv	1.711 MSv
²³⁸ Pu	²³⁸ ₉₃ Np	219.1 gm	920.4 mM	138.9 TBq	634.0 GBq	α ²³⁴ ₉₂ U	87.70 y	5.590 MeV	124.4 W	567.8 mW	31.95 MSv	145.8 kSv
²³⁹ Pu	²³⁹ ₉₃ Np	6.177 kg	25.84 M	14.22 TBq	2.302 GBq	α ^{235m} ₉₂ U	24.11 ky	5.197 MeV	11.84 W	1.917 mW	3.555 MSv	575.5 Sv
					0.06% →	α ²³⁵ ₉₂ U						
²⁴⁰ Pu	^{240m} ₉₃ Np	2.989 kg	12.45 M	25.21 TBq	8.434 GBq	α ²³⁶ ₉₂ U	6.563 ky	5.252 MeV	21.21 W	7.096 mW	6.302 MSv	2.109 kSv
²⁴¹ Pu	²⁴⁵ ₉₆ Cm	161.6 gm	670.4 mM	616.6 TBq	3.816 TBq	β ²⁴¹ ₉₅ Am	14.33 y	5.229 keV	516.5 mW	3.196 mW	2.960 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	4.981 MeV	98.56 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	3.604 mBq	1.811 PBq	β ^{246m} ₉₅ Am	10.85 d	142.0 keV	≤ 1 pW	41.19 W	11.89 pSv	5.976 MSv
C ⁹⁴ Pu		10.42 kg	43.49 M	795.1 TBq	76.30 GBq				158.1 W	15.17 mW	44.79 MSv	4.299 kSv
²⁴¹ Am	²⁴¹ Pu	1.601 kg	6.642 M	203.4 TBq	127.0 GBq	α ²³⁷ ₉₃ Np	432.8 y	5.604 MeV	182.6 W	114.1 mW	40.68 MSv	25.41 kSv
²⁴² Am	^{242m} ₉₅ Am	7.560 μ g	31.23 nM	226.3 GBq	29.93 PBq	β ²⁴² ₉₆ Cm	16.04 h	191.4 keV	6.940 mW	918.0 W	67.89 Sv	8.980 MSv
					16.8% →	ϵ ²⁴² ₉₄ Pu						
^{242m} Am		632.0 mg	2.611 mM	227.4 GBq	359.8 GBq	γ ²⁴² ₉₅ Am	141.0 y	66.62 keV	2.427 mW	3.840 mW	43.21 kSv	68.36 kSv
					0.463% →	α ²³⁸ ₉₃ Np						
²⁴³ Am	²⁴³ Pu	196.1 gm	806.8 mM	1.448 TBq	7.384 GBq	α ²³⁹ ₉₃ Np	7.365 ky	5.419 MeV	1.257 W	6.410 mW	289.6 kSv	1.477 kSv
²⁴⁵ Am	²⁴⁹ ₉₇ Bk	≤ 1 pg	≤ 1 pM	≤ 1 pBq	228.9 PBq	β ²⁴⁵ ₉₆ Cm	2.050 h	312.7 keV	≤ 1 pW	11.47 kW	≤ 1 pSv	14.19 MSv
²⁴⁶ Am		≤ 1 pg	≤ 1 pM	3.604 mBq	1.132 EBq	β ²⁴⁶ ₉₆ Cm	39.00 m	1.362 MeV	≤ 1 pW	246.9 kW	≤ 1 pSv	65.65 MSv
C ⁹⁵ Am		1.798 kg	7.451 M	205.3 TBq	114.2 GBq				183.9 W	102.3 mW	41.01 MSv	22.81 kSv
²⁴² Cm	²⁴² ₉₅ Am	1.529 mg	6.317 μ M	187.1 GBq	122.4 TBq	α ²³⁸ ₉₄ Pu	162.9 d	6.215 MeV	186.3 mW	121.8 W	2.245 kSv	1.468 MSv
²⁴³ Cm		221.4 mg	910.9 μ M	423.0 GBq	1.911 TBq	α ²³⁹ ₉₄ Pu	30.00 y	6.190 MeV	419.5 mW	1.895 W	63.45 kSv	286.6 kSv
					0.24% →	ϵ ²⁴³ ₉₅ Am						
²⁴⁴ Cm		12.53 gm	51.34 mM	37.57 TBq	2.998 TBq	α ²⁴⁰ ₉₄ Pu	18.00 y	5.896 MeV	35.49 W	2.832 W	4.508 MSv	359.8 kSv
²⁴⁵ Cm	²⁴⁵ ₉₅ Am	5.597 gm	22.84 mM	35.58 GBq	6.357 GBq	α ²⁴¹ ₉₄ Pu	8.500 ky	5.596 MeV	31.90 mW	5.699 mW	7.472 kSv	1.335 kSv
²⁴⁶ Cm	²⁴⁶ ₉₅ Am	712.4 mg	2.895 mM	8.101 GBq	11.37 GBq	α ²⁴² ₉₄ Pu	4.730 ky	5.522 MeV	7.167 mW	10.06 mW	1.701 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		4.738 pg	≤ 1 pM	14.42 mBq	3.043 GBq	SF	8.000 ky	123.2 MeV	≤ 1 pW	60.09 mW	63.45 nSv	13.39 kSv
					3% →	α ²⁴⁶ ₉₄ Pu						
C ⁹⁶ Cm		19.07 gm	78.03 mM	38.22 TBq	2.004 TBq				36.13 W	1.895 W	4.583 MSv	240.3 kSv
²³² U	²³⁶ ₉₄ Pu	273.7 μ g	1.180 μ M	216.9 MBq	792.5 GBq	α ²²⁸ ₉₀ Th	69.80 y	5.416 MeV	188.2 μ W	687.6 mW	71.58 Sv	261.5 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
²³³ U	²³³ ₉₁ Pa	12.89 mg	55.31 μM	4.619 MBq	358.3 MBq	α ²²⁹ ₉₀ Th	159.3 ky	4.904 MeV	3.629 μW	281.5 μW	235.6 mSv	18.28 Sv
²³⁴ U	²³⁴ ₉₁ Pa	273.1 gm	1.167 M	63.18 GBq	231.3 MBq	α ²³⁰ ₉₀ Th	245.7 ky	4.858 MeV	49.17 mW	180.0 μW	3.096 kSv	11.34 Sv
²³⁵ U	²³⁹ ₉₄ Pu	7.425 kg	31.59 M	594.4 MBq	80.05 kBq	α ²³¹ ₉₀ Th	703.8 My	4.416 MeV	420.5 μW	56.63 nW	27.94 Sv	3.763 mSv
²³⁶ U	²³⁶ ₉₃ Np	5.538 kg	23.46 M	13.27 GBq	2.396 MBq	α ²³² ₉₀ Th	23.70 My	4.567 MeV	9.710 mW	1.753 μW	623.7 Sv	112.6 mSv
²³⁷ U	²⁴¹ ₉₄ Pu	5.005 μg	21.11 nM	15.13 GBq	3.023 PBq	β ²³⁷ ₉₃ Np	6.750 d	319.0 keV	773.3 μW	154.5 W	11.50 Sv	2.297 MSv
²³⁸ U	²⁴² ₉₄ Pu	921.7 kg	3.872 kM	11.47 GBq	12.44 kBq	α ²³⁴ ₉₀ Th	4.468 Gy	4.279 MeV	7.863 mW	8.531 nW	516.2 Sv	560.0 μSv
²⁴⁰ U	²⁴⁴ ₉₄ Pu	≤ 1 pg	≤ 1 pM	20.34 kBq	34.28 PBq	β ²⁴⁰ ₉₃ Np	14.10 h	138.4 keV	450.9 pW	760.0 W	22.37 μSv	37.71 MSv
C ⁹² U		934.9 kg	3.928 kM	103.9 GBq	111.1 kBq				68.13 mW	72.87 nW	4.347 kSv	4.649 mSv
²³⁶ Np		2.482 mg	10.51 μM	1.211 MBq	487.9 MBq	ε ²³⁶ ₉₂ U	152.0 ky	340.1 keV	65.98 nW	26.58 μW	20.59 mSv	8.295 Sv
²³⁷ Np	²³⁷ ₉₂ U	737.7 gm	3.112 M	19.26 GBq	26.11 MBq	β ²³⁶ ₉₄ Pu						
²³⁸ Np	^{242m} ₉₅ Am	118.5 ng	497.8 pM	1.137 GBq	9.595 PBq	α ²³³ ₉₁ Pa	2.140 My	5.153 MeV	15.90 mW	21.55 μW	2.119 kSv	2.872 Sv
²³⁹ Np	²⁴³ ₉₅ Am	168.6 μg	705.3 nM	1.448 TBq	8.588 PBq	β ²³⁸ ₉₄ Pu	2.117 d	808.1 keV	147.2 μW	1.242 kW	1.035 Sv	8.731 MSv
^{240m} Np		≤ 1 pg	≤ 1 pM	20.34 kBq	3.919 EBq	β ²³⁹ ₉₄ Pu	2.355 d	407.6 keV	94.55 mW	560.8 W	1.158 kSv	6.871 MSv
C ⁹³ Np		737.7 gm	3.112 M	1.468 TBq	1.991 GBq	β ²⁴⁰ ₉₄ Pu	7.400 m	977.4 keV	3.185 nW	613.7 kW	3.278 kSv	4.444 Sv
²²⁷ Th	²²⁷ ₈₉ Ac	872.7 pg	3.844 pM	993.3 kBq	1.138 PBq	α ²²³ ₈₈ Ra	18.72 d	6.155 MeV	979.4 nW	1.122 kW	8.741 mSv	10.02 MSv
²²⁸ Th	²²⁸ ₈₉ Ac	7.343 μg	32.20 nM	222.8 MBq	30.34 TBq	α ²²⁴ ₈₈ Ra	1.913 y	5.516 MeV	196.9 μW	26.81 W	16.04 Sv	2.185 MSv
²²⁹ Th	²³³ ₉₂ U	2.438 μg	10.64 nM	19.20 kBq	7.875 GBq	α ²²⁵ ₈₈ Ra	7.340 ky	5.159 MeV	15.87 nW	6.509 mW	9.408 mSv	3.859 kSv
²³⁰ Th	²³⁴ ₉₂ U	32.88 mg	142.9 μM	24.57 MBq	747.3 MBq	α ²²⁶ ₈₈ Ra	75.40 ky	4.774 MeV	18.79 μW	571.5 μW	5.160 Sv	156.9 Sv
²³¹ Th	²³⁵ ₉₂ U	30.19 ng	130.7 pM	594.4 MBq	19.69 PBq	β ²³¹ ₉₁ Pa	1.063 d	94.61 keV	9.009 μW	298.4 W	202.1 mSv	6.694 MSv
²³² Th	²³⁶ ₉₂ U	8.420 mg	36.29 μM	34.19 Bq	4.061 kBq	α ²²⁸ ₈₈ Ra	14.05 Gy	4.082 MeV	22.36 pW	2.656 nW	7.864 μSv	933.9 μSv
²³⁴ Th	²³⁸ ₉₂ U	13.38 μg	57.17 nM	11.47 GBq	857.2 TBq	β ^{234m} ₉₁ Pa	24.09 d	68.41 keV	125.7 μW	9.395 W	39.00 Sv	2.915 MSv
C ⁹⁰ Th		41.32 mg	179.3 μM	12.31 GBq	298.0 GBq				351.4 μW	8.504 mW	60.42 Sv	1.462 kSv
²³¹ Pa	²³¹ ₉₀ Th	851.6 μg	3.686 μM	1.489 MBq	1.748 GBq	α ²²⁷ ₈₉ Ac	32.76 ky	5.085 MeV	1.213 μW	1.424 mW	1.057 Sv	1.241 kSv
²³³ Pa	²³⁷ ₉₃ Np	25.06 μg	107.5 nM	19.26 GBq	768.6 TBq	β ²³³ ₉₂ U	27.00 d	382.8 keV	1.181 mW	47.13 W	16.76 Sv	668.6 kSv
²³⁴ Pa	^{234m} ₉₁ Pa	201.5 pg	≤ 1 pM	14.92 MBq	74.04 PBq	β ²³⁴ ₉₂ U	6.780 h	2.421 MeV	5.788 μW	28.72 kW	7.609 mSv	37.76 MSv
^{234m} Pa	²³⁴ ₉₀ Th	451.2 pg	1.928 pM	11.47 GBq	25.42 EBq	β ²³⁴ ₉₂ U	1.170 m	833.7 keV	1.532 mW	3.395 MW		
C ⁹¹ Pa		876.7 μg	3.794 μM	30.75 GBq	35.07 TBq	γ ²³⁴ ₉₁ Pa			2.720 mW	3.103 W	17.82 Sv	20.33 kSv
²²³ Ra	²²³ ₈₇ Fr	531.1 pg	2.381 pM	1.007 MBq	1.896 PBq	α ²¹⁹ ₈₆ Rn	11.43 d	6.006 MeV	968.9 nW	1.824 kW	100.7 mSv	189.6 MSv
²²⁴ Ra	²²⁸ ₈₇ Th	37.79 ng	168.7 pM	222.8 MBq	5.896 PBq	α ²²⁰ ₈₆ Rn	3.640 d	5.791 MeV	206.7 μW	5.470 kW	14.48 Sv	383.2 MSv
²²⁵ Ra	²²⁹ ₉₀ Th	13.23 pg	≤ 1 pM	19.20 kBq	1.451 PBq	β ²²⁵ ₈₉ Ac	14.80 d	118.3 keV	363.8 pW	27.50 W	1.901 mSv	143.7 MSv
²²⁶ Ra	²³⁰ ₉₀ Th	7.079 μg	31.32 nM	259.1 kBq	36.60 GBq	α ²²² ₈₆ Rn	1.600 ky	4.871 MeV	202.2 nW	28.56 mW	72.55 mSv	10.25 kSv
²²⁸ Ra	²³² ₉₀ Th	3.220 pg	≤ 1 pM	27.90 Bq	8.665 TBq	β ²²⁸ ₈₉ Ac	5.750 y	12.99 keV	≤ 1 pW	18.04 mW	19.25 μSv	5.979 MSv
E ⁸⁸ Ra		7.117 μg	31.49 nM	224.1 MBq	31.48 TBq				207.9 μW	29.21 W	14.66 Sv	2.059 MSv
²⁰⁶ Pb	²¹⁰ ₈₄ Po	14.27 ng	69.28 pM									
²⁰⁷ Pb	²⁰⁷ ₈₁ Tl	305.8 ng	1.477 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
²⁰⁸ Pb	²⁰⁸ Tl	148.8 μg	715.5 nM									
²⁰⁹ Pb	²⁰⁹ Tl	≤ 1 pg	≤ 1 pM	19.20 kBq	168.3 PBq	β ²⁰⁹ Bi	3.253 h	194.0 keV	596.6 pW	5.229 kW	1.094 μSv	9.592 MSv
²¹⁰ Pb		33.91 ng	161.5 pM	95.86 kBq	2.827 TBq	β ²¹⁰ Bi	22.16 y	39.07 keV	600.0 pW	17.69 mW	66.14 mSv	1.951 MSv
²¹¹ Pb	²¹⁵ Po	1.102 pg	≤ 1 pM	1.007 MBq	913.8 PBq	β ²¹¹ Bi	36.10 m	505.4 keV	81.54 nW	73.99 kW	181.3 μSv	164.5 MSv
²¹² Pb	²¹⁶ Po	4.332 ng	20.43 pM	222.8 MBq	51.43 PBq	β ²¹² Bi	10.64 h	321.1 keV	11.46 μW	2.645 kW	1.337 Sv	308.6 MSv
²¹⁴ Pb	²¹⁸ Po	≤ 1 pg	≤ 1 pM	259.1 kBq	1.214 EBq	β ²¹⁴ Bi	26.80 m	537.7 keV	22.32 nW	104.6 kW	36.27 μSv	170.0 MSv
A ⁸² Pb		149.2 μg	717.2 nM	224.2 MBq	1.503 TBq				11.57 μW	77.54 mW	1.403 Sv	9.407 kSv
²²⁵ Ac	²²⁵ Ra	8.935 pg	≤ 1 pM	19.20 kBq	2.149 PBq	α ²²¹ Fr	10.00 d	5.891 MeV	18.12 nW	2.028 kW	460.8 μSv	51.57 MSv
²²⁷ Ac	²³¹ Pa	375.9 ng	1.656 nM	1.007 MBq	2.679 TBq	β ²²⁷ Th	21.77 y	81.64 keV	13.17 nW	35.04 mW	1.108 Sv	2.947 MSv
²²⁸ Ac	²²⁸ Ra	≤ 1 pg	≤ 1 pM	27.90 Bq	83.01 PBq	α ²²³ Fr						
E ⁸⁹ Ac		375.9 ng	1.656 nM	1.026 MBq	2.730 TBq	β ²²⁸ Th	6.150 h	1.457 MeV	6.514 pW	19.38 kW	12.00 nSv	35.69 MSv
									31.30 nW	83.26 mW	1.108 Sv	2.948 MSv
²⁴⁹ Cf	²⁴⁹ Bk	9.690 μg	38.90 nM	1.470 MBq	151.7 GBq	α ²⁴⁵ Cm	351.0 y	7.805 MeV	1.838 μW	189.7 mW	514.5 mSv	53.10 kSv
²⁵⁰ Cf	²⁵⁰ Bk	144.8 ng	579.0 pM	586.2 kBq	4.048 TBq	α ²⁴⁶ Cm	13.08 y	6.264 MeV	588.3 nW	4.063 W	93.79 mSv	647.7 kSv
²⁵¹ Cf		946.9 ng	3.771 nM	55.59 kBq	58.71 GBq	α ²⁴⁷ Cm	898.0 y	6.026 MeV	53.67 nW	56.68 mW	20.01 mSv	21.13 kSv
²⁵² Cf		1.303 pg	≤ 1 pM	25.95 Bq	19.92 TBq	α ²⁴⁸ Cm	2.645 y	12.04 MeV	50.04 pW	38.40 W	2.335 μSv	1.792 MSv
C ⁹⁸ Cf		10.78 μg	43.25 nM	2.112 MBq	195.9 GBq				2.480 μW	230.0 mW	628.3 mSv	58.28 kSv
²¹⁰ Po	²¹⁰ Bi	576.4 pg	2.745 pM	95.86 kBq	166.3 TBq	α ²⁰⁶ Pb	138.4 d	5.407 MeV	83.03 nW	144.0 W	115.0 mSv	199.6 MSv
²¹¹ Po	²¹¹ Bi	≤ 1 pg	≤ 1 pM	2.820 kBq	3.536×10 ¹²	α ²⁰⁷ Pb	516.0 ms	7.590 MeV	3.429 nW	4.299 GW		
²¹⁵ Po	²¹⁹ Rn	≤ 1 pg	≤ 1 pM	1.007 MBq	1.091×10 ¹⁵	α ²¹¹ Pb	1.780 ms	7.531 MeV	1.215 μW	1.317×10 ¹²		
²¹⁶ Po	²²⁰ Rn	≤ 1 pg	≤ 1 pM	222.8 MBq	1.289×10 ¹³	α ²¹² Pb	150.0 ms	6.906 MeV	246.5 μW	14.26 GW		
²¹⁸ Po	²²² Rn	≤ 1 pg	≤ 1 pM	259.1 kBq	10.47 EBq	α ²¹⁴ Pb	3.098 m	6.112 MeV	253.7 nW	10.25 MW		
A ⁸⁴ Po		576.4 pg	2.745 pM	224.2 MBq	388.9 PBq				248.1 μW	430.3 kW	115.0 mSv	199.6 MSv
²⁰⁸ Bi		≤ 1 pg	≤ 1 pM	119.3 nBq	172.9 MBq	ε ²⁰⁸ Pb	368.0 ky	2.653 MeV	≤ 1 pW	73.50 μW		
²⁰⁹ Bi	²⁰⁹ Pb	6.495 ng	31.08 pM	≤ 1 pBq	3.331 μBq	α ²⁰⁵ Tl	19.00 Ey	3.137 MeV	≤ 1 pW	≤ 1 pW		
²¹⁰ Bi	²¹⁰ Pb	20.87 pg	≤ 1 pM	95.86 kBq	4.593 PBq	β ²¹⁰ Po	5.012 d	388.9 keV	5.973 nW	286.2 W	124.6 μSv	5.971 MSv
^{210m} Bi		≤ 1 pg	≤ 1 pM	90.34 nBq	21.01 MBq	α ²⁰⁶ Tl	3.000 My	5.294 MeV	≤ 1 pW	17.82 μW	≤ 1 pSv	315.1 mSv
²¹¹ Bi	²¹¹ Pb	≤ 1 pg	≤ 1 pM	1.007 MBq	15.49 EBq	α ²⁰⁷ Tl	2.170 m	6.725 MeV	1.085 μW	16.69 MW		
						β ²¹¹ Po						
²¹² Bi	²¹² Pb	410.9 pg	1.938 pM	222.8 MBq	542.2 PBq	β ²¹² Po	1.009 h	2.869 MeV	102.4 μW	249.2 kW	57.93 mSv	141.0 MSv
						β ²¹² Po						
						β α ²⁰⁸ Pb						
²¹³ Bi	²¹⁷ At	≤ 1 pg	≤ 1 pM	19.20 kBq	715.9 PBq	α ²⁰⁸ Tl						
						α ²⁰⁸ Tl						
						β ²¹³ Po	45.59 m	709.1 keV	2.181 nW	81.32 kW	3.840 μSv	143.2 MSv
						α ²⁰⁹ Tl						
²¹⁴ Bi	²¹⁴ Pb	≤ 1 pg	≤ 1 pM	259.1 kBq	1.635 EBq	β ²¹⁴ Po	19.90 m	2.161 MeV	89.71 nW	566.0 kW	28.50 μSv	179.8 MSv
A ⁸³ Bi		6.927 ng	33.12 pM	224.2 MBq	32.36 PBq				103.6 μW	14.95 kW	58.08 mSv	8.385 MSv
²²¹ Fr	²²⁵ Ac	≤ 1 pg	≤ 1 pM	19.20 kBq	6.564 EBq	α ²¹⁷ At	4.900 m	6.509 MeV	20.02 nW	6.844 MW		

‡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 ²²³ Fr ₈₇ Fr	²²⁷ Ac ₈₉ Ac	≤ 1 pg	≤ 1 pM	13.89 kBq	1.432 EBq	β ²²³ Ra ₈₈ Ra	21.80 m	438.0 keV	974.7 pW	100.5 kW	33.34 μ Sv	3.437 GSv
		≤ 1 pg	≤ 1 pM	33.09 kBq	2.621 EBq				20.99 nW	1.663 MW	33.34 μ Sv	2.640 GSv
C ²⁴⁹ Bk ₉₇ Bk	²⁵⁴ Es ₉₉ Es	≤ 1 pg	≤ 1 pM	3.681 nBq	60.67 TBq	β ²⁴⁹ Cf ₉₈ Cf α ²⁴⁵ Am ₉₅ Am β ²⁵⁰ Cf ₉₈ Cf	320.0 d 3.217 h	125.0 keV 1.172 MeV	≤ 1 pW	1.215 W	≤ 1 pSv	58.85 kSv
		≤ 1 pg	≤ 1 pM	2.018 mBq	144.0 PBq				≤ 1 pW	27.04 kW	≤ 1 pSv	20.17 MSv
C ²⁵⁴ Es ₉₉ Es		≤ 1 pg	≤ 1 pM	≤ 1 pBq	69.02 TBq	α ²⁵⁰ Bk ₉₇ Bk	275.7 d	6.621 MeV	≤ 1 pW	73.21 W	≤ 1 pSv	1.932 MSv
G ²⁵⁰ Sf ₀ Sf		110.9 μ g										
G ⁴ He ₂ He		6.185 gm	1.545 M									
A ²⁰⁷ Tl ₈₁ Tl	²¹¹ Bi ₈₃ Bi	≤ 1 pg	≤ 1 pM	1.004 MBq	7.051 EBq	β ²⁰⁷ Pb ₈₂ Pb β ²⁰⁸ Pb ₈₂ Pb β ²⁰⁹ Pb ₈₂ Pb	4.770 m 3.053 m 2.200 m	495.4 keV 3.970 MeV 2.801 MeV	79.68 nW	559.6 kW		
		7.344 pg	≤ 1 pM	80.05 MBq	10.90 EBq				50.91 μ W	6.932 MW		
		≤ 1 pg	≤ 1 pM	414.9 Bq	15.15 EBq				186.2 pW	6.798 MW		
		7.486 pg	≤ 1 pM	81.05 MBq	10.83 EBq				50.99 μ W	6.811 MW		
A ²¹⁷ At ₈₅ At	²²¹ Fr ₈₇ Fr	≤ 1 pg	≤ 1 pM	19.20 kBq	5.959 × 10 ¹³	α ²¹³ Bi ₈₃ Bi	32.30 ms	7.198 MeV	22.14 nW	68.72 GW		
G ²¹⁹ Rn ₈₆ Rn	²²³ Ra ₈₈ Ra	≤ 1 pg	≤ 1 pM	1.007 MBq	481.6 EBq	α ²¹⁵ Po ₈₄ Po α ²¹⁶ Po ₈₄ Po α ²¹⁸ Po ₈₄ Po	3.960 s 55.80 s 3.823 d	6.998 MeV 6.404 MeV 5.589 MeV	1.129 μ W	539.9 MW		
		6.526 pg	≤ 1 pM	222.8 MBq	34.14 EBq				228.6 μ W	35.03 MW		
		45.50 pg	≤ 1 pM	259.1 kBq	5.695 PBq				232.0 nW	5.099 kW		
		52.03 pg	≤ 1 pM	224.1 MBq	4.307 EBq				230.0 μ W	4.420 MW		
Total		947.9 kg	3.984 kM	1.040 PBq	1.097 GBq				378.2 W	399.0 μ W	4.615 MSv	4.869 Sv

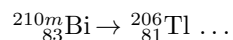
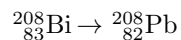
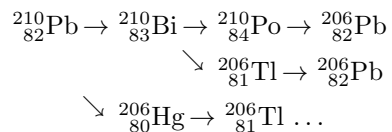
ICRP Publication 119 does not report dose factors for isotopes with half lives less than ten minutes or greater than 10⁹ years.

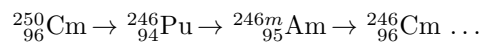
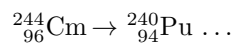
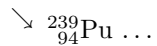
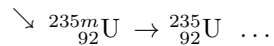
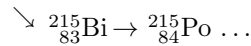
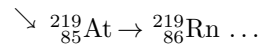
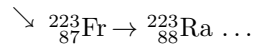
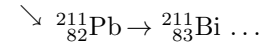
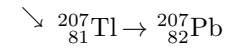
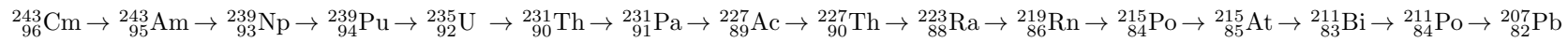
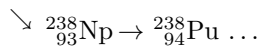
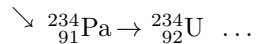
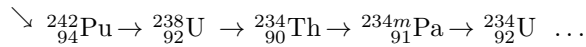
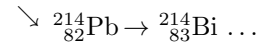
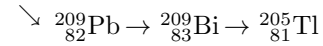
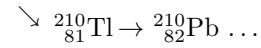
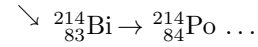
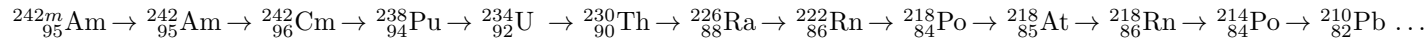
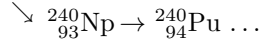
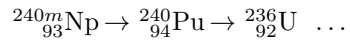
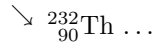
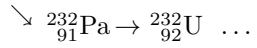
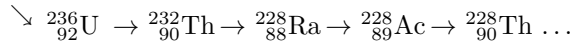
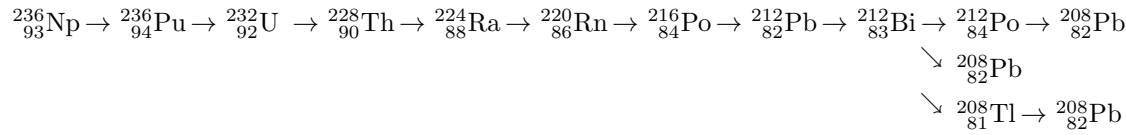
Total radiotoxicity is not the sum of the “Sv” column because ICRP Publication 119 includes radiotoxicity of daughter in radiotoxicity of parent.

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





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 fifty 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 ⁹¹ Zr ⁹² Zr ⁹³ Zr	⁹⁰ Y ₃₉	120.7 kg	1.343 kM									
		26.41 kg	290.5 M									
		41.10 kg	447.2 M									
		160.7 gm	1.730 M									
					14.95 GBq	93.03 MBq 2.5% →	β ^{93m} Nb ₄₁ β ⁹³ Nb ₄₁	1.530 My	19.59 keV	46.93 μ W	292.0 nW	16.44 Sv
⁹⁴ Zr ⁹⁶ Zr A ₄₀ Zr		42.60 kg 6.957 kg 237.9 kg	453.6 M 72.54 M 2.608 kM	1.000 kBq 24.60 mBq 14.95 GBq	23.48 mBq 3.536 μ Bq 62.83 kBq	2β ⁹⁴ Mo ₄₂ 2β ⁹⁶ Mo ₄₂	6.000 Py 39.00 Ey	1.144 MeV 3.350 MeV	183.2 pW ≤ 1 pW 46.93 μ W	≤ 1 pW ≤ 1 pW 197.2 pW	16.44 Sv	69.12 μ Sv
⁹³ Nb ^{93m} Nb ⁹⁴ Nb A ₄₁ Nb	⁹³ Zr ₄₀ ⁹³ Zr ₄₀	2.509 mg 1.260 mg 63.32 ng 3.769 mg	27.01 μ M 13.56 μ M 674.3 pM 40.57 μ M	13.19 GBq 439.3 Bq 13.19 GBq	10.47 TBq 6.938 GBq 3.500 TBq	γ ⁹³ Nb ₄₁ β ⁹⁴ Mo ₄₂	16.13 y 19.99 ky	29.87 keV 1.718 MeV	63.12 μ W 120.9 pW 63.12 μ W	50.10 mW 1.909 mW 16.75 mW	1.583 Sv 746.8 nSv 1.583 Sv	1.256 kSv 11.79 Sv 419.9 Sv
⁸⁷ Sr ⁸⁸ Sr ⁹⁰ Sr E ₃₈ Sr		3.321 mg 325.3 mg 10.39 μ g 328.6 mg	38.21 μ M 3.701 mM 115.6 nM 3.739 mM	52.48 MBq 52.48 MBq	5.051 TBq 159.7 MBq	β ⁹⁰ Y ₃₉	28.79 y	195.8 keV	1.646 μ W 1.646 μ W	158.4 mW 5.009 μ W	1.469 Sv 1.469 Sv	141.4 kSv 4.471 Sv
⁸⁹ Y ⁹⁰ Y E ₃₉ Y	⁹⁰ Sr ₃₈	24.79 mg 2.607 ng 24.79 mg	278.8 μ M 29.00 pM 278.8 μ M	52.52 MBq 52.52 MBq	20.15 PBq 2.119 GBq	β ⁹⁰ Zr ₄₀	2.671 d	934.6 keV	7.864 μ W 7.864 μ W	3.016 kW 317.2 μ W	141.8 mSv 141.8 mSv	54.39 MSv 5.720 Sv
⁹⁸ Tc ⁹⁹ Tc A ₄₃ Tc			4.887 ng 1.152 mg 1.152 mg	49.91 pM 11.65 μ M 11.65 μ M	157.2 mBq 722.8 kBq 722.8 kBq	32.17 MBq 627.4 MBq 627.4 MBq	β ⁹⁸ Ru ₄₄ β ⁹⁹ Ru ₄₄	4.200 My 214.0 ky	1.532 MeV 84.59 keV	≤ 1 pW 9.795 nW 9.795 nW	7.892 μ W 8.503 μ W 8.503 μ W	314.4 pSv 462.6 μ Sv 462.6 μ Sv
¹ H ² H ³ H G ₁ H		12.73 mg 10.72 μ g ≤ 1 pg 12.74 mg	12.63 mM 5.322 μ M ≤ 1 pM 12.64 mM	153.4 Bq 153.4 Bq	357.3 TBq 12.04 kBq	β ³ He ₂	12.33 y	5.680 keV	≤ 1 pW ≤ 1 pW	325.2 mW 10.96 pW	6.443 nSv 6.443 nSv	15.01 kSv 505.7 nSv
¹⁰² Rh ¹⁰³ Rh A ₄₅ Rh		≤ 1 pg 1.108 pg 1.108 pg	≤ 1 pM ≤ 1 pM ≤ 1 pM	158.4 pBq 158.4 pBq	44.75 TBq 143.0 Bq	ϵ ¹⁰² Ru ₄₄	2.902 y	2.152 MeV	≤ 1 pW ≤ 1 pW	15.43 W 49.29 pW	≤ 1 pSv ≤ 1 pSv	53.69 kSv 171.6 nSv
³ He ⁴ He	³ H ₁	6.745 pg 16.30 mg	2.236 pM 4.072 mM									

‡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 ₂ He		16.30 mg	4.072 mM										
⁹⁴ Mo	⁹⁴ Zr ⁴⁰	109.9 pg	1.170 pM										
⁹⁵ Mo		29.03 gm	305.9 mM										
⁹⁶ Mo		⁹⁶ Zr ⁴⁰	1.824 gm	19.02 mM									
⁹⁷ Mo			48.80 gm	503.6 mM									
⁹⁸ Mo			616.9 mg	6.301 mM	833.5 mBq	1.351 Bq	2β ⁹⁸ Ru ₄₄	100.0 Ty	112.0 keV	≤ 1 pW	≤ 1 pW		
¹⁰⁰ Mo			1.234 μg	12.35 nM	16.50 pBq	13.37 μBq	2β ¹⁰⁰ Ru ₄₄	9.900 Ey	3.034 MeV	≤ 1 pW	≤ 1 pW		
A ₄₂ Mo	80.27 gm	834.8 mM	833.5 mBq	10.38 mBq				≤ 1 pW	≤ 1 pW				
⁹⁸ Ru	⁹⁸ Mo ₄₂	≤ 1 pg	≤ 1 pM										
⁹⁹ Ru	⁹⁹ Tc ₄₃	190.5 ng	1.926 nM										
¹⁰⁰ Ru	¹⁰⁰ Mo ₄₂	99.42 μg	995.2 nM										
¹⁰¹ Ru		500.4 ng	4.959 nM										
¹⁰² Ru	¹⁰² Rh ₄₅	9.511 ng	93.33 pM										
¹⁰⁴ Ru		≤ 1 pg	≤ 1 pM										
A ₄₄ Ru		100.1 μg	1.002 μM										
¹⁰⁴ Pd		≤ 1 pg	≤ 1 pM										
¹⁰⁵ Pd		≤ 1 pg	≤ 1 pM										
¹⁰⁶ Pd		≤ 1 pg	≤ 1 pM										
A ₄₆ Pd		≤ 1 pg	≤ 1 pM										
Total		238.0 kg	2.609 kM	28.24 GBq	118.7 kBq				119.6 μW	502.5 pW	17.91 Sv	75.27 μSv	

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

