

## Fission Products Per Tonne of Fuel

used for 50.68 GW-day LWR burnup at power of 36.5 MW 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 ‡	Mass grams	Moles	Radioactivity			Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity	
			GBq	GBq/gm	†			Watts	Watts/gm	Sv	Sv/gm
<sup>86</sup> Sr	923.6 mg	10.75 mM									
<sup>87</sup> Sr	7.616 mg	87.63 μM									
<sup>88</sup> Sr	519.2 gm	5.906 M									
<sup>89</sup> Sr	≤ 1 pg	≤ 1 pM	4.803 μBq	1.076×10 <sup>6</sup>	β	50.57 d	583.0 keV	≤ 1 pW	100.5 W	≤ 1 pSv	2.797 MSv
<sup>90</sup> Sr	615.2 gm	6.843 M	3.106×10 <sup>6</sup>	5.049 TBq	β	28.79 y	195.8 keV	97.44 W	158.4 mW	86.97 MSv	141.4 kSv
E <sub>38</sub> Sr	1.135 kg	12.76 M	3.106×10 <sup>6</sup>	2.736 TBq				97.44 W	85.83 mW	86.97 MSv	76.60 kSv
<sup>133</sup> Cs	1.616 kg	12.16 M									
<sup>134</sup> Cs	8.139 gm	60.78 mM	390.0 TBq	47.92 TBq	ε	2.065 y	1.716 MeV	107.2 W	13.17 W	7.410 MSv	910.4 kSv
<sup>135</sup> Cs	619.6 gm	4.593 M	26.41 GBq	42.62 MBq	β	2.300 My	56.30 keV	238.2 μW	384.4 nW	52.82 Sv	85.25 mSv
<sup>137</sup> Cs	1.436 kg	10.49 M	4.625×10 <sup>6</sup>	3.221 TBq	β	30.04 y	186.7 keV	138.3 W	96.31 mW	60.13 MSv	41.87 kSv
E <sub>55</sub> Cs	3.680 kg	27.30 M	5.015×10 <sup>6</sup>	1.363 TBq				245.5 W	66.72 mW	67.54 MSv	18.35 kSv
<sup>89</sup> Y	676.0 gm	7.604 M									
<sup>90</sup> Y	154.3 mg	1.716 mM	3.107×10 <sup>6</sup>	2.014×10 <sup>7</sup>	β	2.671 d	935.0 keV	465.4 W	3.016 kW	8.389 MSv	54.37 MSv
<sup>91</sup> Y	≤ 1 pg	≤ 1 pM	6.161 mBq	907.6 TBq	β	58.51 d	606.1 keV	≤ 1 pW	88.13 W	14.79 pSv	2.178 MSv
E <sub>39</sub> Y	676.2 gm	7.605 M	3.107×10 <sup>6</sup>	4.595 TBq				465.4 W	688.3 mW	8.389 MSv	12.41 kSv
<sup>150</sup> Eu	375.0 ng	2.501 nM	919.1 kBq	2.451 TBq	ε	36.36 y	1.540 MeV	226.7 nW	604.5 mW	1.195 mSv	3.186 kSv
<sup>151</sup> Eu	1.710 gm	11.43 mM	88.93 μBq	52.00 μBq	α	≥ 10 <sup>18</sup> y	1.905 MeV	≤ 1 pW	≤ 1 pW		
<sup>152</sup> Eu	37.85 mg	249.1 μM	242.3 GBq	6.402 TBq	ε	13.52 y	1.276 MeV	49.53 mW	1.309 W	339.2 Sv	8.962 kSv
<sup>153</sup> Eu	195.8 gm	1.280 M									
<sup>154</sup> Eu	29.45 gm	191.3 mM	294.3 TBq	9.993 TBq	β	8.593 y	1.509 MeV	71.14 W	2.416 W	588.6 kSv	19.99 kSv
<sup>155</sup> Eu	6.383 gm	41.20 mM	109.9 TBq	17.22 TBq	β	4.753 y	122.7 keV	2.160 W	338.4 mW	35.17 kSv	5.510 kSv
E <sub>63</sub> Eu	233.4 gm	1.525 M	404.4 TBq	1.733 TBq				73.35 W	314.3 mW	624.1 kSv	2.674 kSv
<sup>99</sup> Ru	43.95 mg	444.4 μM									
<sup>100</sup> Ru	218.3 gm	2.185 M									
<sup>101</sup> Ru	1.166 kg	11.56 M									
<sup>102</sup> Ru	1.217 kg	11.94 M									
<sup>103</sup> Ru	≤ 1 pg	≤ 1 pM	6.353 pBq	1.194×10 <sup>6</sup>	β	39.26 d	564.5 keV	≤ 1 pW	108.0 W	≤ 1 pSv	871.9 kSv
<sup>104</sup> Ru	863.0 gm	8.306 M									
<sup>106</sup> Ru	231.6 mg	2.187 mM	28.69 TBq	123.9 TBq	β	1.020 y	10.03 keV	46.10 mW	199.1 mW	200.8 kSv	867.1 kSv
A <sub>44</sub> Ru	3.465 kg	33.99 M	28.69 TBq	8.281 GBq				46.10 mW	13.31 μW	200.8 kSv	57.97 Sv
<sup>146</sup> Pm	2.661 mg	18.24 μM	43.84 GBq	16.48 TBq	β	5.531 y	851.0 keV	5.977 mW	2.246 W	39.46 Sv	14.83 kSv
<sup>147</sup> Pm	11.02 gm	75.01 mM	378.1 TBq	34.31 TBq	β	2.623 y	60.54 keV	3.667 W	332.8 mW	98.31 kSv	8.921 kSv

†First emission from decay with highest branching ratio; ‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas

Isotope ‡	Mass grams	Moles	Radioactivity			Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity	
			GBq	GBq/gm	†			Watts	Watts/gm	Sv	Sv/gm
<sup>148</sup> Pm	≤ 1 pg	≤ 1 pM	≤ 1 pBq	6.083×10 <sup>6</sup>	β	5.368 d	1.299 MeV	≤ 1 pW	1.266 kW	≤ 1 pSv	16.42 MSv
<sup>148m</sup> Pm	≤ 1 pg	≤ 1 pM	2.955 pBq	790.7 TBq	β	41.05 d	2.140 MeV	≤ 1 pW	271.1 W	≤ 1 pSv	1.344 MSv
E <sub>61</sub> Pm	11.02 gm	75.03 mM	378.1 TBq	34.31 TBq				3.673 W	333.2 mW	98.35 kSv	8.922 kSv
<sup>121</sup> Sb	12.20 gm	100.9 mM									
<sup>123</sup> Sb	15.25 gm	124.1 mM									
<sup>124</sup> Sb	≤ 1 pg	≤ 1 pM	45.21 μBq	647.7 TBq	β	60.20 d	2.239 MeV	≤ 1 pW	232.4 W	≤ 1 pSv	1.619 MSv
<sup>125</sup> Sb	1.610 gm	12.89 mM	61.53 TBq	38.22 TBq	β	2.759 y	527.5 keV	5.200 W	3.230 W	67.68 kSv	42.04 kSv
<sup>126</sup> Sb	2.019 μg	16.04 nM	6.249 GBq	3.095×10 <sup>6</sup>	β	12.40 d	3.117 MeV	3.120 mW	1.545 kW	15.00 Sv	7.428 MSv
<sup>126m</sup> Sb	15.35 ng	121.9 pM	44.62 GBq	2.907×10 <sup>9</sup>	γ	19.10 m	2.149 MeV	15.36 mW	1.001 MW	1.606 Sv	104.6 MSv
E <sub>51</sub> Sb	29.06 gm	237.9 mM	61.58 TBq	2.119 TBq				5.218 W	179.6 mW	67.70 kSv	2.330 kSv
<sup>108</sup> Cd	694.2 μg	6.434 μM	207.6 nBq	299.0 μBq	ε	410.0 Py	272.0 keV	≤ 1 pW	≤ 1 pW		
<sup>109</sup> Cd	4.558 ng	41.85 pM	435.5 kBq	95.55 TBq	ε	1.267 y	19.61 keV	1.368 nW	300.1 mW	871.0 μSv	191.1 kSv
<sup>110</sup> Cd	77.24 gm	702.8 mM									
<sup>111</sup> Cd	45.72 gm	412.3 mM									
<sup>112</sup> Cd	26.97 gm	241.0 mM									
<sup>113</sup> Cd	212.2 mg	1.879 mM	3.229 mBq	15.22 mBq	β	7.700 Py	93.30 keV	≤ 1 pW	≤ 1 pW	80.72 pSv	380.4 pSv
<sup>113m</sup> Cd	276.1 mg	2.445 mM	2.217 TBq	8.030 TBq	γ	14.10 y	283.8 keV	100.8 mW	365.1 mW	50.99 kSv	184.7 kSv
<sup>114</sup> Cd	34.99 gm	307.2 mM	6.772 mBq	193.5 μBq	2β	600.0 Py	536.0 keV	≤ 1 pW	≤ 1 pW		
<sup>115m</sup> Cd	≤ 1 pg	≤ 1 pM	16.49 pBq	942.8 TBq	β	44.60 d	629.1 keV	≤ 1 pW	95.03 W	≤ 1 pSv	3.111 MSv
<sup>116</sup> Cd	12.55 gm	108.3 mM	42.12 μBq	3.357 μBq	2β	≥ 10 <sup>18</sup> y	2.804 MeV	≤ 1 pW	≤ 1 pW		
A <sub>48</sub> Cd	198.0 gm	1.776 M	2.217 TBq	11.20 GBq				100.8 mW	509.2 μW	50.99 kSv	257.6 Sv
<sup>140</sup> Ce	1.896 kg	13.55 M									
<sup>141</sup> Ce	≤ 1 pg	≤ 1 pM	≤ 1 pBq	1.055×10 <sup>6</sup>	β	32.50 d	247.0 keV	≤ 1 pW	41.72 W	≤ 1 pSv	748.7 kSv
<sup>142</sup> Ce	1.711 kg	12.06 M	3.190 Bq	1.864 mBq	2β	50.00 Py	1.417 MeV	≤ 1 pW	≤ 1 pW		
<sup>144</sup> Ce	55.20 mg	383.6 μM	6.519 TBq	118.1 TBq	β	285.0 d	111.9 keV	116.9 mW	2.118 W	33.90 kSv	614.1 kSv
E <sub>58</sub> Ce	3.607 kg	25.61 M	6.519 TBq	1.807 GBq				116.9 mW	32.41 μW	33.90 kSv	9.398 Sv
<sup>122</sup> Te	1.243 gm	10.20 mM									
<sup>123</sup> Te	21.28 mg	173.1 μM	229.0 mBq	10.76 Bq	ε	92.00 Py	17.10 keV	≤ 1 pW	≤ 1 pW	1.008 nSv	47.35 nSv
<sup>123m</sup> Te	2.644 pg	≤ 1 pM	868.0 Bq	328.3 TBq	γ	119.5 d	245.7 keV	34.17 pW	12.92 W	1.215 μSv	459.6 kSv
<sup>124</sup> Te	963.7 mg	7.778 mM									
<sup>125</sup> Te	27.45 gm	219.8 mM									
<sup>125m</sup> Te	22.52 mg	180.3 μM	15.02 TBq	667.0 TBq	γ	57.40 d	141.8 keV	341.1 mW	15.15 W	13.07 kSv	580.3 kSv
<sup>126</sup> Te	1.322 gm	10.50 mM									
<sup>127</sup> Te	≤ 1 pg	≤ 1 pM	48.91 kBq	9.766×10 <sup>7</sup>	β	9.350 h	227.8 keV	1.785 nW	3.564 kW	8.315 μSv	16.60 MSv
<sup>127m</sup> Te	143.0 pg	1.127 pM	49.95 kBq	349.3 TBq	γ	109.0 d	90.72 keV	726.0 pW	5.077 W	114.9 μSv	803.4 kSv
<sup>128</sup> Te	170.8 gm	1.335 M	8.029 nBq	47.01 pBq	2β	≥ 10 <sup>18</sup> y	867.2 keV	≤ 1 pW	≤ 1 pW		
<sup>129m</sup> Te	≤ 1 pg	≤ 1 pM	≤ 1 pBq	1.115×10 <sup>6</sup>	β	33.60 d	295.8 keV	≤ 1 pW	52.85 W	≤ 1 pSv	3.345 MSv

‡First emission from decay with highest branching ratio; †Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas

Isotope ‡	Mass grams	Moles	Radioactivity			Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity	
			GBq	GBq/gm	†			Watts	Watts/gm	Sv	Sv/gm
<sup>130</sup> Te E <sub>52</sub> Te	547.3 gm 749.1 gm	4.213 M 5.797 M	70.54 nBq 15.02 TBq	128.9 pBq 20.05 GBq	2β	≥ 10 <sup>18</sup> y	2.528 MeV	≤ 1 pW 341.1 mW	≤ 1 pW 455.3 μW	13.07 kSv	17.44 Sv
<sup>146</sup> Sm <sup>147</sup> Sm <sup>148</sup> Sm <sup>149</sup> Sm <sup>150</sup> Sm <sup>151</sup> Sm <sup>152</sup> Sm <sup>154</sup> Sm E <sub>62</sub> Sm	12.68 mg 232.8 gm 309.5 gm 4.616 gm 478.3 gm 21.13 gm 178.3 gm 59.76 gm 1.284 kg	86.90 μM 1.585 M 2.092 M 31.00 mM 3.190 M 140.0 mM 1.174 M 388.2 mM 8.600 M	16.42 kBq 195.8 kBq 3.458 Bq 205.0 mBq 20.58 TBq 20.58 TBq	1.295 MBq 841.1 Bq 11.17 mBq 44.41 mBq 974.0 GBq 16.02 GBq	α α α α β	100.0 My 106.0 Gy 7.000 Py 2.000 Py 90.00 y	2.540 MeV 2.310 MeV 2.014 MeV 1.870 MeV 19.78 keV	6.681 nW 72.47 nW 1.116 pW ≤ 1 pW 65.21 mW 65.21 mW	526.9 nW 311.3 pW ≤ 1 pW ≤ 1 pW 3.086 mW 50.77 μW	886.7 μSv 9.594 mSv 2.017 kSv 2.017 kSv	69.93 mSv 41.21 μSv 95.45 Sv 1.570 Sv
G <sub>1</sub> <sup>3</sup> H	49.11 mg	16.28 mM	17.54 TBq	357.2 TBq	β	12.33 y	5.680 keV	15.96 mW	325.0 mW	736.7 Sv	15.00 kSv
<sup>98</sup> Tc <sup>99</sup> Tc A <sub>43</sub> Tc	10.77 mg 1.136 kg 1.136 kg	110.0 μM 11.49 M 11.49 M	346.4 kBq 712.6 GBq 712.6 GBq	32.16 MBq 627.3 MBq 627.3 MBq	β β	4.200 My 214.0 ky	1.532 MeV 84.62 keV	85.02 nW 9.660 mW 9.660 mW	7.894 μW 8.504 μW 8.504 μW	692.8 μSv 456.1 Sv 456.1 Sv	64.33 mSv 401.5 mSv 401.5 mSv
<sup>141</sup> Pr <sup>144</sup> Pr <sup>144m</sup> Pr E <sub>59</sub> Pr	1.689 kg 2.331 μg 11.65 ng 1.689 kg	11.99 M 16.20 nM 80.95 pM 11.99 M	6.519 TBq 78.22 GBq 6.597 TBq	2.797×10 <sup>9</sup> 6.714×10 <sup>9</sup> 3.906 GBq	β γ	17.28 m 6.900 m	1.240 MeV 57.72 keV	1.295 W 723.3 μW 1.296 W	555.6 kW 62.09 kW 767.2 μW	326.0 Sv 326.0 Sv	139.8 MSv 193.0 mSv
<sup>114</sup> Sn <sup>115</sup> Sn <sup>116</sup> Sn <sup>117</sup> Sn <sup>118</sup> Sn <sup>119</sup> Sn <sup>119m</sup> Sn <sup>120</sup> Sn <sup>121m</sup> Sn <sup>122</sup> Sn <sup>123</sup> Sn <sup>124</sup> Sn <sup>126</sup> Sn E <sub>50</sub> Sn	3.852 mg 490.4 mg 12.26 gm 12.64 gm 12.81 gm 12.76 gm 2.193 μg 12.99 gm 4.782 mg 14.26 gm 1.506 ng 19.24 gm 42.49 gm 139.9 gm	33.82 μM 4.268 mM 105.8 mM 108.1 mM 108.7 mM 107.3 mM 18.44 nM 108.3 mM 39.55 μM 117.0 mM 12.25 pM 155.3 mM 337.5 mM 1.152 M	363.6 MBq 10.46 GBq 55.44 GBq	165.8 TBq 2.187 TBq 396.2 MBq	γ β β 2β β	293.0 d 55.00 y 129.2 d 100.0 Py 230.0 ky	87.19 keV 338.2 keV 526.9 keV 2.287 MeV 210.4 keV	5.079 μW 566.7 μW 38.67 nW ≤ 1 pW 1.504 mW 2.076 mW	2.316 W 118.5 mW 25.68 W ≤ 1 pW 35.40 μW 14.83 μW	123.6 mSv 3.975 Sv 962.0 μSv 209.7 Sv 213.8 Sv	56.37 kSv 831.2 Sv 638.8 kSv 4.936 Sv 1.528 Sv
<sup>127</sup> I <sup>129</sup> I E <sub>53</sub> I	84.19 gm 273.4 gm 357.6 gm	663.4 mM 2.121 M 2.784 M	1.786 GBq 1.786 GBq	6.533 MBq 4.995 MBq	β	16.10 My	78.04 keV	22.33 μW 22.33 μW	81.68 nW 62.45 nW	196.5 Sv 196.5 Sv	718.6 mSv 549.4 mSv

‡First emission from decay with highest branching ratio; †Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas

Isotope ‡	Mass grams	Moles	Radioactivity			Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity	
			GBq	GBq/gm	†			Watts	Watts/gm	Sv	Sv/gm
<sup>90</sup> Zr	207.2 gm	2.305 M									
<sup>91</sup> Zr	876.9 gm	9.646 M									
<sup>92</sup> Zr	956.3 gm	10.41 M									
<sup>93</sup> Zr	1.073 kg	11.55 M	99.79 GBq	93.00 MBq	$\beta$	1.530 My	19.60 keV	313.3 $\mu$ W	292.0 nW	109.8 Sv	102.3 mSv
<sup>94</sup> Zr	1.125 kg	11.98 M	26.41 Bq	23.48 mBq	$2\beta$	6.000 Py	1.144 MeV	4.839 pW	$\leq 1$ pW		
<sup>95</sup> Zr	$\leq 1$ pg	$\leq 1$ pM	374.4 mBq	794.7 TBq	$\beta$	64.03 d	854.9 keV	$\leq 1$ pW	108.9 W	355.7 pSv	755.0 kSv
<sup>96</sup> Zr	1.211 kg	12.63 M	4.282 mBq	3.536 $\mu$ Bq	$2\beta$	$\geq 10^{18}$ y	3.350 MeV	$\leq 1$ pW	$\leq 1$ pW		
A <sub>40</sub> Zr	5.449 kg	58.51 M	99.79 GBq	18.31 MBq				313.3 $\mu$ W	57.49 nW	109.8 Sv	20.14 mSv
<sup>76</sup> Se	12.23 mg	161.1 $\mu$ M									
<sup>77</sup> Se	1.515 gm	19.70 mM									
<sup>78</sup> Se	3.687 gm	47.32 mM									
<sup>79</sup> Se	8.869 gm	112.4 mM	22.87 GBq	2.579 GBq	$\beta$	377.0 ky	42.00 keV	153.9 $\mu$ W	17.35 $\mu$ W	66.32 Sv	7.478 Sv
<sup>80</sup> Se	20.17 gm	252.4 mM									
<sup>82</sup> Se	50.43 gm	615.6 mM	67.30 $\mu$ Bq	1.334 $\mu$ Bq	$2\beta$	$\geq 10^{18}$ y	2.995 MeV	$\leq 1$ pW	$\leq 1$ pW		
E <sub>34</sub> Se	84.68 gm	1.048 M	22.87 GBq	270.1 MBq				153.9 $\mu$ W	1.817 $\mu$ W	66.32 Sv	783.2 mSv
<sup>107</sup> Ag	438.3 $\mu$ g	4.100 $\mu$ M									
<sup>108</sup> Ag	$\leq 1$ pg	$\leq 1$ pM	156.0 kBq	$2.719 \times 10^{10}$	$\beta$	2.400 m	628.2 keV	15.70 nW	2.737 MW		
<sup>108m</sup> Ag	1.817 $\mu$ g	16.84 nM	1.753 MBq	964.8 GBq	$\epsilon$	418.0 y	1.634 MeV	458.8 nW	252.5 mW	4.032 mSv	2.219 kSv
<sup>109</sup> Ag	115.4 gm	1.060 M									
<sup>109m</sup> Ag	$\leq 1$ pg	$\leq 1$ pM	435.5 kBq	$9.673 \times 10^{10}$	$\gamma$	39.70 s	86.99 keV	6.069 nW	1.348 MW		
<sup>110</sup> Ag	$\leq 1$ pg	$\leq 1$ pM	144.2 MBq	$1.543 \times 10^{11}$	$\epsilon$	24.56 s	1.212 MeV	28.01 $\mu$ W	29.97 MW		
<sup>110m</sup> Ag	61.68 $\mu$ g	561.2 nM	10.84 GBq	175.7 TBq	$\gamma$	249.8 d	2.818 MeV	4.894 mW	79.35 W	30.35 Sv	492.1 kSv
E <sub>47</sub> Ag	115.4 gm	1.060 M	10.99 GBq	95.20 MBq				4.922 mW	42.66 $\mu$ W	30.36 Sv	263.0 mSv
<sup>102</sup> Rh	141.1 $\mu$ g	1.385 $\mu$ M	6.312 GBq	44.73 TBq	$\epsilon$	2.902 y	2.152 MeV	2.176 mW	15.42 W	7.574 Sv	53.68 kSv
<sup>103</sup> Rh	611.3 gm	5.940 M									
<sup>103m</sup> Rh	$\leq 1$ pg	$\leq 1$ pM	5.728 pBq	$1.204 \times 10^9$	$\gamma$	56.11 m	38.83 keV	$\leq 1$ pW	7.490 kW	$\leq 1$ pSv	4.576 MSv
<sup>106</sup> Rh	217.7 ng	2.056 nM	28.69 TBq	$1.318 \times 10^{11}$	$\beta$	30.00 s	1.618 MeV	7.437 W	34.16 MW		
A <sub>45</sub> Rh	611.3 gm	5.940 M	28.70 TBq	46.94 GBq				7.439 W	12.17 mW	7.574 Sv	12.39 mSv
<sup>93</sup> Nb	1.725 mg	18.57 $\mu$ M									
<sup>93m</sup> Nb	4.153 mg	44.70 $\mu$ M	43.44 GBq	10.46 TBq	$\gamma$	16.13 y	29.90 keV	208.1 $\mu$ W	50.11 mW	5.213 Sv	1.255 kSv
<sup>94</sup> Nb	1.182 mg	12.59 $\mu$ M	8.195 MBq	6.933 GBq	$\beta$	19.99 ky	1.719 MeV	2.257 $\mu$ W	1.909 mW	13.93 mSv	11.79 Sv
<sup>95</sup> Nb	$\leq 1$ pg	$\leq 1$ pM	831.8 mBq	$1.448 \times 10^6$	$\beta$	34.99 d	809.0 keV	$\leq 1$ pW	187.6 W	482.4 pSv	839.6 kSv
<sup>95m</sup> Nb	$\leq 1$ pg	$\leq 1$ pM	2.779 mBq	$1.410 \times 10^7$	$\beta$	3.608 d	234.5 keV	$\leq 1$ pW	529.7 W	1.556 pSv	7.896 MSv
A <sub>41</sub> Nb	7.060 mg	75.85 $\mu$ M	43.45 GBq	6.154 TBq				210.4 $\mu$ W	29.80 mW	5.227 Sv	740.3 Sv
<sup>165</sup> Ho	285.7 mg	1.732 mM									
<sup>166m</sup> Ho	3.505 mg	21.12 $\mu$ M	232.8 MBq	66.42 GBq	$\beta$	1.200 ky	1.869 MeV	69.71 $\mu$ W	19.89 mW	465.6 mSv	132.8 Sv

†First emission from decay with highest branching ratio; ‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas

Isotope ‡	Mass grams	Moles	Radioactivity			Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity	
			GBq	GBq/gm	†			Watts	Watts/gm	Sv	Sv/gm
E ${}_{67}\text{Ho}$	289.2 mg	1.753 mM	232.8 MBq	805.0 MBq				69.71 $\mu\text{W}$	241.0 $\mu\text{W}$	465.6 mSv	1.610 Sv
${}^{104}\text{Pd}$	463.0 gm	4.456 M									
${}^{105}\text{Pd}$	609.7 gm	5.812 M									
${}^{106}\text{Pd}$	593.8 gm	5.607 M									
${}^{107}\text{Pd}$	361.2 gm	3.379 M	6.875 GBq	19.03 MBq	$\beta$	6.500 My	10.01 keV	11.02 $\mu\text{W}$	30.51 nW	254.4 mSv	704.2 $\mu\text{Sv}$
${}^{108}\text{Pd}$	248.7 gm	2.305 M									
${}^{110}\text{Pd}$	82.30 gm	748.8 mM	16.51 mBq	200.6 $\mu\text{Bq}$	$2\beta$	600.0 Py	2.000 MeV	$\leq 1$ pW	$\leq 1$ pW		
A ${}_{46}\text{Pd}$	2.359 kg	22.31 M	6.875 GBq	2.915 MBq				11.02 $\mu\text{W}$	4.672 nW	254.4 mSv	107.8 $\mu\text{Sv}$
${}^{152}\text{Gd}$	80.72 mg	531.3 $\mu\text{M}$	65.08 mBq	806.2 mBq	$\alpha$	108.0 Ty	2.197 MeV	$\leq 1$ pW	$\leq 1$ pW	2.668 nSv	33.06 nSv
${}^{153}\text{Gd}$	193.4 ng	1.265 nM	25.25 MBq	130.6 TBq	$\epsilon$	240.4 d	152.4 keV	616.4 nW	3.187 W	6.818 mSv	35.25 kSv
${}^{154}\text{Gd}$	42.53 gm	276.3 mM									
${}^{155}\text{Gd}$	19.66 gm	126.9 mM									
${}^{156}\text{Gd}$	125.8 gm	806.8 mM									
${}^{157}\text{Gd}$	196.7 mg	1.253 mM									
${}^{158}\text{Gd}$	33.19 gm	210.2 mM									
${}^{160}\text{Gd}$	2.102 gm	13.14 mM	1.337 mBq	636.2 $\mu\text{Bq}$	$2\beta$	130.0 Py	1.729 MeV	$\leq 1$ pW	$\leq 1$ pW		
E ${}_{64}\text{Gd}$	223.6 gm	1.435 M	25.25 MBq	112.9 kBq				616.4 nW	2.757 nW	6.818 mSv	30.50 $\mu\text{Sv}$
E ${}_{6}^{14}\text{C}$	40.17 $\mu\text{g}$	2.869 $\mu\text{M}$	6.627 MBq	165.0 GBq	$\beta$	5.700 ky	49.48 keV	52.53 nW	1.308 mW	3.844 mSv	95.68 Sv
${}^{85}\text{Rb}$	162.7 gm	1.916 M									
${}^{87}\text{Rb}$	361.8 gm	4.163 M	1.172 MBq	3.239 kBq	$\beta$	48.10 Gy	141.0 keV	26.47 nW	73.16 pW	1.758 mSv	4.859 $\mu\text{Sv}$
E ${}_{37}\text{Rb}$	524.5 gm	6.079 M	1.172 MBq	2.235 kBq				26.47 nW	50.47 pW	1.758 mSv	3.352 $\mu\text{Sv}$
${}^{169}\text{Tm}$	95.30 $\mu\text{g}$	564.1 nM									
${}^{170}\text{Tm}$	$\leq 1$ pg	$\leq 1$ pM	9.923 Bq	221.1 TBq	$\epsilon$	128.6 d	334.7 keV	$\leq 1$ pW	11.86 W	12.90 nSv	287.4 kSv
${}^{171}\text{Tm}$	49.01 ng	286.7 pM	1.975 MBq	40.30 TBq	$\beta$	1.917 y	26.16 keV	8.278 nW	168.9 mW	217.3 $\mu\text{Sv}$	4.433 kSv
E ${}_{69}\text{Tm}$	95.35 $\mu\text{g}$	564.4 nM	1.975 MBq	20.71 GBq				8.279 nW	86.82 $\mu\text{W}$	217.3 $\mu\text{Sv}$	2.279 Sv
${}^9\text{Be}$	29.79 $\mu\text{g}$	3.306 $\mu\text{M}$									
${}^{10}\text{Be}$	198.9 $\mu\text{g}$	19.86 $\mu\text{M}$	164.5 kBq	827.0 MBq	$\beta$	1.600 My	202.6 keV	5.338 nW	26.84 $\mu\text{W}$	180.9 $\mu\text{Sv}$	909.8 mSv
E ${}_{4}\text{Be}$	228.7 $\mu\text{g}$	23.17 $\mu\text{M}$	164.5 kBq	719.3 MBq				5.338 nW	23.34 $\mu\text{W}$	180.9 $\mu\text{Sv}$	791.2 mSv
${}^{113}\text{In}$	195.4 mg	1.731 mM									
${}^{114}\text{In}$	$\leq 1$ pg	$\leq 1$ pM	13.55 pBq	$5.096 \times 10^{10}$	$\beta$	1.198 m	803.4 keV	$\leq 1$ pW	6.559 MW		
${}^{114m}\text{In}$	$\leq 1$ pg	$\leq 1$ pM	14.16 pBq	856.6 TBq	$\epsilon$	50.00 d	239.3 keV	$\leq 1$ pW	32.84 W	$\leq 1$ pSv	3.512 MSv
${}^{115}\text{In}$	2.697 gm	23.47 mM	621.2 mBq	230.3 mBq	$\beta$	441.0 Ty	242.0 keV	$\leq 1$ pW	$\leq 1$ pW	19.88 nSv	7.371 nSv
E ${}_{49}\text{In}$	2.892 gm	25.20 mM	621.2 mBq	214.8 mBq				$\leq 1$ pW	$\leq 1$ pW	19.88 nSv	6.873 nSv
${}^{138}\text{La}$	7.637 mg	55.38 $\mu\text{M}$	5.424 Bq	710.2 Bq	$\epsilon$	102.0 Gy	1.237 MeV	1.075 pW	140.8 pW	5.966 nSv	781.2 nSv
${}^{139}\text{La}$	1.849 kg	13.31 M									
E ${}_{57}\text{La}$	1.849 kg	13.31 M	5.424 Bq	2.933 mBq				1.075 pW	$\leq 1$ pW	5.966 nSv	3.227 pSv

‡First emission from decay with highest branching ratio; †Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas

Isotope ‡	Mass grams	Moles	Radioactivity			Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity	
			GBq	GBq/gm	†			Watts	Watts/gm	Sv	Sv/gm
<sup>159</sup> Tb	4.337 gm	27.29 mM									
<sup>160</sup> Tb	≤ 1 pg	≤ 1 pM	41.74 mBq	418.0 TBq	β	72.30 d	1.373 MeV	≤ 1 pW	91.97 W	66.78 pSv	668.8 kSv
E <sub>65</sub> Tb	4.337 gm	27.29 mM	41.74 mBq	9.624 mBq				≤ 1 pW	≤ 1 pW	66.78 pSv	15.40 pSv
<sup>6</sup> Li	241.9 μg	40.22 μM									
<sup>7</sup> Li	15.49 μg	2.208 μM									
E <sub>3</sub> Li	257.4 μg	42.42 μM									
<sup>66</sup> Zn	53.48 ng	811.2 pM									
<sup>67</sup> Zn	2.226 ng	33.26 pM									
<sup>68</sup> Zn	2.128 mg	31.33 μM									
<sup>70</sup> Zn	7.588 mg	108.5 μM									
E <sub>30</sub> Zn	9.716 mg	139.8 μM									
<sup>69</sup> Ga	5.671 μg	82.28 nM									
<sup>71</sup> Ga	2.257 μg	31.82 nM									
E <sub>31</sub> Ga	7.928 μg	114.1 nM									
<sup>70</sup> Ge	33.14 ng	473.9 pM									
<sup>72</sup> Ge	33.04 mg	459.4 μM									
<sup>73</sup> Ge	66.60 mg	913.3 μM									
<sup>74</sup> Ge	147.3 mg	1.993 mM									
<sup>76</sup> Ge	748.2 mg	9.855 mM	82.50 nBq	110.3 nBq	2β	≥ 10 <sup>18</sup> y	2.039 MeV	≤ 1 pW	≤ 1 pW		
E <sub>32</sub> Ge	995.1 mg	13.22 mM	82.50 nBq	82.91 nBq				≤ 1 pW	≤ 1 pW		
E <sub>33</sub> As	298.2 mg	3.980 mM									
<sup>79</sup> Br	1.133 mg	14.36 μM									
<sup>81</sup> Br	31.96 gm	395.0 mM									
E <sub>35</sub> Br	31.96 gm	395.0 mM									
<sup>80</sup> Kr	358.8 μg	4.490 μM									
<sup>81</sup> Kr	42.36 μg	523.5 nM	32.97 kBq	778.3 MBq	ε	210.0 ky	20.81 keV	109.9 pW	2.594 μW		
<sup>82</sup> Kr	2.022 gm	24.68 mM									
<sup>83</sup> Kr	57.85 gm	697.7 mM									
<sup>84</sup> Kr	172.8 gm	2.059 M									
<sup>85</sup> Kr	18.02 gm	212.2 mM	261.7 TBq	14.52 TBq	β	10.75 y	252.8 keV	10.60 W	588.2 mW		
<sup>86</sup> Kr	282.3 gm	3.286 M									
G <sub>36</sub> Kr	533.0 gm	6.280 M	261.7 TBq	491.0 GBq				10.60 W	19.89 mW		
<sup>95</sup> Mo	1.116 kg	11.76 M									
<sup>96</sup> Mo	80.49 gm	839.3 mM									
<sup>97</sup> Mo	1.202 kg	12.40 M									
<sup>98</sup> Mo	1.238 kg	12.64 M	1.673 kBq	1.351 Bq	2β	100.0 Ty	112.0 keV	30.01 pW	≤ 1 pW		

‡First emission from decay with highest branching ratio; †Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas

Isotope ‡	Mass grams	Moles	Radioactivity			Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity	
			GBq	GBq/gm	†			Watts	Watts/gm	Sv	Sv/gm
<sup>100</sup> Mo A <sub>42</sub> Mo	1.423 kg 5.059 kg	14.24 M 51.89 M	19.03 mBq 1.673 kBq	13.37 μBq 330.6 mBq	2β	≥ 10 <sup>18</sup> y	3.034 MeV	≤ 1 pW 30.02 pW	≤ 1 pW ≤ 1 pW		
<sup>127</sup> Xe <sup>128</sup> Xe <sup>129</sup> Xe <sup>130</sup> Xe <sup>131</sup> Xe <sup>132</sup> Xe <sup>134</sup> Xe <sup>136</sup> Xe G <sub>54</sub> Xe	≤ 1 pg 7.057 gm 52.40 mg 23.11 gm 566.1 gm 1.753 kg 2.246 kg 3.429 kg 8.024 kg	≤ 1 pM 55.17 mM 406.5 μM 177.9 mM 4.325 M 13.29 M 16.77 M 25.23 M 59.85 M	≤ 1 pBq	1.045×10 <sup>6</sup>	ε	36.40 d	309.1 keV	≤ 1 pW	51.75 W		
<sup>132</sup> Ba <sup>134</sup> Ba <sup>135</sup> Ba <sup>136</sup> Ba <sup>137</sup> Ba <sup>137m</sup> Ba <sup>138</sup> Ba E <sub>56</sub> Ba	3.142 mg 334.3 gm 1.050 gm 42.80 gm 453.5 gm 219.7 μg 1.944 kg 2.776 kg	23.82 μM 2.497 M 7.783 mM 314.9 mM 3.312 M 1.605 μM 14.10 M 20.23 M									
<sup>142</sup> Nd <sup>143</sup> Nd <sup>144</sup> Nd <sup>145</sup> Nd <sup>146</sup> Nd <sup>148</sup> Nd <sup>150</sup> Nd E <sub>60</sub> Nd	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									
<sup>142</sup> Nd <sup>143</sup> Nd <sup>144</sup> Nd <sup>145</sup> Nd <sup>146</sup> Nd <sup>148</sup> Nd <sup>150</sup> Nd E <sub>60</sub> Nd	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	40.14 mBq	α	2.290 Py	1.905 MeV	25.38 pW	≤ 1 pW		
<sup>142</sup> Nd <sup>143</sup> Nd <sup>144</sup> Nd <sup>145</sup> Nd <sup>146</sup> Nd <sup>148</sup> Nd <sup>150</sup> Nd E <sub>60</sub> Nd	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	18.65 mBq	33.12 μBq	2β	≥ 10 <sup>18</sup> y	1.929 MeV	≤ 1 pW	≤ 1 pW		
<sup>142</sup> Nd <sup>143</sup> Nd <sup>144</sup> Nd <sup>145</sup> Nd <sup>146</sup> Nd <sup>148</sup> Nd <sup>150</sup> Nd E <sub>60</sub> Nd	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	1.150 mBq	4.201 μBq	2β	≥ 10 <sup>18</sup> y	3.368 MeV	≤ 1 pW	≤ 1 pW		
<sup>142</sup> Nd <sup>143</sup> Nd <sup>144</sup> Nd <sup>145</sup> Nd <sup>146</sup> Nd <sup>148</sup> Nd <sup>150</sup> Nd E <sub>60</sub> Nd	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	83.19 Bq	13.54 mBq				25.39 pW	≤ 1 pW		
<sup>160</sup> Dy <sup>161</sup> Dy <sup>162</sup> Dy <sup>163</sup> Dy <sup>164</sup> Dy E <sub>66</sub> Dy	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									
<sup>166</sup> Er <sup>167</sup> Er <sup>168</sup> Er <sup>170</sup> Er	88.56 mg 5.663 mg 11.31 mg 59.35 ng	533.7 μM 33.92 μM 67.35 μM 349.3 pM									

†First emission from decay with highest branching ratio; ‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas

Isotope ‡	Mass grams	Moles	Radioactivity			Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity	
			GBq	GBq/gm	†			Watts	Watts/gm	Sv	Sv/gm
E <sub>68</sub> Er	105.5 mg	635.0 μM									
<sup>170</sup> Yb	39.44 μg	232.1 nM									
<sup>171</sup> Yb	3.377 μg	19.76 nM									
<sup>172</sup> Yb	143.9 ng	836.9 pM									
E <sub>70</sub> Yb	42.96 μg	252.7 nM									
Total	52.18 kg	443.5 M	1.684×10 <sup>7</sup>	322.7 GBq				1.375 kW	26.35 mW	164.0 MSv	3.143 kSv
ICRP Publication 119 does not report dose factors for isotopes with half lives less than ten minutes or greater than 10 <sup>9</sup> years. Dose factors for gases are given as Sv/day per Bq/m <sup>3</sup> . Radiotoxicity is not computed for gases.											
†First emission from decay with highest branching ratio; ‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas											



## Actinides and Daughters Per Tonne of Fuel

used for 50.68 GW-day LWR burnup at power of 36.5 MW 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 ‡	Mass grams	Moles	Radioactivity			Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity	
			GBq	GBq/gm	†			Watts	Watts/gm	Sv	Sv/gm
<sup>236</sup> Pu	5.150 ng	21.82 pM	101.3 kBq	19.67 TBq	$\alpha$	2.858 y	5.870 MeV	95.27 nW	18.50 W	8.813 mSv	1.711 MSv
<sup>237</sup> Pu	$\leq 1$ pg	$\leq 1$ pM	$\leq 1$ pBq	447.2 TBq	$\epsilon$	45.30 d	62.20 keV	$\leq 1$ pW	4.457 W	$\leq 1$ pSv	44.72 kSv
<sup>238</sup> Pu	300.4 gm	1.262 M	190.4 TBq	633.8 GBq	$\alpha$	87.70 y	5.590 MeV	170.5 W	567.6 mW	43.79 MSv	145.8 kSv
<sup>239</sup> Pu	6.183 kg	25.86 M	14.23 TBq	2.301 GBq	$\alpha$	24.11 ky	5.198 MeV	11.85 W	1.917 mW	3.557 MSv	575.4 Sv
<sup>240</sup> Pu	2.957 kg	12.32 M	24.94 TBq	8.434 GBq	$\alpha$	6.563 ky	5.253 MeV	20.99 W	7.098 mW	6.235 MSv	2.109 kSv
<sup>241</sup> Pu	1.109 kg	4.601 M	$4.229 \times 10^6$	3.813 TBq	$\beta$	14.33 y	5.228 keV	3.542 W	3.194 mW	20.30 MSv	18.30 kSv
<sup>242</sup> Pu	873.8 gm	3.610 M	123.5 GBq	141.3 MBq	$\alpha$	373.5 ky	4.982 MeV	98.57 mW	112.8 $\mu$ W	29.64 kSv	33.92 Sv
<sup>243</sup> Pu	$\leq 1$ pg	$\leq 1$ pM	33.76 kBq	$9.635 \times 10^7$	$\beta$	4.956 h	194.7 keV	1.053 nW	3.005 kW	2.870 $\mu$ Sv	8.189 MSv
<sup>244</sup> Pu	31.02 mg	127.1 $\mu$ M	20.36 kBq	656.4 kBq	$\alpha$	80.00 My	4.893 MeV	15.96 nW	514.5 nW	4.886 mSv	157.5 mSv
<sup>246</sup> Pu	$\leq 1$ pg	$\leq 1$ pM	3.609 mBq	$1.811 \times 10^6$	$\beta$	10.85 d	142.0 keV	$\leq 1$ pW	41.19 W	11.91 pSv	5.976 MSv
C <sub>94</sub> Pu	11.42 kg	47.66 M	$4.459 \times 10^6$	390.3 GBq				207.0 W	18.12 mW	73.91 MSv	6.470 kSv
<sup>241</sup> Cm	$\leq 1$ pg	$\leq 1$ pM	$\leq 1$ pBq	557.1 TBq	$\epsilon$	32.80 d	693.3 keV	$\leq 1$ pW	61.88 W	$\leq 1$ pSv	507.0 kSv
<sup>242</sup> Cm	1.843 mg	7.614 $\mu$ M	225.6 GBq	122.4 TBq	$\alpha$	162.9 d	6.214 MeV	224.6 mW	121.9 W	2.707 kSv	1.469 MSv
<sup>243</sup> Cm	585.7 mg	2.410 mM	1.119 TBq	1.911 TBq	$\epsilon$	30.00 y	6.192 MeV	1.110 W	1.895 W	167.9 kSv	286.6 kSv
<sup>244</sup> Cm	57.94 gm	237.4 mM	173.5 TBq	2.994 TBq	$\alpha$	18.00 y	5.900 MeV	164.0 W	2.831 W	20.82 MSv	359.3 kSv
<sup>245</sup> Cm	5.615 gm	22.91 mM	35.69 GBq	6.356 GBq	$\alpha$	8.500 ky	5.598 MeV	32.01 mW	5.701 mW	7.495 kSv	1.335 kSv
<sup>246</sup> Cm	716.6 mg	2.912 mM	8.147 GBq	11.37 GBq	$\alpha$	4.730 ky	5.523 MeV	7.209 mW	10.06 mW	1.711 kSv	2.387 kSv
<sup>247</sup> Cm	9.829 mg	39.78 $\mu$ M	33.76 kBq	3.435 MBq	$\alpha$	16.00 My	5.390 MeV	29.15 nW	2.966 $\mu$ W	6.414 mSv	652.6 mSv
<sup>248</sup> Cm	760.1 $\mu$ g	3.064 $\mu$ M	119.6 kBq	157.3 MBq	$\alpha$	340.0 ky	21.00 MeV	402.4 nW	529.4 $\mu$ W	92.09 mSv	121.2 Sv
<sup>250</sup> Cm	4.745 pg	$\leq 1$ pM	14.43 mBq	3.041 GBq	$\alpha$	8.000 ky	123.3 MeV	$\leq 1$ pW	60.08 mW	63.49 nSv	13.38 kSv
C <sub>96</sub> Cm	64.87 gm	265.7 mM	174.9 TBq	2.696 TBq				165.4 W	2.549 W	21.00 MSv	323.7 kSv
<sup>241</sup> Am	738.5 gm	3.064 M	93.83 TBq	127.1 GBq	$\alpha$	432.8 y	5.603 MeV	84.23 W	114.1 mW	18.77 MSv	25.41 kSv
<sup>242</sup> Am	9.073 $\mu$ g	37.48 nM	271.5 GBq	$2.992 \times 10^7$	$\beta$	16.04 h	191.5 keV	8.329 mW	918.0 W	81.45 Sv	8.977 MSv
<sup>242m</sup> Am	758.5 mg	3.134 mM	272.8 GBq	359.7 GBq	$\gamma$	141.0 y	66.65 keV	2.913 mW	3.840 mW	51.83 kSv	68.33 kSv
<sup>243</sup> Am	196.9 gm	810.1 mM	1.453 TBq	7.379 GBq	$\alpha$	7.365 ky	5.421 MeV	1.262 W	6.409 mW	290.6 kSv	1.476 kSv
<sup>245</sup> Am	$\leq 1$ pg	$\leq 1$ pM	2.953 Bq	$2.287 \times 10^8$	$\beta$	2.050 h	313.1 keV	$\leq 1$ pW	11.47 kW	183.1 pSv	14.18 MSv
<sup>246</sup> Am	$\leq 1$ pg	$\leq 1$ pM	3.609 mBq	$1.132 \times 10^9$	$\beta$	39.00 m	1.362 MeV	$\leq 1$ pW	246.9 kW	$\leq 1$ pSv	65.64 MSv
C <sub>95</sub> Am	936.2 gm	3.877 M	95.83 TBq	102.4 GBq				85.50 W	91.33 mW	19.11 MSv	20.41 kSv
<sup>232</sup> U	402.3 $\mu$ g	1.734 $\mu$ M	318.7 MBq	792.2 GBq	$\alpha$	69.80 y	5.415 MeV	276.5 $\mu$ W	687.3 mW	105.2 Sv	261.4 kSv
<sup>233</sup> U	4.079 mg	17.50 $\mu$ M	1.461 MBq	358.2 MBq	$\alpha$	159.3 ky	4.905 MeV	1.148 $\mu$ W	281.4 $\mu$ W	74.51 mSv	18.27 Sv
<sup>234</sup> U	193.1 gm	825.1 mM	44.66 GBq	231.3 MBq	$\alpha$	245.7 ky	4.860 MeV	34.77 mW	180.1 $\mu$ W	2.188 kSv	11.33 Sv
<sup>235</sup> U	7.418 kg	31.56 M	593.5 MBq	80.01 kBq	$\alpha$	703.8 My	4.418 MeV	420.1 $\mu$ W	56.63 nW	27.89 Sv	3.760 mSv
<sup>236</sup> U	5.526 kg	23.41 M	13.23 GBq	2.394 MBq	$\alpha$	23.70 My	4.571 MeV	9.688 mW	1.753 $\mu$ W	621.8 Sv	112.5 mSv

†First emission from decay with highest branching ratio; ‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas

Isotope ‡	Mass grams	Moles	Radioactivity			Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity	
			GBq	GBq/gm	†			Watts	Watts/gm	Sv	Sv/gm
<sup>237</sup> U	34.33 μg	144.8 nM	103.7 GBq	3.021×10 <sup>6</sup>	β	6.750 d	319.3 keV	5.304 mW	154.5 W	78.81 Sv	2.296 MSv
<sup>238</sup> U	921.7 kg	3.872 kM	11.47 GBq	12.44 kBq	α	4.468 Gy	4.279 MeV	7.863 mW	8.531 nW	516.2 Sv	560.0 μSv
<sup>240</sup> U	≤ 1 pg	≤ 1 pM	20.34 kBq	3.428×10 <sup>7</sup>	β	14.10 h	138.4 keV	450.9 pW	760.0 W	22.37 μSv	37.71 MSv
C <sub>92</sub> U	934.8 kg	3.928 kM	174.0 GBq	186.1 kBq				58.32 mW	62.39 nW	3.538 kSv	3.785 mSv
<sup>236</sup> Np	2.483 mg	10.52 μM	1.211 MBq	487.7 MBq	β	152.0 ky	340.2 keV	66.00 nW	26.58 μW	20.59 mSv	8.291 Sv
<sup>237</sup> Np	654.6 gm	2.761 M	17.08 GBq	26.09 MBq	α	2.140 My	5.157 MeV	14.11 mW	21.56 μW	1.879 kSv	2.870 Sv
<sup>238</sup> Np	142.2 ng	597.4 pM	1.364 GBq	9.592×10 <sup>6</sup>	β	2.117 d	808.2 keV	176.6 μW	1.242 kW	1.241 Sv	8.729 MSv
<sup>239</sup> Np	169.2 μg	707.8 nM	1.453 TBq	8.587×10 <sup>6</sup>	β	2.355 d	407.7 keV	94.91 mW	560.9 W	1.162 kSv	6.870 MSv
<sup>240m</sup> Np	≤ 1 pg	≤ 1 pM	20.34 kBq	3.919×10 <sup>9</sup>	β	7.400 m	977.4 keV	3.185 nW	613.7 kW		
C <sub>93</sub> Np	654.6 gm	2.761 M	1.471 TBq	2.248 GBq				109.2 mW	166.8 μW	3.042 kSv	4.648 Sv
<sup>227</sup> Th	239.9 pg	1.057 pM	273.0 kBq	1.138×10 <sup>6</sup>	α	18.72 d	6.157 MeV	269.3 nW	1.123 kW	2.402 mSv	10.01 MSv
<sup>228</sup> Th	10.55 μg	46.27 nM	320.2 MBq	30.35 TBq	α	1.913 y	5.517 MeV	283.0 μW	26.82 W	23.05 Sv	2.185 MSv
<sup>229</sup> Th	998.6 ng	4.360 nM	7.862 kBq	7.873 GBq	α	7.340 ky	5.161 MeV	6.501 nW	6.510 mW	3.852 mSv	3.858 kSv
<sup>230</sup> Th	6.672 mg	29.00 μM	4.984 MBq	747.0 MBq	α	75.40 ky	4.775 MeV	3.813 μW	571.5 μW	1.047 Sv	156.9 Sv
<sup>231</sup> Th	30.16 ng	130.5 pM	593.5 MBq	1.968×10 <sup>7</sup>	β	1.063 d	94.67 keV	9.001 μW	298.4 W	201.8 mSv	6.691 MSv
<sup>232</sup> Th	1.981 mg	8.537 μM	8.040 Bq	4.059 kBq	α	14.05 Gy	4.084 MeV	5.261 pW	2.656 nW	1.849 μSv	933.5 μSv
<sup>234</sup> Th	13.38 μg	57.17 nM	11.47 GBq	857.2 TBq	β	24.09 d	68.41 keV	125.7 μW	9.395 W	39.00 Sv	2.915 MSv
C <sub>90</sub> Th	8.678 mg	37.65 μM	12.39 GBq	1.428 TBq				421.8 μW	48.60 mW	63.31 Sv	7.295 kSv
<sup>223</sup> Ra	146.0 pg	≤ 1 pM	276.8 kBq	1.896×10 <sup>6</sup>	α	11.43 d	6.007 MeV	266.4 nW	1.825 kW	27.68 mSv	189.6 MSv
<sup>224</sup> Ra	54.39 ng	242.8 pM	320.7 MBq	5.896×10 <sup>6</sup>	α	3.640 d	5.790 MeV	297.5 μW	5.470 kW	20.85 Sv	383.3 MSv
<sup>225</sup> Ra	5.418 pg	≤ 1 pM	7.862 kBq	1.451×10 <sup>6</sup>	β	14.80 d	118.3 keV	149.0 pW	27.50 W	778.3 μSv	143.7 MSv
<sup>226</sup> Ra	395.2 ng	1.748 nM	14.46 kBq	36.59 GBq	α	1.600 ky	4.874 MeV	11.29 nW	28.57 mW	4.049 mSv	10.24 kSv
<sup>228</sup> Ra	≤ 1 pg	≤ 1 pM	3.505 Bq	8.661 TBq	β	5.750 y	13.00 keV	≤ 1 pW	18.04 mW	2.418 μSv	5.976 MSv
E <sub>88</sub> Ra	449.7 ng	1.992 nM	321.0 MBq	713.7 TBq				297.8 μW	662.1 W	20.88 Sv	46.42 MSv
<sup>231</sup> Pa	564.8 μg	2.445 μM	987.5 kBq	1.748 GBq	α	32.76 ky	5.083 MeV	804.1 nW	1.424 mW	701.1 mSv	1.241 kSv
<sup>233</sup> Pa	22.23 μg	95.39 nM	17.08 GBq	768.3 TBq	β	27.00 d	383.0 keV	1.048 mW	47.14 W	14.86 Sv	668.4 kSv
<sup>234</sup> Pa	201.5 pg	≤ 1 pM	14.91 MBq	7.400×10 <sup>7</sup>	β	6.780 h	2.423 MeV	5.788 μW	28.72 kW	7.604 mSv	37.74 MSv
<sup>234m</sup> Pa	451.2 pg	1.928 pM	11.47 GBq	2.542×10 <sup>10</sup>	β	1.170 m	833.7 keV	1.532 mW	3.395 MW		
C <sub>91</sub> Pa	587.0 μg	2.540 μM	28.57 GBq	48.66 TBq				2.587 mW	4.406 W	15.57 Sv	26.52 kSv
<sup>206</sup> Pb	71.93 pg	≤ 1 pM									
<sup>207</sup> Pb	17.43 ng	84.21 pM									
<sup>208</sup> Pb	30.50 μg	146.7 nM									
<sup>209</sup> Pb	≤ 1 pg	≤ 1 pM	7.862 kBq	1.682×10 <sup>8</sup>	β	3.253 h	194.0 keV	244.4 pW	5.228 kW	448.1 nSv	9.586 MSv
<sup>210</sup> Pb	685.2 pg	3.263 pM	1.936 kBq	2.825 TBq	β	22.16 y	39.08 keV	12.12 pW	17.69 mW	1.336 mSv	1.950 MSv
<sup>211</sup> Pb	≤ 1 pg	≤ 1 pM	276.8 kBq	9.138×10 <sup>8</sup>	β	36.10 m	505.6 keV	22.42 nW	74.02 kW	49.82 μSv	164.5 MSv
<sup>212</sup> Pb	6.236 ng	29.42 pM	320.7 MBq	5.143×10 <sup>7</sup>	β	10.64 h	321.2 keV	16.50 μW	2.646 kW	1.924 Sv	308.6 MSv
<sup>214</sup> Pb	≤ 1 pg	≤ 1 pM	14.46 kBq	1.213×10 <sup>9</sup>	β	26.80 m	537.9 keV	1.246 nW	104.5 kW	2.024 μSv	169.8 MSv

†First emission from decay with highest branching ratio; ‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas

Isotope ‡	Mass grams	Moles	Radioactivity			Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity	
			GBq	GBq/gm	†			Watts	Watts/gm	Sv	Sv/gm
A $_{82}\text{Pb}$	30.52 $\mu\text{g}$	146.8 nM	321.0 MBq	10.52 TBq				16.52 $\mu\text{W}$	541.3 mW	1.926 Sv	63.08 kSv
$^{249}\text{Cf}$	10.48 $\mu\text{g}$	42.08 nM	1.590 MBq	151.7 GBq	$\alpha$	351.0 y	7.804 MeV	1.988 $\mu\text{W}$	189.7 mW	556.5 mSv	53.10 kSv
$^{250}\text{Cf}$	1.206 $\mu\text{g}$	4.823 nM	4.880 MBq	4.046 TBq	$\alpha$	13.08 y	6.266 MeV	4.899 $\mu\text{W}$	4.062 W	780.8 mSv	647.4 kSv
$^{251}\text{Cf}$	976.6 ng	3.890 nM	57.31 kBq	58.68 GBq	$\alpha$	898.0 y	6.030 MeV	55.36 nW	56.69 mW	20.63 mSv	21.13 kSv
$^{252}\text{Cf}$	47.81 ng	189.7 pM	951.6 kBq	19.90 TBq	$\alpha$	2.645 y	12.04 MeV	1.836 $\mu\text{W}$	38.40 W	85.64 mSv	1.791 MSv
$^{254}\text{Cf}$	$\leq 1$ pg	$\leq 1$ pM	$\leq 1$ pBq	314.4 TBq	SF	60.50 d	199.5 MeV	$\leq 1$ pW	10.05 kW	$\leq 1$ pSv	125.8 MSv
C $_{98}\text{Cf}$	12.71 $\mu\text{g}$	50.98 nM	7.479 MBq	588.4 GBq				8.778 $\mu\text{W}$	690.6 mW	1.444 Sv	113.6 kSv
$^{225}\text{Ac}$	3.660 pg	$\leq 1$ pM	7.862 kBq	$2.148 \times 10^6$	$\alpha$	10.00 d	5.893 MeV	7.423 nW	2.028 kW	188.7 $\mu\text{Sv}$	51.55 MSv
$^{227}\text{Ac}$	103.2 ng	454.6 pM	276.4 kBq	2.678 TBq	$\beta$	21.77 y	81.68 keV	3.617 nW	35.05 mW	304.0 mSv	2.946 MSv
$^{228}\text{Ac}$	$\leq 1$ pg	$\leq 1$ pM	3.506 Bq	$8.300 \times 10^7$	$\beta$	6.150 h	1.458 MeV	$\leq 1$ pW	19.39 kW	1.508 nSv	35.69 MSv
E $_{89}\text{Ac}$	103.2 ng	454.6 pM	284.3 kBq	2.754 TBq				11.04 nW	107.0 mW	304.2 mSv	2.948 MSv
$^{208}\text{Bi}$	$\leq 1$ pg	$\leq 1$ pM	119.3 nBq	172.9 MBq	$\epsilon$	368.0 ky	2.653 MeV	$\leq 1$ pW	73.51 $\mu\text{W}$		
$^{209}\text{Bi}$	1.009 ng	4.828 pM	$\leq 1$ pBq	3.331 $\mu\text{Bq}$	$\alpha$	$\geq 10^{18}$ y	3.137 MeV	$\leq 1$ pW	$\leq 1$ pW		
$^{210}\text{Bi}$	$\leq 1$ pg	$\leq 1$ pM	1.937 kBq	$4.593 \times 10^6$	$\beta$	5.012 d	389.0 keV	120.7 pW	286.2 W	2.518 $\mu\text{Sv}$	5.971 MSv
$^{210m}\text{Bi}$	$\leq 1$ pg	$\leq 1$ pM	90.32 nBq	21.00 MBq	$\alpha$	3.000 My	5.296 MeV	$\leq 1$ pW	17.82 $\mu\text{W}$	$\leq 1$ pSv	315.1 mSv
$^{211}\text{Bi}$	$\leq 1$ pg	$\leq 1$ pM	276.8 kBq	$1.549 \times 10^{10}$	$\beta$	2.170 m	6.729 MeV	298.4 nW	16.70 MW		
$^{212}\text{Bi}$	591.5 pg	2.790 pM	320.7 MBq	$5.422 \times 10^8$	$\beta$	1.009 h	2.869 MeV	147.4 $\mu\text{W}$	249.2 kW	83.38 mSv	141.0 MSv
$^{213}\text{Bi}$	$\leq 1$ pg	$\leq 1$ pM	7.862 kBq	$7.160 \times 10^8$	$\beta$	45.59 m	709.2 keV	893.3 pW	81.36 kW	1.572 $\mu\text{Sv}$	143.2 MSv
$^{214}\text{Bi}$	$\leq 1$ pg	$\leq 1$ pM	14.46 kBq	$1.634 \times 10^9$	$\beta$	19.90 m	2.162 MeV	5.009 nW	566.1 kW	1.591 $\mu\text{Sv}$	179.7 MSv
A $_{83}\text{Bi}$	1.601 ng	7.621 pM	321.0 MBq	$2.005 \times 10^8$				147.7 $\mu\text{W}$	92.26 kW	83.39 mSv	52.09 MSv
$^{210}\text{Po}$	10.40 pg	$\leq 1$ pM	1.729 kBq	166.3 TBq	$\alpha$	138.4 d	5.408 MeV	1.498 nW	144.0 W	2.075 mSv	199.5 MSv
$^{211}\text{Po}$	$\leq 1$ pg	$\leq 1$ pM	775.2 Bq	$3.535 \times 10^{12}$	$\alpha$	516.0 ms	7.591 MeV	942.7 pW	4.299 GW		
$^{215}\text{Po}$	$\leq 1$ pg	$\leq 1$ pM	276.8 kBq	$1.091 \times 10^{15}$	$\beta$	1.780 ms	7.532 MeV	334.0 nW	$1.317 \times 10^{12}$		
$^{216}\text{Po}$	$\leq 1$ pg	$\leq 1$ pM	320.7 MBq	$1.289 \times 10^{13}$	$\alpha$	150.0 ms	6.906 MeV	354.8 $\mu\text{W}$	14.26 GW		
$^{218}\text{Po}$	$\leq 1$ pg	$\leq 1$ pM	14.46 kBq	$1.046 \times 10^{10}$	$\beta$	3.098 m	6.117 MeV	14.17 nW	10.25 MW		
A $_{84}\text{Po}$	10.43 pg	$\leq 1$ pM	321.0 MBq	$3.079 \times 10^{10}$				355.2 $\mu\text{W}$	34.06 MW	2.075 mSv	199.0 MSv
$^{249}\text{Bk}$	3.356 ng	13.47 pM	203.6 kBq	60.67 TBq	$\beta$	320.0 d	125.0 keV	4.077 nW	1.215 W	197.5 $\mu\text{Sv}$	58.85 kSv
$^{250}\text{Bk}$	$\leq 1$ pg	$\leq 1$ pM	1.108 Bq	$1.440 \times 10^8$	$\beta$	3.217 h	1.172 MeV	$\leq 1$ pW	27.04 kW	155.1 pSv	20.16 MSv
C $_{97}\text{Bk}$	3.356 ng	13.47 pM	203.6 kBq	60.67 TBq				4.077 nW	1.215 W	197.5 $\mu\text{Sv}$	58.85 kSv
$^{221}\text{Fr}$	$\leq 1$ pg	$\leq 1$ pM	7.862 kBq	$6.563 \times 10^9$	$\alpha$	4.900 m	6.511 MeV	8.201 nW	6.846 MW		
$^{223}\text{Fr}$	$\leq 1$ pg	$\leq 1$ pM	3.815 kBq	$1.432 \times 10^9$	$\beta$	21.80 m	438.0 keV	267.7 pW	100.5 kW	9.156 $\mu\text{Sv}$	3.437 GSv
C $_{87}\text{Fr}$	$\leq 1$ pg	$\leq 1$ pM	11.68 kBq	$3.024 \times 10^9$				8.469 nW	2.193 MW	9.156 $\mu\text{Sv}$	2.371 GSv
C $^{254}_{99}\text{Es}$	$\leq 1$ pg	$\leq 1$ pM	1.106 Bq	69.04 TBq	$\alpha$	275.7 d	6.620 MeV	1.173 pW	73.22 W	30.97 nSv	1.933 MSv
$^{250}_{0}\text{Sf}$	45.96 $\mu\text{g}$										
G $^4_2\text{He}$	2.317 gm	578.9 mM									
$^{207}\text{Tl}$	$\leq 1$ pg	$\leq 1$ pM	276.0 kBq	$7.048 \times 10^9$	$\beta$	4.770 m	495.5 keV	21.91 nW	559.5 kW		

†First emission from decay with highest branching ratio; ‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas

Isotope ‡	Mass grams	Moles	Radioactivity			Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity		
			GBq	GBq/gm	†			Watts	Watts/gm	Sv	Sv/gm	
A <sub>81</sub> Tl	<sup>208</sup> Tl	10.57 pg	≤ 1 pM	115.2 MBq	1.090×10 <sup>10</sup>	β	3.053 m	3.971 MeV	73.29 μW	6.934 MW		
	<sup>209</sup> Tl	≤ 1 pg	≤ 1 pM	169.8 Bq	1.513×10 <sup>10</sup>	β	2.200 m	2.803 MeV	76.26 pW	6.797 MW		
	<sup>81</sup> Tl	10.61 pg	≤ 1 pM	115.5 MBq	1.088×10 <sup>10</sup>				73.31 μW	6.910 MW		
A <sub>85</sub> At	<sup>217</sup> At	≤ 1 pg	≤ 1 pM	7.862 kBq	5.956×10 <sup>13</sup>	β	32.30 ms	7.199 MeV	9.068 nW	68.70 GW		
G <sub>86</sub> Rn	<sup>219</sup> Rn	≤ 1 pg	≤ 1 pM	276.8 kBq	4.816×10 <sup>11</sup>	α	3.960 s	7.000 MeV	310.4 nW	540.0 MW		
	<sup>220</sup> Rn	9.394 pg	≤ 1 pM	320.7 MBq	3.414×10 <sup>10</sup>	α	55.80 s	6.405 MeV	329.1 μW	35.03 MW		
	<sup>222</sup> Rn	2.541 pg	≤ 1 pM	14.46 kBq	5.691×10 <sup>6</sup>	α	3.823 d	5.590 MeV	12.95 nW	5.096 kW		
	<sup>86</sup> Rn	11.94 pg	≤ 1 pM	321.0 MBq	2.689×10 <sup>10</sup>				329.4 μW	27.60 MW		
Total	947.9 kg	3.983 kM	4.729×10 <sup>6</sup>	4.989 GBq					458.1 W	483.3 μW	114.0 MSv	120.3 Sv
ICRP Publication 119 does not report dose factors for isotopes with half lives less than ten minutes or greater than 10 <sup>9</sup> years. Dose factors for gases are given as Sv/day per Bq/m <sup>3</sup> . Radiotoxicity is not computed for gases.												
†First emission from decay with highest branching ratio; ‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas												

## Activation Products Per Tonne of Fuel

used for 50.68 GW-day LWR burnup at power of 36.5 MW 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 ‡	Mass grams	Moles	Radioactivity			Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity	
			GBq	GBq/gm	†			Watts	Watts/gm	Sv	Sv/gm
<sup>90</sup> Zr	120.7 kg	1.343 kM									
<sup>91</sup> Zr	26.41 kg	290.5 M									
<sup>92</sup> Zr	41.10 kg	447.2 M									
<sup>93</sup> Zr	160.7 gm	1.730 M	14.95 GBq	93.03 MBq	$\beta$	1.530 My	19.59 keV	46.93 $\mu$ W	292.0 nW	16.44 Sv	102.3 mSv
<sup>94</sup> Zr	42.60 kg	453.6 M	1.000 kBq	23.48 mBq	$2\beta$	6.000 Py	1.144 MeV	183.2 pW	$\leq 1$ pW		
<sup>95</sup> Zr	$\leq 1$ pg	$\leq 1$ pM	12.72 mBq	795.5 TBq	$\beta$	64.03 d	854.3 keV	$\leq 1$ pW	108.9 W	12.08 pSv	755.7 kSv
<sup>96</sup> Zr	6.957 kg	72.54 M	24.60 mBq	3.536 $\mu$ Bq	$2\beta$	$\geq 10^{18}$ y	3.350 MeV	$\leq 1$ pW	$\leq 1$ pW		
A <sub>40</sub> Zr	237.9 kg	2.608 kM	14.95 GBq	62.83 kBq				46.93 $\mu$ W	197.2 pW	16.44 Sv	69.12 $\mu$ Sv
<sup>87</sup> Sr	3.321 mg	38.21 $\mu$ M									
<sup>88</sup> Sr	325.3 mg	3.701 mM									
<sup>89</sup> Sr	$\leq 1$ pg	$\leq 1$ pM	283.4 pBq	$1.076 \times 10^6$	$\beta$	50.57 d	583.2 keV	$\leq 1$ pW	100.5 W	$\leq 1$ pSv	2.796 MSv
<sup>90</sup> Sr	26.93 $\mu$ g	299.5 nM	136.0 MBq	5.050 TBq	$\beta$	28.79 y	195.8 keV	4.266 $\mu$ W	158.4 mW	3.808 Sv	141.4 kSv
E <sub>38</sub> Sr	328.6 mg	3.739 mM	136.0 MBq	413.8 MBq				4.266 $\mu$ W	12.98 $\mu$ W	3.808 Sv	11.59 Sv
<sup>93</sup> Nb	245.6 $\mu$ g	2.644 $\mu$ M									
<sup>93m</sup> Nb	610.9 $\mu$ g	6.575 $\mu$ M	6.394 GBq	10.47 TBq	$\gamma$	16.13 y	29.88 keV	30.61 $\mu$ W	50.11 mW	767.3 mSv	1.256 kSv
<sup>94</sup> Nb	63.41 ng	675.2 pM	439.6 Bq	6.933 GBq	$\beta$	19.99 ky	1.720 MeV	121.1 pW	1.910 mW	747.3 nSv	11.79 Sv
<sup>95</sup> Nb	$\leq 1$ pg	$\leq 1$ pM	28.23 mBq	$1.448 \times 10^6$	$\beta$	34.99 d	809.3 keV	$\leq 1$ pW	187.7 W	16.37 pSv	839.7 kSv
<sup>95m</sup> Nb	$\leq 1$ pg	$\leq 1$ pM	94.31 $\mu$ Bq	$1.410 \times 10^7$	$\beta$	3.608 d	234.4 keV	$\leq 1$ pW	529.4 W	$\leq 1$ pSv	7.893 MSv
A <sub>41</sub> Nb	856.6 $\mu$ g	9.220 $\mu$ M	6.394 GBq	7.465 TBq				30.61 $\mu$ W	35.74 mW	767.3 mSv	895.8 Sv
<sup>89</sup> Y	24.79 mg	278.8 $\mu$ M									
<sup>90</sup> Y	6.754 ng	75.12 pM	136.0 MBq	$2.014 \times 10^7$	$\beta$	2.671 d	935.4 keV	20.38 $\mu$ W	3.017 kW	367.2 mSv	54.37 MSv
<sup>91</sup> Y	$\leq 1$ pg	$\leq 1$ pM	686.0 nBq	907.6 TBq	$\beta$	58.51 d	606.0 keV	$\leq 1$ pW	88.12 W	$\leq 1$ pSv	2.178 MSv
E <sub>39</sub> Y	24.79 mg	278.8 $\mu$ M	136.0 MBq	5.486 GBq				20.38 $\mu$ W	822.1 $\mu$ W	367.2 mSv	14.81 Sv
<sup>98</sup> Tc	4.887 ng	49.91 pM	157.2 mBq	32.17 MBq	$\beta$	4.200 My	1.532 MeV	$\leq 1$ pW	7.892 $\mu$ W	314.4 pSv	64.33 mSv
<sup>99</sup> Tc	1.152 mg	11.65 $\mu$ M	722.6 kBq	627.3 MBq	$\beta$	214.0 ky	84.62 keV	9.796 nW	8.503 $\mu$ W	462.5 $\mu$ Sv	401.4 mSv
A <sub>43</sub> Tc	1.152 mg	11.65 $\mu$ M	722.6 kBq	627.3 MBq				9.796 nW	8.503 $\mu$ W	462.5 $\mu$ Sv	401.4 mSv
<sup>1</sup> H	12.73 mg	12.63 mM									
<sup>2</sup> H	10.72 $\mu$ g	5.322 $\mu$ M									
<sup>3</sup> H	4.054 pg	1.344 pM	1.448 kBq	357.2 TBq	$\beta$	12.33 y	5.682 keV	1.318 pW	325.1 mW	60.82 nSv	15.00 kSv
G <sub>1</sub> H	12.74 mg	12.64 mM	1.448 kBq	113.7 kBq				1.318 pW	103.4 pW	60.82 nSv	4.773 $\mu$ Sv
<sup>102</sup> Rh	$\leq 1$ pg	$\leq 1$ pM	2.250 $\mu$ Bq	44.74 TBq	$\epsilon$	2.902 y	2.152 MeV	$\leq 1$ pW	15.42 W	$\leq 1$ pSv	53.69 kSv
<sup>103</sup> Rh	1.108 pg	$\leq 1$ pM									

†First emission from decay with highest branching ratio; ‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas

Isotope ‡	Mass grams	Moles	Radioactivity			Half Life	Energy per Bq-s	Thermal Power		Radiotoxicity	
			GBq	GBq/gm	†			Watts	Watts/gm	Sv	Sv/gm
A <sub>45</sub> Rh	1.108 pg	≤ 1 pM	2.250 μBq	2.031 MBq				≤ 1 pW	700.1 nW	≤ 1 pSv	2.437 mSv
<sup>3</sup> He	3.120 pg	1.034 pM									
<sup>4</sup> He	16.30 mg	4.072 mM									
G <sub>2</sub> He	16.30 mg	4.072 mM									
<sup>94</sup> Mo	23.39 pg	≤ 1 pM									
<sup>95</sup> Mo	29.03 gm	305.9 mM									
<sup>96</sup> Mo	1.824 gm	19.02 mM									
<sup>97</sup> Mo	48.80 gm	503.6 mM									
<sup>98</sup> Mo	616.9 mg	6.301 mM	833.5 mBq	1.351 Bq	2β	100.0 Ty	112.0 keV	≤ 1 pW	≤ 1 pW		
<sup>100</sup> Mo	1.234 μg	12.35 nM	16.50 pBq	13.37 μBq	2β	≥ 10 <sup>18</sup> y	3.034 MeV	≤ 1 pW	≤ 1 pW		
A <sub>42</sub> Mo	80.27 gm	834.8 mM	833.5 mBq	10.38 mBq				≤ 1 pW	≤ 1 pW		
<sup>98</sup> Ru	≤ 1 pg	≤ 1 pM									
<sup>99</sup> Ru	40.54 ng	409.9 pM									
<sup>100</sup> Ru	99.42 μg	995.2 nM									
<sup>101</sup> Ru	500.4 ng	4.959 nM									
<sup>102</sup> Ru	9.511 ng	93.33 pM									
<sup>104</sup> Ru	≤ 1 pg	≤ 1 pM									
A <sub>44</sub> Ru	99.97 μg	1.001 μM									
<sup>104</sup> Pd	≤ 1 pg	≤ 1 pM									
<sup>105</sup> Pd	≤ 1 pg	≤ 1 pM									
<sup>106</sup> Pd	≤ 1 pg	≤ 1 pM									
A <sub>46</sub> Pd	≤ 1 pg	≤ 1 pM									
Total	238.0 kg	2.609 kM	21.61 GBq	90.80 kBq				102.2 μW	429.4 pW	21.39 Sv	89.87 μSv
ICRP Publication 119 does not report dose factors for isotopes with half lives less than ten minutes or greater than 10 <sup>9</sup> years. Dose factors for gases are given as Sv/day per Bq/m <sup>3</sup> . Radiotoxicity is not computed for gases.											
†First emission from decay with highest branching ratio; ‡Electrorefiner destination: A = anode, C = cathode, E = electrolyte, G = gas											