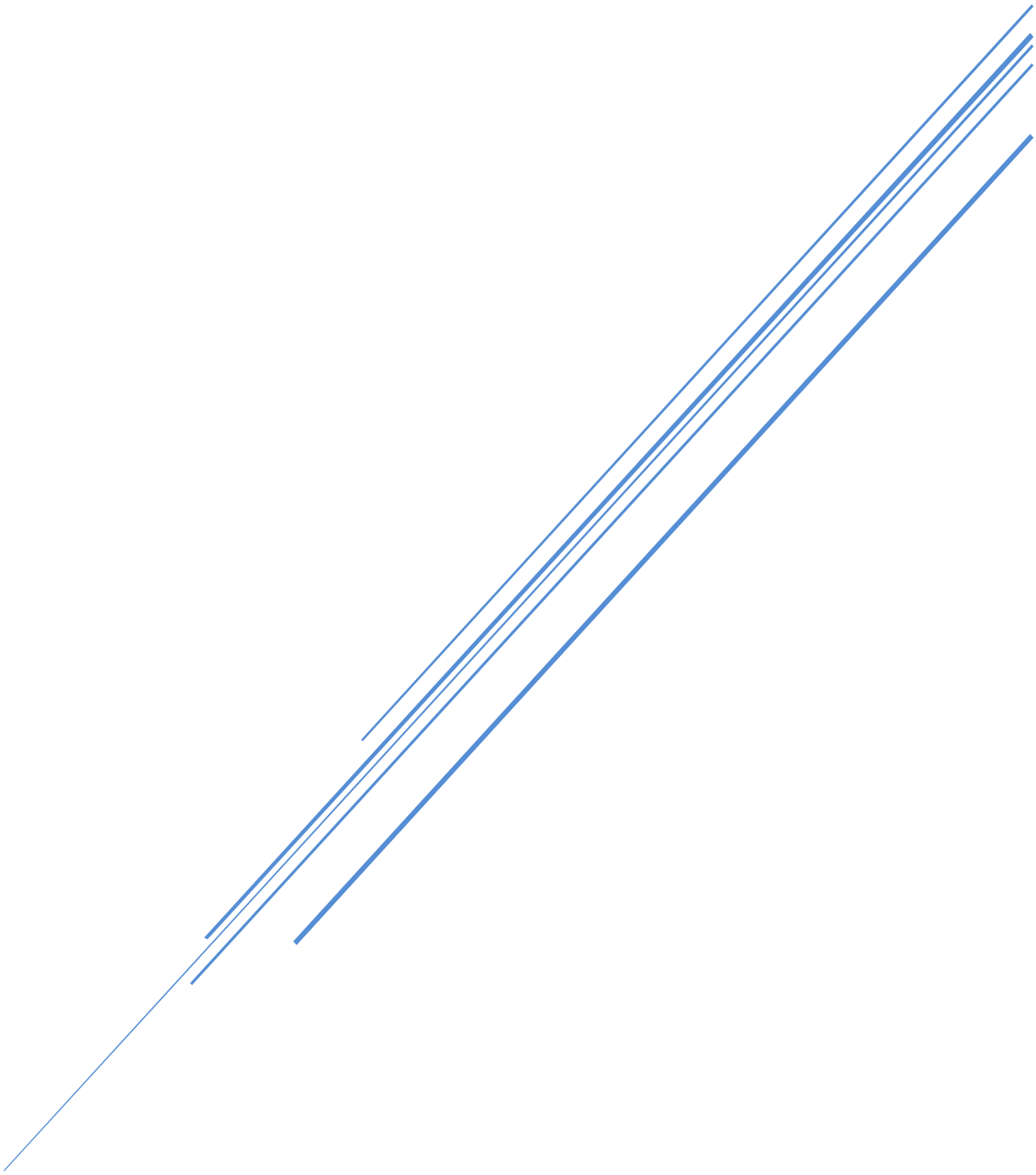
RSU INF 2021-07 (SEPTEMBER 2021)
RADIONUCLIDE DATA SHEET



University of Manchester
Radiation Safety Unit

The University of Manchester

RSU INF 2021-07: Radionuclide data sheet

BASIC PRINCIPLES

SI UNITS

The becquerel (Bq) is the SI unit for measuring the quantity of radioactive material, and is defined as one radioactive disintegration per second. The following conversion factors may be used to convert curies into becquerels.

1 GBq	= 27 mCi	1 Ci	= 37 GBq
1 MBq	= 27 μCi	1 mCi	= 37 MBq
1 kBq	= 27 nCi	1 μCi	= 37 kBq

SOURCE OUTPUT & EXTERNAL DOSE

Gamma source output

The tables included in this Information Sheet give specimen radiation dose rates for most of the commonly used radionuclides. To estimate the output at a fixed distance (1 metre) from a gamma-emitting radioactive source, simply multiply the source activity (in GBq) by the specimen dose rate.

Beta source output

The following formula is acceptable for giving approximate dose rates from beta-emitting radioactive sources where the energy of the beta electron is >0.3 MeV.

$D = 800A$

where,

D = the approx. dose rate (mSv/h) at 0.1 m from the source

A = the activity of the source (in GBq)

Distance

x- and gamma photons follow the inverse square law, the effect of which is that radiation dose rates increase rapidly as the source is approached, and diminish substantially as the distance from the source increases.

$D_1 d_1^2 = D_2 d_2^2$

where

D_1 = the dose rate at x metres from the source

D_2 = the dose rate at y metre from the source

d_1 = the distance x metres

d_2 = the distance y metres

Internal Exposure

The following formula may be used to give an estimate of internal exposure following the ingestion or inhalation of unsealed radioactive materials.

$E = (DPUI_{ingestion} A) + (DPUI_{inhalation} A)$

where,

DPUI = the dose per unit intake factor

Table 1 Radionuclide Data

Radioisotope	Principle particle emission[1]	Half-life[1]	Principal energies of decay[1] (MeV / %)	Specific activity[2] (TBq/g)	Intake data		Gamma dose rate in air at 1 m (μSv/h per GBq)	Relative radiotoxicity per unit activity[2,4]
					DPUI[3] inhalation Sv/Bq	DPUI[3] ingestion Sv/Bq		
americium-241 (^{241}Am)	α, γ	432.2 y	α 5.48/85.2 α 5.44/12.8		$3.9\ 10^{-5}$	$2.0\ 10^{-7}$	2.4	I
caesium-134 (^{134}Cs)	β, γ	2.06 y	β 0.083/32 β 0.660/50 β 0.68/13 γ 0.605/98 γ 0.796/85.4 γ 0.569/15.4	$4.81\ 10^{1}$	$9.6\ 10^{-9}$	$1.9\ 10^{-8}$	23.5	II
caesium-137 (^{137}Cs)	β, γ	30.3 y	β 0.514/95 γ 0.661/85.1	$3.21\ 10^{0}$	$6.7\ 10^{-9}$	$1.3\ 10^{-8}$	89.2	II
calcium-45 (^{45}Ca)	β	162.7	β 0.257/100	$6.51\ 10^{2}$	$2.7\ 10^{-9}$	$7.6\ 10^{-10}$		II
carbon-14 (^{14}C)	β	5715 y	β 0.156/100	$1.65\ 10^{-1}$	$5.8\ 10^{-10}$	$5.8\ 10^{-10}$		III
chlorine-36 (^{36}Cl)	β	$3.0\ 10^{5}$ y	β 0.709/98	$1.19\ 10^{-3}$	$4.9\ 10^{-10}$	$9.3\ 10^{-10}$		II
chromium-51 (^{51}Cr)	EC, γ	27.7 d	γ 0.32/9.83	$3.40\ 10^{3}$	$3.6\ 10^{-11}$	$3.8\ 10^{-11}$	4.3	III
cobalt-60 (^{60}Co)	β, γ	5.271 y	β 0.315/99.7 γ 1.17/100 γ 1.33/100	$4.18\ 10^{1}$	$1.7\ 10^{-8}$	$3.4\ 10^{-9}$	357	II

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					DPUI[3] inhalation Sv/Bq	DPUI[3] ingestion Sv/Bq		
europium-152 (^{152}Eu)	EC, β, γ	13.33 y	β 1.819/28 β 1.874/72 γ 0.344/26.6 γ 0.141/20.9 γ 0.122/28.4		$3.9\ 10^{-8}$	$1.4\ 10^{-9}$	80	II
iodine-125 (^{125}I)	EC, γ	59.4 d	γ 0.035/7	$6.44\ 10^{2}$	$7.3\ 10^{-9}$	$1.5\ 10^{-8}$	135	II
iodine-129 (^{129}I)	β	$1.7\ 10^{7}$ y	β 0.15/100 γ 0.039/7.5		$5.1\ 10^{-8}$	$1.1\ 10^{-7}$		IV
iodine-131 (^{131}I)	β, γ	8.04 d	β 0.606/89.7 γ 0.364/81.8	$4.59\ 10^{3}$	$1.1\ 10^{-8}$	$2.2\ 10^{-8}$	59.5	II
iridium-192 (^{192}Ir)	β, γ	73.83 d	β 0.530/42.6 β 0.670/47.2 γ 0.316/83 γ 0.468/48	$3.39\ 10^{2}$	$2.2\ 10^{-9}$	$1.4\ 10^{-9}$	130	II
iron-55 (^{55}Fe)	EC	2.73 y	γ 0.06/28	$9.25\ 10^{2}$	$9.2\ 10^{-10}$	$3.3\ 10^{-10}$		III
krypton-85 (^{85}Kr)	β, γ	10.73 y	β 0.672/99.6 β 0.15/0.4 γ 0.513/0.4				0.45	III
nickel-63 (^{63}Ni)	β	100 y	β 0.065/100	$2.28\ 10^{0}$	$5.2\ 10^{-10}$	$1.5\ 10^{-10}$		III
phosphorous-32 (^{32}P)	β	14.28 d	β 1.710/100	$1.05\ 10^{4}$	$2.9\ 10^{-9}$	$2.4\ 10^{-9}$		III
phosphorous-33 (^{33}P)	β	25.6 d	β 0.249/100	$5.72\ 10^{9}$	$1.3\ 10^{-9}$	$2.4\ 10^{-10}$		IV

Radioisotope	Principle particle emission[1]	Half-life[1]	Principal energies of decay[1] (MeV / %)	Specific activity[2] (TBq/g)	Intake data		Gamma dose rate in air at 1 m (μSv/h per GBq)	Relative radiotoxicity per unit activity[2,4]
					DPUI[3] inhalation Sv/Bq	DPUI[3] ingestion Sv/Bq		
plutonium-238 (^{238}Pu)	α	87.74 y	α 5.499/71.6 α 5.465/28.3		$3.0\ 10^{-5}$	$2.3\ 10^{-7}$		I
plutonium-239 (^{239}Pu)	α	$2.4\ 10^{4}$ y	α 5.155/73.2 α 5.142/15.1 α 5.104/10.6	$2.27\ 10^{-3}$	$3.2\ 10^{-5}$	$2.5\ 10^{-7}$		I
polonium-210 (^{210}Po)	α	138.38 d	α 5.304/100 γ 0.803/0.001	$1.66\ 10^{2}$	$2.2\ 10^{-6}$	$2.4\ 10^{-7}$		I
potassium-40 (^{40}K)	β, γ	$1.3\ 10^{9}$ y	β 1.312/89 γ 1.461/11	$2.54\ 10^{-1}$	$3.0\ 10^{-9}$	$6.2\ 10^{-9}$		II
promethium-147 (^{147}Pm)	β	2.623 y	β 0.225/100	$3.44\ 10^{1}$	$4.7\ 10^{-9}$	$2.6\ 10^{-10}$		III
radium-226 (^{226}Ra)	α, γ	1599 y	α 4.784/94 α 4.601/5.5 γ 0.609/41.7 γ 1.764/15.9 γ 1.120/14.3	$3.66\ 10^{-2}$	$3.2\ 10^{-6}$	$2.8\ 10^{-7}$	227	I
sodium-22 (^{22}Na)	β, γ	2.605 y	β 0.545/90 γ 1.274/99.9	$2.31\ 10^{2}$	$2.0\ 10^{-9}$	$3.2\ 10^{-9}$	324	II
strontium-90 (^{90}Sr)	β	29.1 y	β 0.546/100	$5.22\ 10^{0}$	$1.5\ 10^{-7}$	$2.8\ 10^{-8}$		I
sulphur-35 (^{35}S)	β	87.2 d	β 0.167/100	$1.57\ 10^{3}$	$1.1\ 10^{-9}$	$1.9\ 10^{-10}$		III
technetium-99m (^{99m}Tc)	β, γ	6.02 h	β 0.293/100 γ 0.140/89	$1.95\ 10^{5}$	$2.9\ 10^{-11}$	$2.2\ 10^{-11}$	17	IV

Radioisotope	Principle particle emission[1]	Half-life[1]	Principal energies of decay[1] (MeV / %)	Specific activity[2] (TBq/g)	Intake data		Gamma dose rate in air at 1 m (μSv/h per GBq)	Relative radiotoxicity per unit activity[2,4]
					DPUI[3] inhalation Sv/Bq	DPUI[3] ingestion Sv/Bq		
thallium-204 (^{204}Tl)	β	3.78 y	β 0.763/97	$1.71\ 10^{1}$	$6.2\ 10^{-10}$	$1.3\ 10^{-9}$		II
thorium-232 (^{232}Th)	α, γ	$1.4\ 10^{10}$ y	α 4.010/77 α 3.952/23 γ 0.293/48 γ 0.511/23 γ 0.583/85.8	$4.03\ 10^{-9}$	$4.2\ 10^{-5}$	$2.2\ 10^{-7}$		IV
tritium (^{3}H)	β	12.3 y	β 0.0186/100	$3.57\ 10^{2}$	$1.8\ 10^{-11}$	$4.2\ 10^{-11}$		IV
uranium-233 (^{233}U)	α	$1.6\ 10^{5}$ y	α 4.824/84.4 α 4.783/13.2	$3.51\ 10^{-4}$	$8.7\ 10^{-6}$	$5.0\ 10^{-8}$		I
uranium-234 (^{234}U)	α	$2.5\ 10^{5}$ y	α 4.776/72.5 α 4.723/27.5	$7.92\ 10^{-8}$	$8.5\ 10^{-6}$	$4.9\ 10^{-8}$		I
uranium-235 (^{235}U)	α, γ	$7.0\ 10^{8}$ y	α 4.395/55 α 4.3644/11 γ 0.185/54 γ 0.144/11	$1.23\ 10^{-8}$	$7.7\ 10^{-6}$	$4.6\ 10^{-8}$		IV
uranium-238 (^{238}U)	α	$4.5\ 10^{9}$ y	α 4.196/77 α 4.147/23	$1.60\ 10^{-8}$	$7.3\ 10^{-6}$	$4.4\ 10^{-8}$		IV
zinc-65 (^{65}Zn)	EC, β	243.8 d	β 0.325/2.0 γ 1.115/50.8	$3.03\ 10^{2}$	$2.9\ 10^{-9}$	$3.9\ 10^{-9}$	73	III

Notes

1) Lide (Ed). CRC Handbook of Chemistry and Physics 72nd Edition 1991-1992 (1991).

2) Brodsky. CRC Handbook of Radiation Measurement and Protection, Volume II Biological and Mathematical Information (1982).

3) Council Directive 96/29/EURATOM, Tables C1 and C2. Official Journal of the European Countries. L159 Volume 39, June 1996.

Toxicity Groups: I = highly toxic, II = medium toxicity (upper sub-group), III = medium toxicity (lower sub-group) IV =