APPENDIX to
Coordinated examination: radiation protection
Expertise Level 3

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examination date: 14 December 2015
duration of examination: 13.30 - 16.30

Instructions:

- ❑ **If you use data other than that provided in this appendix, please state the source!**
- ❑ **In the Dutch Handbook Radionuclides commas are used instead of decimal points.**
- ❑ **This appendix consists of 21 numbered pages. Please check this!**

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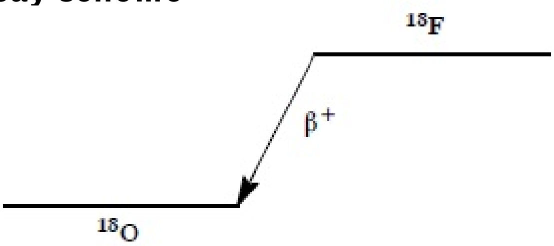
Handboek Radionucliden [Radionuclides Handbook], A.S. Keverling Buisman (2nd edition 2007), pp. 26-27, data on ^{18}F

^{18}F Z = 9

Half-life and decay constant

$T_{1/2}$ = 109,70 min = 6,582×10^{3} s λ = 1,05×10^{-4} s^{-1}

Decay scheme



Main emitted radiation

Straling	y (Bq·s)$^{-1}$	E (keV)
β^+	1,000	250 | 634
$\gamma^{\pm}$	2,000	511

Source constants

Air kerma rate	k = 0,135 µGy/h per MBq/m^2
Ambient dose equivalent rate	h = 0,166 µSv/h per MBq/m^2

Miscellaneous

Specific activity	A_{sp} = 3,52×10^{18} Bq/g
Exemption levels	C_v = 10^1 Bq/g en A_v = 10^6 Bq
Skin contamination	H_{huid} = 5×10^{-10} Sv/s per Bq/cm^2
Wound contamination / injection	e(50) = 1,4×10^{-11} Sv/Bq
Transport	A_1 = 1 TBq
	A_2 = 0,6 TBq

Production and applications

Het radionuclide ^{18}F is een cyclotronproduct. Het nuclide wordt toegepast in de nucleaire geneeskunde voor het maken van afbeeldingen met behulp van positronen-emissie-tomografie (PET).

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N = 9 ^{18}F

Metabolic model

Voor stralingshygiënische doeleinden wordt aangenomen dat fluor na opname in het bloed volledig in het bot wordt opgenomen.
Gezien de korte fysische halveringstijd van ^{18}F (110 minuten) is de biologische halveringstijd van geen belang.

Ingestion and lung clearance classes

Ingestie		
Alle verbindingen	$f_1 = 1$	
Inhalatie		
Afhankelijk	$f_1 = 1$	Klasse S
van	$f_1 = 1$	Klasse M
bindingskation	$f_1 = 1$	Klasse F

Dose conversion coefficient and radiotoxicity equivalent for workers (w) and members of the public (b)

	Ingestie $f_1 = 1$	Inhalatie F	Inhalatie M	Inhalatie S	
$e(50)(w)$	$4,9\times10^{-11}$	$5,4\times10^{-11}$	$8,9\times10^{-11}$	$9,3\times10^{-11}$	Sv/Bq
$A_{Re}(w)$	$2,0\times10^{10}$	$1,9\times10^{10}$	$1,1\times10^{10}$	$1,1\times10^{10}$	Bq
$e(50)(b)$	$4,9\times10^{-11}$	$3,0\times10^{-11}$	$5,7\times10^{-11}$	$6,0\times10^{-11}$	Sv/Bq
$A_{Re}(b)$	$2,0\times10^{10}$	$3,3\times10^{10}$	$1,8\times10^{10}$	$1,7\times10^{10}$	Bq

Data for total body counting (after single intake)

Time (d)	Total body activity (Bq per Bq intake)			
0,25	$1,0\times10^{-1}$	$7,7\times10^{-2}$	$7,7\times10^{-2}$	$7,7\times10^{-2}$
1	$1,1\times10^{-4}$	$6,8\times10^{-5}$	$6,8\times10^{-5}$	$6,8\times10^{-5}$

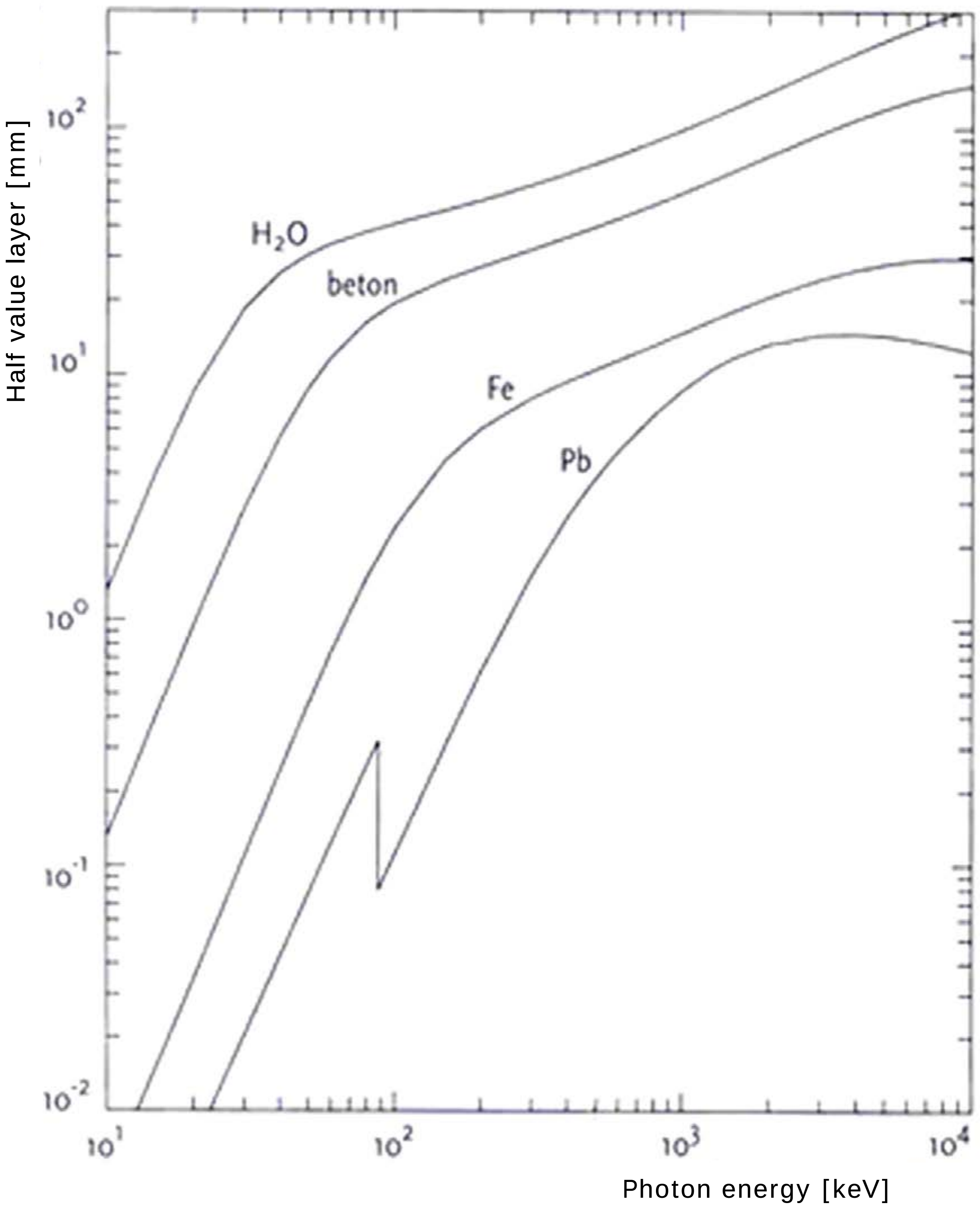


Figure 1: Half-value layer of various shielding materials for narrow beam photon radiation

PLEASE NOTE: Dutch notation of numbers: comma is decimal point

Material	Photon energy [MeV]	μd						
			2	4	7	10	15	20
Water	0,255	3,09	7,14	23,0	72,9	166	456	982
	0,5	2,52	5,14	14,3	38,8	77,6	178	334
	1,0	2,13	3,71	7,68	16,2	27,1	50,4	82,2
	2,0	1,83	2,77	4,88	8,46	12,4	19,5	27,7
	3,0	1,69	2,42	3,91	6,23	8,63	12,8	17,0
Aluminium	0,5	2,37	4,24	9,47	21,5	38,9	80,8	141
	1,0	2,02	3,31	6,57	13,1	21,2	37,9	58,5
	2,0	1,75	2,61	4,62	8,05	11,9	18,7	26,3
	3,0	1,64	2,32	3,78	6,14	8,65	13,0	17,7
Iron	0,5	1,98	3,09	5,98	11,7	19,2	35,4	55,6
	1,0	1,87	2,89	5,39	10,2	16,2	28,3	42,7
	2,0	1,76	2,43	4,13	7,25	10,9	17,6	25,1
	3,0	1,55	2,15	3,51	5,85	8,51	13,5	19,1
Lead	0,5	1,24	1,42	1,69	2,00	2,27	2,65	2,73
	1,0	1,37	1,69	2,26	3,02	3,74	4,81	5,86
	2,0	1,39	1,76	2,51	3,66	4,84	6,87	9,00
	3,0	1,34	1,68	2,43	3,75	5,30	8,44	12,3

Figure 2: Build-up factors for an isotropic point source (Bos et al., p. 268)

PLEASE NOTE: Dutch notation of numbers: comma(,) is decimal point (.)

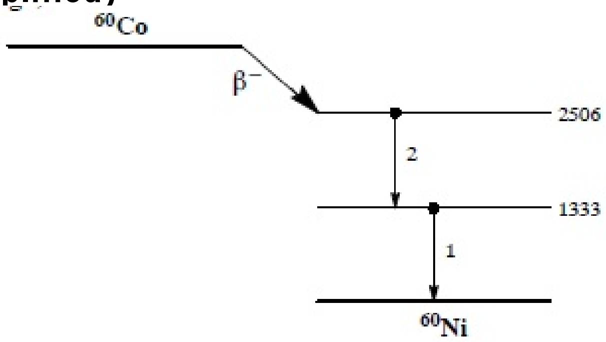
Handboek Radionucliden [Radionuclides Handbook], A.S. Keverling Buisman (2nd edition 2007), pp. 74-75, data on ^{60}Co

^{60}Co Z = 27

Half-life and decay constant

$T_{1/2} = 5{,}272\ j = 1{,}66\times10^8\ s$ $\lambda = 4{,}17\times10^{-9}\ s^{-1}$

Decay scheme (simplified)



Main emitted radiation

Straling	y (Bq·s)$^{-1}$	E (keV)
β^-	0,999	96 | 318
γ_1	1,000	1333
γ_2	0,999	1173

Source constants

Air kerma rate	k = 0,31 µGy/h per MBq/m^2
Ambient dose equivalent rate	h = 0,36 µSv/h per MBq/m^2

Miscellaneous

Specific activity	$A_{sp} = 4{,}18\times10^{13}$ Bq/g
Exemption levels	$C_v = 10^0 = 1$ Bq/g !!
	$A_v = 10^5$ Bq
Skin contamination	$H_{huid} = 3\times10^{-10}$ Sv/s per Bq/cm^2
Wound contamination / injection	$e(50) = 1{,}9\times10^{-8}$ Sv/Bq
Transport	A_1 = 0,4 TBq
	A_2 = 0,4 TBq

Production and applications

Het radionuclide ^{60}Co is een activeringsproduct. Het komt voor als bijproduct in reactoren ten gevolge van de activering van staal. Daarnaast wordt het op velerlei terreinen toegepast. Voorbeelden zijn: radiotherapie, gammagrafie, doorstraling, ijking, demonstratie.

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N = 33 **^{60}Co**

Metabolic model

Voor stralingshygiënische doeleinden wordt aangenomen dat kobalt zich vanuit het bloed als volgt verdeelt: 50% directe uitscheiding, 5% naar lever en 45% naar de rest van het lichaam, met een biologische halveringstijd van 0,5 dag.
De biologische halveringstijden voor de organen zijn:

Fractie	$T_{1/2}$
0,6	6 d
0,2	60 d
0,2	800 d

Ingestion and lung clearance

Ingestie		
Oxide, hydroxide en anorganisch	$f_1 = 0,05$	
Overige verbindingen	$f_1 = 0,1$	
Inhalatie		
Oxide, hydroxide, halogenide, nitraat	$f_1 = 0,05$	Klasse S
Overige	$f_1 = 0,1$	Klasse M

Dose conversion coefficient and radiotoxicity equivalent for workers (w) and members of the public (b)

	Ingestie	Ingestie	Inhalatie	Inhalatie	
	$f_1 = 0,05$	$f_1 = 0,1$	M	S	
$e(50)$(w)	$2,5\times10^{-9}$	$3,4\times10^{-9}$	$7,1\times10^{-9}$	$1,7\times10^{-8}$	Sv/Bq
A_{Re}(w)	$4,0\times10^{8}$	$2,9\times10^{8}$	$1,4\times10^{8}$	$5,9\times10^{7}$	Bq
$e(50)$(b)	$2,5\times10^{-9}$	$3,4\times10^{-9}$	$9,6\times10^{-9}$	$2,9\times10^{-8}$	Sv/Bq
A_{Re}(b)	$4,0\times10^{8}$	$2,9\times10^{8}$	$1,0\times10^{8}$	$3,4\times10^{7}$	Bq

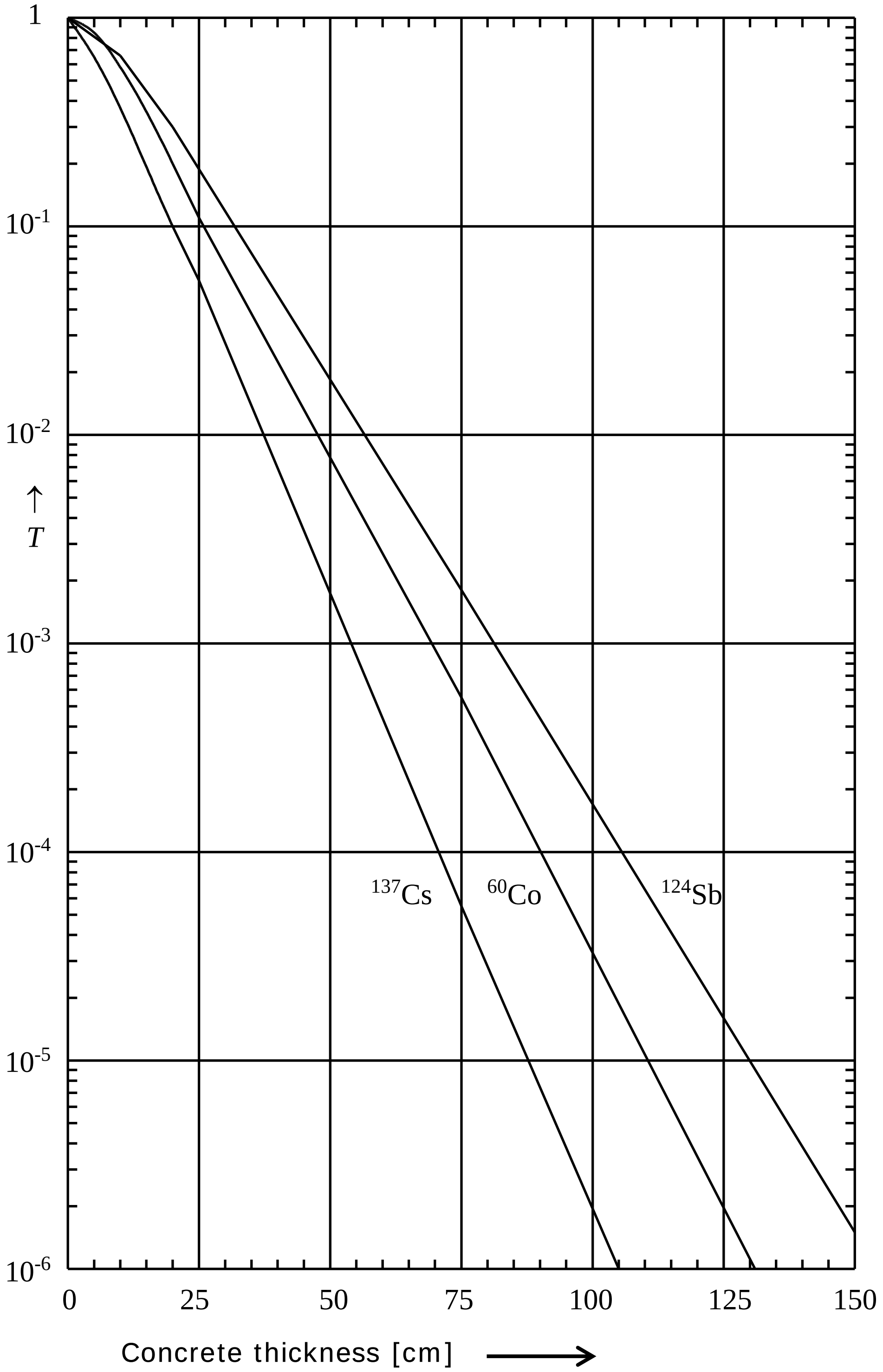
Data for total body counting

Time (d)	Total body activity (Bq per Bq intake)			
0,25	$9,9\times10^{-1}$	$9,9\times10^{-1}$	$7,4\times10^{-1}$	$7,4\times10^{-1}$
1	$7,1\times10^{-1}$	$7,1\times10^{-1}$	$4,9\times10^{-1}$	$4,9\times10^{-1}$
2	$3,4\times10^{-1}$	$3,5\times10^{-1}$	$2,6\times10^{-1}$	$2,5\times10^{-1}$
3	$1,5\times10^{-1}$	$1,6\times10^{-1}$	$1,5\times10^{-1}$	$1,4\times10^{-1}$
5	$3,7\times10^{-2}$	$5,6\times10^{-2}$	$9,1\times10^{-2}$	$8,0\times10^{-2}$
7	$2,0\times10^{-2}$	$3,7\times10^{-2}$	$7,8\times10^{-2}$	$6,9\times10^{-2}$

Annex 1.3 to the Radiation Protection Implementing Regulation (Economic Affairs): Activity values above which a sealed source meets the definition of a high-activity source.

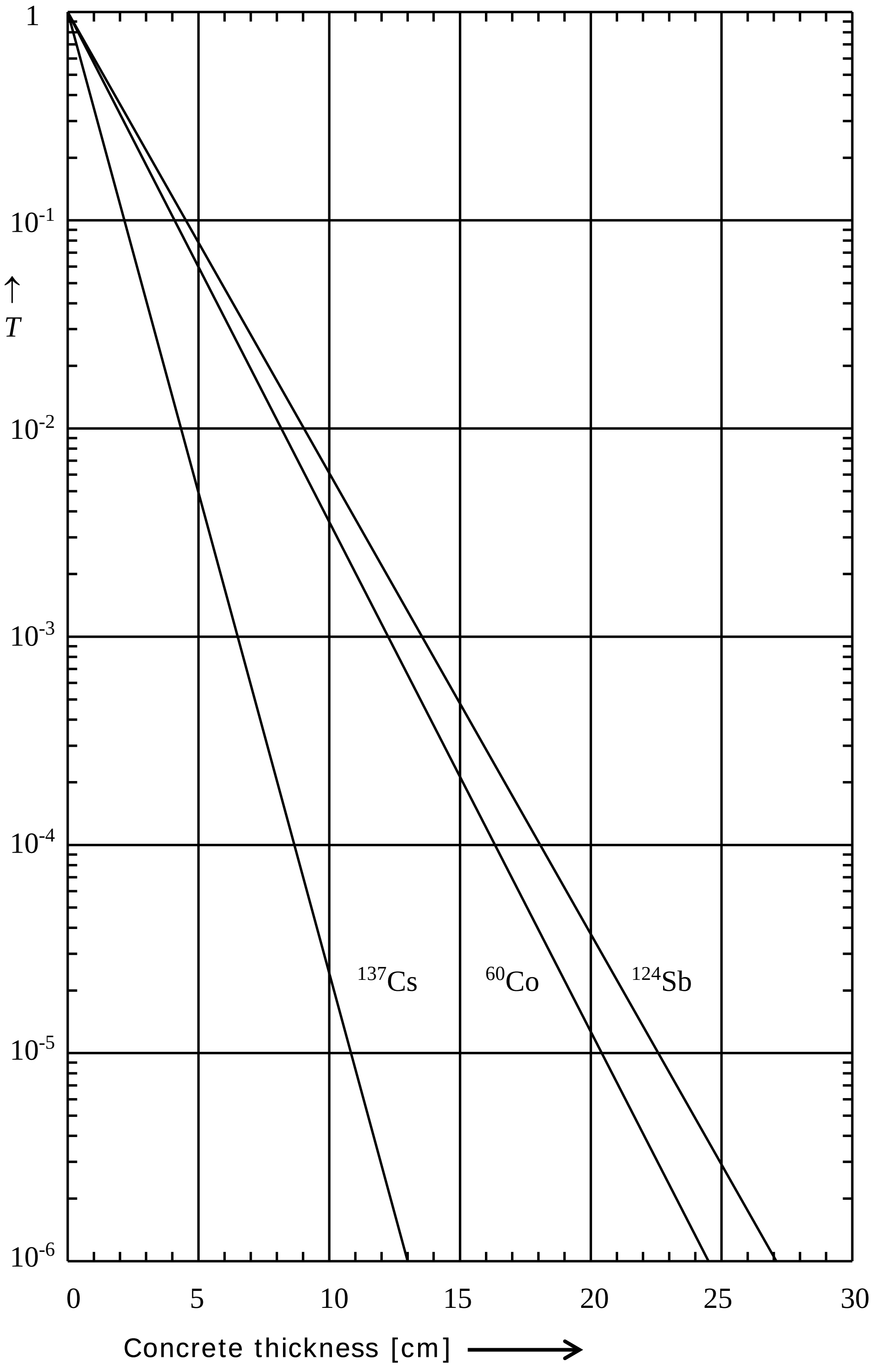
Element (atomic number)	Radionuclide	Activity level (Bq)
Iron (26)	Fe-55	4×10^{11}
Cobalt (27)	Co-60	4×10^{9}
Selenium (34)	Se-75	3×10^{10}
Krypton (36)	Kr-85	1×10^{11}
Strontium (38)	Sr-90 a	3×10^{9}
Palladium (46)	Pd-103 a	4×10^{11}
Iodine (53)	I-125	2×10^{11}
Caesium (55)	Cs-137 a	2×10^{10}
Promethium (61)	Pm-147	4×10^{11}
Gadolinium (64)	Gd-153	1×10^{11}
Thulium (69)	Tm-170	3×10^{10}
Iridium (77)	Ir-192	1×10^{10}
Thallium (81)	Tl-204	1×10^{11}
Radium (88)	Ra-226 b	2×10^{9}
Plutonium (94)	Pu-238 a	1×10^{11}
Americium (95)	Am-241 b	1×10^{11}
Californium (98)	Cf-252	5×10^{8}
a In the activity level the contribution of daughter nuclides with a half-life of less than ten days is included. b including neutron sources with beryllium		

Broad beam transmission of gamma rays from various radionuclides through concrete



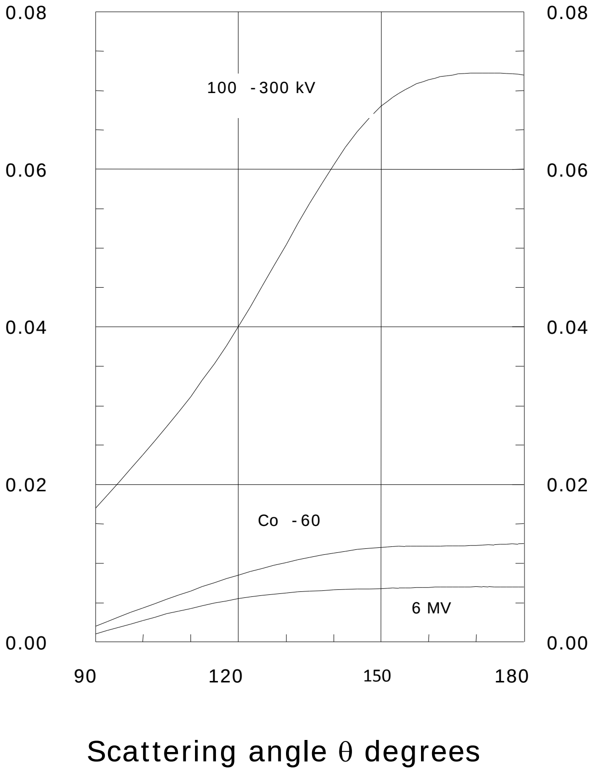
Broad beam transmission T of gamma rays from radionuclides through concrete ρ =2350 kg·m^{-3}

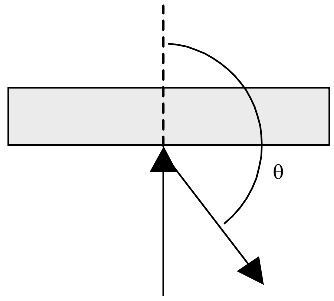
Broad beam transmission of gamma rays from various radionuclides through lead



Broad beam transmission T of gamma rays from radionuclides through lead ρ =11350 kg·m^{-3}

Scatter fraction of incident kerma rate
At 1 meter in percent per 100 cm^2 irradiated concrete surface





Scattering angle θ

Handbook Radionucliden [Radionuclides Handbook], A.S. Keverling Buisman (2nd edition 2007), pp. 228-9, data on ^{210}Po

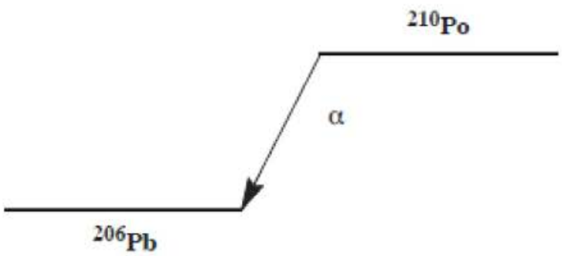
^{210}Po Z = 84

Half-life and decay constant

$T_{1/2}$ = 138,38 d = 1,20×10^{7} s

λ = 5,80×10^{-8} s^{-1}

Decay scheme (simplified)



Main emitted radiation

Straling	y (Bq·s)$^{-1}$	E (keV)
α	1,000	5297
α recoil	1,000	103

Miscellaneous

Specific activity	A_{sp} = 1,66×10^{14} Bq/g
Exemption levels	C_v = 10^{2} Bq/g en A_v = 10^{4} Bq
Skin contamination	H_{huid} < 10^{-14} Sv/s per Bq/cm^{2}
Wound contamination / injection	$e(50)$ = 2,4×10^{-6} Sv/Bq
Transport	A_1 = 40 TBq
	A_2 = 0,02 TBq

Production and applications

Het radionuclide ^{210}Po is een natuurproduct. Het komt voor in de uraniumvervalreeks. De vluchtigheid van polonium maakt dat het nuclide vrijkomt bij processen waarbij stoffen met (sporen) uranium verhit worden.
Grotere hoeveelheden ^{210}Po kunnen worden geproduceerd door bestraling van bismuth met neutronen. In 2006 is bekend geworden dat dit nuclide onder spionnen als effectieve gifstof toepassing vindt. Een inname van enkele microgrammen is al dodelijk (hoge specifieke activiteit, hoge radiotoxiciteit, opname in essentiële organen).

N = 126 ^{210}Po

Metabolic model

For health physics purposes it is assumed that polonium is distributed from the blood as follows: 30% to the liver, 10% to the kidney, 5% to the milt, 10% to red bone marrow en the rest to the remaining organs/tissues. The biological half-life is set at 50 days.

Ingestion and lung clearance

Ingestie		
Alle verbindingen	$f_1 = 0{,}1$	
Inhalatie		
Als natuurlijke (rest)stof	$f_1 = 0{,}01$	Klasse S
Hydroxide, oxide, nitraat	$f_1 = 0{,}1$	Klasse M
Overige verbindingen	$f_1 = 0{,}1$	Klasse F

Dose conversion coefficient and radiotoxicity equivalent for workers (w) and members of the public (b)

	Ingestie	Inhalatie	Inhalatie	Inhalatie	
	$f_1 = 0{,}1$	F	M	S	
$e(50)(w)$	$2{,}4\times10^{-7}$	$7{,}1\times10^{-7}$	$2{,}2\times10^{-6}$	$3{,}2\times10^{-6}$	Sv/Bq
$A_{Re}(w)$	$4{,}2\times10^{6}$	$1{,}4\times10^{6}$	$4{,}5\times10^{5}$	$3{,}1\times10^{5}$	Bq
$e(50)(b)$	$2{,}4\times10^{-7}$	$6{,}0\times10^{-7}$	$3{,}0\times10^{-6}$	$4{,}3\times10^{-6}$	Sv/Bq
$A_{Re}(b)$	$4{,}2\times10^{6}$	$1{,}7\times10^{6}$	$3{,}3\times10^{5}$	$2{,}3\times10^{5}$	Bq

Data for urine analysis (after single intake)

Time (d)	Urine concentration (Bq/day per Bq intake)			
1	$1{,}9\times10^{-4}$	$7{,}8\times10^{-4}$	$1{,}5\times10^{-4}$	$8{,}3\times10^{-6}$
2	$4{,}3\times10^{-4}$	$1{,}3\times10^{-3}$	$2{,}9\times10^{-4}$	$1{,}9\times10^{-5}$
3	$4{,}4\times10^{-4}$	$1{,}3\times10^{-3}$	$3{,}0\times10^{-4}$	$2{,}0\times10^{-5}$
5	$4{,}3\times10^{-4}$	$1{,}3\times10^{-3}$	$2{,}9\times10^{-4}$	$1{,}9\times10^{-5}$
7	$4{,}1\times10^{-4}$	$1{,}2\times10^{-3}$	$2{,}9\times10^{-4}$	$1{,}9\times10^{-5}$

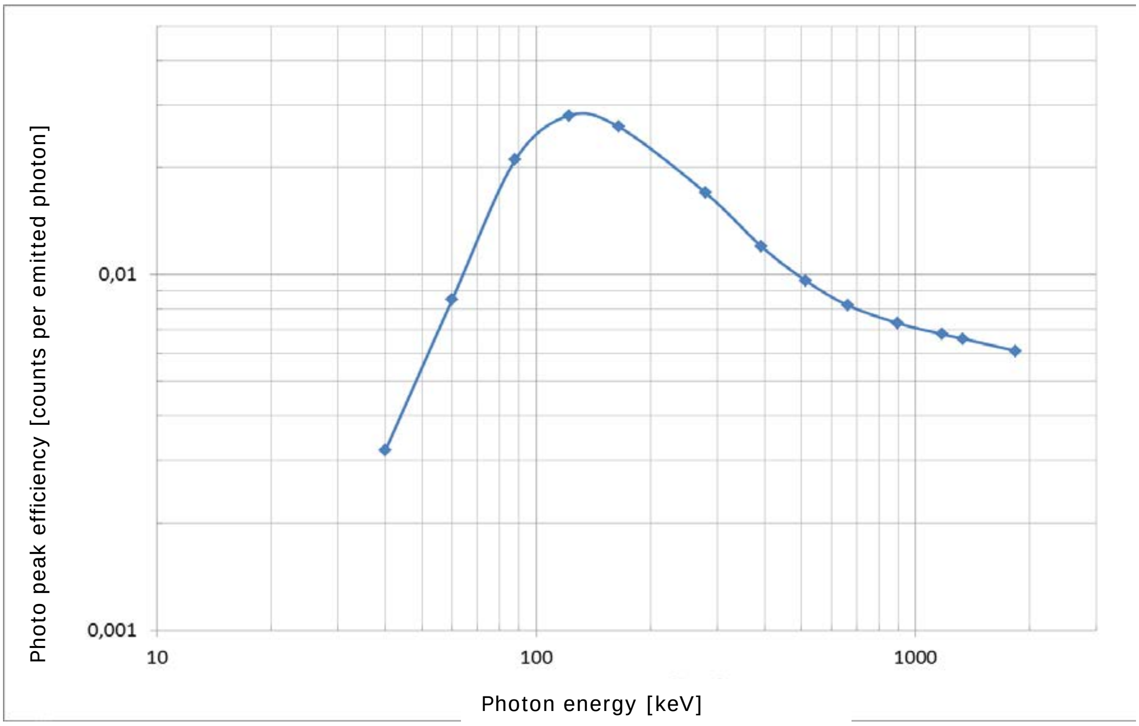


Figure 3: Efficiency calibration for the HPGe detector in the measuring conditions used (photo peak efficiency in counts per emitted photon)

PLEASE NOTE: comma indicates decimal point!

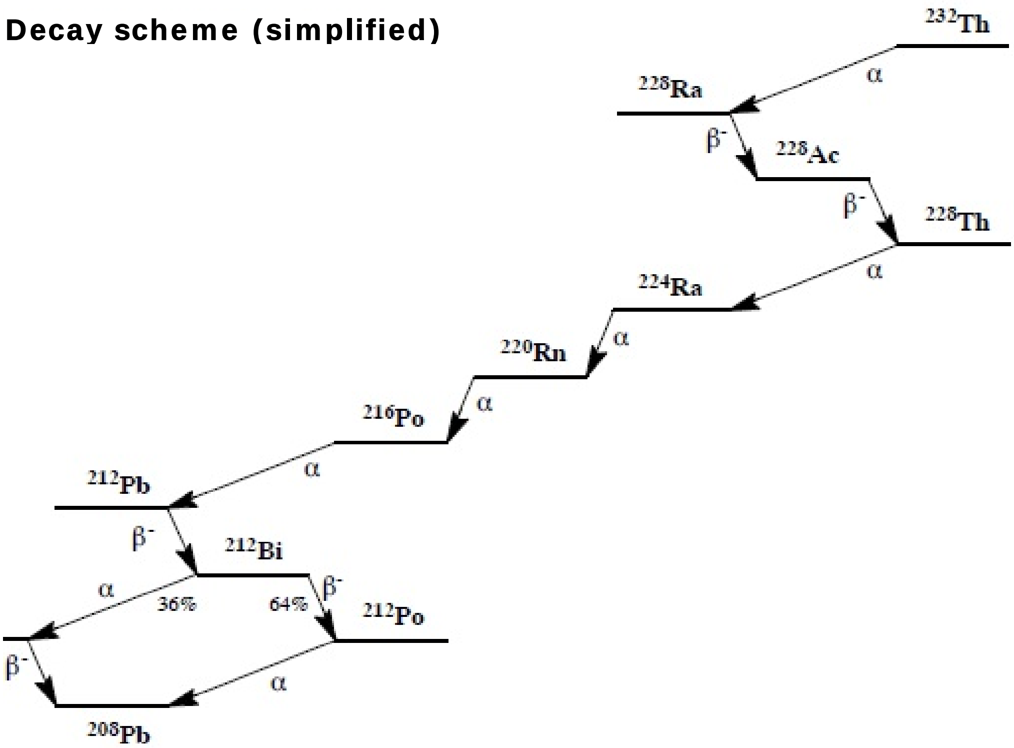
Handboek Radionucliden [Radionuclides Handbook], A.S. Keverling Buisman (2nd edition 2007), pp. 232-233, data on ^{232}Th

^{232}Th (+ dochters) Z = 90

Half-life and decay constant

$T_{1/2} = 1{,}405\times10^{10}$ j $= 4{,}43\times10^{17}$ s $\qquad \lambda = 1{,}56\times10^{-18}$ s^{-1}

Decay scheme (simplified)



Source constants (including daughter nuclides)

Air kerma rate	k = 0,41 µGy/h per MBq/m^2
Ambient dose equivalent rate	h = 0,36 µSv/h per MBq/m^2

Miscellaneous

Specific activity	A_{sp} = $4{,}06\times10^3$ Bq/g
Exemption levels	C_v = 10^1 Bq/g en A_v = 10^4 Bq
In equilibrium with all daughters	C_v = 10^0 = 1 Bq/g en A_v = 10^3 Bq
Skin contamination	H_{huid} = $1{,}5\times10^{-9}$ Sv/s per Bq/cm^2
Wound contamination / injection	$e(50)$ = $2{,}6\times10^{-3}$ Sv/Bq (incl. dochters)
Transport	A_1 = onbeperkt
	A_2 = onbeperkt

N = 142 **^{232}Th**

Production and applications

Het radionuclide ^{232}Th is een natuurproduct. Het komt voor in ertsen. Het wordt gerekend tot de splijtstoffen, omdat het door neutronenvangst in het splijtbare U-233 wordt omgezet. Vanwege zijn grote lichtopbrengst bij verhitting, gekoppeld aan een hoog smeltpunt, vindt thorium toepassing als gaskousje.

Half value life and most important emitted radiation

Radionuclide	$T_{1/2}$	E_α (keV)	$E_{\beta,gem}$ (keV)	$E_{\beta,max}$ (keV)	E_γ (keV)
^{232}Th	$1{,}4\times10^{10}$ j	4010; 3952			
^{228}Ra	5,75 j		10	39	
^{228}Ac	6,13 h		386	1168	338
			611	1741	911
			748	2079	969
^{228}Th	1,91 j	5423; 5340			84
^{224}Ra	3,64 d	5686			241
^{220}Rn	55,6 s	6288			
^{216}Po	0,15 s	6779			
^{212}Pb	10,64 h		94	334	239
			173	573	
^{212}Bi	60,6 min	6051	832	2246	727
^{212}Po (64%)	304 ns	8785			
^{208}Tl (36%)	3,07 min		439	1284	2615
			532	1517	583
			647	1794	

Dose conversion coefficient and radiotoxicity equivalent for workers (w) and members of the public (b) for natural thorium in equilibrium with all daughters

	Ingestie	Inhalatie	
	$f_1 = 2\times10^{-4}$	S	
$e(50)(w)$	$9{,}0\times10^{-7}$	$6{,}0\times10^{-5}$	Sv/Bq
$A_{Re}(w)$	$1{,}1\times10^{6}$	$1{,}7\times10^{4}$	Bq
$e(50)(b)$	$9{,}0\times10^{-7}$	$8{,}2\times10^{-5}$	Sv/Bq
$A_{Re}(b)$	$1{,}1\times10^{6}$	$1{,}2\times10^{4}$	Bq

Handboek Radionucliden [Radionuclides Handbook], A.S. Keverling Buisman (2nd edition 2007), pp. 234-235, data on ^{238}U

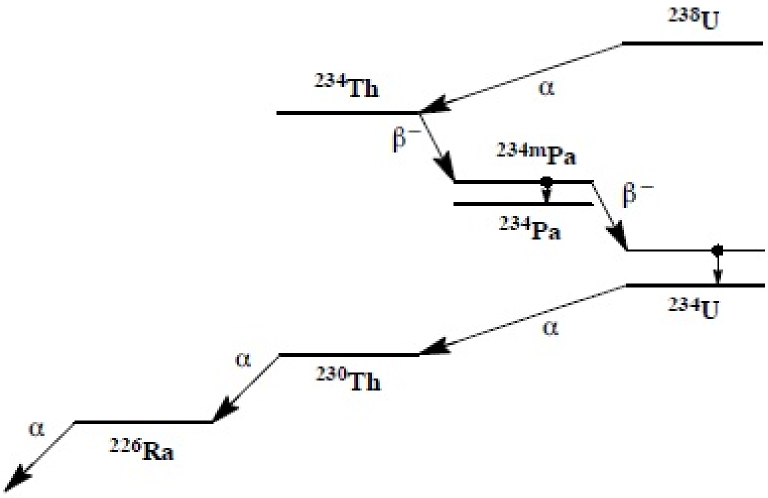
^{238}U (+ dochters) Z = 92

Half-life and decay constant

$T_{1/2} = 4{,}468\times10^{9}$ j $= 1{,}41\times10^{17}$ s

$\lambda = 4{,}92\times10^{-18}$ s^{-1}

Decay scheme (simplified)



Source constants (including daughter nuclides)

Air kerma rate	k = 0,28 µGy/h per MBq/m^2
Ambient dose equivalent rate	h = 0,26 µSv/h per MBq/m^2

Miscellaneous

Specific activity	A_{sp} = $1{,}24\times10^{4}$ Bq/g
Exemption levels	C_v = 10^1 Bq/g en A_v = 10^4 Bq
In equilibrium with all daughters	C_v = 10^0 = 1 Bq/g en A_v = 10^3 Bq
Skin contamination	H_{huid} = 7×10^{-10} Sv/s per Bq/cm^2
Wound contamination / injection	$e(50)$ = $4{,}1\times10^{-6}$ Sv/Bq (incl. dochters)
Transport	A_1 = onbeperkt
	A_2 = onbeperkt

Production and applications

Het radionuclide ^{238}U is een natuurproduct. Van alle uraniumisotopen is ^{238}U de meest voorkomende: 99,3%. De overige natuurlijke U-isotopen zijn ^{235}U (0,72 massaprocent) en ^{234}U (0,0055 massaprocent).

N = 146 **^{238}U**

Half value life and most important emitted radiation

Radionuclide	$T_{1/2}$	E_α (keV)	$E_{\beta,gem}$ (keV)	$E_{\beta,max}$ (keV)	E_γ (keV)
^{238}U	$4,47\times10^9$ j	4198			
^{234}Th	24,10 d		51	186	93
			25	96	
^{234m}Pa	1,17 min		825	2281	1001; 767
^{234}U	$2,45\times10^5$ j	4773; 4721			
^{230}Th	$7,7\times10^4$ j	4688; 4621			
^{226}Ra	1600 j	4784			

More: See ^{226}Ra

Dose conversion coefficient and radiotoxicity equivalent for workers (w) and members of the public (b)

	Ingestie U-nat	Ingestie ^{238}U+	Inhalatie U-nat	Inhalatie ^{238}U+	
$e(50)(w)$	$1,6\times10^{-6}$	$4,0\times10^{-7}$	$4,2\times10^{-5}$	$2,6\times10^{-5}$	Sv/Bq
$A_{Re}(w)$	$6,3\times10^5$	$2,5\times10^6$	$2,4\times10^4$	$3,8\times10^4$	Bq
$e(50)(b)$	$1,6\times10^{-6}$	$4,0\times10^{-7}$	$5,7\times10^{-5}$	$3,7\times10^{-5}$	Sv/Bq
$A_{Re}(b)$	$6,3\times10^5$	$2,5\times10^6$	$1,8\times10^4$	$2,7\times10^4$	Bq

– U-nat: Natural uranium with all daughters in radiological equilibrium, plus ^{235}U with daughters

– ^{238}U+: Uranium-238 with short lived daughters (^{234}Th and ^{234m}Pa) plus ^{235}U and ^{234}U

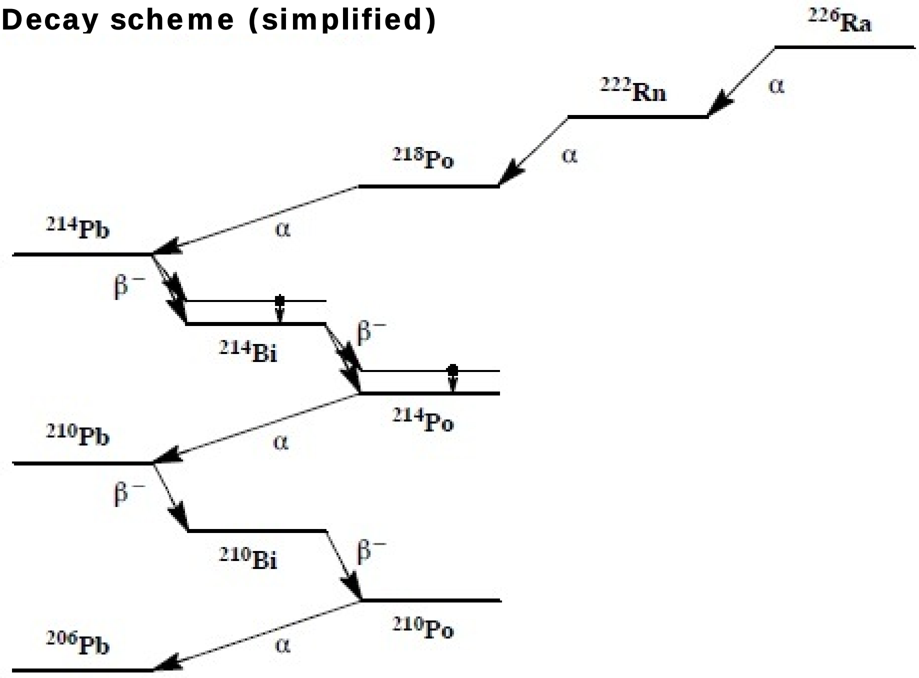
Handboek Radionucliden [Radionuclides Handbook], A.S. Keverling Buisman (2nd edition 2007), pp. 230-231, data on ^{226}Ra

^{226}Ra (+ dochters) Z = 88

Half-life and decay constant

$T_{1/2}$ = 1,60×10^3 j = 5,05×10^{10} s λ = 1,37×10^{-11} s^{-1}

Decay scheme (simplified)



Source constants (including daughter nuclides)

Air kerma rate	k = 0,28 µGy/h per MBq/m^2
Ambient dose equivalent rate	h = 0,26 µSv/h per MBq/m^2

Miscellaneous (including daughter nuclides)

Specific activity (only ^{226}Ra)	A_{sp} = 3,7×10^{10} Bq/g (1 g Ra ≡ 1 Ci !)
Exemption levels	C_v = 10^0 = 1 Bq/g en A_v = 10^4 Bq
Skin contamination	H_{huid} = 6×10^{-10} Sv/s per Bq/cm^2
Wound contamination / injection	$e(50)$ = 4,3×10^{-6} Sv/Bq
Transport	A_1 = 0,2 TBq en A_2 = 0,003 TBq

Production and applications

Het radionuclide ^{226}Ra is een natuurproduct. Het komt voor in de uraniumvervalreeks. Er is een reeks van toepassingen geweest, toen het nuclide de enige radioactieve stof was

230

N = 138

^{226}Ra

met een aanzienlijke activiteit. Toepassingen waren: radiotherapie, lichtgevende verf, bliksemafleiders, medische kwakzalverij. Vanwege de hoge radiotoxiciteit is het langzamerhand verdrongen door minder toxische radionucliden.

Half value life and most important emitted radiation

Radionuclide	$T_{1/2}$	E_α (keV)	$E_{\beta,gem}$ (keV)	$E_{\beta,max}$ (keV)	E_γ (keV)
^{226}Ra	1600 j	4784			
^{222}Rn	3,82 d	5490			
^{218}Po	3,05 min	6003			
^{214}Pb	26,8 min		207	672	352
			227	729	295
^{214}Bi	19,9 min		525	1505	609
			539	1540	1120
			1269	3270	1765
^{214}Po	0,164 ms	7687			
^{210}Pb *	22,3 j		4	16	46
			16	63	
^{210}Bi	5,01 d		389	1161	
^{210}Po *	138,4 d	5297			

* Deze radionucliden zijn tevens apart opgenomen (zie aldaar).

Ingestion and lung clearance classes

Ingestie		
Alle verbindingen	$f_1 = 0,2$	
Inhalatie		
Als natuurlijke (rest)stof	$f_1 = 0,01$	Klasse S
Overige verbindingen	$f_1 = 0,2$	Klasse M

Dose conversion coefficient and radiotoxicity equivalent for workers (w) and members of the public (b)

	Ingestie $f_1 = 0,2$	Inhalatie M*	Inhalatie S*	Inhalatie S**	
$e(50)(w)$	$2,8\times10^{-7}$	$2,2\times10^{-6}$	$7,9\times10^{-6}$	$4,0\times10^{-5}$	Sv/Bq
$A_{Re}(w)$	$3,6\times10^{6}$	$4,5\times10^{5}$	$1,3\times10^{5}$	$2,5\times10^{4}$	Bq
$e(50)(b)$	$2,8\times10^{-7}$	$3,5\times10^{-6}$	$9,5\times10^{-6}$	$5,0\times10^{-5}$	Sv/Bq
$A_{Re}(b)$	$3,6\times10^{6}$	$2,9\times10^{5}$	$1,1\times10^{5}$	$2,0\times10^{4}$	Bq

* aangenomen dat dochter ^{222}Rn grotendeels ontsnapt uit het ingeademde deeltje

** aangenomen dat het ^{222}Rn niet ontsnapt uit het ingeademde deeltje en met alle dochters in radiologisch evenwicht