ATTACHMENT for Exam
Radiation protection expert on the level of coordinating expert

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Nuclear Research and consultancy Group	NRG
Delft University of Technology	TUD
University of Groningen	RUG
Radboudumc	RUMC

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exam date:
May 10th 2021
exam duration: 13.30 - 16.30 hours

Instructions:

- If you use any data other than the data mentioned in this attachment, state the origin!
- This attachment consists of 10 consecutively numbered pages.
  Check this!

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Handboek Radionucliden, A.S. Keverling Buisman (3rd edition 2007), pg. 164 and 165, ^{131}I data

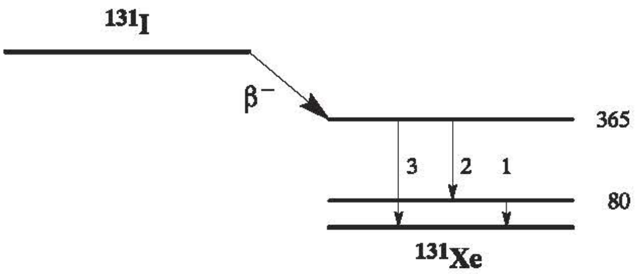
^{131}I

Z = 53

Half-life and decay constant

$T_{1/2}$ = 8,021 d = 6,93×10^{5} s λ = 1,00×10^{-6} s^{-1}

Decay scheme (simplified)



Main emitted radiation

Straling	y (Bq·s)$^{-1}$	E (keV)
β^-	0,894	192 | 606
γ_1	0,026	80
ce K γ_1	0,036	46
γ_2	0,061	284
γ_3	0,812	365

Source constants

Air kerma rate	k = 0,052 μGy/h per MBq/m^2
Ambient dose equivalent rate	h = 0,066 μSv/h per MBq/m^2

Miscellaneous

Specific activity	A_{sp} = 4,60×10^{15} Bq/g
Exemption levels	C_v = 10^2 Bq/g en A_v = 10^6 Bq
Skin contamination	H_{huid} = 4×10^{-10} Sv/s per Bq/cm^2
Wound contamination / injection	$e(50)$ = 2,2×10^{-8} Sv/Bq
Transport	A_1 = 3 TBq
	A_2 = 0,7 TBq

Productie en toepassingen

Het radionuclide ^{131}I is een belangrijk splijtingsproduct. Het wordt veelvuldig toegepast in de diagnostische en therapeutische nucleaire geneeskunde.

N = 78 ^{131}I

Metabolic Model
For radiation protection purposes, it is assumed that iodine distributes itself from the blood as follows: 70% direct excretion and 30% to the thyroid. Iodine in the thyroid remains there with a biological half-life of 80 days and from there it is homogeneously distributed throughout the body in the form of organic iodine. It remains in other organs/tissue with a half-life of 12 days. A tenth of the organic iodine is immediately excreted in faeces, while the rest (90%) is returned to the transfer compartment. In this way, the biological half-life in the thyroid is effectively equal to 90 days.
N.B. This model does not apply to patients; see page 14.

Ingestion and lung clearance classes

Ingestie		
Alle verbindingen	$f_1 = 1$	
Inhalatie		
Damp (I_2)	$f_1 = 1$	Klasse SR-1
Damp (CH_3I)	$f_1 = 1$	Klasse SR-1 70% depositie
Overige verbindingen	$f_1 = 1$	Klasse F

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

	Ingestie	Inhalatie	Inhalatie	Inhalatie	
	$f_1 = 1$	F	I_2	CH_3I	
$e(50)(w)$	$2{,}2\times10^{-8}$	$1{,}1\times10^{-8}$	$2{,}0\times10^{-8}$	$1{,}5\times10^{-8}$	Sv/Bq
$A_{Re}(w)$	$4{,}5\times10^{7}$	$9{,}1\times10^{7}$	$5{,}0\times10^{7}$	$6{,}7\times10^{7}$	Bq
$e(50)(b)$	$2{,}2\times10^{-8}$	$7{,}6\times10^{-9}$	$2{,}0\times10^{-8}$	$1{,}5\times10^{-8}$	Sv/Bq
$A_{Re}(b)$	$4{,}5\times10^{7}$	$1{,}3\times10^{8}$	$5{,}0\times10^{7}$	$6{,}7\times10^{7}$	Bq

Data for thyroid count (after single intake)

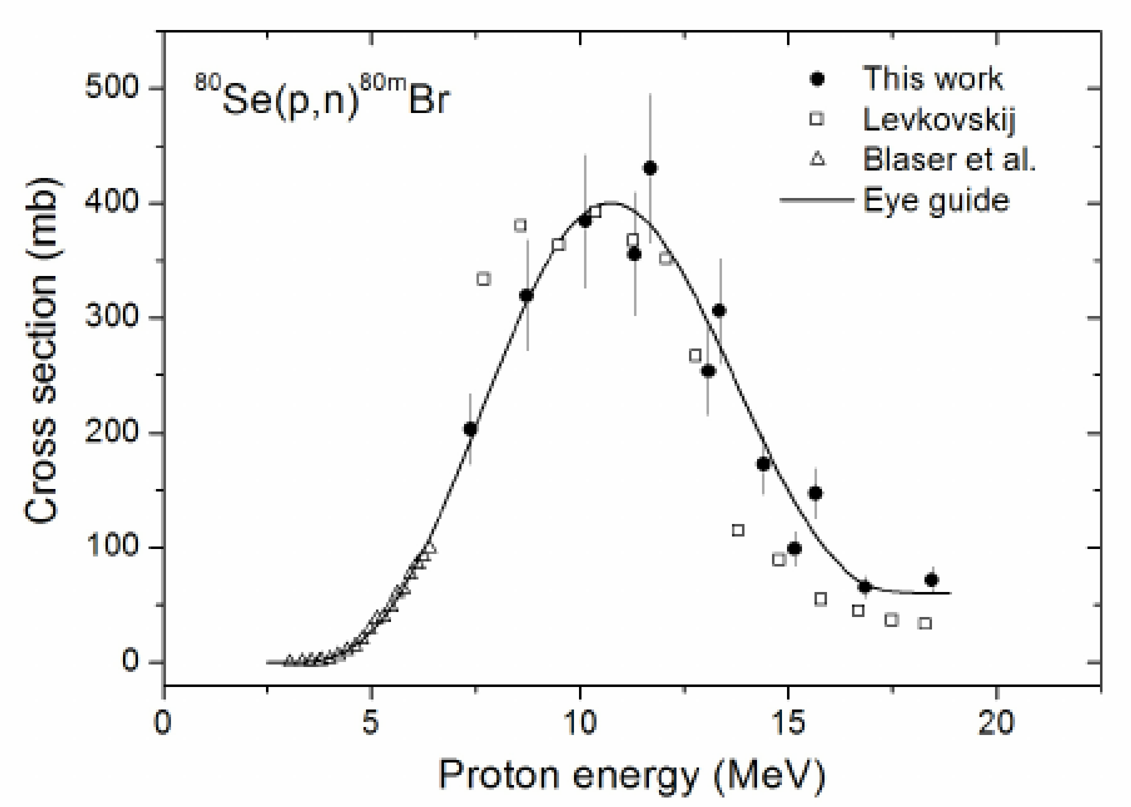
Time (d)	Activity in Thyroid (Bq per Bq intake)			
	$f_1 = 1$	F	I_2	CH_3I
0,25	$6{,}0\times10^{-2}$	$5{,}2\times10^{-2}$	$1{,}1\times10^{-1}$	$1{,}0\times10^{-1}$
1	$2{,}4\times10^{-1}$	$1{,}2\times10^{-1}$	$2{,}3\times10^{-1}$	$1{,}8\times10^{-1}$
2	$2{,}5\times10^{-1}$	$1{,}2\times10^{-1}$	$2{,}2\times10^{-1}$	$1{,}7\times10^{-1}$
3	$2{,}3\times10^{-1}$	$1{,}1\times10^{-1}$	$2{,}0\times10^{-1}$	$1{,}6\times10^{-1}$
5	$1{,}9\times10^{-1}$	$9{,}0\times10^{-2}$	$1{,}7\times10^{-1}$	$1{,}3\times10^{-1}$
7	$1{,}6\times10^{-1}$	$7{,}5\times10^{-2}$	$1{,}4\times10^{-1}$	$1{,}1\times10^{-1}$

Tissue weighting factors (w_T) for weighing the equivalent dose H_T, from ICRP-60 and ICRP-103.

Organ/tissue	w_T (ICRP-60)	w_T (ICRP-103)
Gonads (reproductive organs)	0.20	0.08
Bone marrow (red)	0.12	0.12
Large intestine	0.12	0.12
Lungs	0.12	0.12
Stomach	0.12	0.12
Bladder	0.05	0.04
Breast tissues	0.05	0.12
Liver	0.05	0.04
Esophagus	0.05	0.04
Thyroid	0.05	0.04
Skin	0.01	0.01
Bone surface	0.01	0.01
Salivary glands		0.01
Brain		0.01
Other organs / tissues	0.05[1]	0.12[2]
Total body	1.00	1.00

[1] Other: Adrenal glands, extrathoracic region, gallbladder, heart, kidneys, lymph nodes, muscles, oral mucosa, pancreas, prostate (men), small intestine, spleen, thymus, uterus/cervix (women)
In those cases where one of the other organs or tissues receives an equivalent dose which exceeds one of the twelve organs/tissue mentioned in the ICRP-60, a weighing factor of 0.025 should be assigned to that organ and a weighing factor of 0.025 to the average dose in the remaining other organs
[2] The w_T for other tissues (0.12) applies to the arithmetic mean of the dose of the following 13 organs and tissues of each sex. Other tissue: adrenal glands, extrathoracic region, gallbladder, heart, kidneys, lymph nodes, muscles, oral mucosa, pancreas, prostate (men), small intestine, spleen, thymus, uterus/cervix (women).

Cross section of the nuclear reaction $^{80}Se(p,n)^{80m}Br$ in mbarn (mb).
[from https://www.researchgate.net/figure/Experimentally-determined-cross-sections-for-the-formation-of-80m-Br-together-with-data_fig3_235352989]



Broad beam transmission of photons (X-rays) through concrete (adopted from ICRP-33)

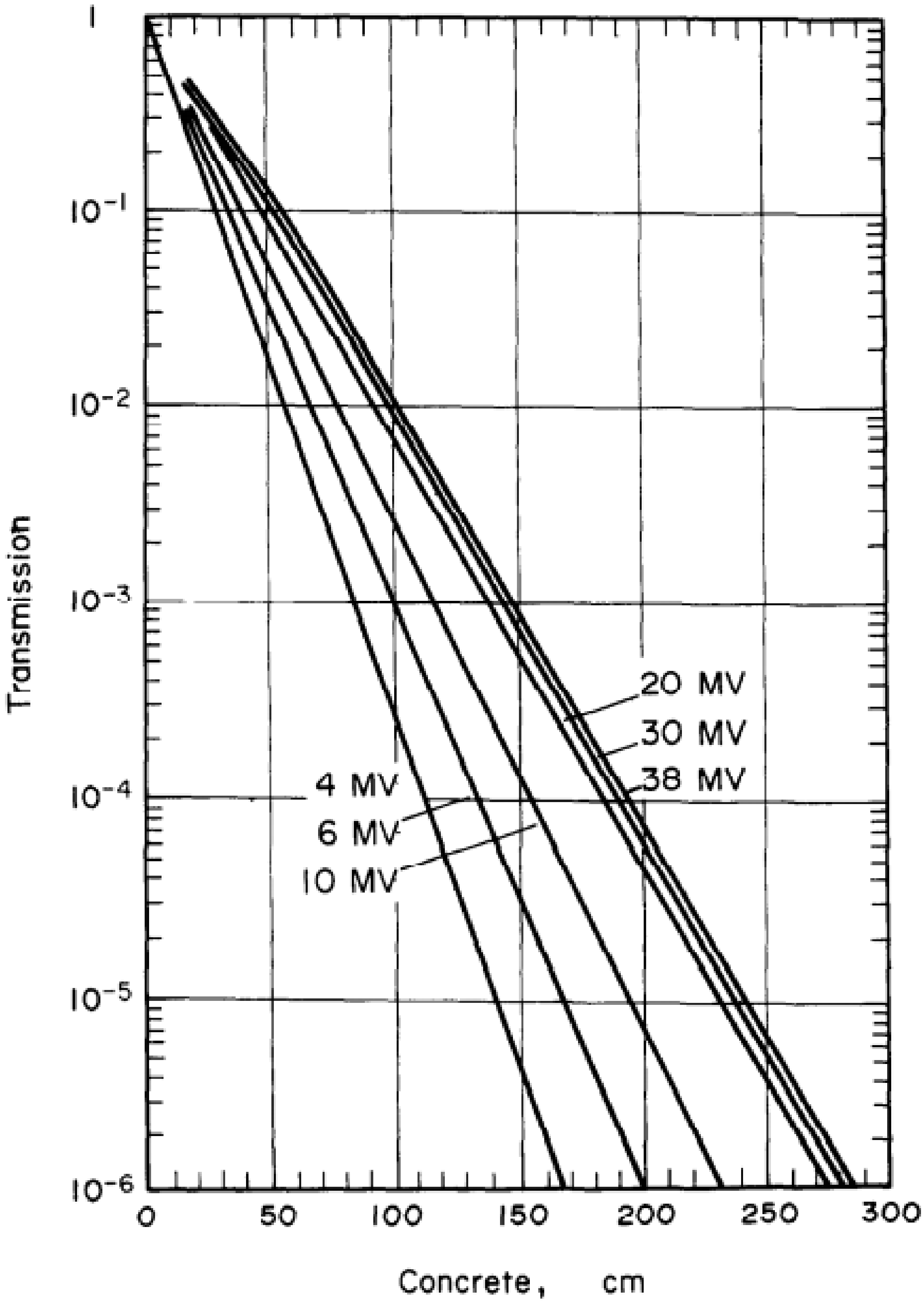
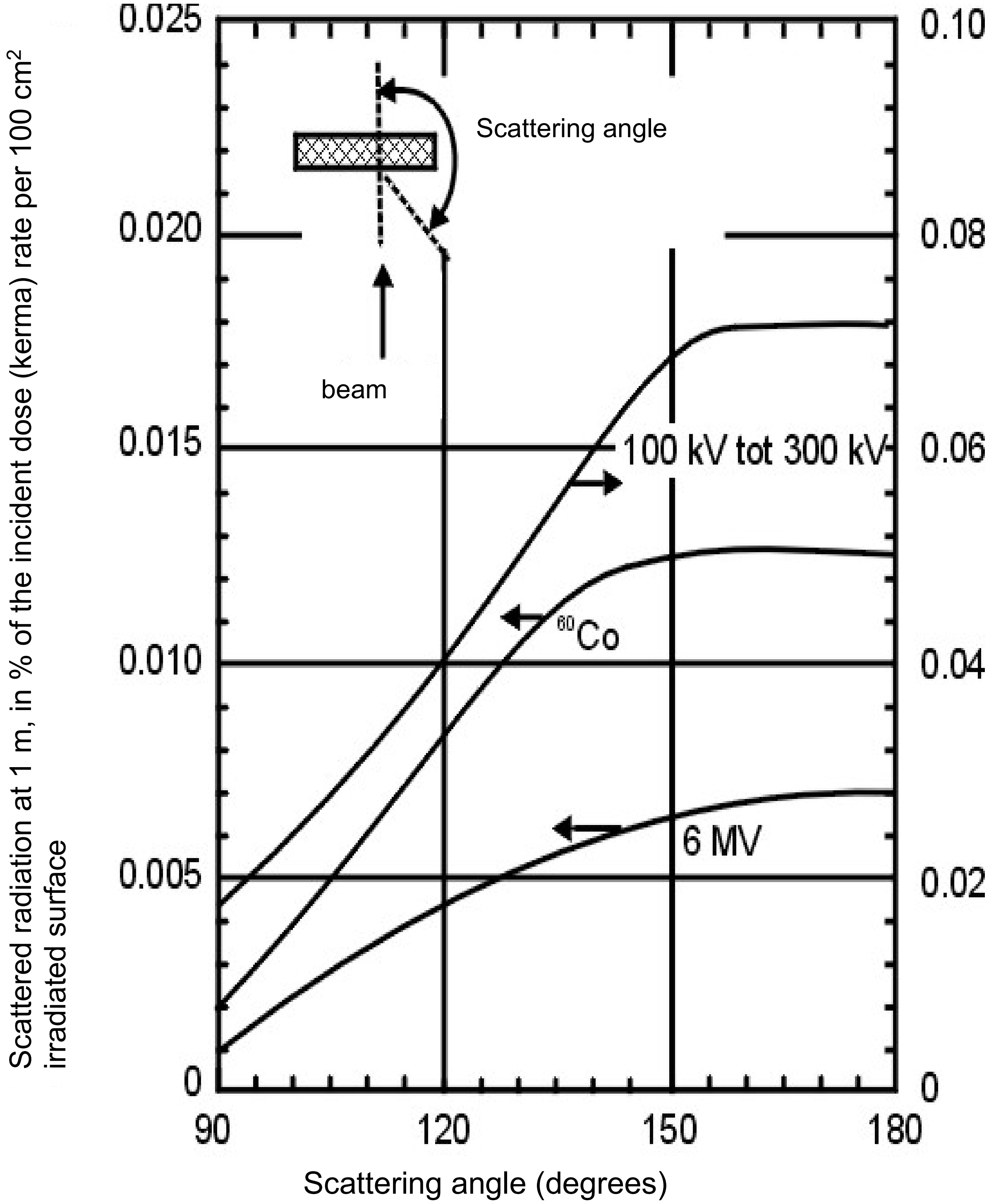


Fig. 13. Broad-beam transmission of x rays through concrete, density 2 350 kg m^{-3}. 4 MV: linear accelerator; 1 mm gold target followed by 20 mm aluminium beam flattener. 6–38 MV: Betatron; target and filtration not stated. The 38 MV curve may be used up to 200 MV (Miller and Kennedy, 1956).

Scattering patterns of divergent X-ray and gamma-ray beams incident perpendicular to a flat concrete wall (adopted from ICRP-33)



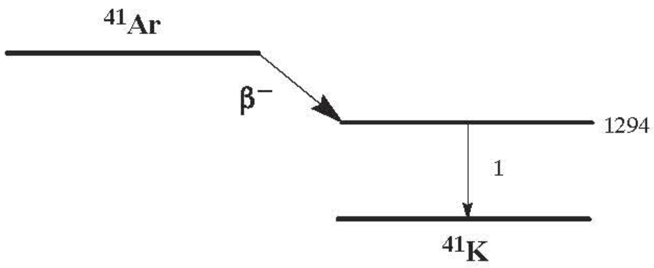
Handbook Radionucliden, A.S. Keverling Buisman (3rd edition 2007), pg. 40 and 41, ^{41}Ar data

^{41}Ar Z = 18

Half-life and decay constant

$T_{1/2}$ = 1,83 h = 6,59×10^{3} s λ = 1,05×10^{-4} s^{-1}

Decay scheme (simplified)



Main emitted radiation

Straling	y (Bq·s)$^{-1}$	E (keV)
β^-	0,992	459 | 1198
γ_1	0,992	1294

Source constants

Air kerma rate	k = 0,16 µGy/h per MBq/m^2
Ambient dose equivalent rate	h = 0,18 µSv/h per MBq/m^2

Miscellaneous

Specific activity	A_{sp} = 1,55×10^{18} Bq/g
Exemption levels	C_v = 10^2 Bq/g en A_v = 10^9 Bq
Skin contamination	H_{huid} = 6×10^{-10} Sv/s per Bq/cm^2
Wound contamination / injection	Niet van toepassing
Transport	A_1 = 0,3 TBq
	A_2 = 0,3 TBq

N = 23

^{41}Ar

Production and applications

Het radionuclide ^{41}Ar is een activeringsproduct dat vrijkomt bij de bestraling van lucht. Bij gebrek aan lucht in de kern speelt het nuclide geen rol bij vermogensreactoren, wel bij de meeste onderzoeksreactoren.

Dose conversion coefficient class SR-0

$e \; = \; 2{,}2 \times 10^{-10}$ Sv/h per Bq/m^3