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

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

exam date:
December 13th 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 8 consecutively numbered pages.
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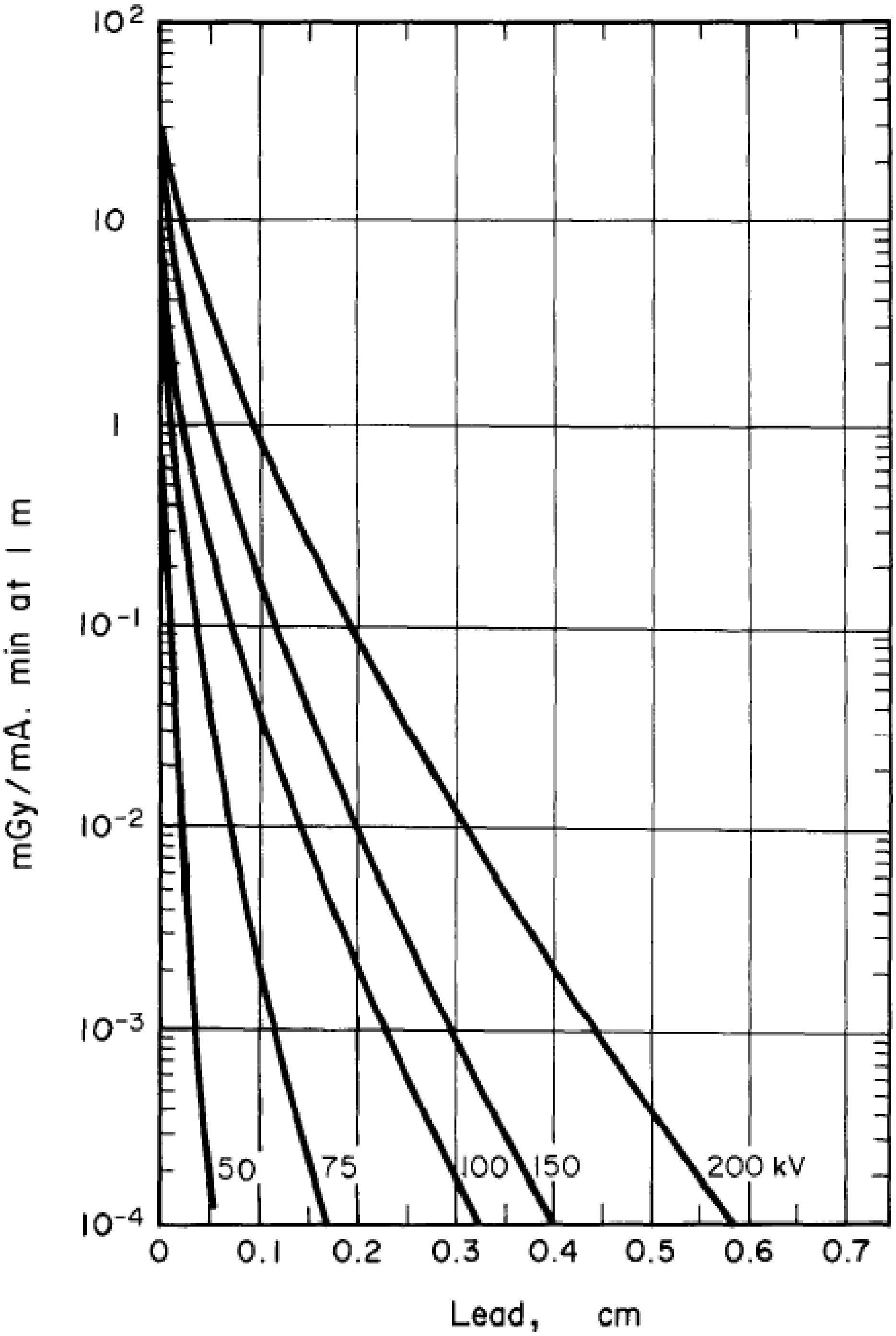
Output of an X-ray tube and transmission of a wide X-ray beam through lead



Transmission of a wide X-ray beam through lead, density 11 350 kg m^{-3}. Numerical values of intersections with the y-axis: 28.7 for 200 kV, 18.3 for 150 kV, 9.6 for 100 kV, 6.1 for 75 kV and 2.6 for 50 kV. From ICRP-33.

The protection efficiency of lead aprons

The protection efficiency represents the relative decrease of the effective dose when wearing a lead apron compared to not wearing a lead apron when exposed to scattering radiation. The protection efficiency depends on the thickness of the lead and the tube voltage at which the X-rays that caused the scattering radiation are generated.

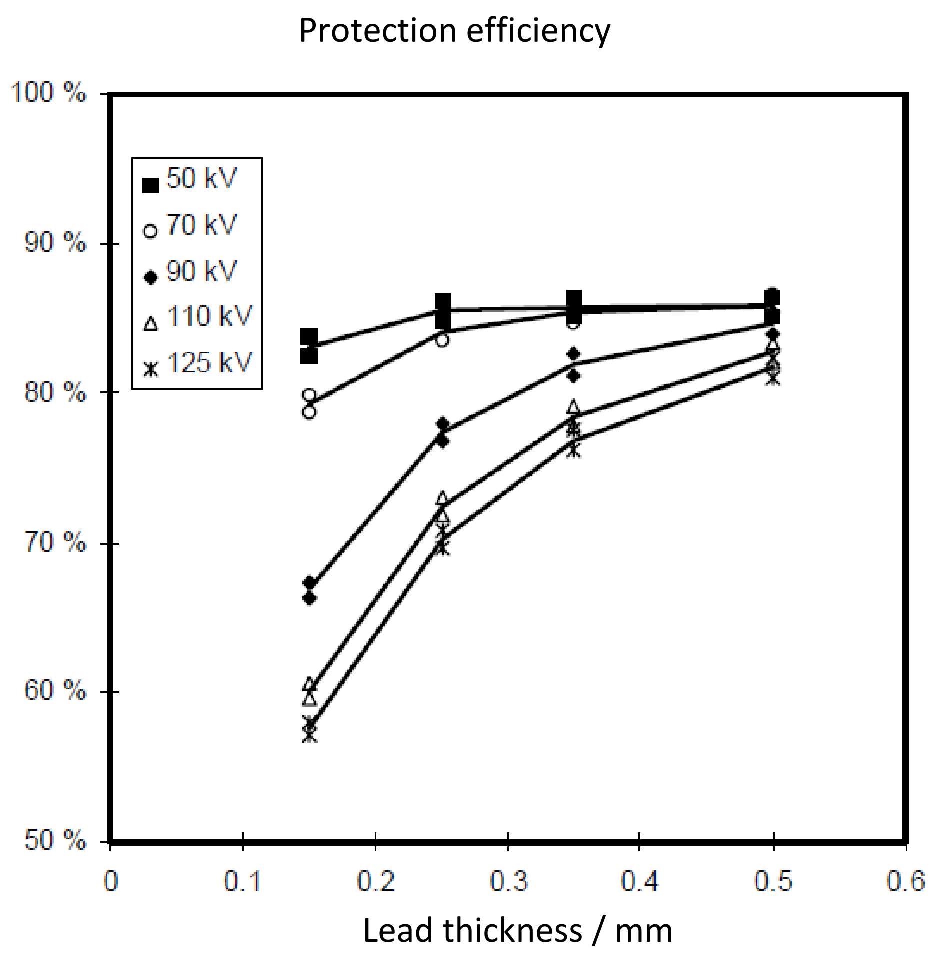


Figure 3 *Protection efficiency front lead aprons (80% AP, 20% LAT) and all-round lead aprons (60% AP, 30% LAT and 10% PA)*

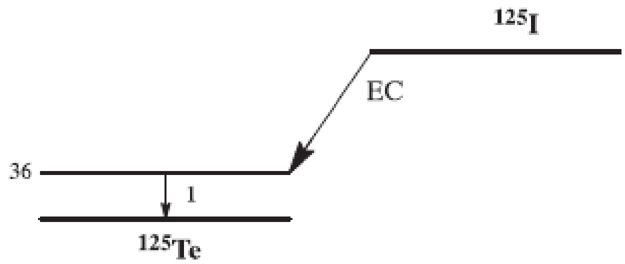
Handboek Radionucliden, A.S. Keverling Buisman (3rd edition 2015), pg. 160-161, ^{125}I data

^{125}I   Z = 53

Half-life and decay constant

$T_{1/2}$ = 59,39 d = 5,13×10^{6} s λ = 1,35×10^{-7} s^{-1}

Decay scheme (simplified)



Main emitted radiation

Straling	y (Bq·s)$^{-1}$	E (keV)	Straling	y (Bq·s)$^{-1}$	E (keV)
γ_1	0,067	35	L_α	0,061	4
ce K γ_1	0,803	4	L_β	0,059	4
ce L γ_1	0,105	31	KLL	0,132	23
K_α	1,140	27	KLX	0,060	26
K_β	0,255	31	LMM	1,010	3
			LXY	0,590	4

Source constants

Air kerma rate k = 0,034 μGy/h per MBq/m^2

Ambient dose equivalent rate h = 0,034 μSv/h per MBq/m^2

Miscellaneous

Specific activity A_{sp} = 6,51×10^{14} Bq/g

Exemption levels C_v = 10^3 Bq/g en A_v = 10^6 Bq

Skin contamination H_{huid} = 4×10^{-12} Sv/s per Bq/cm^2

Wound contamination / injection $e(50)$ = 1,5×10^{-8} Sv/Bq

Transport A_1 = 20 TBq

A_2 = 3 TBq

Productie en toepassingen

Het radionuclide ^{125}I is een cyclotronproduct. Het wordt toegepast in de nucleaire geneeskunde, onder meer bij brachytherapie. Het vindt tevens toepassing als gamma-referentiebron.

N = 72 **^{125}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

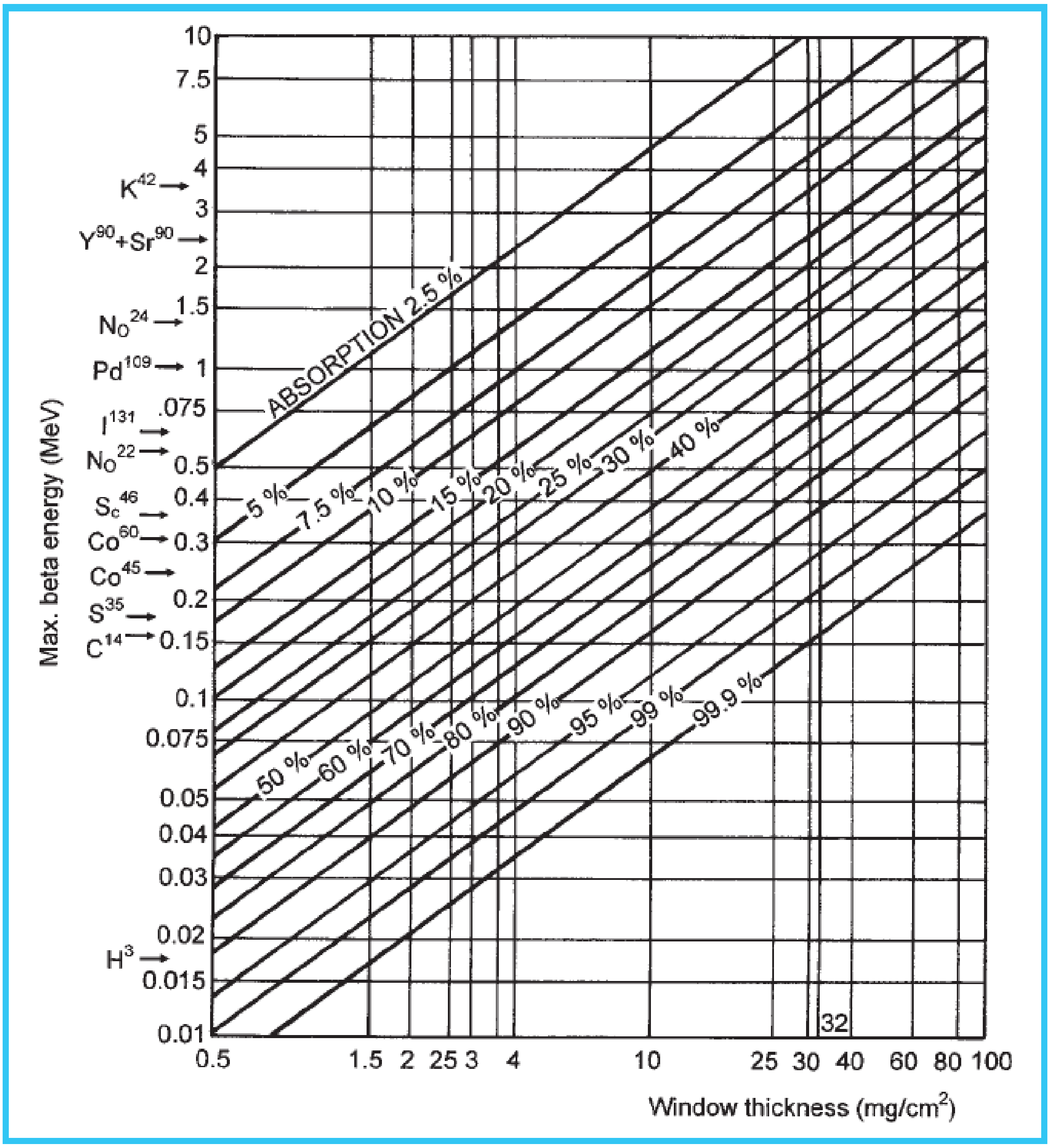
Dose conversion coefficient and radiotoxicity equivalent for workers (w) and members of the public (b)

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

Percentage absorption beta particles in matter



This figure is meant to show the effect of the thickness of a mica window (window thickness) on detection. This figure can be used for the measured layer thickness to determine the absorption of beta radiation in matter (mg/cm^2).

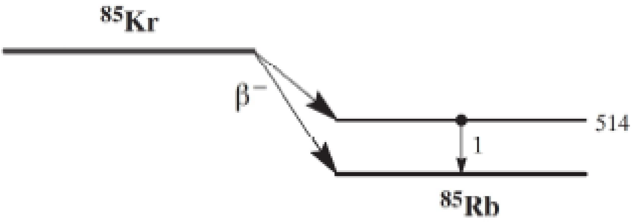
Handboek Radionucliden, A.S. Keverling Buisman (3rd edition 2015), pg. 92, ^{85}Kr data

^{85}Kr Z = 36

Half-life and decay constant

$T_{1/2}$ = 10,70 j = 3,38×10^{8} s λ = 2,05×10^{-9} s^{-1}

Decay scheme (simplified)



Main emitted radiation

Straling	y (Bq·s)$^{-1}$	E (keV)
β^-	0,996	251 | 687
γ_1	0,0043	514

Source constants

Air kerma rate k = 3,0×10^{-4} μGy/h per MBq/m^2
Ambient dose equivalent rate h = 3,7×10^{-4} μSv/h per MBq/m^2

Miscellaneous

Specific activity A_{sp} = 1,45×10^{13} Bq/g
Exemption levels C_v = 10^5 Bq/g
A_v = 10^4 Bq
A_v = 10^{10} Bq (gebruiksartikelen zoals lampen en starters)
Skin contamination H_{huid} = 5×10^{-10} Sv/s per Bq/cm^2
Injection: not applicable Niet van toepassing
Transport A_1 = 10 TBq
A_2 = 10 TBq

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