EMBARGO MAY 13th 2019

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

Nuclear Research and consultancy Group	NRG
Delft University of Technology	TUD
Boerhaave Continuous Medical Education/LUMC	BN/LUMC
University of Groningen	RUG
Radboudumc	RUMC

exam date: May 13th 2019
exam duration: 13.30 - 16.30 hours

Instruction:

- If you use any data other than the data mentioned in this attachment, state the origin!
- This attachment consists of 13 consecutively numbered pages. Check this!

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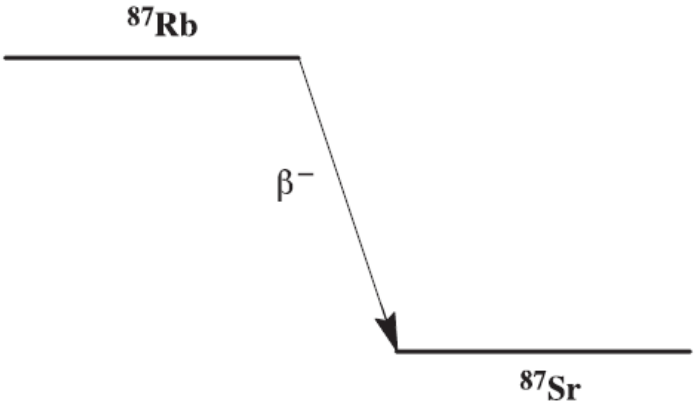
Handboek Radionucliden, A.S. Keverling Buisman (3rd edition 2015), top half of pg. 98, ^{87}Rb data

^{87}Rb Z = 37

Halveringstijd en vervalconstante

$T_{1/2} = 4{,}7\times10^{10}$ j $= 1{,}5\times10^{18}$ s $\qquad \lambda = 4{,}7\times10^{-19}$ s^{-1}

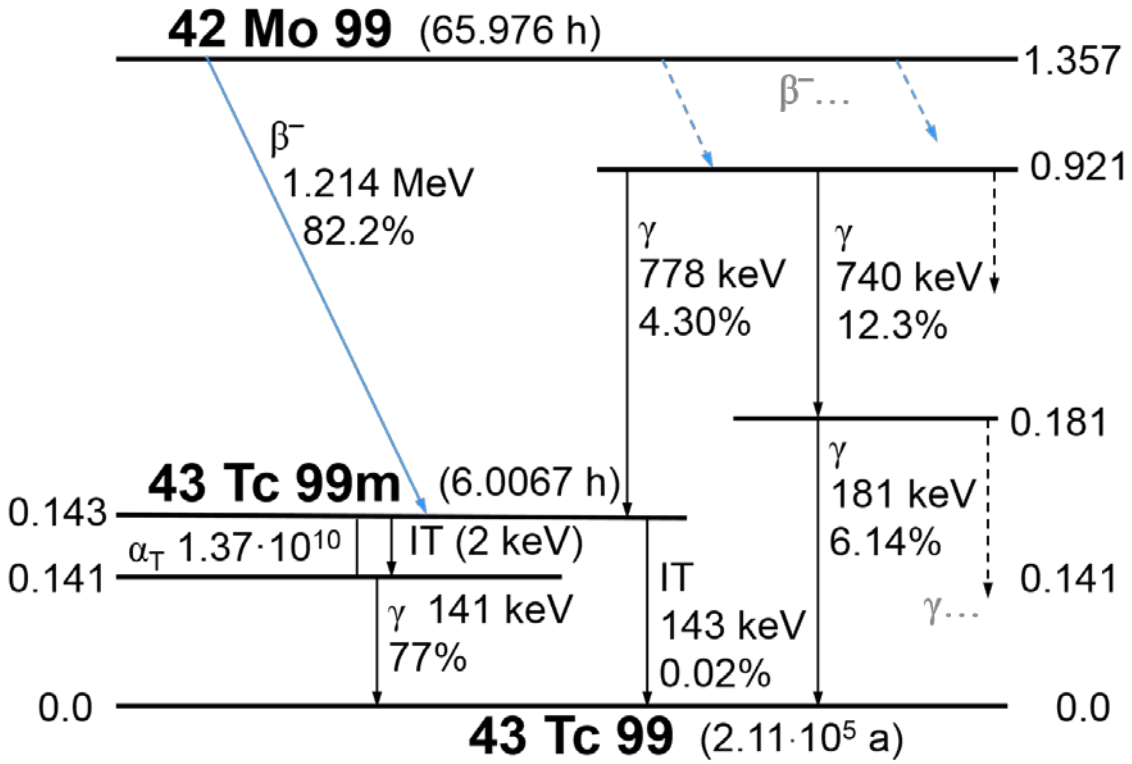
Vervalschema (vereenvoudigd)



Belangrijkste uitgezonden straling

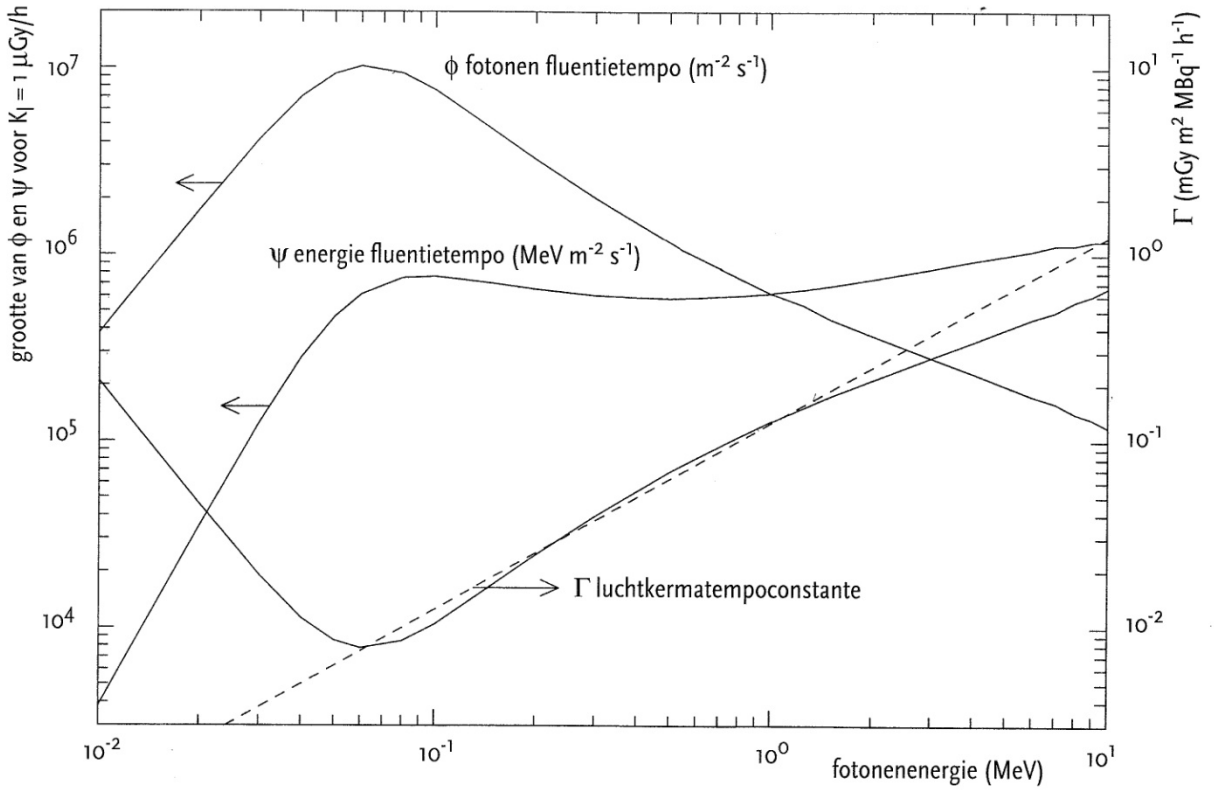
Straling	y (Bq·s)$^{-1}$	E (keV)
β^-	1,000	112 | 273

Decay scheme of ^{99}Mo from Nucleonica.com



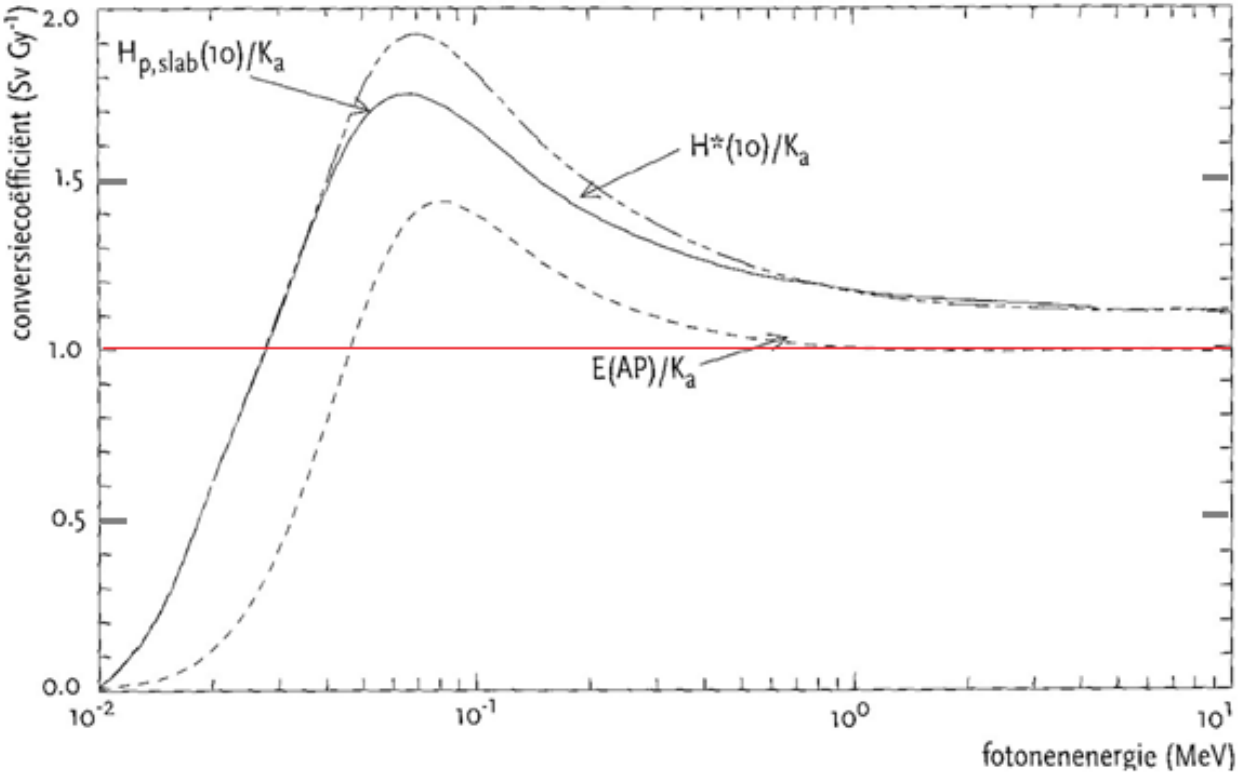
Dosimetric quantities as function of the photon energy

Fluence rate and energy fluence rate (fluentietempo en energie fluentietempo) of photons corresponding to an air kerma rate of 1 µGy/h. The air kerma rate constant (luchtkermatempoconstante) of a hypothetical point source which emits 1 gamma quant of E MeV per nuclear transmutation is also displayed in the figure. The broken line is an approximation according to $\Gamma = 1/8\ E$.



Conversion coefficients as function of the photon energy

Conversion coefficients (in $Sv \cdot Gy^{-1}$) of the air kerma to the ambient dose equivalent, the effective dose in an adult's anthromorphic phantom in the AP irradiation geometry, and the personal dose equivalent in an ICRU slab, $H_{p,slab}(10, 0°)$, as function of the energy of mono-energetic photons.



Attenuation constants for different photon energies in lead

(appendix D of Inleiding tot de Stralingshygiëne)

NB: Lood = lead, in this table commas are used to indicate decimal points.

Fotonen-energie (MeV)	Lood $\rho = 11{,}34\ g/cm^3$		
	μ/ρ (cm^2/g)	μ_{tr}/ρ (cm^2/g)	μ_{en}/ρ (cm^2/g)
0,02	85,5	69,2	69,1
0,03	29,1	24,6	24,6
0,04	13,80	11,83	11,78
0,05	7,71	6,57	6,54
0,06	4,87	4,11	4,08
0,08	2,37	1,924	1,908
0,088005	1,865	1,494	1,481
K edge			
0,088005	7,30	2,47	2,47
0,10	5,78	2,28	2,28
0,15	2,07	1,164	1,154
0,2	1,014	0,637	0,629
0,3	0,406	0,265	0,259
0,4	0,233	0,1474	0,1432
0,5	0,1614	0,0984	0,0951
0,6	0,1249	0,0737	0,0710
0,8	0,0886	0,0503	0,0481
1,0	0,0708	0,0396	0,0377
1,5	0,0518	0,0288	0,0271
2	0,0455	0,0259	0,0240
3	0,0417	0,0260	0,0234

Labeling class 7

klasse	sticker	max. dosistempo op oppervlak	maximale transportindex
I-wit		5 µSv/h	
II-geel		0,5 mSv/h	1,0 (10 µSv/h)
III-geel		2 mSv/h	10 (100 µSv/h)

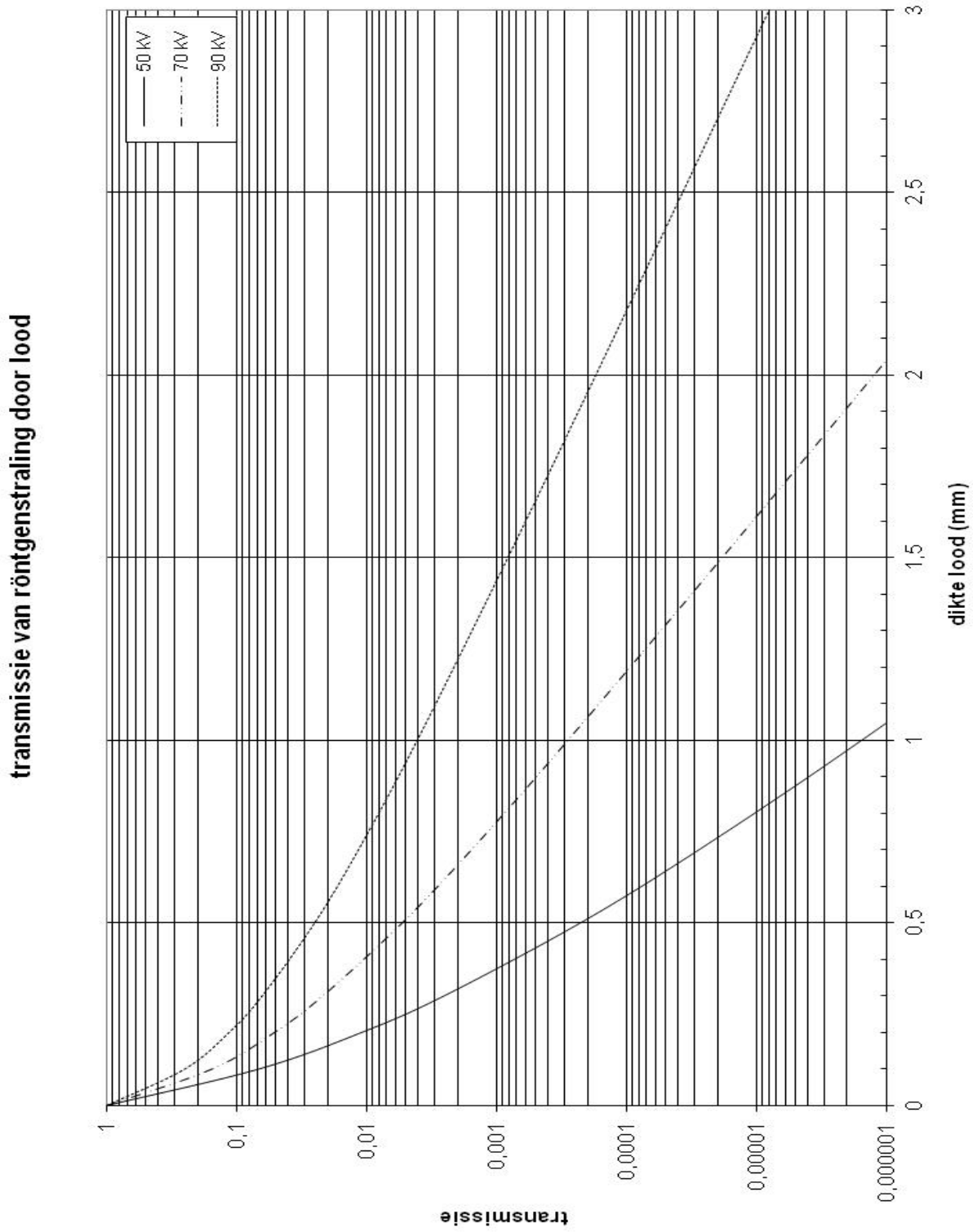
Please note:

klasse = class
wit = white
geel = yellow
dosistempo op oppervlak = dose rate at surface
and again, commas indicate decimal points

Transmission graph of the X-rays through lead

Transmission graph of 50-, 70- and 90-kV X-rays through lead.

Röntgenstraling = X-rays
Dikte lood = thickness lead



Conversion of lead equivalent to lead glass thickness

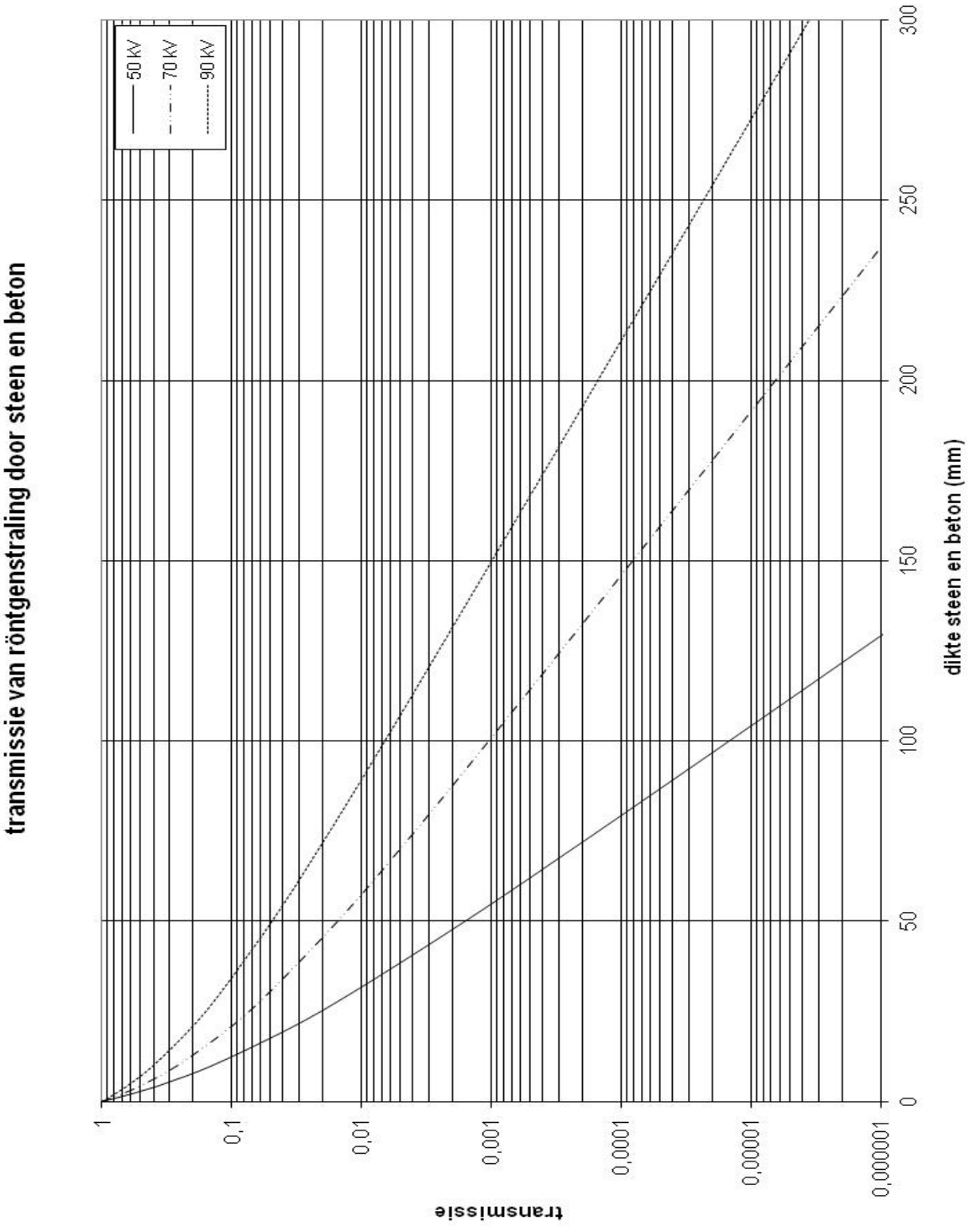
Conversion factors of number of mm of lead equivalent to mm of lead glass equivalent at different tube voltages.

mm lead glass	LEAD EQUIVALENT in mm Pb						
	80 kV	100 kV	110 kV	150 kV	200 kV	250 kV	300 kV
4.0	1.4	1.4	1.3	1.2	1.0	1.0	1.0
5.0	1.7	1.7	1.7	1.5	1.3	1.3	1.3
5.7	1.9	1.9	1.9	1.7	1.5	1.5	1.5
7.0	2.3	2.3	2.3	2.1	1.8	1.8	1.8
8.5	2.7	2.8	2.9	2.6	2.1	2.1	2.2
10.0	3.2	3.2	3.3	2.9	2.5	2.6	2.6
11.0	3.6	3.5	3.6	3.2	2.8	2.8	2.9
12.0	4.0	3.8	4.0	3.5	3.0	3.1	3.2
14.0	4.7	4.5	4.6	4.1	3.5	3.6	3.7
16.0	5.3	5.1	5.3	4.7	4.0	4.1	4.3
18.0	6.0	5.7	5.9	5.2	4.4	4.6	4.8

Transmission graph of X-rays through concrete

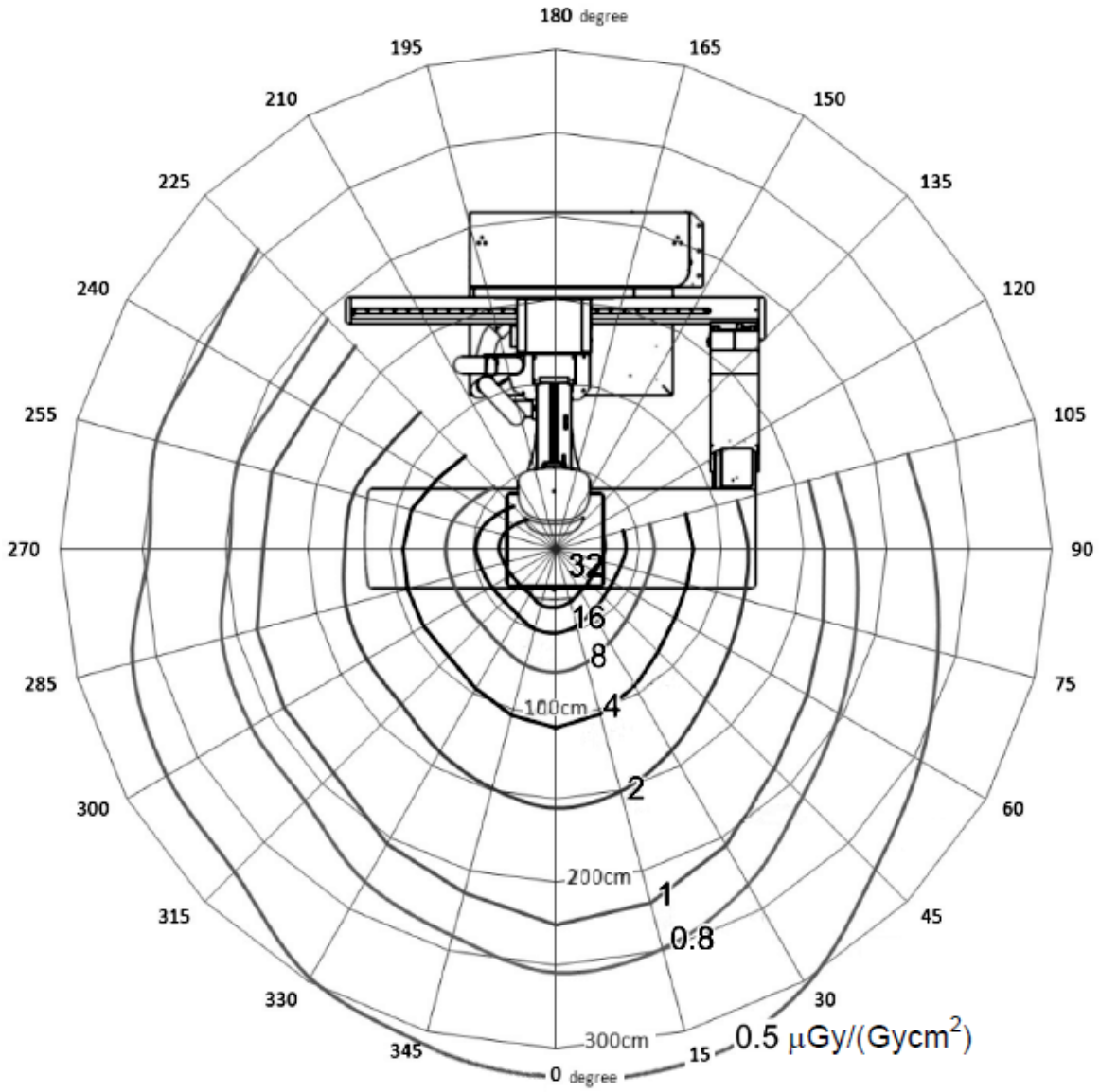
Transmission graph of 50-, 70- and 90-kV X-rays through concrete with a specific weight of 2400 kg/m³.

Röntgenstraling = X-rays
Dikte steen en beton = thickness stone and concrete



Iso kerma map of the C-arm

The image shows a top view of the free-in-air kerma (K_a) at a height of 150 cm. Iso kerma curves are given for 32, 16, 8, 4, 2, 1 and 0.5 µGy per Gy·cm^2. The distance lines display the distance to the iso center of the C-arm, the angles are in degrees with respect to the C-arm



Iso kerma map of the CT scanner

The image shows a top view of the free-in-air kerma (K_a) surrounding the CT scanner as a result of the scattered radiation produced in a 4 x 320 mm water phantom at 120 kV. Iso kerma values have been given in µGy per 200 mAs.