

Equivalent skin dose of the patient

Table

Typical values of the equivalent dose rate (in mSv per mAs) at a distance of 1 meter from the focus of the X-ray tube, for different values of tube voltage and filter thickness.

tube voltage	thickness aluminum filter		
	1 mm	2 mm	3 mm
50 kV	0.07	0.05	0.03
70 kV	0.15	0.09	0.05
90 kV	0.20	0.13	0.08

Excercise 1

Data:

tube voltage	70 kV
filter	2 mm aluminum
yield X-ray tube	see above table
anode current	5 mA
exposure time	0.15 seconds
distance focus - skin	30 cm

- Calculate the equivalent skin dose per X-ray image.
- The tube voltage is decreased from 70 kV to 50 kV while the tube current remains equal to 5 mA. What should the exposure time be in order that the average density is (approximately) the same as in the previous X-ray image?

Excercise 2

Data:

tube voltage	50 kV
filter	2 mm aluminium
yield X-ray tube	see above table
anode current	5 mA
exposure time	0.27 seconde
distance focus - skin	30 cm

- Calculate the equivalent skin dose per X-ray image.
- The tube voltage is increased from 50 kV to 70 kV while the tube current remains equal to 5 mA. What should the exposure time be in order that the average density is (approximately) the same as in the previous X-ray image?

Effective dose of the patient

The main contributions to the effective dose that the patient receives during an intra-oral X-ray photo in the dental practice are:

- irradiation of one or more salivary glands by the direct X-ray beam
- irradiation of the thyroid by scattered radiation

The tissue weighting factors for salivary glands and thyroid are:

- $W_{\text{salivary glands}} = 0.01$
- $W_{\text{thyroid}} = 0.04$

For the next calculation, assume that the equivalent dose on the thyroid is equal to the equivalent skin dose. Use the rule of thumb for the scattering factor.

Excercise 3

Data:

equivalent skin dose	1 mSv
number of irradiated salivary glands	2 of 6
distance exposed skin - thyroid	10 cm

- a Calculate the effective dose of the patient per X-ray image.

Excercise 4

Data:

equivalent skin dose	2 mSv
number of irradiated salivary glands	1 of 6
distance exposed skin - thyroid	10 cm

- a Calculate the effective dose of the patient per X-ray image.

Rules of thumb

Rule 1: for the scattering factor

At a distance of 1 meter and for an irradiated area of 10 cm by 10 cm, the dose is about 1/1000th of the entrance dose at the irradiated object.

Rule 2: for scatter radiation due to intra-oral photos

The dose due to scatter radiation at 1 meter from the patient amounts to 1 μ Sv per intra-oral photo.

While taking an X-ray image, the dentist always stands next to the patient, thus being exposed to scatter radiation. Since the whole body is (more or less) uniformly irradiated, the tissue weighting factor is $w_{\text{body}} = 1$.

Excercise 5

Data:	
equivalent skin dose	1 mSv
tube opening	4 cm \times 5 cm
distance patient - dentist	1 meter
number of X-ray photos per year	1000

- Use the above data to calculate the equivalent dose at 1 meter due to scattering.
- Calculate the annual effective dose of the dentist.

Excercise 6

Data:	
distance patient - dentist	1 meter
number of X-ray photos per year	1000

- Use the above data to calculate the equivalent dose at 1 meter due to scattering.
- Calculate the annual effective dose of the dentist.

Shielding

Excercise 7

In the dental practice there is one intra-oraal X-ray device. There is a single-glass window in the wall on the street side of the treatment room. The X-ray beam is never aimed directly at the window.

Data:

average tube voltage	70 kV
number of X-ray photos per year	1000
distance patient - street	3 meters
thickness single glass	6 mm
transmission through glass	see Figure 1 on page 5

- a What is the legal limit that applies outside of the dental practice?
- b Check by means of a calculation whether or not the glass window provides sufficient shielding to comply with the legal limit.

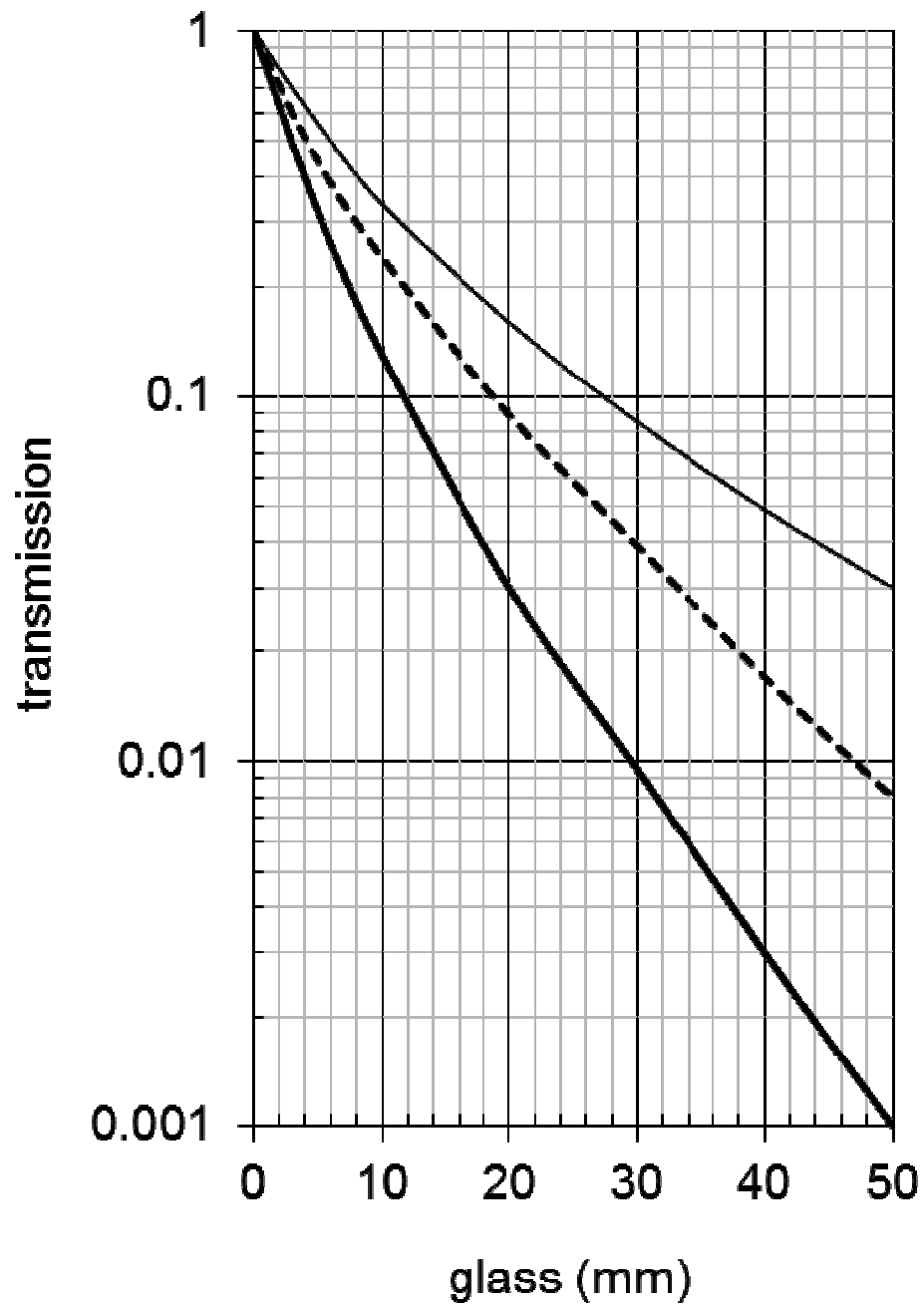
Excercise 8

In the dental practice there is one intra-oraal X-ray device. For half of the images, the X-ray beam is directed perpendicular to the wall between treatment room and waiting room. This wall is made of plaster.

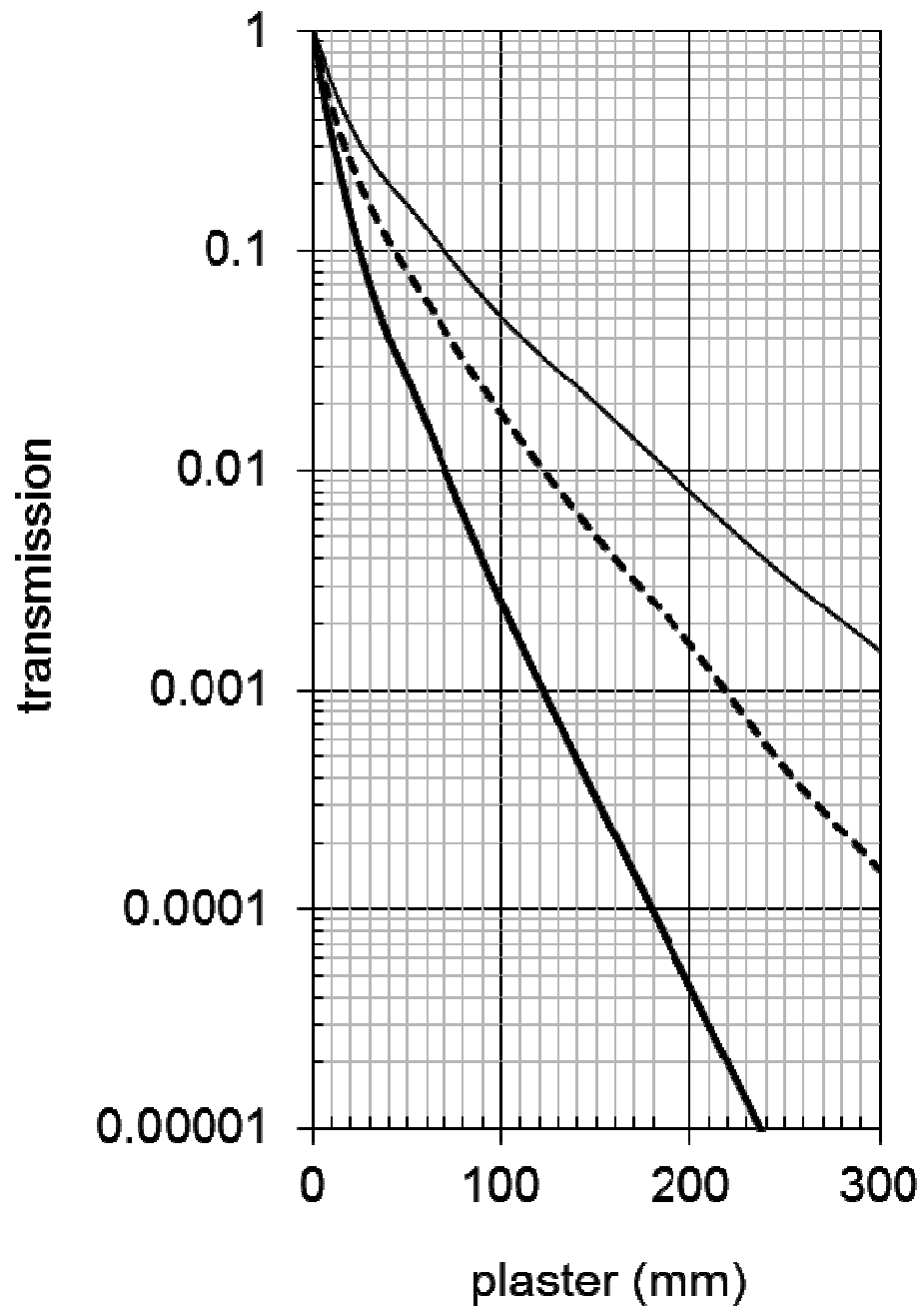
Data:

average tube voltage	70 kV
filter	2 mm aluminum
yield X-ray tube	see Table on page 1
average mAs value	1 mAs per image
distance focus - waiting room	2 meters
thickness plaster wall	12 mm
transmission through plaster	see Figure 2 on page 6
neglect the contribution due to scattered radiation	

- a What is the legal limit that applies inside of the dental practice?
- b Check by means of a calculation whether or not the plaster wall provides sufficient shielding to comply with the legal limit.



Figuur 1. Transmission of X-radiation through glass for tube voltages of 50 kV (bottom), 70 kV (middle) and 90 kV (top).



Figuur 2. Transmission of X-radiation through plaster for tube voltages of 50 kV (bottom), 70 kV (middle) and 90 kV (top).