The External Radiation Hazard

External Hazard

Source types exhibiting an external hazard :

- Sealed sources
- Unsealed sources
- Electrical equipment generating EM radiation
- Natural sources

Estimating the External Hazard

Calculation depends on -

- Estimate of biological damage (absorbed dose)
- Type of isotope (alpha, beta or gamma)
- Radiation generators (e.g.X-ray)
- Geometry of source (isotropic)
- Activity of source
- Distance from the source
- Exposure time

Alpha emitters :

- Not generally considered to be an external hazard
- Penetrate less than 4 cm in air
- Generally considered an Internal Hazard

Beta emitters :

- Dose depends on number of beta particles per unit area
- Independent of beta energy
- The dose rate D_b in mSv/hr produced by a point source of beta activity M MBq at distance 0.1m is given by :
- $D\beta = 1000$ M μSv/hr at a distance of 0.1 m

Gamma emitters e.g. Cr^{51}, Co^{60}

Dose rate, D_g, produced by a point source of gamma radiation, activity M MBq, with a total gamma photon energy per disintegration E_g (Mev) at distance 0.1m is given by :

$$D_g = \frac{ME_g}{7} \text{ mSv/hr at 1.0m } (>0.1\text{MeV})$$

Example :

Find the gamma dose rate at a distance of **0.5**m from a ^{60}Co source, **50** MBq activity.

Each disintegration of ^{60}Co results in the emission of two gamma ray photons of energy, 1.17 and 1.33 MeV respectively

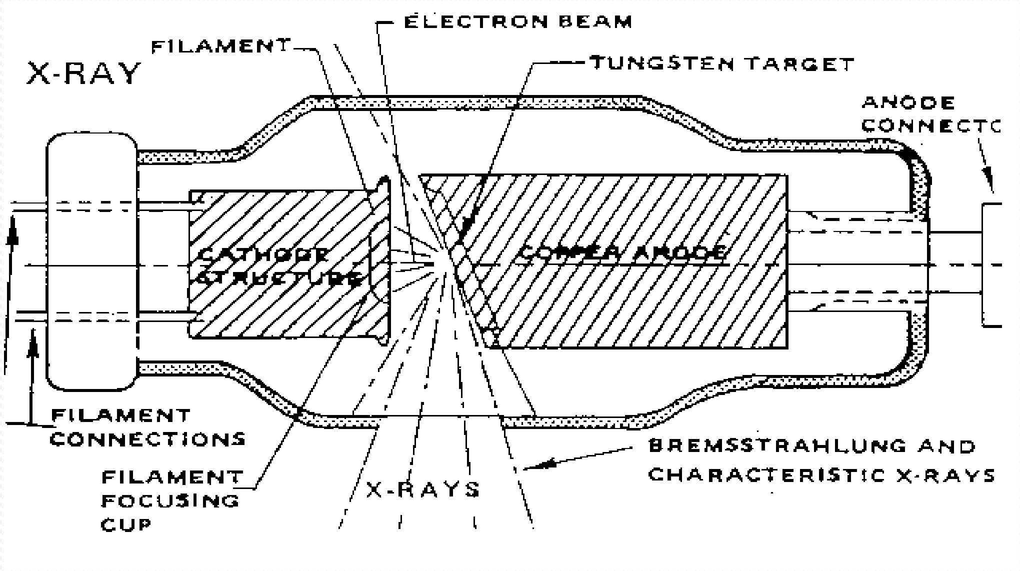
$$D_g = \frac{\text{Activity x Total Energy}}{7} \text{ mSv/hr at } \mathbf{1m}$$

Total Energy = 1.17 + 1.33 = **2.5** MeV

$$\text{Dose rate at 1m} = \frac{\mathbf{50} \times \mathbf{2.5}}{7} = 17.9 \text{ mSv/hr}$$

Dose rate at 0.5m = 17.9 x 4 = **71 mSv/hr**

X-Ray Tube


X-RAY
FILAMENT
ELECTRON BEAM
TUNGSTEN TARGET
ANODE
CONNECT
CATHODE STRUCTURE
COPPER ANODE
FILAMENT CONNECTIONS
FILAMENT FOCUSING CUP
X-RAYS
BREMSSTRAHLUNG AND CHARACTERISTIC X-RAYS

Dose rate

Dependant on -

- Target material (atomic number)
- Applied tube voltage (kV)
- Tube current (mA)
- Distance from the source (mm)
- Any filtration

$$D = \frac{670\ ZVI}{d2}\ \text{mGy/s}$$

Z = Atomic No.
V = Energy (kV)
I = mA
d = Distance (cm)

Example:

Calculate dose rate at 50 cm from an X-ray tube using a copper target and tube voltage 50 kV at 10 mA.

$$D = \frac{670\,ZVI}{d2}\ \text{mGy/s}$$

Z = Atomic No.
V = Energy (kV)
I = mA
d = Distance(cm)
Z = 29 for copper

$$D = \frac{670 \times 29 \times 50 \times 10}{2500} = \mathbf{3.9\ Gy/s}$$

Finger dose limit of 500 mSv will be reached in 128 ms!

Estimation of Dose Rate by Monitoring

Sign on side of monitor gives response to 10μSv hr^{-1} thus by using mini monitor, counts per second can be approximately converted to dose rate :

<u>EP15 Monitor:</u>

Contamination	- 3Bq/cm2 for 14C or 35S	~ 4cps.
Contamination	- 3Bq/cm2 for 32P	~ 12cps

Dose rate	– 10μSv/hr gamma	~ 50cps
Dose rate	– 10μSv/hr beta	~ 50cps

∴ If ~50 cps = 10μSv hr^{-1} , then ~37 cps = 7.5 μSv hr^{-1}

7.5 μSv hr-1 - ADEQUATE SHIELDING LEVEL

Minimising the External Hazard

ALARP PRINCIPAL

- Use Least Activity
- Use Least Time
- Use Distance Protection
- Use Shielding

Least Time Example:

A classified radiation worker is permitted to receive up to 20 mSv per year ~ 400 μSv per week.

How many hours per week can he spend in an area having an average dose rate of 100 μSv/hr ?

Dose = Dose Rate x Time

400 μSv = 100 μSv x T

$\Rightarrow$ T = 4h each week

Shielding

- Alpha emitters – thin sheet of paper or plastic
- Beta emitters – plastic / perspex, thickness dependent on energy
- Gamma emitters – lead shielding or leaded glass
- For high activity sources bremsstrahlung may be an issue

To Summarise :

Activity Use the least activity required to get good results

Time Remember dose = dose rate x time

Distance Inverse square law

Shielding Use the correct shielding for the isotope