Radiation protection

Units

SI Becquerel (Bq) 1 dis/s
Old Curie (Ci) 3.7×10^{10} Bq → (based on 1 g Ra)

SI Energy deposition of 1 J/kg (Absorbed dose)

Old rad 0.01 Gy
equivalent dose

SI Sievert (Sv)

Old rem = 0.015 Sv

Radiation WR

| X, Y, β | 1 |
| P       | 5 |
| Thermal n | 5 |
| Fast n   | 5-20 |
| α, fission | 20 |

Dose rate 5 Sv/h

Physiology

10^{-10} s H_2O \xrightarrow{\text{radiation}} H_2O^+ + e^-

10^{-8} s H_2O \xrightarrow{L} H^+ + OH^- \quad e^- + H_2O \rightarrow H_2O^-

H, OH highly reactive free radicals

0H + OH → H_2O_2 strong oxidant to cell
damage

Can cause mutations → erythema, cataracts

or kill cell → radiation sickness, suppress immune system

LD_{50/60 day} = 3-5 Gy gastrointestinal death, infection death

CNS death

Fatal Cancer risk 0.05/5 Sv depends on organ - higher for gut, bone marrow

Additional risk of fatal cancer in average individual: Genetic: none

See A. Marti & S.A. Harbison
An Intro to Radium Protection (4th ed.)
**Effective Dose**

Takes into account differences among organs - tissue weighting factor

\[ E = \sum_{T} W_{T} H_{T} \]

\( E \) = Equivalent dose in Sv  \( H_{T} \) = Equivalent dose in Sv  \( W_{T} \) = Tissue weighting factor

<table>
<thead>
<tr>
<th>Organ</th>
<th>WT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonads</td>
<td>0.20</td>
</tr>
<tr>
<td>Bone marrow</td>
<td>0.12</td>
</tr>
<tr>
<td>Colon, lung, stomach</td>
<td>0.05</td>
</tr>
<tr>
<td>Skin</td>
<td>0.01</td>
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</tbody>
</table>

Dose - response curve

- Known
- Large
- Unknown
- Small

**Dose - response curve**

Deterministic effects - early, late
Stochastic effects - cancer, genetic mutations
Hard to quantify low dose
Does cell repair itself?
Some mutations, probably permanent

ICRP (Int'l Comm Radial Prot.)

20 mSv/y - dose limit for workers averaged over 5 yrs
50 mSv may 1 yr
1 mSv/y - general population (effective)
Typical dosage from natural sources + man-made sources

Cosmic rays (depends on latitude + altitude)
- 0.25 mSv/y, 50°N, sea level
- 0.2 mSv/y, equator, sea level
- 1 mSv/y, 3000 m (more relevant to Utah)

Local Y's from rocks
- 238U
- 232Th
- 40K

Local Y's from body
- 222Rn (3.82 d)
- 220Rn (x, 55.6 s)
- Thoron

Gaseous products of 238U and 232Th decay
- 4.5 x 10^7 y
- 1.4 x 10^10 y

Typical annual UK

Local Y's
- 0.35 mSv

Cos rays
- 0.25

Radon, thoron, daughter
- 1.30

40K in body
- 0.18

14C
- 0.01

238U, 232Th in body
- 0.11

2.20

UK general population

Diagnostic X-rays
- 0.28 mSv

Radioactive waste
- 0.002

Weapons-fallout
- 0.01