Dosages and detectors

D. Craig

2006–03–31

Various dose units

Roentgen amount of ionizing radiation to produce 3.33×10^{-10} Coulomb of charge in one cm^3 of air. An obsolete unit.

Rad radiation that deposits 0.01 J in 1 kg of absorbing material.

Rem is the rad scaled by the effect of the radiation type on biological systems. It is

$$\text{rem dose} = \text{rad dose} \times \text{RBE}$$

where RBE is the *relative biological effectiveness.*

Relative biological effectiveness (RBE)

Different types of ionizing radiation have differing effects on living cells. The RBE is the relative "damaging power" of the radiation, compared to γ or X-radiation. This gives you the **dose equivalent.**

Radiation	**RBE**
X and γ	1.0
β particles	1.0–1.7
α particles	10–20
Slow neutrons	4–5
Fast $\mathfrak{n}$, protons	10
Heavy ions	20

Heavy ions are a particular concern for astronauts.

SI units for dosage

The SI unit for absorbed dose is the **gray**, and for dose equivalent, the **sievert**.

Symbol	Base units	Conversion
Gy	= 1 J/kg	1 Gy = 100 rad
Sv	= 1 J/kg	1 Sv = 100 rem

You can think of the older units as just percentages of the SI units.

Doses and effects

background	0.13 rem/yr (1.3 mSv)
"Legal limit"	0.5 rem/yr
Acute doses:	
Sickness	50–100 rem
50% mortality	400–500 rem
100% mortality	1 000 rem
immediate coma	10 000 rem

Detectors

Ionization: ion chamber proportional counters, Geiger counters, diode detectors.

Scintillation: Optically excited materials, use photomultiplier or CCD to measure flash.

Track detectors: Photographic emulsion; cloud, bubble and spark chambers;Wire and drift chambers.

Neutron detectors: use neutron capture or elastic recoil.

What they can measure

Type	measure	sensitivity
Ion chamber	energy	poor
Geiger	count only	medium
Diode	energy	high
Scintillator	energy	high
Emulsion	track	medium
Cloud	track	varies
Bubble	track	high
Spark	track	high $\mathbb{E}$
Drift, etc.	track	high $\mathbb{E}$

Track recording detectors are commonly used with strong $\vec{\mathbf{B}}$ fields to measure momentum and energy as well.