Units of Radiation Becquerel and Sievert



Units of Radiation Origin of Sievert



Rolf Sievert (1896-1966)

Founder of the physics laboratory at Sweden's Radiumhemmet

Participated in the foundation of the International Commission on Radiological Protection

Units of Radiation Relationship between Units



Units of
RadiationConversion from Gray to Sievert



Equivalent dose (Sv) = Radiation weighting factor $w_R \times$ Absorbed dose (Gy)

Type of radiation	Tissue weighting factor w _R
γ-rays, X-rays, β-particles	1
Proton beams	2
α-particles, heavy ions	20
Neutron beams	2.5~21

Effective dose (Sv) = Σ (Tissue weighting factor $W_T \times$ Equivalent dose)

Tissue	Tissue weighting factor
	w _T
Red bone marrow, colon, lungs, stomach, breasts	0.12
Gonad	0.08
Bladder, esophagus, liver, thyroid	0.04
Bone surface, brain, salivary gland, skin	0.01
Total of the remaining tissues	0.12

Effective dose (sievert (Sv)) = Σ (Tissue weighting factor \times Equivalent dose)



When only the head is exposed to **1 mGy** of γ-ray irradiation

Effective dose = 0.04 X 1 (mSv): thyroid + 0.01 X 1 (mSv): brain + 0.01 X 1 (mSv): salivary gland + 0.12 X 1 (mSv) × 0.1: bone marrow (10%) + 0.01 X 1 (mSv) × 0.15: skin (15%)

= 0.07 millisieverts (mSv)

Units of Concepts of Doses: Physical Quantities, Radiation Protection Quantities and Operational Quantities

Physical quantities: directly measurable

Radiation intensity (Bq: becquerels)

Number of nuclei that decay per second **Radiation fluence** (s⁻¹m⁻²: fluence) Number of particles incident on a unit area

Absorbed dose (Gy: grays)

Energy absorbed per 1 kg of substances Irradiation dose (for X-rays and γ-rays) (C/kg) Energy imparted to 1 kg of air

Doses indicating the effects of exposure on humans: not directly measurable

Defined based on physical quantity

Protection quantities

Equivalent dose (Sv: sievert) indicates effects on individual human organs and tissues

Effective dose (Sv: sievert)

indicates effects on the whole body by combining effects on individual organs and tissues

Operational quantities

Ambient dose equivalent (Sv: sievert) Directional dose equivalent (Sv: sievert) Approximate value for protection quantity used in environmental monitoring

Personal dose equivalent (Sv: sievert) Approximate value for protection quantity used in personal monitoring

Units of Dose Equivalents: Measurable Operational Radiation Quantities for Deriving Effective Doses

Dose equivalent = Absorbed dose at a reference point that meets

certain requirements × Quality factor

To substitute for "effective doses" that cannot be actually measured, "operational quantities" that can be measured as conservative values or as nearly the same values as effective doses, such as an ambient dose equivalent and personal dose equivalent, are defined under certain conditions.

Ambient dose equivalent (1cm dose equivalent) Dose equivalent is a dose that would be produced at a depth of 1 cm from the surface of an ICRU sphere, which is 30 cm in diameter and simulates human tissue, placed in a field where radiation is coming from one direction; Ambient dose equivalent is used in measurements of ambient doses using survey meters, etc.



Personal dose equivalent (1 cm dose equivalent) Dose equivalent at a depth of 1 cm at a designated point on the human body; Since measurement is conducted using an instrument worn on the body, exposure from all directions is evaluated while a self-shielding effect is always at work.

⇒ Personal dose equivalents are always smaller than survey meter readings!



Units of
RadiationDifference between Values of Effective Dose and
Dose Equivalent





The ambient dose equivalent measured with a survey meter is defined as the dose equivalent at a depth of 1 cm from the surface of an ICRU sphere that is 30 cm in diameter. The ambient dose equivalent is also called 1 cm dose equivalent.

Source: Partially revised material 1 for the 9th meeting of the Atomic Energy Commission of Japan in 2012 (a report by Akira Endo of JAEA)

* Air kerma is a unit of physical quantity.

Units of
RadiationDoses in Units of Sieverts

