

CHAPTER 1 QUANTITIES, UNITS & DEFINITIONS

1.1 QUANTITIES AND UNITS

Activity - A measure of the intensity of radioactivity in a sample of material, quantified by the number of radioactive disintegrations occurring in a given quantity of material per unit time. Unit is the Curie (Ci); the SI unit is the Becquerel (Bq).

Absorbed Dose (D) - The energy imparted to matter by ionizing radiation per unit mass of irradiated material. The absorbed dose is expressed in units of rad; the SI unit is the Gray (Gy).

Dose Equivalent (H) - The product of absorbed dose in rads (SI: Gray) in tissue, a quality factor (Q), and other modifying factors (N). Dose Equivalent is expressed in units of rem; the SI unit is the Sievert.

Exposure - The amount of ionizations produced in air by X or gamma photons. The unit is the Roentgen; the SI unit is the coulomb per kilogram.

	Traditional	SI	Conversion
Exposure	Roentgen (R)	Coul/kg	$1 \text{ R} = 2.58 \times 10^{-4} \text{ Coul/kg}$
Activity	Curie (Ci) $1 \text{ Ci} = 3.7 \times 10^{10} \text{ dps}$ $1 \text{ Ci} = 2.22 \times 10^{12} \text{ dpm}$	Becquerel (Bq) $1 \text{ Bq} = 1 \text{ dps}$	$1 \text{ Ci} = 3.7 \times 10^{10} \text{ Bq}$ $1 \text{ Bq} = 2.7 \times 10^{-11} \text{ Ci}$
Dose	Rad Gray (Gy) $1 \text{ Rad} = 100 \text{ ergs/gm}$	$1 \text{ Rad} = 0.01 \text{ Gy}$ $1 \text{ Gray} = 1 \text{ J/kg}$	$1 \text{ Gy} = 100 \text{ Rad}$
Dose Equivalent (H)	Rem Sievert (Sv) $\text{Rem} = \text{Rad} \times \text{QF}$	$1 \text{ Rem} = 0.01 \text{ Sv}$ $\text{Sv} = \text{Gray} \times \text{QF}$	$1 \text{ Sv} = 100 \text{ Rem}$

1.2 DEFINITIONS

Airborne Radioactivity - Any radioactive material dispersed in the air in the form of dusts, fumes, mists, vapors, or gases.

ALARA - An acronym for "As Low as Reasonably Achievable," a basic concept of radiation protection that specifies that radioactive discharges from radiation releases and exposure to the workforce and the general public be kept as far below regulation limits as feasible.

ALI - An acronym for "Annual Limit on Intake," which is the quantity of a single radionuclide which, if inhaled or ingested in 1 year, would irradiate a person represented by reference man (ICRP Publication 23) to the limiting value for control of the workplace.

Bioassay - The collection and analysis of human hair, tissue, nasal smears, urine, or fecal samples to determine the amount of radioactive material that might have been ingested by the body.

Contamination - The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.

DAC - An acronym for "Derived Air Concentration." It is obtained by dividing the ALI for any given radionuclide by the volume of air breathed by a Reference man during a working year ($2.4 \times 10^3 \text{m}^3$). The unit of DAC is in uCi/m^3 or Bq/m^3 .

Direct Ionizing Particles - Any electrically charged particles (electrons, protons, alpha particles, muons, etc.) having sufficient energy to produce ionization by collision.

Dose Terms

Dose - A quantity (total or accumulated) of ionizing radiation received.

Dose Rate - A quantity (total or accumulated) of ionizing radiation delivered per unit time and measured, for example, in rem per hour.

Occupational Dose - This includes radiation dose to an individual received during the course of employment, support, support activities, or research. Occupational dose does not include dose incurred during medical or dental procedures.

Dose Equivalent (H) - The product of absorbed dose in rads (SI:Gray) in tissue, a quality factor (Q), and other modifying factors (N). Dose Equivalent is expressed in units of rem; the SI unit is the sievert.

Annual Does Equivalent - The dose equivalent received in a year. Annual dose equivalent is expressed in units or rem (or sievert).

Annual Effective Dose Equivalent - The effective dose equivalent received in a year. The annual effective dose equivalent is expressed in units of rem (or sievert).

Collective Dose Equivalent - The sum of the dose equivalents of all individuals in an exposed population. Collective effective dose equivalent is expressed in units of person-rme (or person-sievert).

Committed Dose Equivalent - The calculated dose equivalent projected to be received by a tissue or organ over a 50-year period after an intake of radionuclide into the body. It does not include contributions from external dose. Committed dose equivalent is expressed in units of rem (or sievert).

Committed Effective Dose Equivalent ($H_E, 50$) - The sum of the committed dose equivalent to various tissues in the body, each multiplied by its weighting factor. It does not include contributions from external dose. Committed effective dose equivalent is expressed in units of rem (or sievert).

Cumulative Annual Effective Dose Equivalent - The sum of the annual effective dose equivalents recorded for an individual for each year of employment at a DOE or DOE contractor facility.

Effective Dose Equivalent (H_E) - The sum over specified tissues of the products of the dose equivalent in a tissue (H_t) and weighting factor (W_t) for that tissue, i.e., $H_E = \sum W_t H_t$. The effective dose equivalent is expressed in units or rem (or sievert).

Quality Factor (Q) - A modifying factor that is employed to derive dose equivalent from absorbed dose.

Shallow, Deep, and Lens of Eye Dose Equivalent - The dose equivalent at the respective depths of 0.007 cm, and 0.3 cm in tissue.

Weighting Factor (W_T) - Is used in the calculation of annual and committed effective dose equivalent to equate the risk arising from the irradiation of tissue T to the total risk when the whole body is uniformly irradiated. The weighting factors as defined in ICRP Publication 26 and NCRP Report 91 are:

<u>Organs or Tissues</u>	<u>Weighting Factor</u>
Gonads	0.25
Breasts	0.15
Red Bone Marrow	0.12
Lungs	0.12
Thyroid	0.03
Bone Surfaces	0.03
Remainder	0.30

Remainder means the five other organs or tissue with the highest dose (e.g., liver, kidney, spleen, thymus, adrenal, pancreas, stomach, small intestine, upper large intestine or lower large intestine). The weighting factor for each remainder organ or tissue is 0.06. The extremities, skin, and lens of the eye are excluded from the "remainder" organs or tissue for assessment of effective dose equivalent.

Dosimeter - A portable instrument for measuring and registering the total accumulated exposure to ionizing radiation.

Enclosed Beam X-Ray System - An enclosed beam x-ray system is one in which all possible x-ray paths are fully enclosed and dose rates at any accessible surface are less than 0.5 mR/hour.

Exclusion Areas - An area defined by safety requirements to be restricted to all personnel during operation of a radiation producing device.

Exposure - A general term for absorption of radiation or ingestion of a radionuclide. Acute exposure is generally accepted to mean a large exposure received over a short period of time; chronic exposure is a lower exposure rate received over a long period of time or over a lifetime.

Exposure Rate - The time rate at which exposure occurs. It is normally expressed in Roentgens per hour (R/hr) or milliRoentgens per hour mR/hr.

External Dosimetry - Measuring exposure to ionizing radiation when the radiation source is located outside the body.

Extremity - Extremity includes hands and arms below the elbow or feet and legs below the knee.

Fail Safe Design - One in which all failures of indicators or safety components that can reasonably be anticipated to cause the equipment to fail in a mode such that personnel are safe from exposure to radiation. For example:

- if an "X-ray on" or "beam on" light fails, the production of x-rays or particles shall be prevented.
- if a shutter status indicator fails, the shutter shall close.

Indirectly Ionizing Particles - Any uncharged particles (neutrons, photons, etc.) which can liberate (by decay or interaction) directly ionizing particles, or can initiate nuclear transformations.

Interlock - any entrance or exit which is interlocked in a fail-safe, redundant manner to prevent unauthorized access to the area it encloses.

Internal Dosimetry - Measuring exposure to ionizing radiation resulting from radioactive substances in the body.

Ionizing Radiation - Consists of directly or indirectly ionizing particles, or a mixture of both.

Monitoring - Actions intended to detect and evaluate radiological conditions.

Non-Stochastic Effects - Effects such as the opacity of the lens of the eye for which the severity of the effect varies with the radiation dose and for which a threshold may therefore occur.

Open Beam X-Ray System - an X-ray system that does not comply with all requirements of this section shall be classified as an open beam X-ray system.

Radiation Emergency - Any situation involving radiation which places or may place in jeopardy human life, health or safety, or valuable property. Swift action is usually very important - minutes count.

Radioactivity - The spontaneous emission of particulate or electromagnetic radiation from an unstable isotope.

Reference man - A person with the anatomical and physiological characteristics defined in the report of the ICRP Task Group of Reference man (ICRP 23).

RPM - An abbreviation for Radiation Producing Machine. A device which produces ionizing radiation fields during its operation.

SI Units - An international system of measurement which has been internationally adopted to replace the British and metric systems.

Stochastic Effects - Malignant and hereditary disease for which the probability of an effect occurring, rather than its severity, is regarded as a function of dose without a threshold for radiation protection purposes.

Survey - A determination of the radiological conditions in a given area.