COMMONWEALTH DEPARTMENT OF HEALTH

Australian Radiation Laboratory

Glossary of Terms Recommended for Use in Radiation Control
Legislation and Associated Codes of Practice

Compiled by

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Prepared for the Radiation Health Committee
of the National Health and Medical Research Council

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FOREWORD

Members of the Radiation Health Committee of the National Health and Medical Research Council had, in recent years, become increasingly aware of the need for a comprehensive glossary of terms associated with radiological health and related matters. It considered that use of such a glossary could introduce some degree of uniformity into documentation and regulations in these areas. The new concepts embodied in "Recommendations of the International Commission on Radiological Protection (Publication No. 26)" in 1977, and the introduction into Australia of SI units for the measurement of radioactivity and of ionizing radiation, increased the desirability for such a glossary to be compiled. In addition, it could be particularly useful for interpretation of codes of practice and as a source document for reference purposes.

Compilation of the glossary was undertaken by staff of the Australian Radiation Laboratory for the Radiation Health Committee. In general, the definitions were taken from the national and international reference documents listed in the bibliography. Minor changes were made to some definitions to provide internal consistency within the glossary. Where a suitable definition of a term could not be found in the literature, one was proposed by the authors.

Following comments made by the Radiation Health Committee and by other persons involved in the writing of relevant Codes, the final document was adopted by the National Health and Medical Research Council at its meeting in June 1982. Council recommended that the glossary be used by organizations producing official documents and by appropriate regulatory authorities.

SECTION (I) BASIC PHYSICS TERMS

Alpha particle, means an energetic charged particle emitted by the nucleus of a radionuclide during alpha decay. An alpha particle consists of two protons and two neutrons.

Alpha rays, means a stream of alpha particles with one or more discrete energies, emitted by the nuclei of certain radionuclides.

Beta particle, means an energetic electron emitted by the nucleus of a radionuclide during beta decay. The beta particle may be either positively or negatively charged.

Beta rays, means a stream of beta particles with a wide range of energies, emitted by the nuclei of certain radionuclides.

Bremsstrahlung, means ionizing radiation produced by the deceleration of electrons in the vicinity of nuclei.

Daughter product, means any nuclide which is formed as a result of radioactive decay of a specified radionuclide.

Decay constant, symbol λ, means, for a radionuclide, the quotient of dP by dt, where dP is the probability of a given nucleus undergoing a spontaneous transformation into another nuclide or from the existing energy level of that radionuclide.

$$\lambda = \frac{dP}{dt}$$

Directly ionizing radiation, means charged particles that have sufficient kinetic energy to produce ionization by collision.

Electron, means a particle of specific mass and electrical charge. The particle may be positively charged (positron) or negatively charged (negatron), but the term is mostly used to apply to the negatively charged particle.

Fission, means a nuclear transformation characterised by the splitting of a nucleus into at least two other nuclei, with the release of energy.

Fusion, means the coalescing of two or more atomic nuclei to form another atomic nucleus.

Gamma rays, means electromagnetic radiation emitted spontaneously
by certain radionuclides in the process of a nuclear
transition.

Indirectly ionizing radiation, means uncharged particles, including
photons, capable of causing ionization by secondary processes.

Ionization, means a process in which one or more electrons are
liberated from a parent atom or molecule or other bound state.

Ionizing radiation, means radiation capable of causing ionization
by primary and secondary processes.

Isomeric nuclide (isomer), means a nuclide that can exist for a
finite period in states having different energy levels.

Isomeric transition, means the process by which an isomeric nuclide
decays to a lower energy level.

Mean life, means the average time during which an atom or other
system exists in a particular configuration.

Neutron, means a particle of zero charge that is a constituent of
most nuclei.

Nuclear transformation, means a change of nuclide or a change in
energy level of a nuclide induced by particle or by
high-energy photon bombardment.

Nuclide, means a species of atom having specified numbers of
neutrons and protons in its nucleus.

Proton, means a positively charged particle that forms the nucleus
of the hydrogen atom and is a constituent particle of all
nuclei.

Radiation, means energy propagated through space or through a
material medium in the form of waves or in the form of
kinetic energy of particles.

Radioactive decay, (radioactivity), means the spontaneous
transformation of a radionuclide into another nuclide (which
may or may not be radioactive) or a spontaneous change in
energy level of the nucleus of a radionuclide.

Radioactive half-life, symbol $T_{1/2}$, means, for a single
radioactive decay process, the time in which the amount of a
radioactive nuclide decays to half its original value.

$$T_{1/2} = \frac{\ln 2}{\lambda}$$

Radioactive material, means material which spontaneously emits
ionizing radiation.

Radionuclide, means a species of radioactive atom having specified
numbers of neutrons and protons in specified energy states.

Radon, means the radioactive gas radon-222.

Radon daughters, means the short-lived radioactive products of
decay of radon, namely, polonium-218 (radium A), lead-214
(radium B), bismuth-214 (radium C) and polonium-214
(radium C').

Specific activity, means the activity of a radionuclide per unit
mass of the element.

Thermal neutron, means a neutron that is approximately in thermal
equilibrium with its surroundings.

Thoron, means the radioactive gas radon-220.

Thoron daughters, means the short-lived radioactive products of
decay of thoron, namely, polonium-216 (thorium A), lead-212
(thorium B), bismuth-212 (thorium C), polonium-212 (thorium
C') and thallium-208 (thorium C").

X-rays, means ionizing radiation which is produced either by the
transitions of electrons between the various electron shells
of an atom, or by the deceleration of electrons in the
vicinity of nuclei.

SECTION (II)   QUANTITIES AND UNITS

A. QUANTITIES

Absorbed dose, symbol D, means quotient of $d\bar{E}$ by dm, where $d\bar{E}$ is
the mean energy imparted by ionizing radiation to matter of
mass dm.

$$D = \frac{d\bar{E}}{dm}$$

The unit of absorbed dose is the gray, symbol Gy.
1 Gy = 1 J kg^{-1}. This replaces the rad as the unit of
absorbed dose. 1 Gy = 100 rad.

Activity, symbol A, means, for a radioactive nuclide in a
particular energy state, the quotient of dN by dt, where dN
is the expectation value of the number of spontaneous nuclear
transitions from that energy state in the time interval dt.

$$A = \frac{dN}{dt}$$

The unit of activity is the becquerel, symbol Bq.
1 Bq = 1 s^{-1}. This replaces the curie (Ci) as the unit of
activity. 1 Bq = 2.7 x 10^{-11} Ci.

Collective dose equivalent, symbol S, means the product of the per
caput effective dose equivalent received by a subgroup (H_i)
and the number of people (P_i) in that subgroup, summed over
all subgroups in a population.

$$S = \sum_i H_i P_i$$

Collective dose-equivalent commitment, symbol S_c, means the
infinite time-integral of the collective dose equivalent.

Committed dose equivalent, symbol H_{50}, means the dose equivalent
to the body, organ or tissue integrated over a fifty year
period from a specified intake of radioactive material.

Deep dose-equivalent index, symbol $H_{I,d}$, means, for the point of
interest, the maximum dose equivalent at a depth of 1 cm or
greater within a 30 cm diameter sphere centred at the point
and consisting of material equivalent to soft tissue with a
density of 1 g cm^{-3}.

Dose equivalent, symbol H, means the product of D, Q, and N at the point of interest in tissue where D is the absorbed dose, Q is the quality factor and N is the product of all other modifying factors.

$$H = DQN$$

The unit of dose equivalent is the sievert, symbol Sv. This replaces the rem as the unit of dose equivalent. 1 Sv = 100 rem.

Dose-equivalent commitment, symbol H_c, means, for a given decision or practice, the infinite time integral of the per caput dose equivalent in a given organ or tissue for a specified population.

Dose-equivalent index, symbol H_I, means, for the point of interest, the maximum dose equivalent within a 30 cm diameter sphere centred at the point and consisting of material equivalent to soft tissue with a density of 1 g cm^{-3}. The unit of dose-equivalent index is the sievert, symbol Sv.

Effective dose equivalent, symbol H_E, means the sum for all tissues of the product of the weighting factor, w_T, which represents the proportion of the stochastic risk resulting from irradiation of tissue T to the total risk when the whole body is uniformly irradiated and the annual dose equivalent H_T in tissue T. (The effective dose equivalent is derived by summation of the dose equivalent arising from external radiation sources and the committed dose equivalent arising from internal sources).

$$H_E = \sum_T w_T H_T$$

Exposure, symbol X, means the quotient of dQ by dm, where the value of dQ is the absolute value of the total charge of the ions of one sign produced in air when all the electrons (negatrons and positrons) liberated by photons in air of mass dm are completely stopped in air.

$$X = \frac{dQ}{dm}$$

The unit of exposure is the coulomb per kilogram, (C kg^{-1}). This replaces the roentgen (R) as the unit of exposure. 1 C kg^{-1} = 3876 R.

Exposure rate constant, symbol Γ , means the exposure rate at a specified point from a given radioactive source of unit activity. For a radioactive source emitting photons, it is the quotient of $1^2 \dot{X}$ by A, where $\dot{X}$ is the exposure rate in air at distance 1 from a point source of activity A.

$$\Gamma = \frac{1^2 \dot{X}}{A}$$

Kerma, symbol K, means the quotient of dE_{tr} by dm, where dE_{tr}
is the sum of the initial kinetic energies of all the charged
ionizing particles liberated by uncharged ionizing particles
in a material of mass dm.

$$K = \frac{dE_{tr}}{dm}$$

The unit of kerma is the gray, symbol Gy. 1 Gy = 1 J kg^{-1}.

Quality factor, symbol Q, means a factor which is a function of
the linear collision stopping power in water of the radiation
at the point of interest. It is one of the modifying factors
used for calculation of dose equivalent.

Radon daughter exposure, means, for all exposures of a person to
inhaled radon daughters within a stated period of time, the
sum of all products formed by multiplying the radon daughter
concentration in the inhaled air and the time for which that
concentration was inhaled.

Relative biological effectiveness, symbol RBE, means the ratio of
the absorbed dose of a reference radiation to the absorbed
dose of a given test radiation, which will produce the same
level of biological response, all other conditions being kept
constant.

Shallow dose-equivalent index, symbol $H_{I,s}$, means, for the point
of interest, the maximum dose equivalent between depths of
0.07 mm and 1 cm within a 30 cm diameter sphere centred at
the point and consisting of material equivalent to soft
tissue with a density of 1 g cm^{-3}.

Thoron daughter exposure, means, for all exposures of a person to
inhaled thoron daughters within a stated period of time, the
sum of all products formed by multiplying the thoron daughter
concentration in the inhaled air and the time for which that
concentration was inhaled.

Unrestricted dose-equivalent index, means the dose equivalent index
that is the larger of the deep and shallow dose equivalent
indices.

Working level, symbol WL, means the concentration of any
combination of radon daughters or of thoron daughters in one
litre of air, such that the sum of energies of the alpha
particles emitted by the complete decay of the daughters is
1.3 x 10^5 MeV.

(1 WL = 1.3 x 10^5 MeV/l = 21 μJ m^{-3}).

Working level month, symbol WLM, is the unit of exposure to radon daughters or thoron daughters. 1 WLM is approximately equivalent to an exposure to 1 WL for a working month of 170 hours.

(1 WLM = 8.0 x 10^{10} MeV.s/l = 13 J s m^{-3}).

B. UNITS

Becquerel, symbol Bq, is the SI unit of activity, corresponding to one nuclear transition per second.

1 Bq = 1 s^{-1}.

Curie, symbol Ci, is the former unit of activity, corresponding to 3.7 x 10^{10} nuclear transitions per second.

1 Ci = 3.7 x 10^{10} Bq.

Electron volt, symbol eV, is a unit of energy and is equal to the change in energy of an electron in passing through a potential difference of one volt in vacuum.

1 eV = 1.602 x 10^{-19} J (approximately)

Gray, symbol Gy, is the SI unit of absorbed dose and kerma, corresponding to the absorption of one joule per kilogram of matter.

1 Gy = 1 J kg^{-1}

Rad, is the former unit of absorbed dose and kerma, corresponding to the absorption of 100 ergs per gram of matter.

1 rad = 10^{-2} Gy

Rem, is the former unit of dose equivalent, corresponding to the absorption of 100 erg in one gram of biological matter, taking into account the quality factor and other modifying factors.

1 rem = 10^{-2} Sv.

Roentgen, symbol R, is the former unit of exposure, corresponding to the production of 2.58 x 10^{-4} coulomb of charge in 1 kilogram of dry air.

1 R = 2.58 x 10^{-4} C kg^{-1}

Sievert, symbol Sv, is the SI unit of dose equivalent, corresponding to the absorption of one joule in one kilogram of biological matter, taking into account the quality factor and other modifying factors.

Multiples and submultiples, means the multiplying factors used in conjunction with units for ease of expression, and which are often represented by prefixes. The prefixes, symbols and multiplying factors to be applied to the units are as follows:

Prefix	Symbol	Multiplying Factor	Prefix	Symbol	Multiplying Factor
exa	E	10^{18}	milli	m	10^{-3}
peta	P	10^{15}	micro	μ	10^{-6}
tera	T	10^{12}	nano	n	10^{-9}
giga	G	10^{9}	pico	p	10^{-12}
mega	M	10^{6}	femto	f	10^{-15}
kilo	k	10^{3}	atto	a	10^{-18}

SECTION (III)   RADIOLOGICAL PHYSICS TERMS

Additional filtration, means the filtration effected by filters
and other materials in the radiation beam which are placed
between the radiation source and a defined plane.

Biological half-life, means the time required for half of a
quantity of specified material in a living organism to be
biologically eliminated.

Effective energy, means, for a beam of heterogeneous radiation,
the energy of a beam of homogeneous radiation that, under the
same conditions, is absorbed or scattered to the same extent
as that beam.

Effective half-life, means the time required for the activity of a
radionuclide in a living organism to fall to half its
original value as a result of both biological elimination and
radioactive decay. The effective half-life is given by

$$\frac{T_{b\ 1/2} \times T_{r\ 1/2}}{T_{b\ 1/2} + T_{r\ 1/2}}$$

where $T_{b\ 1/2}$ and $T_{r\ 1/2}$ are the biological and
radioactive half-lives respectively.

Filtration, means the modification of characteristics of the
ionizing radiation in passing through matter.

Half-value layer, means the thickness of a specified material that
attenuates a beam of radiation so that the exposure rate or
absorbed dose rate at a point is reduced by half. The
contribution of all scattered radiation, other than that
which might be present in the beam initially, is deemed to be
excluded.

Inherent filtration, means the filtration effected by the
irremovable materials through which the radiation beam passes
before emerging from the radiation source. The inherent
filtration is expressed in terms of the thickness of a
reference material, which is the same as the specified
material for measurement of half-value layer, and is measured
at a specified potential difference.

Leakage radiation, means ionizing radiation emerging after
transmission through the protective shielding of the
radiation source.

Primary radiation, or primary beam, means radiation emanating
through defined geometry from a radiation emitting device.

Radiation beam, means the flux of radiation from a radiation
source, being essentially a point source, and is or is not
limited in solid angle. Leakage radiation and scattered
radiation are, neither in part nor in total, considered to
form a radiation beam.

Radiation emitting device, means a device containing material, or
equipment, which emits or is capable of emitting ionizing or
non-ionizing radiation.

Radiation quality, means the ability of a radiation beam to
penetrate into the medium or object irradiated. It is often
expressed in terms of the half value layer.

Radioactive source, means any quantity of radioactive material
having an activity above a specified level.

Radioactive substance, means any substance, either in solid, liquid
or gaseous form, which consists of or contains more than a
prescribed concentration or activity of any radioactive
material, whether naturally occurring or artificially
produced.

Radiological, means relating to the generation and application of
ionizing radiation for scientific, medical and technical
purposes.

Radiology, means the study and application of X-rays, gamma rays
and other ionizing radiations in the diagnosis and treatment
of disease in humans.

Residual radiation, means that part of the primary beam which
after passing through a specified area or material, has no
further useful purpose.

Scattered radiation, means radiation resulting from the
interaction of ionizing radiation with matter, the
interaction being accompanied by a reduction in radiation
energy and/or by a change in direction of the radiation.

Sealed (radioactive) source, means radioactive material sealed in a
container or having a bonded cover, with the container or
cover being strong enough to prevent contact with and
dispersion of the radioactive material under the conditions
of use and wear for which it was designed.

Stray radiation, means all radiation except that of the specified
radiation beam under consideration, but including its
residual radiation.

Total filtration, means the total of inherent filtration and
additional filtration.

SECTION (IV)   RADIATION PROTECTION TERMS

Accidental exposure, means an involuntary exposure to sources of
radiation.

ALARA, means the reduction of exposure of persons such that the
doses received are As Low As Reasonably Achievable, economic
and social factors being taken into account.

Annual limit on intake, symbol ALI, means the smaller value of
activity of intake of a given radionuclide in a year by the
relevant reference individual, which would result in either
an effective dose equivalent at the appropriate annual limit
for stochastic effects or a committed dose equivalent in any
organ or tissue at the appropriate annual limit for
non-stochastic effects. The annual limits on intake form
secondary limits for internal exposure.

Appreciable bodily injury, means any bodily injury or effect that
is deleterious to the health or well-being of the individual.

Authorized limit, means a limit laid down by a competent authority
or by the management of an institution.

Background radiation, means the ionizing radiation at a point,
consisting of natural background radiation and ionizing
radiation from man-made sources other than that emitted from
the source or sources under consideration.

Contaminant, means the radionuclide which is a component of a
specified contamination.

Contamination, means undesirable radioactive material in unsealed
gaseous, liquid or particulate form in air, water or other
substances or on surfaces.

Controlled area, means a defined area which is under surveillance
regarding the level of ionizing radiation, and for which
access, occupancy and working conditions are regulated and
controlled and is an area in which the occupational exposure
may exceed three-tenths of the prescribed annual
dose-equivalent limits.

Critical group, means that group in a population group with such
characteristics and living in such an environment that it is
likely to be exposed from a given practice at a higher level
than the rest of the exposed population.

Critical organ, means an organ, essential to the functioning of the whole body, that is most likely to be damaged when exposed, internally or externally, to specified ionizing radiation.

Critical pathway, means that route for the transport of radioactive materials from the point of release into the body of the receptor which accounts for most of the intake of a particular radionuclide.

Derived limit, means a limit used in radiation protection which is related to the relevant dose-equivalent limits by a defined model of the situation and is such that its application will ensure these limits are not exceeded.

Discharge limit, means the maximum permissible discharge rate for radioactive effluent and is derived so as to ensure that the prescribed dose-equivalent limits for members of the public are not exceeded.

Dose, means either dose equivalent or absorbed dose, depending on the context in which it is used.

Dose-equivalent limit, means the dose equivalent that, in light of present knowledge, is not expected to cause appreciable bodily injury to a person at any time during his lifetime, or to any of his offspring. The limit is usually expressed in terms of an annual limit.

Emergency exposure, means voluntary exposure to ionizing radiation in emergency situations.

External exposure, means exposure to ionizing radiation from sources of radiation external to the human body.

Internal exposure, means exposure to ionizing radiation from radioactive material taken into the human body.

Intervention level, means that level of a specified quantity which, when exceeded, requires intervention.

Investigation level, means that level of dose equivalent or intake above which the results are considered sufficiently important to justify further investigation.

Maximum permissible body burden, symbol q, means the maximum
permissible amount of radionuclide that may be deposited
within the body so that the relevant prescribed
dose-equivalent limits are not exceeded. Body burden is
measured in units of activity.

Maximum permissible concentration, symbol MPC, means the
calculated quantity that prescribes limits for the permitted
concentration of particular radionuclides in air, food or
water. MPC values ensure that the prescribed dose equivalent
limits for particular organs are not exceeded for an
occupational exposure of 50 years. MPC values are quoted in
activity per unit volume.

Member of the public, means a person who is not a radiation worker.

Natural background radiation, means ionizing radiation which is
attributable to natural sources (including living organisms
in the environment, and extra-terrestrial sources). For
radiation protection purposes, it may be necessary to
distinguish between normal natural background radiation and
enhanced natural background radiation due to man's activities
or to special environments.

Non-stochastic effect, means an effect for which its severity
varies with dose and for which a threshold may occur.

Occupancy factor, symbol T, means the fraction of a specified time
in which a location is or may be occupied.

Personal monitoring device, means a device worn by persons to
monitor levels of ionizing radiation.

Planned special exposure, means an exposure to radiation from a
procedure which does not occur during normal operations and
for which special planning is required.

Radiation hazard, means the risk of deleterious effects to a whole
population or to groups or to particular individuals,
attributable to deliberate or accidental irradiation by
natural or man-made sources.

Radiation worker, means a person who, in the course of his
employment, may be exposed to ionizing radiation arising from
his direct involvement with sources of such radiation.

Recording level, means that level of dose equivalent or intake
above which the result is of sufficient interest to be worth
recording and keeping.

Reference level, means that level of dose equivalent or intake
above which or below which planned alternative courses of
action may be implemented.

Reference man, means a person with the anatomical and physiological
characteristics defined in the report of the ICRP Task Group
on Reference Man (ICRP Publication 23).

Secondary limit, means for external exposure of the whole body,
the maximum value of the deep dose-equivalent index in the
body, and for internal exposure the annual limits on intake
by inhalation or ingestion.

Stochastic effect, means an effect, the probability of which
occurring, rather than its severity, is regarded as a
function of dose, without threshold.

Supervised area, means a defined area which is under surveillance
regarding the levels of ionizing radiation, and for which
access, occupancy and working conditions are regulated and
controlled and is an area in which the occupational exposure
may exceed one-tenth but is unlikely to exceed three-tenths
of the prescribed annual dose-equivalent limits.

Transport index, means, for a package containing radioactive
material, the number expressing the maximum radiation level
in millirem per hour at 1 metre from the external surface of
the package.

Workload, symbol W, means the measure, in suitable units, of the
amount of use of equipment emitting ionizing radiation.

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