Radiological Terms

absorbed dose (*D*): The quotient of d*E* by d*m*, where d*E* is the mean energy imparted by ionizing radiation to matter of mass d*m*. The unit for absorbed dose is the joule per kilogram (J kg^{-1}), with the special name gray (Gy).

accelerator: In this Report, refers to an electron accelerator, which is a device for imparting kinetic energy to electrons, with the kinetic energy being >2 and <50 MeV.

accelerator head: The part of the accelerator enclosing the x-ray target or source from which the useful beam emanates. The accelerator head contains shielding and may rotate about an axis.

activation: The process of inducing radioactivity by irradiation. An example is the process of creating radionuclides by neutron and gamma-ray activation of materials within the treatment room.

activity: The number of spontaneous nuclear transformations that occur in a quantity of a radioactive nuclide per unit time. The unit of activity is one transformation per second (s^{-1}) with the special name becquerel (Bq).

air kerma (K_a): (see **kerma**).

annihilation: The process by which electromagnetic radiation is emitted as a result of the combination and disappearance of an electron and a positron. Two gamma rays of 0.511 MeV energy each are emitted in most cases.

as low as reasonably achievable (ALARA): A principle of radiation protection philosophy that requires that exposures to ionizing radiation be kept as low as reasonably achievable, economic and social factors being taken into account. The protection from radiation exposure is ALARA when the expenditure of further resources would be unwarranted by the reduction in exposure that would be achieved.

atomic number (*Z*) (low-*Z*, high-*Z*): The atomic number of a nucleus is the number of protons contained in the nucleus. Low-*Z* describes nuclei with $Z \leq 26$. High-*Z* describes nuclei with $Z > 26$.

attenuation: The reduction of dose equivalent or other physical properties of a radiation field upon the passage of radiation through matter. This Report is concerned primarily with broad-beam attenuation that occurs when the area of the radiation field is large at the barrier (in contrast to a small diameter beam).

barn: Special unit for the cross section. 1 barn = 10^{-28} m^2 (10^{-24} cm^2) (see **cross section**).

barrier (or **protective barrier):** A protective wall of radiation attenuation material(s) used to reduce the dose equivalent on the side beyond the radiation source (see **primary** and **secondary barriers**).

beam-on time: The time that the radiation source is actually producing radiation.

bremsstrahlung: The spectrum of photons produced by the acceleration or deceleration of high-energy electrons, particularly near the coulomb fields of nuclei (see also **x-ray target**).

broad beam: Conditions of a radiation-shielding situation in which the beam impinging on a barrier surface includes scattered radiation and is laterally extensive.

collimator: A device used to reduce the cross-sectional area of the useful beam of photons or electrons with an absorbing material.

concrete: (see **ordinary concrete**).

controlled area: A limited-access area in which the occupational exposure of personnel to radiation or to radioactive material is under the supervision of an individual in charge of radiation protection. This implies that access, occupancy, and working conditions are controlled for radiation protection purposes.

cross section (σ): The quotient of probability by particle fluence, referring to the probability of an interaction for a single target entity when subjected to a given particle fluence [see **fluence (particle)**]. The interaction is produced by incident charged or uncharged particles. The special unit for the cross section is **barn**.

deep dose equivalent: Dose equivalent at a tissue depth of 1 cm (NRC, 1996). Also called personnel dose equivalent at a depth of 1 cm (ICRU, 1993). The unit for deep dose equivalent is J kg^{-1}, with the special name sievert (Sv).

directly ionizing radiation: Charged particles (electrons, protons, alpha particles) having sufficient kinetic energy to produce ionization by collision (see **ionizing radiation**).

direct radiation: Radiation emitted from the target or source that passes though the collimator opening (see also **useful beam** and **primary radiation**).

dose: In this Report, used as a generic term when not referring to a specific quantity, such as absorbed dose or dose equivalent.

dose equivalent (*H*): The product of absorbed dose (*D*) and the radiation quality factor at a specified point of interest in tissue. The unit for *H* is joule per kilogram (J kg^{-1}), with the special name sievert (Sv).

effective dose (*E*): The sum of the weighted equivalent doses for the radiosensitive tissues and organs of the body. It is given by the expression $E = \Sigma_T (w_T H_T)$, in which H_T is the equivalent dose in tissue or organ T and w_T is the tissue weighting factor for tissue or organ T. The unit of E and H_T is joule per kilogram (J kg^{-1}), with the special name sievert (Sv) (see **equivalent dose** and **tissue weighting factor**).

energy, low or high: In this Report, for bremsstrahlung, low-energy is 10 MV or less, and high-energy is >10 MV. For a particle, unless otherwise specified, the term refers only to its kinetic energy in million electron volts.

equilibrium tenth-value layer (TVL_e): The thickness of a specific material that attenuates a specified radiation by a factor of 10, under broad-beam conditions, in that penetration region in which the directional and spectral distributions of the radiation are practically independent of thickness.

equivalent dose (H_T): The mean absorbed dose (D_T) in a tissue or organ modified by the radiation weighting factor (w_R) for the type and energy of the radiation. The unit for H_T is J kg^{-1}, with the special name sievert (Sv).

exposure: In this Report, exposure is used most often in its general sense, meaning to be irradiated. When used as the specifically defined radiation quantity, exposure is a measure of the ionization produced in air by x or gamma radiation. The unit of exposure is coulomb per kilogram (C kg^{-1}). The special unit for exposure is roentgen (R), where 1 R = 2.58 $\times$ 10^{-4} C kg^{-1}.

fluence (particle) (Φ): The quotient of dN by da, where dN is the number of particles or photons that enter a sphere of cross-sectional area da. The unit for particle fluence is m^{-2}, but it is also commonly expressed in cm^{-2} (*i.e.*, particles per m^2, or per cm^2).

fluence (particle) rate (ϕ): The quotient of dΦ by dt, where dΦ is the increment of particle fluence in the time interval dt. The unit for particle fluence rate is m^{-2} s^{-1}, but it is also commonly expressed in cm^{-2} s^{-1}(*i.e.*, particles per m^2 s^{-1}, or per cm^2 s^{-1}).

gamma ray: A photon emitted in the process of nuclear transition or radioactive decay.

gantry: The rotating arm on which the accelerator head (or ^{60}Co source) is mounted. The gantry, and therefore the useful beam of radiation, typically can rotate 360 degrees about its axis.

gray (Gy): The special name for the unit of the quantities absorbed dose and air kerma. 1 Gy = 1 J kg^{-1}.

half-life, radioactive: The time for the activity of any particular radionuclide to be reduced to one-half its initial value.

half-value layer (*HVL*): The thickness of a specified substance which, when introduced into the path of a given beam of radiation, reduces the radiation field quantity to one-half its original value.

indirectly ionizing radiation: Uncharged particles (*e.g.*, neutrons, photons, gamma rays) that are capable of releasing charged particles when interacting with matter (see **ionizing radiation**).

instantaneous dose-equivalent rate (IDR): The dose-equivalent rate in Sv h^{-1} as measured with the accelerator operating at the absorbed- dose output rate $\dot{D}_o$. IDR is specified at 30 cm beyond the penetrated barrier.

interlock: Device that automatically shuts off or reduces the radiation emission rate from an accelerator to acceptable levels (*e.g.*, by the opening of a door into a radiation area). In certain applications, an interlock can be used to prevent entry into a treatment room.

inverse square law: The rule that states that the intensity of radiation from a point source decreases as 1/d^2 from the source in a nonabsorbing medium, where d is the distance from the source.

ionizing radiation: Any radiation consisting of directly or indirectly ionizing particles or photons or a mixture of both. These radiations can produce ions as a consequence of interactions with matter.

irradiation: Exposure to ionizing radiation (see also **exposure**).

isocenter: The point defined by intersection of the gantry axis of rotation and the beam centerline of a medical accelerator or cobalt unit. Typically, the isocenter is located 1 m from the radiation source.

kerma (kinetic energy released per unit mass): The sum of the initial kinetic energies of all the charged particles liberated by uncharged particles per unit mass of specified material. The unit for kerma is J kg^{-1}, with the special name gray (Gy). Kerma can be quoted for any specified material at a point in free space or in an absorbing medium (*e.g.*, air kerma).

lead equivalence: The thickness of lead affording the same attenuation, under specified conditions, as the material in question.

leakage radiation: All radiation, except the useful beam, coming from within the accelerator head and other beam-line components. It is attenuated by shielding in the protective source housing as specified by IEC (2002).

lower limit of detection (LLD): The smallest value of the quantity of interest that can be measured reliably (*e.g*., personal dosimetry system).

mean absorbed dose (D_T): The mean absorbed dose in an organ or tissue, obtained by integrating or averaging absorbed doses at points in the organ or tissue.

members of the public: All persons who are not already considered occupationally exposed by a source or practice under consideration. When being irradiated as a result of medical care, patients are a separate category.

monitor unit (MU): The unit of measure of the quantity of ionizing radiation passing through a monitor chamber assembly located in the path of the useful beam from an accelerator. The value of the monitor unit is determined by calibrating the resulting absorbed dose in water usually at the isocenter under specified conditions.

monoenergetic: Possessing a single energy, or being within a narrowly- limited band of energies.

narrow beam: Conditions in which the measurement of ionizing radiation passing through a barrier does not include a contribution from scattered radiation within the barrier. These conditions can be met with a parallel beam of radiation having a small cross-sectional area impinging on a thin barrier and using a small detector located far from the barrier.

neutron capture: A process in which a neutron becomes part of the nucleus with which it interacts without release of another heavy particle.

neutron capture gamma ray: A photon emitted as an immediate result of the neutron-capture process.

neutron source strength (Q_n): The number of neutrons emitted from the head of the linear accelerator per gray of x-ray absorbed dose at the isocenter.

occupancy factor (T): The factor ($\leq$1) by which the workload should be multiplied to correct for the degree of occupancy (by any one person) of the area in question while the radiation source is in the "on" position and emitting radiation.

occupational exposure: Exposures to individuals that are incurred in the workplace as the result of situations that can reasonably be regarded as being the responsibility of management (exposures associated with medical diagnosis or treatment are excluded).

occupied area: Any room or other space, indoors or outdoors, that is likely to be occupied by any person, either regularly or periodically during the course of the person's work, habitation or recreation, and in which an ionizing radiation field exists because of radiation sources in the vicinity.

ordinary concrete: A Portland-cement concrete whose constituents are those usually utilized in construction. Thus, ordinary concrete excludes those mixtures called heavy concrete, in which a special material (*e.g*., iron) has been added to enhance the radiation-shielding properties. Cured ordinary concrete is specified with a density of 2.35 g cm^{-3}. Other terms found in the literature that are synonymous with ordinary concrete are standard-weight and normal-weight concrete. Often the density is rounded off to 2.4 g cm^{-3}.

phantom: As used in this Report, a volume of tissue- or water-equivalent material used to simulate the absorption and scattering characteristics of the patient's body or portion thereof.

photoneutron: A neutron released from a nucleus as the result of the absorption of an energetic photon.

photon: An energy quantum of electromagnetic radiation. In this Report, an x or gamma ray.

point source (of radiation): Any radiation source as viewed from a distance that is much greater than the linear size of the source, and for which the inverse square law is applicable. In this Report, when the distance from the source exceeds 10 times the largest linear dimension of the source, it may be considered a point source.

primary beam: (see **primary radiation**).

primary barrier: A wall, ceiling, floor or other structure designed to attenuate the useful beam to the required degree.

primary radiation (useful beam): In this Report, radiation emitted directly from the source that is intended to be used for medical purposes.

protective source housing: The part of the accelerator or teletherapy unit enclosing the x-ray target and/or source(s) from which the useful beam emanates. This component contains shielding and may rotate about an axis.

pulse cycle: The fraction of the operation cycle of an accelerator during which radiation is produced; the product of the pulse duration and the pulse-repetition frequency.

qualified expert: A medical or health physicist who is competent to design radiation shielding in radiotherapy facilities, and who is certified by the American Board of Radiology, American Board of Medical Physics, American Board of Health Physics, or Canadian College of Physicists in Medicine.

radiation protection survey: An evaluation of the radiation protection in and around an installation that includes radiation measurements, inspections, evaluations and recommendations.

reflection coefficient (α): The fraction of radiation (*e.g.*, fluence, energy, absorbed dose) expressed by the ratio of the amount backscattered to that incident.

scattered radiation: Radiation that, during passage through matter, is changed in direction, and the change is usually accompanied by a decrease in energy.

scatter fraction [$\alpha(\theta)$]: The ratio of absorbed dose of photons at 1 m from a tissue-equivalent scattering object to the absorbed dose measured at the isocenter at the surface of the scattering object with the objects removed. This quantity is a function of the scatter angle (θ), incident beam quality, and beam area. A scattering phantom is typically a water-equivalent sphere or right circular cylinder of 28 to 30 cm diameter.

secondary barrier: A wall, ceiling, floor or other structure designed to attenuate the leakage and scattered radiations to the required degree.

secondary radiation: All radiation produced by scattering off of objects or leakage through the protective source housing of the treatment unit. That is, all radiation in the treatment room except for the primary beam.

shielding design goal (*P*): Practical values, for a single radiotherapy source or set of sources, that are evaluated at a reference point beyond a protective barrier. When used in conjunction with the conservatively safe assumptions recommended in this Report, the shielding design goals will ensure that the respective annual values for effective dose recommended by NCRP (2004) for controlled and uncontrolled areas are not exceeded. For mixtures of low and high linear-energy-transfer radiation, the quantity dose equivalent is used. *P* can be expressed as a weekly or annual value (*e.g.*, mSv week^{-1} or mSv y^{-1} dose equivalent), but is most often expressed as weekly values since the workload for a radiotherapy source has traditionally utilized a weekly format.

skyshine: Radiation scattered back to Earth by the atmosphere above a radiation-producing facility.

slant thickness (t_s): For radiation that is obliquely incident on a shielding barrier, the slant thickness (t_s) equals $t/\cos\theta$, where θ is the angle of obliquity and t is the thickness of the barrier.

slowing down (of neutrons): Decrease in neutron kinetic energy, usually due to repetitive collisions with the matter through which they traverse.

tenth-value layer (*TVL*): The thickness of a specified substance which, when introduced into the path of a given beam of radiation, reduces the radiation field quantity to one-tenth of its original value.

tenth-value distance (*TVD*): The distance that radiation must traverse in order to reduce the radiation field quantity to one-tenth of its original value.

thermal neutrons: Neutrons in thermal equilibrium with their surroundings. In this Report, all neutrons with energies of less than ~1 eV are considered "thermal."

threshold, radiation-effect (or radiation-damage): The minimum absorbed dose (or dose equivalent) of radiation that will produce a specified effect or a specified type of damage to the irradiated material.

time averaged dose-equivalent rate (TADR): The barrier attenuated dose-equivalent rate averaged over a specified time or period of accelerator operation. TADR is proportional to instantaneous dose-equivalent rate (IDR), and depends on the values of workload (W) and use factor (U).

total effective dose equivalent (TEDE): The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

transmission factor (or barrier transmission) (for photons or neutrons) (*B*): For a given radiation type and quality, *B* is the ratio of any radiation field quantity at a location behind the barrier on which radiation is incident to the field quantity at the same location without the presence of the shield. *B* is a measure of the shielding effectiveness of the barrier.

two-source rule: This phrase refers to the conservatively safe, and often used, guideline that, when a location is to be shielded from two different sources of radiation, each passing through the same barrier, the resultant thickness of the barrier should be equal to the greater of the two individual thicknesses if they differ from one another by more than a *TVL*, or else it should be equal to the greater thickness plus one added *HVL*, as determined by the more penetrating of the two radiation sources.

uncontrolled area: Any space not meeting the definition of controlled area.

useful beam: (see **primary radiation**).

vault: A shielded room in which a high-intensity radiation source is housed.

week, calendar: Seven consecutive days.

week, work: Any combination of time intervals adding up to 40 h within seven consecutive days.

workload (*W*): The average absorbed dose of radiation produced by a source over a specified time (most often one week) at a specific location. In this Report, the workload is defined as the absorbed dose from photons at the isocenter, at 1 m from the source over a one week period averaged over a year. This Report defines two workload quantities: primary workload, and leakage-radiation workload.

workload, primary (W_{pri}): The workload arising from the primary beam (or useful beam).

workload, leakage-radiation (W_{L}): The workload arising from leakage radiation and measured at 1 m from the source of leakage radiation.

x-ray target: In this Report, the high-atomic number material used to convert an energetic electron beam into x rays by the bremsstrahlung process.