

## 9. GLOSSARY

**Absorbed Dose** -- The mean energy imparted to the irradiated medium, per unit mass, by ionizing radiation. Units: gray (GY), rad.

**Absorbed Fraction** -- A term used in internal dosimetry. It is that fraction of the photon energy (emitted within a specified volume of material) which is absorbed by the volume. The absorbed fraction depends on the source distribution, the photon energy, and the size, shape and composition of the volume.

**Absorption** -- The process by which radiation imparts some or all of its energy to any material through which it passes.

**Self-Absorption** -- Absorption of radiation (emitted by radioactive atoms) by the material in which the atoms are located; in particular, the absorption of radiation within a sample being assayed.

**Absorption Coefficient** -- Fractional decrease in the intensity of an unscattered beam of x or gamma radiation per unit thickness (linear absorption coefficient), per unit mass (mass absorption coefficient), or per atom (atomic absorption coefficient) of absorber, due to deposition of energy in the absorber. The total absorption coefficient is the sum of individual energy absorption processes. (See Compton Effect, Photoelectric Effect, and Pair Production.)

**Linear Absorption Coefficient** -- A factor expressing the fraction of a beam of x or gamma radiation absorbed in a unit thickness of material. In the expression  $I = I_0 e^{-\mu x}$ ,  $I_0$  is the initial intensity,  $I$  the intensity of the beam after passage through a thickness of the material  $x$ , and  $\mu$  is the linear absorption coefficient.

**Mass Absorption Coefficient** -- The linear absorption coefficient per cm divided by the density of the absorber in grams per cubic centimeter. It is frequently expressed as  $\mu/\rho$ , where  $\mu$  is the linear absorption coefficient and  $\rho$  the absorber density.

**Absorption Ratio, Differential** -- Ratio of concentration of a nuclide in a given organ or tissue to the concentration that would be obtained if the same administered quantity of this nuclide were uniformly distributed throughout the body.

**Activation** -- The process of inducing radioactivity by irradiation.

**Activity** -- The number of nuclear transformations occurring in a given quantity of material per unit time. (See Curie.)

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**Activity Median Aerodynamic Diameter (AMAD)** -- The diameter of a unit-density sphere with the same terminal settling velocity in air as that of the aerosol particulate whose activity is the median for the entire aerosol.

**Acute Exposure** -- Exposure to a chemical for a duration of 14 days or less, as specified in the toxicological profiles.

**Acute Radiation Syndrome** -- The symptoms which taken together characterize a person suffering from the effects of intense radiation. The effects occur within hours or weeks.

**Adsorption Coefficient (Koc)** -- The ratio of the amount of a chemical adsorbed per unit weight of organic carbon in the soil or sediment to the concentration of the chemical in solution at equilibrium.

**Adsorption Ratio (Kd)** -- The amount of a chemical adsorbed by a sediment or soil (i.e., the solid phase) divided by the amount of chemical in the solution phase, which is in equilibrium with the solid phase, at a fixed solid/solution ratio. It is generally expressed in micrograms of chemical sorbed per gram of soil or sediment.

**Alpha Particle** -- A charged particle emitted from the nucleus of an atom. An alpha particle has a mass charge equal in magnitude to that of a helium nucleus; i.e., two protons and two neutrons and has a charge of +2.

**Annihilation (Electron)** -- An interaction between a positive and a negative electron in which they both disappear; their energy, including rest energy, being converted into electromagnetic radiation (called annihilation radiation) with two 0.51 Mev gamma photons emitted at an angle of 180° to each other.

**Atomic Mass** -- The mass of a neutral atom of a nuclide, usually expressed in terms of "atomic mass units." The "atomic mass unit is one-twelfth the mass of one neutral atom of carbon-12; equivalent to  $1.6604 \times 10^{-24}$  gm. (Symbol: u)

**Atomic Number** -- The number of protons in the nucleus of a neutral atom of a nuclide. The "effective atomic number" is calculated from the composition and atomic numbers of a compound or mixture. An element of this atomic number would interact with photons in the same way as the compound or mixture. (Symbol: Z)

**Atomic Weight** -- The weighted mean of the masses of the neutral atoms of an element expressed in atomic mass units.

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**Auger Effect** -- The emission of an electron from the extranuclear portion of an excited atom when the atom undergoes a transition to a less excited state.

**Background Radiation** -- Radiation arising from radioactive material other than that under consideration. Background radiation due to cosmic rays and natural radioactivity is always present. There may also be background radiation due to the presence of radioactive substances in building materials.

**Becquerel (Bq)** -- International System of Units unit of activity and equals one transformation (disintegration) per second. (See Units.)  
**Beta Particle** -- Charged particle emitted from the nucleus of an atom. A beta particle has a mass and charge equal in magnitude to that of the electron. The charge may be either +1 or -1.

**Biologic Effectiveness of Radiation** -- (See Relative Biological Effectiveness)

**Bone Seeker** -- Any compound or ion which migrates in the body preferentially into bone.

**Branching** -- The occurrence of two or more modes by which a radionuclide can undergo radioactive decay. For example, radium C can undergo  $\alpha$  or  $\beta$  decay,  $^{64}\text{Cu}$  can undergo  $\beta^-$ ,  $\beta^+$ , or electron capture decay. An individual atom of a nuclide exhibiting branching disintegrates by one mode only. The fraction disintegrating by a particular mode is the "branching fraction" for that mode. The "branching ratio" is the ratio of two specified branching fractions (also called multiple disintegration).

**Bremsstrahlung** -- The production of electromagnetic radiation (photons) by the negative acceleration that a fast, charged particle (usually an electron) undergoes from the effect of an electric or magnetic field, for instance, from the field of another charged particle (usually a nucleus).

**Cancer Effect Level (CEL)** -- The lowest dose of chemical in a study, or group of studies, that produces significant increases in the incidence of cancer (or tumors) between the exposed population and its appropriate control.

**Capture, Electron** -- A mode of radioactive decay involving the capture of an orbital electron by its nucleus. Capture from a particular electron shell is designated as "K-electron capture," "L-electron capture, II etc.

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**Capture, K-Electron** -- Electron capture from the K shell by the nucleus of the atom. Also loosely used to designate any orbital electron capture process.

**Carcinogen** -- A chemical capable of inducing cancer.

**Carcinoma** -- Malignant neoplasm composed of epithelial cells, regardless of their derivation.

**Cataract** -- A clouding of the crystalline lens of the eye which obstructs the passage of light.

**Ceiling Value (DL)** -- A concentration of a substance that should not be exceeded, even instantaneously.

**Chronic Exposure** -- Exposure to a chemical for 365 days or more, as specified in the Toxicological Profiles.

**Compton Effect** -- An attenuation process observed for x or gamma radiation in which an incident photon interacts with an orbital electron of an atom to produce a recoil electron and a scattered photon of energy less than the incident photon.

**Containment** -- The confinement of radioactive material in such a way that it is prevented from being dispersed into the environment or is released only at a specified rate.

**Contamination, Radioactive** -- Deposition of radioactive material in any place where it is not desired, particularly where its presence may be harmful.

**Cosmic Rays** -- High-energy particulate and electromagnetic radiations which originate outside the earth's atmosphere.

**Count (Radiation Measurements)** -- The external indication of a radiation-measuring device designed to enumerate ionizing events. It may refer to a single detected event to the total number registered in a given period of time. The term often is erroneously used to designate a disintegration, ionizing event, or voltage pulse.

**Counter, Geiger-Mueller** -- Highly sensitive, gas-filled radiation-measuring device. It operates at voltages sufficiently high to produce avalanche ionization.

**Counter, Scintillation** -- The combination of phosphor, photomultiplier tube, and associated circuits for counting light emissions produced in the phosphors by ionizing radiation.

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**Curie** - A unit of activity. One curie equals  $3.7 \times 10^{10}$  nuclear transformations per second. (Abbreviated Ci.) Several fractions of the curie are in common usage.

**Megacurie** -- One million curies. Abbreviated MCi.

**Microcurie** -- One-millionth of a curie ( $3.7 \times 10^4$  disintegrations per sec). Abbreviated  $\mu$ Ci.

**Millicurie** -- One-thousandth of a curie ( $3.7 \times 10^7$  disintegrations per sec). Abbreviated mCi.

**Nanocurie** -- One-billionth of a curie. Abbreviated nCi.

**Picocurie** -- One-millionth of a microcurie ( $3.7 \times 10^2$  disintegrations per second or 2.22 disintegrations per minute). Abbreviated pCi; replaces the term  $\mu$ uc.

**Decay, Radioactive** -- Transformation of the nucleus of an unstable nuclide by spontaneous emission of charged particles and/or photons.

**Decay Chain or Decay Series** -- A sequence of radioactive decays (transformations) beginning with one nucleus. The initial nucleus, the parent, decays into a daughter nucleus that differs from the first by whatever particles were emitted during the decay. If further decays take place, the subsequent nuclei are also usually called daughters. Sometimes, to distinguish the sequence, the daughter of the first daughter is called the granddaughter, etc.

**Decay Constant** -- The fraction of the number of atoms of a radioactive nuclide which decay in unit time. (Symbol  $\lambda$ ). (See Disintegration Constant).

**Decay Product, Daughter Product** -- A new isotope formed as a result of radioactive decay. A nuclide resulting from the radioactive transformation of a radionuclide, formed either directly or as the result of successive transformations in a radioactive series. A decay product (daughter product) may be either radioactive or stable.

**Delta Ray** -- Energetic or swiftly moving electrons ejected from an atom during the process of ionization. Delta rays cause a track of secondary ionizations along their path.

**Developmental Toxicity** -- The occurrence of adverse effects on the developing organism that may result from exposure to a chemical prior to conception (either parent), during prenatal development, or postnatally to the time of sexual maturation. Adverse developmental effects may be detected at any point in the lifespan of the organism.

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**Disintegration Constant** -- The fraction of the number of atoms of a radioactive nuclide which decay in unit time;  $\lambda$ , is the symbol for the decay constant in the equation  $N=N_0e^{-\lambda t}$  where  $N_0$  is the initial number of atoms present, and  $N$  is the number of atoms present after some time,  $t$ . (See Decay Constant.)

**Disintegration, Nuclear** -- A spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus. When large numbers of nuclei are involved, the process is characterized by a definite half-life. (See Transformation, Nuclear.)

**Dose** -- A general term denoting the quantity of radiation or energy absorbed. For special purposes it must be appropriately qualified. If unqualified, it refers to absorbed dose.

**Absorbed Dose** -- The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. The unit of absorbed dose is the rad. One rad equals 100 ergs per gram. In SI units, the absorbed dose is the gray which is 1 J/kg. (See Rad.)

**Cumulative Dose (Radiation)** -- The total dose resulting from repeated or continuous exposures to radiation.

**Dose Assessment** -- An estimate of the radiation dose to an individual or a population group usually by means of predictive modeling techniques, sometimes supplemented by the results of measurement.

**Dose Equivalent (DE)** -- A quantity used in radiation protection. It expresses all radiations on a common scale for calculating the effective absorbed dose. It is defined as the product of the absorbed dose in rad and certain modifying factors. (The unit of dose equivalent is the rem. In SI units, the dose equivalent is the sievert, which equals 100 rem.)

**Dose, Radiation** -- The amount of energy imparted to matter by ionizing radiation per unit mass of the matter, usually expressed as the unit rad, or in SI units, 100 rad=1 gray (Gy). (See Absorbed Dose.)

**Maximum Permissible Dose Equivalent (MPD)** -- The greatest dose equivalent that a person or specified part thereof shall be allowed to receive in a given period of time.

**Median Lethal Dose (MLD)** -- Dose of radiation required to kill, within a specified period, 50 percent of the individuals in a large group of animals or organisms. Also called the  $LD_{50}$ .

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**Threshold Dose** -- The minimum absorbed dose that will produce a detectable degree of any given effect.

**Tissue Dose** -- Absorbed dose received by tissue in the region of interest, expressed in rad. (See Dose and Rad.)

**Dose, Fractionation** -- A method of administering radiation, in which relatively small doses are given daily or at longer intervals.

**Dose, Protraction** -- A method of administering radiation by delivering it continuously over a relatively long period at a low dose rate.

**Dose-distribution Factor** -- A factor which accounts for modification of the dose effectiveness in cases in which the radionuclide distribution is nonuniform.

**Dose Rate** -- Absorbed dose delivered per unit time.

**Dosimetry** -- Quantification of radiation doses to individuals or populations resulting from specified exposures.

**Early Effects (of radiation exposure)** -- Effects which appear within 60 days of an acute exposure.

**Electron** -- A stable elementary particle having an electric charge equal to  $\pm 1.60210 \times 10^{-19}$  C (Coulombs) and a rest mass equal to  $9.1091 \times 10^{-31}$  kg. A positron is a positively charged "electron." (See Positron.)

**Electron Volt** -- A unit of energy equivalent to the energy gained by an electron in passing through a potential difference of one volt. Larger multiple units of the electron volt are frequently used: keV for thousand or kilo electron volts; MeV for million or mega electron volts. (Abbreviated: eV,  $1 \text{ eV} = 1.6 \times 10^{-12}$  erg.)

**Embryotoxicity and Fetotoxicity** -- Any toxic effect on the conceptus as a result of prenatal exposure to a chemical; the distinguishing feature between the two terms is the stage of development during which the insult occurred. The terms, as used here, include malformations and variations, altered growth, and in utero death.

**Energy** -- Capacity for doing work. "Potential energy" is the energy inherent in a mass because of its spatial relation to other masses. "Kinetic energy" is the energy possessed by a mass because of its motion; MKSA unit:  $\text{kg}\cdot\text{m}^2/\text{sec}^2$  or joules.

**Binding Energy** -- The energy represented by the difference in mass between the sum of the component parts and the actual mass of the nucleus.

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**Excitation Energy** -- The energy required to change a system from its ground state to an excited state. Each different excited state has a different excitation energy.

**Ionizing Energy** -- The average energy lost by ionizing radiation in producing an ion pair in a gas. For air, it is about 33.73 eV.

**Radiant Energy** -- The energy of electromagnetic radiation, such as radio waves, visible light, x and gamma rays.

**Enriched Material** -- (1) Material in which the relative amount of one or more isotopes of a constituent has been increased. (2) Uranium in which the abundance of the  $^{235}\text{U}$  isotope is increased above normal.

**EPA Health Advisory** -- An estimate of acceptable drinking water levels for a chemical substance based on health effects information. A health advisory is not a legally enforceable federal standard, but serves as technical guidance to assist federal, state, and local officials.

**Equilibrium, Radioactive** -- In a radioactive series, the state which prevails when the ratios between the activities of two or more successive members of the series remains constant.

**Secular Equilibrium** -- If a parent element has a very much longer half-life than the daughters (so there is not appreciable change in its amount in the time interval required for later products to attain equilibrium) then, after equilibrium is reached, equal numbers of atoms of all members of the series disintegrate in unit time. This condition is never exactly attained, but is essentially established in such a case as radium and its series to Radium D. The half-life of radium is about 1,600 years; of radon, approximately 3.82 days, and of each of the subsequent members, a few minutes. After about a month, essentially the equilibrium amount of radon is present; then (and for a long time) all members of the series disintegrate the same number of atoms per unit time.

**Transient Equilibrium** -- If the half-life of the parent is short enough so the quantity present decreases appreciably during the period under consideration, but is still longer than that of successive members of the series, a stage of equilibrium will be reached after which all members of the series decrease in activity exponentially with the period of the parent. An example of this is radon (half-life of approximately 3.82 days) and successive members of the series to Radium D. **Equilibrium, Radiation** -- The condition in a radiation field where the energy of the radiations entering a volume equals the energy of the radiations leaving that volume.



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**Equilibrium Fraction (F)** -- In radon-radon daughter equilibrium, the parents and daughters have equal radioactivity, that is, as many decay into a specific nuclide as decay out. However, if fresh radon is continually entering a volume of air or if daughters are lost by processes other than radioactive decay, e.g., plate out or migration out of the volume, a disequilibrium develops. The equilibrium fraction is a measure of the degree of equilibrium/disequilibrium. The working-level definition of radon does not take into account the amount of equilibrium. The equilibrium fraction is used to estimate working levels based on measurement of radon only.

**Excitation** -- The addition of energy to a system, thereby transferring it from its ground state to an excited state. Excitation of a nucleus, an atom, or a molecule can result from absorption of photons or from inelastic collisions with other particles. The excited state of an atom is a metastable state and will return to ground state by radiation of the excess energy.

**Exposure** -- A measure of the ionization produced in air by x or gamma radiation. It is the sum of the electrical charges on all ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by the mass of the air in the volume element. The special unit of exposure is the roentgen.

**Fission, Nuclear** -- A nuclear transformation characterized by the splitting of a nucleus into at least two other nuclei and the release of a relatively large amount of energy.

**Gamma Ray** -- Short wavelength electromagnetic radiation of nuclear origin (range of energy from 10 keV to 9 MeV).

**Genetic Effect of Radiation** -- Inheritable change, chiefly mutations, produced by the absorption of ionizing radiation by germ cells. On the basis of present knowledge these effects are purely additive; there is no recovery.

**Gray (Gy)** -- SI unit of absorbed dose. One gray equals 100 rad. (See Units.)

**Half-Life, Biological** -- The time required for the body to eliminate one-half of any absorbed substance by regular processes of elimination. Approximately the same for both stable and radioactive isotopes of a particular element. This is sometimes referred to as half-time.

**Half-Life, Effective** -- Time required for a radioactive element in an animal body to be diminished 50% as a result of the combined action of radioactive decay and biological elimination.

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Effective half-life: =  $\frac{\text{Biological half-life} \times \text{Radioactive half-life}}{\text{Biological half-life} + \text{Radioactive half-life}}$

**Half-life, Radioactive** -- Time required for a radioactive substance to lose 50% of its activity by decay. Each radionuclide has a unique half-life.

**Immediately Dangerous to Life or Health (IDLH)** -- The maximum environmental concentration of a contaminant from which one could escape within 30 minutes without any escape-impairing symptoms or irreversible health effects.

**Immunologic Toxicity** -- The occurrence of adverse effects on the immune system that may result from exposure to environmental agents such as chemicals.

**In Vitro** -- Isolated from the living organism and artificially maintained, as in a test tube.

**In Vivo** -- Occurring within the living organism.

**Intensity** -- Amount of energy per unit time passing through a unit area perpendicular to the line of propagation at the point in question.

**Intermediate Exposure** -- Exposure to a chemical for a duration of 15 to 364 days as specified in the Toxicological Profiles.

**Internal Conversion** -- One of the possible mechanisms of decay from the metastable state (isomeric transition) in which the transition energy is transferred to an orbital electron, causing its ejection from the atom. The ratio of the number of internal conversion electrons to the number of gamma quanta emitted in the de-excitation of the nucleus is called the "conversion ratio." II

**Ion** -- Atomic particle, atom, or chemical radical bearing a net electrical charge, either negative or positive.

**Ion Pair** -- Two particles of opposite charge, usually referring to the electron and positive atomic or molecular residue resulting after the interaction of ionizing radiation with the orbital electrons of atoms.

**Ionization** -- The process by which a neutral atom or molecule acquires a positive or negative charge.

**Primary Ionization** -- (1) In collision theory: the ionization produced by the primary particles as contrasted to the "total ionization" which includes the "secondary ionization" produced by

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delta rays. (2) In counter tubes: the total ionization produced by incident radiation without gas amplification.

**Specific Ionization** -- Number of ion pairs per unit length of path of ionizing radiation in a medium; e.g., per centimeter of air or per micrometer of tissue.

**Total Ionization** -- The total electric charge of one sign on the ions produced by radiation in the process of losing its kinetic energy. For a given gas, the total ionization is closely proportional to the initial ionization and is nearly independent of the nature of the ionizing radiation. It is frequently used as a measure of radiation energy.

**Ionization Density** -- Number of ion pairs per unit volume.

**Ionization Path (Track)** -- The trail of ion pairs produced by ionizing radiation in its passage through matter.

**Isobars** -- Nuclides having the same mass number but different atomic numbers.

**Isomers** -- Nuclides having the same number of neutrons and protons but capable of existing, for a measurable time, in different quantum states with different energies and radioactive properties. Commonly the isomer of higher energy decays to one with lower energy by the process of isomeric transition.

**Isotones** -- Nuclides having the same number of neutrons in their nuclei.

**Isotopes** -- Nuclides having the same number of protons in their nuclei, and hence the same atomic number, but differing in the number of neutrons, and therefore in the mass number. Almost identical chemical properties exist between isotopes of a particular element. The term should not be used as a synonym for nuclide.

**Stable Isotope** -- A nonradioactive isotope of an element.

**Joule** -- The unit for work and energy, equal to one newton expended along a distance of one meter ( $1\text{J}=1\text{N}\times 1\text{m}$ ).

**Labeled Compound** -- A compound consisting, in part, of labeled molecules. That is molecules including radionuclides in their structure. By observations of radioactivity or isotopic composition, this compound or its fragments may be followed through physical, chemical, or biological processes.

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**Late Effects (of radiation exposure)** -- Effects which appear 60 days or more following an acute exposure.

**Lethal Concentration** <sub>(LO)</sub> (**LC<sub>LO</sub>**) -- The lowest concentration of a chemical in air which has been reported to have caused death in humans or animals.

**Lethal Concentration** <sub>(50)</sub> (**LC<sub>50</sub>**) -- The calculated concentration of a chemical in air to which exposure for a specific length of time is expected to cause death in 50% of a defined laboratory animal population.

**Lethal Dose** <sub>(LO)</sub> (**LD<sub>LO</sub>**) -- The lowest dose of a chemical introduced by a route other than inhalation that is expected to have caused death in humans or animals.

**Lethal Dose** <sub>(50)</sub> (**LD<sub>50</sub>**) -- The dose of a chemical which has been calculated to cause death in 50% of a defined laboratory animal population.

**Lethal Time** <sub>(50)</sub> (**LT<sub>50</sub>**) -- A calculated period of time within which a specific concentration of a chemical is expected to cause death in 50% of a defined laboratory animal population.

**Linear Energy Transfer (LET)** -- The average amount of energy transferred locally to the medium per unit of particle track length.

**Low-LET** -- Radiation characteristic of electrons, x-rays, and gamma rays.

**High-LET** -- Radiation characteristic of protons or fast neutrons.

**Average LET** -- is specified to even out the effect of a particle that is slowing down near the end of its path and to allow for the fact that secondary particles from photon or fast-neutron beams are not all of the same energy.

**Lowest-Observed-Adverse-Effect Level (LOAEL)** -- The lowest dose of chemical in a study, or group of studies, that produces statistically or biologically significant increases in frequency or severity of adverse effects between the exposed population and its appropriate control.

**Linear Hypothesis** -- The assumption that a dose-effect curve derived from data in the high dose and high dose-rate ranges may be extrapolated through the low dose and low dose range to zero, implying that, theoretically, any amount of radiation will cause some damage.

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**Malformations** -- Permanent structural changes in an organism that may adversely affect survival, development, or function.

**Mass Numbers** -- The number of nucleons (protons and neutrons) in the nucleus of an atom. (Symbol: A)

**Minimal Risk Level** -- An estimate of daily human exposure to a chemical that is likely to be without an appreciable risk of deleterious effects (noncancerous) over a specified duration of exposure.

**Mutagen** -- A substance that causes mutations. A mutation is a change in the genetic material in a body cell. Mutation can lead to birth defects, miscarriages, or cancer.

**Neurotoxicity** -- The occurrence of adverse effects on the nervous system following exposure to chemical.

**Neutrino** -- A neutral particle of very small rest mass originally postulated to account for the continuous distribution of energy among particles in the beta-decay process.

**No-Observed-Adverse-Effect Level (NOAEL)** -- The dose of chemical at which there were no statistically or biologically significant increases in frequency or severity of adverse effects seen between the exposed population and its appropriate control. Effects may be produced at this dose, but they are not considered to be adverse.

**Nucleon** -- Common name for a constituent particle of the nucleus. Applied to a proton or neutron.

**Nuclide** -- A species of atom characterized by the constitution of its nucleus. The nuclear constitution is specified by the number of protons (Z) number of neutrons (N), and energy content; or, alternatively, by the atomic number (Z), mass number  $A=(N+Z)$ , and atomic mass. To be regarded as a distinct nuclide, the atom must be capable of existing for a measurable time. Thus, nuclear isomers are separate nuclides, whereas promptly decaying excited nuclear states and unstable intermediates in nuclear reactions are not so considered.

**Octanol-Water Partition Coefficient (Kow)** -- The equilibrium ratio of the concentrations of a chemical in n-octanol and water, in dilute solution.

**Pair Production** -- An absorption process for x and gamma radiation in which the incident photon is annihilated in the vicinity of the nucleus of the absorbing atom, with subsequent production of an electron and positron pair. This reaction only occurs for incident photon energies exceeding 1.02 MeV.

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**Parent** -- A radionuclide which, upon disintegration, yields a specified nuclide--either directly or as a later member of a radioactive series.

**Photon** -- A quantity of electromagnetic energy (E) whose value in joules is the product of its frequency ( $\nu$ ) in hertz and Planck constant (h). The equation is:  $E=h\nu$ .

**Photoelectric Effect** -- An attenuation process observed for x- and gamma- radiation in which an incident photon interacts with an orbital electron of an atom delivering all of its energy to produce a recoil electron, but with no scattered photon.

**Positron** -- Particle equal in mass to the electron ( $9.1091 \times 10^{-31}$  kg) and having an equal but positive charge ( $+1.60210 \times 10^{-19}$  Coulombs). (See Electron).

**Potential Ionization** -- The potential necessary to separate one electron from an atom, resulting in the formation of an ion pair.

**Power, Stopping** -- A measure of the effect of a substance upon the kinetic energy of a charged particle passing through it.

**Progeny** -- The decay products resulting after a series of radioactive decays. Progeny can also be radioactive, and the chain continues until a stable nuclide is formed.

**Proton** -- Elementary nuclear particle with a positive electric charge equal numerically to the charge of the electron and a rest mass of 1.007277 mass units.

**$q_1^*$**  -- The upper-bound estimate of the low-dose slope of the doseresponse curve as determined by the multistage procedure. The  $q_1^*$  can be used to calculate an estimate of carcinogenic potency, the incremental excess cancer risk per unit of exposure (usually  $\mu\text{g/L}$  for water,  $\text{mg/kg/day}$  for food, and  $\mu\text{g/m}^3$  for air).

**Quality** -- A term describing the distribution of the energy deposited by a particle along its track; radiations that produce different densities of ionization per unit intensity are said to have different "qualities."

**Quality Factor (QF)** -- The linear-energy-transfer-dependent factor by which absorbed doses are multiplied to obtain (for radiation protection purposes) a quantity that expresses - on a common scale for all ionizing radiation - the effectiveness of the absorbed dose.

**Rad** -- The unit of absorbed dose equal to 0.01 J/kg in any medium. (See Absorbed Dose.)

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**Radiation** -- (1) The emission and propagation of energy through space or through a material medium in the form of waves; for instance, the emission and propagation of electromagnetic waves, or of sound and elastic waves. (2) The energy propagated through space or through a material medium as waves; for example, energy in the form of electromagnetic waves or of elastic waves. The term radiation or radiant energy, when unqualified, usually refers to electro-magnetic radiation. Such radiation commonly is classified, according to frequency, as Hertzian, infra-red, visible (light), ultra-violet, X-ray and gamma ray. (See Photon.) (3) By extension, corpuscular emission, such as alpha and beta radiation, or rays of mixed or unknown type, as cosmic radiation.

**Annihilation Radiation** -- Photons produced when an electron and a positron unite and cease to exist. The annihilation of a positron-electron pair results in the production of two photons, each of 0.51 MeV energy.

**Background Radiation** -- Radiation arising from radioactive material other than the one directly under consideration. Background radiation due to cosmic rays and natural radioactivity is always present. There may also be background radiation due to the presence of radioactive substances in other parts of the building, in the building material itself, etc.

**Characteristic (Discrete) Radiation** -- Radiation originating from an atom after removal of an electron of excitation of the nucleus. The wavelength of the emitted radiation is specific, depending only on the nuclide and particular energy levels involved.

**External Radiation** -- Radiation from a source outside the body -- the radiation must penetrate the skin.

**Internal Radiation** -- Radiation from a source within the body (as a result of deposition of radionuclides in body tissues).

**Ionizing Radiation** -- Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.

**Monoenergetic Radiation** -- Radiation of a given type (alpha, beta, neutron, gamma, etc.) in which all particles or photons originate with and have the same energy.

**Scattered Radiation** -- Radiation which during its passage through a substance, has been deviated in direction. It may also have been modified by a decrease in energy.

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**Secondary Radiation** -- Radiation that results from absorption of other radiation in matter. It may be either electromagnetic or particulate.

**Radioactivity** -- The property of certain nuclides to spontaneously emit particles or gamma radiation or x radiation following orbital electron capture or after undergoing spontaneous fission.

**Artificial Radioactivity** -- Man-made radioactivity produced by particle bombardment or electromagnetic irradiation, as opposed to natural radioactivity.

**Induced Radioactivity** -- Radioactivity produced in a substance after bombardment with neutrons or other particles. The resulting activity is "natural radioactivity" if formed by nuclear reactions occurring in nature, and "artificial radioactivity" if the reactions are caused by man.

**Natural Radioactivity** -- The property of radioactivity exhibited by more than 50 naturally occurring radionuclides.

**Radioisotopes** -- A radioactive atomic species of an element with the same atomic number and usually identical chemical properties.

**Radionuclide** -- A radioactive species of an atom characterized by the constitution of its nucleus.

**Radiosensitivity** -- Relative susceptibility of cells, tissues, organs, organisms, or any living substance to the injurious action of radiation. Radiosensitivity and its antonym, radioresistance, are currently used in a comparative sense, rather than in an absolute one.

**Reaction (Nuclear)** -- An induced nuclear disintegration, i.e., a process occurring when a nucleus comes in contact with a photon, an elementary particle, or another nucleus. In many cases the reaction can be represented by the symbolic equation:  $X+a \rightarrow Y+b$  or, in abbreviated form,  $X(a,b) Y$ . X is the target nucleus, a is the incident particle or photon, b is an emitted particle or photon, and Y is the product nucleus.

**Reference Dose (RfD)** -- An estimate (with uncertainty spanning perhaps an order of magnitude) of the daily exposure of the human population to a potential hazard that is likely to be without risk of deleterious effects during a lifetime. The RfD is operationally derived from the NOAEL (from animal and human studies) by a consistent application of uncertainty factors that reflect various types of data used to estimate RfDs and an additional modifying factor, which is based on a



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professional judgment of the entire database on the chemical. The RfDs are not applicable to nonthreshold effects such as cancer.

**Relative Biological Effectiveness (RBE)** -- The RBE is a factor used to compare the biological effectiveness of absorbed radiation doses (i.e., rad) due to different types of ionizing radiation. More specifically, it is the experimentally determined ratio of an absorbed dose of a radiation in question to the absorbed dose of a reference radiation required to produce an identical biological effect in a particular experimental organism or tissue. NOTE: This term should not be used in radiation protection. (See Quality Factor.)

**Rem** -- A unit of dose equivalent. The dose equivalent in rem is numerically equal to the absorbed dose in rad multiplied by the quality factor, the distribution factor, and any other necessary modifying factors.

**Reportable Quantity (RQ)** -- The quantity of a hazardous substance that is considered reportable under CERCLA. Reportable quantities are (1) 1 lb or greater or (2) for selected substances, an amount established by regulation either under CERCLA or under Section 311 of the Clean Water Act. Quantities are measured over a 24-hour period.

**Reproductive Toxicity** -- The occurrence of adverse effects on the reproductive system that may result from exposure to a chemical. The toxicity may be directed to the reproductive organs and/or the related endocrine system. The manifestation of such toxicity may be noted as alterations in sexual behavior, fertility, pregnancy outcomes, or modifications in other functions that are dependent on the integrity of this system.

**Roentgen (R)** -- A unit of exposure for photon radiation. One roentgen equals  $2.58 \times 10^{-4}$  Coulomb per kilogram of air.

**Short-Term Exposure Limit (STEL)** -- The maximum concentration to which workers can be exposed continually for up to 15 minutes. No more than four excursions are allowed per day, and there must be at least 60 minutes between exposure periods. The daily TLV-TWA may not be exceeded.

**SI Units** -- The International System of Units as defined by the General Conference of Weights and Measures in 1960. These units are generally based on the meter/kilogram/second units, with special quantities for radiation including the becquerel, gray, and sievert.

**Sickness, Radiation** -- (Radiation Therapy): A self-limited syndrome characterized by nausea, vomiting, diarrhea, and psychic depression following exposure to appreciable doses of ionizing radiation,

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particularly to the abdominal region. Its mechanism is unknown and there is no satisfactory remedy. It usually appears a few hours after irradiation and may subside within a day. It may be sufficiently severe to necessitate interrupting the treatment series or to incapacitate the patient. (General): The syndrome associated with intense acute exposure to ionizing radiations. The rapidity with which symptoms develop is a rough measure of the level of exposure.

**Sievert** -- The SI unit of radiation dose equivalent. It is equal to dose in grays times a quality factor times other modifying factors, for example, a distribution factor; 1 sievert equals 100 rem.

**Specific Activity** -- Total activity of a given nuclide per gram of an element.

**Specific Energy** -- The actual energy per unit mass deposited per unit volume in a given event. This is a stochastic quantity as opposed to the average value over a large number of instance (i.e., the absorbed dose).

**Standard Mortality Ratio (SMR)** -- Standard mortality ratio is the ratio of the disease or accident mortality rate in a certain specific population compared with that in a standard population. The ratio is based on 200 for the standard so that an SMR of 100 means that the test population has twice the mortality from that particular cause of death.

**Stopping Power** -- The average rate of energy loss of a charged particle per unit thickness of a material or per unit mass of material traversed.

**Surface-seeking Radionuclide** -- A bone-seeking internal emitter that is deposited and remains on the surface for a long period of time. This contrasts with a volume seeker, which deposits more uniformly throughout the bone volume.

**Target Organ Toxicity** -- This term covers a broad range of adverse effects on target organs or physiological systems (e.g., renal, cardiovascular) extending from those arising through a single limited exposure to those assumed over a lifetime of exposure to a chemical.

**Target Theory (Hit Theory)** -- A theory explaining some biological effects of radiation on the basis that ionization, occurring in a discrete volume (the target) within the cell, directly causes a lesion which subsequently results in a physiological response to the damage at that location. One, two, or more "hits" (ionizing events within the target) may be necessary to elicit the response.

**Teratogen** -- A chemical that causes structural defects that affect the development of a fetus.

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**Threshold Limit Value (TLV)** -- An allowable exposure concentration averaged over a normal 8-hour workday or 40-hour workweek.

**Toxic Dose (TD<sub>50</sub>)** -- A calculated dose of a chemical, introduced by a route other than inhalation, which is expected to cause a specific toxic effect in 50% of a defined laboratory animal population.

**Transformation, Nuclear** -- The process by which a nuclide is transformed into a different nuclide by absorbing or emitting a particle.

**Transition, Isomeric** -- The process by which a nuclide decays to an isomeric nuclide (i.e., one of the same mass number and atomic number) of lower quantum energy. Isomeric transitions, often abbreviated I.T., proceed by gamma ray and/or internal conversion electron emission.

**Tritium** -- The hydrogen isotopes with one proton and two neutrons in the nucleus (Symbol: <sup>3</sup>H or T).

**Unattached Fraction** -- That fraction of the radon daughters, usually <sup>218</sup>Po (Radium A), which has not yet attached to a particle. As a free atom, it has a high probability of being retained within the lung and depositing alpha energy when it decays.

**Uncertainty Factor (UF)** -- A factor used in operationally deriving the RfD from experimental data. UFs are intended to account for (1) the variation in sensitivity among the members of the human population, (2) the uncertainty in extrapolating animal data to the case of human, (3) the uncertainty in extrapolating from data obtained in a study that is of less than lifetime exposure, and (4) the uncertainty in using LOAEL data rather than NOAEL data. Usually each of these factors is set equal to 10.

**Units, Radiological** --

Units	Equivalents
Becquerel*	1 Bq = 1 disintegration per second = $2.7 \times 10^{-11}$ Ci
Curie	1 Ci = $3.7 \times 10^{10}$ disintegrations per second = $3.7 \times 10^{10}$ Bq
Gray*	1 Gy = 1 J/kg = 100 rad
Rad	1 Rad = 100 erg/g = 0.01 Gy
Rem	1 Rem = 0.01 Sievert
Sievert*	1 Sv = 100 rem

\*International Units are designated (SI).

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**Working Level (WL)** -- Any combination of short-lived radon daughters in 1 liter of air that will result in the ultimate emission of  $1.3 \times 10^5$  MeV of potential alpha energy.

**Working Level Month (WLM)** -- Inhalation of air with a concentration of 1 WL of radon daughters for 170 working hours results in an exposure of 1 WLM.

**X-rays** -- Penetrating electromagnetic radiations whose wave lengths are shorter than those of visible light. They are usually produced by bombarding a metallic target with fast electrons in a high vacuum. In nuclear reaction, it is customary to refer to photons originating in the extranuclear part of the atom as X-rays. These rays are sometimes called roentgen rays after their discoverer, W.C. Roentgen.