Glossary

Absorbed Dose

[See Radiation Dose] the amount of energy deposited in any material by ionizing radiation. The unit of absorbed dose, the rad (radiation absorbed dose), is a measure of energy absorbed per gram of material. The unit used in countries other than the U.S. is the gray (Gy). One gray equals 100 rad.

Absorbed Dose Rate

Equals absorbed dose divided by the time taken to deliver that dose. High dose rates are usually more damaging to humans and animals than low dose rates. This is because repair of damage is more efficient when the dose rate is low.

Activity

The number of nuclear transformations occurring in a given quantity of material per unit of time. Special units of activity are the curie (Ci), used in the U.S., and becquerel (Bq), used elsewhere.

Activity Concentration

Radioactivity per mass or volume.

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 particle whose activity is the median for the entire aerosol.

Acute Dose

An acute dose means a received radiation dose over a short period of time.

Acute Exposure

Exposure to radiation lasting for only a short time period: i.e., usually less than 24 hours.

Aerosols

Aerosols are suspended particles in the air that are too small to fall out due to gravity and have an extended residence time in the lungs.

ALARA

The guiding principle behind radiation protection is that radiation exposures should be kept "As Low As Reasonably Achievable (ALARA)," economic and social factors being taken into account. This common sense approach means that

radiation doses for both workers and the public are typically kept lower than their regulatory limits.

Alpha Particle (α)

A particle made up of two protons and two neutrons and consequently bearing an electrical charge of 2+ and a mass of 4 atomic mass units. Alpha particles are emitted by some heavy elements that include uranium, plutonium, and radon. Alpha radiation has greater ionizing ability but less penetrating ability than beta or gamma radiation. Alpha particles can be stopped easily, for example, by a piece of paper or the dead protective layer of the skin and are only a concern when alpha-emitting isotopes are taken into the body (e.g., by inhalation).

Anion

An ion with more electrons than protons. A negatively charged particle, atom or group of atoms.

Annual Limit on Intake (ALI)

The activity of a radionuclide taken into the body by inhalation or ingestion that commits a worker to receiving the relevant dose equivalent limit. The ALI is used to control worker intakes of radionuclides. The ALI for a radionuclide is the amount that delivers a dose commitment of 5 rem to the whole body (CEDE) or 50 rem to any single organ or tissue (CDE) when that amount is taken into the body by inhalation or ingestion in a year by reference man.

Anode

Positive electrode. The electron-collecting end of an electron tube.

Atom

An atom is the smallest particle of an element that has all of the chemical properties of that element. Atoms are made up of a nucleus that is surrounded by electrons. The nucleus contains protons and neutrons, which in turn are made up of other particles. In an uncharged atom the number of electrons orbiting the nucleus equals the number of protons in the nucleus. The atom is primarily empty space.

Atomic

Of, relating to, or concerning atoms.

Atomic Mass (Weight)

The mass of a neutral atom of a nuclide, or of a subatomic particle. The atomic weight of an atom is the weight of the atom based on a scale standardized to carbon where $^{12}C = 12$. The atomic weight of an element is the weighted (on

abundance) average of each isotope. Measured in grams or atomic mass units (amu).

Atomic Mass Number (A)

The number of nucleons (protons and neutrons) in the nucleus of an atom. It is the whole number nearest to the atomic mass of the atom, measured in atomic mass units. Sometimes simply called mass number.

Atomic Mass Unit (amu)

A unit of mass, used to express weights of atoms, molecules, or subatomic particles. Equal to one-twelfth the mass of an atom of the most abundant carbon isotope, carbon-12, or 1.66×10^{-4} grams. Also called unified atomic mass unit or dalton.

Atomic Number (Z)

The number of protons in the nucleus. Defines the atom as a certain element, and determines its place in the periodic table of elements.

Auger Electron

Electron emitted in competition with X-ray emission during rearrangement of orbital electrons. Energy normally released as an X-ray is transferred to another outer electron that is ejected from the atom. Auger electrons are monoenergetic. The Auger effect dominates in the light elements, whereas X-ray emission is dominant in the heavier elements.

Background Radiation

Radiation arising from natural sources. These sources include: (1) terrestrial radiation from naturally occurring radioactive isotopes in the soil; (2) cosmic radiation originating in outer space; and (3) naturally occurring radioactive isotopes in the body. All of us were born with some naturally occurring radionuclides in our body (e.g., radioactive carbon and potassium). When taking radiation measurements, background is considered to be ambient environmental radiation levels due to causes other than the specific source being measured.

Becquerel (Bq)

The Becquerel is a unit in the S.I. system used to measure radioactivity. One Becquerel is that quantity of a radioactive material that will have one transformation in one second, or one transformation per second (tps). It is also referred to as one disintegration or decay per second (dps). Often radioactivity is expressed in larger units such as: thousands (KBq), millions (MBq) or even billions (GBq) [of a] Becquerel[s]. As a result of having one Becquerel being equal to one transformation per second, there are 3.7×10^{10} Bq in one curie.

Beta Decay

Nuclear decay by emission of an electron or a positron. Positron decay is always accompanied by electron capture decay.

Beta Particle (β; sometimes β- or β+)

An electron (positive or negative) emitted during decay of some isotopes. Beta particles have a short range in air and even shorter range in more dense material. For example, they can travel only about one half an inch in human tissue, and they may travel a few meters in air. They are not capable of penetrating something as thin as a pad of paper or a few centimeters of transparent plastic.

Beta Radiation

Ionizing radiation consisting of beta particles. Lower penetrating ability than gamma radiation but greater than alpha radiation.

Binding Energy

That energy in the nucleus that holds the protons and neutrons together

Biological Dosimetry

Area of radiation dosimetry that uses biological damage produced by radiation to estimate radiation dose. Chromosomal damage in blood lymphocytes is often used in biological dosimetry for exposure of humans to gamma radiation.

Bohr Model

Simple model (theory) for the atom that describes the arrangement of its constituent particles in a manner consistent with the explanation of most atomic physical and chemical properties, i.e., a positively charged nucleus surrounded by negatively charged electrons.

Bremsstrahlung

X-rays produced when fast electrons pass through matter. Bremsstrahlung is an energy loss mechanism for a negatively charged, high-energy electron that passes near a positively charged nucleus, whose coulomb force field momentarily attracts and accelerates the electron resulting in a change in angular momentum. The bremsstrahlung (German for "slowing-down or braking radiation") energy spectrum is continuous and varies from zero to the energy of

the electron. Bremsstrahlung is a relatively minor energy loss mechanism, but is important in human use and usually encountered as the mechanism for production of "secondary" X-rays by beta radiation for medical diagnostic procedures.

Byproduct Material

Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or utilizing special nuclear material.

Calibration

The process of normalizing of the response of an instrument to ensure that its output readings accurately reflect the magnitude of the properties being measured. For example, radiation survey meters are calibrated to sources that emit known types, energies, and quantities of radiations.

Carcinogenic Agent

A physical, chemical or biological agent capable of causing cancer.

Cathode

Negative electrode. In an electron tube or “gun”, the cathode emits the electrons.

Cation

An ion with more protons than electrons.

Chronic Dose

A chronic dose describes a radiation or other dose to which a person is exposed, usually low-level, over an extended period of time.

Committed Dose Equivalent (CDE or $H_{T,50}$)

The total radiation dose to a part of the body (tissue of reference, T) that will result from retention of radioactive material in the body. For the purposes of estimating the dose commitment, it is assumed that from the time of intake, the period of exposure to retained material will not exceed 50 years.

Committed Effective Dose Equivalent (CEDE or $H_{E,50}$)

The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the CDE to these organs or tissues.

Compton Effect (Scattering)

Collision process between a gamma ray and a loosely bound atomic electron where only part of the gamma-ray energy is transferred to the electron, which is ejected. Compton scattering the dominant interaction mode of medium energy (0.5 – 1.5 MeV) gamma rays encountering absorbers of medium to low atomic number.

Contamination

Radioactive material in any place or on any item where it is not wanted, especially where it may be an environmental or health hazard.

Controlled Area

An area, outside of a restricted area but inside the site boundary, access to which can be limited by the licensee for any reason.

Conversion Electron

Internal conversion is an alternate process to X-ray emission during the de-excitation of an excited atom. Instead of emission of excess energy from the nucleus as gamma radiation, the energy is transferred to an inner orbital electron that is immediately ejected from the atom at high velocity. Unlike beta particles, conversion electrons are emitted with discrete energies characteristic for a given nuclide, that is, they are monoenergetic. Internal conversion is more probable for nuclides of higher atomic number and for lower transition energies.

Coulomb Excitation

When two nuclei pass each other, the electrostatic repulsion (coulomb force) can excite a nucleus enough to release the excess energy as gamma rays.

Coulomb Force

Force that acts between two electrically charged objects: repulsive for like charges and attractive for opposite charges.

Cosmic Radiation

Particulate and electromagnetic radiation originating outside the earth from both solar (from the sun) and galactic (from the far reaches of the universe) sources. Consists of charged particles (mainly protons) that can approach the speed of light and electromagnetic radiation with a wide range of energies.

Cosmogenic

Produced by the interaction of cosmic radiation with matter. For example, carbon-14 is produced by the interaction of slow neutrons with nitrogen in the atmosphere. The neutrons are a product of the interaction of high-energy cosmic particles with gases in our atmosphere.

Curie (Ci)

The curie is a unit used to measure radioactivity. One curie is the amount of radioactivity in one gram of the element, Radium, first discovered by Madame Curie. It is the expression of quantity of a radioactive material that will have 37,000,000,000 transformations in one second. Often radioactivity is expressed in smaller units such as: thousandths (mCi), millionths (µCi) or trillionths (pCi) of a curie. The relationship between Becquerel and curie is: 3.7×10^{10} Bq in one curie. (See Becquerel)

Daughter Product (Progeny)

Any nuclide that originates from a given radionuclide, the parent, by radioactive decay. Daughters may be also radioactive, or stable.

Decay Branching %

The isotope decay rate by a particular decay mode. Some isotopes decay by only one mode (100%) and others by more than one mode. For example, Bi-212 decays by beta decay (~64%) and alpha decay (~36%).

Decay Mode

Disappearance of a radioactive substance due to nuclear emission of an alpha or beta particle, capture of an atomic electron, neutrinos, spontaneous fission, and the emission of bremsstrahlung, X-rays, and conversion electrons. Other decay modes are possible, but rare.

Decay Scheme

A drawing depicting the decay of a parent nucleus to a daughter nucleus, and usually indicating emission energies and probabilities. Alpha or beta emissions are shown as arrows from the parent level to daughter level(s) followed by gamma rays de-exciting daughter levels.

Declared Pregnant Woman

A woman who has voluntarily informed the licensee, in writing, of her pregnancy and the estimated date of conception. The declaration remains in effect until the declared pregnant woman withdraws the declaration in writing or is no longer pregnant.

Derived Air Concentration (DAC)

Measure of airborne radioactive material. The concentration of a radionuclide, which if inhaled by an average person under conditions of light work for 2000 hours per year, would result in the intake of 1 ALI.

Deep-Dose Equivalent (DDE or H_d)

The dose equivalent at a tissue depth of 1 cm. (Applies to external whole-body exposure.)

DNA (deoxyribonucleic acid)

The molecular basis of heredity in many organisms. DNA is constructed of two molecular chains in a double helix geometry held together by hydrogen bonds between purine and pyrimidine complementary base pairs (adenine and thymine or cytosine and guanine). The bases project inward from the two wound chains containing alternating links of deoxyribose (sugar) and phosphate. The sequence of sugar/phosphate/base (nucleotide) groups known as genes determines all hereditary characteristics of the organism.

Dose Equivalent (H_T)

The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent the rem and the sievert (Sv). Please note that the Dose Equivalent and the Equivalent Dose are not exactly the same. The Equivalent Dose replaces the Dose Equivalent for a tissue or organ. Dose equivalent is defined as a point function with absorbed dose weighted by a quality factor everywhere. Equivalent dose is a simple average absorbed dose weighted by the radiation weighting factor (similar to the quality factor).

Dosimeter

An instrument used to measure accumulated radiation exposure. Most often a passive device that integrates the dose over the time the device is worn by a worker. Usually designed so that dose equivalent due to gamma, X-ray, beta, and even neutron radiation may be determined.

Dosimetry

The theory and application of the principles and techniques involved in the measurement and recording of radiation dose. Its practical aspect is concerned with the use of various types of radiation instruments with which measurements are made. See “survey meter”.

Effective Dose Equivalent (H_E)

The sum of the products of the dose equivalent to the organ or tissue (H_T) and the weighting factors (W_T) applicable to each of the body organs or tissues that are irradiated ($H_E = \Sigma W_T H_T$)

Electromagnetic Radiation

Non-particulate radiation consisting of electric and magnetic waves that travel at the speed of light. Characterized by its wavelength or frequency. Examples: ultraviolet and visible light, infrared radiation, radio waves, gamma rays, X-rays.

Electron

An elementary particle with a mass 1836 times smaller than a proton. Negatively charged electrons orbit around the nucleus and determine the chemical properties of an atom. The electron has a rest mass of 9.11×10^{-31} kilograms.

Electron Capture Decay

Nuclear decay by capture of an inner shell atomic electron. If the decay energy is greater than 1022 keV (or 1.022 MeV), positron emission can also occur in competition with electron capture. Both decay modes have the effect of decreasing the atom's atomic number (Z) by one.

Electron Volt

Unit of energy commonly used to describe the energy of radiation. Frequently expressed as kilo electron volts (keV = 10^3 eV) and mega electron volts (MeV = 10^6 eV). The electron volt is the magnitude equal to the energy gained by an electron when accelerated through a potential difference of 1 volt.

Element

One of over one hundred known types of atoms characterized by their atomic number. Uranium is the naturally occurring element of the highest atomic number (Z = 92).

Embryo/Fetus

The developing human organism from conception until the time of birth.

Energy Scale

The energy scale used by most nuclear scientists is electron volts (eV). One eV equals 1.6021×10^{-12} ergs or 1.6021×10^{-19} joules (absolute). Masses are also given by their "mass-equivalent" energy ($E=mc^2$). The mass of the proton is 938.27231 MeV.

$E=mc^2$

Equation describing how mass and energy are related, where: e is energy, m is mass, and c is the speed of light. Mass accelerated at the square of the speed of light is converted into energy in the form of electromagnetic waves. A small amount of matter represents a very large amount of energy.

Equivalent Dose

The equivalent dose is a measure of the impact of radiation on humans. Not all types of radiation produce the same effect. The equivalent dose takes into account the type of radiation and the absorbed dose. For example when considering beta, X-ray, and gamma ray radiation, the equivalent dose (expressed in rem (roentgen equivalent man)) is equal to the absorbed dose (expressed in rad), or a ratio of 1:1. For alpha radiation, the equivalent dose is assumed to be twenty times the absorbed dose, or a ratio of 20:1.

Excitation

The addition of energy to an orbital electron, thereby transferring the atom or molecule from the ground state to an excited state of excess energy.

Exposure

Radiation exposure is a measure of the amount of ionization produced by X-rays or gamma rays as they travel through air. The unit of radiation exposure is the roentgen (R), named after Wilhelm von Roentgen, the German scientist who discovered X-rays in 1895. The roentgen is equivalent to 2.58×10^{-4} coulombs per kilogram of air. In colloquial use, the amount of radiation to which an individual is exposed, also expressed in roentgens. See also “air KERMA”.

Exposure Rate

Radiation exposure per unit time.

Eye Dose Equivalent

The dose equivalent at a tissue depth of 0.3 cm. (Applies to the external exposure of the lens of the eye.)

Fission

The concept of certain uranium atoms absorbing a neutron allowing them to break apart into radioactive fission fragments, releasing neutrons, heat and gamma radiation. A sustained rate of fissioning of uranium atoms is called criticality.

Flux

The amount of radiation particles passing through a certain area of interest.

Free Radical

Chemically reactive atom or molecule characterized by having at least one unpaired electron. These reactive free radicals can damage healthy cells and DNA. Ionizing radiation can produce free radicals by direct and indirect action.

Frisk

Informal term for personal survey to determine the presence or extent of contamination on the skin or clothing. Portable radiation detectors with large detection surfaces used for this purpose are often called “friskers”.

Gamete

A germ cell possessing the haploid number of chromosomes, i.e., a mature sperm or egg capable of participating in fertilization.

Gamma Radiation (γ)

High-energy, penetrating radiation emitted in the radioactive decay of many radionuclides. Gamma rays are similar to X-rays, but X-rays generally have lower energy (longer wavelength). The main difference between gamma rays and X-rays is their origin. Gamma ray emission is a decay mode by which excited state of a nucleus de-excites to a lower (more stable) state in the same nucleus. Therefore, the gamma ray originates in the nucleus, while X-rays are extranuclear in origin. They are capable of traveling long distances through air and most other materials, and can penetrate deep into or completely through the human body. Gamma rays require more "shielding" material, such as lead or steel, to reduce their numbers than is required for alpha and beta particles. Ten (10) gray delivered briefly to the total body would be considered lethal for all persons exposed. A dose of three gray of gamma rays delivered briefly to the total body would be lethal to about 50% of humans exposed because of severe damage to the hematopoietic system. Deaths would be expected to occur within about 60 days. However, spreading the 3 gray dose over a number of years would be expected to lead to far less net damage to the hematopoietic system. Some nuclear workers in Russia exposed over years, at low rates, to up to 10 gray of gamma rays survived.

Gas Amplification Curve

Graph that describes the magnitude of the electrical signal from a gas-filled detector as a function of the voltage applied across its electrodes.

Geiger Counter (Geiger-Mueller Counter)

A radiation detection device consisting of two electrodes with a low-pressure gas in between. A voltage is maintained such that if radiation passing through the counter ionizes the gas, an avalanche of electrons will occur. Thus, there is a momentary discharge for every ionization event. Geiger counters can count radiation as these discharge events, but cannot distinguish either the energy magnitude or kind of radiation.

Genetic Effects

Genetic effects are effects from some agent that are seen in the offspring of the individual who received the agent. The agent must be encountered pre-conception.

Gray (Gy)

The gray is a unit used to measure absorbed dose, the amount of energy actually absorbed in some material over a given period of time. The term applies to any type of radiation absorbed by any material. One gray is equal to one joule of energy deposited in one kg of a material. The unit gray can be used for any type of radiation. It does not describe the biological effects of the different radiations. Absorbed dose is often expressed in terms of hundredths of a gray, or centi-grays. One gray is equivalent to 100 RAD. (See sievert)

Ground State

The lowest energy state of the atomic nucleus.

Half-Life

The average time it takes for one-half of any given number of unstable atoms to decay. Half-life as defined here is also called physical half-life. Half-lives of isotopes range from small fractions of a second to more than a billion years. The decay rate of a radionuclide is considered to be a physical constant. Changes in temperature and pressure have no effect on half-life. There has been some variability observed for a few radionuclides due to chemical changes that alter the electron density near the nucleus, but such effects are rare and small in magnitude. The longer the half-life the more stable the nuclide, e.g., uranium-238 has such a long half-life that it is nearly stable. After one half-life, half the original atoms will remain; after two half-lives, one fourth (or 1/2 of 1/2) will remain; after three half-lives one eighth of the original number (1/2 of 1/2 of 1/2) will remain; and so on until no appreciable radioactivity remains.

Half-Life, Biological

The time required for the body to eliminate half of any radioactive material ingested by natural biological means.

Half-Life, Effective

The time required for half of a specific radionuclide present in the body to be reduced by one-half as a result of the combined action of radioactive decay and biological elimination.

Haploid

Having the number of chromosomes present in the normal germ cell, equal to half the number in the normal somatic cell.

Health Physics

Health Physics is an interdisciplinary science. Its object and its application is the radiation protection of humans and the environment. In practice, Health Physics combines aspects of physics, biology, chemistry, statistics and electronic instrumentation.

High-LET Radiation

Radiation that produces significant damage over a short distance in tissue or other material. In contrast, low-LET radiation produces only a small amount of damage when evaluated over a short distance. Alpha particles represent high-LET radiation. Gamma and X-rays represent low-LET radiations. To produce a given amount of damage, it takes a larger absorbed dose of low-LET radiation than for high-LET radiation. Biological damage produced by low-LET radiation is usually more efficiently repaired than damage produced by high-LET radiation.

High Radiation Area

An area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or 30 centimeters from any surface that the radiation penetrates.

Hormesis (hermetic)

The term derived from “hormaein” which means “to excite”. A beneficial or stimulating effect induced by low doses from an agent, whereby the potential detrimental effects at linearly higher doses from the same agent cannot be predicted.

International Commission on Radiological Protection (ICRP)

Organization that provides guidance on standards and limits, and useful data for radiation protection for the international community.

International Commission on Radiological Units and Measurements (ICRU)

Organization that provides definitions, procedures, and useful data for radiation protection.

In-utero

Within the uterus.

Ion

An atom or molecule that has a net electrical charge as a result of the number of electrons and the number of protons being different (an imbalance). If an atom has more electrons than protons, it has a negative charge, and is called a negative ion (anion). Atoms that have fewer electrons than protons are positively charged, and are called positive ions (cations).

Ionization

The process of producing electrically charged ions by breaking up or by removing or adding electrons to electrically neutral atoms or molecules Different types of radiation have differing ionization abilities. For example, alpha particles produce a large amount of ionization per unit distance traveled while gamma rays produce much less.

Ionizing Radiation

Ionizing radiation is radiation with sufficient energy that during an interaction with an atom it can remove tightly bound electrons from their orbits, causing the atom to become charged or ionized. Examples are gamma rays and neutrons. Radiation is measured in many ways, and commonly expressed in units of R (roentgen).

Ion Pair

A closely associated positive ion and negative ion having charges of the same magnitude and formed from a neutral atom or molecule by ionizing radiation. For example, H_2O can for the H_2O^+ and e^- ion pair after interaction with ionizing radiation.

Irradiate

Expose to radiation.

Isobars

Nuclides of the same atomic mass (A) but different atomic number (Z).

Isomers

A long-lived excited state of the nucleus frequently called the isomeric state. Arbitrarily defined in the Table of Isotopes as having a half-life greater than 1 ms.

Isotones

Nuclides with the same number of neutrons. For example, H-2 and He-3 are isotones, because each has just one neutron.

Isotopes

Forms of the same chemical element having different numbers of neutrons, i.e., forms having the same number of protons or atomic number (Z), but different

mass numbers (A). Many isotopes are produced in nuclear reactors and particle accelerators. The field of nuclear medicine depends on a constant supply of radioactive isotopes (i.e., radioisotopes). Naturally occurring chemical elements are usually mixtures of isotopes so that observed (non-integer) atomic weights are average values for the mixture.

Lens Dose Equivalent (LDE)

Applies to the external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 centimeter (300 mg/cm^2).

Licensed Material

Source material, special nuclear material, or byproduct material received, possessed, used, transferred or disposed of under a general or specific license issued by the USNRC.

Linear Energy Transfer (LET)

Acronym for linear energy transfer. LET represents the average amount of radiation energy lost when traversing a given distance.

Linear No Threshold (also Linear Non-threshold)

A concept of risk in which affirms that an increase in dose results in a proportional increase in risk; and, any dose, no matter how small, produces some risk.

Mass Number

The sum of the number of nucleons (neutrons and protons) in a nucleus. Note that this is the sum of the number (count), not the masses, so it is an integer.

Material Safety Data Sheets (MSDS)

Product safety information sheets prepared by manufacturers and marketers of products containing toxic chemicals. These sheets can be obtained from the manufacturer or marketer.

Meiosis

The cell division in sexually reproducing organisms that reduces the number of chromosomes in reproductive cells, leading to the production of gametes in animals and spores in plants.

Member of the Public (MOP)

Any individual except when that individual is receiving an occupational dose.

Microcurie

One curie divided by one million. To convert microcuries to curies, divide by one million. To convert microcuries to becquerels, multiply by 37,000. To convert microcuries to kilobecquerels, multiply by 37. A kilobecquerel is 1000 becquerels.

Microroentgen

A unit of radiation exposure in common usage, equal to one-millionth of a roentgen.

Milllrem

A unit of radiation dose in common usage, equal to one-thousandth of a rem.

Minimum Detectable Activity (MDA)

The minimum amount of radioactivity in a sample that can be measured with a pre-determined reliability by a particular laboratory measuring instrument.

Mitosis

The sequential differentiation and segregation of replicated chromosomes in a cell nucleus that precedes complete cell division. The entire sequence of processes in cell division in which the diploid number of chromosomes is retained in both daughter cells.

Molecule

The smallest part of a substance that is made up of two or more atoms that retains the definitive physical and chemical properties of that substance.

Monitoring (radiation monitoring, radiation protection monitoring)

The measurement of radiation levels, concentrations, surface area concentrations or quantities of radioactive material and the use of the results of these easurements to evaluate potential exposures and doses.

Mutagenesis (mutagen, mutation)

The procedure in which a certain sequence of DNA is modified.

National Council on Radiation Protection and Measurements (NCRP)

Organization that makes recommendations regarding radiological protection for the U.S.

Natural Abundance

Percentage of an element occurring on earth in a particular isotopic form. For example, see Natural Uranium.

Natural Uranium

Uranium that has not been modified by human intervention. Natural uranium is made up of 99.3 percent uranium-238 and 0.7 percent uranium-235.

Neutrino

An electrically neutral particle with negligible mass first postulated by Pauli in 1931 and later proven to exist experimentally in 1956. Beta particles are emitted over a continuous spectrum of energies up to the maximum energy for the decay. The "make-up" energy is emitted as a neutrino. Neutrinos are extremely penetrating and virtually non-interacting and consequently are of no significance to health.

Neutron

An uncharged particle that makes up part of an atomic nucleus. A neutron and a proton have about the same mass, but the neutron has no electrical charge. Uranium-235 and plutonium-239 atoms split (fission) when they absorb neutrons. This causes additional neutrons and heat to be released, leading to a chain reaction. The controlled chain reactions that occur in nuclear power reactors and uncontrolled chain reactions that occur in nuclear weapons are due to neutrons being absorbed by atoms that then fission.

Non-ionizing Radiation

Non-ionizing radiation is radiation without sufficient energy to remove tightly bound electrons from their orbits around atoms. Examples are microwaves, visible light, radio and TV.

Non-stochastic Effects

Non-stochastic effects are health effects that can be related directly to a radiation dose received. The higher the dose, the more severe the effect: i.e., the burn gets worse as the dose increases. Typically, there is a threshold, below which an effect will not occur. Radiation-induced cataract formation is an example of a non-stochastic effect (also called a deterministic effect). [See Stochastic Effects]

NORM

Naturally Occurring Radioactive Material

Nuclear

Of, pertaining to, or constituting an atomic nucleus.

Nuclear Force

Strong, charge-independent, short-range force responsible for holding the nucleus of an atom together.

Nuclei

Plural of nucleus.

Nucleon

A proton or neutron, especially in the atomic nucleus.

Nucleus

The core of the atom, where nearly all of its mass and all of its positive charge is concentrated. The nucleus contains protons and neutrons comprising the center of the Bohr atom model, and is surrounded by orbiting electrons. Hydrogen-1 is the only atom with no neutrons.

Nucleus Recoil

A component of alpha radiation due to the recoil of the parent nucleus which is a result of the conservation of momentum requiring the parent nucleus to move in the opposite direction of the alpha emission.

Nuclide

Any atom, characterized by its atomic number, atomic mass, and energy state. Radioactive atoms are referred to as radionuclides. While there are only a little more than one hundred known elements, there are thousands of nuclides.

Optically-Stimulated Luminescent Dosimeter

Dosimetry device that allows the measurement of a dose by absorbing and "storing" energy deposited by low and high energy gamma and x-radiation and beta particles. These devices are typically small amounts of some solid (such as aluminum oxide) encased in a plastic holder. The energy is released from the powder in the form of a measurable energy upon light stimulation.

Pair Production

A collision process only for gamma rays with energies greater than 1022-keV (two electron masses) where an electron /positron pair is produced. This phenomenon occurs when the gamma ray interacts directly with the nuclear force field. A heavy nucleus (high Z) must be present for pair production to take place. For high-energy gamma rays the pair production process is proportional to Z^2 and above 4 MeV the probability is proportional to log E_{gamma}.

Periodic Table

Arrangement of atomic elements in order of increasing atomic number by row and grouped according to their chemical properties by column. First published in 1869 by Dmitri Mendeleev.

Photoelectric Effect

Collision process between an X-ray or gamma ray and a bound atomic electron where the photon transfers all of its energy to the electron and disappears, the bound electron is ejected, and the incident energy is shared between the ejected electron and the remaining atom. The photon energy must be greater than the atomic binding energy, and the kinetic energy of the ejected electron is equal to the photon energy minus the binding energy. The probability for the photoelectric effect is approximately proportional to Z^5 of the absorber and falls off by about $E(gamma)^{3.5}$. So the photoelectric effect is most important for photon energies less than about 0.5 MeV and heavy element absorbers. Since an electron is ejected, this effect is accompanied by X-ray emission or Auger electron emission in competition.

Photomultiplier

The device within a scintillation detector that converts light photons to electrical signals. The output signal is quite large compared to the light that is "seen" by the photomultiplier. The photomultiplier contains a photosensitive layer that absorbs the light photons and emits photoelectrons. The number of electrons emitted is actually less than the number of incident photons, but is proportional to them. A series of electrodes called dynodes is used to amplify the electrical signal up to about a million times so that the signal is measurable.

Photon Radiation

Forms of electromagnetic radiation such as X-rays, gamma rays, and sunlight.

Positron

A positively charged electron found in the atomic nucleus. In theoretical terms, the positive charge of the proton is emitted as the positron which results in the mass of the proton remaining in the nucleus which is now minus the positive charge, thus is converted to a neutron. This emission changes the element as the number of protons has been reduce by one.

Positron Annihilation

Positron decay in matter by annihilation with an electron. An "atom" of positronium (e^+e^-) forms which annihilates to produce two 511-keV photons which travel away in opposite directions. Occasionally, the positron will annihilate in flight to produce one or more photons sharing the total rest mass

and kinetic energy of the positron and electron. This is direct evidence of how mass and energy are interconvertible.

Proton

Protons and neutrons make up the nucleus of an atom. Protons have a single positive electrical charge equivalent to the negative charge of an electron. While protons and neutrons are similar in mass and about 2,000 times heavier than electrons, they are still very small particles. The proton rest mass is slightly less than that of a neutron at $1.6726231 \times 10^{-27}$ kilograms. A grain of sand weighs about a hundred million trillion (100,000,000,000,000,000,000) times more than a proton or a neutron.

Quality Factor (QF)

A proportionality factor that relates radiation damage to body tissue to the actual radiation energy absorbed. The QF is dependent upon the type and energy of the radiation.

Quantum Theory

The theory that energy is radiated intermittently in small units of definite magnitude called quanta, and absorbed in a like manner.

Q value

The energy available for decay. Decay can only occur if the Q value is positive. This energy is released by the nucleus mainly as gammas, betas, neutrinos, and/or alpha particles. In general, for a given element, the half-lives of its radioactive isotopes are inversely related to the decay energy Q.

Radiation

Energy released in the form of particles or electromagnetic waves by the disintegration (decay) of unstable isotopes. It can be in the form of gamma rays, X-rays, alpha or beta particles, or neutrons. We encounter electromagnetic waves every day. They make up our visible light, radio and television waves, ultraviolet (UV), and microwaves with a spectrum of energies. These electromagnetic waves do not cause ionizations of atoms because they do not carry sufficient energy to separate molecules or remove electrons from atoms. However, if the energy is sufficient (gamma rays or X-rays) electromagnetic radiation can remove electrons from atoms and is then considered ionizing radiation. All particulate forms of radiation are ionizing.

Radiation Absorbed Dose (RAD)

The RAD is a unit used to measure a quantity called absorbed dose. This relates to the amount of energy actually absorbed in some material, and is used for any of radiation and any material. One RAD is defined as the absorption of 100 ergs of energy per gram of material. The unit RAD can be used for any type of radiation. It does not describe the biological effects of the different radiations.

Radiation Dose

The quantity of radiation energy deposited in a material. The effect of radiation on any material is determined by the "dose" of radiation that material receives. There are several terms used in radiation protection to precisely describe the various aspects associated with the concept of dose and how radiation energy deposited in tissue affects humans.

Radiation Safety Officer (RSO)

The RSO is designated by the plant and approved by the regulatory agency to be responsible for managing and implementing the radiation protection program within the facility. Typical duties include, but is not limited to: Training of employees, liaison with regulators and management, and review doses to employees and make corrections, as necessary, to keep doses to the workers and public as low as reasonably achievable (ALARA).

Radiotoxicity

Measure of how detrimental a radionuclide is to one's health

Radioactive

Exhibiting radioactivity.

Radioactive Decay

The process where an energetically unstable atom transforms itself to a more energetically favorable, or stable, state. The unstable atom can emit ionizing radiation in order to become more stable. This atom is said to be "radioactive," and the process of change is called "radioactive decay."

Radioactivity

The spontaneous emission of radiation from unstable atoms. Radionuclides lose particles (e.g., alpha or beta) and energy (e.g. gamma) through radioactive decay.

Radionuclide

A radioactive species of an atom characterized by its atomic number, atomic mass, and energy state.

Radon

A radioactive inert gas that arises from the decay of radium. Radon occurs naturally in many minerals and is a chief hazard of uranium mining and in the use of uranium mill tailings. Radon emits alpha particles as it decays into other isotopes, some of which also emit alpha radiation. Some radon occurs naturally in our homes. Inhaling the alpha-emitting isotopes may increase the risk of lung cancer. However, there is growing evidence that low doses of radiation to the lung as found in most homes may not cause lung cancer, as contrasted with high doses in underground mines which definitely cause cancer. There may be a threshold dose below which there is no risk of lung cancer.

Relative Biological Effectiveness (RBE)

A comparison of how two different types of radiation differ quantitatively in the biological effects they cause. If one radiation type requires 10 Gy to produce a given level of biological effect and another type requires only 5 Gy for the same level of effect, the relative biological effectiveness (RBE) of the second relative to the first is 10 Gy/ 5 Gy or its RBE = 2.

Restricted Area

An area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

Roentgen (R)

A unit used to measure a quantity called exposure. The term is used solely to describe an amount of gamma and X-rays, only in air. One roentgen of radiation exposure produces a charge of 2.58×10^{-4} coulombs on all ions of one sign per kilogram of dry air at standard temperature and pressure. The roentgen is only defined for and only applies to photons with energies below 4 MeV (mega electron volts). It is a measure of the ionizations of the molecules in a mass of air. The main advantage of this unit is that it is easy to measure directly, but it is limited because it is only for deposition in air, and only for gamma and X-rays.

Roentgen Equivalent Man (REM)

A unit used to derive a quantity called equivalent dose, which relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose. Equivalent dose is often expressed in terms of thousandths of a rem, or millirem. To determine equivalent dose (rem), you

multiply absorbed dose (RAD) by a quality factor (Q) that is unique to the type of incident radiation (one for gamma and beta; twenty for alpha).

Scintillation Counter

A scintillation counter consists of a sensitive volume of material that emits light when radiation passes through it, a device to convert the light to electrical energy, and electronics to interpret the signal. The counter measures the intensity of light or counts flashes of light induced in the sensitive volume by the deposition of energy from radiation. Various liquid, plastic, and crystalline materials have scintillation properties. Scintillation light is measured with photomultiplier tubes that convert the flashes of light into amplified electrical signals. In general, the amount of scintillator light detected is proportional to the energy of the radiation. Therefore, scintillation detectors may be used for spectroscopy, which enables identification of the radionuclide that emitted the radiation by matching to a library of known emission energies by radionuclide.

Self Absorption

The concept during radiation detection when the geometry, density, structure or moisture content of the radioactive materials prevents some radiations from reaching the detector due to shielding. See Geometry and Shielding

Semiconductor Detector

Radiation striking very pure germanium (Ge), silicon (Si and lithium drifted Si), or cadmium zinc telluride (CdZnTe) semiconductor detectors can excite a large number of electrons into the conduction band leading to a measurable current. This current is proportional to the energy of the radiation. Semiconductor detectors can be used to accurately measure the energy and intensity of radiation. Semiconductor radiation detectors have unique capabilities and provide superior performance in many respects over other kinds of detectors. The types of radiation that can be measured with semiconductor detectors include a large portion of the electromagnetic spectrum, with photon energies ranging from <1 eV (near infrared) to ~10 MeV (gamma rays), and charged particles with energies from keV to GeV.

Shallow-dose Equivalent

The dose equivalent at a tissue depth of 0.007 cm. (Applies to external exposure of the skin or an extremity.)

Sievert (Sv)

A unit used to derive a quantity called equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed

dose. Equivalent dose is often expressed in terms of millionths of a sievert, or micro-sievert. To determine equivalent dose (Sv), multiply absorbed dose (Gy) by a quality factor (Q) that is unique to the type (and energy for neutrons) of incident radiation. A sievert is an equivalent joule per kilogram. One sievert is equivalent to100 rem.

SI Units

The international system of units (Système Internationale d'Unités). SI units for radiation include becquerel (Bq), gray (Gy), and sievert (Sv). Used for all scientific and most technical measurements as approved by international consensus. Still only partially accepted for radiation protection in the United States where the traditional system is also used.

Somatic Effects

Effects from some agent, such as radiation, that are seen in the individual who is exposed to the agent.

Source Material

(1) Uranium or thorium or any combination of uranium and thorium in any physical or chemical form; or
(2) Ores that contain, by weight, one-twentieth of 1 percent (0.05 percent), or more, of uranium, thorium, or any combination of uranium and thorium. Source material does not include special nuclear material.

Special Nuclear Material

(1) Plutonium, uranium-233, uranium enriched in the isotope 233 or in the isotope 235, or any other material that the USNRC, pursuant to the provisions of section 51 of the Act, determines to be special nuclear material, but does not include source material; or
(2) Any material artificially enriched by any of the foregoing but does not include source material.

Spectroscopy

The measurement of the relationship between radiation and matter as a function of wavelength, frequency or energy.

Spontaneous Fission

Nuclear decay by splitting the nucleus into two lighter nuclei (fission fragments) that are not always the same for a given radionuclide. Fission is accompanied by emission of neutrons and gamma radiation. Spontaneous fission occurs rarely and only as a minor decay mode (weak) in very heavy naturally occurring

radionuclides, e.g., U-238, U-236, U-235, U-234, U-233, U-232, Pa-236, and possibly Th-232.

Stochastic Effects

Occur on a random basis, their effect being independent of the dose. The effect typically has no threshold and is based on probabilities, with the chances of seeing the effect increasing with increasing exposure. Some cancers are thought to be a stochastic effect of radiation.

Survey

An evaluation of the radiological conditions and the potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.

Survey Meter

Any portable radiation detection instrument especially adapted for inspecting an area to establish the existence and amount of radioactive materials present.

TENORM

Technologically enhanced naturally occurring radioactive material. Materials that have concentrated activity concentrations of naturally occurring radioactivity as the result of man's activities.

Teratogenic Effects

Effects from some agent that are seen in the offspring of the individual who received the agent. The agent must be encountered during the gestation period.

Terrestrial Radiation

The portion of background radiation that originates from radionuclides present in the earth, or that have been transferred to the atmosphere or hydrosphere.

Thermoluminescent Dosimeter (TLD)

Dosimetry device that allows measurement of dose by absorbing and "storing" energy deposited by radiation. These devices are typically small amounts of some solid (such as lithium fluoride or calcium fluoride) encased in a plastic holder with absorbers to discriminate radiation energies. The energy is released from the powder in the form of a measurable flash of light upon heating. The thermoluminescent material can then be re-used.

Total Effective Dose Equivalent (TEDE)

The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).
TEDE = DDE + CEDE

Total Organ Dose Equivalent (TODE)

The sum of the DDE and the CDE to an organ or tissue.

Transition Series (decay series)

Decay to stability through a sequence of radionuclides. Natural uranium and thorium decay through three different series headed by U-238, U-235, and Th-232. All three decay to a different stable isotope of lead.

Transuranic

Radioactive material having more protons than uranium. All are man-made and are radioactive.

Unrestricted Area

An area, access to which is neither limited nor controlled by the licensee.

Uranium

A naturally occurring material used for nuclear technology. There are a variety of uranium isotopes such as uranium-235 and uranium-238.

Uranium-235

This isotope is used in nuclear weapons. It is the only naturally occurring fissile element. Uranium-235 makes up 0.7% of the uranium that is mined from the ground. The half-life of uranium-235 is 700 million years.

Uranium-238

This isotope makes up over 99% of uranium that is mined from the ground. The isotope also makes up most of the uranium used in armor for military vehicles and in uranium munitions (penetrators) used by the military. Uranium is called depleted when some of the uranium-235 has been removed from natural uranium. Thus, depleted uranium is the natural uranium depleted in the U-235 isotope. The half-life of uranium-238 is 4.5 billion years.

Uranyl

A cation of uranium which forms salts and acids. This is the most common form of uranium in the aqueous phase. Uranyl compounds are the more toxic form of uranium due to its higher solubility and faster incorporation into tissues.

Very High Radiation Area

An area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in 1 hour at 1 meter from the radiation source or 1 meter from any surface that the radiation penetrates.

Weighting Factor (W_T)

For an organ or tissue (T) is the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly.

Whole Body Dose

The dose to the body from radiation in which the entire body, rather than an isolated part, is irradiated. Where a radioisotope is uniformly distributed throughout the body tissues, rather than being concentrated in certain parts, the irradiation can be considered as a whole-body dose. See also TEDE.

X-rays

Penetrating photon radiation often used in medical diagnosis. Sunlight is also a form of photon radiation but less hazardous than X-rays. X-rays are of higher frequency (and energy) than visible light, but generally lower than gamma rays. X-rays are usually produced by fast electrons going through matter or by the de-excitation of excited atoms. De-excitation occurs when inner orbital electrons change their orbital levels around the atomic nucleus. X-rays, like gamma rays are capable of traveling long distances through air and most other materials.