0 | NUCLEAR 101

Nuclear Lingo

Table of Contents

Glossary

Nuclear "Lingo"

Terms, acronyms, abbreviations, and definitions

A

Absorber: Any material that stops ionizing radiation. For example, lead is a suitable absorber for gamma rays, boron for neutrons, and any metal for beta.

Accelerator: A device that accelerates charged particles or ions to very high speeds.

Actinides: Elements with 89 or more protons in their nucleus that behave chemically like actinium. All are radioactive and many are long-lived alpha emitters.

Activation: The process of making a radioisotope by bombarding a stable element with neutrons or protons.

Activity (of a substance): The number of disintegrations per unit time taking place in a radioactive material. The unit of activity is the becquerel (Bq). One becquerel is equivalent to one disintegration per second.

ALARA: ALARA is an acronym for "as low as (is) reasonably achievable," which means making every reasonable effort to maintain exposures to ionizing radiation as far below the dose limits as practical, consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state

of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.

Alpha particle (α): A positively charged particle emitted from the nucleus of an atom during radioactive decay. It consists of two protons and two neutrons (a helium-4 nucleus). Although alpha particles are normally highly energetic, they travel only a few centimeters in the air and are stopped by a sheet of paper or the outer layer of dead skin.

Atom: A particle of matter that cannot be broken down by chemical means. Atoms have a nucleus consisting of positively charged protons and uncharged neutrons of about the same mass. In a neutral atom the positive charges of the protons in the nucleus are balanced by the same number of negatively charged electrons in motion around the nucleus.

Atomic energy: The energy that is released through a nuclear reaction or radioactive decay process. Of particular interest is the process known as fission, which occurs in a nuclear reactor and produces energy usually in the form of heat. In a nuclear power plant, this heat is used to boil water to produce steam that can be used to drive large turbines. This, in turn, activates generators to produce electrical power. Atomic energy is more correctly called *nuclear energy*.

Atomic mass unit (amu): One-twelfth of the mass of a carbon-12 atom. It is approximately equal to the mass of a single proton or neutron.

Atomic number (Z): Number of protons in the nucleus of an atom, which also indicates the position of the element it represents in the periodic table.

Attenuation: The process by which the number of particles or photons entering a body of matter is reduced by absorption and scattered radiation.

B

Background radiation: The ionizing radiation in the environment to which we are all exposed. It comes from many sources including outer space, the sun, rocks, soil, buildings, the air we breathe, the food we eat, and our own bodies. The average annual background radiation dose in the Philippines is about 0.1 millisieverts. (See: dose, effective)

Becquerel (Bq): Unit of activity equal to one radioactive disintegration per second. Replaces the older unit, the Curie (Ci): 1 Ci = 3.7×10^{10} Bq.

Beta particle (β): A particle emitted from the nucleus of an atom during radioactive decay. Beta particles are electrons with either negative or positive electric charge. High energy beta particles may travel meters in air and several millimeters into the human body; low energy betas are unable to penetrate the skin. Most beta particles may be stopped by a small thickness of a light material such as aluminum or plastic.

Beyond design-basis accidents: This term is used as a technical way to discuss accident sequences that are possible but were not fully considered in the design process because they were judged to be too unlikely. (In that sense, they are considered beyond the scope of design-basis accidents that a nuclear facility must be designed and built to withstand.) As the regulatory process strives to be as thorough as possible, "beyond design-

basis" accident sequences are analyzed to fully understand the capability of a design.

Binding Energy: The minimum energy required to separate the nucleus of an atom into its component neutrons and protons.

Bioassay: The determination of kinds, quantities, or concentrations and, in some cases, locations of radioactive material in the human body, whether by direct measurement (in vivo counting) or by analysis and evaluation of materials excreted or removed (in vitro) from the human body.

Biological shield: A mass of absorbing material placed around a reactor or radioactive source to reduce the radiation to a level safe for humans.

Boiling-water reactor (BWR): A common nuclear power reactor design in which water flows upward through the core, where it is heated by fission and allowed to boil in the reactor vessel. The resulting steam then drives turbines, which activate generators to produce electrical power.

Bone seeker: A radioisotope that tends to accumulate in the bones when it is introduced into the body. An example is strontium-90, which behaves chemically like calcium.

Brachytherapy: A nuclear medicine procedure during which a sealed radioactive source is implanted directly into a person being treated for cancer (usually of the mouth, breast, lung, prostate, ovaries, or uterus). The radioactive implant may be temporary or permanent, and the radiation attacks the tumor as long as the device remains in place. Brachytherapy uses radioisotopes, such as iridium-192 or iodine-125, which are regulated by the PNRI.

Breeder: A reactor that produces more nuclear fuel than it consumes. A fertile material, such as uranium-238, when bombarded by neutrons, is transformed into a fissile material, such as plutonium-239, which can be used as fuel.

Burnup: Either the percentage of a nuclear fuel that has been 'fissioned', sometimes expressed as megawatt days per tonne (MWD/t), or the percentage change in other materials.

C

Calibration: The adjustment, as necessary, of a measuring device such that it responds within the required range and accuracy to known values of input.

Carbon-14: A naturally occurring radioactive isotope. Its half-life is approximately 5,730 years.

Cask: A heavily shielded container used for the dry storage or shipment (or both) of radioactive materials such as spent nuclear fuel or other high-level radioactive waste. Casks are often made from lead, concrete, or steel. Casks must meet regulatory requirements and are not intended for long-term disposal in a repository.

Category of radioactive sources: The International Atomic Energy Agency's Code of Conduct on the Safety and Security of Radioactive Sources defines the five categories for radiation sources to help ensure that sufficient controls are being used to achieve safety and security:

- *Category 1 sources*, if not safely or securely managed, would be likely to cause permanent injury to a person who handled them or was otherwise in contact with them for more than a few minutes. It would probably be fatal to be close to this amount of unshielded material for a period of a few minutes to an hour. These sources are typically used in radiothermal generators, irradiators, and radiation teletherapy.

- *Category 2 sources*, if not safely or securely managed, could cause permanent injury to a person who handled them or was otherwise in contact with them for a short time (minutes to hours). It could possibly be fatal to be close to this amount of unshielded radioactive material for a period of hours to days. These sources are typically used in industrial gamma radiography, high- and medium-dose rate brachytherapy, and radiography.

- *Category 3 sources*, if not safely or securely managed, could cause permanent injury to a person who handled them or was otherwise in contact with them for hours. It could possibly—although it is unlikely to—be fatal to be close to this amount of unshielded radioactive material for a period of days to weeks. These sources are typically used in fixed industrial gauges such as level gauges, dredger gauges, conveyor gauges, spinning pipe gauges, and well-logging gauges.

- *Category 4 sources*, if not safely managed or securely protected, could possibly cause temporary injury to someone who handled them or was otherwise in contact with or close to them for a period of many weeks, though this is unlikely. It is very unlikely anyone would be permanently injured by this amount of radioactive material. These sources are typically used in fixed or portable gauges, static eliminators, or low-dose brachytherapy.

- *Category 5 sources* cannot cause permanent injury. They are used in x-ray fluorescence devices and electron capture devices.

Cerenkov radiation: The emission of light by a charged particle passing through a transparent non-conducting liquid or solid material at a speed greater than the speed of light in that material. The high energy beta particles from spent nuclear fuel immersed in water give rise to blue Cerenkov radiation.

Chain reaction: A process in which one nuclear transformation sets up conditions for a similar nuclear transformation in another nearby atom. Thus, when fission occurs in uranium-235 atoms, neutrons are released, which in turn may produce fission in other uranium-235 atoms.

Cladding: The thin-walled metal tube that forms the outer jacket of a nuclear fuel rod. It prevents corrosion of the fuel by the coolant and the release of fission products into the coolant. Aluminum, stainless steel, and zirconium alloys are common cladding materials.

Containment, reactor: The prevention of release, even under the conditions of a reactor accident, of unacceptable quantities of radioactive material beyond a controlled area. Also, commonly refers to the containing system itself.

Contamination: Undesirable radiological, chemical, or biological material (with a potentially harmful effect) that is either airborne or deposited in (or on the surface of) structures, objects, soil, water, or living organisms in a concentration that makes the medium unfit for its next intended use.

Control rods: Rods, plates or tubes containing cadmium, hafnium or some other strong absorber of neutrons. They are used to control the rate of the nuclear fission reaction in a reactor.

Control Rod Worth: The change in reactivity per unit movement of the control rod into the core.

Controlled area: At a nuclear facility, an area outside a restricted area but within the site boundary, to which the licensee can limit access for any reason.

Coolant: A fluid circulated through a nuclear reactor to remove or transfer heat generated by the fuel elements. Common coolants are water, air and carbon dioxide.

Core, reactor: That region of a nuclear reactor in which the fuel is located and where the fission chain reaction can take place. The fuel elements in the core of a reactor contain fissile material.

Cosmic radiation: A source of natural background radiation, which originates in outer space and is composed of penetrating ionizing radiation (both particulate and electromagnetic). The sun and stars send a constant stream of cosmic radiation to Earth. Differences in elevation, atmospheric conditions, and the Earth's magnetic field can change the amount (or dose) of cosmic radiation that we receive.

Counter: A general designation applied to radiation detection instruments or survey meters that detect and measure radiation. The signal that announces an ionization event is called a count.

Criticality: The state in which a reactor can sustain chain reaction. A nuclear reactor is critical when the rate of neutrons produced is equal to the rate of neutrons lost due to absorption or leakage.

Critical mass: The smallest mass of fissile material that will support a self-sustaining chain reaction under specified conditions.

Cross-section: A measure of the probability of a particular nuclear reaction occurring between a projectile and a target. The probability is expressed as an area that the target presents. The unit of measurement is the barn: $10^{-24}cm^2$

Curie (Ci): A measure of radioactivity. Now superseded by the becquerel: 1 Ci = 3.7 x 10^{10} Bq.

Cyclotron: A machine to accelerate charged particles to high energies by the application of electromagnetic forces. The accelerated particles may be used to bombard suitable target materials to produce radioisotopes.

D

Decay heat: The heat produced by the decay of radioactive fission products after a reactor has been shut down.

Decay, radioactive: The spontaneous radioactive disintegration of an atomic nucleus resulting in the release of energy in the form of particles (for example, alpha or beta), gamma radiation, or a combination of these.

Decommissioning: In relation to a nuclear reactor, its shutdown, dismantling and eventual removal.

Decontamination: A process used to reduce, remove, or neutralize radiological, chemical, or biological contamination to reduce the risk of exposure. Decontamination may be accomplished by cleaning or treating surfaces to reduce or remove the contamination; filtering contaminated air or water;

subjecting contamination to evaporation and precipitation; or covering the contamination to shield or absorb the radiation. The process can also simply allow adequate time for natural radioactive decay to decrease the radioactivity.

Design basis accident: A postulated accident that a nuclear facility must be designed and built to withstand without loss to the systems, structures, and components necessary to ensure public health and safety.

Detector: A material or device that is sensitive to ionizing radiation and can display its characteristics and/or produce a signal suitable for measurement or analysis.

Deterministic effect: The health effects of radiation, the severity of which varies with the dose and for which a threshold is believed to exist. Radiation-induced cataract formation is an example of a deterministic effect. Also called non-stochastic effect.

Deuterium: Also called 'heavy hydrogen', deuterium is a non-radioactive isotope of hydrogen having one proton and one neutron in the nucleus (that is, an atomic mass of two). It occurs in nature in the proportion of one atom to 6,500 atoms of normal hydrogen. *(Normal hydrogen atoms contain one proton and no neutrons.)*

Dose: A general term, which may be used to refer to the amount of energy absorbed by an object or person per unit mass. Known as the "absorbed dose," this reflects the amount of energy that ionizing radiation sources deposit in materials through which they pass and is measured in units of radiation-absorbed dose (rad). The related international system unit is the gray (Gy), where 1 Gy is equivalent to 100 rad.

Dose rate: The dose of ionizing radiation delivered per unit time.

Dose, absorbed: A measure of the amount of energy deposited in a material by ionizing radiation. The unit is the joule per kilogram, given the name Gray (Gy).

Dose, equivalent: Equivalent dose is a measure of the biological effect of radiation on a tissue or organ and takes into account the type of radiation. The unit is the sievert (Sv), but doses are usually measured in millisieverts (mSv) or microsieverts (μSv).

Dose, effective: Effective dose is a measure of the biological effect of radiation on the whole body. It takes into account the equivalent dose and the differing radio sensitivities of body tissues. The unit is the sievert (Sv), but doses are usually measured in millisieverts (mSv) or microsieverts (μSv).

Dosimeter (or Dosemeter): A device used to measure the radiation dose a person receives over a period of time.

Dose limits: The maximum radiation dose, excluding doses from background radiation and medical exposures, that a person may receive over a stated period of time. International recommended limits, adopted by the Philippines, are that occupationally exposed workers should not exceed 20 mSv per year (averaged over five years, no single year to exceed 50 mSv), and that members of the public should not receive more than 1 mSv per year above background radiation.

E

Electron: The negatively charged particle that is a common constituent of all atoms. Electrons surround the positively charged nucleus of an atom and determine the chemical properties of the atom.

Element: A chemical substance that cannot be divided into simpler substances by chemical means; all atoms of a given element have the same number of protons.

Enrichment, isotope: The elevation of the content of a specified isotope in a sample of a particular element (or compound thereof). To be used as fuel for power reactors, uranium usually has to be enriched – the natural isotopic abundance of uranium-235 (~0.71 percent) has to be increased to about 3 percent. Material at 20 percent or greater enrichment is called high enriched uranium (HEU); below 20 percent is low enriched uranium (LEU). Isotope enrichment processes include gas centrifugation and gaseous diffusion.

Exposure: Absorption of ionizing radiation or ingestion of a radioisotope. Acute exposure is a large exposure received over a short period of time. Chronic exposure is exposure received over a long period of time, such as during a lifetime.

External radiation: Exposure to ionizing radiation when the radiation source is located outside the body.

F

Fertile material: A material not itself fissionable by thermal neutrons that can be converted directly or indirectly into a fissile material by neutron capture. There are two basic fertile materials, uranium-238 and thorium-232. When these fertile materials capture neutrons they are converted into fissile plutonium-239 and uranium-233 respectively.

Fissile material: Any material capable of undergoing fission by thermal (or slow) neutrons. For example, uranium-235 and plutonium-239 are fissile nuclides.

Fission: Usually refers to the division of a heavy nucleus into two unequal masses and the emission of neutrons, gamma radiation, and a great deal of energy.

Fission fragments: The two atoms initially formed from the fission of a heavier atom, such as uranium-235 or plutonium-239. The fission fragments resulting from each fission of uranium-235, for example, are not necessarily the same. Various pairs of atoms can be produced. When initially formed, most fission fragments are radioactive, and emit beta particles and gamma rays, and decay into other atoms.

Fission products: The collective term for the various fission fragments and their resulting decay products formed after fission of a heavy atom.

Flux, neutron: The number of neutrons that pass through one square centimeter per second.

Fuel cycle, nuclear: The series of steps involved in supplying fuel for nuclear reactors and managing the waste products. It includes the mining, refining and enrichment of uranium, fabrication of fuel elements, their use in a reactor, reprocessing to recover the fissionable material remaining in the spent fuel, possible re-enrichment of the fuel material, possible re-fabrication into more fuel, waste processing and long-term storage.

Fuel rod: A single rod of fissionable material encased in cladding to contain the fission products and to allow heat removal using coolant. Fuel rods are assembled into fuel elements forming the core of a nuclear reactor.

Fusion: The formation of a heavier nucleus from two lighter ones (such as hydrogen isotopes) with an attendant release of energy (as in a fusion reactor or the sun).

G

Gamma radiation (y): Gamma radiation is short wavelength electromagnetic radiation of the same physical nature as light, X-rays, radio waves etc. However, gamma radiation is highly penetrating and, depending on its energy, may require a considerable thickness of lead or concrete to absorb it. Since gamma radiation causes ionization it constitutes a biological hazard. High-energy gamma rays are commonly used to sterilize medical products.

Gas-cooled reactor: A nuclear reactor in which the coolant is a gas.

Gauging devices: Devices used to measure, monitor, and control the thickness of sheet metal, textiles, paper napkins, newspaper, plastics, photographic film, and other products as they are manufactured. Gauges mounted in fixed locations are designed for measuring or controlling material density, flow, level, thickness, or weight. The gauges contain sealed sources that radiate through the substance being measured to a readout or controlling device. Portable gauging devices, such as moisture density gauges, are used at field locations. These gauges contain a gamma-emitting sealed source, usually cesium-137, or a sealed neutron source, usually americium-241 or beryllium.

Geiger counter or Geiger-Muller counter: An instrument or device used to detect and measure radiation caused by the ionization in the gas chamber.

Geological repository: An excavated, underground facility that is designed, constructed, and operated for safe and secure permanent disposal of high-level radioactive waste. A geological repository uses an engineered barrier system and a portion of the site's natural geology, hydrology, and geochemical systems to isolate the radioactivity of the waste.

Graphite, nuclear grade: A form of carbon that can be used as a neutron moderator and reflector in some reactors.

Gray (Gy): A measure of absorbed dose. Replaces the rad. 1 Gy = 100 rad.

H

Half-life, biological: The time required for a biological system, such as that of a human, to eliminate, by natural processes, half of the amount of a substance (such as a radioactive material) that has entered it.

Half-life, effective: The time required for the activity of a particular radioisotope deposited in a living organism, such as a human or an animal, to be reduced by 50 percent because of the combined action of radioactive decay and biological elimination.

Half-life, radiological ($t_{1/2}$): For a single radioactive decay process, the time required for the activity to decrease to half its value by that process. Half-lives vary, according to the isotope, from less than a millionth of a second to more than a billion years.

Heavy water (D_2O): Water containing significantly more than the natural proportion (one in 6,500) of heavy hydrogen (deuterium atoms to normal hydrogen atoms). Heavy water is used as a moderator in some reactors because it effectively slows down neutrons to become thermalized.

Heavy water moderated reactor: A reactor that uses heavy water as its moderator. Heavy water is an excellent moderator and thus permits the use of unenriched uranium as a fuel.

High-level radioactive waste (HLW): The highly radioactive materials produced as byproducts of fuel reprocessing or of the reactions that occur inside nuclear reactors. HLW includes:

- Irradiated spent nuclear fuel discharged from commercial nuclear power reactors
- The highly radioactive liquid and solid materials resulting from the reprocessing of spent nuclear fuel, which contain fission products in concentration (this includes some reprocessed HLW from defense activities and a small quantity of reprocessed commercial HLW)
- Other highly radioactive materials that the PNRI may determine to require permanent isolation

Hot: A colloquial term meaning highly radioactive.

Hot spot: The region in a radiation/contamination area where the level of radiation/contamination is significantly greater than in neighboring regions in the area.

Hot cell: A heavily shielded enclosure for handling highly radioactive materials. It may be used for their handling or processing by remote means or for their storage.

I

Induced radioactivity: Radioactivity that is created when stable substances are bombarded by ionizing radiation. For example, the stable isotope cobalt-59 becomes the radioactive isotope cobalt-60 under neutron bombardment.

International Atomic Energy Agency (IAEA): The center of worldwide cooperation in the nuclear field, through which member countries and multiple international partners work together to promote the safe, secure, and peaceful use of

nuclear technologies. The IAEA was established in 1957 within the United Nations family as part of the "Atoms for Peace" initiative.

Ion: An atom that has lost or gained one or more orbiting electrons, thus becoming electrically charged.

Ionizing radiation: Radiation capable of causing ionization of the matter through which it passes. Ionizing radiation may damage living tissue.

Ionization: Any process by which an atom or molecule gains or loses electrons.

Irradiation: Exposure to ionizing radiation.

Isotopes: Atoms that have the same atomic number but different mass numbers. Different isotopes of the same element have the same chemical properties, but different physical properties.

Isomers, nuclear: Nuclear isomers are atoms with the same mass number and atomic number, but with different states of excitation in the atomic nucleus.

K

Kilovolt (kV): The unit of electrical potential equal to 1000 volts.

Kilowatt (kW): A unit of power equivalent to one thousand watts.

L

Lethal dose (LD): The dose of radiation expected to cause death to 50 percent of an exposed population within 30 days (LD 50/30). Typically, the LD 50/30 is in the range from 4 to 5 sieverts (400 to 450 rem) received over a very short period.

Licensed material: Source material, byproduct material, or special nuclear material that is received, possessed, used, transferred, or disposed of under a general license or specific license issued by the PNRI.

Licensee: A company, organization, institution, or other entity to which PNRI has granted a general license or specific license to construct or operate a nuclear facility, or to receive, possess, use, transfer, or dispose of source material, byproduct material, or special nuclear material.

Light water reactor (LWR): Reactors that are moderated and cooled by normal water. They account for most of the world's installed nuclear power generating capacity. Included in this group are pressurized water reactors (PWRs) and boiling water reactors (BWRs).

Loss of coolant accident (LOCA): Pertains to postulated accidents that result in a loss of reactor coolant at a rate that is more than the capability of the reactor makeup system from breaks in the reactor coolant pressure boundary, up to and including a break equivalent in size to the double-ended rupture of the largest pipe of the reactor coolant system.

Low level radioactive waste (LLW): A general term for a wide range of items that have become contaminated with radioactive

material or have become radioactive through exposure to neutron radiation. A variety of industries, hospitals and medical institutions, educational and research institutions, private or government laboratories, and nuclear fuel cycle facilities generate LLW as part of their day-to-day use of radioactive materials. Some examples include radioactively-contaminated protective shoe covers and clothing; cleaning rags, mops, filters, and reactor water treatment residues; equipment and tools; medical tubes, swabs, and hypodermic syringes; and carcasses and tissues from laboratory animals. The radioactivity of these waste materials can range from just above natural background levels to much higher levels, such as seen in parts from inside the reactor vessel in a nuclear power plant. Low-level waste is typically stored onsite by licensees, either until it has decayed away and can be disposed of as ordinary trash, or until the accumulated amount becomes large enough to warrant shipment to a low-level waste disposal site.

M

Mass defect (also mass deficiency): The amount by which the mass of an atomic nucleus is less than the sum of the masses of its constituent particles.

Mass spectrometer: A device that uses magnetic fields, electric fields, or both, to separate and thus analyze the masses of various isotopes in a sample.

Megawatt (MW): Unit of power equal to one million watts.

Metamict: A state of a substance that lost its crystalline structure due to the decay of uranium and thorium within it.

Metastable state: A particular excited state of an atom or nucleus that has a longer lifetime than the ordinary excited states and that generally has a shorter lifetime than the lowest, often stable, energy state, called the ground state. A metastable state may thus be considered a kind of temporary energy level or a somewhat stable intermediate stage of a system. Radionuclides at a metastable state emit only gamma rays and are often called nuclear isomers. (See: nuclear isomers)

Microsievert (μSv): One millionth of a sievert.

Millisievert (mSv): One thousandth of a sievert.

Moderator: A material used in a reactor to slow down high speed neutrons, thus increasing the likelihood of further fission. Examples of good moderators include normal water, heavy water, beryllium and graphite.

Monitoring, radiation: The collection and assessment of radiological information to determine the adequacy of radiation protection. Radiation can be monitored using equipment such as Geiger counters and scintillation counters.

N

Naturally Occurring Radioactive Material (NORM): Radioactive materials that occur naturally, such as uranium-238, uranium-235, potassium-40, wherein people are exposed to and are considered the source of background radiation.

Neutron: An uncharged subatomic particle with a mass slightly greater than that of the proton and found in the nucleus of

every atom except ordinary hydrogen. Neutrons are the links in a chain reaction in a nuclear reactor.

Neutrons, delayed: Neutrons resulting from fission that are emitted by fission products after a significant time delay. They are important in the control of a nuclear reactor.

Neutrons, fast: Neutrons emitted from fission events. They are thousands of times faster than slow neutrons and maintain chain reactions in fast reactors.

Neutrons, thermal or slow: Neutrons travelling with energy comparable to those of everyday atoms, required as links in the chain reactions in thermal reactors.

Neutron activation analysis: A method of analysis based on the identification and measurement of characteristic radiation from radionuclides formed by irradiating a sample of material with neutrons.

Neutron flux: A measure of the intensity of neutron radiation, determined by the rate of flow of neutrons.

Neutron generation: The release, thermalization, and absorption of fission neutrons by a fissile material and the fission of that material producing a second generation of neutrons. In a typical nuclear power reactor system, there are about 40,000 generations of neutrons every second.

Neutron leakage: Neutrons that escape from the vicinity of the fissionable material in a reactor core. Neutrons that leak out of the fuel region are no longer available to cause fission and must be absorbed by shielding placed around the reactor pressure vessel for that purpose.

Neutron scattering: A technique for 'seeing' fine details of the structure of a substance. It involves firing a beam of neutrons at a sample and observing how they are scattered or diffracted. Most neutrons pass between atoms. Some of the neutrons collide with the nucleus of atoms and may be absorbed while others passing close to the nucleus are deflected by the intense electrostatic forces. Different structures and different atoms create different pathways for the neutrons.

Neutron source: Any material that emits neutrons, such as a mixture of radium and beryllium, that can be inserted into a reactor to ensure a neutron flux large enough to be distinguished from background to register on neutron detection equipment.

Non-power reactor: A nuclear reactor that is used for research, training, or development purposes (which may include producing radioisotopes for medical and industrial uses) but has no role in producing electrical power. These reactors, which are also known as research and test reactors, contribute to almost every field of science, including physics, chemistry, biology, medicine, geology, archeology, and ecology.

Nuclear reactor: A structure in which a fission chain reaction can be maintained and controlled. It usually contains fuel, coolant, moderator, control absorbers and safety devices and is most often surrounded by a concrete biological shield to absorb neutron and gamma ray emission.

Nuclear poison or neutron poison: In reactor physics, a substance (other than fissionable material) that has a large capacity for absorbing neutrons in the vicinity of the reactor core.

Nucleon: Common name for a constituent particle of the atomic

nucleus. At present, applied to protons and neutrons, but may include any other particles found to exist in the nucleus.

Nucleus: The positively charged core of an atom. It is about 1/10,000 the diameter of the atom but contains nearly all the atom's mass. All nuclei contain protons and neutrons, except the nucleus of normal hydrogen (atomic mass of one), which consists of a single proton.

Nuclide: A nucleus of a species of atom characterized by its mass number (protons and neutrons), atomic number (protons) and the nuclear energy state.

O

Occupational Dose: The internal and external dose of ionizing radiation received by workers in the course of employment in nuclear facilities and areas such as fuel cycle facilities, industrial radiography, nuclear medicine, and nuclear power plants. These workers are exposed to varying amounts of radiation, depending on their jobs and the sources with which they work. The PNRI requires its licensees to limit occupational exposure to 20 mSv per year. Occupational dose does not include the dose received from natural background sources, doses received as a medical patient or participant in medical research programs, or "second-hand doses" received through exposure to individuals treated with radioactive materials.

Orphan sources: Unwanted radioactive materials that fall in any one or more of the following conditions:

- An uncontrolled condition that requires removal to protect public health and safety from a radiological threat
- A controlled or uncontrolled condition, for which a responsible party cannot be readily identified
- A controlled condition, compromised by an inability to ensure the continued safety of the material (e.g., the licensee may have few or no options to provide for safe disposition of the material)
- An uncontrolled condition, in which the material is in the possession of a person who did not seek, and is not licensed, to possess it
- An uncontrolled condition, in which the material is in the possession of a State radiological protection program solely to mitigate a radiological threat resulting from one of the above conditions, and for which the State does not have the necessary means to provide for the appropriate disposition of the material

P

Particle detector, bubble chamber: An apparatus in which the movement and collision of ionizing particles is determined by the examination of trails of gas bubbles that form in the paths of the particles as they move through a superheated liquid.

Particle detector, cloud chamber: A supersaturated vapor chamber in which the path of charged subatomic particles can be detected by the formation of chains of droplets on ions generated by their passage. It is also used to infer the presence of neutral particles and to study certain nuclear reactions.

Personnel monitoring: The use of portable survey meters to determine the amount of radioactive contamination on individuals, or the use of dosimetry to determine an individual's occupational radiation dose.

Plutonium: A heavy radioactive, man-made metallic element. Its most important isotope is fissionable plutonium-239, produced by neutron irradiation of uranium-238. Plutonium-239 is used as a fuel for power reactors or at high concentrations as explosives for nuclear weapons.

Pool reactor: A reactor in which the fuel elements are suspended in a pool of water that serves as the reflector, moderator, and coolant. Popularly called a "swimming pool reactor," it is used for research and training, not for electrical generation.

Positron: Particle equal in mass but opposite in charge to the electron. A positive electron.

Power reactor: A reactor designed to produce heat for electric generation (as distinguished from reactors used for research), for producing radiation or fissionable materials or for reactor component testing.

Pressurized-water reactor (PWR): A common nuclear power reactor design in which very pure water is heated to a very high temperature by fission, kept under high pressure (to prevent it from boiling), and converted to steam by a steam generator (rather than by boiling, as in a boiling-water reactor). The resulting steam is used to drive turbines, which activate generators to produce electrical power.

Progeny: A nuclide formed in the radioactive decay of a radionuclide (called the parent).

Proton: A subatomic particle with a single positive electrical charge and a mass approximately 1,837 times that of the electron and slightly less than that of a neutron. Also, the nucleus of an ordinary or light hydrogen atom. Protons are constituents of all nuclei. Elements are defined by the number of protons.

Public Dose: The dose received by a member of the public from exposure to radiation or to radioactive material released by a licensee, or to any other source of radiation under the control of a licensee. Public dose does not include occupational dose or doses received from background radiation, from any medical administration the individual has received, from exposure to individuals administered with radioactive materials, or from voluntary participation in medical research programs.

Q

Quality factor: The factor by which the absorbed dose (rad or gray) is to be multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the biological damage (rem or sievert) to an exposed individual. It is used because some types of radiation, such as alpha particles, are more biologically damaging internally than other types.

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

Quark: Any of a group of six elementary fundamental matter particles having electric charges of a magnitude one-third or two-thirds that of the electron, regarded as constituents of all

hadrons (which include neutrons and protons). Each quark type is called a flavour. Quarks only exist inside hadrons.

R

Rad (radiation absorbed dose): Measure of absorbed dose. Now superseded by the Gray (Gy).

Radiation, nuclear: Radiation originating from the nucleus of an atom. It includes electromagnetic waves (gamma rays) as well as streams of fast-moving charged particles (electrons, protons, mesons, etc.) and neutrons of all velocities.

Radiation shielding: Reduction of radiation by interposing a shield of absorbing material between any radioactive source and a person, work area, or radiation-sensitive device.

Radiation sickness: The complex of symptoms characterizing the disease known as radiation injury, resulting from excessive exposure (greater than 2 gray or 200 rads) of the whole body (or large part) to ionizing radiation. The earliest of these symptoms are nausea, fatigue, vomiting, and diarrhea, which may be followed by loss of hair (epilation), hemorrhage, inflammation of the mouth and throat, and general loss of energy. In severe cases, where the radiation exposure has been approximately 10 gray (1000 rad) or more, death may occur within two to four weeks. Those who survive six weeks after the receipt of a single large dose of radiation to the whole body may generally be expected to recover.

Radiation therapy (radiotherapy): The therapeutic use of ionizing radiation to treat disease in patients. Although most

radiotherapy procedures are intended to kill cancerous tissue or reduce the size of a tumor, therapeutic doses may also be used to reduce pain or treat benign conditions.

Radioactive material: Any natural or artificial material whether in the solid or liquid form, or in the form of a gas or vapor, that exhibits radioactivity. For regulatory purposes, radioactive substances may be defined as any radioactive material that has an activity level of 100 becquerels per gram or greater.

Radioactive waste: Material that contains or is contaminated with radionuclides at concentrations or radioactivity levels greater than clearance levels established by the appropriate authority and for which no use is foreseen.

Radioactive waste, low level: Any waste material that contains quantities of radioactive material above the clearance level (as determined in regulations) that requires minimum standards of protection for personnel when the waste is handled, transported and stored. (See: low level radioactive waste)

Radioactive waste, intermediate: Any waste material that contains quantities of radioactive material above clearance levels, requires shielding and has a thermal power below two kilowatts per cubic meter.

Radioactive waste, high level: Waste which contains large concentrations of both short and long lived radioactive nuclides, and is sufficiently radioactive to require both shielding and cooling. It generates more than two kilowatts of heat per cubic meter. (See: high-level radioactive waste)

Radioactivity: The ability of certain nuclides to emit particles, gamma rays or X-rays during their spontaneous decay into other nuclei. The final outcome of radioactive decay is a stable nuclide.

Radiography: The use of sealed sources of ionizing radiation for nondestructive examination of the structure of materials. When the radiation penetrates the material, it produces a shadow image by blackening a sheet of photographic film that has been placed behind the material, and the differences in blackening suggest flaws and unevenness in the material.

Radiological survey: The evaluation of the radiation hazards accompanying the production, use, or existence of radioactive materials under a specific set of conditions. Such evaluation customarily includes a physical survey of the disposition of materials and equipment, measurements or estimates of the levels of radiation that may be involved, and a sufficient knowledge of processes affecting these materials to predict hazards resulting from expected or possible changes in materials or equipment.

Radioisotope: An isotope that is radioactive. Most natural elements lighter than bismuth are not naturally radioactive. Three natural radioisotopes are radon-222, carbon-14 and potassium-40.

Radionuclide: The nucleus of a radioisotope.

Radiopharmaceutical: A radiopharmaceutical is a molecule that consists of a radioisotope tracer attached to a pharmaceutical. After entering the body, the radio-labelled pharmaceutical will accumulate in a specific organ or tumor. The radiopharmaceutical will spontaneously produce specific amounts of radiation that can be safely used to diagnose or treat diseases, injuries or infections.

Radiosensitivity: The relative susceptibility of cells, tissues, organs, organisms, or other substances to the injurious action of radiation.

Radon: A radioactive element and the heaviest known gas. It is a progeny of radium in the uranium decay series. Radon gives rise to a significant part of the radiation dose from natural background radiation. It emanates from the ground, bricks and concrete.

Rem: Measure of biological effect of radiation (dose). Rem stands for radiation equivalent man. Rem is now superseded by the sievert (Sv): 1 Sv = 100 rems.

Reactivity: A term expressing the departure of a reactor system from criticality. A positive reactivity addition indicates a move toward supercriticality (power increase). A negative reactivity addition indicates a move toward subcriticality (power decrease).

Reprocessing: The chemical dissolution of spent fuel to separate unused uranium and plutonium from fission products and other transuranic elements. The recovered uranium and plutonium may then be recycled into new fuel elements.

S

Scram: The sudden shutting down of a nuclear reactor, usually by rapid insertion of control rods, either automatically or manually by the reactor operator. Also known as a "reactor trip".

Sealed source: Any radioactive material or byproduct encased in a capsule designed to prevent leakage or escape of the material.

Secondary radiation: Radiation originating as the result of absorption of other radiation in matter. It may be either electromagnetic or particulate in nature.

Sievert: A measurement of equivalent dose and effective dose. Replaces the rem: 1 Sv = 100 rem.

Source, nuclear: A radioactive material that produces radiation that is used for experimental, industrial and medical use.

Spent fuel: Nuclear fuel elements in which fission products have built up and the fissile material depleted to a level where a chain reaction does not operate efficiently. Also referred to as irradiated fuel.

Stable isotope: An isotope incapable of spontaneous radioactive decay.

Stochastic effects: Effects that occur by chance, generally occurring without a threshold level of dose, whose probability is proportional to the dose and whose severity is independent of the dose. In the context of radiation protection, the main stochastic effects are cancer and genetic effects.

Subcritical mass: An amount of fissionable material insufficient in quantity or of improper geometrical configuration to sustain a fission chain reaction.

Subcriticality: : The condition of a nuclear reactor system, in which nuclear fuel no longer sustains a fission chain reaction (that is, the reaction fails to initiate its own repetition, as it would in a reactor's normal operating condition). A reactor becomes subcritical when its fission events fail to release enough neutrons to sustain an ongoing series of reactions,

possibly because of increased neutron leakage or poisons.

Supercritical reactor: A reactor in which the power level is increasing with time.

Supercriticality: The condition for increasing the level of operation of a reactor. The rate of fission neutron production exceeds all neutron losses, and the overall neutron population increases.

Survey meter: Any hand-held device or portable instrument used to check the presence of ionizing radiation.

Synchrotron: A cyclotron in which the magnetic field strength and frequency of accelerating voltage increases with the energy of the particles to keep their orbital radius constant.

T

Teletherapy: Treatment in which the source of the therapeutic radiation is at a distance from the body. Because teletherapy is often used to treat malignant tumors deep within the body by bombarding them with a high-energy beam of gamma rays (from a radioisotope such as cobalt-60) projected from outside the body, it is often called “external beam radiotherapy.”

Terrestrial radiation: The portion of the natural background radiation that is emitted by naturally occurring radioactive materials, such as uranium, thorium, and radon in the earth.

Thermal reactor: A reactor in which the fission chain reaction is sustained primarily by slow or thermal neutrons.

Thorium: A naturally occurring radioactive element. With the absorption of neutrons, thorium-232 is converted to the fissionable isotope uranium-233.

Thermo-luminescent dosimeter (TLD): A dosimeter which uses the thermo-luminescent properties of a material to measure the dose of ionizing radiation over a period.

Tracer, radioisotope: A radioisotope introduced into a system as a tracking signal, the movement of which can be followed to trace the movement of parts of that system.

Transmutation: Conversion of a chemical element into another chemical element.

Transuranics: Elements with an atomic number above 92. They are produced artificially, for example, when uranium is bombarded with neutrons. Some are therefore present in spent fuel. (See: actinides)

Tritium: The isotope of hydrogen of atomic mass of three (hydrogen-3). It is very rare, naturally radioactive, but can be made in a number of ways, including neutron absorption in a) lithium, b) deuterium, or c) heavy water.

U

Unstable isotope: A radioactive isotope.

Uranium: A radioactive element with two isotopes that are fissile (uranium-235 and uranium-233) and two that are fertile (uranium-238 and uranium-234). Uranium is the basic raw

material of nuclear energy.

Uranium, depleted: Uranium having less than the naturally occurring percentage of uranium-235 (~0.71 percent). As a by-product of enrichment in the fuel cycle it generally has 0.20-0.25 percent uranium-235, the rest being uranium-238.

Uranium, enriched: Uranium in which the content of the fissile isotope uranium-235 has been increased above the ~0.71 percent natural content. Enriched uranium with 20-40 percent of uranium-235 is a fuel for many research and power reactors, whereas higher enriched uranium with over 90 percent of uranium-235 is a fuel for fast breeder reactors and the explosive in nuclear weapons.

Uranium hexafluoride (UF_6): A compound of uranium that is a gas above 56°C and is thus a suitable form for processing uranium to enrich it in the fissile isotope uranium-235.

V

Void: In a nuclear power reactor, an area of lower density in a moderating system (such as steam bubbles in water) that allows more neutron leakage than does the denser material around it.

Vitrification: The incorporation of intermediate and high-level radioactive waste into glass for long-term storage.

W

Watt: A unit of power (in the international system of units) defined as the consumption or conversion of one joule of energy per second. In electricity, a watt is equal to current (in amperes) multiplied by voltage (in volts).

Weighing factor (WT): Multipliers of the equivalent dose to an organ or tissue used for radiation protection purposes to account for different sensitivities of different organs and tissues to the induction of stochastic effects of radiation.

Whole-body counter or contamination monitor: An assembly for measuring the total gamma radiation emitted from radioactivity on clothing or skin. The monitor uses one or more radiation detectors shielded against natural background radiation.

Wipe sample: A sample made for the purpose of determining the presence of removable radioactive contamination on a surface. It is done by wiping, with slight pressure, a piece of soft filter paper over a representative type of surface area. It is also known as a "swipe" or "smear" sample.

X

X-ray: Electromagnetic radiations with wavelengths much shorter than visible light but usually longer than gamma rays.

Y

Yellowcake: The mixture of uranium oxides produced after milling uranium ore from a mine. It is usually represented by the formula U_3O_8. If dried at low temperature, it is yellow. If dried at higher temperature, it is light brown. Uranium is exported from Australia in this form. Also referred to as Uranium Ore Concentrate (UOC).

Z

Zirconium: A chemical element used (in the form of "Zircaloy" metals) in cladding for nuclear fuel rods. The thin zirconium tubes contain pellets of nuclear fuel and are bundled together into assemblies for use in a reactor.

Acronyms and Abbreviations

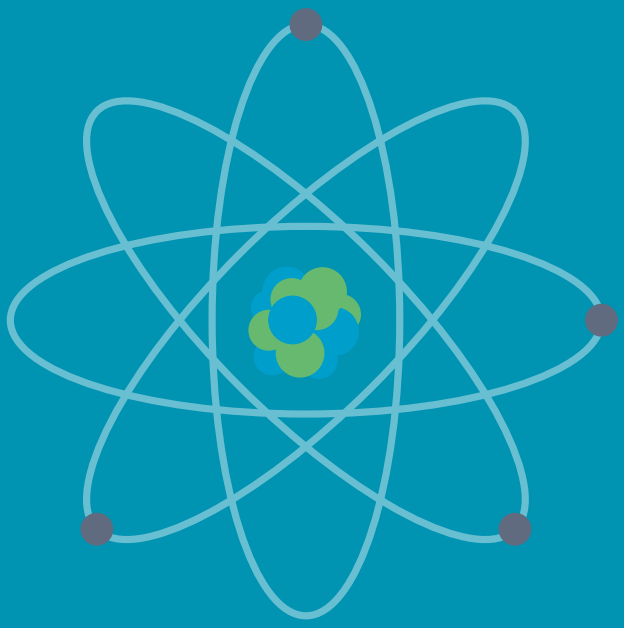
ALARA - As Low As Reasonably Achievable
AGR - Advanced Gas-cooled Reactor
amu - Atomic Mass Unit
BWR - Boiling Water Reactor
Ci - Curie
ECCS - Emergency Core Cooling System
EIS - Environmental Impact Statement
Euratom - European Atomic Energy Community
FBR - Fast Breeder Reactor
GCR - Gas-cooled Reactor
HEU - High/Highly-Enriched Uranium
HIFAR - High Flux Australian Reactor
HLW - High level nuclear waste
HTR - High Temperature Reactor
HWR - Heavy Water Reactor
IAEA - International Atomic Energy Agency
ICRP - International Commission on Radiological Protection
ICRU - International Commission on Radiation Units
INES - International Nuclear Event Scale
INIS - International Nuclear Information System
LEU - Low Enriched Uranium
LOCA - Loss-of-coolant Accident
LWR - Light Water Reactor
mSv - Millisievert
µSv - Microsievert
MWD/t - Megawatt days per tonne

MW - Megawatt
NAA - Neutron Activation Analysis
NPT - Non-proliferation Treaty or Treaty on the Non-proliferation of Nuclear Weapons
OECD NEA - Organization of Economic Cooperation and Development Nuclear Energy Agency
OSL - Optically Stimulated Luminescence
PNRI - Philippine Nuclear Research Institute
PRR-1 - Philippine Research Reactor 1
PWR - Pressurized Water Reactor
Sv - Sievert
SPECT - Single Photon Emission Computed Tomography
TLD - Thermo-Luminescent Dosimeter
UIC - Uranium Information Centre

DEVELOPED BY

Department of Science and Technology

PHILIPPINE NUCLEAR RESEARCH INSTITUTE



PNRI.DOST.GOV.PH

DOE.GOV.PH