Glossary of Nuclear terms and phrases

A glossary of commonly used nuclear terms and phrases with a short explanation for each.

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Terms covered elsewhere in the glossary are denoted by bold lettering.

**Activation**
A radioactive isotope of an element (e.g., in the steel of a reactor core), which has been created by neutron bombardment.

**ALARA**
As Low As Reasonably Achievable, economic and social factors being taken into account. This is the optimisation principle of radiation protection.

**Alpha Particle**
A positively charged particle from the nucleus of an atom, emitted during radioactive decay. An alpha particle is a helium nucleus made up of two protons and two neutrons.

**Atom**
A particle of matter which cannot be broken up by chemical means. Atoms have a nucleus consisting of positively charged protons and uncharged neutrons of the same mass. The positive charges on the protons are balanced by a number of negatively charged electrons in motion round the nucleus.

**Atomic Bomb**
An explosive device whose energy comes from the fission of heavy elements such as uranium or plutonium.

**Becquerel (Bq)**
A unit of radiation equal to one disintegration per second (the SI unit). One Becquerel is a minute quantity of radioactivity; discharges are normally expressed in:
- Kilobecquerels (kBq) – one thousand Bq, or
- Gigabecquerels (gBq) – one thousand million Bq, or
- Terabecquerels (tBq) – one million million Bq.

**Beta Particle**
An electron or particle emitted from an atom during radioactive decay.

**Biological Shield**
A mass of absorbing material e.g., thick concrete walls) placed around a reactor or radioactive material to reduce the radiation, especially neutrons and gamma rays.

**Boiling Water Reactor (BWR)**
A common type of light water reactor (LWR), where water is allowed to boil in the core thus generating steam directly in the reactor vessel.

**Breed**
To form fissile nuclei, usually as a result of neutron capture.

**Burnable Poison**
A neutron absorber included in the fuel which progressively disappears and compensates for the loss of reactivity as the fuel is consumed. Gadolinium is commonly used.

**Calandria**
(in a CANDU reactor) a cylindrical reactor vessel which contains the heavy water moderator. It is penetrated from end to end by calandria tubes which hold the pressure tubes containing fuel and coolant.

**CANDU**
Canadian Deuterium Uranium reactor, moderated and usually cooled by heavy water.

**Chain Reaction**
A nuclear reaction that is self-sustaining, in particular where the neutrons originating from nuclear fission cause an ongoing series of fission reactions.
Control Rods
Devices to absorb neutrons so that the chain reactions in a reactor core may be controlled or terminated.

Conversion
Chemical process turning $\text{U}_3\text{O}_8$ into $\text{UF}_6$ preparatory to enrichment.

Core
The central part of a nuclear reactor containing the fuel elements and any moderator.

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

Curie (Ci)
A unit of radiation measurement, equal to $3.7 \times 10^{10}$ disintegrations per second. Now superseded by the SI unit: the Becquerel.

Decay
Decrease in activity of a radioactive substance due to the disintegration of an atomic nucleus resulting in the release of alpha or beta particles or gamma radiation.

Decommissioning
Removal of a facility (e.g., reactor) from service, also making the site available for unrestricted use.

Depleted Uranium
Uranium having less that the natural 0.7% $\text{U}^{235}$. As a by-product of enrichment in the fuel cycle it generally has 0.25-0.30% $\text{U}^{235}$, the rest being $\text{U}^{238}$. Can be blended, for example, with highly enriched uranium to make reactor fuel.

Deuterium
'Heavy Hydrogen', an isotope having one proton and one neutron in the nucleus. It occurs in nature as 1 atom to 6,500 atoms of normal hydrogen (hydrogen atoms contain one proton and no neutrons).
- Deuterium oxide, or Heavy Water, can be used as a moderator in reactors.

Dose Equivalent
The absolute measurement of exposure to a dose of ionising radiation depends on the type of particle and the body tissue with which it interacts - hence the conversion to dose equivalent, which has units of Rem. Rads are converted to rems by multiplying by a factor that depends on the type of ionising radiation and it's biological effect. For example, with gamma radiation the factor is 1 and a rad is equal to a rem. See Sievert, the SI unit now used.

Element
A chemical substance that cannot be divided into simpler substances by chemical means; atomic species with same number of protons.

Enriched Uranium
Uranium in which the proportion of $\text{U}^{235}$ has been increased above the natural 0.7%. Reactor grade uranium is usually enriched to about 3.5% $\text{U}^{235}$, weapons grade uranium is more than 90% $\text{U}^{235}$.

Enrichment
Physical process of increasing the proportion of $\text{U}^{235}$ to $\text{U}^{238}$.

Excursion
A change in a reactor’s operating conditions outside normal operating parameters.

Fast Breeder Reactor (FBR)
A fast neutron reactor configured to produce more fissile material than it consumes, using fertile material such as depleted uranium.
Fertile (of an isotope)
Capable of becoming fissile, by capturing one or more neutrons, possibly followed by radioactive decay, e.g. \(^{238}\text{U}\) becoming Plutonium (\(^{239}\text{Pu}\)).

Fissile (of an isotope)
Capable of capturing a neutron and undergoing nuclear fission, e.g. \(^{235}\text{U}\) & \(^{239}\text{Pu}\).

Fission
The splitting of a heavy nucleus into two, accompanied by the release of a relatively large amount of energy and generally one or more neutrons. It may be spontaneous but usually is due to a nucleus absorbing a neutron.

Fission Products
Daughter nuclei resulting from either the fission of heavy elements such as uranium, or the radioactive decay of these primary daughters. Usually highly radioactive.

Fossil Fuel
A fuel based on carbon presumed to be originally from living matter, e.g., coal, oil, gas. Burned with oxygen to yield energy.

Fuel Fabrication
Making reactor fuel elements, usually from uranium or uranium oxide.

Gamma Rays
High energy electro-magnetic radiation.

Genetic Mutation
Sudden changes in the chromosomal DNA of an individual gene. It may produce inherited changes in descendants. Mutation can be made more frequent by irradiation.

Graphite
A form of carbon used in very pure form as a moderator, principally in gas cooled reactors, but also in Soviet designed RBMK reactors.

Gray (Gy)
The SI unit of radiation dose. 1 Gy is equivalent to 100 rads.

Greenhouse Gases
Thermal gases in the earth’s atmosphere, which absorb heat radiation from the earth’s surface and re-radiate it, thereby warming the earth. Carbon dioxide (\(\text{CO}_2\)), water vapour (\(\text{H}_2\text{O}\)) and methane (\(\text{CH}_4\)) are the most important ones. A higher level of greenhouse gases in the environment, e.g. due to the combustion of fossil fuels, can enhance the greenhouse effect and may lead to global warming.

Half-Life
The period required for half of the atoms of a parent radioactive isotope to decay into a daughter nucleide, i.e. an isotope of another element.

Heavy Water
Water containing an elevated concentration with molecules of deuterium (heavy hydrogen) atoms. Its symbol is D\(_2\)O.

Heavy Water Reactor (HWR)
A reactor which uses heavy water as a moderator, e.g. Canadian CANDU.

High Level Waste
Extremely radioactive fission products and transuranic elements (usually other than plutonium) separated as a result of reprocessing spent nuclear fuel.

Highly (or High) Enriched Uranium (HEU)
Uranium enriched to at least 20% \(^{235}\text{U}\). Uranium in weapons is about 90% \(^{235}\text{U}\).

In Situ Leaching
The recovery by chemical means of minerals from porous orebodies without physical excavation.
**Megawatt (MW)**
A unit of power, $= 10^6$ Watts. MWe refers to electric output from a generator, MWt to thermal output from a reactor or heat source (e.g., the gross heat output of a reactor itself, typically three times the MWe figure).

**Metal Fuels**
Natural uranium metal as used, for example, in Magnox gas-cooled reactor.

**Micro**
One millionth of a unit (e.g., microsievert is one millionth of a Sv).

**Isotope**
An atomic form of an element having a particular number of neutrons. Different isotopes of an element have the same number of protons but different numbers of neutrons and hence different atomic masses, e.g., $U^{235}$ and $U^{238}$.

**Moderator**
A material such as light or heavy water or graphite used in a reactor to slow down fast neutrons so as to expedite further fission.

**Natural Uranium**
Uranium with an isotopic composition as found in nature, containing 99.3% $U^{238}$, 0.7% $U^{235}$ and a trace of $U^{234}$.

**Neutral Energy**
The SI unit of energy. The release or transfer of one joule per second is one Watt, the SI derived unit of power.

**Light Water**
Ordinary water ($H_2O$) as distinct from heavy water ($D_2O$).

**Low Enriched Uranium**
Uranium enriched to less than 20% $U^{235}$. Uranium in power reactors is about 3.5% $U^{235}$.

**Magnox reactor**
First generation British gas cooled nuclear reactor type, named after its magnesium alloy fuel elements.

**Ionising Radiation**
Radiation capable of breaking chemical bonds, thus causing ionisation of the matter through which it passes and damage to living tissue. Alpha particles, Beta particles and Gamma rays are all forms of ionising radiation.

**Light Water Reactor (LWR)**
A common nuclear reactor cooled and usually moderated by ordinary water.

**Lixiviant**
The term used to describe the chemical solutions used in uranium In Situ Leach mining.

**Neutron**
An uncharged subatomic elementary particle. Neutrons are found in the nucleus of every atom except hydrogen. Solitary mobile neutrons travelling at various speeds originate from fission reactions. Slow neutrons can in turn readily cause fission in atoms of some isotopes, e.g., $U^{235}$ and fast neutrons can readily cause fission in atoms of others, e.g., $Pu^{239}$. Sometimes atomic nuclei simply capture neutrons.
Nuclear Reactor
An engineering construction in which a nuclear fission chain reaction occurs under controlled conditions so that the heat yield can be harnessed or the neutron beams utilised. All commercial reactors to date are thermal reactors, using a moderator to slow down the neutrons.

Oxide Fuels
Enriched or natural uranium in the form of the oxide UO$_2$ used in many types of reactor.

Plutonium
A transuranic element formed in a nuclear reactor by neutron capture. It has several isotopes, some of which are fissile and some of which undergo spontaneous fission, releasing neutrons.

Pressurised Water Reactor (PWR)
The most common type of light water reactor (LWR).

Radiation
The emission and propagation of energy by means of electromagnetic waves or sub-atomic particles.

Radioactivity
The spontaneous decay of an unstable atomic nucleus, giving rise to the emission of radiation, i.e. Alpha particles, Beta particles and Gamma rays.

Radionuclide
A radioactive isotope of an element.

Radiotoxicity
The adverse health effects of a radionuclide due to its radioactivity.

Radium (Ra)
A highly radioactive element often found in uranium ore. It has several radioactive isotopes. Radium$^{226}$ decays to Radon$^{222}$. Radium is used in radiotherapy and luminous paints.

Radon (Rn)
A natural radioactive gas given off by rocks and soils containing radium (or thorium). Radon is the largest single contributor to radioactive exposure of the UK population.

Radon daughters
Radioactive decay products of radon$^{222}$ (Polonium$^{218}$, Lead$^{214}$, Bismuth$^{214}$, Polonium$^{214}$, Lead$^{210}$).

Rad
A unit to measure the absorption of ionising radiation by the body. A rad is equivalent to 0.01 joules of energy from ionising radiation absorbed per kilogram of soft tissue.

RBMK
Russian reactor design which uses a graphite moderator and natural water coolant.

Reactor
See Nuclear Reactor.

Rem
The unit of Dose Equivalent. This measure takes account of the biological damage caused by ionising radiation.

Repository
A safe permanent disposal place for radioactive waste.

Reprocessing
Chemical treatment of spent reactor fuel to separate the uranium and the plutonium from the small quantity of fission products, leaving a much reduced quantity of high-level waste.
Separative Work Unit
This is a complex unit which is a function of the amount of uranium processed and the degree to which it is enriched, i.e., the extent of increase in the concentration of the U-235 isotope relative to the remainder. The unit is strictly Kilogram Separative Work Unit, and it measures the quantity of separative work (indicative of energy used in enrichment) when feed and product quantities are expressed in kilograms.

Sievert (Sv)
SI derived unit of dose equivalent of ionising radiation. The unit takes into account the type of radiation involved, its effect on the body’s tissue and the sensitivity of the different body organs to radiation. One joule (J) of Beta or Gamma radiation absorbed per kilogram of tissue has 1 Sv of biological effect; 1 J/kg of alpha radiation has 20 Sv effect and 1 J/kg of neutrons has 10 Sv effect. 1 Sv equals 100 rem.

- 1 millisievert (msv) is one thousandth of a sievert. The UK population yearly average dose is 2.6 millisieverts.
- 1 millisievert is equal to 1000 microsieverts (µsv).

Stable
Incapable of spontaneous decay; not radioactive.

Tailings
Ground rock remaining after particular ore minerals (e.g., uranium oxides) are extracted.

Tails
Depleted uranium (cf. Enriched uranium), with about 0.3% U²³⁵.

Thermal Reactor
A reactor in which the fission chain is sustained primarily by slow neutrons (as distinct from Fast Reactor).

Transmutation
Changing atoms of one element into those of another by a nuclear reaction, e.g. neutron bombardment, causing neutron capture.

Transuranic Element
A very heavy element formed artificially by neutron capture and subsequent beta decay(s). Has a higher atomic number than uranium (92). All are radioactive. Neptunium, plutonium and americium are the best known.

Uranium
A mildly radioactive element with two isotopes which are fissile (U²³⁵ and U²³³) and two which are fertile (U²³⁸ and U²³⁴). Uranium is the basic raw material of nuclear energy.

Uranium Hexafluoride (UF₆)
A compound of uranium with fluorine which is a gas at 56°C and is thus a suitable form in which to enrich the uranium by gaseous diffusion or the gas centrifuge process.

Uranium Oxide Concentrate (U₃O₈)
The mixture of uranium oxides produced after milling uranium ore from a mine. Sometimes termed yellowcake. It is khaki in colour and is usually represented by the empirical formula U₃O₈.

Vitrification
The incorporation of high level waste into borosilicate glass blocks, to make up about 14% of the product by mass. It is designed to immobilise radionuclides in an insoluble matrix for disposal.

Waste (High Level)
High-level waste (HLW) is highly radioactive material arising from nuclear fission. It is recovered from reprocessing spent fuel, though some countries regard spent fuel itself as HLW and plan to dispose of it in that form. It requires very careful handling, storage and disposal, taking the waste heating effect into account.
Waste (Intermediate Level)
Intermediate level waste (ILW) is more radioactive than Low Level Waste but does not require heating to be taken into account in the design of the storage facilities.

Waste (Low Level)
Low-level waste (LLW) is mildly radioactive material usually disposed of by incineration and near surface burial.

Yellowcake
See Uranium Oxide Concentrate.

Further Information
- IET Energy related factfiles
  http://www.theiet.org/factfiles/energy/index.cfm

IET nuclear factfile series
- The principles of nuclear power
  http://www.theiet.org/factfiles/energy/nuc-prin-page.cfm
- Nuclear reactor types
  http://www.theiet.org/factfiles/energy/nuc-reac-page.cfm
- Nuclear safety
- Legal framework of nuclear power in the UK
- Nuclear decommissioning
  http://www.theiet.org/factfiles/energy/nuc-dec-page.cfm
- Nuclear waste disposal and transport of spent fuel
  http://www.theiet.org/factfiles/energy/nuc-waste-page.cfm
- The nuclear fuel cycle
  http://www.theiet.org/factfiles/energy/nuc-fuel-page.cfm
- The radioactive decay of uranium$^{238}$
  http://www.theiet.org/factfiles/energy/uranium238-page.cfm
- Glossary of nuclear terms
  http://www.theiet.org/factfiles/energy/nuc-terms-page.cfm

Further Reading
- Wood, J.
  IET Power and Energy Series 52
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