

# Glossary of Nuclear terms and phrases



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

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  $U_3O_8$  into  $UF_6$  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 than the natural 0.7%  $U^{235}$ . As a by-product of enrichment in the fuel cycle it generally has 0.25-0.30%  $U^{235}$ , the rest being  $U^{238}$ . 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 its 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  $U^{235}$  has been increased above the natural 0.7%. Reactor grade uranium is usually enriched to about 3.5%  $U^{235}$ , weapons grade uranium is more than 90%  $U^{235}$ .

## Enrichment

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

## 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.  $U^{238}$  becoming Plutonium ( $Pu^{239}$ ).

## Fissile (of an isotope)

Capable of capturing a **neutron** and undergoing nuclear fission, e.g.  $U^{235}$  &  $Pu^{239}$ .

## 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 ( $CO_2$ ), water vapour ( $H_2O$ ) and methane ( $CH_4$ ) 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 nuclide, i.e. an isotope of another element.

## Heavy Water

Water containing an elevated concentration with molecules of deuterium (**heavy hydrogen**) atoms. Its symbol is  $D_2O$ .

## 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%  $U^{235}$ . Uranium in weapons is about 90%  $U^{235}$ .

## In Situ Leaching

The recovery by chemical means of minerals from porous orebodies without physical excavation.

## 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.

## 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  $U^{238}$ .

## Joule

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** ( $D_2O$ ).

## 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.

## 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.

## 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).

## Mixed Oxide Fuel (MOX)

Reactor fuel which contains both uranium and plutonium in the form of a ceramic.

## 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  $U^{234}$ .

## 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  $\text{UO}_2$  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<sup>226</sup> decays to Radon<sup>222</sup>. 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<sup>222</sup> (Polonium<sup>218</sup>, Lead<sup>214</sup>, Bismuth<sup>214</sup>, Polonium<sup>214</sup>, Lead<sup>210</sup>).

## 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 ( $\mu\text{sv}$ ).

## 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%  $\text{U}^{235}$ .

## 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** ( $\text{U}^{235}$  and  $\text{U}^{233}$ ) and two which are fertile ( $\text{U}^{238}$  and  $\text{U}^{234}$ ). Uranium is the basic raw material of nuclear energy.

## Uranium Hexafluoride ( $\text{UF}_6$ )

A compound of uranium with fluorine which is a gas at  $56^\circ\text{C}$  and is thus a suitable form in which to **enrich** the uranium by gaseous diffusion or the gas centrifuge process.

## Uranium Oxide Concentrate ( $\text{U}_3\text{O}_8$ )

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  $\text{U}_3\text{O}_8$ .

## 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**  
<http://www.theiet.org/factfiles/energy/nuc-safety-page.cfm>
- **Legal framework of nuclear power in the UK**  
<http://www.theiet.org/factfiles/energy/legal-frame-nuc-page.cfm>
- **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<sup>238</sup>**  
<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.  
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The Institution of  
Engineering and Technology

The Institution of Engineering & Technology  
Michael Faraday House  
Six Hills Way  
Stevenage Herts  
SG1 2AY

**T:** +44 (0)1438 765690  
**E:** [policy@theiet.org](mailto:policy@theiet.org)  
[www.theiet.org/policy](http://www.theiet.org/policy)

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