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Nuclear energy, nuclear technologies, and radiological protection — Vocabulary —

Part 5: Nuclear reactors

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Partie 5: Réacteurs nucléaires

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Foreword

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This document was prepared by Technical Committee ISO/TC 85, *Nuclear energy, nuclear technologies, and radiological protection*.

This second edition cancels and replaces the first edition (ISO 12749-5:2018), which has been technically revised.

The main changes are as follows:

— the addition of the following sentence in the Scope: “The scope of this document does not cover nuclear fusion reactors.”

— the updated of all the sources of the terminological entries.

— the addition of the heading “Terms related to nuclear fission”.

— the deletion of the heading “Terms related to multiple-purpose reactors”.

A list of all parts in the ISO 12749 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document provides terms and definitions for main concepts in the whole field of nuclear reactor science, technology, engineering, projects and operations, excluding quantitative data. Terminological data are taken from ISO standards developed by TC 85/SC 6, from other technically validated documents issued by international organizations, especially IAEA and IEC, while several definitions have been drafted by WG 1 experts based on their experience and after detailed discussions on concept characteristics, the best wording for their designations and definitions, as well as the most important links between concepts.

In most cases, international consensus exists among the communities of nuclear reactor specialists world-wide, on the most relevant concepts in the nuclear reactor field. Nevertheless, clear, and unambiguous terms for these concepts are also needed.

The foregoing should also be considered together with the fact that many people are involved in the broad nuclear reactor field, having different scopes and levels of scientific and technical knowledge, and frequently having very specific activities within that broad field. Thus, there can be different understandings and assumptions about concepts. Hence, the result could be a poor communication that might lead into unexpected, different risky situations or consequences, if a conceptual difference is behind.

Nuclear energy, nuclear technologies, and radiological protection — Vocabulary —

Part 5: Nuclear reactors

1 Scope

This document encompasses the collection of terms, definitions, notes to entry and examples corresponding to nuclear reactors, excluding quantitative data. It provides the minimum essential information for each nuclear reactor concept represented by a single term. Full understanding of concepts requires background knowledge of the nuclear field. It is intended to facilitate communication and promote common understanding.

The scope of this document does not cover nuclear fusion reactors.

NOTE See Annex A for the methodology used to develop the vocabulary.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 General terms related to nuclear reactors

3.1.1
nuclear installation
nuclear facility subject to authorization that is part of the nuclear fuel cycle, except facilities for the mining or processing of uranium ores or thorium ores and disposal facilities for radioactive waste

[SOURCE: IAEA. *IAEA Nuclear Safety and Security Glossary. Terminology Used in Nuclear Safety, Nuclear Security, Radiation Protection and Emergency Preparedness and Response*. Vienna: IAEA, 2022. 246 p. ISBN 978-92-0-141822-7]

3.1.2
nuclear reactor
special device having an inventory of nuclear fuel material containing *fissionable nuclides* (3.2.16) and, depending on the technology, can have neutron moderating, neutron absorbing and cooling materials, all of them geometrically arranged in a particular *neutron multiplicative configuration* (3.2.10) designed and built for having the capability of initiating, maintaining and extinguishing a controlled, self-sustaining *nuclear fission* (3.2.1) chain reaction, under adequate safety conditions

3.1.3
research reactor
nuclear reactor (3.1.2) used mainly for the generation and utilization of neutron flux and ionizing radiation for research and other purposes

Note 1 to entry: Experimental facilities associated with the reactor and storage, handling and treatment facilities for radioactive material on the same site, which are directly related to safe operation of the research reactor, are included.

Note 2 to entry: Facilities commonly known as critical assemblies are included.

[SOURCE: IAEA. *IAEA Nuclear Safety and Security Glossary. Terminology Used in Nuclear Safety, Nuclear Security, Radiation Protection and Emergency Preparedness and Response*. Vienna: IAEA, 2022. 246 p. ISBN: 978-92-0-141822-7, modified. By splitting the definition into a definition and two notes to entry.]

3.1.4
nuclear power plant
NPP
nuclear reactor (3.1.2) installation with the main purpose of producing heat energy, converting it to electricity, or both

Note 1 to entry: Nuclear power plant is a *nuclear reactor* (3.1.2) or reactors together with all *structures* (3.8.2), systems and *components* (3.8.13) necessary for ensuring safe and secure operation in compliance with safeguards agreements and for the production of power, i.e. heat or electricity.

3.1.5
nuclear island
part of the *nuclear power plant* (3.1.4) that consists of the *containment* (3.8.3), auxiliary and fuel buildings

3.1.5.1
reactor core
part of a *nuclear reactor* (3.1.2), where the fuel assemblies sustaining the fission chain are located

Note 1 to entry: In most cases, *moderator* (3.1.5.1.2) and coolant are also included in the reactor core.

3.1.5.1.1
core reflector
material placed around the *reactor core* (3.1.5.1), totally or partially enveloping it, in order to scatter most of leaking neutrons back into the core, improving neutron economy

Note 1 to entry: Since most of *nuclear reactors* (3.1.2), have a preferred vertical cylinder geometry, they have three different reflectors: upper axial, lower axial and radial.

Note 2 to entry: The most used materials as reflectors for slow or *thermal neutrons* (3.2.18), are H_2O (light or ordinary water), D_2O (heavy water), Be (beryllium), C (carbon, graphite). The most used material *for fast neutrons* (3.2.19) is stainless steel.

3.1.5.1.2
moderator
material that reduces neutron energy by scattering without appreciable capture

Note 1 to entry: Materials of prime concern are those containing light nuclei with large scattering cross sections and relatively low absorption cross sections (e.g. water, hydrocarbons, polyethylene, oils and graphite).

3.1.5.2
reactor internals
any of the different structural parts inside the *nuclear reactor* (3.1.2), covering various functions, either as part of the nuclear reactor itself or as part of reactor-associated systems

Note 1 to entry: Some of these functions are:

a) to direct inlet and outlet *primary coolant* (3.1.5.4) flow and its distribution among all reactor heat sources, similar *structure* (3.8.2) for other fluids inside the reactor (like liquid *moderator* (3.1.5.1.2) and reflectors or both);

b) to provide in-core locations and protection for *in-core instrumentation* (3.8.5.1.1) and for elements and *components* (3.8.13) related to *reactivity* (3.2.12);

c) to provide power control and safety shutdown.

3.1.5.3
reactor vessel
enveloping *structure* (3.8.2) for housing all parts of a *reactor core* (3.1.5.1) and supporting *reactor internals* (3.1.5.2)

Note 1 to entry: Main parts usually allocated inside the reactor vessel, are as follows:

a) the *reactor core* (3.1.5.1) and its reflectors;

b) all *structures* (3.8.2) and tubes of *reactor internals* (3.1.5.2).

Note 2 to entry: The reactor vessel additionally serves as confining *structure* (3.8.2) for the *primary coolant* (3.1.5.4). Moreover, depending on the reactor technology, this vessel is also part of a high-pressure boundary for the primary coolant, mainly encompassing the *reactor core* (3.1.5.1).

3.1.5.4
primary coolant
fluid circulating through the *reactor core* (3.1.5.1), in order to extract the heat produced by the nuclear fission reactions

Note 1 to entry: The primary coolant normally removes instantaneous fission and decay heat generated in the *reactor core* (3.1.5.1) and can remove abnormal excessive heat. It circulates within the *primary heat transport system* (3.8.9) and transfers all reactor thermal power to a final heat sink. Such thermal power transfer can be either “direct”, or more usually “indirect”, by means of chained circuits circulating appropriate fluids, between the *nuclear reactor* (3.1.2) and that final heat sink.

Note 2 to entry: The primary or main coolant is always a fluid and then it can be, either a liquid in single phase, or a boiling two-phase fluid, or a gas. The most widely employed are:

a) liquid-state ordinary or light water (H_2O) at atmospheric or high pressure;

b) liquid-state heavy water (D_2O) at atmospheric or high pressure;

c) boiling H_2O at high pressure;

d) CO_2 or He gases.

Note 3 to entry: The final heat sink usually can be either: the atmosphere, a river, a lake, a sea or an ocean. In a *nuclear power plant* (3.1.4) one of such sinks shares its function with a *turbine-generator* (3.4.7) set, where part of the total thermal power is converted to kinetic power and immediately to electric power.

Note 4 to entry: For molten salt reactors, a similar role to primary coolant is played by a fluid sometimes defined as intermediate coolant.

3.2 Terms related to nuclear fission

3.2.1
nuclear fission
process by which a nucleus undergoes a partition in two, infrequently in three, main fission fragments, releasing energy

Note 1 to entry: There are two types of nuclear fission: “spontaneous” fission and “induced” fission.

Note 2 to entry: The nucleus usually has a high mass number A, together with an intermediate or low average binding-energy-per-nucleon; hence, an inherent instability exists, and the fission fragments are usually highly unstable.

Note 3 to entry: According to their capability for undergoing fission, a nucleus and its associated nuclide can be qualified as fissionable or eventually fissile.

3.2.2
induced nuclear fission
nuclear fission (3.2.1) initiated by a nucleus when an external colliding particle is absorbed

Note 1 to entry: The absorption of the external colliding particle, usually a neutron, generates a strong increase in the compound nucleus internal energy and, hence, increases the compound nucleus instability, favouring a large energy release by means of *nuclear fission* (3.2.1).

3.2.3
spontaneous nuclear fission
nuclear fission (3.2.1) produced in a nucleus, having an inherent instability, that develops itself in a purely stochastic way and without intervention of any external colliding particle

3.2.4
fissile nuclide
nuclide capable of undergoing fission by interaction with neutrons of any energy

Note 1 to entry: There is no fission energy threshold to undergo fission.

Note 2 to entry: The term is usually applied to fission predominantly with slow neutrons. The interpretation of “slow” can vary but the properties of fissile nuclides are clearly distinct from other *fissionable nuclides* (3.2.16).

Note 3 to entry: Particular examples are ^{233}U, ^{235}U, ^{239}Pu and ^{241}Pu.

3.2.5
fertile nuclide
nuclide that becomes a *fissile nuclide* (3.2.4) after absorbing a neutron

Note 1 to entry: In practice, the main fertile nuclides are: ^{238}U (producing the fissile ^{239}Pu), ^{240}Pu (producing the fissile ^{241}Pu) and ^{232}Th (producing the fissile ^{233}U), in all cases after the absorption of one neutron and the fast emission of some gamma photons.

3.2.6
fission energy
energy released in the fission process, which is primarily in the form of the kinetic energy of the fission fragments

3.2.7
fission product
radionuclide produced by *nuclear fission* (3.2.1)

[SOURCE: IAEA. *IAEA Nuclear Safety and Security Glossary. Terminology Used in Nuclear Safety, Nuclear Security, Radiation Protection and Emergency Preparedness and Response*. Vienna: IAEA, 2022. 246 p. ISBN: 978-92-0-141822-7.]

3.2.8
delayed fission radiation
gamma, beta radiations or both, in certain cases also alpha radiations released in a stochastic way, from a *fission product* (3.2.7)

Note 1 to entry: Every possible fission product decay has extremely diverse half-lives, covering the range around 0,1 s up to more than a billion years.

Note 2 to entry: These “delayed” released gamma, beta and alpha radiations, after interactions with neighbouring atoms, are mainly absorbed by the surrounding materials and then finally converted into heat: they are the source of what is designated as decay-power or decay-heat or residual-heat.

3.2.9
delayed fission neutron
neutron emitted in few particular *fission product* (3.2.7) decays, typically with half-lives roughly in the range 0,1 s to 1 min, following initiation of a *nuclear fission* (3.2.1) process

Note 1 to entry: Such decay occurs between two energy levels of a *fission product* (3.2.7) namely precursor-favouring a neutron release, hence, the emitted neutron will have a quite defined kinetic energy at its release, typically below 1 MeV.

Note 2 to entry: In a fission neutron population, since delayed neutrons have kinetic evolutions dictated by those rather long periods, as compared to the extremely fast evolutions of prompt neutrons, the first ones provide an important contribution to the kinetic control of that neutron population.

3.2.10
neutron multiplicative configuration
geometrical disposition of materials, one or more containing *fissionable nuclides* (3.2.16), the whole configuration being capable of maintaining a multiplicative chain reaction of neutron-*induced nuclear fissions* (3.2.2)

3.2.11
nuclear chain reaction
successive *induced nuclear fissions* (3.2.2) initiated by neutrons released, for the most part, from previous fissions in *fissionable nuclides* (3.2.16)

Note 1 to entry: The free neutron population in a system is multiplied by fissions releasing several neutrons per fission, compensating partially or totally, or exceeding the total neutron losses by capture and leakage from the system.

Note 2 to entry: A nuclear chain reaction can be initiated by a pre-existent small neutron population (like that resulting from photoneutrons in particular materials for this purpose), or by neutrons released by spontaneous fissions, or by a specific "neutron source" emitting neutrons that initiates its own repetition chain reaction, a fissionable nucleus absorbs a neutron and fissions spontaneously, releasing additional neutrons.

3.2.12
reactivity
ρ
for a nuclear chain reacting medium:

$$\rho = (k_{\mathrm{eff}} - 1)/k_{\mathrm{eff}}$$

where k_{eff} (3.2.15) is the ratio between the number of fissions in two succeeding generations (later to earlier) of the chain reaction

Note 1 to entry: A measure of the deviation from *criticality* (3.2.15) of a nuclear chain reacting medium, such that positive values correspond to a supercritical state and negative values correspond to a subcritical state.

[SOURCE: IAEA. *IAEA Nuclear Safety and Security Glossary. Terminology Used in Nuclear Safety, Nuclear Security, Radiation Protection and Emergency Preparedness and Response*. Vienna: IAEA, 2022. 246 p. ISBN: 978-92-0-141822-7 (Retrieved: 4 July 2024)]

3.2.13
poison
substance used to reduce *reactivity* (3.2.12), typically in a *reactor core* (3.1.5.1), by virtue of its high neutron absorption cross-section

[SOURCE: IAEA. *IAEA Nuclear Safety and Security Glossary. Terminology Used in Nuclear Safety, Nuclear Security, Radiation Protection and Emergency Preparedness and Response*. Vienna: IAEA, 2022. 246 p. ISBN: 978-92-0-141822-7. (Retrieved: 4 July 2024)]

3.2.14
effective neutron multiplication factor
k_{eff}
ratio between current to previous generation of neutron population in multiplicative medium

Note 1 to entry: The total number of produced neutrons per unit time includes all prompt and delayed neutrons released in fissions; while, the total number of lost neutrons are the sum of all absorbed neutrons (in fission and capture reactions), plus all leaking neutrons escaping.

Note 2 to entry: There are three possible circumstances: a) $k_{eff} > 1$: fission power increases in time; b) $k_{eff} = 1$: fission power remains constant in time; c) $k_{eff} < 1$: fission power decreases in time. When $k_{eff} > 1$, system is called supercritical; when $k_{eff} = 1$, system is called critical; and finally, when $k_{eff} < 1$, then system is called subcritical

3.2.15
criticality
state of a nuclear chain reacting medium when the *nuclear chain reaction* (3.2.11) is just self-sustaining or critical, i.e. when the *reactivity* (3.2.12) is zero

[SOURCE: IAEA. *IAEA Nuclear Safety and Security Glossary. Terminology Used in Nuclear Safety, Nuclear Security, Radiation Protection and Emergency Preparedness and Response*. Vienna: IAEA, 2022. 246 p. ISBN: 978-92-0-141822-7 (Retrieved: 4 July 2024)]

3.2.16
fissionable nuclide
nuclides that are capable of supporting a self-sustaining *nuclear chain reaction* (3.2.11) with neutrons of any speed

[SOURCE: IAEA. *IAEA Nuclear Safety and Security Glossary. Terminology Used in Nuclear Safety, Nuclear Security, Radiation Protection and Emergency Preparedness and Response*. Vienna: IAEA, 2022. 246 p. ISBN: 978-92-0-141822-7 (Retrieved: 4 July 2024)]

Note 1 to entry: Fissionable nuclides include ^{238}U, ^{240}Pu, and others with neutron-energy fission thresholds, in addition to those nuclides that are fissile.

[SOURCE: LA-11627-MS, Glossary of Nuclear Criticality Terms. Los Alamos National Laboratory, 1989.]

3.2.17
prompt fission neutron
neutron emitted from a fission fragment in a stochastic way, with high kinetic-energy just following initiation of a *nuclear fission* (3.2.1) process

Note 1 to entry: The number of prompt neutrons released per fission, is stochastic as indicated, with an average value in the range 2,5 to 3 for most of concerned nuclides.

3.2.18
thermal neutron
neutron with a kinetic energy of about 0,025 eV, which is the energy corresponding to the most probable speed of 2 000 m/s at 293 K

3.2.19
fast neutron
neutron with kinetic energy greater than 1 keV

Note 1 to entry: Neutrons with energy levels greater than 0,025 eV and up to 1 keV are termed epithermal or resonance neutrons.

3.3 Terms related to nuclear reactor types

3.3.1
nuclear reactor
(See 3.1.2)

3.3.1.1
power reactor
nuclear reactor (3.1.2) designed to produce electrical power or propulsion

3.3.1.2
research reactor
(See 3.1.3)

3.3.1.3
special-purpose reactor
nuclear reactor (3.1.2) designed with a particular target

EXAMPLE *Prototype reactors* (3.6.1.3), *demonstration reactors* (3.6.1.2), naval propulsion reactors, *desalination reactors* (3.6.1.5), *material testing reactors* (3.5.1.4), hydrogen production reactors.

3.3.1.4
breeder reactor
nuclear reactor (3.1.2) designed to produce more *fissile nuclides* (3.2.4) than it uses, having the conversion ratio greater than one

Note 1 to entry: The conversion ratio (CR) or conversion coefficient measures the ability of a *nuclear reactor* (3.1.2) to transfer a *fertile nuclide* (3.2.5), e.g., ^{238}U, into a *fissile* (3.2.4), e.g., ^{239}Pu.

[SOURCE: Koelzer, W. Glossary of Nuclear Terms. Germany, 2013]

3.3.1.5
converter reactor
nuclear reactor (3.1.2) designed to produce less *fissile nuclides* (3.2.4) than it uses, having a conversion ratio smaller than one

3.3.1.6
transmutation reactor
nuclear reactor (3.1.2) designed for the purpose of eliminating partially the radioactive wastes contained in other reactors spent nuclear fuel

3.3.1.7
fast reactor
nuclear reactor (3.1.2) designed and operated mainly using a predominantly *fast neutron* (3.2.19) energy spectrum

Note 1 to entry: The main contribution to fission power typically from neutrons with energies above 100 keV.

3.3.1.8
thermal reactor
nuclear reactor (3.1.2) designed and operated using predominantly *thermal neutron* (3.2.18) reactions

Note 1 to entry: The main contribution to fission power typically from neutrons with energies below 1 eV.

3.3.1.9
gas cooled reactor
GCR
nuclear reactor (3.1.2) that uses gas as *primary coolant* (3.1.5.4)

Note 1 to entry: A gas cooled reactor can be either a gas-cooled *thermal reactor* (3.3.1.8) or a gas cooled *fast reactor* (3.3.1.7).

Note 2 to entry: The gas is usually helium (He) or carbon dioxide (CO_2).

3.3.1.10
light water reactor
LWR
nuclear *thermal reactor* (3.3.1.8) cooled and moderated by light water

3.3.1.11
heavy water reactor
nuclear *thermal reactor* (3.3.1.8) that uses heavy water as its *moderator* (3.1.5.1.2)

Note 1 to entry: Heavy water is a moderator and thus permits the use of unenriched uranium as fuel.

[SOURCE: NRC. *Nuclear Regulatory Commission Glossary.*http://www.nrc.gov/readig-rm/basic-ref/glossary.html. (Retrieved 16 April 2025). modified. By adding "nuclear thermal" at the beginning of the definition and splitting the definition into a definition and one note to entry.]

3.3.1.12
liquid metal reactor
liquid metal fast reactor
LMFR
nuclear reactor (3.1.2) using as coolant a liquid metal, like sodium, lead, or some alloy

3.3.1.13
boiling water reactor
BWR
nuclear reactor (3.1.2) with water as a coolant and as a *moderator* (3.1.5.1.2), boiling in the core

Note 1 to entry: In a boiling water reactor the generated heat is removed from the core by evaporation.

[SOURCE: Koelzer, W. & FORSCHUNGSZENTRUM KARLSRUHE GMBH TECHNIK UND UMWELT. *Dictionary of nuclear power*. upd. ed.; Lexikon zur Kernenergie. Germany: N. p., 2011.]

3.3.1.14
pressurized water reactor
PWR
nuclear *power reactor* (3.3.1.1) with water as a coolant and as a *moderator* (3.1.5.1.2), sufficiently high pressurized to remain liquid in the core

Note 1 to entry: In a *boiling water reactor* (3.3.1.13), the generated heat is removed from the core by evaporation.

[SOURCE: Koelzer, W. & FORSCHUNGSZENTRUM KARLSRUHE GMBH TECHNIK UND UMWELT. *Dictionary of nuclear power*. upd. ed.; Lexikon zur Kernenergie. Germany: N. p., 2011.]

Note 2 to entry: Where water is uses as *moderator* (3.1.5.1.2) and as a coolant to remove heat from the core.

3.3.1.15
pressurized heavy water reactor
PHWR
nuclear *thermal reactor* (3.3.1.8) cooled and moderated by heavy water (D_2O), having a pressurized D_2O coolant to be kept permanently in the liquid state

3.4 Terms related to nuclear power plants

3.4.1
nuclear power plant
NPP
(See 3.1.4)

3.4.1.1
single-unit nuclear power plant
single-unit NPP
nuclear power plant (3.1.4) having a single electric production line

3.4.1.2
multiple-unit nuclear power plant
multiple-unit NPP
nuclear power plant (3.1.4) having on a common site, two or more electric production lines

Note 1 to entry: The electricity generation can be either almost identical or different between them, though usually sharing various support or auxiliary installations, systems, supplies or both.

3.4.2
reference unit power
maximum (electrical) power that could be maintained continuously throughout a prolonged period of *operation* (3.9.1) under reference ambient conditions

Note 1 to entry: The power value is expressed in units of megawatt (electrical).

[SOURCE: IAEA. *Glossary of terms in PRIS reports – PRIS: Power reactor information system.* (Retrieved: 22 July, 2024), modified. By splitting the definition into a definition and a note to entry. https://www.iaea.org/PRIS/Glossary.aspx.]

3.4.3
energy availability factor
ratio of the energy that the available capacity could have produced during a specified period, to the energy that the *reference unit power* (3.4.2) could have produced during the same period

[SOURCE: IAEA. *Glossary of terms in PRIS reports – PRIS: Power reactor information system.* (Retrieved: 22 July, 2024) https://www.iaea.org/PRIS/Glossary.aspx.]

3.4.4
NPP unit

each unit represents a separate reactor (*nuclear island* (3.1.5) and *BOP* (3.4.5)) capable of being operated

Note 1 to entry: In the case of dual- or multi-unit plants, a unit can operate independently of the state of completion or operating condition of any other units co-located on the same site but in different *containment* (3.8.3)/confinement buildings, even though the units can have some shared or common systems.

[SOURCE: IAEA. Terms for describing advance nuclear power plants. IAEA Nuclear Energy Series No. NR-T-1.19. Vienna: IAEA, 2023. 20p. ISBN 978-92-0-145923-7, modified by splitting the definition into a definition and a note to entry.]

3.4.5
balance of plant
BOP
part of the *nuclear power plant* (3.1.4) that consists of a set of a main *turbine generator* (3.4.7) unit and all associated systems, *structures* (3.8.2) and *components* (3.8.13) necessary to produce electric power

3.4.6
turbine island
part of the *nuclear power plant* (3.1.4) that consists of the turbine building

[SOURCE: IAEA. *Construction technologies for nuclear power plants*. IAEA Nuclear Energy Series No. NP-T-2.5. Vienna: IAEA, 2011. 207 p. ISBN 978-92-0-119510-4]

3.4.7
turbine generator
equipment that produces electrical energy and which type is defined by the turbine-driving fluid

3.4.8
steam turbine balance of plant
steam turbine BOP
balance of plant (3.4.5) type that produces electric energy associated to a *nuclear steam supply system* (3.4.9)