INTERNATIONAL STANDARD

ISO 12749-3

First edition
2015-08-15

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

Part 3: Nuclear fuel cycle

Énergie nucléaire, technologies nucléaires et protection radiologique — Vocabulaire —

Partie 3: Cycle de combustibles nucléaires

Reference number
ISO 12749-3:2015(E)

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary Information

The committee responsible for this document is ISO/TC 85, *Nuclear energy, nuclear technologies, and radiological protection.*

This first edition cancels and replaces ISO 921:1997, of which it forms the subject of a technical revision.

ISO 12749 consists of the following parts, under the general title *Nuclear energy, nuclear technologies, and radiological protection*:

— *Part 2: Radiological protection*

— *Part 3: Nuclear fuel cycle*

— *Part 4: Dosimetry for radiation processing*

The following parts are under preparation:

— *Part 5: Reactors*

Introduction

This part of ISO 12749 will provide terms and definitions for nuclear fuel cycle concepts dealing with specific subjects such as fuel fabrication, fuel characteristics, and nuclear criticality safety and with transport and radioactive waste related topics, excluding reactors operations. Terminological data are taken from ISO standards developed by TC 85/SC 5 and other technically validated documents issued by international organizations.

Unambiguous communication of nuclear energy concepts is crucial taking into account the relevant implications that may arise from misunderstandings with regard to equipment and materials involved in the standards dealing with any subject regarding nuclear energy activities. Nuclear fuels for different power reactors are produced according to different designs. However, several concepts are present in all of them and need to be designated by common terms and described by harmonized definitions in order to avoid misunderstandings. In another nuclear fuel technology subfield, difficulties arise due to the wide variety of units employed to measure the fuel burnout level. Thus, to enhance comprehension, it is advisable to adopt unified measure units.

Conceptual arrangement of terms and definitions is based on concepts systems that show corresponding relationships among nuclear energy concepts. Such arrangement provides users with a structured view of the nuclear energy sector and will facilitate common understanding of all related concepts. Besides, concepts systems and conceptual arrangement of terminological data will be helpful to any kind of user because it will promote clear, accurate, and useful communication.

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

Part 3:
Nuclear fuel cycle

1 Scope

This part of ISO 12749 lists unambiguous terms and definitions related to nuclear fuel cycle concepts in the subject field of nuclear energy, excluding reactor operations. It is intended to facilitate communication and promote common understanding.

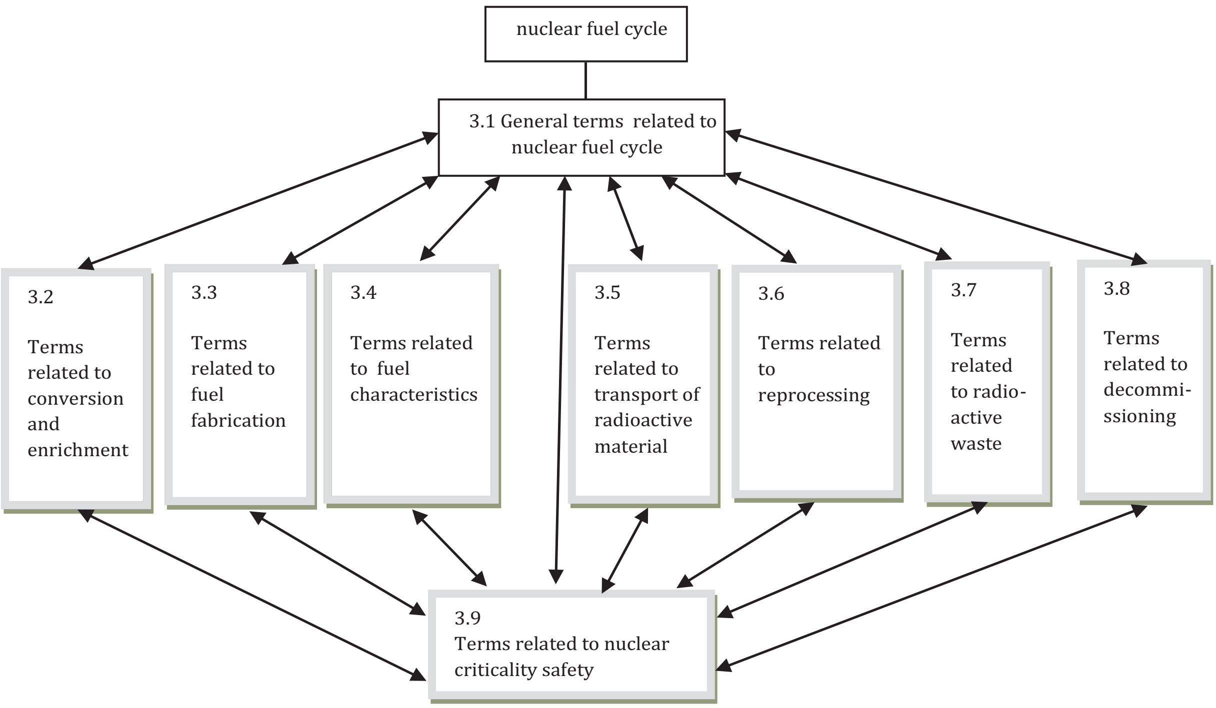
2 Structure of the vocabulary

The terminology entries are presented in the conceptual order of the English preferred terms. The structure of each entry is in accordance with ISO 10241-1:2011.

All the terms included in this part of ISO 12749 deal exclusively with nuclear fuel cycle. When selecting terms and definitions, special care has been taken to include the terms that need to be defined, that is to say, either because the definitions are essential to the correct understanding of the corresponding concepts or because some specific ambiguities need to be addressed.

The notes appended to certain definitions offer clarification or examples to facilitate understanding of the concepts described. In certain cases, miscellaneous information is also included, for example, the units in which a quantity is normally measured, recommended parameter values, references, etc.

According to the title, the vocabulary deals with concepts belonging to the general ***nuclear energy*** subject field within which concepts in the **nuclear fuel cycle** sub-subject field are taken into account. See Annex A for the methodology used to develop the vocabulary.



3 Terms and definitions

3.1 General terms related to nuclear fuel cycle

3.1.1
nuclear fuel
fissionable nuclear material used in a reactor core or intended for use in a reactor core

3.1.1.1
nuclear fuel cycle
operations associated with the production of nuclear energy

Note 1 to entry: The nuclear fuel cycle includes the following stages:

a) mining and processing of uranium or thorium ores;

b) conversion;

c) enrichment of uranium;

d) manufacture of *nuclear fuel* (3.1.1);

e) uses of the nuclear fuel;

f) *reprocessing* (3.1.1.1.2.2) and *recycling* (3.1.1.1.2.3) of spent fuel;

g) temporary *radioactive material storage* (3.1.1.1.2.1) of spent fuel and *radioactive waste* (3.7.1) from *fuel fabrication* (3.1.1.1.1.3) and reprocessing (3.1.1.1.2.2) and disposal of *spent nuclear fuel* (3.1.1.1.5) [*open fuel cycle* (3.1.1.7)] or high-level waste (*closed fuel cycle* (3.1.1.8)];

h) any related research and development activities;

i) transport of radioactive material;

j) all *waste management* (3.7.7) activities [including *decommissioning* (3.8.1]) relating to operations associated with the production of nuclear energy.

Note 2 to entry: Reactor operation and other activities at a reactor site are not addressed in this part of ISO 12749, but are to be addressed in ISO 12749-5.

[SOURCE: Adapted from IAEA Safety Glossary, 2007 Edition, modified — By splitting the definition into a definition and a note.]

3.1.1.1.1
front end
steps of the *nuclear fuel cycle* (3.1.1.1) ending with fuel introduction into the reactor core

3.1.1.1.1.1
nuclear material conversion
modification of the chemical composition of nuclear material so as to facilitate its further use or processing; in particular, to provide feed material for enrichment of isotopes of interest and/or reactor *fuel fabrication* (3.1.1.1.1.3)

Note 1 to entry: To produce material for *fuel fabrication* (3.1.1.1.1.3), the following are examples of conversion that can be carried out: U_3O_8 or UF_6 to uranium dioxide (UO_2), U or Pu nitrate to oxide, or U or Pu oxides to metal.

[SOURCE: IAEA Safeguards Glossary, 2001 Edition, modified — By splitting the definition into a definition and note 1 to entry.]

3.1.1.1.1.2
isotope enrichment
isotope separation process by which the fractional abundance of a specified isotope in an element is increased such as increasing the abundance of ^{235}U relative to *natural uranium* (3.1.1.2) or increasing the abundance of the D_2O in water

Note 1 to entry: Usually, the term will be "enrichment".

3.1.1.1.1.2.1
enriched fuel
fuel made with uranium that has been modified by increasing the abundance of the fissile isotope ^{235}U

3.1.1.1.1.3
fuel fabrication
process for manufacturing *fuel elements* (3.3.6) or other reactor components containing nuclear material

Note 1 to entry: Manufacturing process includes *nuclear material conversion* (3.1.1.1.1.1), storage, and physic-chemical analyses of materials.

[SOURCE: IAEA Safeguards Glossary, 2001 Edition]

3.1.1.1.2
back end
steps of the *nuclear fuel cycle* (3.1.1.1) beginning with the final removal of the fuel from the reactor core

Note 1 to entry: The processes can include *radioactive material storage* (3.1.1.1.2.1)at or away from reactor, *reprocessing* (3.1.1.1.2.2), *recycling* (3.1.1.1.2.3), conditioning and disposal.

[SOURCE: IAEA-TECDOC-1613 "Nuclear fuel cycle information system", 2009, modified — By splitting the definition into a definition and note 1 to entry.]

3.1.1.1.2.1
radioactive material storage
holding of radioactive sources, *spent nuclear fuel* (3.1.1.1.5), or *radioactive waste* (3.7.1) in a facility that provides for containment with the intention of retrieval

[SOURCE: IAEA Safety Glossary 2007]

3.1.1.1.2.2
reprocessing
process or operation of extracting *fission products* (3.1.5) from *spent nuclear fuel* (3.1.1.1.5) to enable reuse of the *nuclear fuel* (3.1.1)in a reactor

3.1.1.1.2.3
recycling
use, for the fabrication of *nuclear fuel* (3.1.1), of *fissionable materials* (3.1.3) separated from *spent nuclear fuel* (3.1.1.1.5)

3.1.1.1.2.3.1
mixed oxide fuel
MOX fuel
mixture of oxides of different fissionable elements

Note 1 to entry: In the *nuclear fuel cycle* (3.1.1.1), MOX is interpreted as mixed uranium and plutonium oxides unless otherwise specified.

3.1.1.1.2.4
encapsulation
encasement of radioactive contaminants in a suitable material for final disposal

3.1.1.1.3
burnup
average energy released by a defined region of the fuel during its irradiation

Note 1 to entry: This region could be a complete *fuel assembly* (3.3.6.1) or some part of the assembly. Burnup is commonly expressed as energy released per mass of initial fissionable *actinides* (3.1.8) (uranium only for this part of ISO 12749). Units commonly used are expressed in megawatt day per metric ton of initial uranium (MWd/t) or gigawatt day per metric ton of initial uranium (GWd/t).

[SOURCE: ISO 27468:2011, 3.4]

3.1.1.1.4
used nuclear fuel
fuel that has been activated in the fission process of a nuclear reactor core

3.1.1.1.5
spent nuclear fuel
fuel that has been burned in the core of a nuclear reactor and is no longer efficient to maintain its specific nuclear service

3.1.1.2
natural uranium
elemental uranium containing the naturally occurring uranium isotopes (approximately 99,28% ^{238}U, 0,72% ^{235}U by mass, and small amount of ^{234}U)

[SOURCE: Adapted from IAEA Safety Glossary, 2007]

3.1.1.2.1
depleted uranium
uranium containing ^{235}U fractional abundance less than that of *natural uranium* (3.1.1.2)

Note 1 to entry: Depleted uranium is the complement product to *enriched uranium* (3.1.1.2.2) where in the former, ^{238}U mass fraction is higher than that of *natural uranium* (3.1.1.2).

[SOURCE: Adapted from IAEA Safety Glossary, 2007]

3.1.1.2.2
enriched uranium
uranium containing a greater mass fraction or percentage of ^{235}U than in *natural uranium* (3.1.1.2)

[SOURCE: IAEA Safety Glossary, 2007 Edition, modified — By adding “fraction or” before “percentage” and replacing “0,72%” with “in natural uranium”.]

3.1.1.3
uranium concentrate
product with a high concentration in uranium obtained by physical and chemical treatments of the ores requiring further refinement before it is suitable for nuclear use

[SOURCE: ISO 921:1997, modified — The word “abundance” has been changed to “concentration”.]

EXAMPLE Yellowcake, concentrated crude oxide U_3O_8.

3.1.1.4
nuclear criticality
state of a nuclear chain reacting medium when the chain reaction is just self-sustaining

[SOURCE: IAEA Safety Glossary 2007, modified — The phrase “(or *critical*), i.e. when the reactivity is zero” has been removed as being unnecessary to the definition and not defined in ISO 12749.]

3.1.1.5
nuclear criticality safety
protection against the consequences of a *nuclear criticality accident* (3.1.1.6) preferably by prevention of the accident and responses to such accidents should they occur

3.1.1.6
nuclear criticality accident
nuclear criticality excursion
release of energy as a result of accidentally producing a self-sustaining or divergent fission chain reaction

[SOURCE: LA— 11627-MS DE90 000884, Glossary of Nuclear Criticality Terms]

3.1.1.7
open fuel cycle
once-through fuel cycle
nuclear fuel cycle (3.1.1.1) excluding *recycling* (3.1.1.1.2.3) of *actinide* (3.1.8) nuclides from *used nuclear fuel* (3.1.1.1.4)

3.1.1.8
closed fuel cycle
nuclear fuel cycle (3.1.1.1) including *recycling* (3.1.1.1.2.3) of *actinide* (3.1.8) nuclides from *used nuclear fuel* (3.1.1.1.4)

Note 1 to entry: The fuel cycle can be "closed" in various ways, for example, by the recycling of *enriched uranium* (3.1.1.2.2) and plutonium through thermal reactors (thermal recycle) by the re-enrichment of the uranium recovered as a result of spent fuel *reprocessing* (3.1.1.1.2.2)or by the use of plutonium in a fast breeder reactor.

3.1.2
fissile nuclide
nuclide capable of undergoing fission by interaction with any energy neutrons

3.1.3
fissionable material

material capable of undergoing fission by interaction with neutrons of some neutron energy range

3.1.4
fertile nuclide

nuclide which is not itself fissile, but can be converted into a *fissile nuclide* (3.1.2) by irradiation in a reactor

Note 1 to entry: There are two basic fertile nuclides, uranium-238 and thorium-232. When these fertile nuclides capture neutrons, they are converted into fissile plutonium-239 and uranium-233, respectively.

3.1.5
fission product
nuclide produced from nuclear fission or from subsequent radioactive decay of such a nuclide

[SOURCE: ISO 27468:2011, 3.9, modified — By adding "or from subsequent radioactive decay of such a nuclide" in the definition.]

3.1.6
moderator
material that has high potential for significantly reducing the energy of a free neutron

Note 1 to entry: A moderator may be important for different reasons, e.g. increasing the fission probability [of *fissile nuclide* (3.1.2)], increasing the neutron absorption probability (non-fissile *actinide* (3.1.8) nuclides and many other nuclides), and for obtaining a specific neutron energy spectrum for irradiation.

3.1.7
nuclear grade
material of a quality adequate for use in nuclear application

3.1.8
actinide
element with atomic number in the range from 89 to 103

Note 1 to entry: Many actinides are produced during the irradiation due to neutron capture and/or decay of other actinides. The corresponding nuclides are all neutron producers and some are net (considering neutron production and absorption) neutron producers in a slow neutron energy spectrum.

3.2 Terms related to conversion and enrichment

3.2.1
nuclear material conversion
see 3.1.1.1.1.1

3.2.2
isotope enrichment
see 3.1.1.1.1.2

3.2.3
empty UF_6 cylinder
UF_6 cylinder containing a *heel* (3.2.8) in quantities equal to or less than those specified in the documents in force

[SOURCE: Adapted from ISO 7195:2005, 3.3]

3.2.4
maximum allowable working pressure
MAWP
maximum value of UF_6 cylinder design gauge pressure (rounded up to two significant figures) at the maximum value of UF_6 cylinder design temperature

[SOURCE: ISO 7195:2005, 3.5]

3.2.5
minimum design metal temperature
minimum value of design metal temperature at the maximum value of UF_6 cylinder design pressure to meet ASME Code requirements

[SOURCE: ISO 7195:2005, 3.6]

3.2.6
tare mass
mass of the cleaned UF_6 cylinder including its service equipment and its permanently attached structural features

Note 1 to entry: The standard value of the mass tolerance is ±0,1 %.

[SOURCE: Adapted from IAEA TECDOC 608 (1991)]

3.2.7
effective threads
threads that are capable of providing reasonable engagement in mating threads; the first effective thread at a run out begins one thread length below the run out scratch

[SOURCE: ISO 7195:2005, 3.2]

3.2.8
heel
residual amount of UF_6 and non-volatile reaction products of uranium, uranium daughters (if the UF_6 cylinder has contained irradiated uranium) *fission products* (3.1.5), and transuranic elements

[SOURCE: ISO 7195:2005, 3.4]

3.3 Terms related to fuel fabrication

3.3.1
fuel fabrication
see 3.1.1.1.1.3

3.3.2
presintering
<fuel pellet> heating of a *compact* (3.3.3.1) at a temperature below the normal final sintering temperature, for example, to increase the ease of handling or shaping the compact or to remove a lubricant or *binder* (3.3.3.2) before *sintering* (3.3.3)

3.3.2.1
sinterable powder
<fuel pellet> powder in which the bonding of adjacent surfaces of particles can be accomplished by heating

3.3.3
sintering
<fuel pellet> process to form a metallic bond among particles and characterization of sintered *compacts* (3.3.3.1)

[SOURCE: ASTM B243-11]

Note 1 to entry: The objective is to increase the density, the grain size, and the mechanical strength of the *fuel pellets* (3.3.4).

3.3.3.1
compact
briquet
object produced by the compression of a powder, generally while confined in a die, eventually with the addition of a *binder* (3.3.3.2)

3.3.3.2
binder
cementing medium

Note 1 to entry: The binder is either a material added to the powder to increase the strength of the *compact* (3.3.3.1) and that is expelled during *sintering* (3.3.3) or a material (usually of relatively low melting point) added to a powder mixture for the specific purpose of cementing together powder particles that alone would not sinter into a strong body.

[SOURCE: ASTM B243–04a, modified — By splitting the description into a definition and a note.]

3.3.4
fuel pellet
small body of fuel, often cylindrical, formed by powder metallurgy processes

Note 1 to entry: The pellet may or may not have been sintered following compaction.

3.3.5
cladding
external layer of material applied to *nuclear fuel* (3.1.1) or other material to contain radioactive products

Note 1 to entry: Material also provides protection from a chemically reactive environment.

3.3.6
fuel element
nuclear fuel (3.1.1), its *cladding* (3.3.5), and any associated components necessary to form a structural entity

Note 1 to entry: Commonly referred to as “fuel rod” in light water reactors.