IAEA Safety Glossary

Terminology Used in Nuclear Safety and Radiation Protection

2018 Edition
IAEA SAFETY STANDARDS AND RELATED PUBLICATIONS

IAEA SAFETY STANDARDS

Under the terms of Article III of its Statute, the IAEA is authorized to establish or adopt standards of safety for protection of health and minimization of danger to life and property, and to provide for the application of these standards.

The publications by means of which the IAEA establishes standards are issued in the IAEA Safety Standards Series. This series covers nuclear safety, radiation safety, transport safety and waste safety. The publication categories in the series are Safety Fundamentals, Safety Requirements and Safety Guides.

Information on the IAEA’s safety standards programme is available on the IAEA Internet site
https://www.iaea.org/resources/safety-standards

The site provides the texts in English of published and draft safety standards. The texts of safety standards issued in Arabic, Chinese, French, Russian and Spanish, the IAEA Safety Glossary and a status report for safety standards under development are also available. For further information, please contact the IAEA at: Vienna International Centre, PO Box 100, 1400 Vienna, Austria.

All users of IAEA safety standards are invited to inform the IAEA of experience in their use (e.g. as a basis for national regulations, for safety reviews and for training courses) for the purpose of ensuring that they continue to meet users’ needs. Information may be provided via the IAEA Internet site or by post, as above, or by email to Official.Mail@iaea.org.

RELATED PUBLICATIONS

The IAEA provides for the application of the standards and, under the terms of Articles III and VIII.C of its Statute, makes available and fosters the exchange of information relating to peaceful nuclear activities and serves as an intermediary among its Member States for this purpose.

Reports on safety in nuclear activities are issued as Safety Reports, which provide practical examples and detailed methods that can be used in support of the safety standards.

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Security related publications are issued in the IAEA Nuclear Security Series.

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- Iraq
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- Italy
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- Kuwait
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- Vanuatu
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- Viet Nam
- Yemen
- Zambia
- Zimbabwe

The Agency’s Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is “to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world”.

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INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2019
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PREFACE TO THE 2018 EDITION

The 2018 Edition of the IAEA Safety Glossary is a new edition of the IAEA Safety Glossary, originally issued in 2007. The 2018 Edition has been revised and updated to take into account new terminology and usage in safety standards issued between 2007 and 2018, in particular Safety Standards Series Nos GSR Part 3 (Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards), GSR Part 7 (Preparedness and Response for a Nuclear or Radiological Emergency), SSR-2/1 (Rev. 1) (Safety of Nuclear Power Plants: Design), SSR-3 (Safety of Research Reactors), SSR-4 (Safety of Nuclear Fuel Cycle Facilities) and SSR-6 (Rev. 1) (Regulations for the Safe Transport of Radioactive Material, 2018 Edition). The revisions and updates reflect developments in the technical areas of application of the safety standards and changes in regulatory approaches in Member States. Account has also been taken of comments, queries, suggestions and requests received over this period from within the Secretariat and from users and reviewers in Member States.

Novel and revised terminology — in particular in the areas of the design of nuclear power plants, emergency preparedness and response, and protection against radiation risks — needs to be paid careful attention. The introduction of novel concepts and terminology can lead to difficulties in comprehension, and the profusion of defined terms can complicate drafting and review. Once terms have been defined, their usage wherever applicable is necessary, and reviewers and specialists will need to verify proper usage (see the Introduction to this publication).

Terms relating to nuclear security have been excluded from this revision pending their revision and harmonization.

Comments on the IAEA Safety Glossary may be provided by users of IAEA safety standards via the safety standards web site and the IAEA safety standards contact point (Safety.Standards@iaea.org). Please read the Foreword and the Introduction to the 2018 Edition of the IAEA Safety Glossary before using the Safety Glossary and before submitting comments or queries.

Versions of the 2007 Edition of the IAEA Safety Glossary in English and in the five other official languages of the United Nations (Arabic, Chinese, French, Spanish and Russian) are available on the IAEA web site (https://www.iaea.org/resources/safety-standards/safety-glossary) for informational purposes and may be downloaded free of charge. Advice on the translation of new glossary entries into the five other official languages of the United Nations is available from the IAEA Terminology and Reference Contact Point (TaRCP@iaea.org).
FOREWORD

In developing and establishing standards of safety for protecting people and the environment from harmful effects of ionizing radiation and for the safety of facilities and activities that give rise to radiation risks, clear communication on scientific and technical concepts is essential. The principles, requirements and recommendations that are established and explained in the IAEA safety standards and elaborated on in other publications must be clearly expressed. To this end, the IAEA Safety Glossary defines and explains technical terms used in IAEA safety standards and other safety and security related IAEA publications, and provides information on their usage.

The primary purpose of the IAEA Safety Glossary is to harmonize terminology and usage in the IAEA safety standards, and in their application. Once definitions of terms have been established, they are, in general, intended to be observed in IAEA safety standards and other safety and security related IAEA publications and in the work of the IAEA Department of Nuclear Safety and Security generally.

The achievement of consistently high quality in its publications contributes to the authority and credibility of the IAEA, and thus to its influence and effectiveness. High quality in publications and documents is achieved not only by review to ensure that the relevant requirements are met, but also by managing their preparation so as to achieve high quality in their drafting.

The IAEA Safety Glossary provides guidance primarily for the drafters and reviewers of safety standards, including IAEA technical officers and consultants, and bodies for the endorsement of safety standards. It is also a source of information for users of IAEA safety standards and other safety and security related IAEA publications and for other IAEA staff — notably writers, editors, translators, revisers and interpreters.

Users of the IAEA Safety Glossary, in particular drafters of national legislation, should be aware that the terms included have been chosen and the definitions and explanations given have been drafted for the purpose mentioned above. Terminology and usage may differ in other contexts, such as in binding international legal instruments and in the publications of other organizations.

The IAEA Safety Glossary has been revised and updated in the light of changes in terminology and usage in the safety standards, due in part to developments in technology and in regulatory approaches in Member States. The IAEA Secretariat invites the submission of comments and suggestions concerning the definitions of technical terms and the explanations of their usage given in the IAEA Safety Glossary from users of IAEA safety standards (in English and
in translation) and of other safety and security related IAEA publications for consideration in a possible future revision of the IAEA Safety Glossary.

The first version of the IAEA Safety Glossary was compiled and developed by I. Barraclough and issued as a document in 2000. The 2007 Edition of the IAEA Safety Glossary, in which account was taken of safety standards issued between 2000 and 2007 and of comments and suggestions submitted in the revision process and in the course of translation and editing, was published as a revised and updated multilingual version.

The IAEA gratefully acknowledges the contributions of all those who provided comments and suggestions on the IAEA Safety Glossary.

The IAEA officers responsible for this publication were K. Asfaw and D. Delves of the Office of Safety and Security Coordination.

**EDITORIAL NOTE**

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INTRODUCTION

BACKGROUND

Terminology in IAEA safety standards

The IAEA safety standards for nuclear installations, radiation protection, radioactive waste management and the transport of radioactive material were historically developed in four separate programmes. For nuclear installations and radioactive waste management, safety standards programmes were set up to coordinate the development of standards covering the different parts of the subject. The radiation and transport safety standards programmes were each centred on one key set of safety requirements — the Basic Safety Standards (the current edition of which is IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [1]) and the Transport Regulations (the current edition of which is IAEA Safety Standards Series No. SSR-6 (Rev. 1), Regulations for the Safe Transport of Radioactive Material, 2018 Edition [2]), respectively — with other safety requirements and guidance elaborating on particular parts of these central publications. Each of the four groups of safety standards had developed its own terminology:

(a) In 1986, the IAEA published a Radiation Protection Glossary\(^1\) in the former Safety Series, which provided, in English, French, Russian and Spanish, a collection of fundamental terms associated with radiation protection and their definitions. Many of the terms and definitions in this publication are now obsolete, and the Basic Safety Standards issued in 1996\(^2\) (superseded in 2014 [1]) included more up to date definitions of key terms in radiation protection and safety.

(b) In 1982, a Radioactive Waste Management Glossary was published by the IAEA as IAEA-TECDOC-264\(^3\). A revised and updated version was issued

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\(^1\) INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection Glossary (Safety Guide), Safety Series No. 76, IAEA, Vienna (1986).


in 1988 as IAEA-TECDOC-447⁴, a third edition was published in 1993⁵ and a fourth edition was published in 2003 [3].

c) In nuclear safety, compilations of terms and definitions were produced for internal use but not published. Nevertheless, the lists of definitions given in the Nuclear Safety Standards Codes published by the IAEA in 1988⁶ provided a set of the fundamental terms.


With the creation of the Department of Nuclear Safety in 1996, and the adoption of a harmonized procedure for the preparation and review of safety standards in all areas, the need for greater consistency in the use of terminology became apparent. The incorporation of the Office of Nuclear Security in 2004 further extended the Department’s scope. The IAEA Safety Glossary is intended to contribute towards harmonizing the use of terminology in IAEA safety standards and the IAEA’s other safety and security related publications.

Scope of ‘protection and safety’ and coverage of ‘nuclear security’

In the context of the IAEA’s Major Programme on Nuclear Safety and Security, ‘protection and safety’ denotes the protection of people and the environment against radiation risks, and the safety of facilities and activities that give rise to radiation risks. ‘Nuclear safety’ is usually abbreviated to ‘safety’ in IAEA publications. In IAEA safety standards, ‘safety’ means ‘nuclear safety’ unless otherwise stated. ‘Protection and safety’ (i.e. radiation protection and nuclear safety) encompasses the safety of nuclear installations, radiation safety, the safety of radioactive waste management and safety in the transport of

radioactive material; it does not include aspects of safety that are not related to radiation protection and nuclear safety.

Safety is concerned with both radiation risks under normal circumstances and radiation risks as a consequence of incidents, as well as with other possible direct consequences of a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation. ‘Radiation’ in this context means ionizing radiation. ‘Incidents’ includes initiating events, accident precursors, near misses, accidents and unauthorized acts (including malicious and non-malicious acts).

‘Safety measures’ includes actions to prevent incidents and arrangements put in place to mitigate their consequences if they were to occur. ‘Nuclear security’ denotes the prevention and detection of, and response to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material, other radioactive substances or their associated facilities.

Safety measures and security measures have in common the aim of protecting human life and health and the environment. The safety standards concern the security of facilities and activities to the extent that they require ‘security for safety’ measures that contribute to both safety and security, such as:

(a) Appropriate provisions in the design and construction of nuclear installations and other facilities;
(b) Controls on access to nuclear installations and other facilities to prevent the loss of, and the unauthorized removal, possession, transfer and use of, radioactive material;
(c) Arrangements for mitigating the consequences of accidents and failures, which also facilitate measures for dealing with breaches in security that give rise to radiation risks;
(d) Measures for the security of the management of radioactive sources and radioactive material.

GENERAL REMARKS

Purpose

The IAEA Safety Glossary serves a number of different purposes:

(a) To explain the meanings of technical terms that may be unfamiliar to the reader;
To explain any special meanings ascribed to common words or terms (since words can have several different meanings, it may be necessary to clarify which meaning is intended, in particular for non-native English speakers);

to define precisely how terms — whose general meaning may be clear to readers — are used in a particular publication or set of publications, in order to avoid ambiguity concerning some important aspect(s) of their meaning;

to explain the connections or differences between similar or related terms, or the specific meanings of the same technical term in different contexts;

to clarify and, if possible, reconcile differences in the usage of specialized terms in different subject areas, since such differences in usage may be potentially misleading;

to recommend terms that should be used in IAEA publications and documents (and identify those that should not), and provide the definitions that should be ascribed to them.

Definitions of the type used in legal texts such as the Convention on Nuclear Safety [4] or the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [5], or in regulations such as the Transport Regulations [2], are intended primarily for purpose (c) and, in some cases, do not serve the other purposes at all. Furthermore, definitions of this nature tend to be tailored to the needs of the specific text to which they relate, and hence are often not generally applicable. The ‘definitions’ included in other safety standards are, however, less easily classified, tending towards a mixture of definition and explanation, and of context specific and generally applicable definitions and/or explanations.

For the purposes of the IAEA Safety Glossary, an effort has been made to distinguish between the ‘definition’ — material that could be used in the definitions in an individual publication — and the ‘explanation’, which is provided to assist drafters and reviewers but is not part of the ‘definition’. However, this distinction is not always as clear-cut as might be wished.

Note that a glossary is not the place to specify requirements or guidance. The definition of a term should contain the conditions that must be met in order for the term to be applicable, but not other conditions. This is best illustrated by an example. The definition of regulatory body indicates the conditions that must be met in order for an organization to be described as a regulatory body, but not the attributes of a regulatory body as required by IAEA safety standards. Hence, the definition specifies that it is “designated by the government of a State as having legal authority for conducting the regulatory process” — otherwise, it is not a regulatory body. However, the definition does not, for example, specify that it is “independent in its safety related decision making and that it has functional separation from entities having responsibilities or interests that
could unduly influence its decision making” [6] — it can be a regulatory body without being independent, even though it would then not satisfy the IAEA safety requirements on legal and governmental infrastructure for safety.

Scope

The scope of the IAEA Safety Glossary is necessarily limited, and is intended to focus on the key terms that are specific to, or that are used in a specific way in, protection and safety (and, to a limited extent, security). A number of general categories of terms that may be used in safety and security related IAEA publications have been specifically excluded from the IAEA Safety Glossary (except where a specific point needs to be made about a specific term). These groups of excluded terms include:

(a) Basic terms from radiation and nuclear physics (e.g. alpha particle, decay, fission, radionuclide). An understanding of these terms is assumed.
(b) The specialized terminology of fields other than protection and safety (e.g. geology, seismology, meteorology, medicine, computing). This terminology may be used in protection and safety contexts, but the definition of such terms is left to the experts in the relevant fields.
(c) Very specialized terminology from a specific field within protection and safety (e.g. the detailed terminology of dosimetry and safety assessment). If necessary, such terminology can be defined in the specialized publications to which it is relevant.

USE OF THE IAEA SAFETY GLOSSARY

Interpretation of entries in the IAEA Safety Glossary

The entry for each term generally starts with one or more recommended definition(s). Alternative definitions are given:

(a) If the term is used in two or more distinct safety related contexts (e.g. the term clearance, which is used for an administrative mechanism

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7 A few terms are included without a recommended definition. In most such cases, the term in question is the general (unqualified) term used to group a number of qualified terms and has no special meaning in unqualified form (e.g. emergency action level, recording level, etc., are listed under level, but level itself is not defined). In some cases guidance is given on usage for terms with no definition.
for removing regulatory control from material and for a biological process affecting the movement of inhaled radionuclides in the body);

(b) If it is necessary to include in the IAEA Safety Glossary an established definition that is still needed but is not considered suitable as a general definition (this includes, in particular, some of the definitions from GSR Part 3 [1] and SSR-6 (Rev. 1) [2] that may need to be retained in supporting publications but which would not be the preferred general definitions);

(c) To include definitions of which drafters and reviewers of IAEA publications should be aware, even though they are unlikely to be used in IAEA publications (definitions in the main safety related conventions are an important example of this group); or

(d) For a small number of basic terms that have two distinct definitions, depending on whether they are being used in a scientific or regulatory (i.e. standards) context. An important example in the context of protection and safety is the adjective ‘radioactive’. Scientifically, something is described as radioactive if it exhibits the phenomenon of radioactivity or — in the somewhat less precise, but generally accepted, usage — if it contains any substance that exhibits radioactivity. Scientifically, therefore, virtually any material (including material that is considered to be waste) is radioactive. However, it is common regulatory practice to define terms such as radioactive material and radioactive waste in such a way as to include only that material or waste that is subject to regulation by virtue of the radiological hazard that it poses. Although the exact specifications vary from State to State, this typically excludes material and waste with very low concentrations of radionuclides and those that contain only ‘natural’ concentrations of naturally occurring radionuclides.

Different definitions of a given term are numbered. Unless otherwise indicated in the text, drafters should use the most appropriate definition for their purposes.

A small number of ‘catch-all’ terms — namely, facilities and activities; protection and safety; radiation risks; and structures, systems and components — are defined in the IAEA Safety Glossary. These terms may be used in exactly the form listed to describe a whole group of things without cumbersome repetition, or slight variations of the terms may be used to refer to particular subgroups. Although the definitions include an indication of the meanings of the separate elements of the terms, these are not intended to be applied rigidly: if precise reference is needed to particular items covered by the catch-all term, more precise terms should be used.
In many cases, the recommended definition(s) is(are) followed by further information as appropriate, such as:

(a) Particular notes of caution, such as for terms that do not mean what they might appear to mean (e.g. annual dose), or potential conflicts with other safety or security related terminology; denoted by !.

(b) Explanation of the context(s) in which the term is usually used (and, in some cases, contexts in which it should not be used); denoted by ①.

(c) Reference to related terms: synonyms, terms with similar but not identical meanings, ‘contrasting’ terms, and terms that supersede or are superseded by the term being described; denoted by ①.

(d) Miscellaneous information, such as the units in which a quantity is normally measured, recommended parameter values and references; denoted by ①.

This supplementary information is not part of the definition, but it is included to assist drafters and reviewers in understanding how to use (or how not to use) the term in question. Note that the use of italics in the text denotes a term or subterm with an entry in the IAEA Safety Glossary. The use of bold italics in the text denotes a subterm with its definition or with an explanation.

Use by drafters

Drafters of safety and security related IAEA publications — in particular safety standards — should, as far as possible, use the terms in the IAEA Safety Glossary with the meanings given. Terms should also be used consistently, especially in safety standards. Variety of expression — a virtue in most forms of writing — should be avoided if there is any possibility of causing confusion or ambiguity. Terms that are not listed in the IAEA Safety Glossary may be used, provided that there is no suitable alternative term listed in the IAEA Safety Glossary.

A publication may contain a list of key terms used in that publication and their definitions. However, the first question concerning the inclusion of the definition of any term in a publication should always be whether the term actually needs to be defined. Terms should be explicitly defined in a publication only if a definition is essential to the correct understanding of that publication.

If the term is used with its usual meaning, or if its meaning in a particular publication will be obvious to the reader from the context, then there should be no need for a definition. A term whose meaning is imprecise may need to be defined, if the imprecision actually detracts from a correct understanding of the text; in many cases, however, the precise meaning of a term will not matter for the purposes of a given publication. Similarly, obvious derivatives of a defined
term need not themselves be defined unless there is some specific ambiguity that needs to be addressed.

If it is considered necessary to include a term in a list of definitions in an individual publication, the recommended definition should be used wherever possible. If the recommended definition is not suitable (e.g. if the subject of the publication falls outside the scope of the existing definition), the wording of the definition may be modified, but its meaning should not be changed. The technical officer responsible for the IAEA Safety Glossary should be informed of any such modifications to the wording of definitions.

Similarly, definitions of any additional — usually more specialized — terms needed in a specific publication can be provided by the drafters or the technical officer responsible for the publication and included either in the text (in the main body of the text or footnotes) or in a list of definitions. Such definitions should be copied for information to the technical officer responsible for the IAEA Safety Glossary.

Some terms and usages that have been used in the past or are used in the publications of other organizations, but whose use is discouraged in IAEA publications, are included in the IAEA Safety Glossary. Such terms are listed in square brackets and should be used only if they are essential for referring to other publications; alternative terms for use in IAEA publications are recommended. Similarly, some definitions are in square brackets, indicating that they have been included for information but should not be used as working definitions for IAEA publications.

The technical officer and reviewers for a publication are responsible for ensuring that any definitions given in that publication are in accordance with these rules.

Terms defined in the IAEA Safety Glossary are likely to be used in informing the public on matters concerning nuclear safety and security and radiation risks, and in covering these matters in the news media. The technical terms that must be used to explain difficult concepts will be interpreted and employed by writers, journalists and broadcasters who might not have a clear understanding of their significance. It must be borne in mind by drafters, reviewers and editors that certain terms that have specific and clear meanings in their scientific or technical context may be subject to misrepresentation or misunderstanding in a more general context.

The incautious use of language can and does give rise to widespread false impressions among the public that are difficult or impossible to correct. In attempting to summarize, interpret and simplify technical texts so as to communicate with a broader audience, therefore, care must be taken not to oversimplify by omitting conditions and qualifications, and not to mislead by using terms with both scientific and more general meanings.
Potentially misleading words include, for example, ‘attributable’, ‘contamination’, ‘[excess, statistical] deaths’, ‘exposure’, ‘illicit trafficking (in nuclear or radioactive material)’, ‘nuclear [terrorism, trafficking]’, ‘protection’, ‘radioactive’, ‘risk’ and ‘safe’, and related words and phrases. This caution applies in particular to matters of life and health, especially fatal accidents and other major incidents, and other emotionally charged subjects.

Finally, there are cases where special ‘safety’ or ‘IAEA’ meanings are attached so strongly to words that the use of those words in their everyday sense could cause confusion. Examples include ‘activity’, ‘critical’, ‘justification’, ‘practice’, ‘requirement’, ‘recommendation’, ‘guide’ and ‘standard’ (and also ‘shall’ and ‘should’). Although it would be unreasonable to prohibit the use of such words in their everyday sense in any IAEA publications, particular care should be taken to ensure that they are not used in a manner that could be ambiguous.

**Use by reviewers**

Reviewers should consider whether each term included in a list of definitions in an individual publication really needs to be defined, and if so whether a list of definitions (as opposed to the text or a footnote) is the most appropriate place for the definition. (Reviewers should also consider, of course, whether any terms not defined in the publication need to be defined.)

If a draft safety standard or other safety related publication gives a definition different from that recommended in the IAEA Safety Glossary, reviewers should check:

(a) That the definition recommended in the IAEA Safety Glossary could not reasonably have been used;
(b) That the definition given in the draft publication reflects essentially the same meaning as the recommended definition.

Reviewers should make any appropriate recommendations to the IAEA technical officer responsible for the publication under review.

Reviewers will need to verify that drafters select, use and relate defined terms and other words in such a way that clear distinctions are drawn and may be inferred between, for example: events and situations (see the entry for event); accidents and other incidents; what is actual (i.e. what is), possible (i.e. what might be) or potential (i.e. what could become), and what is hypothetical (i.e. what is postulated or assumed); and what is observed or determined objectively and what is decided or declared subjectively.
Novel and revised terminology — in particular in the areas of the design of nuclear power plants, emergency preparedness and response, and protection against radiation risks — needs to be paid careful attention. The introduction of novel concepts and terminology can lead to difficulties in comprehension, and the profusion of defined terms can complicate drafting and review. Once terms have been defined, their usage wherever applicable is necessary, and reviewers and specialists will need to verify proper usage.

FUTURE DEVELOPMENT OF THE IAEA SAFETY GLOSSARY

The IAEA Safety Glossary is intended to be reviewed and revised as necessary, to accurately represent the current terminology of the IAEA safety standards. The review and revision of the IAEA Safety Glossary is subject to appropriate consultation, as the IAEA Safety Glossary is also intended to bring about stability and harmonization in terminology and usage.

Comments on the IAEA Safety Glossary may be provided by users of the IAEA safety standards (in English and in translation) via the safety standards web site and the IAEA safety standards contact point (Safety.Standards@iaea.org). Please read the Preface and Foreword and this Introduction to the 2018 Edition of the IAEA Safety Glossary before using the IAEA Safety Glossary and before submitting comments or queries.
A

A₁

The activity value of *special form radioactive material* that is listed in Table 2 or derived in Section IV [both of the Transport Regulations] and is used to determine the *activity limits* for the *requirements* of [the Transport] Regulations. (See SSR-6 (Rev. 1) [2], sections II and IV and table 2.)

1. $A₁$ is the maximum activity of *special form radioactive material* that can be transported in a Type A package. Fractions and multiples of $A₁$ are also used as criteria for other package types, etc.
2. The corresponding value for any other form of *radioactive material* is $A₂$.

A₂

The activity value of *radioactive material*, other than *special form radioactive material*, that is listed in Table 2 or derived in Section IV [both of the Transport Regulations] and is used to determine the *activity limits* for the *requirements* of [the Transport] Regulations. (See SSR-6 (Rev. 1) [2], sections II and IV and table 2.)

1. $A₂$ is the maximum activity of any *radioactive material* other than *special form radioactive material* that can be transported in a Type A package. Fractions and multiples of $A₂$ are also used as criteria for other package types, etc.
2. The corresponding value for *special form radioactive material* is $A₁$.

abnormal operation

See *plant states (considered in design): anticipated operational occurrence*.

absorbed dose

See *dose quantities*.

absorbed fraction

The fraction of energy emitted as a specified *radiation* type in a specified *source region* that is absorbed in a specified *target tissue*. 

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absorption

1. See sorption.

2. See lung absorption type.

absorption type, lung

See lung absorption type.

accelerogram

A recording of ground acceleration, usually in three orthogonal directions (i.e. components), two in the horizontal plane and one in the vertical plane.

acceptable limit

See limit.

acceptance criteria

Specified bounds on the value of a functional indicator or condition indicator used to assess the ability of a structure, system or component to perform its design function.

accident

1. Any unintended event, including operating errors, equipment failures and other mishaps, the consequences or potential consequences of which are not negligible from the point of view of protection and safety.

   criticality accident. An accident involving criticality.
   (1) Typically, a criticality accident is an accidental release of energy as a result of unintentionally producing a criticality in a facility in which fissile material is used.
   (2) A criticality accident is also possible for fissile material in storage or in transport, for example.

   nuclear accident. [Any accident involving facilities or activities from which a release of radioactive material occurs or is likely to occur and which has resulted or may result in an international significant transboundary release that could be of radiological safety significance for another State.] (See Ref. [7].)
This is not explicitly stated to be a definition of nuclear accident, but it is derived from the statement of the scope of application in Article 1 of the Convention on Early Notification of a Nuclear Accident. However, this Convention has a limited scope of application, and it is unreasonable to consider a nuclear accident to be only an accident that results or may result in an international significant transboundary release.

severe accident. Accident more severe than a design basis accident and involving significant core degradation.

2. See event and International Nuclear and Radiological Event Scale (INES)

In the 2008 INES Manual [8], there was a fundamental mismatch between the terminology used in safety standards and the designations used in INES. In short, events that would be considered accidents according to the safety standards definition may be accidents or incidents (i.e. not accidents) in INES terminology. This was not a serious day to day problem because the two areas are quite separate and have quite different purposes. However, it was a potential cause of confusion in communication with the news media and the public.

accident conditions

See plant states (considered in design).

accident management

The taking of a set of actions during the evolution of an accident:

(a) To prevent escalation to a severe accident;
(b) To mitigate the consequences of a severe accident;
(c) To achieve a long term safe stable state.

 Aspect (b) of accident management (to mitigate the consequences of a severe accident) is also termed severe accident management.

 By extension, accident management for a severe accident includes the taking of a set of actions during the evolution of the accident to mitigate degradation of the reactor core.

accident precursor

An initiating event that could lead to accident conditions.

accuracy

See validation (1): system code validation.
activation

The process of inducing radioactivity in matter by irradiation of that matter.

1. In the context of nuclear installations, activation is used to refer to the unintentional induction of radioactivity in moderators, coolants, and structural and shielding materials, caused by irradiation with neutrons.

1. In the context of the production of radioisotopes, activation is used to refer to the intentional induction of radioactivity by neutron activation.

1. In other contexts, activation is an incidental side effect of irradiation carried out for other purposes, such as the sterilization of medical products or enhancement of the colour of gemstones for aesthetic reasons.

Care may be needed to avoid confusion when using the term activation in its everyday sense of bringing into action (e.g. of safety systems, for which ‘actuation’ may be used).

activation product

A radionuclide produced by activation.

1. Often used to distinguish from fission products. For example, in decommissioning waste comprising structural materials from a nuclear facility, activation products might typically be found primarily within the matrix of the material, whereas fission products are more likely to be present in the form of contamination on surfaces.

active component

A component whose functioning depends on an external input such as actuation, mechanical movement or supply of power.

1. An active component is any component that is not a passive component.

1. Examples of active components are pumps, fans, relays and transistors. It is emphasized that this definition is necessarily general in nature, as is the corresponding definition of passive component. Certain components, such as rupture discs, check valves, safety valves, injectors and some solid state electronic devices, have characteristics that require special consideration before designation as an active component or a passive component.


See also component, core components and structures, systems and components.

Care may be needed to avoid confusion with radioactive components.

activity

1. The quantity $A$ for an amount of radionuclide in a given energy state at a given time, defined as:
\[ A(t) = \frac{dN}{dt} \]

where \( dN \) is the expectation value of the number of spontaneous nuclear transformations from the given energy state in the time interval \( dt \).

1. The rate at which nuclear transformations occur in a radioactive material. The equation is sometimes given as:

\[ A(t) = -\frac{dN}{dt} \]

where \( N \) is the number of nuclei of the radionuclide, and hence the rate of change of \( N \) with time is negative. Numerically, the two forms are identical.

1. The SI unit for activity is reciprocal second (s\(^{-1}\)), termed the becquerel (Bq).
1. Formerly expressed in curies (Ci); activity values may be given in Ci (with the equivalent in Bq in parentheses) if they are being quoted from a reference that uses Ci as the unit.

**specific activity.** Of a radionuclide, the activity per unit mass of that nuclide.

The *specific activity* of a material is the activity per unit mass or volume of the material in which the radionuclides are essentially uniformly distributed.

The *specific activity* of a material, for the purposes of the Transport Regulations, is the activity per unit mass of the material in which the radionuclides are essentially uniformly distributed. (See SSR-6 (Rev. 1) [2].)

1. The distinction in usage between *specific activity* and *activity concentration* is controversial. Some regard the terms as synonymous, and may favour one or the other (as above). ISO 921 [9] distinguishes between *specific activity* as the activity per unit mass and *activity concentration* as the activity per unit volume.
1. Another common distinction is that *specific activity* is used (usually as activity per unit mass) with reference to a pure sample of a radionuclide or, less strictly, to cases where a radionuclide is intrinsically present in the material (e.g. \(^{14}\)C in organic materials, \(^{235}\)U in natural uranium), even if the abundance of the radionuclide is artificially changed. In this usage, *activity concentration* (which may be activity per unit mass or per unit volume) is used for any other situation (e.g. when the activity is in the form of contamination in or on a material).
1. In general, the term *activity concentration* is more widely applicable, is more self-evident in meaning, and is less likely than *specific activity* to be confused with unrelated terms (such as ‘specified activities’). *Activity concentration* is therefore preferred to *specific activity* for general use in safety related IAEA publications.

2. See *facilities and activities*.

**activity concentration**

See activity (1): *specific activity*.
activity median aerodynamic diameter (AMAD)

The value of aerodynamic diameter such that 50% of the airborne activity in a specified aerosol is associated with particles smaller than the AMAD, and 50% of the activity is associated with particles larger than the AMAD.

1. Used in internal dosimetry for simplification as a single ‘average’ value of aerodynamic diameter representative of the aerosol as a whole.
2. The AMAD is used for particle sizes for which deposition depends principally on inertial impaction and sedimentation (i.e. typically those greater than about 0.5 μm).

activity median thermodynamic diameter (AMTD). For smaller particles, deposition typically depends primarily on diffusion, and the AMTD — defined in an analogous way to the AMAD, but with reference to the thermodynamic diameter of the particles — is used.

aerodynamic diameter. The aerodynamic diameter of an airborne particle is the diameter that a sphere of unit density would need to have in order to have the same terminal velocity when settling in air as the particle of interest.

thermodynamic diameter. The thermodynamic diameter of an airborne particle is the diameter that a sphere of unit density would need to have in order to have the same diffusion coefficient in air as the particle of interest.

activity median thermodynamic diameter (AMTD)

See activity median aerodynamic diameter (AMAD).

actuated equipment

An assembly of prime movers and driven equipment used to accomplish one or more safety tasks.

actuation device

A component that directly controls the motive power for actuated equipment.

1. Examples of actuation devices include circuit breakers and relays that control the distribution and use of electric power, and pilot valves controlling hydraulic or pneumatic fluids.
acute exposure

See exposure.

acute intake

See intake (2).

additive risk projection model

See model: risk projection model.

adsorption

See sorption.

advection

The movement of a substance or the transfer of heat by the motion of the gas (usually air) or liquid (usually water) in which it is present.

- Sometimes used with the more common meaning — transfer of heat by the horizontal motion of the air — but in IAEA publications is more often used in a more general sense, in particular in safety assessment, to describe the movement of a radionuclide due to the movement of the liquid in which it is dissolved or suspended.
- Usually contrasted with diffusion, where the radionuclide moves relative to the carrying medium.

aerodynamic diameter

See activity median aerodynamic diameter (AMAD).

aerodynamic dispersion

See dispersion.

ageing

General process in which characteristics of a structure, system or component gradually change with time or use.

- Although the term ageing is defined in a neutral sense — the changes involved in ageing may have no effect on protection or safety, or could even have a beneficial effect — it is most commonly used with a connotation of changes that are (or could be) detrimental to protection and safety (i.e. as a synonym of ageing degradation).
**non-physical ageing.** The process of becoming out of date (i.e. obsolete) owing to the evolution of knowledge and technology and associated changes in codes and standards.

Examples of non-physical ageing effects include the lack of an effective containment or emergency core cooling system, the lack of safety design features (such as diversity, separation or redundancy), the unavailability of qualified spare parts for old equipment, incompatibility between old and new equipment, and outdated procedures or documentation (e.g. which thus do not comply with current regulations).

Strictly, this is not always ageing as defined above, because it is sometimes not due to changes in the structure, system or component itself. Nevertheless, the effects on protection and safety, and the solutions that need to be adopted, are often very similar to those for physical ageing.

The term *technological obsolescence* is also used.

**physical ageing.** Ageing of structures, systems and components due to physical, chemical and/or biological processes (ageing mechanisms).

Examples of ageing mechanisms include wear, thermal or radiation embrittlement, corrosion and microbiological fouling.

The term *material ageing* is also used.

**ageing degradation**

Ageing effects that could impair the ability of a structure, system or component to function within its acceptance criteria.

Examples include reduction in diameter due to wear of a rotating shaft, loss in material toughness due to radiation embrittlement or thermal ageing, and cracking of a material due to fatigue or stress corrosion cracking.

**ageing management**

Engineering, operations and maintenance actions to control within acceptable limits the ageing degradation of structures, systems and components.

Examples of engineering actions include design, qualification and failure analysis. Examples of operations actions include surveillance, carrying out operating procedures within specified limits and performing environmental measurements.

**life management** (or lifetime management). The integration of ageing management with economic planning: (1) to optimize the operation, maintenance and service life of structures, systems and components; (2) to maintain an acceptable level of safety and performance; and (3) to improve economic performance over the service life of the facility.
agricultural countermeasure

See countermeasure.

air kerma

See kema.

aircraft

cargo aircraft. Any aircraft, other than a passenger aircraft, that is carrying goods or property. (See SSR-6 (Rev. 1) [2].)

passenger aircraft. An aircraft that carries any person other than a crew member, a carrier’s employee in an official capacity, an authorized representative of an appropriate national authority, or a person accompanying a consignment or other cargo. (See SSR-6 (Rev. 1) [2].)

ALARA (as low as reasonably achievable)

See optimization (of protection and safety).

aleatory uncertainty

See uncertainty.

alert

See emergency class.

ambient dose equivalent

See dose equivalent quantities (operational).

analysis

Often used interchangeably with assessment, especially in more specific terms such as ‘safety analysis’. In general, however, analysis suggests the process and result of a study aimed at understanding the subject of the analysis, while assessment may also include determinations or judgements of acceptability. Analysis is also often associated with the use of a specific technique. Hence, one or more forms of analysis may be used in assessment.
cost–benefit analysis. A systematic technical and economic evaluation of the positive effects (benefits) and negative effects (disbenefits, including monetary costs) of undertaking an action. A decision aiding technique commonly used in the optimization of protection and safety. This and other techniques are discussed in Ref. [10].

event tree analysis. An inductive technique that starts by hypothesizing the occurrence of basic postulated initiating events and proceeds through their logical propagation to system failure events. The event tree is the diagrammatic illustration of alternative outcomes of specified postulated initiating events. Fault tree analysis considers similar chains of events, but starts at the other end (i.e. with the ‘results’ rather than the ‘causes’). The completed event trees and fault trees for a given set of events would be similar to one another.

fault tree analysis. A deductive technique that starts by hypothesizing and defining failure events and systematically deduces the events or combinations of events that caused the failure events to occur. The fault tree is the diagrammatic illustration of the events. Event tree analysis considers similar chains of events, but starts at the other end (i.e. with the ‘causes’ rather than the ‘results’). The completed event trees and fault trees for a given set of events would be similar to one another.

safety analysis. Evaluation of the potential hazards associated with the operation of a facility or the conduct of an activity. The formal safety analysis is part of the overall safety assessment; that is, it is part of the systematic process that is carried out throughout the design process (and throughout the lifetime of the facility or the activity) to ensure that all the relevant safety requirements are met by the proposed (or actual) design. Safety analysis is often used interchangeably with safety assessment. However, when the distinction is important, safety analysis should be used as a documented process for the study of safety, and safety assessment should be used as a documented process for the evaluation of safety — for example, evaluation of the magnitude of hazards, evaluation of the performance of safety measures and judgement of their adequacy, or quantification of the overall radiological impact or safety of a facility or activity.

sensitivity analysis. A quantitative examination of how the behaviour of a system varies with change, usually in the values of the governing parameters. A common approach is parameter variation, in which the variation of results is investigated for changes in the value of one or more input parameters within a reasonable range around selected reference or mean values, and perturbation analysis, in which the variations of results with respect to changes in the values of all the input parameters are obtained by applying differential or integral analysis.
uncertainty analysis. An analysis to estimate the uncertainties and error bounds of the quantities involved in, and the results from, the solution of a problem.

annual dose

See dose concepts.

annual limit on exposure (ALE)

See limit.

annual limit on intake (ALI)

See limit.

annual risk

See risk (3).

anticipated operational occurrence

See plant states (considered in design).

anticipated transient without scram (ATWS)

For a nuclear reactor, an accident for which the initiating event is an anticipated operational occurrence and in which the system for fast shutdown of the reactor fails to function.

applicant

Any person or organization applying to a regulatory body for authorization (or approval) to undertake specified activities.

Strictly, an applicant would be such from the time at which an application is submitted until the requested authorization is either granted or refused. However, the term is often used a little more loosely than this, in particular in cases where the authorization process is long and complex.

approval

The granting of consent by a regulatory body.
Typically used to represent any form of consent from the regulatory body that does not meet the definition of authorization. However, the usage in the Transport Regulations [2] (see multilateral approval and unilateral approval; the term approval is not separately defined in the context of the Transport Regulations) is that approval is essentially synonymous with authorization.

**multilateral approval.** Approval by the relevant competent authority of the country of origin of the design or shipment, as applicable, and also, where the consignment is to be transported through or into any other country, approval by the competent authority of that country. (See SSR-6 (Rev. 1) [2].)

**unilateral approval.** An approval of a design that is required to be given by the competent authority of the country of origin of the design only. (See SSR-6 (Rev. 1) [2].)

**area**

**controlled area.** A defined area in which specific protection measures and safety provisions are or could be required for controlling exposures or preventing the spread of contamination in normal working conditions, and preventing or limiting the extent of potential exposures.

1. A controlled area is often within a supervised area, but need not be.
2. The term [radiation area] is sometimes used to describe a similar concept, but controlled area is preferred in IAEA publications.

**operations area.** A geographical area that contains an authorized facility. It is enclosed by a physical barrier (the operations boundary) to prevent unauthorized access, by means of which the management of the authorized facility can exercise direct authority.

1. This applies to larger facilities.

[radiation area]. See area: controlled area.

**site area.** A geographical area that contains an authorized facility, authorized activity or source, and within which the management of the authorized facility or authorized activity or first responders may directly initiate emergency response actions.

1. This is typically the area within the security perimeter fence or other designated property marker. It may also be the controlled area around a radiography source or an inner cordoned off area established by first responders around a suspected hazard.

1. This area is often identical to the operations area, except in situations (e.g. research reactors, irradiation installations) where the authorized facility is on a site where
other activities are being carried out beyond the operations area, but where the management of the authorized facility can be given some degree of authority over the whole site area.

1. The term activity is used here in the sense of activity (2).

site boundary. The boundary of the site area.

supervised area. A defined area not designated as a controlled area but for which occupational exposure conditions are kept under review, even though specific protection measures or safety provisions are not normally needed.

See also controlled area.

area monitoring

See monitoring (1).

area survey

See survey.

arrangements (for emergency response)

See emergency arrangements.

arrangements (for operations)

The integrated set of infrastructural elements necessary to provide the capability for performing a specified function or task required to carry out a specified operation.

1. The infrastructural elements may include authorities and responsibilities, organization, coordination, personnel, plans, procedures, facilities, equipment or training.

assessment

1. The process, and the result, of analysing systematically and evaluating the hazards associated with sources and practices, and associated protection and safety measures.

1. Assessment is often aimed at quantifying performance measures for comparison with criteria.
In IAEA publications, assessment should be distinguished from analysis. Assessment is aimed at providing information that forms the basis of a decision on whether or not something is satisfactory. Various kinds of analysis may be used as tools in doing this. Hence an assessment may include a number of analyses.

**consequence assessment.** Assessment of the radiological consequences (e.g. doses, activity concentrations) of normal operation and possible accidents associated with an authorized facility or part thereof.

Care should be taken in discussing ‘consequences’ in this context to distinguish between radiological consequences of events causing exposure, such as doses, and health consequences, such as cancers, that could result from doses. ‘Consequences’ of the former type generally imply a probability of experiencing ‘consequences’ of the latter type.

This differs from risk assessment in that probabilities are not included in the assessment.

See also end point.

**dose assessment.** Assessment of the dose(s) to an individual or group of people.

For example, assessment of the dose received or committed by an individual on the basis of results from workplace monitoring or bioassay.

The term exposure assessment is also sometimes used.

**hazard assessment.** Assessment of hazards associated with facilities, activities or sources within or beyond the borders of a State in order to identify:

(a) Those events and the associated areas for which protective actions and other response actions may be required within the State;
(b) Actions that would be effective in mitigating the consequences of such events.

**performance assessment.** Assessment of the performance of a system or subsystem and its implications for protection and safety at an authorized facility.

This differs from safety assessment in that it can be applied to parts of an authorized facility (and its surroundings) and does not necessarily require the assessment of radiological impacts.

**radiological environmental impact assessment.** Assessment of the expected radiological impacts of facilities and activities on the environment for the
purposes of protection of the public and protection of the environment against radiation risks.

risk assessment. Assessment of the radiation risks and other risks associated with normal operation and possible accidents involving facilities and activities.
1. This will normally include consequence assessment, together with some assessment of the probability of those consequences arising.

safety assessment
1. Assessment of all aspects of a practice that are relevant to protection and safety; for an authorized facility, this includes siting, design and operation of the facility.
1. This will normally include risk assessment.

See also probabilistic safety assessment (PSA).

2. Analysis to predict the performance of an overall system and its impact, where the performance measure is the radiological impact or some other global measure of the impact on safety.

3. The systematic process that is carried out throughout the design process (and throughout the lifetime of the facility or the activity) to ensure that all the relevant safety requirements are met by the proposed (or actual) design.
1. Safety assessment includes, but is not limited to, the formal safety analysis; that is, it includes the evaluation of the potential hazards associated with the operation of a facility or the conduct of an activity.
1. Stages in the lifetime of a facility or activity at which a safety assessment is carried out and updated and the results are used by the designers, the operating organization and the regulatory body include:

(a) Site evaluation for the facility or activity;
(b) Development of the design;
(c) Construction of the facility or implementation of the activity;
(d) Commissioning of the facility or of the activity;
(e) Commencement of operation of the facility or conduct of the activity;
(f) Normal operation of the facility or normal conduct of the activity;
(g) Modification of the design or operation;
(h) Periodic safety reviews;
(i) Life extension of the facility beyond its original design life;
(j) Changes in ownership or management of the facility;
(k) Decommissioning of a facility;
(l) Closure of a disposal facility for radioactive waste and the post-closure phase;
(m) Remediation of a site and release from regulatory control.
See GSR Part 4 (Rev. 1) [11].

2. Activities carried out to determine whether requirements are met and processes are adequate and effective, and to encourage managers to implement improvements, including safety improvements.

- This usage originated in quality assurance and related fields.
- The IAEA revised the requirements and guidance in the subject area of quality assurance for safety standards on management systems for the safety of facilities and activities involving the use of ionizing radiation. The terms quality management and management system have been adopted in the revised standards in place of the terms quality assurance and quality assurance programme.
- Assessment activities may include reviewing, checking, inspecting, testing, surveillance, auditing, peer evaluation and technical review. These activities can be divided into two broad categories: independent assessment and self-assessment.

**Independent assessment.** Assessments such as audits or surveillance carried out to determine the extent to which the requirements for the management system are fulfilled, to evaluate the effectiveness of the management system and to identify opportunities for improvement. They can be conducted by or on behalf of the organization itself for internal purposes, by interested parties such as customers and regulators (or by other persons on their behalf), or by external independent organizations.

- This definition applies in management systems and related fields.
- Persons conducting independent assessments do not participate directly in the work being assessed.
- Independent assessment activities include internal and external audit, surveillance, peer evaluation and technical review, which are focused on safety aspects and areas where problems have been found.
- An audit is used in the sense of a documented activity performed to determine by investigation, examination and evaluation of objective evidence the adequacy of, and adherence to, established procedures, instructions, specifications, codes, standards, administrative or operational programmes and other applicable documents, and the effectiveness of their implementation.

**Self-assessment.** A routine and continuing process conducted by senior management and also by management at other levels to evaluate the effectiveness of performance in all areas of their responsibility.

- This definition applies in management systems and related fields.
- Self-assessment activities include review, surveillance and discrete checks, which are focused on preventing, or identifying and correcting, management problems that hinder the achievement of the organization’s objectives, in particular safety objectives.
- Self-assessment provides an overall view of the performance of the organization and the degree of maturity of the management system. It also helps to identify areas for
improvement in the organization, to determine priorities and to set a baseline for further improvement.

See also *management system review: senior management*.

**assisted operation**

An operation undertaken by a State or group of States to which assistance is provided by or through the IAEA in the form of materials, services, equipment, *facilities* or information pursuant to an agreement between the IAEA and that State or group of States.

① The word ‘operation’ is used here in its usual sense.

**atmospheric dispersion**

See *dispersion*.

**attenuation**

The reduction in intensity of *radiation* passing through matter due to *processes* such as *absorption* and scattering.

① By analogy, also used in other situations in which some radiological property, characteristic or parameter is gradually reduced in the course of passing through a medium (e.g. the reduction in *activity concentration* in groundwater passing through the *geosphere* due to *processes* such as *sorption)*.

**attributable risk**

See *risk* (3).

**audit**

See *assessment* (2): *independent assessment*.

**authorization**

The granting by a *regulatory body* or other governmental body of written permission for a *person* or *organization* (the *operator*) to conduct specified *activities*.

① *Authorization* could include, for example, licensing (issuing a *licence*), *certification* (issuing a *certificate*) or *registration*.

① The term *authorization* is also sometimes used to describe the document granting such permission.
Authorization is generally a more formal process than approval. Approval is typically used to represent any form of consent from the regulatory body that does not meet the definition of authorization. However, the usage in the Transport Regulations [2] is that approval is essentially synonymous with authorization.

See also approval: multilateral approval and unilateral approval.

authorized activity

See facilities and activities.

authorized discharge

See discharge (1).

authorized facility

See facilities and activities.

authorized limit

See limit.

authorized party

The person or organization (the operator) responsible for an authorized facility or an authorized activity that gives rise to radiation risks who has been granted written permission (i.e. authorized) by a regulatory body or other governmental body to conduct specified activities.

The authorized party for an authorized facility or an authorized activity is usually the operating organization or the registrant or licensee (although forms of authorization other than registration or licensing may apply) [6].

authorized termination of responsibility

The release by the regulatory body of an operator (or a former operator) from any further regulatory responsibilities in relation to an authorized facility or authorized activity.

This may be a separate process from termination of an authorization; for example, termination of the responsibility to maintain active institutional control over a disposal facility or termination of the authorization for decommissioning.
**authorized transfer**

The transfer of regulatory responsibility for specified *radioactive material* from one *operator* to another.

This does not necessarily involve any movement of the material itself.

**authorized use**

See *use*.

**availability**

1. The ability of an item or a *system* to be in a state to perform a required function under given conditions at a given instant of time or over a given time interval, given that the necessary external resources are provided [12].

1. The definition was previously “The fraction of time for which a *system* is capable of fulfilling its intended purpose”.

1. *Reliability* represents essentially the same information but in a different form.

**averted dose**

See *dose concepts*.
backfill

Material used to refill excavated portions of a disposal facility after waste has been emplaced.

background

The dose or dose rate (or an observed measure related to the dose or dose rate) attributable to all sources other than the one(s) specified.

1 Strictly, this applies to measurements of dose rate or count rate from a sample, where the background dose rate or count rate must be subtracted from all measurements. However, background is used more generally, in any situation in which a particular source (or group of sources) is under consideration, to refer to the effects of other sources. It is also applied to quantities other than doses or dose rates, such as activity concentrations in environmental media.

natural background. The doses, dose rates or activity concentrations associated with natural sources, or any other sources in the environment that are not amenable to control.

1 This is normally considered to include doses, dose rates or activity concentrations associated with natural sources and global fallout (but not local fallout) from atmospheric nuclear weapon tests.

barrier

A physical obstruction that prevents or inhibits the movement of people, radionuclides or some other phenomenon (e.g. fire), or provides shielding against radiation.

See also cladding, containment and defence in depth.

intrusion barrier. Components of a disposal facility designed to prevent inadvertent access to the waste by people, animals or plants.

multiple barriers. Two or more natural or engineered barriers used to isolate radioactive waste in, and to prevent or to inhibit migration of radionuclides from, a disposal facility.

! The term ‘chemical barrier’ is sometimes used in the context of waste disposal to describe the chemical effect of a material that enhances the extent to which radionuclides react chemically with the material or with the host rock, thus inhibiting the migration of the radionuclides.
This is not strictly a *barrier* as defined above (unless the material also constitutes a physical *barrier*), but the effect may be equivalent to that of a *barrier*, and it may therefore be convenient to regard it as such.

**multiple safety functions.** In the context of the fulfilment of *multiple safety functions* by a *disposal system*, the *containment* and *isolation* of waste (the *confinement* function) is fulfilled by two or more natural or engineered *barriers* of the *disposal facility*, by means of diverse physical and chemical properties or processes, together with operational controls.

**Bayesian statistics**

1. *Bayesian statistics* provide a means for probabilistic inference that depends on the specification of prior distributions for all unknown parameters, followed by an application of Bayes’ theorem to incorporate the extra information included in the data.
2. *Bayesian statistics* can be used in volcanology, for example, as a method to help constrain the results and uncertainty estimates of statistical and numerical modelling, by taking advantage of as much data and relevant information as are available. In contrast, frequentist statistics rely on patterns of past events to model the likelihood that an event will occur in the future.
3. Bayesian methods can incorporate more geological information into an estimate of probability of occurrence than is possible with a frequentist approach.

**becquerel (Bq)**

The SI unit of *activity*, equal to one (transformation) per second.

1. Supersedes the non-SI unit *curie (Ci)*. 1 Bq = 27 pCi ($2.7 \times 10^{-11}$ Ci) approximately. 1 Ci = $3.7 \times 10^{10}$ Bq.

**beyond design basis accident**

See *plant states (considered in design).*

**bias**

A measure of the systematic error between an actual or true value and a prediction by a *model* or a measured mean value. The *bias* of a model represents the tendency of a *model* to overpredict or to underpredict.
bioassay

Any procedure used to determine the nature, activity, location or retention of radionuclides in the body by direct (in vivo) measurement or by in vitro analysis of material excreted or otherwise removed from the body.

Sometimes referred to as ‘radio-bioassay’.

biological half-life

See half-life (2).

biophysical model

See model.

biosphere

That part of the environment normally inhabited by living organisms.

In practice, the biosphere is not usually defined with great precision, but is generally taken to include the atmosphere and the Earth’s surface, including the soil and surface water bodies, seas and oceans, and their sediments. There is no generally accepted definition of the depth below the surface at which soil or sediment ceases to be part of the biosphere, but this might typically be taken to be the depth affected by basic human activities, in particular, farming.

In the safety of radioactive waste management, in particular, the biosphere is normally distinguished from the geosphere.

buffer

Any substance placed around a waste package in a disposal facility to serve as a barrier to restrict the access of groundwater to the waste package and to reduce by sorption and precipitation the rate of eventual migration of radionuclides from the waste.

The above definition is clearly specific to the safety of radioactive waste management. The term buffer (e.g. in buffer solution) is also used, in its usual scientific sense (and therefore usually without specific definition), in a variety of contexts.

burnable absorber

Neutron absorbing material, used to manage reactivity, with the particular capability of being depleted by neutron absorption.
A burnable absorber is used to manage reactivity by flattening the radial neutron flux within a reactor and to compensate for the depletion of fissile material due to operation of the reactor, thereby improving the utilization of the fuel.

[burnable poison]

See burnable absorber and poison.

bypass

1. A device to inhibit, deliberately but temporarily, the functioning of a circuit or system by, for example, short circuiting the contacts of a relay.

maintenance bypass. A bypass of safety system equipment during maintenance, testing or repair.

operational bypass. A bypass of certain protective actions when they are not necessary in a particular mode of plant operation.

An operational bypass may be used when the protective action prevents, or might prevent, reliable operation in the required mode.

2. A route that allows fission products released from a reactor core to enter the environment without passing through the containment or other enclosure designed to confine and reduce a radioactive release in the event of an emergency.

This route may be established intentionally by the operator or as a result of the event.
calibration

① A set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by measurement standards [12].

② The definition was previously “A measurement of, or adjustment to, an instrument, component or system to ensure that its accuracy or response is acceptable”.

③ A calibration may be expressed by a statement, calibration function, calibration diagram, calibration curve or calibration table. In some cases, it may consist of an additive or multiplicative correction of the indication with associated measurement uncertainty.

④ Calibration should not be confused with adjustment of a measuring system, often mistakenly called ‘self-calibration’, or with verification of calibration.

calibration of a dosimeter. The process by which a dosimeter is characterized with a calibration factor. The calibration factor is the quotient of the conventionally true value of the measured quantity and the indicated value of the dosimeter under reference conditions. If the dosimeter is used under reference conditions, the value of the measured quantity is the product of the indicated value and the calibration factor. If the dosimeter is used under non-reference conditions, the value of the measured quantity is the product of the indicated value, the calibration factor and additional correction factor(s).

model calibration. The process whereby predictions by a model are compared with field observations and/or experimental measurements from the system being modelled, and the model is adjusted for bias if necessary to achieve a best fit to the measured and/or observed data.

！This usage of the term is not universally accepted. The terms model validation and model verification are more commonly used to describe related processes in relation to models.

See also bias.

calibration of a dosimeter

See calibration.
canister, waste

See waste container.

capable fault

See geological fault.

capable volcanic field

See volcano: capable volcano.

capable volcano

See volcano.

carers and comforters

Persons who willingly and voluntarily help (other than in their occupation) in the care, support and comfort of patients undergoing radiological procedures for medical diagnosis or medical treatment.

cargo aircraft

See aircraft.

carrier

Any person, organization or government undertaking the carriage of radioactive material by any means of transport.

The term includes both carriers for hire or reward (known as common or contract carriers in some countries) and carriers on own account (known as private carriers in some countries). (See SSR-6 (Rev. 1) [2].)

cause

direct cause. The latent weakness (and the reasons for the latent weakness) that allows or causes the observed cause of an initiating event to happen.

Corrective actions designed to address direct causes are sometimes termed repairs.

latent weakness. An undetected degradation in an element of a safety layer.
Such a degradation could lead to that element failing to perform as expected if it were called upon to perform a function.

**observed cause.** The *failure*, action, omission or condition that directly leads to an *initiating event*.

**root cause.** The fundamental cause of an *initiating event*, correction of which will prevent recurrence of the *initiating event* (i.e. the *root cause* is the failure to detect and correct the relevant *latent weakness(es)* and the reasons for that *failure*).

Corrective actions designed to address *root causes* are sometimes termed *remedies*.

**certificate**

A legal document issued by the *regulatory body* stating the applicable conditions to be met for *certification* and certifying compliance with regulatory *requirements* if the conditions are met.

Certificates are required for some *package* types [2].

**certification**

The issue of a *certificate*.

**channel**

An arrangement of interconnected *components* within a *system* that initiates a single output.

A *channel* loses its identity where single output signals are combined with signals from other *channels* (e.g. from a monitoring *channel* or a *safety actuation channel*).

The above definition is specific to a particular area of *nuclear safety*. The term channel is also used in its usual senses (and therefore usually without specific definition) in a variety of contexts.

**characterization**

1. Determination of the nature and *activity* of radionuclides present in a specified place.

For example, *characterization* is the determination of the radionuclides present in a *bioassay sample* or in an area contaminated with *radioactive material* (e.g. as a first step in planning remediation). For the latter example, care should be taken to avoid confusion with the existing, and different, definition of the term *site characterization*. 

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2. Determination of the character of something.

   (1) This is the standard dictionary definition and would not need to be included in an individual glossary. It is included here only to distinguish the usual usage from the more restricted usage indicated in (1).

characterization of waste. Determination of the physical, mechanical, chemical, radiological and biological properties of radioactive waste to establish the need for further adjustment, treatment or conditioning, or its suitability for further handling, processing, storage or disposal.

   (1) Characterization of waste, in accordance with requirements established or approved by the regulatory body, is a process in the predisposal management of waste that at various steps provides information relevant to process control and provides assurance that the waste form or waste package will meet the waste acceptance criteria for the processing, storage, transport and disposal of the waste.

site characterization (of the site for a disposal facility). Detailed surface and subsurface investigations and activities at a site to determine the radiological conditions at the site or to evaluate candidate disposal sites to obtain information to determine the suitability of the site for a disposal facility and to evaluate the long term performance of a disposal facility at the site.

   (1) Site characterization is a stage in the siting of a disposal facility; it follows area survey and precedes site confirmation for a disposal facility.

   (2) Site characterization may also refer to the siting process for any other authorized facility.

See also site evaluation, which includes site characterization and is not specific to a disposal facility site, and area survey.

characterization of waste

   See characterization (2).

chemisorption

   See sorption.

child

   (1) In dosimetry (e.g. in tables of dose per unit intake values), a child is often assumed to be a 10 year old. If such an assumption is made, it should be clearly stated.

See also infant and reference individual.
chronic intake

See intake (2).

cladding

1. An external layer of material applied directly to another material to provide protection in chemically reactive conditions (e.g. cladding over ferritic material to prevent corrosion).

2. Typically, the tube of material that houses nuclear fuel pellets and provides the containment (means of confinement) of radionuclides produced during fission.
   1. Cladding may also provide structural support.
   1. The cladding tube, together with the end cups or plugs, also typically provides structural support.

cleanup

See decommissioning (1).

clearance

1. Removal of regulatory control by the regulatory body from radioactive material or radioactive objects within notified or authorized facilities and activities.
   1. Removal from regulatory control in this context refers to regulatory control applied for radiation protection purposes.
   1. Conceptually, clearance — freeing certain materials or objects in authorized facilities and activities from further control — is closely linked to, but distinct from and not to be confused with, exemption — determining that controls do not need to be applied to certain sources and facilities and activities.
   1. Various terms (e.g. ‘free release’) are used in different States to describe this concept.
   1. A number of issues relating to the concept of clearance and its relationship to other concepts were resolved in RS-G-1.7 [13].

2. The net effect of the biological processes by which radionuclides are removed from a tissue, organ or area of the body.
   1. The clearance rate is the rate at which these biological processes occur.
clearance level

See level.

clearance rate

See clearance (2).

cliff edge effect

An instance of severely abnormal conditions caused by an abrupt transition from one status of a facility to another following a small deviation in a parameter or a small variation in an input value.

1. In a nuclear power plant or nuclear fuel cycle facility, a cliff edge effect is an instance of severely abnormal facility behaviour caused by an abrupt transition from one facility status to another following a small deviation in a facility parameter, and thus a sudden large variation in facility conditions in response to a small variation in an input.

closed nuclear fuel cycle

See nuclear fuel cycle.

closure

1. Administrative and technical actions directed at a disposal facility at the end of its operating lifetime — for example, covering of the disposed waste (for a near surface disposal facility) or backfilling and/or sealing (for a geological disposal facility and the passages leading to it) — and the termination and completion of activities in any associated structures.

2. For other types of facilities, the term decommissioning is used.

1. The terms siting, design, construction, commissioning, operation and decommissioning are normally used to delineate the six major stages of the lifetime of an authorized facility and of the associated licensing process. In the special case of disposal facilities for radioactive waste, decommissioning is replaced in this sequence by closure.

2. [The completion of all operations at some time after the emplacement of spent fuel or radioactive waste in a disposal facility. This includes the final engineering or other work required to bring the facility to a condition that will be safe in the long term.] (See Ref. [5].)
cloud shine

Gamma radiation from radionuclides in an airborne plume.

See also ground shine.

sky shine. Radiation emitted upwards and deflected by the air back down to the ground.
  ① The presence of sky shine could result in an increase in neutron flux rates further away from the facility.
  ① Sky shine can be an important consideration in health physics for high energy experimental accelerator facilities as well as installations with medical linear accelerators for radiation therapy, in relation to the evaluation of shielding designs and to environmental monitoring.

coincidence (as a feature of design)

A feature of protection system design such that two or more overlapping or simultaneous output signals from several channels are necessary in order to produce a protective action signal by the logic.

collective dose

See dose concepts.

commissioning

The process by means of which systems and components of facilities and activities, having been constructed, are made operational and verified to be in accordance with the design and to have met the required performance criteria.
  ① Commissioning may include both non-nuclear and/or non-radioactive and nuclear and/or radioactive testing.
  ① The terms siting, design, construction, commissioning, operation and decommissioning are normally used to delineate the six major stages of the lifetime of an authorized facility and of the associated licensing process. In the special case of disposal facilities for radioactive waste, decommissioning is replaced in this sequence by closure.

committed dose

1. See dose concepts.

2. See dose (2).
committed effective dose

See dose quantities.

committed equivalent dose

See dose quantities.

common cause failure

See failure.

common mode failure

See failure.

competent authority

Any body or authority designated or otherwise recognized as such for any purpose in connection with [the Transport] Regulations. (See SSR-6 (Rev. 1) [2].)

This term is used only with reference to the Transport Regulations [2] for consistency with terminology used in the wider field of regulation of the transport of dangerous goods. Otherwise, the more general term regulatory body should be used, with which competent authority is essentially synonymous.

compliance assurance

A systematic programme of measures applied by a regulatory body that is aimed at ensuring that the provisions of regulations are met in practice.

1 Compliance assurance is a systematic programme of measures applied by a competent authority that is aimed at ensuring that the provisions of [the Transport] Regulations are met in practice. (See SSR-6 (Rev. 1) [2].)

1 The term may be used in a variety of contexts with essentially the same meaning, but often without explicit definition.

component

See structures, systems and components.

computational model

See model.
computer system validation

See validation (1).

computer system verification

See verification (1).

concept of operations

See emergency plan.

conceptual model

See model.

condition based maintenance

See maintenance: predictive maintenance.

condition indicator

See indicator.

condition monitoring

See monitoring (2).

conditional probability value (CPV)

The upper bound for the conditional probability that a particular type of event will cause unacceptable radiological consequences.

The term is used in the detailed event screening process for site evaluation.

conditional risk

See risk (3).

conditioning

See radioactive waste management (1).
configuration management

The process of identifying and documenting the characteristics of a facility's structures, systems and components (including computer systems and software), and of ensuring that changes to these characteristics are properly developed, assessed, approved, issued, implemented, verified, recorded and incorporated into the facility documentation.

1 ‘Configuration’ is used in the sense of the physical, functional and operational characteristics of the structures, systems and components and parts of a facility.

confinement

Prevention or control of releases of radioactive material to the environment in operation or in accidents.

1 Confinement is closely related in meaning to containment, but confinement is typically used to refer to the safety function of preventing the ‘escape’ of radioactive material, whereas containment refers to the means for achieving that function.

1 The Transport Regulations [2] adopt a different distinction between confinement and containment, namely that confinement relates to preventing criticality and containment to preventing releases of radioactive material (see confinement system and containment system).

1 The main issue here is the differences in usage between the safety of nuclear installations and safety in the transport of radioactive material. Both terms, containment and confinement, are used in both areas (in the Transport Regulations [2], in the form of confinement system and containment system), and the usages of containment are (it seems) conceptually consistent, but the usages of confinement are not. Confinement in nuclear safety is the safety function that is performed by the containment.

confinement system

The assembly of fissile material and packaging components specified by the designer and agreed to by the competent authority as intended to preserve criticality safety. (See SSR 6 (Rev. 1) [2].)

1 This usage is specific to the Transport Regulations [2].

See confinement for more general usage.

1 A confinement system as defined in the Transport Regulations [2] has the primary function of controlling criticality (as compared with the containment system, the function of which is to prevent leakage of radioactive material).

1 Discussions with experts in the field confirmed that a distinct term is needed to describe this distinct concept, and that confinement is the term that has become established, but failed to reveal any compelling reasons for the choice of that particular word.
consequence assessment

See assessment (1).

consignee

Any person, organization or government that is entitled to take delivery of a consignment. (See SSR-6 (Rev. 1) [2].)

consignment

Any package or packages, or load of radioactive material, presented by a consignor for transport. (See SSR-6 (Rev. 1) [2].)

consignor

Any person, organization or government that prepares a consignment for transport. (See SSR-6 (Rev. 1) [2].)

constraint

A prospective and source related value of individual dose (see dose constraint) or of individual risk (see risk constraint) that is used in planned exposure situations as a parameter for the optimization of protection and safety for the source, and that serves as a boundary in defining the range of options in optimization.

construction

The process of manufacturing and assembling the components of a facility, the carrying out of civil works, the installation of components and equipment, and the performance of associated tests.

1 The terms siting, design, construction, commissioning, operation and decommissioning are normally used to delineate the six major stages of the lifetime of an authorized facility and of the associated licensing process. In the special case of disposal facilities for radioactive waste, decommissioning is replaced in this sequence by closure.

consumer product

A device or manufactured item into which radionuclides have deliberately been incorporated or produced by activation, or which generates ionizing
radiation, and which can be sold or made available to members of the public without special surveillance or regulatory control after sale.

1. Consumer products include items such as smoke detectors and luminous dials into which radionuclides have deliberately been incorporated and ion generating tubes. It does not include building materials, ceramic tiles, spa waters, minerals and foodstuffs, and it excludes products and appliances installed in public places (e.g. exit signs).

container, waste

See waste container.

containment

Methods or physical structures designed to prevent or control the release and the dispersion of radioactive substances.

1. Although related to confinement, containment is usually used to refer to methods or structures that perform a confinement function in facilities and activities, namely preventing or controlling the release of radioactive substances and their dispersion in the environment.

See confinement for a more extensive discussion.

1. In the context of waste disposal, the containment of the radionuclides associated with the waste is through the provision of engineered barriers and natural barriers — including the waste form and packaging, backfill materials, the host environment and geological formations — for confinement of the radionuclides within the waste matrix, the packaging and the disposal facility and thus its isolation from the environment.

containment system

1. A structurally closed physical barrier (especially in a nuclear installation) designed to prevent or control the release and the dispersion of radioactive substances, and its associated systems.

2. The assembly of components of the packaging specified by the designer as intended to retain the radioactive material during transport. (See SSR-6 (Rev. 1) [2].)

1. Containment system is consistent with the general safety usage of containment, unlike confinement system and confinement.
contamination

1. *Radioactive substances* on surfaces, or within solids, liquids or gases (including the human body), where their presence is unintended or undesirable, or the *process* giving rise to their presence in such places.
   ① Also used less formally to refer to a quantity, namely the *activity* on a surface (or on a unit area of a surface).
   ① Contamination does not include residual *radioactive material* remaining at a site after the completion of decommissioning.
   ! The term contamination may have a connotation that is not intended. The term contamination refers only to the presence of radioactivity, and gives no indication of the magnitude of the hazard involved.

2. The presence of a *radioactive substance* on a surface in quantities in excess of 0.4 Bq/cm² for beta and gamma emitters and *low toxicity alpha emitters*, or 0.04 Bq/cm² for all other alpha emitters. (See SSR-6 (Rev. 1) [2].)
   ① This is a regulatory definition of contamination, specific to the Transport Regulations [2]. Levels below 0.4 Bq/cm² or 0.04 Bq/cm² would still be considered contamination according to the scientific definition (1).

   **fixed contamination.** Contamination other than non-fixed contamination. (See SSR-6 (Rev. 1) [2].)

   **non-fixed contamination.** Contamination that can be removed from a surface during routine conditions of transport. (See SSR-6 (Rev. 1) [2].)
   ① Also termed removable contamination.

contamination zone

A zone in which special *protective actions* are necessary, owing to actual or potential air contamination or loose surface contamination in excess of a specified level.

control

1. The function or power or (usually as controls) means of directing, regulating or restraining.
   ① It should be noted that the usual meaning of the English word control in safety related contexts is somewhat ‘stronger’ (more active) than that of its usual translations and other similar words in some other languages. For example, control typically implies not only checking or monitoring something but also ensuring that corrective or enforcement measures are taken if the results of the checking or monitoring indicate such a need. This is in contrast, for example, to the more limited usage of the equivalent word in French and Spanish.
**institutional control.** Control of a radioactive waste site by an authority or institution designated under the laws of a State. This control may be active (monitoring, surveillance, remedial work) or passive (land use control) and may be a factor in the design of a facility (e.g. a near surface disposal facility).

1. Most commonly used to describe controls over a disposal facility after closure or a facility undergoing decommissioning.
2. Also refers to the controls placed on a site that has been released from regulatory control under the condition of observing specified restrictions on its future use to ensure that these restrictions are complied with.
3. The term institutional control is more general than regulatory control (i.e. regulatory control may be thought of as a special form of institutional control).
4. Institutional control measures may be passive, they may be imposed for reasons not related to protection or safety (although they may nevertheless have some impact on protection and safety), they may be applied by organizations that do not meet the definition of a regulatory body, and they may apply in situations which do not fall within the scope of facilities and activities. As a result, some form of institutional control may be considered more likely to endure further into the future than regulatory control.

**regulatory control**

1. Any form of control or regulation applied to facilities and activities by a regulatory body for reasons relating to nuclear safety and radiation protection or to nuclear security.
   - In the IAEA Nuclear Security Series, the phrase ‘out of regulatory control’ is used for a situation in which nuclear material or other radioactive material is present without an appropriate authorization, either because controls have failed for some reason, or because they never existed.

See also institutional control.

2. [Any form of control or regulation applied to facilities or activities by a regulatory body for reasons relating to radiation protection or to the safety or security of radioactive sources.] (See Ref. [14].)

   - This definition is particular to the Code of Conduct on the Safety and Security of Radioactive Sources [14].

2. A standard of comparison used to check the inferences deduced from an experiment.

   - In protection and safety, a control is most commonly a sample or a group of people that has not been exposed to radiation from a particular source; the occurrence of particular effects in a sample or group of people that has been exposed is compared with that in the control to provide some indication of the effects that may be attributable to the exposure.
For example, a case–control study is a common type of epidemiological study in which the incidence of health effects (the ‘cases’) in a population that has been exposed to radiation from a particular source is compared with the incidence in a similar population (the ‘control’) that has not been exposed, to investigate whether exposure due to that source may be causing health effects.

controlled area

See area.

controlled state

See plant states (considered in design).

conveyance

(a) For transport by road or rail: any vehicle;
(b) For transport by water: any vessel, or any hold, compartment, or defined deck area of a vessel;
(c) For transport by air: any aircraft. (See SSR-6 (Rev. 1) [2].)

core components

The elements of a reactor core, other than fuel assemblies, that are used to provide structural support of the core construction, or the tools, devices or other items that are inserted into the reactor core for core monitoring, flow control or other technological purposes and are treated as core elements. Examples of core components are reactivity control devices or shutdown devices, neutron sources, dummy fuel, fuel channels, instrumentation, flow restrictors and burnable absorbers.

corrective maintenance

See maintenance.

cost–benefit analysis

See analysis.

countermeasure

An action aimed at alleviating the radiological consequences of an accident.
Countermeasures are forms of intervention. They may be protective actions or remedial actions, and these more specific terms should be used where possible. The terms countermeasure and agricultural countermeasure are not used in GSR Part 7 [15].

**agricultural countermeasure.** Action taken to reduce contamination of food, or agricultural or forestry products before they reach consumers.

Note that restrictions on the sale, movement or use of contaminated food, or agricultural or forestry products (i.e. measures to prevent their reaching consumers) are countermeasures, but are not considered to be agricultural countermeasures.

‘cradle to grave’ approach

An approach in which all the stages in the lifetime of a facility, activity or product are taken into consideration.

For example, the ‘cradle to grave’ approach to the safety and security of radioactive sources.

See ageing management.

See life cycle management.

**critical (adjective)**

In view of the number of special meanings attached to this word, particular care should be taken when using the adjective ‘critical’ in its more common English senses (i.e. to mean extremely important, or as a derivative of the verb ‘criticize’).

1. Having a reactivity of zero.
   Also used, more loosely, when the reactivity is greater than zero.

   See criticality.

2. Relating to the highest doses or risks attributable to a specified source.
   As in, for example, critical exposure pathway or critical radionuclide.

3. Capable of sustaining a nuclear chain reaction.
   As in, for example, critical mass.
critical assembly

An assembly containing fissile material intended to sustain a controlled fission chain reaction at a low power level, used to investigate reactor core geometry and composition.

A critical assembly — as a device that is designed and used to sustain nuclear reactions — may be subject to frequent changes to the configuration of the reactor core and the lattice, and may frequently be used as a mock-up of a configuration of a reactor core.

[critical group]

A group of members of the public which is reasonably homogeneous with respect to its exposure for a given radiation source and is typical of individuals receiving the highest effective dose or equivalent dose (as applicable) from the given source.

See representative person.

[hypothetical critical group]. A hypothetical group of individuals which is reasonably homogeneous with respect to the risk to which its members are subject from a given radiation source, and is representative of the individuals likely to be most at risk from the given source.

critical level

See minimum significant activity (MSA).

criticality

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

Often used, slightly more loosely, to refer to states in which the reactivity is greater than zero.

criticality accident

See accident (1).
criticality safety index (CSI)

A number assigned to a package, overpack or freight container containing fissile material that is used to provide control over the accumulation of packages, overpacks or freight containers containing fissile material. (See SSR-6 (Rev. 1) [2].)

1 The procedure for calculating the criticality safety index and the restrictions on the total sum of the criticality safety index in a freight container or aboard a conveyance are prescribed in sections V and VI of the Transport Regulations [2].

crust, Earth’s

See Earth’s crust.

[curie (Ci)]

Unit of activity, equal to $3.7 \times 10^{10}$ Bq (exactly).

1 Superseded by the becquerel (Bq). Activity values may be given in Ci (with the equivalent in Bq in parentheses) if they are being quoted from a reference which uses that unit.

1 Originally, the activity of a gram of radium.
dangerous source

See source (2).

[de minimis]

The appropriate terminology of exemption, clearance, etc., should be used in IAEA publications.

1. A general term used historically to describe concepts that would now be referred to by terms such as exemption or clearance. The term is also sometimes used to describe a related (and controversial) philosophy that assessments of collective dose should exclude that portion delivered at very low individual dose rates.

1. The term de minimis is still used in some specific contexts, such as the London Convention 1972 [16].

1. Derived from the Latin maxim ‘de minimis non curat lex’ (the law does not concern itself with trivia).

decay constant, \( \lambda \)

For a radionuclide in a particular energy state, the quotient of \( dP \) by \( dt \), where \( dP \) is the likelihood of a single nucleus undergoing a spontaneous nuclear transition from that energy state in the time interval \( dt \).

\[
\lambda = \frac{dP}{dt} = -\frac{1}{N} \frac{dN}{dt} = \frac{A}{N}
\]

where \( N \) is the number of nuclei of concern existing at time \( t \) and \( A \) is the activity.

1. The decay constant is a constant of proportionality describing the likelihood that a single nucleus will undergo a spontaneous nuclear transition from a higher energy state to a lower energy state within a differential time period. It also corresponds to:

\[
\lambda = -\lim_{\Delta t \to 0} \frac{\Delta N / N}{\Delta t} = -\frac{1}{N} \frac{dN}{dt} = \frac{A}{N}
\]

1. Unit: reciprocal second (s\(^{-1}\)).

1. The activity is the decay constant multiplied by the number of nuclei of the radionuclide present.

1. The decay constant is related to the radioactive half-life, \( T_{1/2} \), of the radionuclide by the expression:

\[
\lambda = \frac{\ln 2}{T_{1/2}}
\]
decision limit

See minimum significant activity (MSA).

decommissioning

1. Administrative and technical actions taken to allow the removal of some or all of the regulatory controls from a facility.
   ! This does not apply for that part of a disposal facility in which radioactive waste is emplaced, or for certain facilities used for the disposal of naturally occurring radioactive material (NORM) or of residues from the mining and processing of radioactive ores. For all of these the term closure is used instead of decommissioning.
   ! Decommissioning typically includes dismantling of the facility (or part thereof) to reduce the associated radiation risks, but in the IAEA’s usage this need not be the case. A facility could, for example, be decommissioned without dismantling and the existing structures subsequently put to another use (after decontamination).
   ① The use of the term decommissioning implies that no further use of the facility (or part thereof) for its existing purpose is foreseen.
   ① Actions for decommissioning are taken at the end of the operating lifetime of a facility to retire it from service with due regard for the health and safety of workers and members of the public and protection of the environment.
   ① Subject to national legal and regulatory requirements, a facility (or its remaining parts) may also be considered decommissioned if it is incorporated into a new or existing facility, even if the site on which it is located is still under regulatory control or institutional control.
   ① The actions will need to be such as to ensure the long term protection of the public and protection of the environment, and typically include reducing the levels of residual radionuclides in the materials and on the site of the facility so that the materials can be safely recycled, reused or disposed of as exempt waste or as radioactive waste and the site can be released for unrestricted use or otherwise reused.
   ① Decommissioning can entail activities that are similar to remediation (also an authorized process), such as removal of contaminated soil from an area within the authorized boundary of a facility, but in this case, such removals are normally referred to as cleanup activities and are typically performed under the authorization for decommissioning.
   ① The terms siting, design, construction, commissioning, operation and decommissioning are normally used to delineate the six major stages of the lifetime of an authorized facility and of the associated licensing process. In the special case of disposal facilities for radioactive waste, decommissioning is replaced in this sequence by closure.

decommissioning plan. A document containing detailed information on the proposed decommissioning of a facility.
   ① The approved decommissioning plan describes the actions (including decontamination and/or the removal of structures, systems and components) to be taken in carrying out procedures, processes and work activities for the purposes of decommissioning.
The decommissioning plan is considered to have been fulfilled when the approved end state of the facility has been reached.

**dismantling.** The taking apart, disassembling and tearing down of the structures, systems and components of a facility for the purposes of decommissioning.

The two main types of dismantling are immediate dismantling and deferred dismantling.

**Deferred dismantling** is deferred after permanent shutdown. For a nuclear installation, the nuclear fuel is first removed. Part or all of a facility containing radioactive material is either processed or put in such a condition that it can be put into storage. The facility is maintained until it can subsequently be decontaminated and/or dismantled.

Deferred dismantling can involve the early dismantling of some parts of the facility and the early processing of some radioactive material and its removal from the facility, as preparatory steps for storage of the remaining parts of the facility.

**Immediate dismantling** begins shortly after permanent shutdown. Equipment and the structures, systems and components of a facility containing radioactive material are removed and/or are decontaminated to a level that permits the removal of regulatory control from the facility and its release, either for unrestricted use or with restrictions on its future use.

**entombment.** The encasing of part or all of a facility in a structure of long lived material for the purposes of decommissioning.

Entombment is not considered an acceptable strategy for decommissioning a facility following planned permanent shutdown.

Entombment may be considered acceptable only under exceptional circumstances (e.g. following a severe accident). In this case, the entombment structure is maintained and surveillance is continued until the radioactive inventory decays to a level permitting termination of the licence and unrestricted release of the structure.

2. [All steps leading to the release of a nuclear facility, other than a disposal facility, from regulatory control. These steps include the processes of decontamination and dismantling.] (See Ref. [5].)

**decommissioning plan**

See decommissioning (1).
decontamination

The complete or partial removal of contamination by a deliberate physical, chemical or biological process.

1 This definition is intended to include a wide range of processes for removing contamination from people, equipment and buildings, but to exclude the removal of radionuclides from within the human body or the removal of radionuclides by natural weathering or migration processes, which are not considered to be decontamination.

See also remediation.

decontamination factor

The ratio of the activity per unit area (or per unit mass or volume) before a particular decontamination technique is applied to the activity per unit area (or per unit mass or volume) after application of the technique.

1 This ratio may be specified for a particular radionuclide or for gross activity.

1 The background activity may be deducted from the activity per unit area both before and after a particular decontamination technique is applied.

decorporation

The action of the biological processes by means of which incorporated radionuclides are removed from the human body.

1 Decorporation may be promoted by chemical or biological agents.

deep sea disposal

See disposal (3).

defence in depth

A hierarchical deployment of different levels of diverse equipment and procedures to prevent the escalation of anticipated operational occurrences and to maintain the effectiveness of physical barriers placed between a radiation source or radioactive material and workers, members of the public or the environment, in operational states and, for some barriers, in accident conditions.

1 The objectives of defence in depth are:

(a) To compensate for human induced events and component failures;
(b) To maintain the effectiveness of the barriers by averting damage to the facility and to the barriers themselves;
(c) To protect workers, members of the public and the environment from harm in accident conditions in the event that these barriers are not fully effective.
The Fundamental Safety Principles (IAEA Safety Fundamentals) [17] (para. 3.31) states that: “Defence in depth is implemented primarily through the combination of a number of consecutive and independent levels of protection that would have to fail before harmful effects could be caused to people or to the environment. If one level of protection or barrier were to fail, the subsequent level or barrier would be available. When properly implemented, defence in depth ensures that no single technical, human or organizational failure could lead to harmful effects, and that the combinations of failures that could give rise to significant harmful effects are of very low probability. The independent effectiveness of the different levels of defence is a necessary element of defence in depth.”

Five levels of defence in depth are discussed in SSR-2/1 (Rev. 1) [18] (See SSR-2/1 (Rev. 1) [18] for further information):

(a) The purpose of the first level of defence is to prevent deviations from normal operation and the failure of items important to safety.
(b) The purpose of the second level of defence is to detect and control deviations from normal operation in order to prevent anticipated operational occurrences from escalating to accident conditions.
(c) The purpose of the third level of defence is to prevent damage to the reactor core and releases of radioactive material requiring off-site protective actions and to return the plant to a safe state by means of inherent and/or engineered safety features, safety systems and procedures.
(d) The purpose of the fourth level of defence is to prevent the progress of, and to mitigate the consequences of, accidents that result from failure of the third level of defence by preventing accident sequences that lead to large release of radioactive material or early release of radioactive material from occurring.
(e) The purpose of the fifth and final level of defence is to mitigate radiological consequences of a large release of radioactive material or an early release of radioactive material that could potentially result from an accident.

The International Nuclear Safety Group (INSAG) defined five levels of defence in depth (see Ref. [19] for further information):

(a) Level 1: Prevention of abnormal operation and failures.
(b) Level 2: Control of abnormal operation and detection of failures.
(c) Level 3: Control of accidents within the design basis.
(d) Level 4: Control of severe plant conditions, including prevention of accident progression and mitigation of the consequences of severe accidents.
(e) Level 5: Mitigation of radiological consequences of significant releases of radioactive material.

The levels of defence are sometimes grouped into three safety layers: hardware, software and management control.

In the context of waste disposal, the term multiple barriers is used to describe a similar concept.

Note that defence in depth is used with a different meaning in the IAEA Nuclear Security Series in the context of nuclear security.
deferred dismantling

See decommissioning (1).

defined deck area

The area of the weather deck of a vessel, or of a vehicle deck of a roll-on/roll-off ship or ferry, that is allocated for the stowage of radioactive material. (See SSR-6 (Rev. 1) [2].)

dependability

A general term describing the overall trustworthiness of a system; that is, the extent to which reliance can justifiably be placed on this system. Reliability, availability and safety are attributes of dependability.

depleted uranium

See uranium.

derived air concentration (DAC)

A derived limit on the activity concentration in air of a specified radionuclide, calculated such that the reference individual, breathing air with constant contamination at the DAC with the breathing behaviour of a reference worker for a working year, would receive an intake corresponding to the annual limit on intake for the radionuclide in question.

1. The parameter values recommended by the International Commission on Radiological Protection for calculating DACs are a breathing rate of 1.2 m³/h and a working year of 2000 h [20–22].

1. The breathing behaviour of a reference worker as defined by the International Commission on Radiological Protection [21].

derived limit

See limit.

design

1. The process and the result of developing a concept, detailed plans, supporting calculations and specifications for a facility and its parts.
The terms sitting, design, construction, commissioning, operation and decommissioning are normally used to delineate the six major stages of the lifetime of an authorized facility and of the associated licensing process. In the special case of disposal facilities for radioactive waste, decommissioning is replaced in this sequence by closure.

2. The description of fissile material excepted [in the Transport Regulations], special form radioactive material, low dispersible radioactive material, package or packaging that enables such an item to be fully identified. The description may include specifications, engineering drawings, reports demonstrating compliance with regulatory requirements, and other relevant documentation. (See SSR-6 (Rev. 1) [2].)

This is a much more restricted definition than (1), and is specific to the Transport Regulations [2].

design basis

The range of conditions and events taken explicitly into account in the design of structures, systems and components and equipment of a facility, according to established criteria, such that the facility can withstand them without exceeding authorized limits.

Used as a noun, with the definition above. Also often used as an adjective, applied to specific categories of conditions or events to mean ‘included in the design basis’; as, for example, in design basis accident, design basis external events and design basis earthquake.

design basis accident

See plant states (considered in design).

design basis external events

The external event(s) or combination(s) of external events considered in the design basis of all or any part of a facility.

design basis probability value (DBPV)

A value of the annual probability for a particular type of event to cause unacceptable radiological consequences. It is the ratio between the screening probability level and the conditional probability value.

The term is used in the detailed event screening process for site evaluation.
design extension conditions

See plant states (considered in design).

design life

See life, lifetime.

detection limit

See minimum detectable activity (MDA).

determination level

See minimum detectable activity (MDA).

deterministic analysis

Analysis using, for key parameters, single numerical values (taken to have a probability of 1), leading to a single value for the result.

1 In the safety of nuclear installations, for example, this implies focusing on accident types, releases of radioactive material and consequences, without considering the probabilities of different event sequences.

1 Typically used with either ‘best estimate’ or ‘conservative’ values, based on expert judgement and knowledge of the phenomena being modelled.

1 Contrasting terms: probabilistic analysis or stochastic analysis.

See also probabilistic analysis.

deterministic effect

See health effects (of radiation).

detriment

See radiation detriment.

deviation

A departure from specified requirements.
diagnostic exposure

See exposure categories: medical exposure.

diagnostic reference level

See level.

diffusion

The movement of radionuclides relative to the medium in which they are distributed, under the influence of a concentration gradient.

1. Usually used for the movement of airborne radionuclides (e.g. from discharges or resulting from an accident) relative to the air, and for movement of dissolved radionuclides (e.g. in groundwater or surface water, from migration following waste disposal, or in surface water from discharges) relative to the water.

See also advection (where the radionuclide does not move relative to the carrying medium, but moves with it) and dispersion.

direct cause

See cause.

direct disposal

See disposal (1).

directional dose equivalent

See dose equivalent quantities (operational).

discharge

1. Planned and controlled release of (usually gaseous or liquid) radioactive substances to the environment.

1. Strictly, the act or process of releasing the radioactive substances, but also used to describe the radioactive substances released.

authorized discharge. Discharge in accordance with an authorization.
radioactive discharges. Radioactive substances arising from sources within facilities and activities which are discharged as gases, aerosols, liquids or solids to the environment, generally with the purpose of dilution and dispersion.

2. [A planned and controlled release to the environment, as a legitimate practice, within limits authorized by the regulatory body, of liquid or gaseous radioactive material that originates from regulated nuclear facilities during normal operation.] (See Ref. [5].)

dismantling

See decommissioning (1).

dispersal

The spreading of radioactive material in the environment.

1. In normal language synonymous with dispersion, but tends to be used in a general sense, not implying the involvement of any particular processes or phenomena, for example the uncontrolled spreading of material that has escaped from confinement, or as a result of damage to (or the destruction of) a sealed source, special form radioactive material or low dispersible radioactive material.

dispersion

The spreading of radionuclides in air (aerodynamic dispersion) or water (hydrodynamic dispersion) resulting mainly from physical processes affecting the velocity of different molecules in the medium.

1. Often used in a more general sense combining all processes (including molecular diffusion) that result in the spreading of a plume. The terms atmospheric dispersion and hydrodynamic dispersion are used in this more general sense for plumes in air and water, respectively.

1. In usual language synonymous with dispersal, but dispersion is mostly used more specifically as defined above, whereas dispersal is typically (though not universally) used as a more general expression.

See also advection and diffusion.

disposal

1. Emplacement of waste in an appropriate facility without the intention of retrieval.
In some States, the term *disposal* is used to include *discharges* of effluents to the environment.

In some States, the term *disposal* is used administratively in such a way as to include, for example, incineration of *waste* or the transfer of *waste* between operators.

In *IAEA* publications, *disposal* should be used only in accordance with the more restrictive definition given above.

In many cases, the only element of this definition that is important is the distinction between *disposal* (with no intent to retrieve) and *storage* (with intent to retrieve). In such cases, a definition is not necessary; the distinction can be made in the form of a footnote at the first use of the term *disposal* or *storage* (e.g. “The use of the term ‘disposal’ indicates that there is no intention to retrieve the waste. If retrieval of the waste at any time in the future is intended, the term ‘storage’ is used.”).

The term *disposal* implies that retrieval is not intended and would require deliberate action to regain access to the waste; it does not mean that retrieval is not possible.

For *storage* in a combined *storage* and *disposal* facility, for which a decision may be made at the time of its closure whether to remove the *waste* stored during the operation of the *storage* facility or to dispose of it by encasing it in concrete, the question of intention of retrieval may be left open until the time of closure of the facility.

Contrasted with *storage*.

**direct disposal.** Disposal of spent fuel as waste.

**geological disposal.** Disposal in a geological disposal facility.

See also *repository*.

The term ‘intermediate depth disposal’ is sometimes used for the *disposal* of *low level waste* and *intermediate level waste*, for example in boreholes (i.e. between near surface disposal and geological disposal).

**near surface disposal.** Disposal, under an engineered cover, with or without additional engineered barriers, in a near surface disposal facility.

**sub-seabed disposal.** Disposal in a geological disposal facility in the rock underlying the seabed.

2. [The emplacement of spent fuel or radioactive waste in an appropriate facility without the intention of retrieval.] (See Ref. [5].)

3. The act or process of getting rid of waste, without the intention of retrieval.

The terms *deep sea disposal* and *seabed disposal* do not strictly satisfy definitions (1) or (2), but are consistent with the everyday meaning of *disposal* and are used as such.
**deep sea disposal.** Disposal of waste packaged in containers on the deep ocean floor.

1. The commonly used, but informal, term ‘sea dumping’ should not be used in IAEA publications.

1. As practised until 1982 in accordance with the requirements of the London Convention 1972 [16].

**seabed disposal.** Emplacement of waste packaged in suitable containers at some depth into the sedimentary layers of the deep ocean floor.

1. This may be achieved by direct emplacement, or by placing the waste in specially designed ‘penetrators’ which, when dropped into the sea, embed themselves in the sediment.

**disposal facility**

An engineered facility where waste is emplaced for disposal.

1. Synonymous with repository.

**disposal system.** The system of properties of the site for a disposal facility, design of the disposal facility, physical structures and items, procedures for control, characteristics of waste and other elements that contribute in different ways and over different timescales to the fulfilment of safety functions for disposal.

**geological disposal facility.** A facility for radioactive waste disposal located underground (usually several hundred metres or more below the surface) in a stable geological formation to provide long term isolation of radionuclides from the biosphere.

**near surface disposal facility.** A facility for radioactive waste disposal located at or within a few tens of metres of the Earth’s surface.

1. The practice of disposal of waste in a near surface disposal facility with an engineered cover is also referred to as ‘shallow land burial’ of waste.

**disposal system**

See disposal facility.

**disposition**

Consigning of, or arrangements for the consigning of, radioactive waste for some specified (interim or final) destination, for example for the purpose of processing, disposal or storage.
disused sealed source

See source (2): disused source.

disused source

See source (2).

diversity

The presence of two or more independent (redundant) systems or components to perform an identified function, where the different systems or components have different attributes so as to reduce the possibility of common cause failure, including common mode failure.

• Examples of such attributes are: different operating conditions, different working principles or different design teams (which provide functional diversity), and different sizes of equipment, different manufacturers, and types of equipment (which provide diversity of equipment) that use different physical methods (which provide physical diversity).

functional diversity. Application of diversity at the level of functions in applications in process engineering (e.g. for the actuation of a trip on both a pressure limit and a temperature limit).

dose

1. A measure of the energy deposited by radiation in a target.

• For definitions of the most important such measures, see dose quantities and dose concepts.

2. Absorbed dose, committed equivalent dose, committed effective dose, equivalent dose, effective dose or organ dose, as indicated by the context.

committed dose. Committed equivalent dose or committed effective dose.

dose and dose rate effectiveness factor (DDREF)

The ratio between the risk or radiation detriment per unit effective dose for high doses and/or dose rates and that for low doses and dose rates.

• Used in the estimation of risk coefficients for low doses and dose rates from observations and epidemiological findings at high doses and dose rates.

• Supersedes the dose rate effectiveness factor (DREF).
dose assessment

See assessment (1).

dose coefficient

① Used by the International Commission on Radiological Protection and others as a synonym for dose per unit intake, but sometimes also used to describe other coefficients linking quantities or concentrations of activity to doses or dose rates, such as the external dose rate at a specified distance above a surface with a deposit of a specified activity per unit area of a specified radionuclide.

! To avoid confusion, the term dose coefficient should be used with care.

[dose commitment]

See dose concepts.

dose concepts

annual dose. The dose from external exposure in a year plus the committed dose from intakes of radionuclides in that year.

① The individual dose, unless otherwise stated.

! This is not, in general, the same as the dose actually delivered during the year in question, which would include doses from radionuclides remaining in the body from intakes in previous years, and would exclude doses delivered in future years from intakes of radionuclides during the year in question.

averted dose. The dose prevented by protective actions.

collective dose. The total radiation dose incurred by a population.

① This is the sum of all of the individual doses to members of the population. If the doses continue for longer than a year, then the annual individual doses must also be integrated over time.

① Unless otherwise specified, the time over which the dose is integrated is infinite; if a finite upper limit is applied to the time integration, the collective dose is described as ‘truncated’ at that time.

① Although the upper limit for the integral for collective dose could in principle be infinite, in most assessments of collective dose the component part associated with individual doses or dose rates that are higher than the thresholds for the induction of deterministic effects would be considered separately.

① Unless otherwise specified, the relevant dose is normally the effective dose (collective effective dose has a formal definition).

① Unit: person-sievert (person Sv). This is, strictly, just a sievert, but the unit person-sievert is used to distinguish the collective dose from the individual dose which a dosimeter would measure (just as, for example, ‘person-hours’ are used to measure...
the total effort devoted to a task, as opposed to the elapsed time that would be shown by a clock).

Contrasting term: *individual dose*.

**committed dose.** The *lifetime dose* expected to result from an *intake*.

This term partially supersedes *dose commitment*.

See dose quantities: *committed equivalent dose* and *committed effective dose*.

**[dose commitment]**. The total *dose* that would eventually result from an event (e.g. a *release* of radioactive material), a deliberate action or a finite portion of a *practice*.

More specific and precise terms such as *committed dose* or *collective dose* should be used as appropriate.

**individual dose.** The *dose* incurred by an individual.

Contrasting term: *collective dose*.

**lifetime dose.** The total *dose* received by an individual during his or her lifetime.

In practice, often approximated as the sum of the *annual doses* incurred. Since *annual doses* include *committed doses*, some parts of some of the *annual doses* may not actually be delivered within the lifetime of the individual, and therefore this may overestimate the true *lifetime dose*.

For prospective assessments of *lifetime dose*, a lifetime is normally interpreted as 70 years.

**projected dose.** The *dose* that would be expected to be received if planned *protective actions* were not taken.

**residual dose.** The *dose* expected to be incurred after *protective actions* have been terminated (or after a decision has been taken not to take *protective actions*).

Residual dose applies for an *emergency exposure situation* or for an *existing exposure situation*.

**dose constraint**

A prospective and *source* related value of *individual dose* that is used in planned exposure situations as a parameter for the optimization of protection and safety for the *source*, and that serves as a boundary in defining the range of options in optimization.
For occupational exposure, the dose constraint is a constraint on individual dose to workers established and used by registrants and licensees to set the range of options in optimizing protection and safety for the source.

For public exposure, the dose constraint is a source related value established or approved by the government or the regulatory body, with account taken of the doses from planned operations of all sources under control.

The dose constraint for each particular source is intended, among other things, to ensure that the sum of doses from planned operations for all sources under control remains within the dose limit.

For medical exposure, the dose constraint is a source related value used in optimizing the protection of carers and comforters of patients undergoing radiological procedures, and the protection of volunteers subject to exposure as part of a programme of biomedical research.

dose conversion convention

The assumed relationship between potential alpha energy exposure and effective dose.

1. Used to estimate doses from measured or estimated exposure due to radon.

See also exposure (4).

1. Unit: mSv per J·h/m³.

dose equivalent

The product of the absorbed dose at a point in the tissue or organ and the appropriate quality factor for the type of radiation giving rise to the dose.

1. A measure of the dose to a tissue or organ designed to reflect the amount of harm caused.

1. For radiation protection purposes the quantity dose equivalent has been superseded by equivalent dose.

1. Dose equivalent is also a term used by the International Commission on Radiation Units and Measurements in defining the following operational quantities: ambient dose equivalent, directional dose equivalent and personal dose equivalent (see dose equivalent quantities).

[effective dose equivalent, $H_E$]. A measure of dose designed to reflect the risk associated with the dose, calculated as the weighted sum of the dose equivalents in the different tissues of the body.

1. Superseded by effective dose.

dose equivalent quantities (operational)

ambient dose equivalent, $H^*(d)$. The dose equivalent that would be produced by the corresponding aligned and expanded field in the
ICRU sphere at a depth $d$ on the radius vector opposing the direction of the aligned field.

1. Parameter defined at a point in a radiation field. Used as a directly measurable proxy (i.e. substitute) for effective dose for use in monitoring of external exposure.

2. The recommended value of $d$ for strongly penetrating radiation is 10 mm.

**directional dose equivalent, $H'(d,\Omega)$.** The dose equivalent that would be produced by the corresponding expanded field in the ICRU sphere at a depth $d$ on a radius in a specified direction $\Omega$.

1. Parameter defined at a point in a radiation field. Used as a directly measurable proxy (i.e. substitute) for equivalent dose in the skin in monitoring of external exposure.

2. The recommended value of $d$ for weakly penetrating radiation is 0.07 mm.

**personal dose equivalent, $H_p(d)$.** The dose equivalent in soft tissue below a specified point on the body at an appropriate depth $d$.

1. Parameter used as a directly measurable proxy (i.e. substitute) for equivalent dose in tissues or organs or (with $d = 10$ mm) for effective dose, in individual monitoring of external exposure.

2. The recommended values of $d$ are 10 mm for strongly penetrating radiation and 0.07 mm for weakly penetrating radiation.

3. $H_p(0.07)$ is used for monitoring for hands and feet for all radiation types.

4. $H_p(3)$ is used for monitoring exposure of the lens of the eye.

5. ’Soft tissue’ is commonly interpreted as the ICRU sphere.

6. Recommended by the International Commission on Radiation Units and Measurements [23, 24] as a simplification of the two separate terms [individual dose equivalent, penetrating, $H_p(d)$], and [individual dose equivalent, superficial, $H_s(d)$], defined in Ref. [25].

**dose limit**

See limit.

**dose per unit intake**

The committed effective dose or the committed equivalent dose resulting from intake, by a specified means (usually ingestion or inhalation), of unit activity of a specified radionuclide in a specified chemical form.

1. Values are specified in GSR Part 3 [1] and recommended by the International Commission on Radiological Protection [22].

2. For intakes, synonymous with dose coefficient.

3. Unit: Sv/Bq.

**dose quantities**

**absorbed dose, $D$.** The fundamental dosimetric quantity $D$, defined as:
$D = \frac{d\bar{E}}{dm}$

where $d\bar{E}$ is the mean energy imparted by ionizing radiation to matter in a volume element and $dm$ is the mass of matter in the volume element.

1. The energy can be averaged over any defined volume, the average dose being equal to the total energy imparted in the volume divided by the mass in the volume.
2. Absorbed dose is defined at a point; for the average dose in a tissue or organ, see organ dose.
3. The SI unit for absorbed dose is joule per kilogram (J/kg), termed the gray (Gy) (formerly, the rad was used).

**Relative biological effectiveness (RBE) weighted absorbed dose, $AD_{T,R}$.**

The quantity $AD_{T,R}$, defined as:

$$AD_{T,R} = D_{T,R} \times RBE_{T,R}$$

where $D_{T,R}$ is the absorbed dose delivered by radiation of type R averaged over a tissue or organ T and $RBE_{T,R}$ is the relative biological effectiveness for radiation of type R in the production of severe deterministic effects in a tissue or organ T. When the radiation field is composed of different radiation types with different values of $RBE_{T,R}$, the RBE weighted absorbed dose is given by:

$$AD_T = \sum_R D_{T,R} \times RBE_{T,R}$$

1. The unit of RBE weighted absorbed dose is the gray (Gy), equal to 1 J/kg.
2. RBE weighted absorbed dose is a measure of the dose to a tissue or organ, intended to reflect the risk of development of severe deterministic effects.
3. Values of RBE weighted absorbed dose to a specified tissue or organ from any type(s) of radiation can be compared directly.

**Committed effective dose, $E(\tau)$.** The quantity $E(\tau)$, defined as:

$$E(\tau) = \sum_T w_T \cdot H_T(\tau)$$

where $H_T(\tau)$ is the committed equivalent dose to tissue or organ T over the integration time $\tau$ elapsed after an intake of radioactive substances and $w_T$ is the tissue weighting factor for tissue or organ T. Where $\tau$ is not specified, it will be taken to be 50 years for adults and the time to the age of 70 years for intakes by children.

1. That is, for intakes by children, 70 years minus the age in years: so, for example, 60 years for a 10 year old child.
**committed equivalent dose, \( H_T(\tau) \).** The quantity \( H_T(\tau) \), defined as:

\[
H_T(\tau) = \int_{t_0}^{t_0+\tau} \dot{H}_T(t) \, dt
\]

where \( t_0 \) is the time of intake, \( \dot{H}_T(t) \) is the *equivalent dose rate* at time \( t \) in tissue or organ \( T \) and \( \tau \) is the integration time elapsed after an *intake* of radioactive substances. Where \( \tau \) is not specified, it is taken to be 50 years for adults and the time to the age of 70 years for *intakes* by children.\(^1\) That is, for *intakes* by children, 70 years minus the age in years: so for example 60 years for a 10 year old child.

**effective dose, \( E \).** The quantity \( E \), defined as a summation of the tissue or organ *equivalent doses*, each multiplied by the appropriate *tissue weighting factor*:

\[
E = \sum_T w_T \cdot H_T
\]

where \( H_T \) is the *equivalent dose* in tissue or organ \( T \) and \( w_T \) is the *tissue weighting factor* for tissue or organ \( T \).

From the definition of *equivalent dose*, it follows that:

\[
E = \sum_T w_T \cdot \sum_R w_R \cdot D_{T,R}
\]

where \( w_R \) is the *radiation weighting factor* for radiation type \( R \) and \( D_{T,R} \) is the average *absorbed dose* in the tissue or organ \( T \) delivered by radiation type \( R \).\(^1\) The SI unit for *effective dose* is joule per kilogram (J/kg), termed the *sievert* (Sv). An explanation of the quantity is given in annex B to Ref. [26].\(^1\) The *rem*, equal to 0.01 Sv, is sometimes used as a unit of *equivalent dose* and *effective dose*. This should not be used in IAEA publications, except when quoting directly from other publications, in which case the value in sieverts should be added in parentheses.\(^1\)

*Effective dose* is a measure of *dose* designed to reflect the amount of *radiation detriment* likely to result from the *dose*.\(^1\)*Effective dose* cannot be used to quantify higher *doses* or to make decisions on the need for any medical treatment relating to *deterministic effects*.\(^1\) Values of *effective dose* from *exposure* for any type(s) of *radiation* and any mode(s) of *exposure* can be compared directly.\(^1\)

**equivalent dose, \( H_{T,R} \).** The quantity \( H_{T,R} \), defined as:

\[
H_{T,R} = w_R \cdot D_{T,R}
\]
where \( D_{T,R} \) is the \textit{absorbed dose} delivered by \textit{radiation} type \( R \) averaged over a tissue or organ \( T \) and \( w_R \) is the \textit{radiation weighting factor} for \textit{radiation} type \( R \).

When the \textit{radiation} field is composed of different \textit{radiation} types with different values of \( w_R \), the \textit{equivalent dose} is:

\[
H_T = \sum_R w_R \cdot D_{T,R}
\]

1. The SI unit for \textit{equivalent dose} is joule per kilogram (J/kg), termed the sievert (Sv). An explanation of the quantity is given in annex B to Ref. [26].

2. The \textit{rem}, equal to 0.01 Sv, is sometimes used as a unit of \textit{equivalent dose} and \textit{effective dose}. This should not be used in \textit{IAEA publications}, except when quoting directly from other publications, in which case the value in sieverts should be added in parentheses.

3. \textit{Equivalent dose} is a measure of the \textit{dose} to a tissue or organ designed to reflect the amount of harm caused.

4. \textit{Equivalent dose} cannot be used to quantify higher \textit{doses} or to make decisions on the need for any medical treatment relating to \textit{deterministic effects}.

5. \textit{Values of equivalent dose} to a specified tissue or organ from any type(s) of \textit{radiation} can be compared directly.

\textbf{organ dose}. The mean \textit{absorbed dose} \( D_T \) in a specified tissue or organ \( T \) of the human body, given by:

\[
D_T = \frac{1}{m_T} \int_{m_T}^D D \cdot dm = \frac{\varepsilon_T}{m_T}
\]

where \( m_T \) is the mass of the tissue or organ, \( D \) is the \textit{absorbed dose} in the mass element \( dm \) and \( \varepsilon_T \) is the total energy imparted.

1. Sometimes called \textit{tissue dose}.

\textbf{dose rate}

1. The \textit{dose} per unit time.

    ! Although \textit{dose rate} could, in principle, be defined over any unit of time (e.g. an annual dose is technically a dose rate), in \textit{IAEA publications} the term \textit{dose rate} should be used only in the context of short periods of time, for example \textit{dose} per second or \textit{dose} per hour.

2. The \textit{ambient dose equivalent} or the \textit{directional dose equivalent}, as appropriate, per unit time, measured at the point of interest. (See SSR-6 (Rev. 1) [2].)

    ! This usage is specific to the Transport Regulations [2].
[dose rate effectiveness factor (DREF)]

The ratio between the risk per unit effective dose for high dose rates and that for low dose rates.

Superseded by dose and dose rate effectiveness factor (DDREF).

double contingency principle

See single failure criterion.

drawdown

A falling of the water level at a coastal site.

driven equipment

A component such as a pump or valve that is operated by a prime mover.

dry storage

See storage.
early effect

See health effects (of radiation).

early protective actions

See protective action (1).

early release of radioactive material

A release of radioactive material for which off-site protective actions are necessary but are unlikely to be fully effective in due time.

① See also large release of radioactive material and defence in depth.

early response phase

See emergency response phase.

Earth’s crust

The outermost solid layer of the Earth.

① The Earth’s crust represents less than 1% of the Earth’s volume and varies in thickness from approximately 6 km beneath the oceans to approximately 60 km beneath mountain chains.

Earth’s mantle

A solid layer of the Earth, approximately 2300 km thick, located between the Earth’s crust and the Earth’s core.

① Basaltic magma forms from the partial melting of mantle rocks.

effective dose

See dose quantities.

[effective dose equivalent]

See dose equivalent.
effective half-life

See half-life (2).

effusive eruption

See eruption.

elimination, practical

See practical elimination.

emergency

A non-routine situation or event that necessitates prompt action, primarily to mitigate a hazard or adverse consequences for human life, health, property and the environment.

1. This includes nuclear and radiological emergencies and conventional emergencies such as fires, releases of hazardous chemicals, storms or earthquakes.

2. This includes situations for which prompt action is warranted to mitigate the effects of a perceived hazard.

3. Terms and definitions relating to an emergency are taken from GSR Part 7 [15].

See also emergency class.

nuclear or radiological emergency. An emergency in which there is, or is perceived to be, a hazard due to:

(a) The energy resulting from a nuclear chain reaction or from the decay of the products of a chain reaction; or

(b) Radiation exposure.

1. Points (a) and (b) approximately represent nuclear and radiological emergencies, respectively. However, this is not an exact distinction.

1. Radiation emergency is used in some cases when an explicit distinction in the nature of the hazard is immaterial (e.g. national radiation emergency plan), and it has essentially the same meaning.

transnational emergency. A nuclear or radiological emergency of actual, potential or perceived radiological significance for more than one State.
This may include:

1. A significant transboundary release of radioactive material (however, a transnational emergency does not necessarily imply a significant transboundary release of radioactive material);
2. A general emergency at a facility or other event that could result in a significant transboundary release (atmospheric or aquatic) of radioactive material;
3. Discovery of the loss or illicit removal of a dangerous source that has been transported across, or is suspected of having been transported across, a national border;
4. An emergency resulting in significant disruption to international trade or travel;
5. An emergency warranting the taking of protective actions for foreign nationals or embassies in the State in which it occurs;
6. An emergency resulting or potentially resulting in severe deterministic effects and involving a fault and/or problem (such as in equipment or software) that could have serious implications for safety internationally;
7. An emergency resulting in or potentially resulting in great concern among the population of more than one State owing to the actual or perceived radiological hazard.

emergency action level (EAL)

See level.

emergency arrangements

The integrated set of infrastructural elements, put in place at the preparedness stage, that are necessary to provide the capability for performing a specified function or task required in response to a nuclear or radiological emergency.

These elements may include: authorities and responsibilities, organization, coordination, personnel, plans, procedures, facilities, equipment or training.

emergency class

A set of conditions that warrant a similar immediate emergency response.

This is the term used for communicating to the response organizations and to the public the level of response needed. The events that belong to a given emergency class are defined by criteria specific to the installation, source or activities, which, if exceeded, indicate classification at the prescribed level. For each emergency class, the initial actions of the response organizations are predefined.
IAEA safety standards specify five emergency classes, namely general emergency, site area emergency, facility emergency, alert and other nuclear or radiological emergency [15]:

(a) **general emergency.** At facilities in emergency preparedness category I or II, an emergency that warrants taking precautionary urgent protective actions, urgent protective actions and early protective actions and other response actions on the site and off the site.

When a general emergency is declared, appropriate actions are promptly taken, on the basis of the available information relating to the emergency, to mitigate the consequences of the emergency on the site and to protect people on the site and off the site.

(b) **site area emergency.** At facilities in emergency preparedness category I or II, an emergency that warrants taking protective actions and other response actions on the site and in the vicinity of the site.

When a site area emergency is declared, actions are promptly taken: (i) to mitigate the consequences of the emergency on the site and to protect people on the site; (ii) to increase the readiness to take protective actions and other response actions off the site if this becomes necessary on the basis of observable conditions, reliable assessments and/or results of monitoring; and (iii) to conduct off-site monitoring, sampling and analysis.

(c) **facility emergency.** At facilities in emergency preparedness category I, II or III, an emergency that warrants taking protective actions and other response actions at the facility and on the site but does not warrant taking protective actions off the site.

When a facility emergency is declared, actions are promptly taken to mitigate the consequences of the emergency and to protect people.

(d) **alert.** At facilities in emergency preparedness category I, II or III, an event that warrants taking actions to assess and to mitigate the potential consequences at the facility.

When an alert is declared, actions are promptly taken to assess and to mitigate the potential consequences of the event and to increase the readiness of the on-site response organizations.

(e) **other nuclear or radiological emergency.** An emergency in emergency preparedness category IV that warrants taking protective actions and other response actions at any location.

When such an emergency is declared, actions are promptly taken to mitigate the consequences of the emergency on the site; to protect those in the vicinity (e.g. workers and emergency workers and the public) and to determine where and for whom protective actions and other response actions are warranted; to assess and to mitigate the potential consequences of the event; and to increase the readiness of the on-site response organizations.

**emergency classification**

The process whereby an authorized official classifies an emergency in order to declare the applicable emergency class.
Upon declaration of the emergency class, the response organizations initiate the predefined emergency response actions for that emergency class.

emergency exposure

See exposure situations: emergency exposure situation.

emergency exposure situation

See exposure situations.

emergency phase

See emergency response phase.

emergency plan

A description of the objectives, policy and concept of operations for the response to an emergency and of the structure, authorities and responsibilities for a systematic, coordinated and effective response. The emergency plan serves as the basis for the development of other plans, procedures and checklists.

Emergency plans are prepared at several different levels: international, national, regional, local and facility. They may include all activities planned to be carried out by all relevant organizations and authorities, or may be primarily concerned with the actions to be carried out by a particular organization.

Details regarding the accomplishment of specific tasks outlined in an emergency plan are contained in emergency procedures.

custom of operations. A brief description of an ideal response to a postulated nuclear or radiological emergency, used to ensure that all those personnel and organizations involved in the development of a capability for emergency response share a common understanding.

emergency planning distance

The extended planning distance and the ingestion and commodities planning distance.

extended planning distance (EPD). The area around a facility within which emergency arrangements are made to conduct monitoring following the declaration of a general emergency and to identify areas warranting emergency response actions to be taken off the site within a period
following a significant radioactive release that would allow the risk of stochastic effects among members of the public to be effectively reduced.

1. The area within the extended planning distance serves for planning purposes and may not be the actual area in which monitoring is to be conducted to identify areas where early protective actions such as relocation are necessary.

2. While efforts need to be made at the preparedness stage to prepare for taking effective early protective actions within this area, the actual area will be determined by the prevailing conditions in an emergency.

3. As a precaution, some urgent actions may be warranted within the extended planning distance to reduce the risk of stochastic effects among members of the public.

**Ingestion and commodities planning distance (ICPD).** The area around a facility for which emergency arrangements are made to take effective emergency response actions following the declaration of a general emergency in order to reduce the risk of stochastic effects among members of the public and to mitigate non-radiological consequences as a result of the distribution, sale and consumption of food, milk and drinking water and the use of commodities other than food that may have contamination from a significant radioactive release.

1. The area within the ingestion and commodities planning distance serves for planning purposes to prepare for emergency response actions to monitor and control commodities, including food, either for domestic use or international trade.

2. The actual area will be determined on the basis of the prevailing conditions in an emergency.

3. As a precaution, some urgent protective actions may be warranted within the ingestion and commodities planning distance to prevent the ingestion of food, milk or drinking water and to prevent the use of commodities that may have contamination following a significant radioactive release.

**Emergency planning zone**

The precautionary action zone and the urgent protective action planning zone.

**Precautionary action zone (PAZ).** An area around a facility for which emergency arrangements have been made to take urgent protective actions in the event of a nuclear or radiological emergency to avoid or to minimize severe deterministic effects off the site. Protective actions within this area are to be taken before or shortly after a release of radioactive material or an exposure, on the basis of prevailing conditions at the facility.

**Urgent protective action planning zone (UPZ).** An area around a facility for which arrangements have been made to take urgent protective actions in the event of a nuclear or radiological emergency to avert doses off the
site in accordance with international safety standards. Protective actions within this area are to be taken on the basis of environmental monitoring — or, as appropriate, prevailing conditions at the facility.

**emergency preparedness**

The capability to take actions that will effectively mitigate the consequences of an emergency for human life, health, property and the environment.

**emergency preparedness category.** A category for hazards assessed by means of a hazard assessment to provide the basis for a graded approach to the application of the requirements established in GSR Part 7 [15] and for developing generically justified and optimized arrangements for preparedness and response for a nuclear or radiological emergency.

1. Table 1 of GSR Part 7 [15] describes the emergency preparedness categories.

**preparedness stage.** The stage or phase at which arrangements for an effective emergency response are established prior to a nuclear or radiological emergency.

**emergency preparedness category**

See emergency preparedness.

**emergency procedures**

A set of instructions describing in detail the actions to be taken by emergency workers in an emergency.

**emergency response**

The performance of actions to mitigate the consequences of an emergency for human life, health, property and the environment.

1. The emergency response also provides a basis for the resumption of normal social and economic activity.

**emergency response action.** An action to be taken in response to a nuclear or radiological emergency to mitigate the consequences of an emergency for human life, health, property and the environment.

1. Emergency response actions comprise protective actions and other response actions.

1. Also called emergency action.
**other response action.** An emergency response action other than a protective action.

1. The most common other response actions are: medical examination, consultation and treatment; registration and long term medical follow-up; provision of psychological counselling; and public information and other actions for mitigating non-radiological consequences and for public reassurance.

**emergency response action**

See emergency response.

**emergency response commander**

The individual responsible for directing the response of all organizations responding to an emergency (including the response to radiological hazards, the response to conventional hazards and law enforcement).

1. Also referred to as incident commander.

**emergency response facility or location**

A facility or location necessary for supporting an emergency response, for which specific functions are to be assigned at the preparedness stage, and which need to be usable under emergency conditions.

1. There are two different types of emergency response facility or location: those established in advance (e.g. a technical support centre for a nuclear power plant) and those designated at the time of an emergency (e.g. a medical screening and triage area).

1. For both types, advance preparations are necessary to ensure their operability under emergency conditions. Depending on the emergency preparedness category and on the nature of an emergency, an emergency response facility may be designated an emergency response location.

1. For a nuclear power plant and other facilities in emergency preparedness category 1, emergency response facilities (which are separate from the control room and the supplementary control room) include: the technical support centre, from which technical support can be provided to the operating personnel in the control room in an emergency; the operational support centre, from which operational control can be maintained by personnel performing tasks at or near the facility; and the emergency centre, from which the on-site emergency response is managed.

**emergency response phase**

The period of time from the detection of conditions warranting an emergency response until the completion of all the emergency response actions.
taken in anticipation of or in response to the radiological conditions expected in the first few months of the emergency.

1. The emergency response phase typically ends when the situation is under control, the off-site radiological conditions have been characterized sufficiently well to identify whether and where food restrictions and temporary relocation are required, and all required food restrictions and temporary relocations have been put into effect.

2. Also called the emergency phase.

early response phase. The period of time, within the emergency response phase, from which a radiological situation is already characterized sufficiently well that a need for taking early protective actions and other response actions can be identified, until the completion of all such actions.

1. The early response phase may last from days to weeks depending on the nature and scale of the nuclear or radiological emergency.

urgent response phase. The period of time, within the emergency response phase, from the detection of conditions warranting emergency response actions that must be taken promptly in order to be effective until the completion of all such actions.

1. Such emergency response actions include mitigatory actions by the operator and urgent protective actions on the site and off the site.

1. The urgent response phase may last from hours to days depending on the nature and scale of the nuclear or radiological emergency.

emergency services

The local off-site response organizations that are generally available and that perform emergency response functions. These may include police, firefighters and rescue brigades, ambulance services, and control teams for hazardous materials.

emergency worker

A person having specified duties as a worker in response to an emergency.

1. Emergency workers may include workers employed, both directly and indirectly, by registrants and licensees, as well as personnel of response organizations, such as police officers, firefighters, medical personnel, and drivers and crews of vehicles used for evacuation.

1. Emergency workers may or may not be designated as such in advance of an emergency. Emergency workers not designated as such in advance of an emergency are not necessarily workers prior to the emergency.
employer

A person or organization with recognized responsibilities, commitments and duties towards a worker in the employment of the person or organization by virtue of a mutually agreed relationship.

A self-employed person is regarded as being both an employer and a worker.

depend point

1. The final stage of a process, especially the point at which an effect is observed.

   ① Used, somewhat loosely, to describe a range of different results or consequences. For example, the term ‘biological end point’ is used to describe a health effect (or a probability of that health effect) that could result from exposure.

2. A radiological or other measure of protection or safety that is the calculated result of an analysis or assessment.

   ① Common end points include estimates of dose or risk, estimated frequency or probability of an event or type of event (such as damage to the reactor core), expected number of health effects in a population, predicted environmental concentrations of radionuclides, etc.

3. A predetermined criterion defining the point at which a specific task or process will be considered completed.

   ① This usage often occurs in contexts such as decontamination or remediation, where the end point is typically the level of contamination beyond which further decontamination or remediation is considered unnecessary.

   ① In such a context, this criterion may also be an end point in the sense of definition (2) — such criteria are often calculated on the basis of a level of dose or risk that is considered acceptable — but its application to the actual decontamination or remediation operations is in the sense of definition (3).

depend state

1. The state of radioactive waste in the final stage of radioactive waste management, in which the waste is passively safe and does not depend on institutional control.

   ① In the context of radioactive waste management, the end state refers to disposal.

2. A predetermined criterion defining the point at which a specific task or process is to be considered completed.

   ① Used in relation to decommissioning activities as the final state of decommissioning of a facility; and used in relation to remediation as the final status of a site at the
end of activities for decommissioning and/or remediation, including approval of the radiological and physical conditions of the site and remaining structures.

energy fluence

See fluence.

enforcement

The application by a regulatory body of sanctions against an operator, intended to correct and, as appropriate, penalize non-compliance with conditions of an authorization.

enriched uranium

See uranium.

entombment

See decommissioning (1).

entrance surface dose

Absorbed dose in the centre of the field at the surface of entry of radiation for a patient undergoing a radiodiagnostic examination, expressed in air and with backscatter.

environment

The conditions under which people, animals and plants live or develop and which sustain all life and development; especially such conditions as affected by human activities.

environmental monitoring

See monitoring (1).
epicentre

The point on the Earth’s surface directly above the focus (i.e. hypocentre) of an earthquake.

episodic uncertainty

See uncertainty.

equilibrium, radioactive

See radioactive equilibrium.

equilibrium equivalent concentration (EEC)

The activity concentration of $^{222}$Rn or $^{220}$Rn in radioactive equilibrium with its short lived progeny that would have the same potential alpha energy concentration as the actual (non-equilibrium) mixture.

1. The equilibrium equivalent concentration of $^{222}$Rn is given by:
$$EEC^{^{222}Rn} = (0.104 \times C(218Po)) + (0.514 \times C(214Pb)) + (0.382 \times C(214Bi))$$
where $C(x)$ is the activity concentration of nuclide $x$ in air. 1 Bq/m$^3$ $EEC^{^{222}Rn}$ corresponds to $5.56 \times 10^{-6}$ mJ/m$^3$.

2. The equilibrium equivalent concentration of $^{220}$Rn is given by:
$$EEC^{^{220}Rn} = (0.913 \times C(212Pb)) + (0.087 \times C(212Bi))$$
where $C(x)$ is the activity concentration of nuclide $x$ in air. 1 Bq/m$^3$ $EEC^{^{220}Rn}$ corresponds to $7.57 \times 10^{-5}$ mJ/m$^3$.

equilibrium factor

The ratio of the equilibrium equivalent concentration of $^{222}$Rn to the actual $^{222}$Rn activity concentration.

equipment qualification

See qualification.

equivalent dose

See dose quantities.

eruption, volcanic

See volcanic eruption.
eruption cloud

A cloud of tephra and gases that forms above a *volcanic vent* during explosive *volcanic eruptions*.

1. The vertical pillar of tephra and gases that forms during most explosive activity is referred to as an *eruption column*, or strong plume, and includes a momentum dominated region and a buoyancy dominated region.
2. *Eruption clouds* may rapidly spread laterally under gravity, especially in the most energetic eruptions, and may drift thousands of kilometres downwind.
3. Large *eruption clouds* can encircle the Earth within days.

essential services

1. The supply of resources, including electricity, gas, water, compressed air, fuel and lubricants, necessary to maintain *safety systems* of a nuclear power plant operational at all times.

evacuation

The rapid, temporary removal of people from an area to avoid or reduce short term *radiation exposure* in a *nuclear or radiological emergency*.

1. *Evacuation* is an *urgent protective action*. It is expected to be in place for a short period of time (e.g. a day to a few weeks). If *evacuation* cannot be lifted within this short period of time, it should be substituted by *relocation*.
2. *Evacuation* may be taken as a *precautionary urgent protective action* based on observable conditions or plant conditions.

See also *relocation*.

event

In the context of the reporting and *analysis* of *events*, an *event* is any occurrence unintended by the *operator*, including operating error, equipment *failure* or other mishap, and deliberate action on the part of others, the consequences or potential consequences of which are not negligible from the point of view of *protection and safety*.

1. The terminology related to the reporting and *analysis* of *events* is not consistent with the terminology used in *safety standards*, and great care should be taken to avoid confusion.
2. In particular, the definition of *event* given above is identical in essence to the *safety standards* definition (1) of *accident*.
3. This difference derives from the fact that *event* reporting and *analysis* is concerned directly with the question of whether an *event* that could develop into an *accident* with significant consequences actually does so; terms such as *accident* are used only
to describe the end result and therefore other terms are needed to describe the earlier stages.

See also *initiating event* and *initiating event: postulated initiating event*.

1. *Event* is also used in the phrase ‘features, *events* and *processes*’ associated with the site and the *facility* in the context of *site characterization* for a *disposal facility* for radioactive waste.

1. Relevant features, *events* and *processes* relating to the site are those that might influence the long term performance of the *disposal facility* and thus could affect *safety*. These are addressed in a *safety case* and in a supporting *safety assessment*.

Types of events and circumstances are shown in the table below.

<table>
<thead>
<tr>
<th>Events (including anticipated operational occurrences)</th>
<th>Circumstances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidents (including initiating events, accident precursors and near misses)</td>
<td>Scenarios: postulated incidents</td>
</tr>
<tr>
<td>Accidents (unintentional causes)</td>
<td>Intentional causes (unauthorized acts: malicious and non-malicious) (e.g. sabotage, theft)</td>
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<tr>
<td>E.g. acute potential exposure</td>
<td>E.g. chronic potential exposure</td>
</tr>
<tr>
<td>Operational states, design basis accident conditions</td>
<td>Nuclear and radiological emergencies, beyond design basis accident conditions</td>
</tr>
</tbody>
</table>

**Notes:** A *scenario* is a postulated or assumed set of conditions and/or events. A *scenario* may represent the conditions at a single point in time or a single *event*, or a time history of conditions and/or *events*. *Anticipated operational occurrence*, *beyond design basis accident*, *design basis accident*: see *plant states* (considered in design).

These terms use the following attributes: acute and chronic; actual and postulated; unintentional and intentional causes; malicious and non-malicious; *nuclear* and *radiological*.

Dictionary (Concise Oxford English Dictionary [27]) definitions:

*Circumstance*: A fact or condition connected with or relevant to an *event* or an action.

*Occurrence*: The fact or frequency of something occurring; an *incident* or *event*.

*Situation*: A set of circumstances in which one finds oneself.

**event tree analysis**

See *analysis*.

**excepted package**

See *package*.
exception

① The terms exception and excepted are sometimes used to describe cases in which some of the requirements or guidance in safety standards are deemed not to apply.
① In this regard, the effect of exception may be compared with the effects of exemption and exclusion.
① However, this is in fact a usual usage of the English term exception, not a specialized term.
① The terms exemption and exclusion are necessarily linked to specific reasons for non-application, whereas exception is not.
① The term ‘excepted package’ in the Transport Regulations [2] is an example of this usage; packages may be excepted from specified requirements of the Transport Regulations if they satisfy conditions specified in the Transport Regulations.

excess risk

See risk (3).

excluded exposure

Exposure not considered amenable to control through a regulatory instrument.
① The term excluded exposure is most commonly applied to those exposures due to natural sources that are least amenable to control, such as exposures due to cosmic radiation at the Earth’s surface, 40K in the human body or naturally occurring radioactive material (NORM) in which the activity concentrations of natural radionuclides are below the relevant values given in IAEA safety standards.
① The concept is related to those of clearance (which is normally used in relation to materials) and exemption (which relates to facilities and activities or sources).
① See also exclusion.

exclusion

The deliberate excluding of a particular type of exposure from the scope of an instrument of regulatory control on the grounds that it is not considered amenable to control through the regulatory instrument in question.

exclusive use

The sole use, by a single consignor, of a conveyance or of a large freight container, in respect of which all initial, intermediate and final loading and unloading and shipment are carried out in accordance with the directions of the consignor or consignee, where so required by [the Transport] Regulations. (See SSR-6 (Rev. 1) [2].)
exempt waste

See waste.

exemption

The determination by a regulatory body that a source or practice need not be subject to some or all aspects of regulatory control on the basis that the exposure and the potential exposure due to the source or practice are too small to warrant the application of those aspects or that this is the optimum option for protection irrespective of the actual level of the doses or risks.

See also clearance (1) and exclusion.

exemption level

See level.

existing exposure situation

See exposure situations.

explosive eruption

See eruption.

exposure

1. The state or condition of being subject to irradiation.

Exposure should not be used as a synonym for dose. Dose is a measure of the effects of exposure.

Exposure to ionizing radiation can be broadly divided into exposure categories according to the status of the individual(s) exposed; into exposure situations according to the circumstances of the exposure; and according to the source of the exposure.

acute exposure. Exposure received within a short period of time.

Normally used to refer to exposure of sufficiently short duration that the resulting doses can be treated as instantaneous (e.g. less than an hour).

external exposure. Exposure to radiation from a source outside the body.

Contrasted with internal exposure.
**internal exposure.** Exposure to radiation from a source within the body.

1. Contrasted with **external exposure.**

**transboundary exposure.** Exposure of members of the public in one State due to radioactive material released via accidents, discharges or waste disposal in another State.

1. See also **potential exposure.**

2. The sum of the electrical charges of all the ions of one sign produced in air by X rays or gamma radiation when all electrons liberated by photons in a suitably small element of volume of air are completely stopped in air, divided by the mass of the air in the volume element.

   1. Unit: C/kg (in the past, the röntgen (R) was used).

3. The time integral of the potential alpha energy concentration in air, or of the corresponding equilibrium equivalent concentration, to which an individual is exposed over a given period (e.g. a year).

   1. Used in connection with exposure due to decay products of $^{222}$Rn or $^{220}$Rn.
   2. The SI unit is J·h/m$^3$ for potential alpha energy concentration or Bq·h/m$^3$ for equilibrium equivalent concentration.

**exposure due to radon.** The time integral over the activity concentration of radon for a defined period of time. Exposure due to radon is a measurand related to the potential alpha energy exposure with the equilibrium factor taken into account and is, therefore, related to the effective dose.

4. “[T]he product of the air concentration of a radionuclide to which a person is exposed … and the time of exposure. More generally, when the air concentration varies with time, the time integral of the air concentration of a radionuclide to which a person is exposed, integrated over the time of exposure.”

1. This definition, quoted verbatim from Ref. [28], reflects a loose usage of exposure found in particular in the context of airborne radon. This usage is listed here for information, but it is discouraged.

**exposure assessment**


**exposure categories**

**medical exposure.** Exposure incurred by patients for the purposes of their own medical or dental diagnosis (diagnostic exposure) or medical treatment
(therapeutic exposure); by carers and comforters; and by volunteers subject to exposure as part of a programme of biomedical research.

1 See patient.

**occupational exposure.** Exposure of workers incurred in the course of their work.

**public exposure.** Exposure incurred by members of the public due to sources in planned exposure situations, emergency exposure situations and existing exposure situations, excluding any occupational exposure or medical exposure.

**exposure due to radon**

See exposure (3).

**exposure pathway**

A route by which radiation or radionuclides can reach humans and cause exposure.

1 An exposure pathway may be very simple, for example the external exposure pathway from airborne radionuclides, or a more complex chain, for example the internal exposure pathway from drinking milk from cows that ate grass contaminated with deposited radionuclides.

**exposure situations**

The exposure situation is indicated by the circumstances of exposure of the individual(s) undergoing exposure; it cannot be used to characterize a jurisdiction or the geographical area, for example, although for practical purposes such generalizations are sometimes assumed.

1 Three broad exposure situations were used as the basis for organizing the safety requirements established in GSR Part 3 [1]. The characterizations in terms of ‘situations’ (which derive from Ref. [26]) are not clearly delineated or conceptually distinct and the descriptions of the three types of exposure situation are not always sufficient to determine unequivocally which type of exposure situation applies for particular circumstances. In the safety standards, the most appropriate type of exposure situation for particular circumstances is determined by taking practical considerations into account.

**emergency exposure situation.** A situation of exposure that arises as a result of an accident, a malicious act or other unexpected event, and requires prompt action in order to avoid or to reduce adverse consequences.
Exposure in an emergency can include both occupational exposure and public exposure, and can include unplanned exposures resulting directly in the emergency exposure situation and planned exposures to emergency workers and helpers in an emergency undertaking actions to mitigate the consequences of the emergency.

Exposure in an emergency can be reduced only by protective actions and other response actions.

**existing exposure situation.** A situation of exposure that already exists when a decision on the need for control needs to be taken.

Existing exposure situations include exposure to natural background radiation that is amenable to control; exposure due to residual radioactive material that derives from past practices that were never subject to regulatory control; and exposure due to residual radioactive material deriving from a nuclear or radiological emergency after an emergency has been declared to be ended.

See para. 5.1 and Requirement 52 of GSR Part 3 [1].

**planned exposure situation.** The situation of exposure that arises from the planned operation of a source or from a planned activity that results in an exposure due to a source.

Since provision for protection and safety can be made before embarking on the activity concerned, associated exposures and their probabilities of occurrence can be restricted from the outset.

The primary means of controlling exposure in planned exposure situations is by good design of installations, equipment and operating procedures. In planned exposure situations, a certain level of exposure is expected to occur.

**extended planning distance (EPD)**

See emergency planning distance.

**external event**

Events unconnected with the operation of a facility or the conduct of an activity that could have an effect on the safety of the facility or activity.

Typical examples of external events for nuclear facilities include earthquakes, tornadoes, tsunamis and aircraft crashes.

In the case of safety assessment for long term safety in waste management, a relevant external event is one that could have an effect on the functioning of multiple barriers.

**external exposure**

See exposure (1).
external zone

The area immediately surrounding a proposed site area in which population distribution and density, and land and water uses, are considered with respect to their impact on planning effective emergency response actions.

1. Used in the context of siting of facilities.
2. This is the area that would be the emergency planning zones if the facility were in place.
facilities and activities

A general term encompassing nuclear facilities, uses of all sources of ionizing radiation, all radioactive waste management activities, transport of radioactive material and any other practice or circumstances in which people may be subject to exposure to radiation from naturally occurring or artificial sources.

‘Facilities’ includes: nuclear facilities; irradiation installations; some mining and raw material processing facilities such as uranium mines; radioactive waste management facilities; and any other places where radioactive material is produced, processed, used, handled, stored or disposed of — or where radiation generators are installed — on such a scale that consideration of protection and safety is required.

‘Activities’ includes: the production, use, import and export of radiation sources for industrial, research and medical purposes; the transport of radioactive material; the decommissioning of facilities; radioactive waste management activities such as the discharge of effluents; and some aspects of the remediation of sites affected by residues from past activities.

The intention is to include any human activity that introduces additional sources of radiation or additional exposure pathways, or that modifies the network of exposure pathways from existing sources, so as to increase the exposure or the likelihood of exposure of people or the number of people exposed.

The term ‘facilities and activities’ is intended to provide an alternative to the terminology of sources and practices (or interventions) to refer to general categories of situations.

For example, a practice may involve many different facilities and/or activities, whereas the general definition (1) of source is too broad in some cases: a facility or activity might constitute a source, or might involve the use of many sources, depending upon the interpretation used.

The term ‘facilities and activities’ is very general, and includes those for which little or no regulatory control may be necessary or achievable: the more specific terms authorized facility and authorized activity should be used to distinguish those facilities and activities for which any form of authorization has been given.

In the Fundamental Safety Principles (Safety Fundamentals), the term ‘facilities and activities — existing and new — utilized for peaceful purposes’ is abbreviated for convenience to facilities and activities as a general term encompassing any human activity that may cause people to be exposed to radiation risks arising from naturally occurring or artificial sources (see SF-1 [17], para. 1.9).

Facilities and activities are listed as follows in GSR Part 4 (Rev. 1) [11]:

‘Facilities’ includes:

(a) Nuclear power plants;
(b) Other reactors (such as research reactors and critical assemblies);
(c) Enrichment facilities and nuclear fuel fabrication facilities;
(d) Conversion facilities used to generate uranium hexafluoride (UF₆);
(e) Storage facilities and reprocessing plants for irradiated fuel;
(f) Facilities for radioactive waste management where radioactive waste is treated, conditioned, stored or disposed of;
(g) Any other places where radioactive materials are produced, processed, used, handled or stored;
(h) Irradiation installations for medical, industrial, research and other purposes, and any places where radiation generators are installed;
(i) Facilities where the mining and processing of radioactive ores (such as ores of uranium and thorium) are carried out.

‘Activities’ includes:

(a) The production, use, import and export of radiation sources for medical, industrial, research and other purposes;
(b) The transport of radioactive material;
(c) The decommissioning of facilities and the closure of repositories for radioactive waste;
(d) The close-out of facilities where the mining and processing of radioactive ores was carried out;
(e) Activities for radioactive waste management such as the discharge of effluents;
(f) The remediation of sites affected by residues from past activities.

facility

See facilities and activities.

facility states (considered in design)

1 The concept of facility states as it is used in the safety standards for research reactors and for nuclear fuel cycle facilities is broadly equivalent to the concept of plant states for nuclear power plants. See plant states (considered in design) for related terms and definitions (namely operational states, normal operation, anticipated operational occurrences, accident conditions, design basis accident, design extension conditions, controlled state, safe state); see also plant equipment (for a nuclear power plant): safety features (for design extension conditions).
1. **facility states** (postulated states of a *research reactor* facility as considered for design purposes).

<table>
<thead>
<tr>
<th>Operational states</th>
<th>Accident conditions</th>
</tr>
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<tbody>
<tr>
<td>Normal operation</td>
<td>Anticipated operational occurrences</td>
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</table>

See SSR-3 [29].

2. **facility states** (postulated states of a *nuclear fuel cycle facility* as considered for design purposes).

<table>
<thead>
<tr>
<th>Operational states</th>
<th>Accident conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal operation</td>
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<tr>
<td></td>
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</tbody>
</table>

See SSR-4 [30].

**facility emergency**

See *emergency class*. 
failure (technical)

Loss of the ability of a *structure, system or component* to function within acceptance criteria.

Note that the *structure, system or component* is considered to fail when it becomes incapable of functioning, whether or not this is needed at that time.

A failure in, for example, a backup *system* may not be manifest until the *system* is called upon to function, either during testing or on failure of the *system* it is backing up.

A failure may be the result of, for example, a hardware fault, a software fault, a system fault, an operator error or a maintenance error.

*common cause failure.* Failures of two or more *structures, systems or components* due to a single specific *event* or cause.

For example, the single specific *event* or cause of failures (which may be failures of different types) could be a design deficiency, a manufacturing deficiency, operation and maintenance errors, a natural phenomenon, a human induced *event*, saturation of signals, or an unintended cascading effect from any other operation or failure within the plant or from a change in ambient conditions.

Common causes may be internal or external to a system.

*common mode failure.* Failures of two or more *structures, systems or components* in the same manner or mode due to a single specific *event* or cause.

*Common mode failure* is a type of *common cause failure* in which the *structures, systems or components* fail in the same way (although they may not be in close proximity).

failure mode

The manner or state in which a *structure, system or component* fails.

far field

The *geosphere* outside a *disposal facility*, comprising the surrounding geological strata, at a distance from the *disposal facility* such that, for modelling purposes, the *disposal facility* may be considered a single entity and the effects of individual *waste packages* are not distinguished.

For practical purposes, this is often interpreted simply as the *geosphere* beyond the *near field*.

fault, geological

See geological fault.
fault tree analysis

See analysis.

feed

Any single material or multiple materials, whether processed, semi-processed or raw, that is or are intended to be fed directly to food producing animals.

first responders

The first members of an emergency service to respond at the site of an emergency.

fissile material

1. Material containing any fissile nuclides.

   fissile nuclide. Nuclides, in particular $^{233}$U, $^{235}$U, $^{239}$Pu and $^{241}$Pu, that are able to support a self-sustaining nuclear chain reaction with neutrons of all energies, but predominantly with slow neutrons.

2. Uranium-233, $^{235}$U, $^{239}$Pu and $^{241}$Pu.

Excluded from this definition are the following:

(a) Natural uranium or depleted uranium that is unirradiated;
(b) Natural uranium or depleted uranium that has been irradiated in thermal reactors only;
(c) Material with fissile nuclides less than a total of 0.25 g;
(d) Any combination of (a), (b) or (c).

These exclusions are valid only if there is no other material with fissile nuclides in the package or in the consignment if shipped unpackaged. (See SSR-6 (Rev. 1) [2].)

1 This definition is specific to the Transport Regulations [2]. As with radioactive material, this is not a scientific definition, but one designed to serve a specific regulatory purpose.

See also fissionable material.
fissile nuclide

See fissile material (1).

fission fragment

A nucleus resulting from nuclear fission carrying kinetic energy from that fission.

1 Used only in contexts where the particles themselves have kinetic energy and thus could represent a hazard, irrespective of whether the particles are radioactive.

1 Otherwise, the more usual term fission product is used.

fission product

A radionuclide produced by nuclear fission.

1 Used in contexts where the radiation emitted by the radionuclide is the potential hazard.

fissionable material

Material containing any fissionable nuclides.

fissionable nuclide. Nuclides such as $^{238}$U that are capable of supporting a self-sustaining nuclear chain reaction, including a self-sustaining nuclear chain reaction with fast neutrons.

See also fissile material.

fissionable nuclide

See fissionable material.

fixed contamination

See contamination (2).

fluence

1 A measure of the strength of a radiation field. Commonly used without qualification to mean particle fluence.
**energy fluence**, \( \Psi \). A measure of the energy density of a *radiation* field, defined as:

\[
\Psi = \frac{dR}{da}
\]

where \( dR \) is the *radiation* energy incident on a sphere of cross-sectional area \( da \).

1. The **energy fluence rate**

\[
\frac{d\Psi}{dt}
\]

is denoted by a lower case \( \psi \).

See Ref. [31].

**particle fluence**, \( \Phi \). A measure of the density of particles in a *radiation* field, defined as:

\[
\Phi = \frac{dN}{da}
\]

where \( dN \) is the number of particles incident on a sphere of cross-sectional area \( da \).

1. The **particle fluence rate**

\[
\frac{d\Phi}{dt}
\]

is denoted by a lower case \( \phi \).

See Ref. [31].

**food**

Any substance, whether processed, semi-processed or raw, that is intended for human consumption.

1. This includes foodstuffs and drink (other than fresh water), chewing gum and substances used in the preparation or processing of *food*; it does not include cosmetics, tobacco or drugs. Consumption in this context refers to ingestion.
fractional absorption in the gastrointestinal tract, \( f_i \), or in the alimentary tract, \( f_A \)

The fraction of an ingested element that is directly absorbed to body fluids. (See Refs [20–22, 32].)

1. Often referred to colloquially as gut transfer factor or \('f_i\) value’.

See also lung absorption type, a similar concept for activity in the respiratory tract.

free field ground motion

Motion that would occur at a given point on the ground owing to an earthquake if vibratory characteristics were not affected by structures and facilities.

freight container

An article of transport equipment that is of a permanent character and accordingly strong enough to be suitable for repeated use; specially designed to facilitate the transport of goods, by one or other modes of transport without intermediate reloading, designed to be secured and/or readily handled, having fittings for these purposes.

1. The freight container does not include the vehicle.

small freight container. A freight container that has an internal volume of not more than 3 \( m^3 \). (See SSR-6 (Rev. 1) [2].)

large freight container. A freight container that has an internal volume of more than 3 \( m^3 \). (See SSR-6 (Rev. 1) [2].)

frequency of exceedance

The frequency at which a specified level of seismic hazard will be exceeded at a site or in a region within a specified time interval.

1. In probabilistic seismic hazard analysis, generally a one year time interval (i.e. annual frequency) is assumed.

1. When the frequency is very small and it cannot exceed unity (in the prescribed interval), this number approaches the probability of the same event if the random process is assumed to be Poissonian.
fresh fuel

See nuclear fuel.

fuel

See nuclear fuel.

fuel assembly

A set of fuel elements and associated components which are loaded into and subsequently removed from a reactor core as a single unit.

fuel cycle

See nuclear fuel cycle.

fuel element

A rod of nuclear fuel, its cladding and any associated components necessary to form a structural entity.

Commonly referred to as a fuel rod in light water reactors.

fuel rod

See fuel element.

functional diversity

See diversity.

functional indicator

See indicator.

functional isolation

Prevention of adverse consequences from the mode of operation or failure of one circuit or system on another.

fundamental safety function

See safety function.
gap release

Release, especially in a reactor core, of fission products from the fuel pin gap, which occurs immediately after failure of the fuel cladding and is the first radiological indication of fuel damage or fuel failure.

general emergency

See emergency class.

generic criteria

Levels for the projected dose or the dose that has been received at which protective actions and other response actions are to be taken.

1 The term generic criteria as defined here relates to emergency preparedness and emergency response only.

genetic effect

See health effects (of radiation): hereditary effect.

geological disposal

See disposal (1).

geological disposal facility

See disposal facility.

geological fault

A planar or gently curved fracture surface or zone of the Earth across which there has been relative displacement.

capable fault. A geological fault that has a significant potential for displacement at or near the ground surface.

1 A geological fault is to be considered a capable fault if, on the basis of geological, geophysical, geodetic or seismological data (including paleoseismological and geomorphological data), one or more of the following conditions applies:
(a) The geological fault shows evidence of past movement or movements (significant deformations and/or dislocations) of a recurring nature within such a period that it is reasonable to infer that further movements at or near the surface could occur.

(b) A structural relationship with a known capable fault has been demonstrated such that movement of the one may cause movement of the other at or near the surface.

(c) The maximum potential earthquake associated with a seismogenic structure is sufficiently large and at such a depth that it is reasonable to infer that, in the geodynamic setting of the site, movement at or near the surface could occur [33].

① In highly active areas, where both earthquake data and geological data consistently reveal short earthquake recurrence intervals, periods of the order of tens of thousands of years may be appropriate for the assessment of capable faults. In less active areas, it is likely that much longer periods may be required.

geological record

The sequence of rock layers in a vertical section of the Earth.

① Also termed the stratigraphic record. The oldest layers occur at the base of the section, with successively younger layers occurring higher in the sequence.

① Geologists use the geological record to assign relative ages to deposits.

① Volcanic stratigraphy is often complex, with deposits characterized by having relatively limited lateral extent, exhibiting rapid facies changes and having undergone multiple episodes of erosion and refilling of valleys.

geosphere

Those parts of the lithosphere not considered to be part of the biosphere.

① In safety assessment, usually used to distinguish the subsoil and rock (below the depth affected by usual human activities, in particular agriculture) from the soil that is part of the biosphere.

‘grace period’

The period of time during which a safety function is ensured in an event with no necessity for action by personnel.

① Typical ‘grace periods’ range from 20 min to 12 h. The ‘grace period’ may be achieved by means of the automation of actuations, the adoption of passive systems or the inherent characteristics of a material (such as the heat capacity of the containment structure), or by any combination of these.
graded approach

1. For a system of control, such as a regulatory system or a safety system, a process or method in which the stringency of the control measures and conditions to be applied is commensurate, to the extent practicable, with the likelihood and possible consequences of, and the level of risk associated with, a loss of control.

   - An example of a graded approach in general would be a structured method by means of which the stringency of application of requirements is varied in accordance with the circumstances, the regulatory systems used, the management systems used, etc.

   - For example, a method in which:

     1. The significance and complexity of a product or service are determined;
     2. The potential impacts of the product or service on health, safety, security, the environment, and the achieving of quality and the organization’s objectives are determined;
     3. The consequences if a product fails or if a service is carried out incorrectly are taken into account.

   - The use of a graded approach is intended to ensure that the necessary levels of analysis, documentation and actions are commensurate with, for example, the magnitudes of any radiological hazards and non-radiological hazards, the nature and the particular characteristics of a facility, and the stage in the lifetime of a facility.

2. An application of safety requirements that is commensurate with the characteristics of the facilities and activities or the source and with the magnitude and likelihood of the exposures.

See also exclusion, exemption, clearance and optimization.

gray (Gy)

The SI unit of kerma and absorbed dose, equal to 1 J/kg.

ground shine

Gamma radiation from radionuclides deposited on the ground.

- Ground shine is of concern as an exposure pathway for external exposure principally — but not exclusively — to gamma radiation.

- Ground shine may also be used to mean radiation that is incident on, and reflected back from, the ground.

See also cloud shine.
guidance level

See level.

guidance level for medical exposure

See level.

gut transfer factor

See fractional absorption in the gastrointestinal tract, $f_1$, or in the alimentary tract, $f_A$. 
habit survey

See survey.

half-life, $T_{1/2}$

1. For a radionuclide, the time required for the activity to decrease, by a radioactive decay process, by half.
   - Where it is necessary to distinguish this from other half-lives (see (2)), the term radioactive half-life should be used.
   - The half-life is related to the decay constant, $\lambda$, by the expression:
     \[
     T_{1/2} = \frac{\ln 2}{\lambda}
     \]

2. The time taken for the quantity of a specified material (e.g. a radionuclide) in a specified place to decrease by half as a result of any specified process or processes that follow exponential patterns similar to radioactive decay.

   biological half-life. The time taken for the quantity of a material in a specified tissue, organ or region of the body (or any other specified biota) to halve as a result of biological processes.

   effective half-life, $T_{eff}$. The time taken for the activity of a radionuclide in a specified place to halve as a result of all relevant processes.

   \[
   \frac{1}{T_{eff}} = \sum \frac{1}{T_i}
   \]

   where $T_i$ is the half-life for process $i$.

   radioactive half-life. For a radionuclide, the time required for the activity to decrease, by a radioactive decay process, by half.
   - The term physical half-life is also used for this concept.

(harmful) tissue reaction

See health effects (of radiation): deterministic effect: severe deterministic effect.
hazard

The potential for harm or other detriment, especially for radiation risks; a factor or condition that might operate against safety.

hazard assessment

See assessment (1).

health authority

A governmental authority (at the national, regional or local level) that is responsible for policies and interventions, including the development of standards and the provision of guidance, for maintaining or improving human health, and that has the legal power of enforcing such policies and interventions.

health effects (of radiation)

deterministic effect. A radiation induced health effect for which generally a threshold level of dose exists above which the severity of the effect is greater for a higher dose.

severe deterministic effect. A deterministic effect that is fatal or life threatening or results in a permanent injury that reduces quality of life.

1 The level of the threshold dose is characteristic of the particular health effect but may also depend, to a limited extent, on the exposed individual.

1 Examples of deterministic effects include erythema, damage to the haemopoietic system and acute radiation syndrome (radiation sickness).

1 Deterministic effects are also referred to as (harmful) tissue reactions.

1 The term [non-stochastic effect] is used in some older publications, but is now superseded.

1 Contrasting term: stochastic effect.

early effect. A radiation induced health effect that occurs within months of the exposure that caused it.

1 All early effects are deterministic effects; most, but not all, deterministic effects are early effects.

hereditary effect. A radiation induced health effect that occurs in a descendant of the exposed person.

1 The less precise term genetic effect is also used, but hereditary effect is preferred.
Hereditary effects are usually stochastic effects.

Contrasting term: somatic effect.

**late effect.** A radiation induced health effect that occurs years after the exposure that caused it.

- The most common late effects are stochastic effects, such as leukaemia and solid cancers, but some deterministic effects can also be late effects.

**somatic effect.** A radiation induced health effect that occurs in the exposed person.

- This includes effects occurring after birth that are attributable to exposure in utero.
- Deterministic effects are normally also somatic effects; stochastic effects may be somatic effects or hereditary effects.
- Contrasting term: hereditary effect.

**stochastic effect.** A radiation induced health effect, the probability of occurrence of which is greater for a higher radiation dose and the severity of which (if it occurs) is independent of dose.

- Stochastic effects may be somatic effects or hereditary effects and generally occur without a threshold level of dose. Examples include solid cancers and leukaemia.
- Contrasting term: deterministic effect.

**health professional**

An individual who has been formally recognized through appropriate national procedures to practise a profession related to health (e.g. medicine, dentistry, chiropractic, podiatry, nursing, medical physics, medical radiation technology, radiopharmacy, occupational health).

- Used to distinguish from a referring medical practitioner or a radiological medical practitioner, who satisfy additional criteria.

**health screening programme**

A programme in which health tests or medical examinations are performed for the purpose of early detection of disease.

**health surveillance**

See workers’ health surveillance.

[heat generating waste (HGW)]

See waste classes.
helper in an emergency

Member of the public who willingly and voluntarily helps in the response to a nuclear or radiological emergency.

 Helpers in an emergency are protected and are aware that they could be exposed to radiation while helping in response to a nuclear or radiological emergency.

hereditary effect

See health effects (of radiation).

high energy radiation therapy equipment

X ray equipment and other types of radiation generators capable of operating at generating potentials above 300 kV, and radionuclide teletherapy equipment.

high enriched uranium (HEU)

See uranium.

high level waste (HLW)

See waste classes.

high linear energy transfer (LET) radiation

See radiation.

Holocene

The most recent epoch of the geological Quaternary period, defined as the interval from 10 000 years before the present to the present.

Holocene volcano

See volcano.
human factors engineering

Engineering in which factors that could influence human performance and that could affect safety are understood and are taken into account, especially in the design and operation of facilities.

human intrusion

1 The term human intrusion is used for human activities that could affect the integrity of a disposal facility and which could potentially give rise to radiological consequences.

2 Only those human activities (such as construction work, mining or drilling) that could result in direct disturbance of the disposal facility (i.e. disturbance of the waste itself, of the contaminated near field or of materials of the engineered barrier) are included.

hydrodynamic dispersion

See dispersion.

hypocentre

The point (focus) within the Earth at which an earthquake is initiated.

[hypothetical critical group]

See [critical group].
IAEA publication

An IAEA copyrighted hard copy or electronic product issued with unlimited distribution and bearing the IAEA emblem (logo) on the front and officially approved by the Publications Committee on behalf of the Director General.

① An IAEA document is an official non-copyrighted hard copy or electronic product issued with limited distribution and bearing the IAEA emblem (logo) on the front.

① A manuscript is an unissued copy of a draft publication or a draft document.

① A TECDOC is a publication, not a document.

ICRU sphere

A sphere of 30 cm diameter made of tissue equivalent material with a density of 1 g/cm³ and a mass composition of 76.2% oxygen, 11.1% carbon, 10.1% hydrogen and 2.6% nitrogen.

① The ICRU (International Commission on Radiation Units and Measurements) sphere is used as a reference phantom in defining dose equivalent quantities.

See Ref. [34].

igneous rock

Rock that has formed from magma.

① Extruded igneous rocks (volcanic rocks) are typically divided into four basic types according to their SiO₂ content: basalt, andesite, dacite and rhyolite.

immediate dismantling

See decommissioning (1).

immobilization

See radioactive waste management (1).

in-service inspection

See inspection.
incident

Any unintended event, including operating errors, equipment failures, initiating events, accident precursors, near misses or other mishaps, or unauthorized act, malicious or non-malicious, the consequences or potential consequences of which are not negligible from the point of view of protection and safety.

See also event and INES.

! The word incident is sometimes used, for example in the INES 2008 Manual [8], to describe events that are, in effect, minor accidents, i.e. that are distinguished from accidents only in terms of being less severe.

! This is a distinction with little basis in general usage, in which an incident can be minor or major, just as an accident can; however, unlike an accident, an incident can be caused intentionally.

① The definition of incident given was derived on the basis of the entries for accident and event and the explanation of the term incident given in SF-1 [17].

[nuclear incident]. Any occurrence or series of occurrences having the same origin which causes nuclear damage or, but only with respect to preventive measures, creates a grave and imminent threat of causing such damage. (See Ref. [35].)

! This usage is specific to the Convention on Supplementary Compensation for Nuclear Damage [35], for the purposes of the Convention, and should otherwise be avoided.

See also [nuclear damage].

independent assessment

See assessment (2).

independent equipment

Equipment that possesses both of the following characteristics:

(a) The ability to perform its required function is unaffected by the operation or failure of other equipment.

(b) The ability to perform its required function is unaffected by the occurrence of the effects resulting from the initiating event for which it is required to function.
indicator

*condition indicator.* Characteristic of a *structure, system or component* that can be observed, measured or trended to infer or directly indicate the current and future ability of the *structure, system or component* to function within *acceptance criteria.*

*functional indicator.* *Condition indicator* that is a direct indication of the current ability of a *structure, system or component* to function within *acceptance criteria.*

*performance indicator.* Characteristic of a *process* that can be observed, measured or trended to infer or directly indicate the current and future performance of the *process,* with particular emphasis on satisfactory performance for *safety.*

individual dose

See *dose concepts.*

[individual dose equivalent, penetrating]

See *dose equivalent quantities: personal dose equivalent.*

[individual dose equivalent, superficial]

See *dose equivalent quantities: personal dose equivalent.*

individual monitoring

See *monitoring* (1).

industrial package

See *package.*

INES

See *International Nuclear and Radiological Event Scale (INES).*
infant

① In dosimetry, unless otherwise stated, an *infant* is assumed to be three months old, and annual quantities (e.g. *annual dose*, *annual intake*) relating to an *infant* refer to the year starting at birth.
① The values for the three month old *infant* are intended to be valid for the first year of life.
① In common usage for internal dosimetry an *infant* is taken to be 100 days old.

See also *child* and *reference individual*.

‘informed customer’ capability

① The capability of an organization to have a clear knowledge and understanding of the product being supplied or the service being provided.

ingestion and commodities planning distance (ICPD)

See *emergency planning distance*.

[inhalation class]

See *lung absorption type*.

initiating event

An identified *event* that leads to *anticipated operational occurrences* or *accident conditions*.
① This term (often shortened to *initiator*) is used in relation to *event* reporting and *analysis*; that is, when such *events* have occurred.
① For the consideration of hypothetical *events* at the *design* stage, the term *postulated initiating event* is used.

*postulated initiating event (PIE)*. A postulated *event* identified in *design* as capable of leading to *anticipated operational occurrences* or *accident conditions*.
① The primary causes of *postulated initiating events* may be credible equipment *failures* and *operator* errors (both within and external to the *facility*), human induced *events* or natural *events*.

initiator

See *initiating event*. 

114
inner cordon off area

An area established by first responders in an emergency around a potential radiation hazard, within which protective actions and other response actions are taken to protect first responders and the public from possible exposure and contamination.

inspection

1. An examination, observation, surveillance, measurement or test undertaken to assess structures, systems and components and materials, as well as operational activities, technical processes, organizational processes, procedures and personnel competence.

   in-service inspection. Inspection of structures, systems and components undertaken over the operating lifetime by or on behalf of the operating organization for the purpose of identifying age related degradation or conditions that, if not addressed, might lead to the failure of structures, systems or components.

   ① Inspection of operational activities, processes, etc., by or on behalf of the operating organization would normally be described by terms such as self-assessment and audit.

   regulatory inspection. Inspection undertaken by or on behalf of the regulatory body.

2. An evaluation of the conformity to a requirement.

inspection imaging device

An imaging device designed specifically for imaging persons or cargo conveyances for the purpose of detecting concealed objects on or within the human body or within cargo or a vehicle.

   ① In some types of inspection imaging device, ionizing radiation is used to produce images by backscatter, transmission or both.

   ① Other types of inspection imaging device utilize imaging by means of electrical and magnetic fields, ultrasound and sonar waves, nuclear magnetic resonance, microwaves, terahertz rays, millimetre waves, infrared radiation or visible light.

institutional control

See control (1).
intake

1. The act or process of taking radionuclides into the body by inhalation or ingestion or through the skin.
   - Other exposure pathways by intake are injection (e.g. in nuclear medicine) and intake via a wound, as distinguished from intake through (intact) skin.

2. The activity of a radionuclide taken into the body in a given time period or as a result of a given event.

   **acute intake.** An intake occurring within a time period short enough that it can be treated as instantaneous for the purposes of assessing the resulting committed dose.
   - The exposure that results from an acute intake is not necessarily acute exposure. For a long lived radionuclide that is retained in the body, an acute intake will result in chronic (i.e. long term) exposure.

   **chronic intake.** An intake over an extended period of time, such that it cannot be treated as a single instantaneous intake for the purposes of assessing the resulting committed dose.
   - Chronic intake may, however, be treated as a series of acute intakes.

integrated management system

See management system.

interacting event

An event or a sequence of associated events that, interacting with a facility, affect site personnel or items important to safety in a manner that could adversely influence safety.

interested party

A person, company, etc., with a concern or interest in the activities and performance of an organization, business, system, etc.
   - The term interested party is used in a broad sense to mean a person or group having an interest in the performance of an organization.
   - Those who can influence events may effectively become interested parties — whether their ‘interest’ is regarded as ‘genuine’ or not — in the sense that their views need to be considered.
   - Interested parties would need to be specified as relevant.
Interested parties have typically included the following: customers, owners, operators, employees, suppliers, partners and trade unions; the regulated industry or professionals; scientific bodies; governmental agencies or regulatory bodies (national, regional and local) whose responsibilities may cover nuclear energy; the media; the public (individuals, community groups and interest groups); and other States, especially neighbouring States that have entered into agreements providing for an exchange of information concerning possible transboundary impacts, or States involved in the export or import of certain technologies or materials [36].

The term [stakeholder] is used in the same broad sense as interested party and the same provisos are necessary.

The term stakeholder has disputed usage, and it is misleading and too all-encompassing for clear use. In view of the potential for misunderstanding and misrepresentation, use of the term is discouraged in favour of interested party.

The Handbook on Nuclear Law [36] states that: “Owing to the differing views on who has a genuine interest in a particular nuclear related activity, no authoritative definition of stakeholder has yet been offered, and no definition is likely to be accepted by all parties.”

[interim storage]

See storage.

intermediate bulk container (IBC)

A portable packaging that:

(a) Has a capacity of not more than 3 m³;
(b) Is designed for mechanical handling;
(c) Is resistant to the stresses produced in handling and transport, as determined by tests.

(See SSR-6 (Rev. 1) [2].)

intermediate level waste (ILW)

See waste classes.

internal exposure

See exposure (1).
International Nuclear and Radiological Event Scale (INES)

1. The INES is a scale developed for use by States for the purpose of communicating with the public on the safety significance of events associated with sources of radiation.

2. The INES should not be confused with emergency classification system, and should not be used as a basis for emergency response actions.

3. In the 2008 INES Manual [8], there was a fundamental mismatch between the terminology and usage in safety standards and the designations used in INES.

4. The INES 2008 terminology — in particular the use of the terms incident and accident — was different from that in safety standards and from the usual English meanings of the words, and great care should be taken to avoid confusion between the two areas.

5. In short, events that would be considered accidents according to the safety standards definition may be accidents or incidents (i.e. not accidents) in INES 2008 terminology (see incident and accident (1)).

6. This was not a serious day to day problem because the two areas are quite separate and have quite different purposes. However, it was a potential cause of confusion in communication with the news media and the public.

7. See the information notes associated with the terms event, incident and accident for further information.

[International nuclear transport]

See transport (1).

Interplate tectonic processes

Tectonic processes occurring at the interfaces between the Earth’s tectonic plates.

Intervention

Any action intended to reduce or avert exposure or the likelihood of exposure due to sources that are not part of a controlled practice or that are out of control as a consequence of an accident.

1. This definition is somewhat more explicit than (though not necessarily inconsistent with) that of Ref. [37].

2. The term facilities and activities is intended to provide an alternative to the terminology of sources and practices (or interventions) to refer to general categories of situations.

3. In emergency preparedness and response, the concepts of protective actions and protection strategy are now used instead.
intraplate

Of tectonic processes, within the Earth’s tectonic plates.

intrusion (human)

See human intrusion.

intrusion barrier

See barrier.

investigation level

See level.

iodine thyroid blocking

The administration of a compound of stable iodine (usually potassium iodide) to prevent or reduce the uptake of radioactive isotopes of iodine by the thyroid in a nuclear or radiological emergency involving radioactive iodine.

1 Iodine thyroid blocking is an urgent protective action.

1 The terms ‘stable iodine prophylaxis’, ‘thyroid blocking’ or ‘iodine blockade’ are sometimes used to describe the same concept, but iodine thyroid blocking is preferred in IAEA publications.

ionizing radiation

See radiation.

irradiation installation

A structure or an installation that houses a particle accelerator, X ray apparatus or large radioactive source and that can produce high radiation fields.

1 Irradiation installations include installations for external beam radiation therapy, installations for sterilization or preservation of commercial products and some installations for industrial radiography.

isolation (of radioactive waste in a disposal facility)

The physical separation and retention of radioactive waste away from people and from the environment.
Isolation of radioactive waste with its associated hazards in a disposal facility involves the minimization of the influence of factors that could reduce the integrity of the disposal facility; provision for a very low mobility of most long lived radionuclides to impede their migration from the disposal facility; and making access to the waste by people difficult without special technical capabilities.

Design features are intended to provide isolation (a confinement function) for several hundreds of years for short lived waste and for at least several thousand years for intermediate level waste and high level waste. Isolation is an inherent feature of geological disposal.

**Item important to safety**

See plant equipment (for a nuclear power plant).
justification

1. The process of determining for a planned exposure situation whether a practice is, overall, beneficial; that is, whether the expected benefits to individuals and to society from introducing or continuing the practice outweigh the harm (including radiation detriment) resulting from the practice.

2. The process of determining for an emergency exposure situation or an existing exposure situation whether a proposed protective action or remedial action is likely, overall, to be beneficial; that is, whether the expected benefits to individuals and to society (including the reduction in radiation detriment) from introducing or continuing the protective action or remedial action outweigh the cost of such action and any harm or damage caused by the action.
The quantity \( K \), defined as:

\[
K = \frac{dE_{tr}}{dm}
\]

where \( dE_{tr} \) is the sum of the initial kinetic energies of all charged ionizing particles liberated by uncharged ionizing particles in a material of mass \( dm \).

1. The SI unit for kerma is joules per kilogram (J/kg), termed the gray (Gy).
2. Kerma was originally an acronym for kinetic energy released in matter but is now accepted as a word.

**air kerma.** The kerma value for air.

1. Under charged particle equilibrium conditions, the air kerma (in gray) is numerically approximately equal to the absorbed dose in air (in gray).

**reference air kerma rate.** The kerma rate to air, in air, at a reference distance of 1 m, corrected for air attenuation and scattering.

1. This quantity is expressed in \( \mu \text{Gy/h} \) at 1 m.

**kerma factor**

The kerma per unit particle fluence.

**knowledge management**

An integrated, systematic approach to identifying, managing and sharing an organization’s knowledge and enabling groups of people to create new knowledge collectively to help in achieving the organization’s objectives.

1. In the context of management systems, knowledge management helps an organization to gain insight and understanding from its own experience.
2. Specific activities in knowledge management help the organization to better acquire, record, store and utilize knowledge.
3. The term ‘knowledge’ is often used to refer to bodies of facts and principles accumulated by humankind over the course of time.
4. Explicit knowledge is knowledge that is contained in, for example, documents, drawings, calculations, designs, databases, procedures and manuals.
5. Tacit knowledge is knowledge that is held in a person’s mind and has typically not been captured or transferred in any form (if it were, it would become explicit knowledge).
Knowledge is distinct from information: data yield information and knowledge is gained by acquiring, understanding and interpreting information.

Knowledge and information each consist of true statements, but knowledge serves a purpose: knowledge confers a capacity for effective action.

Knowledge for an organization is the acquiring, understanding and interpreting of information.

Knowledge may be applied for such purposes as: problem solving and learning; forming judgements and opinions; decision making, forecasting and strategic planning; generating feasible options for action and taking actions to achieve desired results.

Knowledge also protects intellectual assets from decay, augments intelligence and provides increased flexibility.
large freight container

See freight container.

large release of radioactive material

A release of radioactive material for which off-site protective actions that are limited in terms of times and areas of application are insufficient for protecting people and the environment.

See also early release of radioactive material; see also defence in depth.

late effect

See health effects (of radiation).

latent weakness

See cause.

lava

Molten rock erupted at the Earth’s surface by a volcano or by an eruptive fissure as an effusive dome or flow.

When first emitted from a volcanic vent, lava is a liquid at very high temperature, typically 700–1200°C.

Lava flows vary by many orders of magnitude in their viscosities and this strongly influences their flow properties.

[legal person]

Any organization, corporation, partnership, firm, association, trust, estate, public or private institution, group, political or administrative entity or other person designated in accordance with national legislation who or which has responsibility and authority for any action having implications for protection and safety.

Contrasted in legal texts with ‘natural person’, meaning an individual.

Superseded by the term person or organization, which should be used.

See also applicant, licence and registration.
level

**clearance level.** A value, established by a *regulatory body* and expressed in terms of *activity concentration*, at or below which *regulatory control* may be removed from a *source of radiation* within a notified or authorized *practice*.

See also *clearance (1)*.

**diagnostic reference level.** A level used in medical imaging to indicate whether, in routine conditions, the *dose* to the *patient* or the amount of radiopharmaceuticals administered in a specified radiological procedure for medical imaging is unusually high or unusually low for that procedure [1].

1 For the use of radiopharmaceuticals, the *diagnostic reference level* is a level of *activity* for typical examinations for groups of standardized *patients* or for a standard phantom and for broadly defined types of equipment.

1 The *diagnostic reference levels* are indicative of good practice, when not exceeded, for standard procedures in which good practices and normal practices are applied with regard to diagnostic performance and technical performance.

**emergency action level (EAL).** A specific, predetermined criterion for observable conditions used to detect, recognize and determine the *emergency class*.

1 An *emergency action level* could represent an instrument reading, the status of a piece of equipment or any observable *event*, such as a fire.

**exemption level.** A value, established by a *regulatory body* and expressed in terms of *activity concentration*, total *activity*, *dose rate* or *radiation* energy, at or below which a *source of radiation* need not be subject to some or all aspects of *regulatory control*.

1 A *regulatory body* may also grant *exemption* on a case by case basis, following *notification*.

1 Although the term *exemption level* does not strictly apply in such a situation, a criterion for *exemption* may nevertheless be established by the *regulatory body*, expressed in similar terms or, alternatively, expressed in terms of *annual dose* on the basis of an appropriate *dose assessment*. (See GSR Part 3 [1] and para. 5.12 of RS-G-1.7 [13].)

1 Values of *exemption levels* are specified in table I.1 and table I.2 of schedule I of GSR Part 3 [1].

**investigation level.** The value of a quantity such as *effective dose*, *intake* or *contamination* per unit area or volume at or above which an investigation would be conducted.
**operational intervention level (OIL).** A set level of a measurable quantity that corresponds to a generic criterion.

1. **Operational intervention levels** are typically expressed in terms of dose rates or of activity of radioactive material released, time integrated air activity concentrations, ground or surface concentrations, or activity concentrations of radionuclides in environmental, food or water samples.

2. **An operational intervention level** is used immediately and directly (without further assessment) to determine the appropriate protective actions on the basis of an environmental measurement.

**recording level.** A level of dose, exposure or intake specified by the regulatory body at or above which values of dose to, exposure of or intake by workers are to be entered in their individual exposure records.

**reference level.** For an emergency exposure situation or an existing exposure situation, the level of dose, risk or activity concentration above which it is not appropriate to plan to allow exposures to occur and below which optimization of protection and safety would continue to be implemented.

1. The value chosen for a reference level will depend upon the prevailing circumstances for the exposure under consideration.

**licence**

1. A legal document issued by the regulatory body granting authorization to perform specified activities relating to a facility or activity.

   1. A **licence** is a product of the authorization process (although the term licensing process is sometimes used), and a **practice** with a current licence is an authorized practice.

   2. **Authorization** may take other forms, such as registration or certification.

2. [Any authorization granted by the regulatory body to the applicant to have the responsibility for the siting, design, construction, commissioning, operation or decommissioning of a nuclear installation.] (See Ref. [4].)

3. [Any authorization, permission or certification] granted by a regulatory body to carry out any activity related to management of spent fuel or of radioactive waste.] (See Ref. [5].)

   1. The definitions (2) and (3) from the Conventions [4, 5] are somewhat more general in scope than the usual IAEA usage in definition (1).

   2. In IAEA usage, a licence is a particular type of authorization, normally representing the primary authorization for the operation of a whole facility or activity.

   3. The conditions attached to the licence may require that further, more specific, authorization or approval be obtained by the licensee before carrying out particular activities.
licensee

1. The holder of a current licence. The licensee is the person or organization having overall responsibility for a facility or activity.

licensing basis

A set of regulatory requirements applicable to a nuclear installation.

1. The licensing basis, in addition to a set of regulatory requirements, may also include agreements and commitments made between the regulatory body and the licensee (e.g. in the form of letters exchanged or of statements made in technical meetings).

licensing process

See licence (1).

life, lifetime

*design life*. The period of time during which a facility or component is expected to perform according to the technical specifications to which it was produced.

*operating lifetime, operating life*

1. The period during which an authorized facility is used for its intended purpose, until decommissioning or closure.

   1. The synonyms operating period and operational period are also used.

2. [The period during which a spent fuel or a radioactive waste management facility is used for its intended purpose. In the case of a disposal facility, the period begins when spent fuel or radioactive waste is first emplaced in the facility and ends upon closure of the facility.] (See Ref. [5].)

*qualified life*. Period for which a structure, system or component has been demonstrated, through testing, analysis or experience, to be capable of functioning within acceptance criteria during specific operating conditions while retaining the ability to perform its safety functions in accident conditions for a design basis accident or a design basis earthquake.

*service life*. The period from initial operation to final withdrawal from service of a structure, system or component.
Life cycle management

Life management (or lifetime management) in which due recognition is given to the fact that at all stages in the lifetime there may be effects that need to be taken into consideration.

1. An example is the approach to products, processes and services in which it is recognized that at all stages in the lifetime of a product (extraction and processing of raw materials, manufacturing, transport and distribution, use and reuse, and recycling and waste management) there are environmental impacts and economic consequences.

2. The term ‘life cycle’ (as opposed to lifetime) implies that the life is genuinely cyclical (as in the case of recycling or reprocessing).

See also ‘cradle to grave’ approach and ageing management.

Life management

See ageing management.

Lifetime

See life, lifetime.

Lifetime dose

See dose concepts.

Lifetime management

See ageing management.

Lifetime risk

See risk (3).

Limit

The value of a quantity used in certain specified activities or circumstances that must not be exceeded.

! The term limit should only be used for a criterion that must not be exceeded; for example, where exceeding the limit would cause some form of legal sanction to be invoked.
Criteria used for other purposes — for example, to indicate a need for closer investigation or a review of procedures, or as a threshold for reporting to a regulatory body — should be described using other terms, such as reference level.

acceptable limit. A limit acceptable to the regulatory body.

1. The term acceptable limit is usually used to refer to a limit on the predicted radiological consequences of an accident (or on potential exposures if they occur) that is acceptable to the relevant regulatory body when the probability of occurrence of the accident or potential exposures has been taken into account (i.e. on the basis that it is unlikely to occur).

2. The term authorized limit should be used to refer to limits on doses or risks, or on releases of radionuclides, which are acceptable to the regulatory body on the assumption that they are likely to occur.

annual limit on exposure (ALE). The potential alpha energy exposure in a year that would result in inhalation of the annual limit on intake (ALI).

1. Used for exposure due to decay products of $^{222}$Rn or $^{220}$Rn.

2. In units of J·h/m$^3$.

annual limit on intake (ALI). The intake by inhalation or ingestion or through the skin of a given radionuclide in a year by the reference individual which would result in a committed dose equal to the relevant dose limit.

1. The annual limit on intake is expressed in units of activity.

See Refs [21, 22].

authorized limit. A limit on a measurable quantity, established or formally accepted by a regulatory body.

1. Wherever possible, authorized limit should be used in preference to prescribed limit.

2. Equivalent in meaning to prescribed limit, authorized limit has been more commonly used in radiation safety and the safety of radioactive waste management, in particular in the context of limits on discharges.

derived limit. A limit on a measurable quantity set, on the basis of a model, such that compliance with the derived limit may be assumed to ensure compliance with a primary limit.

dose limit. The value of the effective dose or the equivalent dose to individuals in planned exposure situations that is not to be exceeded.

operational limits and conditions. A set of rules setting forth parameter limits, the functional capability and the performance levels of equipment and personnel approved by the regulatory body for safe operation of an authorized facility.
[prescribed limit]. A limit established or accepted by the regulatory body.
- The term authorized limit is preferred.

primary limit. A limit on the dose or risk to an individual.

safety limits. Limits on operational parameters within which an authorized facility has been shown to be safe.
- Safety limits are operational limits and conditions beyond those for normal operation.

[secondary limit]. A limit on a measurable quantity that corresponds to a primary limit.
- Such a limit meets the definition of derived limit, and derived limit should be used.
- For example, the annual limit on intake, a derived limit, corresponds to the primary limit on annual effective dose for a worker.

linear energy transfer (LET), \( L_\Delta \)

Defined generally as:

\[
L_\Delta = \left( \frac{dE}{d\ell} \right)_\Delta
\]

where \( dE \) is the energy lost in traversing distance \( d\ell \) and \( \Delta \) is an upper bound on the energy transferred in any single collision.
- A measure of how, as a function of distance, energy is transferred from radiation to the exposed matter. A high value of linear energy transfer indicates that energy is deposited within a small distance.
- \( L_\infty \) (i.e. with \( \Delta = \infty \)) is termed the unrestricted linear energy transfer in defining the quality factor.
- \( L_\Delta \) is also known as the restricted linear collision stopping power.

linear–no threshold (LNT) hypothesis

The hypothesis that the risk of stochastic effects is directly proportional to the dose for all levels of dose and dose rate below those levels at which deterministic effects occur.
- That is, that any non-zero dose implies a non-zero risk of stochastic effects.
- This is the working hypothesis on which the IAEA’s safety standards (and the International Commission on Radiological Protection’s recommendations) are based.
- The hypothesis is not proven — indeed it is probably not provable — for low doses and dose rates, but it is considered the most defensible assumption in radiobiological terms on which to base safety standards.
Other hypotheses conjecture that the risk of stochastic effects at low doses and/or dose rates is:

(a) Greater than that implied by the linear–no threshold hypothesis (superlinear hypotheses);
(b) Less than that implied by the linear–no threshold hypothesis (sublinear hypotheses);
(c) Zero below some threshold value of dose or dose rate (threshold hypotheses); or
(d) Negative below some threshold value of dose or dose rate, that is, that low doses and dose rates protect individuals against stochastic effects and/or other types of harm (hormesis hypotheses).

‘living’ probabilistic safety assessment

See probabilistic safety assessment (PSA).

logic

The generation of a required binary output signal from a number of binary input signals according to predetermined rules.

The term is also applied to the types of equipment used for generating this signal (e.g. logic gate, logic board).

long lived waste

See waste classes.

low dispersible radioactive material

Either solid radioactive material, or solid radioactive material in a sealed capsule, that has limited dispersibility and is not in powder form. (See SSR-6 (Rev. 1) [2].)

This usage is specific to the Transport Regulations [2], and should otherwise be avoided.

low enriched uranium (LEU)

See uranium.

low level waste (LLW)

See waste classes.
low linear energy transfer (LET) radiation

See radiation.

low specific activity (LSA) material

Radioactive material that by its nature has a limited specific activity, or radioactive material for which limits of estimated average specific activity apply. (See SSR-6 (Rev. 1) [2].)

! External shielding materials surrounding the low specific activity material are required not to be considered in determining the estimated average specific activity.

! This usage is specific to the Transport Regulations [2], and should otherwise be avoided.

low toxicity alpha emitters

Natural uranium; depleted uranium; natural thorium; $^{235}\text{U}$ or $^{238}\text{U}$; $^{232}\text{Th}$; $^{228}\text{Th}$ and $^{230}\text{Th}$ when contained in ores or physical and chemical concentrates; or alpha emitters with a half-life of less than 10 days. (See SSR-6 (Rev. 1) [2].)

lower limit of detection

See minimum detectable activity (MDA).

lung absorption type

A classification used to distinguish between the different rates at which inhaled radionuclides are transferred from the respiratory tract to the blood.

Reference [38] classifies materials into four lung absorption types:

(a) Type V (very fast) are materials that, for dosimetric purposes, are assumed to be instantaneously absorbed into the blood;
(b) Type F (fast) are materials that are readily absorbed into the blood;
(c) Type M (moderate) are materials that have intermediate rates of absorption into the blood;
(d) Type S (slow) are materials that are relatively insoluble and are only slowly absorbed into the blood.

The lung absorption types supersede the [inhalation classes] D (days), M (months) and Y (years) previously recommended in Refs [20–22] (often referred to informally as ‘lung classes’).

There is an approximate correspondence between lung absorption type F and inhalation class D, between lung absorption type M and inhalation class M and between lung absorption type S and inhalation class Y.
See also *gut transfer factor*, a similar concept for ingested radionuclides in the gastrointestinal tract.
magma

A mixture of molten rock (800–1200°C) which can also contain suspended crystals, dissolved gases and sometimes gas bubbles.

1. **Magma** forms by the melting of existing rock in the Earth’s crust or in the Earth’s mantle.
2. **Magma** composition and gas content generally control the type of eruption at a volcano.
3. In general terms, hotter, less viscous magma (e.g. basalt) allows gas to separate more efficiently, limiting the explosivity of the eruption, while cooler, more viscous magma (e.g. andesite, dacite, rhyolite) is more likely to fragment violently during eruption.

magma chamber

An underground reservoir that is filled with magma and tapped during a volcanic eruption.

1. Magma in these reservoirs can partially crystallize or mix with new magma, which can change the eruption composition or hazard over time.

main safety function

See safety function.

maintenance

The organized activity, both administrative and technical, of keeping structures, systems and components in good operating condition, including both preventive and corrective (or repair) aspects.

**Corrective maintenance.** Actions that restore, by repair, overhaul or replacement, the capability of a failed structure, system or component to function within acceptance criteria.

1. Corrective maintenance does not necessarily result in a significant extension of the expected useful life of a functional structure, system or component.
2. Contrasted with preventive maintenance.

**Periodic maintenance.** Form of preventive maintenance consisting of servicing, parts replacement, surveillance or testing at predetermined intervals of calendar time, operating time or number of cycles.

1. Also termed time based maintenance.
planned maintenance. Form of preventive maintenance consisting of refurbishment or replacement that is scheduled and performed prior to unacceptable degradation of a structure, system or component.

predictive maintenance. Form of preventive maintenance performed continuously or at intervals governed by observed condition to monitor, diagnose or trend condition indicators of a structure, system or component; results indicate present and future functional ability or the nature of and schedule for planned maintenance.

preventive maintenance. Actions that detect, preclude or mitigate degradation of a functional structure, system or component to sustain or extend its useful life by controlling degradation and failures to an acceptable level.

reliability centred maintenance (RCM). A process for specifying applicable preventive maintenance requirements for safety related systems and equipment in order to prevent potential failures or to control the failure modes optimally.

magnitude (of an earthquake)

Measure of the size of an earthquake relating to the energy released in the form of seismic waves.

maximum potential magnitude. Reference value used in seismic hazard analysis characterizing the potential of a seismic source to generate earthquakes.
maintenance bypass

See bypass (1).

management (of sealed radioactive sources)

[The administrative and operational activities that are involved in the manufacture, supply, receipt, possession, storage, use, transfer, import, export, transport, maintenance, recycling or disposal of radioactive sources.] (See Ref. [14].)

This usage is specific to the Code of Conduct on the Safety and Security of Radioactive Sources [14].

management self-assessment

See assessment (2).

management system

A set of interrelated or interacting elements (system) for establishing policies and objectives and enabling the objectives to be achieved in an efficient and effective manner.

1. The component parts of the management system include the organizational structure, resources and organizational processes.
2. Management is defined (in ISO 9000) [39] as coordinated activities to direct and control an organization.
3. The management system integrates all elements of an organization into one coherent system to enable all of the organization’s objectives to be achieved. These elements include the organizational structure, resources and processes.
4. Personnel, equipment and organizational culture as well as the documented policies and processes form parts of the management system.
5. The organization’s processes have to address the totality of the requirements on the organization as established in, for example, IAEA safety standards and other international codes and standards.

integrated management system. A single coherent management system for facilities and activities in which all the component parts of an organization are integrated to enable the organization’s objectives to be achieved.

1. These component parts of an organization that are integrated include the organizational structure, resources and organizational processes.
management system review

A regular and systematic evaluation by senior management of an organization of the suitability, adequacy, effectiveness and efficiency of its management system in executing the policies and achieving the goals and objectives of the organization.

mantle, Earth’s

See Earth’s mantle.

material ageing

See ageing: physical ageing.

mathematical model

See model.

maximum normal operating pressure

The maximum pressure above atmospheric pressure at mean sea level that would develop in the containment system in a period of one year under the conditions of temperature and solar radiation corresponding to environmental conditions in the absence of venting, external cooling by an ancillary system or operational controls during transport. (See SSR-6 (Rev. 1) [2].)

maximum potential magnitude

See magnitude (of an earthquake).

mechanistic model

See model.

medical exposure

See exposure categories.
medical physicist

A *health professional* with specialist education and training in the concepts and techniques of applying physics in medicine and competent to practise independently in one or more of the subfields (specialties) of medical physics.

1. Competence of persons is normally assessed by the State by having a formal mechanism for registration, accreditation or *certification of medical physicists* in the various specialties (e.g. diagnostic radiology, radiation therapy, nuclear medicine).
2. States that have yet to develop such a mechanism would need to assess the education, training and competence of any individual proposed by the *licensee* to act as a *medical physicist* and to decide, on the basis of either international accreditation standards or standards of a State where such an accreditation system exists, whether such an individual could undertake the functions of a *medical physicist*, within the required specialty.

medical radiation facility

A medical *facility* in which *radiological procedures* are performed.

medical radiation technologist

A *health professional*, with specialist education and training in medical radiation technology, competent to perform *radiological procedures*, on delegation from the *radiological medical practitioner*, in one or more of the specialties of medical radiation technology.

1. Competence of persons is normally assessed by the State by having a formal mechanism for registration, accreditation or *certification of medical radiation technologists* in the various specialties (e.g. diagnostic radiology, radiation therapy, nuclear medicine).
2. States that have yet to develop such a mechanism would need to assess the education, training and competence of any individual proposed by the *licensee* to act as a *medical radiation technologist* and to decide, on the basis of either international standards or standards of a State where such a system exists, whether such an individual could undertake the functions of a *medical radiation technologist*, within the required specialty.

medical radiological equipment

Radiological equipment used in *medical radiation facilities* to perform *radiological procedures* that either delivers an *exposure* to an individual or directly controls or influences the extent of such exposure. The term applies to *radiation* generators, such as X ray machines or medical linear accelerators; to devices containing *sealed sources*, such as $^{60}$Co teletherapy units; to devices used in a medical imaging procedure involving *ionizing radiation* to capture images,
such as gamma cameras, image intensifiers or flat panel detectors; and to hybrid systems such as positron emission tomography–computed tomography scanners.

**member of the public**

For purposes of protection and safety, in a general sense, any individual in the population except when subject to occupational exposure or medical exposure. For the purpose of verifying compliance with the annual dose limit for public exposure, this is the representative person.

**migration**

The movement of radionuclides in the environment as a result of natural processes.

1. Most commonly, movement of radionuclides in association with groundwater flow.

**[mill]**

See [mine or mill processing radioactive ores].

**[milling]**

See [mining and milling].

**[mine or mill processing radioactive ores]**

Installation for mining, [milling] or processing ores containing uranium series or thorium series radionuclides.

1. A mine processing radioactive ores is any mine that yields ores containing uranium series or thorium series radionuclides, either in amounts or concentrations sufficient to warrant exploitation or, when present in conjunction with other substances being mined, in amounts or concentrations that require radiation protection measures to be taken as determined by the regulatory body.

1. A mill processing radioactive ores is any facility for processing radioactive ores from a mine processing radioactive ores as here defined to produce a physical or chemical concentrate.

1. This entry was restricted to those mining and processing operations aimed at extracting uranium series or thorium series radionuclides and those aimed at the extraction of other substances from ore where this represents a significant radiological hazard.

1. Strictly speaking, a mill in the context of the processing of minerals is a facility for the processing of ore to reduce its particle size, especially by crushing or grinding. However, the term [mill] was used in a broader sense to denote a facility in which additional processing (e.g. hydrometallurgical processing) may also be carried out.
minimization (of waste)

The process of reducing the amount and activity of radioactive waste to a level as low as reasonably achievable, at all stages from the design of a facility or activity to decommissioning, by reducing the amount of waste generated and by means such as recycling and reuse, and treatment to reduce its activity, with due consideration for secondary waste as well as primary waste.

Minimization of waste is not to be confused with volume reduction.

minimization (of waste)

See radioactive waste management.

recycling. The process of converting waste materials into new products.

Recycling reduces the wastage of useful materials, the use of raw materials and energy use.

Recycling contributes to reducing air pollution (caused by incineration) and reducing water pollution (caused by use of landfill sites) by reducing the need for disposal of conventional waste, and also contributes to reducing emissions of greenhouse gases.

reuse. The use of an item again after it has been used before.

Reuse includes conventional reuse, in which an item is used again to perform the same functions, and reuse in which an item is used again to perform a different function.

minimum detectable activity (MDA)

The radioactivity which, if present in a sample, produces a counting rate that will be detected (i.e. considered to be above background) with a certain level of confidence.

The ‘certain level of confidence’ is normally set at 95%; that is, a sample containing exactly the minimum detectable activity will, as a result of random fluctuations, be taken to be free of radioactivity 5% of the time.

The minimum detectable activity is sometimes referred to as the detection limit or lower limit of detection.

The counting rate from a sample containing the minimum detectable activity is termed the determination level.
minimum significant activity (MSA)

The radioactivity which, if present in a sample, produces a counting rate that can be reliably distinguished from background with a certain level of confidence.

1. A sample containing exactly the minimum significant activity will, as a result of random fluctuations, be taken to be free of radioactivity 50% of the time, whereas a true background sample will be taken to be free of radioactivity 95% of the time.
2. The minimum significant activity is sometimes referred to as the decision limit. The counting rate from a sample containing the minimum significant activity is termed the critical level.

[ mining and milling ]

Mining in a mine that yields radioactive ores containing uranium series or thorium series radionuclides, either in amounts or concentrations sufficient to warrant exploitation or, when present in conjunction with other substances being mined, in amounts or concentrations that require radiation protection measures to be taken as determined by the regulatory body; and processing of radioactive ores from such mines to produce a chemical concentrate.

1. This entry was restricted to those mining and processing operations aimed at extracting uranium series or thorium series radionuclides and those aimed at the extraction of other substances from ore where this represents a significant radiological hazard.
2. Strictly speaking, milling in the context of the processing of minerals is the processing of ore to reduce its particle size, especially by crushing or grinding.
3. However, in the context of this entry, the term [milling] was used in a broader sense to include additional processing (e.g. hydrometallurgical processing).
4. Owing to the possibility of confusion, the use of the word [milling] in this broader sense, in this expression or elsewhere, is discouraged.
5. Mining includes in situ leaching, also known as solution mining or in situ recovery, which involves recovering minerals from ores in the ground by dissolving them and pumping the resultant solution to the surface so that the minerals can be recovered.
6. This entry has been included for information only. The terms mining and [milling] should be used with their usual dictionary meanings, qualified where necessary (e.g. by use of the term radioactive ores).

See also mine or mill processing radioactive ores.

[ mining and milling waste (MMW) ]

See waste.
mitigatory action

See protective action (1).

mixed waste

See waste.

model

An analytical or physical representation or quantification of a real system and the ways in which phenomena occur within that system, used to predict or assess the behaviour of the real system under specified (often hypothetical) conditions.

computational model. A calculational tool that implements a mathematical model.

conceptual model. A set of qualitative assumptions used to describe a system (or part thereof).

These assumptions would normally cover, as a minimum, the geometry and dimensionality of the system, initial and boundary conditions, time dependence, and the nature of the relevant physical, chemical and biological processes and phenomena.

mathematical model. A set of mathematical equations designed to represent a conceptual model.

mechanistic model (biophysical model). Representation of an assumed or proven radiation induced biophysical process occurring on the molecular level, cellular level, organ level or level of the whole organism.

physical model. A physical representation, at different scale and/or using different materials, of a structure or component, the performance of which may be related to that of the real structure or component.

risk projection model. A conceptual model such as that for estimating the risk from radiation exposure at low doses and dose rates on the basis of epidemiological evidence concerning the risk from high doses and/or dose rates.
**additive risk projection model.** A risk projection model in which exposure is assumed to lead to an attributable risk that is proportional to the dose but independent of the natural probability of the effect.

**multiplicative risk projection model.** A risk projection model in which exposure is assumed to lead to an attributable risk that is proportional to the dose and to the natural probability of the effect.

**seismotectonic model.** A model that characterizes seismic sources in the region around a site of interest, including the aleatory uncertainties and the epistemic uncertainties in the seismic source characteristics.

**model calibration**

See calibration.

**model validation**

See validation (1).

**model verification**

See verification (1).

**monitoring**

1. The measurement of dose, dose rate or activity for reasons relating to the assessment or control of exposure to radiation or exposure due to radioactive substances, and the interpretation of the results.
   ① ‘Measurement’ is used somewhat loosely. The ‘measurement’ of dose often means the measurement of a dose equivalent quantity as a proxy (i.e. substitute) for a dose quantity that cannot be measured directly. Also, sampling may be involved as a preliminary step to measurement.
   ② Measurements may actually be of radiation levels, airborne activity concentrations, levels of contamination, quantities of radioactive material or individual doses.
   ③ The results of these measurements may be used to assess radiological hazards or doses resulting or potentially resulting from exposure.
   ④ Monitoring may be subdivided in two different ways: according to where the measurements are made, into individual monitoring, workplace monitoring, source monitoring and environmental monitoring; and, according to the purpose of the monitoring, into routine monitoring, task related monitoring and special monitoring.
area monitoring. A form of workplace monitoring in which an area is monitored by taking measurements at different points in that area.
① As opposed to measurements by a static monitor.

environmental monitoring. The measurement of external dose rates due to sources in the environment or of radionuclide concentrations in environmental media.
① Contrasted with source monitoring.

individual monitoring. Monitoring using measurements by equipment worn by individuals, or measurements of quantities of radioactive substances in or on, or taken into, the bodies of individuals, or measurements of quantities of radioactive substances excreted from the body by individuals.
① Also called personal monitoring.
① For workers, usually contrasted with workplace monitoring.
① It includes, for example, measurements of quantities of radioactive substances taken into the body made using breathing zone air samplers.

[personal monitoring]. Synonymous with individual monitoring.
① This usage may be confusing and is discouraged in favour of individual monitoring.

[personnel monitoring]. A combination of individual monitoring and workplace monitoring.
① This usage may be confusing and is discouraged in favour of individual monitoring and/or workplace monitoring, as appropriate.

routine monitoring. Monitoring associated with continuing operations and intended: (1) to demonstrate that working conditions, including the levels of individual dose, remain satisfactory; and (2) to meet regulatory requirements.
① Routine monitoring can be individual monitoring or workplace monitoring.
① Contrasting terms: task related monitoring and special monitoring.

source monitoring. The measurement of activity in radionuclides being released to the environment or of external dose rates due to sources within a facility or activity.
① Contrasted with environmental monitoring.

special monitoring. Monitoring designed to investigate a specific situation in the workplace for which insufficient information is available to demonstrate adequate control, by providing detailed information to elucidate any problems and to define future procedures.
Special monitoring would normally be undertaken at the commissioning stage of new facilities, following major modifications either to facilities or to procedures, or when operations are being carried out under abnormal circumstances, such as following an accident.

Special monitoring can be individual monitoring or workplace monitoring.

Contrasting terms: routine monitoring and task related monitoring.

**task related monitoring.** Monitoring in relation to a specific operation, to provide data to support immediate decisions on the management of the operation.

Task related monitoring can be individual monitoring or workplace monitoring.

Contrasting terms: routine monitoring and special monitoring.

**workplace monitoring.** Monitoring using measurements made in the working environment.

Usually contrasted with individual monitoring.

2. Continuous or periodic measurement of radiological or other parameters or determination of the status of a structure, system or component.

Sampling may be involved as a preliminary step to measurement.

Although the concept is not fundamentally different from definition (1), this definition is more suited to the types of monitoring concerned primarily with safety (i.e. keeping sources under control) rather than with protection (i.e. controlling exposure).

This definition is particularly relevant to monitoring the status of a nuclear installation by tracking plant variables, or monitoring the long term performance of a waste disposal facility by tracking variables such as water fluxes.

These examples differ from definition (1) in that the routine measurements are themselves of no particular interest; the monitoring is only intended to detect unexpected deviations if they occur.

**condition monitoring.** Continuous or periodic tests, inspections, measurement or trending of the performance or physical characteristics of structures, systems and components to indicate current or future performance and the potential for failure.

Condition monitoring is usually conducted on a non-intrusive basis.

**multilateral approval**

See approval.
multiple barriers

See barrier.

multiple safety functions

See barrier.

multiplexing

Transmission and reception of two or more signals or messages over a single data channel; for example, by the use of time division, frequency division or pulse code techniques.

multiplicative risk projection model

See model: risk projection model.
N
natural analogue
A situation in nature used as a model for processes affecting human made
systems.

 The use of a natural analogue allows conclusions to be drawn that are relevant in
making judgements about the safety of an existing or planned nuclear facility.
 In particular, mineral deposits containing radionuclides whose migration history
over very long time periods can be analysed and the results used in modelling the
potential behaviour of these or similar radionuclides in the geosphere over a long
period of time can be used as natural analogues.

natural background
See background.
natural source
See source (1).
natural uranium
See uranium.
naturally occurring radioactive material (NORM)
Radioactive material containing no significant amounts of radionuclides
other than naturally occurring radionuclides.

 The exact definition of ‘significant amounts’ would be a regulatory decision.
 Material in which the activity concentrations of the naturally occurring
radionuclides have been changed by a process is included in naturally occurring
radioactive material (NORM).
 Naturally occurring radioactive material or NORM should be used in the singular
unless reference is explicitly being made to various materials.

naturally occurring radionuclides
See radionuclides of natural origin.

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near field

The excavated area of a disposal facility near or in contact with the waste packages, including filling or sealing materials, and those parts of the host medium/rock whose characteristics have been or could be altered by the disposal facility or its contents.

See also far field.

dear miss

A potential significant event that could have occurred as the consequence of a sequence of actual occurrences but did not occur owing to the conditions prevailing at the time.

See also event, incident and safety.

near surface disposal

See disposal (1).

near surface disposal facility

See disposal facility.

non-fixed contamination

See contamination (2).

non-physical ageing

See ageing.

non-radiological consequences

Adverse psychological, societal or economic consequences of a nuclear or radiological emergency or of an emergency response affecting human life, health, property or the environment.

① The definition relates to emergency preparedness and response only [15].
[non-stochastic effect]

See health effects (of radiation): deterministic effect: severe deterministic effect.

NORM

See naturally occurring radioactive material.

NORM residue

Material that remains from a process and comprises or is contaminated by naturally occurring radioactive material (NORM).

A NORM residue may or may not be waste.

NORM waste

See waste.

normal operation

See plant states (considered in design).

notification

1. A document submitted to the regulatory body by a person or organization to notify an intention to carry out a practice or other use of a source.

   This includes the notification of appropriate competent authorities by a consignor that a shipment will pass through or into their countries, as required in section V of the Transport Regulations [2].

2. A report submitted promptly to a national or international authority providing details of an emergency or a possible emergency; for example, as required by the Convention on Early Notification of a Nuclear Accident [7].

3. A set of actions taken upon detection of emergency conditions with the purpose of alerting all organizations with responsibility for emergency response in the event of such conditions.
notification point

A designated organization with which *arrangements* have been made to receive *notification* (meaning (3)) and to initiate promptly the predetermined actions to activate a part of the *emergency response*.

notifying State

The State that is responsible for notifying (see *notification* (2)) potentially affected States and the IAEA of an *event* of actual, potential or perceived radiological significance for other States.

\[\begin{align*}
\text{①} & \text{ This includes:} \\
(a) & \text{ The State Party that has jurisdiction or } \textit{control} \text{ over the } \textit{facility} \text{ or } \textit{activity} \text{ (including space objects) in accordance with Article 1 of the Convention on Early Notification of a Nuclear Accident [7];} \\
(b) & \text{ The State that initially detects or discovers evidence of a } \textit{transnational emergency}, \text{ for example by: detecting significant increases in atmospheric } \textit{radiation} \text{ levels of unknown origin; detecting } \textit{contamination} \text{ in transboundary } \textit{shipments}; \text{ discovering a } \textit{dangerous source} \text{ that may have originated in another State; or diagnosing clinical symptoms that may have resulted from } \textit{exposure} \text{ outside the State.}
\end{align*}\]

nuclear

\[\begin{align*}
\text{①} & \text{ Strictly: relating to a nucleus; relating to or using energy released in nuclear fission or fusion. (adjective)} \\
\text{!} & \text{ The adjective ‘nuclear’ is used in many phrases to modify a noun that it cannot logically modify. It must be borne in mind that the meaning of such phrases may be unclear (as opposed to nuclear).} \\
\text{!} & \text{ The phrases may therefore need to be explained, and their usage may be open to misunderstanding, misrepresentation or mistranslation.} \\
\text{!} & \text{ Such phrases include: nuclear accident; nuclear community; nuclear emergency; nuclear facility; nuclear fuel; nuclear incident; nuclear installation; nuclear material; nuclear medicine; (a) nuclear power; nuclear safety; and nuclear security.}
\end{align*}\]

nuclear accident

See *accident* (1).
[nuclear damage]

“(i) loss of life or personal injury;
(ii) loss of or damage to property;

“and each of the following to the extent determined by the law of the competent court:

(iii) economic loss arising from loss or damage referred to in sub-paragraph (i) or (ii), insofar as not included in those sub-paragraphs, if incurred by a person entitled to claim in respect of such loss or damage;
(iv) the costs of measures of reinstatement of impaired environment, unless such impairment is insignificant, if such measures are actually taken or to be taken, and insofar as not included in sub-paragraph (ii);
(v) loss of income deriving from an economic interest in any use or enjoyment of the environment, incurred as a result of a significant impairment of that environment, and insofar as not included in sub-paragraph (ii);
(vi) the costs of preventive measures, and further loss or damage caused by such measures;
(vii) any other economic loss, other than any caused by the impairment of the environment, if permitted by the general law on civil liability of the competent court,

“in the case of sub-paragraphs (i) to (v) and (vii) above, to the extent that the loss or damage arises out of or results from ionizing radiation emitted by any source of radiation inside a nuclear installation, or emitted from nuclear fuel or radioactive products or waste in, or of nuclear material coming from, originating in, or sent to, a nuclear installation, whether so arising from the radioactive properties of such matter, or from a combination of radioactive properties with toxic, explosive or other hazardous properties of such matter.” (From Ref. [35].)

1 In this context, ‘preventive measures’ are any reasonable measures taken by any person after a nuclear incident has occurred to prevent or minimize damage referred to in sub-paragraphs (i) to (v) or (vii), subject to any approval of the competent authorities required by the law of the State where the measures were taken.

nuclear emergency

See emergency.
nuclear facility

1. A facility (including associated buildings and equipment) in which nuclear material is produced, processed, used, handled, stored or disposed of.
   ① Also nuclear fuel cycle facility.

See also facilities and activities and nuclear installation.

2. [A facility (including associated buildings and equipment) in which nuclear material is produced, processed, used, handled, stored or disposed of, if damage to or interference with such facility could lead to the release of significant amounts of radiation or radioactive material.] (See Refs [40–43].)
   ① This usage is specific to the revised Convention on the Physical Protection of Nuclear Material and Nuclear Facilities [40–43], for the purposes of the Convention, and should otherwise be avoided.
   ① The Final Act of the Convention on the Physical Protection of Nuclear Material and Nuclear Facilities was approved on 8 July 2005.

3. “[A] civilian facility and its associated land, buildings and equipment in which radioactive materials are produced, processed, used, handled, stored or disposed of on such a scale that consideration of safety is required”.] (From Ref. [5].)
   ① This usage is specific to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [5], for the purposes of the Joint Convention, and should otherwise be avoided.
   ① Essentially synonymous with authorized facility, and hence more general than nuclear installation.
   ① Note that this differs from safeguards terminology, in which installation is more general than facility.

nuclear fuel

Fissionable nuclear material in the form of fabricated elements for loading into the reactor core of a civil nuclear power plant or research reactor.

fresh fuel. New fuel or unirradiated fuel, including fuel fabricated from fissionable material recovered by reprocessing previously irradiated fuel.
nuclear fuel cycle

All operations associated with the production of nuclear energy.

Operations in the nuclear fuel cycle associated with the production of nuclear energy include the following:

(a) Mining and processing of uranium ores or thorium ores;
(b) Enrichment of uranium;
(c) Manufacture of nuclear fuel;
(d) Operation of nuclear reactors (including research reactors);
(e) Reprocessing of spent fuel;
(f) All waste management activities (including decommissioning) relating to operations associated with the production of nuclear energy;
(g) Any related research and development activities.

closed nuclear fuel cycle. Mining, processing, conversion, enrichment of uranium, nuclear fuel fabrication, reactor operation, electrical generation or other energy products, reprocessing to recover fissile material, storage of reprocessed fissile material, disposal (for highly radioactive fission products) and final end states for all waste.

open nuclear fuel cycle. Mining, processing, conversion, enrichment of uranium, nuclear fuel fabrication, reactor operation, electrical generation or other energy products, storage of spent fuel, disposal and final end states for all waste.

nuclear fuel cycle facility

See nuclear facility.

[nuclear incident]

See incident.

nuclear installation

1. Any 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.

This definition thus includes: nuclear power plants; research reactors (including subcritical and critical assemblies) and any adjoining radioisotope production facilities; storage facilities for spent fuel; facilities for the enrichment of uranium; nuclear fuel fabrication facilities; conversion facilities; facilities for the reprocessing
of spent fuel; facilities for the predisposal management of radioactive waste arising from nuclear fuel cycle facilities; and nuclear fuel cycle related research and development facilities.

2. [For each Contracting Party, any land-based civil nuclear power plant under its jurisdiction, including such storage, handling and treatment facilities for radioactive materials as are on the same site and are directly related to the operation of the nuclear power plant. Such a plant ceases to be a nuclear installation when all nuclear fuel elements have been removed permanently from the reactor core and have been stored safely in accordance with approved procedures, and a decommissioning programme has been agreed to by the regulatory body.] (See Ref. [4].)

nuclear material

Plutonium except that with isotopic concentration exceeding 80% in $^{238}$Pu; $^{233}$U; uranium enriched in the isotope 235 or 233; uranium containing the mixture of isotopes as occurring in nature other than in the form of ore or ore residue; any material containing one or more of the foregoing. (See Refs [40–43].)

- Nuclear material is necessary for the production of nuclear weapons or other nuclear explosive devices. Under comprehensive safeguards agreements, the IAEA verifies that all nuclear material subject to safeguards has been declared and placed under safeguards.
- Certain non-nuclear materials are essential for the use or production of nuclear material and may also be subject to IAEA safeguards under certain agreements.
- The Final Act of the Convention on the Physical Protection of Nuclear Material and Nuclear Facilities was approved on 8 July 2005.
- The Statute of the IAEA [44] uses the term special fissionable material, with the meaning essentially of nuclear material as defined here, but explicitly excluding source material.
- For the purposes of IAEA safeguards agreements, nuclear material is defined as “any source material…or special fissionable material…as defined in Article XX of [the Statute of the IAEA]” [45]. The meaning is essentially the same as that of nuclear material as defined here.
- The Paris Convention on Third Party Liability in the Field of Nuclear Energy [46] uses the term ‘nuclear substances’, which means nuclear fuel (other than natural uranium and depleted uranium) and radioactive products or radioactive waste.

See also source material.

nuclear or radiological emergency

See emergency.
(nuclear) safety

The achievement of proper operating conditions, prevention of accidents and mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation risks.

- Often abbreviated to safety in IAEA publications on nuclear safety. Safety means nuclear safety unless otherwise stated, in particular when other types of safety (e.g. fire safety, conventional industrial safety) are also being discussed.

See protection and safety for a discussion of the relationship between nuclear safety and radiation protection.

nuclear security

1. The prevention and detection of, and response to, criminal or intentional unauthorized acts involving nuclear material, other radioactive material, associated facilities or associated activities.

See IAEA Nuclear Security Series No. 20 [47].

- Often abbreviated to security in IAEA publications on nuclear security.
- Security of nuclear material for reasons relating to non-proliferation of nuclear weapons is outside the scope of the IAEA safety standards and of the IAEA Nuclear Security Series.

2. The prevention and detection of, and response to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material, other radioactive material or their associated facilities.

See IAEA GOV/2005/50.

- This includes, but is not limited to, the prevention and detection of, and response to, the theft of nuclear material or other radioactive material (with or without knowledge of the nature of the material), sabotage, and other malicious acts, illicit trafficking and unauthorized transfer.
- The response element of the definition refers to those actions aimed at ‘reversing’ the immediate consequences of unauthorized access or actions (e.g. recovering material). Response to radiological consequences that might ensue is considered part of safety.
- There is not an exact distinction between the general terms safety and security. In general, security is concerned with intentional actions by people that could cause or threaten harm to other people; safety is concerned with the broader issue of harmful consequences to people (and to the environment) arising from exposure to radiation, whatever the cause.
1 The interaction between arrangements for security and arrangements for safety depends on the context. Areas in which arrangements for safety and arrangements for security interact include, for example: the regulatory infrastructure; engineering provisions in the design and construction of nuclear installations and other facilities; controls on access to nuclear installations and other facilities; the categorization of radioactive sources; source design; the security of the management of radioactive sources and radioactive material; the recovery of sources that are not under regulatory control; emergency response plans; and radioactive waste management.

2 ‘Security’ in a general sense encompasses related issues of global security — the sustainability of human life — in terms of energy security, environmental security, food security and water security, as well as nuclear security — to all of which the use of nuclear energy is related.

3 Joint sponsorship of safety standards, and in particular of IAEA Safety Standards Series Nos SF-1 [17], GSR Part 3 [1] and GSR Part 7 [15], reinforces a global view of protection of people and protection of the environment.

**nuclear security event**

An event that has potential or actual implications for nuclear security that must be addressed.

1 Such events include criminal or intentional unauthorized acts involving or directed at nuclear material, other radioactive material, associated facilities or associated activities.

1 A nuclear security event, for example, sabotage of a nuclear facility or detonation of a radiological dispersal device, may give rise to a nuclear or radiological emergency.
observed cause

See cause.

occupancy factor

A typical fraction of the time for which a location is occupied by an individual or group.

occupational exposure

See exposure categories.

off-site (area)

Outside the site area.

on-site (area)

Within the site area.

open nuclear fuel cycle

See nuclear fuel cycle.

operating conditions

See plant states (considered in design): operational states.

operating lifetime, operating life

See life, lifetime.

operating organization

1. Any organization or person applying for authorization or authorized to operate an authorized facility or to conduct an authorized activity and responsible for its safety.
Note that such an organization may be the *operating organization* before operation starts.

1. This includes, inter alia, private individuals, governmental bodies, *consignors* or *carriers*, licensees, hospitals and self-employed persons.

1. *Operating organization* includes either those who are directly in control of a *facility* or an *activity* during use of a *source* (such as radiographers or carriers) or, in the case of a *source* not under *control* (such as a lost or illicitly removed source or a re-entering satellite), those who were responsible for the *source* before *control* over it was lost.

1. In practice, for an *authorized facility*, the *operating organization* is normally also the *registrant* or *licensee*. However, the separate terms are retained to refer to the two different capacities.

See also *operator*.

2. The organization (and its contractors) which undertakes the *siting*, *design*, *construction*, *commissioning* and/or *operation* of a *nuclear facility*.

   This usage is particular to documentation relating to the *safety* of *radioactive waste management*, with the corresponding understanding of *siting* as a multistage process.

   This difference is partly a reflection of the particularly crucial role of *siting* in the *safety* of *repositories*.

**operating period**

See *life, lifetime: operating lifetime, operating life* (1).

**operating personnel**

Individual *workers* engaged in the *operation* of an *authorized facility* or the conduct of an *authorized activity*.

This may be shortened to *operator(s)*, provided that there is no danger of confusion with *operator* in the sense of *operating organization*.

**operation**

All *activities* performed to achieve the purpose for which an *authorized facility* was constructed.

1. For a nuclear power plant, this includes *maintenance*, refuelling, *in-service inspection* and other associated *activities*.

1. The terms *siting*, *design*, *construction*, *commissioning*, *operation* and *decommissioning* are normally used to delineate the six major stages of the *lifetime* of an *authorized facility* and of the associated *licensing process*. In the special case of *disposal facilities* for *radioactive waste*, *decommissioning* is replaced in this sequence by *closure*. 

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See also abnormal operation and normal operation.

**operational bypass**

See bypass (1).

**operational criteria**

Values of measurable quantities or observable conditions (i.e. observables) to be used in the response to a nuclear or radiological emergency in order to determine the need for appropriate protective actions and other response actions.

1. Operational criteria used in an emergency include operational intervention levels (OILs), emergency action levels (EALs), specific observable conditions (i.e. observables) and other indicators of conditions on the site.
2. Operational criteria are sometimes referred to as triggers.

**operational intervention level (OIL)**

See level.

**operational limits and conditions**

See limit.

**operational period**

See life, lifetime: operating lifetime, operating life (1).

**operational quantities**

Quantities used in practical applications for monitoring and investigations that involve external exposure.

1. Operational quantities are defined for the purpose of measurement and assessment of doses in the human body.
2. In internal dosimetry, no operational dose quantities have been defined that directly provide an assessment of equivalent dose or effective dose.
3. Different methods are applied to assess the equivalent dose or effective dose from exposure due to radionuclides in the human body.
4. These methods are mostly based on various activity measurements and the application of biokinetic models (computational models).
5. It is possible to use the measurable properties of radiation fields and of radionuclides associated with external exposure or with intake of radionuclides to estimate...
protection quantities and to demonstrate compliance with requirements involving protection quantities. These measurable quantities are called operational quantities.

operational states

See plant states (considered in design).

operations area

See area.

operations boundary

See area: operations area.

operator

Any person or organization applying for authorization or authorized and/or responsible for safety when undertaking activities or in relation to any nuclear facilities or sources of ionizing radiation.

1. Operator includes, inter alia, private individuals, governmental bodies, consignors or carriers, licensees, hospitals, self-employed persons.
   ! Operator is sometimes used to refer to operating personnel (e.g. control room operators). If used in this way, particular care should be taken to ensure that there is no possibility of confusion.

2. Operator includes either those who are directly in control of a facility or an activity during use or transport of a source (such as radiographers or carriers) or, in the case of a source not under control (such as a lost or illicitly removed source or a re-entering satellite), those who were responsible for the source before control over it was lost.

3. Synonymous with operating organization.

optimization (of protection and safety)

1. The process of determining what level of protection and safety would result in the magnitude of individual doses, the number of individuals (workers and members of the public) subject to exposure and the likelihood of exposure being as low as reasonably achievable, economic and social factors being taken into account (ALARA).

2. The management of the radiation dose to the patient commensurate with the medical purpose.
   ! For medical exposures of patients.
‘Optimization of protection and safety’ means that optimization of protection and safety has been applied and the results of that process have been implemented.

This is not the same as optimization of the process or practice concerned. An explicit term such as optimization of protection and safety should be used.

The acronym ALARA should not be used to mean optimization of protection and safety.

organ dose

See dose quantities.

orphan source

See source (2).

other nuclear or radiological emergency

See emergency class.

other response actions

See emergency response: emergency response action.

overpack

1. See radioactive waste management (1).

2. An enclosure used by a single consignor to contain one or more packages and to form one unit for convenience of handling and stowage during transport. (See SSR-6 (Rev. 1) [2].)
package

The complete product of the packing operation, consisting of the packaging and its contents prepared for transport. The types of package covered by [the Transport] Regulations [2] that are subject to the activity limits and material restrictions of Section IV [of the Transport Regulations [2]] and meet the corresponding requirements are:

(a) Excepted package;
(b) Industrial package Type 1 (Type IP-1);
(c) Industrial package Type 2 (Type IP-2);
(d) Industrial package Type 3 (Type IP-3);
(e) Type A package;
(f) Type B(U) package;
(g) Type B(M) package;
(h) Type C package.

Packages containing fissile material or uranium hexafluoride are subject to additional requirements. (See SSR-6 (Rev. 1) [2].)

The detailed specifications and requirements for these package types are specified in SSR-6 (Rev. 1) [2].

package, waste

See waste package.

packaging

1. One or more receptacles and any other components or materials necessary for the receptacles to perform containment and other safety functions. (See SSR-6 (Rev. 1) [2].)

2. See radioactive waste management (1).

palaeoseismicity

The evidence of a prehistoric or historical earthquake manifested as displacement on a fault or secondary effects such as ground deformation (i.e. liquefaction, tsunami, landslides).
particle fluence

See fluence.

passenger aircraft

See aircraft.

passive component

A component whose functioning does not depend on an external input such as actuation, mechanical movement or supply of power.

1. A passive component has no moving part, and, for example, only experiences a change in pressure, in temperature or in fluid flow in performing its functions. In addition, certain components that function with very high reliability based on irreversible action or change may be assigned to this category.

2. Examples of passive components are heat exchangers, pipes, vessels, electrical cables and structures. It is emphasized that this definition is necessarily general in nature, as is the corresponding definition of active component.

3. Certain components, such as rupture discs, check valves, safety valves, injectors and some solid state electronic devices, have characteristics which require special consideration before designation as an active component or a passive component.

4. Any component that is not a passive component is an active component.

See also component, core components and structures, systems and components.

pathway

See exposure pathway.

patient

An individual who is a recipient of services of health professionals and/or their agents that are directed at (a) promotion of health; (b) prevention of illness and injury; (c) monitoring of health; (d) maintaining health; and (e) medical treatment of diseases, disorders and injuries in order to achieve a cure or, failing that, optimum comfort and function. Some asymptomatic individuals are included.

1. For the purpose of the requirements on medical exposure in the IAEA safety standards, the term ‘patient’ refers only to those individuals undergoing radiological procedures.
peak ground acceleration

The maximum absolute value of ground acceleration displayed on an accelerogram; the greatest ground acceleration produced by an earthquake at a site.

peer review

An examination or review of commercial, professional or academic efficiency, competence, etc., by others in the same occupation.

Peer review is also: the evaluation, by experts in the relevant field, of a scientific research project for which a grant is sought; the process by which a learned journal passes a paper received for publication to outside experts for their comments on its suitability and worth; refereeing.

performance assessment

See assessment (1).

performance indicator

See indicator.

performance standard

Description of the performance required of a structure, system or component or other item of equipment, a person or a procedure with the aim of ensuring a high level of safety.

periodic maintenance

See maintenance.

periodic safety review

A systematic reassessment of the safety of an existing facility (or activity) carried out at regular intervals to deal with the cumulative effects of ageing, modifications, operating experience, technical developments and siting aspects, and aimed at ensuring a high level of safety throughout the service life of the facility (or activity).
permanent relocation

See relocation.

permanent shutdown

See shutdown.

person or organization

Any organization, corporation, partnership, firm, association, trust, estate, public or private institution, group, political or administrative entity, or other persons designated in accordance with national legislation who or which has responsibility and authority for any action having implications for protection and safety.

Supersedes the term legal person, which is contrasted in legal texts with ‘natural person’, meaning an individual.

personal dose equivalent, $H_p(d)$

See dose equivalent quantities.

[personal monitoring]

See monitoring (1).

[personnel monitoring]

See monitoring (1).

phreatic eruption

See eruption.

phreatomagmatic eruption

See eruption.

physical ageing

See ageing.
physical diversity

See diversity.

physical half-life

See half-life (2): radioactive half-life.

physical model

See model.

physical protection

See protection (3).

physical separation

Separation by geometry (distance, orientation, etc.), by appropriate barriers, or by a combination thereof.

physisorption

See sorption.

planned exposure situation

See exposure situations.

planned maintenance

See maintenance.

planning target volume

A geometrical concept used in radiation therapy for planning medical treatment with consideration of the net effect of movements of the patient and of the tissues to be irradiated, variations in size and shape of the tissues, and variations in beam geometry such as beam size and beam direction.
plant equipment (for a nuclear power plant)

Items important to safety include:

- Those structures, systems and components whose malfunction or failure could lead to undue radiation exposure of site personnel or members of the public;
- Those structures, systems and components that prevent anticipated operational occurrences from leading to accident conditions;
- Safety features (for design extension conditions);
- Those features that are provided to mitigate the consequences of malfunction or failure of structures, systems and components.

Protection system. System that monitors the operation of a reactor and which, on sensing an abnormal condition, automatically initiates actions to prevent an unsafe or potentially unsafe condition.

Safety actuation system. The collection of equipment required to accomplish the necessary safety actions when initiated by the protection system.

Safety feature (for design extension conditions). Item that is designed to perform a safety function for or that has a safety function for design extension conditions.

In this context, an 'item' is a structure, system or component.
**safety related item.** An item important to safety that is not part of a safety system.

**safety related system.** A system important to safety that is not part of a safety system.
1. A safety related instrumentation and control system, for example, is an instrumentation and control system that is important to safety but which is not part of a safety system.

**safety system.** A system important to safety, provided to ensure the safe shutdown of the reactor or the residual heat removal from the reactor core, or to limit the consequences of anticipated operational occurrences and design basis accidents.
1. Safety systems consist of the protection system, the safety actuation systems and the safety system support features.
2. Components of safety systems may be provided solely to perform safety functions, or may perform safety functions in some plant operational states and non-safety functions in other operational states.

**safety system settings.** Settings for levels at which safety systems are automatically actuated in the event of anticipated operational occurrences or design basis accidents, to prevent safety limits from being exceeded.

**safety system support features.** The collection of equipment that provides services such as cooling, lubrication and energy supply required by the protection system and the safety actuation systems.
1. After an initiating event, some required safety system support features may be initiated by the protection system and others may be initiated by the safety actuation systems they serve; other required safety system support features may not need to be initiated if they are in operation at the time of the initiating event.

**plant states (considered in design)**

1. The entries that follow (terms and definitions) relate to consideration at the design stage (i.e. by means of hypothetical scenarios).
2. Care needs to be taken to select, use and relate defined terms and other words in such a way that clear distinctions are drawn and may be inferred between, for example: events and situations (see the entry for event); accidents and other incidents; what is actual (i.e. what is), possible (i.e. what might be) or potential (i.e. what could become), and what is hypothetical (i.e. what is postulated or assumed); and what is observed or determined objectively, and what is decided or declared subjectively.
3. ‘Conditions’, for example, is used in terms in the sense of rules set in design (as in operational limits and conditions) and also circumstances of operation (as in plant conditions); and in terms used in both design and operation (e.g. in accident conditions, service conditions).
Drafters and reviewers thus need to bear in mind whether text concerns *design* or *operation*, or both. The potential, the postulated or the assumed in *design* needs to be distinguished from the observed or the determined in *operation*; and the decided on or declared (such as an *emergency*), in both *design* and *operation*, needs to be distinguished from the former (i.e. the potential, the postulated, the assumed, the observed and the determined).

The concept of *facility states* as it is used in the *safety standards* for *research reactors* and for *nuclear fuel cycle facilities* is broadly equivalent to the concept of *plant states* for nuclear power plants. Unless otherwise indicated, the definitions of terms grouped under ‘*plant states*’ apply for nuclear power plants, *research reactors* and *nuclear fuel cycle facilities*.

See also *event*, *model*, *probabilistic safety assessment*, *uncertainty*.

<table>
<thead>
<tr>
<th>Operational states</th>
<th>Accident conditions</th>
</tr>
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<td>Normal operation</td>
<td>Design basis accidents</td>
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<td>Design extension conditions</td>
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<tr>
<td></td>
<td>Without significant fuel degradation</td>
</tr>
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<td></td>
<td>With core melting</td>
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</table>

**accident conditions.** Deviations from normal operation that are less frequent and more severe than *anticipated operational occurrences*.

더라도 Accident conditions comprise *design basis accidents* and *design extension conditions*.

Examples of such deviations include a major *fuel failure* or a loss of coolant accident (LOCA).

See also *accident* and *event*.

**anticipated operational occurrence.** A deviation of an operational process from normal operation that is expected to occur at least once during the *operating lifetime* of a facility but which, in view of appropriate design provisions, does not cause any significant damage to *items important to safety* or lead to *accident conditions*.

Examples of anticipated operational occurrences are loss of normal electrical power and faults such as a turbine trip, malfunction of individual items of a normally running plant, *failure* to function of individual items of *control* equipment, and loss of power to the main coolant pump.
Some States and organizations use the term abnormal operation (for contrast with normal operation) for this concept.

**beyond design basis accident.** Postulated accident with accident conditions more severe than those of a design basis accident.

**controlled state.** Plant state, following an anticipated operational occurrence or accident conditions, in which fulfilment of the fundamental safety functions can be ensured and which can be maintained for a time sufficient to implement provisions to reach a safe state.

**design basis accident.** A postulated accident leading to accident conditions for which a facility is designed in accordance with established design criteria and conservative methodology, and for which releases of radioactive material are kept within acceptable limits.

**design extension conditions.** Postulated accident conditions that are not considered for design basis accidents, but that are considered in the design process of the facility in accordance with best estimate methodology, and for which releases of radioactive material are kept within acceptable limits.

For nuclear power plants and research reactors, design extension conditions comprise conditions in events without significant fuel degradation and conditions in events with melting of the reactor core.

**normal operation.** Operation within specified operational limits and conditions.

For a nuclear power plant, this includes startup, power operation, shutting down, shutdown, maintenance, testing and refuelling.

**operational states.** States defined under normal operation and anticipated operational occurrences.

Some States and organizations use the term operating conditions (in contrast to accident conditions) for this concept.

**safe state.** Plant state, following an anticipated operational occurrence or accident conditions, in which the reactor is subcritical and the fundamental safety functions can be ensured and maintained stable for a long time.

**plinian eruption**

See eruption.
Pliocene

An interval of geological time extending from 5.3 to 2.6 million years ago.

poison

A substance used to reduce reactivity (typically in a reactor core), by virtue of its high neutron absorption cross-section.

[burnable poison]. A poison that becomes less effective as a result of absorbing neutrons.

! The term burnable absorber is preferred.

postulated initiating event (PIE)

See initiating event.

potential alpha energy

The total alpha energy ultimately emitted during the decay of decay products of $^{222}$Rn or $^{220}$Rn through the decay chain.

! Note that the definition of radon decay products includes the decay chain up to but not including $^{210}$Pb.

potential alpha energy exposure. The time integral of the potential alpha energy concentration in air over the time period for which an individual is exposed to radiation from decay products of $^{222}$Rn or $^{220}$Rn.

! This is not a type of potential exposure.

1 Used in measuring exposure due to decay products of $^{222}$Rn or $^{220}$Rn, in particular for occupational exposure.

1 Unit: J·h/m³.

potential exposure

Prospectively considered exposure that is not expected to be delivered with certainty but that may result from an anticipated operational occurrence or accident at a source or owing to an event or sequence of events of a probabilistic nature, including equipment failures and operating errors.

! Potential exposure is not an exposure and is not a type of exposure.

1 Potential exposure includes prospectively considered (i.e. hypothetical or postulated) exposures due to a source in an event or sequence of events of a probabilistic nature, including exposures resulting from an accident, equipment failures, operating errors,
natural events or phenomena (such as hurricanes, earthquakes and floods) and inadvertent human intrusion (such as a human intrusion into a near surface disposal facility after institutional control is removed).

In the case of a geological disposal facility, assessment of the long term action of processes and events that are uncertain leads to projections of long term potential exposure.

practical elimination

The phrase ‘practically eliminated’ was used in requirements for the design of nuclear power plants to convey the notion that, for a nuclear power plant, the possibility of the potential occurrence of certain hypothetical event sequences in scenarios could be considered to be excluded (“practically eliminated”) provided that (1) it would be physically impossible for the relevant event sequences to occur or that (2) these sequences “could be considered with a high level of confidence to be extremely unlikely to arise” [18].

The phrase ‘practically eliminated’ is misleading as it actually concerns the possible exclusion of event sequences from hypothetical scenarios rather than practicalities of safety. The phrase can also all too readily be misinterpreted, misrepresented or mistranslated as referring to the ‘elimination’ of ‘accidents’ by practical measures (or else ‘practically’ in the sense of ‘almost’). Clear drafting in natural language would be preferable.

practice

Any human activity that introduces additional sources of exposure or additional exposure pathways, or that modifies the network of exposure pathways from existing sources, so as to increase the exposure or the likelihood of exposure of people or the number of people exposed.

Radioactive waste is generated as a result of practices that involve some beneficial effect, such as the generation of electricity by nuclear means or the diagnostic application of radioisotopes. The management of this waste is therefore only one part of the overall practice.

The term facilities and activities is intended to provide an alternative to the terminology of sources and practices (or interventions) to refer to general categories of situations.

Terms such as ‘authorized practice’, ‘controlled practice’ and ‘regulated practice’ are used to distinguish those practices that are subject to regulatory control from other activities that meet the definition of a practice but do not need or are not amenable to control.

precautionary action zone (PAZ)

See emergency planning zones.
precautionary urgent protective action

See protective action: urgent protective action.

predictive maintenance

See maintenance.

predisposal management (of waste)

See radioactive waste management (1).

preparedness stage

See emergency preparedness.

[prescribed limit]

See limit.

pretreatment (of waste)

See radioactive waste management (1).

preventive maintenance

See maintenance.

primary limit

See limit.

prime mover

A component that converts energy into action when commanded by an actuation device.

Such as a motor, solenoid operator or pneumatic operator.
probabilistic analysis

1. Probabilistic analysis is often taken to be synonymous with stochastic analysis. Strictly, however, ‘stochastic’ conveys directly the idea of randomness (or at least apparent randomness), whereas ‘probabilistic’ is directly related to probabilities, and hence only indirectly concerned with randomness.

2. A natural event or process might more correctly be described as ‘stochastic’ (as in stochastic effect), whereas ‘probabilistic’ would be more appropriate for describing a mathematical analysis of stochastic events or processes and their consequences (such an analysis would, strictly, only be ‘stochastic’ if the analytical method itself included an element of randomness, e.g. Monte Carlo analysis).

probabilistic safety assessment (PSA)

A comprehensive, structured approach to identifying failure scenarios, constituting a conceptual and mathematical tool for deriving numerical estimates of risk.

1. Three levels of probabilistic safety assessment are generally recognized:

   — Level 1 comprises the assessment of failures leading to determination of the frequency of core damage.
   — Level 2 includes the assessment of containment response, leading, together with Level 1 results, to the determination of frequencies of failure of the containment and release to the environment of a given percentage of the reactor core’s inventory of radionuclides.
   — Level 3 includes the assessment of off-site consequences, leading, together with the results of Level 2 analysis, to estimates of public risks.

(See, for example, Ref. [48].)

‘living’ probabilistic safety assessment. A probabilistic safety assessment that is updated as necessary to reflect the current design and operational features, and is documented in such a way that each aspect of the PSA model can be directly related to existing plant information and plant documentation, or to the analysts’ assumptions in the absence of such information.

procedure

A series of specified actions conducted in a certain order or manner.

1. The set of actions to be taken to conduct an activity or to perform a process is typically specified in a set of instructions.
process

1. A course of action or proceeding, especially a series of progressive stages in the manufacture of a product or some other operation.

2. A set of interrelated or interacting activities that transforms inputs into outputs.
   ① A product is the result or output of a process.

processing (of waste)

See radioactive waste management (1).

projected dose

See dose concepts.

protection

1. (against radiation):

radiation protection (also radiological protection). The protection of people from harmful effects of exposure to ionizing radiation, and the means for achieving this.

See also protection and safety.
   ① The International Commission on Radiological Protection and others use the term radiological protection, which is synonymous.
   ① The accepted understanding of the term radiation protection is restricted to protection of people. Suggestions to extend the definition to include the protection of non-human species or the protection of the environment are controversial.

2. (of a nuclear reactor). See plant equipment (for a nuclear power plant): protection system.

3. (of nuclear material):

physical protection. Measures for the protection of nuclear material or authorized facilities, designed to prevent unauthorized access or removal of fissile material or sabotage with regard to safeguards, as, for example, in the Convention on the Physical Protection of Nuclear Material. (See Refs [40–43].)
The Final Act of the Convention on the Physical Protection of Nuclear Material and Nuclear Facilities was approved on 8 July 2005.

**protection and safety**

The protection of people against exposure to ionizing radiation or exposure due to radioactive material and the safety of sources, including the means for achieving this, and the means for preventing accidents and for mitigating the consequences of accidents if they do occur.

1. Safety is primarily concerned with maintaining control over sources, whereas (radiation) protection is primarily concerned with controlling exposure to radiation and its effects.
2. Clearly the two are closely connected: radiation protection (or radiological protection) is very much simpler if the source in question is under control, so safety necessarily contributes towards protection.
3. Sources come in many different types, and hence safety may be termed the safety of nuclear installations, radiation safety, the safety of radioactive waste management or safety in the transport of radioactive material, but protection (in this sense) is primarily concerned with protecting people against exposure, whatever the source, and so is always radiation protection.
4. For the purposes of the IAEA safety standards, protection and safety includes the protection of people against ionizing radiation and safety; it does not include non-radiation-related aspects of safety.
5. Protection and safety is concerned with both radiation risks under normal circumstances and radiation risks as a consequence of incidents, as well as with other possible direct consequences of a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation.
6. Safety measures include actions to prevent incidents and arrangements put in place to mitigate their consequences if they were to occur.

**protection of the environment**

Protection and conservation of: non-human species, both animal and plant, and their biodiversity; environmental goods and services such as the production of food and feed; resources used in agriculture, forestry, fisheries and tourism; amenities used in spiritual, cultural and recreational activities; media such as soil, water and air; and natural processes such as carbon, nitrogen and water cycles.

1. See also environment.

**protection quantities**

Dose quantities developed for purposes of radiological protection that allow quantification of the extent of exposure of the human body to ionizing
radiation due to both whole body and partial body external irradiation and intakes of radionuclides.

1. Dosimetric quantities that are designated as protection quantities are intended for specifying and calculating the numerical limits and levels that are used in safety standards for radiation protection.

2. Protection quantities relate the magnitude of exposures to the risks of health effects of radiation in a way that is applicable to an individual and that is largely independent of the type of radiation and the nature of the exposure (internal or external).

3. Protection quantities were developed to provide an index of the risks arising from the energy imparted by radiation to tissue.

**protection system**

See plant equipment (for a nuclear power plant).

**protective action**

1. An action for the purposes of avoiding or reducing doses that might otherwise be received in an emergency exposure situation or an existing exposure situation.

   See also remedial action.

   1. This is related to radiation protection (see protection (1), and protection and safety).

**early protective action.** A protective action in the event of a nuclear or radiological emergency that can be implemented within days to weeks and can still be effective.

   1. The most common early protective actions are relocation and longer term restriction of the consumption of food potentially affected by contamination.

**mitigatory action.** Immediate action by the operator or other party:

   (1) To reduce the potential for conditions to develop that would result in exposure or a release of radioactive material requiring emergency response actions on the site or off the site; or

   (2) To mitigate source conditions that may result in exposure or a release of radioactive material requiring emergency response actions on the site or off the site.

**urgent protective action.** A protective action in the event of a nuclear or radiological emergency which must be taken promptly (usually within hours to a day) in order to be effective, and the effectiveness of which will be markedly reduced if it is delayed.
1. *Urgent protective actions* include iodine thyroid blocking, *evacuation*, short term *sheltering*, actions to reduce inadvertent ingestion, *decontamination* of individuals and prevention of ingestion of *food*, milk and drinking water possibly with contamination.

2. A *precautionary urgent protective action* is an *urgent protective action* taken before or shortly after a release of *radioactive material*, or an *exposure*, on the basis of the prevailing conditions to avoid or to minimize *severe deterministic effects*.

2. A *protection system* action calling for the *operation* of a particular *safety actuation device*.

3. This is related to definition (2) of *protection*.

**protective task**

The generation of at least those *protective actions* necessary to ensure that the *safety task* required by a given *initiating event* is accomplished.

**public exposure**

See *exposure categories*.

**publication, IAEA**

See *IAEA publication*.
**qualification**

Process of determining whether a *system* or *component* is suitable for operational use.

1. *Qualification* is generally performed in the context of a specific set of *qualification requirements* for the specific *facility* and class of *system* and for the specific application.

2. *Qualification* may be accomplished in stages: for example, first, by the qualification of pre-existing equipment (usually early in the *system* realization process), then, in a second step, by the *qualification* of the integrated *system* (i.e. in the final realized design).

3. *Qualification* may rely on *activities* performed outside the framework of a specific *facility design* (this is called ‘generic *qualification*’ or ‘prequalification’).

4. Prequalification may significantly reduce the necessary effort in *facility* specific *qualification*; however, the application specific *qualification requirements* must still be met and be shown to be met.

**equipment qualification.** Generation and *maintenance* of evidence to ensure that equipment will operate on demand, under specified *service conditions*, to meet *system* performance *requirements*.

See also GSR Part 4 (Rev. 1) [11].

- More specific terms are used for particular equipment or particular conditions; for example, *seismic qualification* is a form of *equipment qualification* that relates to conditions that could be encountered in the event of earthquakes.

- The proof that an item of equipment can perform its function, which is an important part of *equipment qualification*, is sometimes termed *substantiation*.

**qualified equipment**

Equipment certified as having satisfied *equipment qualification requirements* for the conditions relevant to its *safety function(s)*.

**qualified expert**

An individual who, by virtue of *certification* by appropriate boards or societies, professional licence or academic qualifications and experience, is duly recognized as having expertise in a relevant field of specialization, for example medical physics, *radiation protection*, occupational health, fire safety, quality management or any relevant engineering or *safety* speciality.
qualified life

See life, lifetime.

quality assurance

The function of a management system that provides confidence that specified requirements will be fulfilled.

The IAEA revised the requirements and guidance in the subject area of quality assurance for its safety standards on management systems for the safety of facilities and activities involving the use of ionizing radiation.

The terms quality management and management system were adopted in the revised standards in place of the terms quality assurance and quality assurance programme.

Planned and systematic actions are necessary to provide adequate confidence that an item, process or service will satisfy given requirements for quality; for example, those specified in the licence.

This statement was slightly modified from that in the International Organization for Standardization’s publication ISO 921:1997 [9] to say ‘an item, process or service’ instead of ‘a product or service’ and to add the example.

A more general definition of quality assurance (all those planned and systematic actions necessary to provide confidence that a structure, system or component will perform satisfactorily in service) and definitions of related terms can be found in the International Organization for Standardization’s publication ISO 9000:2015 [39].

quality control (QC)

Part of quality management intended to verify that structures, systems and components correspond to predetermined requirements.

This definition is taken from ISO 921:1997 (Nuclear Energy: Vocabulary) [9]. A more general definition of quality control and definitions of related terms can be found in ISO 9000:2015 [39].

quality factor, Q

A number by which the absorbed dose in a tissue or organ is multiplied to reflect the relative biological effectiveness of the radiation, the result being the dose equivalent.

Superseded by radiation weighting factor in the definition of equivalent dose in Ref. [37], but still defined, as a function of linear energy transfer, for use in calculating the dose equivalent quantities used in monitoring.

GSR Part 3 [1] also states that the mean quality factor $Q$ at 10 mm depth in the ICRU sphere can be used as a value of radiation weighting factor for radiation types for which GSR Part 3 does not specify a value (see radiation weighting factor).
**R**

[rad]

Unit of *absorbed dose*, equal to 0.01 Gy.

1. Superseded by the *gray* (Gy).
2. Abbreviation of *röntgen absorbed dose* or *radiation absorbed dose*.

**radiation**

When used in *IAEA publications*, the term *radiation* usually refers to *ionizing radiation* only. The IAEA has no statutory responsibilities in relation to non-ionizing radiation.

1. Ionizing radiation can be divided into *low linear energy transfer radiation* and *high linear energy transfer radiation* (as a guide to its relative biological effectiveness), or into *strongly penetrating radiation* and *weakly penetrating radiation* (as an indication of its ability to penetrate shielding or the human body).

**high linear energy transfer (LET) radiation.** Radiation with high linear energy transfer, normally assumed to comprise protons, neutrons and alpha particles (or other particles of similar or greater mass).

1. These are the types of *radiation* for which the International Commission on Radiological Protection recommends a *radiation weighting factor* greater than 1.
2. Contrasting term: *low linear energy transfer radiation*.

**ionizing radiation.** For the purposes of *radiation protection*, radiation capable of producing ion pairs in biological material(s).

**low linear energy transfer (LET) radiation.** Radiation with low linear energy transfer, normally assumed to comprise photons (including X rays and gamma radiation), electrons, positrons and muons.

1. These are the types of *radiation* for which the International Commission on Radiological Protection recommends a *radiation weighting factor* of 1.
2. Contrasting term: *high linear energy transfer radiation*.

**strongly penetrating radiation.** Radiation for which limits on *effective dose* are generally more restrictive than limits on *equivalent dose* to any tissue or organ; that is, the fraction of the relevant dose limit received will, for a given *exposure*, be higher for *effective dose* than for *equivalent dose* to any tissue or organ.

1. For most practical purposes, it may be assumed that *strongly penetrating radiation* includes photons of energy above about 12 keV, electrons of energy more than about 2 MeV and neutrons.
2. Contrasting term: *weakly penetrating radiation*. 
**weakly penetrating radiation.** Radiation for which limits on equivalent dose to any tissue or organ are generally more restrictive than limits on effective dose; that is, the fraction of the relevant dose limit received will, for a given exposure, be higher for equivalent dose to any tissue or organ than for effective dose.

1. For most practical purposes, it may be assumed that weakly penetrating radiation includes photons of energy below about 12 keV, electrons of energy less than about 2 MeV, and massive charged particles such as protons and alpha particles.


[radiation area]

See area: controlled area.

**radiation detriment**

The total harm that would eventually be incurred by a group that is subject to exposure and by its descendants as a result of the group’s exposure to radiation from a source.

1. In its Publication 60 [37], the International Commission on Radiological Protection defines a measure of radiation detriment that has the dimensions of probability, and that could therefore also be considered a measure of risk.

**radiation emergency**

See emergency: nuclear or radiological emergency.

**radiation generator**

See source (1).

[radiation level]

The corresponding dose rate expressed in millisieverts per hour or microsieverts per hour.

1. This usage was specific to previous editions of the Transport Regulations [2] and should be avoided.

**radiation protection**

See protection (1).
radiation protection officer

A person technically competent in radiation protection matters relevant for a given type of practice who is designated by the registrant, licensee or employer to oversee the application of regulatory requirements.

radiation protection programme

Systematic arrangements that are aimed at providing adequate consideration of radiation protection measures. (See SSR-6 (Rev. 1) [2].)

radiation risks

Detrimental health effects of exposure to radiation (including the likelihood of such effects occurring), and any other safety related risks (including those to the environment) that might arise as a direct consequence of:

(a) Exposure to radiation;
(b) The presence of radioactive material (including radioactive waste) or its release to the environment;
(c) A loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation. (See SF-1 [17].)

For the purposes of the IAEA safety standards, it is assumed that there is no threshold level of radiation dose below which there are no associated radiation risks.

Safety Requirements and Safety Guides specify the radiation exposures and other radiation risks to which they refer.

radiation safety

See safety.

radiation source

See source (1).

radiation weighting factor, $w_R$

A number by which the absorbed dose in a tissue or organ is multiplied to reflect the relative biological effectiveness of the radiation in inducing stochastic effects at low doses, the result being the equivalent dose.

Values are selected by the International Commission on Radiological Protection to be representative of the relevant relative biological effectiveness and are broadly
compatible with the values previously recommended for quality factors in the
definition of dose equivalent.

1 The radiation weighting factor values recommended in Ref. [26] are set out below.

<table>
<thead>
<tr>
<th>Type of radiation</th>
<th>$w_R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photons, all energies</td>
<td>1</td>
</tr>
<tr>
<td>Electrons and muons, all energies$^a$</td>
<td>1</td>
</tr>
<tr>
<td>Protons and charged pions</td>
<td>2</td>
</tr>
<tr>
<td>Alpha particles, fission fragments, heavy ions</td>
<td>20</td>
</tr>
<tr>
<td>Neutrons</td>
<td>A continuous function of neutron energy:</td>
</tr>
</tbody>
</table>
|                           | $w_R = \begin{cases} 
2.5 + 18.2 \ e^{-[\ln(E_n)/9]^{2/3}}, & E_n < 1 \text{ MeV} \\
5.0 + 17.0 \ e^{-[\ln(2E_n)/9]^{2/3}}, & 1 \text{ MeV} \leq E_n \leq 50 \text{ MeV} \\
2.5 + 3.25 \ e^{-[\ln(0.04E_n)/9]^{2/3}}, & E_n > 50 \text{ MeV} 
\end{cases}$ |

Note: All values relate to the radiation incident on the body or, for internal radiation sources, radiation emitted from the incorporated radionuclide(s).

$^a$ Excluding Auger electrons emitted from radionuclides bound to deoxyribonucleic acid (DNA) in the human body, for which special microdosimetric considerations apply.

1 For radiation types and energies not included in the table, $w_R$ can be taken to be equal to $\bar{Q}$ at 10 mm depth in the ICRU sphere and can be obtained as follows:

$$\bar{Q} = \frac{1}{D} \int_0^\infty Q(L) \ D_L \ dL$$

where $D$ is the absorbed dose, $Q(L)$ is the quality factor in terms of the unrestricted linear energy transfer $L$ in water, specified in Ref. [37], and $D_L$ is the distribution of $D$ in $L$.

$$Q(L) = \begin{cases} 
1 & \text{for } L \leq 10 \\
0.32L - 2.2 & \text{for } 10 < L < 100 \\
300/\sqrt{L} & \text{for } L \geq 100 
\end{cases}$$

where $L$ is expressed in keV/µm.
radioactive

1. Exhibiting radioactivity; emitting or relating to the emission of ionizing radiation or particles. (adjective)
   ! This is the ‘scientific’ definition, and should not be confused with the ‘regulatory’ definition (2).

2. Designated in national law or by a regulatory body as being subject to regulatory control because of its radioactivity. (adjective)
   ! This is the ‘regulatory’ definition, and should not be confused with the ‘scientific’ definition (1).

radioactive contents

The radioactive material together with any contaminated or activated solids, liquids and gases within the packaging. (See SSR-6 (Rev. 1) [2].)

radioactive discharges

See discharge (1).

radioactive equilibrium

The state of a radioactive decay chain (or part thereof) where the activity of each radionuclide in the chain (or part of the chain) is the same.
   ① This state is achieved when the parent nuclide has a much longer half-life than any of the decay products, and after a time equal to several times the half-life of the longest lived of the decay products.
   ② Hence, the term ‘secular equilibrium’ is also used (with secular in this context meaning ‘eventual’, as contrasted with ‘transient equilibrium’).

radioactive half-life

See half-life (2).

radioactive material

1. Material designated in national law or by a regulatory body as being subject to regulatory control because of its radioactivity.
   ! This is the ‘regulatory’ meaning of radioactive (2), and should not be confused with the ‘scientific’ meaning of radioactive (1): ‘exhibiting radioactivity; emitting or relating to the emission of ionizing radiation or particles’.
The ‘scientific’ meaning of radioactive (1) — as in radioactive substance — refers only to the presence of radioactivity, and gives no indication of the magnitude of the hazard involved.

The term radioactive substance is also used to indicate that the ‘scientific’ meaning of radioactive (see radioactive (1)) is intended, rather than the ‘regulatory’ meaning of radioactive (see radioactive (2)) suggested by the term radioactive material.

However, in some States the term radioactive substance is used for the ‘regulatory’ purpose. It is therefore essential that any such distinctions in meaning are clarified.

In regulatory terminology in some States, radioactive material ceases to be radioactive material when it becomes radioactive waste; the term radioactive substance is used to cover both, that is radioactive substance includes radioactive material and radioactive waste.

Radioactive material should be used in the singular unless reference is expressly being made to the presence of various types of radioactive material.

2. Any material containing radionuclides where both the activity concentration and the total activity in the consignment exceed the values specified in [section IV of the Transport Regulations [2]]. (See SSR-6 (Rev. 1) [2].)

This usage is specific to the Transport Regulations [2], and should otherwise be avoided.

radioactive source

See source (2).

radioactive sources, safety of

See safety of radioactive sources.

radioactive substance

See radioactive material (1).

radioactive waste

1. For legal and regulatory purposes, material for which no further use is foreseen that contains, or is contaminated with, radionuclides at activity concentrations greater than clearance levels as established by the regulatory body.

In effect, radioactive material in gaseous, liquid or solid form for which no further use is foreseen.

It should be recognized that this definition is purely for regulatory purposes, and that material with activity concentrations equal to or less than clearance levels is radioactive from a physical viewpoint, although the associated radiological hazards are considered negligible.
See also radioactive, radioactive material and radioactive substance.

1. Waste should be used in the singular unless reference is expressly being made to the presence of various types of waste.

2. [Radioactive material in gaseous, liquid or solid form for which no further use is foreseen by the Contracting Party or by a natural or legal person whose decision is accepted by the Contracting Party, and which is controlled as radioactive waste by a regulatory body under the legislative and regulatory framework of the Contracting Party.] (See Ref. [5].)

**radioactive waste management**

1. All administrative and operational activities involved in the handling, pretreatment, treatment, conditioning, transport, storage and disposal of radioactive waste.

**conditioning.** Those operations that produce a waste package suitable for handling, transport, storage and/or disposal.

Conditioning may include the conversion of the waste to a solid waste form, enclosure of the waste in containers and, if necessary, provision of an overpack.

**immobilization.** Conversion of waste into a waste form by solidification, embedding or encapsulation.

Immobilization reduces the potential for migration or dispersion of radionuclides during handling, transport, storage and/or disposal.
overpack. A secondary (or additional) outer container for one or more waste packages, used for handling, transport, storage and/or disposal.

packaging. Preparation of radioactive waste for safe handling, transport, storage and/or disposal by means of enclosing it in a suitable container.

predisposal management. Any waste management steps carried out prior to disposal, such as pretreatment, treatment, conditioning, storage and transport activities.
① Predisposal is not a form of disposal: predisposal is used as a contraction of ‘pre-disposal management of radioactive waste’.

pretreatment. Any or all of the operations prior to waste treatment, such as collection, segregation, chemical adjustment and decontamination.

processing. Any operation that changes the characteristics of waste, including pretreatment, treatment and conditioning.

segregation. An activity where types of waste or material (radioactive or exempt) are separated or are kept separate on the basis of radiological, chemical and/or physical properties, to facilitate waste handling and/or processing.

treatment. Operations intended to benefit safety and/or economy by changing the characteristics of the waste. Three basic treatment objectives are:

(a) Volume reduction;
(b) Removal of radionuclides from the waste;
(c) Change of composition.

Treatment may result in an appropriate waste form.
① If treatment does not result in an appropriate waste form, the waste may be immobilized.

volume reduction. A treatment method that decreases the physical volume of a waste.
① Typical volume reduction methods are mechanical compaction, incineration and evaporation.
① Should not be confused with waste minimization.

See also minimization of waste.
2. [All activities, including decommissioning activities, that relate to the handling, pretreatment, treatment, conditioning, storage or disposal of radioactive waste, excluding off-site transportation. It may also involve discharges.] (See Ref. [5].)

**radioactive waste management facility**

1. Facility specifically designed to handle, treat, condition, store or permanently dispose of radioactive waste.

2. [Any facility or installation the primary purpose of which is radioactive waste management, including a nuclear facility in the process of being decommissioned only if it is designated by the Contracting Party as a radioactive waste management facility.] (See Ref. [5].)

**radioactivity**

The phenomenon whereby atoms undergo spontaneous random disintegration, usually accompanied by the emission of radiation.

* In IAEA publications, radioactivity should be used only to refer to the phenomenon.
* To refer to the physical quantity or to an amount of a radioactive substance, use activity.

**radiological assessor**

A person or team who in the event of a nuclear or radiological emergency assists the operator or off-site response organizations by performing radiological surveys, performing dose assessments, controlling contamination, ensuring the radiation protection of emergency workers and formulating recommendations on protective actions and other response actions.

1. The radiological assessor could be the radiation protection officer.

**radiological emergency**

See emergency.

**[radiological material]**

* Avoid this term.

See also nuclear material and radioactive material.
radiological medical practitioner

A health professional with specialist education and training in the medical uses of radiation, who is competent to perform independently or to oversee radiological procedures in a given specialty.

1. Competence of persons is normally assessed by the State by having a formal mechanism for registration, accreditation or certification of radiological medical practitioners in the given specialty (e.g. radiology, radiation therapy, nuclear medicine, dentistry, cardiology).

1. States that have yet to develop such a mechanism need to assess the education, training and competence of any individual proposed by the licensee to act as a radiological medical practitioner and to decide, on the basis of either international standards or standards of a State where such a system exists, whether such an individual could undertake the functions of a radiological medical practitioner, within the required specialty.

radiological procedure

A medical imaging procedure or therapeutic procedure that involves ionizing radiation — such as a procedure in diagnostic radiology, nuclear medicine or radiation therapy, or a planning procedure, image guided interventional procedure or other interventional procedure involving radiation — delivered by a radiation generator, a device containing a sealed source or an unsealed source, or by means of a radiopharmaceutical administered to a patient.

radiological protection

See protection (1).

[radionuclear]

! ‘Radionuclear’ is not a legitimate word.

See also nuclear material and radioactive material.

! Radionuclear has been used in nuclear medicine to mean ‘involving the use of radionuclides’; thus ‘radionuclear tests’ has been used in nuclear medicine to mean tests in which radiopharmaceuticals are administered. This usage is to be avoided.

! Radionuclear has also been used as a journalese shorthand form for ‘nuclear and/or radiological’, as in the terms ‘radionuclear weapon’ and ‘radionuclear emergency’; or used for ‘nuclear and/or radioactive’, as in the term ‘radionuclear material’. These and other such usages are to be avoided.
radionuclides of artificial origin

See radionuclides of natural origin.

radionuclides of natural origin

Radionuclides that occur naturally on Earth in significant quantities.
① The term is usually used to refer to the primordial radionuclides $^{40}$K, $^{235}$U, $^{238}$U, $^{232}$Th and their radioactive decay products.
① Contrasted with radionuclides of artificial origin, anthropogenic radionuclides and human made radionuclides (which all mean the same), and also with artificial radionuclides (which exclude radionuclides of artificial origin that are also naturally occurring).
！Radionuclides of artificial origin may include radionuclides that are also naturally occurring but may not include radionuclides of natural origin.

radiopharmacist

A health professional, with specialist education and training in radiopharmacy, who is competent to prepare and dispense radiopharmaceuticals used for the purposes of medical diagnosis and radionuclide therapy.
① Competence of persons is normally assessed by the State by having a formal mechanism for registration, accreditation or certification of radiopharmacists.
① States that have yet to develop such a mechanism need to assess the education, training and competence of any individual proposed by the licensee to act as a radiopharmacist and to decide, on the basis of either international standards or standards of a State where such a system exists, whether such an individual could undertake the functions of a radiopharmacist.

radon

1. Any combination of isotopes of the element radon.
① For the purposes of the IAEA safety standards, radon refers to $^{220}$Rn and $^{222}$Rn.

2. [$^{222}$Rn.]
① When contrasted with thoron ($^{220}$Rn).

radon progeny

The short lived radioactive decay products of $^{220}$Rn and of $^{222}$Rn.
① For $^{222}$Rn, this includes the decay chain up to but not including $^{210}$Pb, namely $^{218}$Po, $^{214}$Pb, $^{214}$Bi and $^{214}$Po, plus traces of $^{218}$At and $^{210}$Tl. Lead-210, which has a half-life of 22.3 years, and its radioactive progeny — $^{210}$Bi and $^{210}$Po, plus traces of $^{206}$Hg and $^{206}$Tl — are, strictly, progeny of $^{222}$Rn, but they are not included in this listing.
because they will not normally be present in significant amounts in airborne form. For $^{220}\text{Rn}$, this includes $^{216}\text{Po}$, $^{212}\text{Pb}$, $^{212}\text{Bi}$, $^{212}\text{Po}$ and $^{208}\text{Tl}$.

**reactivity, $\rho$**

For a nuclear chain reacting medium:

$$\rho = 1 - \frac{1}{k_{\text{eff}}}$$

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

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

**shutdown reactivity.** The reactivity when all *control* devices are introducing their maximum negative reactivity.

1. A reactor is shut down quickly by moving *control* devices rapidly into position to introduce their negative reactivity into the reactor core.

**recording level**

See *level*.

**recycling**

See *minimization of waste*.

**redundancy**

Provision of alternative (identical or diverse) *structures, systems and components*, so that any single *structure, system or component* can perform the required function regardless of the state of *operation or failure* of any other.

**reference air kerma rate**

See *kerma*.
reference individual

An idealized human with characteristics defined by the International Commission on Radiological Protection for radiation protection purposes.

1. Reference values for eight reference individuals — a newborn; a one year old; a five year old; a ten year old; male and female 15 year olds; and male and female adults — are given in Ref. [49].

2. These reference values are based on data for western European and North American populations, but Ref. [49] also provides additional information on individual variation among grossly normal individuals resulting from differences in age, gender, ethnicity and other factors.

3. This is a refinement of the Reference Man concept.

reference level

See level.

[Reference Man]

An idealized adult Caucasian human male defined by the International Commission on Radiological Protection for the purpose of radiation protection assessment.

See Ref. [50].

1. Although Reference Man is now being superseded by the more general concept of the reference individual (see Refs [49, 51]), some concepts and quantities are still defined in terms of Reference Man.

reference scenario

See scenario.

referring medical practitioner

A health professional who, in accordance with national requirements, may refer individuals to a radiological medical practitioner for medical exposure.

registrant

The holder of a current registration.
registration

A form of authorization for facilities and activities of low or moderate risks whereby the person or organization responsible for the practice has, as appropriate, prepared and submitted a safety assessment of the facilities and equipment to the regulatory body. The practice or use is authorized with conditions or limitations as appropriate.

1. The requirements for safety assessment and the conditions or limitations applied to the facilities and activities would be less severe for registration than those for issuing a licence.

1. Typical facilities and activities that are amenable to registration are those for which: (a) safety can largely be ensured by the design of the facilities and equipment; (b) the operating procedures are simple to follow; (c) the safety training requirements are minimal; and (d) there is a history of few problems with safety in operations. Registration is best suited to those facilities and activities for which operations do not vary significantly.

See also registrant.

1. Derivative terms should not be needed; a registration is a product of the authorization process, and a facility or activity with a current registration is an authorized facility or activity.

[Regulatory Authority]

An authority or authorities designated or otherwise recognized by a government for regulatory purposes in connection with protection and safety.

! Superseded by the term regulatory body, which should be used.

regulatory body

1. An authority or a system of authorities designated by the government of a State as having legal authority for conducting the regulatory process, including issuing authorizations, and thereby regulating the nuclear, radiation, radioactive waste and transport safety.

1. The regulatory body is generally a national entity, established and empowered by law, whose organization, management, functions, processes, responsibilities and competences are subject to the requirements of IAEA safety standards.

1. The national competent authority for the regulation of radioactive material transport safety (see SSR-6 (Rev. 1) [2]) is included in this description, as is the regulatory body for protection and safety.

! Supersedes the term Regulatory Authority, which should not be used.
2. [For each Contracting Party any body or bodies given the legal authority by that Contracting Party to grant licences and to regulate the siting, design, construction, commissioning, operation or decommissioning of nuclear installations.] (See Ref. [4].)

3. [Any body or bodies given the legal authority by the Contracting Party to regulate any aspect of the safety of spent fuel or radioactive waste management including the granting of licences.] (See Ref. [5].)

4. [An entity or organization or a system of entities or organizations designated by the government of a State as having legal authority for exercising regulatory control with respect to radioactive sources, including issuing authorizations, and thereby regulating one or more aspects of the safety or security of radioactive sources.] (See Ref. [14].)

regulatory control

See control (1).

regulatory inspection

See inspection.

relative biological effectiveness (RBE)

A measure of the relative effectiveness of different radiation types at inducing a specified health effect, expressed as the inverse ratio of the absorbed doses of two different radiation types that would produce the same degree of a defined biological end point.

1 Values of relative biological effectiveness in causing the development of deterministic effects are selected to be representative of the severe deterministic effects that are significant to emergency preparedness and response.

1 The tissue or organ specific and radiation type specific values of $RBE_{TR}$ for the development of selected severe deterministic effects are as shown in the following table.
<table>
<thead>
<tr>
<th>Health effect</th>
<th>Critical tissue or organ</th>
<th>Exposure(^a)</th>
<th>RBE(_{T,R})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haematopoietic</td>
<td>Red marrow</td>
<td>External and internal (\gamma)</td>
<td>1</td>
</tr>
<tr>
<td>syndrome</td>
<td></td>
<td>External and internal (\eta)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Internal (\beta)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Internal (\alpha)</td>
<td>2</td>
</tr>
<tr>
<td>Pneumonitis</td>
<td>Lung(^b)</td>
<td>External and internal (\gamma)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>External and internal (\eta)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Internal (\beta)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Internal (\alpha)</td>
<td>7</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>Colon</td>
<td>External and internal (\gamma)</td>
<td>1</td>
</tr>
<tr>
<td>syndrome</td>
<td></td>
<td>External and internal (\eta)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Internal (\beta)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Internal (\alpha)</td>
<td>0(^c)</td>
</tr>
<tr>
<td>Necrosis</td>
<td>Tissue(^d)</td>
<td>External (\beta, \gamma)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>External (\eta)</td>
<td>3</td>
</tr>
<tr>
<td>Moist desquamation</td>
<td>Skin(^e)</td>
<td>External (\beta, \gamma)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>External (\eta)</td>
<td>3</td>
</tr>
<tr>
<td>Hypothyroidism</td>
<td>Thyroid</td>
<td>Intake of iodine isotopes(^f)</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other thyroid seekers</td>
<td>1</td>
</tr>
</tbody>
</table>

\(^a\) External \(\beta, \gamma\) exposure includes exposure due to bremsstrahlung produced within the material of the source.

\(^b\) Tissue of the alveolar–interstitial region of the respiratory tract.

\(^c\) For alpha emitters uniformly distributed in the contents of the colon, it is assumed that irradiation of the walls of the intestine is negligible.

\(^d\) Tissue at a depth of 5 mm below the skin surface over an area of more than 100 cm\(^2\).

\(^e\) Tissue at a depth of 0.4 mm below the skin surface over an area of more than 100 cm\(^2\).

\(^f\) Uniform irradiation of the tissue of the thyroid gland is considered to be five times more likely to produce deterministic effects than internal exposure due to low energy beta emitting isotopes of iodine such as \(^{131}\)I, \(^{129}\)I, \(^{125}\)I, \(^{124}\)I and \(^{123}\)I. Thyroid seeking radionuclides have a heterogeneous distribution in thyroid tissue. The isotope \(^{131}\)I emits low energy beta particles, which leads to a reduced effectiveness of irradiation of critical thyroid tissue owing to the dissipation of the energy of the particles within other tissues.
relative biological effectiveness (RBE) weighted absorbed dose, AD<sub>T</sub>

See dose quantities: absorbed dose

relative risk

See risk (3).

release

The action or process of setting free or being set free, or of allowing or being allowed to move or flow freely.

! Release is used in both a physical ‘scientific’ sense (see discharge (1)) and a ‘regulatory’ sense (see clearance), as well as in the usual sense of, for example, a release of energy.

reliability

The probability that a system or component or an item will meet its minimum performance requirements when called upon to do so, for a specified period of time and under stated operating conditions.

① The reliability of a computer based system, for example, includes the reliability of hardware, which is usually quantified, and the reliability of software, which is usually a qualitative measure as there are no generally recognized means of quantifying the reliability of software.

See also availability.

reliability centred maintenance (RCM)

See maintenance.

relocation

The non-urgent removal or extended exclusion of people from an area to avoid long term exposure from deposited radioactive material.

① Relocation is an early protective action. It may be a substitution for the urgent protective action of evacuation.

See also evacuation.

① Relocation is considered to be permanent relocation if return is not foreseeable; otherwise it is temporary relocation.
Unit of dose equivalent and effective dose equivalent, equal to 0.01 Sv.
① Superseded by the sievert (Sv).
② Abbreviation of röntgen equivalent man.

remedial action

The removal of a source or the reduction of its magnitude (in terms of activity or amount) for the purposes of preventing or reducing exposures that might otherwise occur in an emergency or in an existing exposure situation.
① Remedial actions could also be termed protective actions, but protective actions are not necessarily remedial actions.

See also remediation and protective action.

remediation

Any measures that may be carried out to reduce the radiation exposure due to existing contamination of land areas through actions applied to the contamination itself (the source) or to the exposure pathways to humans.
① Complete removal of the contamination is not implied.
② The use of the terms cleanup, rehabilitation and restoration as synonyms for remediation is discouraged. Such terms may be taken to imply that the conditions that prevailed before the contamination can be achieved again and unconditional use of the land areas can be restored, which is not usually the case (e.g. owing to the effects of the remedial action itself). Often remediation is used to restore land areas to conditions suitable for limited use under institutional control.
① In some contexts (e.g. the wider chemical industry), the terms remediation and restoration are used to describe different parts of overall recovery.
① The term cleanup is used in the context of decommissioning.

See also decontamination.

remediation plan

A document setting out the various activities and actions and the timescales necessary to apply the approach and to achieve the objectives of the remediation strategy in order to meet the legal and regulatory requirements for remediation.

remedy

Corrective actions designed to address root causes.
See also cause: root cause.

**removable contamination**

See contamination (2): non-fixed contamination

**repair**

An action on a non-conforming product to make it acceptable for its intended use (see Ref. [39]).

See also cause: direct cause.

**repository**

1 Synonymous with disposal facility.

**representative person**

An individual receiving a dose that is representative of the doses to the more highly exposed individuals in the population.

1 The representative person will generally be a hypothetical construct and not an actual member of the population. The concept is used to determine compliance or in prospective assessments.

1 In estimating the dose to the representative person, a number of factors are taken into account for the population exposed: (i) all relevant exposure pathways for the source and all locations under consideration; (ii) the spatial distribution of radionuclides in the environment, to ensure that individuals with higher exposures are included; (iii) age dependent physiological parameters and information on diet, habits, residence and use of local resources; (iv) dosimetric models and appropriate dose coefficients.

1 Application of the concept of a representative person to potential exposures, such as those that may occur in the future as a result of radioactive waste disposal, is complicated by the facts that both the dose (if it occurs) and the probability of receiving the dose are relevant, and that these two parameters are essentially independent of one another.

1 Hence, a population can be homogeneous with respect to dose but not risk, and, more importantly, vice versa.

1 A possible approach is to define a representative person that is reasonably representative with respect to risk, and that is typical of those people who might be subject to the highest risk.

1 ICRP Publication 101 [51] indicates that the dose to the representative person “is the equivalent of, and replaces, the mean dose in the ‘critical group’”, and provides guidance on assessing doses to the representative person. The concept of critical group remains valid.
See also member of the public.

**reprocessing**

A process or operation, the purpose of which is to extract radioactive isotopes from spent fuel for further use.

**requirement (safety)**

That which is established or required by the Fundamental Safety Principles (IAEA Safety Fundamentals) [17] or IAEA Safety Requirements publications or by (national or international) laws or regulations.

In IAEA publications, requirement (and ‘required’ and other words deriving from the verb ‘to require’) should be used in this sense only. Care should be taken to avoid confusion: the use of ‘requirement’ in the more general sense of something that is necessary should be avoided.

Requirements, including numbered ‘overarching’ requirements, are expressed as ‘shall’ statements. Reported (quoted) requirements, e.g. in a Safety Guide, are reported using a formulation such as ‘it is required to…’.

**research reactor**

[A nuclear reactor used mainly for the generation and utilization of neutron flux and ionizing radiation for research and other purposes, including experimental facilities associated with the reactor and storage, handling and treatment facilities for radioactive material on the same site that are directly related to safe operation of the research reactor. Facilities commonly known as critical assemblies are included.]

This definition is particular to the Code of Conduct on the Safety of Research Reactors [52].

**residual dose**

See dose concepts.

**residual heat**

The sum of the heat originating from radioactive decay and shutdown fission and the heat stored in reactor related structures and in heat transport media.
response organization

An organization designated or recognized by a State as being responsible for managing or implementing any aspect of an emergency response.

1 This also includes those organizations or services necessary to support the management and/or conduct of an emergency response, such as meteorological services.

response spectrum

A curve calculated from an accelerogram that gives the value of peak response in terms of the acceleration, velocity or displacement of a damped single-degree-of-freedom linear oscillator (with a given damping ratio) as a function of its natural frequency or period of vibration.

uniform hazard response spectrum. Response spectrum with an equal probability of exceedance for each of its spectral ordinates.

response time (of a component)

The period of time necessary for a component to achieve a specified output state from the time that it receives a signal requiring it to assume that output state.

1 Note that this is not related to emergency response.

restricted linear collision stopping power

See linear energy transfer (LET).

restricted use

See use.

reuse

See minimization of waste.

risk

1 Depending on the context, the term risk may be used to represent a quantitative measure (as, for example, in definitions (1) and (2)) or as a qualitative concept (as often for definitions (3) and (4)).
1. A multiattribute quantity expressing \textit{hazard}, danger or chance of harmful or injurious consequences associated with \textit{exposures} or \textit{potential exposures}. It relates to quantities such as the probability that specific deleterious consequences may arise and the magnitude and character of such consequences.

   \begin{enumerate}
   \item In mathematical terms, this can be expressed generally as a set of triplets,
   \[ R = \{ (S_i, p_i, X_i) \} \]
   where \( S_i \) is an identification or description of a \textit{scenario} \( i \), \( p_i \) is the probability of that \textit{scenario} and \( X_i \) is a measure of the consequence of the \textit{scenario}. The concept of \textit{risk} is sometimes also considered to include uncertainty in the probabilities \( p_i \) of the \textit{scenarios}.
   \end{enumerate}

2. The mathematical mean (expectation value) of an appropriate measure of a specified (usually unwelcome) consequence:

\[
R = \sum p_i \cdot C_i
\]

where \( p_i \) is the probability of occurrence of \textit{scenario} or \textit{event} sequence \( i \) and \( C_i \) is a measure of the consequence of that \textit{scenario} or \textit{event} sequence.

   \begin{enumerate}
   \item Typical consequence measures \( C_i \) include core damage frequency, the estimated number or probability of \textit{health effects}, etc.
   \item If the number of \textit{scenarios} or \textit{event} sequences is large, the summation is replaced by an integral.
   \item The summing of \textit{risks} associated with \textit{scenarios} or \textit{event} sequences with widely differing values of \( C_i \) is controversial. In such cases the use of the term ‘expectation value’, although mathematically correct, is misleading and should be avoided if possible.
   \item Methods for treating uncertainty in the values of \( p_i \) and \( C_i \) — and in particular whether such uncertainty is represented as an element of \textit{risk} itself or as uncertainty in estimates of \textit{risk} — vary.
   \end{enumerate}

3. The probability of a specified \textit{health effect} occurring in a person or group as a result of \textit{exposure} to \textit{radiation}.

   \begin{enumerate}
   \item The \textit{health effect(s)} in question must be stated — for example, \textit{risk} of fatal cancer, \textit{risk} of serious \textit{hereditary effects} or overall \textit{radiation detriment} — as there is no generally accepted ‘default’.
   \item Commonly expressed as the product of the probability that \textit{exposure} will occur and the probability that the \textit{exposure}, assuming that it occurs, will cause the specified \textit{health effect}.
   \item The latter probability is sometimes termed the \textit{conditional risk}.
   \end{enumerate}

\textit{annual risk.} The probability that a specified \textit{health effect} will occur at some time in the future in an individual as a result of \textit{dose} received or \textit{dose} committed in a given year, taking account of the probability of \textit{exposure} occurring in that year.

   \begin{enumerate}
   \item This is not the probability of the \textit{health effect} occurring in the year in question; it is the \textit{lifetime risk} resulting from the \textit{annual dose} for that year.
   \end{enumerate}
attributable risk. The risk of a specified health effect assumed to result from a specified exposure.

excess risk. The difference between the incidence of a specified stochastic effect observed in an exposed group to that in an unexposed control group.

lifetime risk. The probability that a specified health effect will occur at some time in the future in an individual as a result of radiation exposure.

relative risk. The ratio between the incidence of a specified stochastic effect observed in an exposed group and that in an unexposed control group. (See control (2).)

4. radiation risks. See radiation risks.

risk assessment

See assessment (1).

risk coefficient, \( \gamma \)

The lifetime risk or radiation detriment assumed to result from exposure to unit equivalent dose or effective dose.

risk constraint

A prospective and source related value of individual risk that is used in planned exposure situations as a parameter for the optimization of protection and safety for the source, and that serves as a boundary in defining the range of options in optimization.

1. The risk constraint is a source related value that provides a basic level of protection for the individuals most at risk from a source.
2. This risk is a function of the probability of an unintended event causing a dose, and the probability of the detriment due to such a dose.
3. Risk constraints correspond to dose constraints but apply to potential exposure.

[risk factor]

! Sometimes misused as a synonym for risk coefficient. This is different from the normal medical use of the term risk factor to indicate a factor that influences an individual’s risk, and its use as a synonym for risk coefficient should be avoided.

! Risk factor should be used only in the medical sense.
risk monitor

A plant specific real time analysis tool used to determine the instantaneous risk based on the actual status of the systems and components.

At any given time, the risk monitor reflects the current plant configuration in terms of the known status of the various systems and/or components; for example, whether there are any components out of service for maintenance or tests.

The model used by the risk monitor is based on, and is consistent with, the ‘living’ probabilistic safety assessment for the facility.

risk projection model

See model.

rock, igneous

See igneous rock.

[röntgen (R)]

Unit of exposure, equal to \(2.58 \times 10^{-4} \text{ C/kg (exactly)}\).

Superseded by the SI unit C/kg.

root cause

See cause.

root uptake

See uptake (1).

routine monitoring

See monitoring (1).

runup

A sudden surge of water up a beach or a structure.
safe state

See plant states (considered in design).

safeguards agreement

An agreement between the IAEA and one or more Member States which contains an undertaking by one or more of those States not to use certain items in such a way as to further any military purpose and which gives the IAEA the right to observe compliance with such undertaking. Such an agreement may concern:

(a) An IAEA project;
(b) A bilateral or multilateral arrangement in the field of nuclear energy under which the IAEA may be asked to administer safeguards; or
(c) Any of a State’s nuclear activities unilaterally submitted to IAEA safeguards.

safety

See (nuclear) safety and protection and safety.

① In the Fundamental Safety Principles (IAEA Safety Fundamentals), the generalized usage in this particular text of the term safety (i.e. to mean protection and safety) is explained as follows (SF-1 [17], paras 3.1 and 3.2):

“3.1. For the purposes of this publication, ‘safety’ means the protection of people and the environment against radiation risks, and the safety of facilities and activities that give rise to radiation risks. ‘Safety’ as used here and in the IAEA safety standards includes the safety of nuclear installations, radiation safety, the safety of radioactive waste management and safety in the transport of radioactive material; it does not include non-radiation-related aspects of safety.

“3.2. Safety is concerned with both radiation risks as a consequence of incidents as, as well as with other possible direct consequences of a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation. Safety measures include actions to prevent incidents and arrangements put in place to mitigate their consequences if they were to occur.

“④ ‘Incidents’ includes initiating events, accident precursors, near misses, accidents and unauthorized acts (including malicious acts and non-malicious acts).”
safety action

A single action taken by a safety actuation system.

For example, insertion of a control rod, closing of containment valves or operation of the safety injection pumps.

safety actuation system

See plant equipment (for a nuclear power plant).

safety analysis

See analysis.

safety assessment

See assessment (1).

safety case

A collection of arguments and evidence in support of the safety of a facility or activity.

This will normally include the findings of a safety assessment and a statement of confidence in these findings.

For a disposal facility, the safety case may relate to a given stage of development. In such cases, the safety case should acknowledge the existence of any unresolved issues and should provide guidance for work to resolve these issues in future development stages.

safety categorization

For nuclear power plants, the categorization into a limited number of safety categories of the functions that are required for fulfilling the main safety functions in different plant states, including all modes of normal operation, on the basis of their safety significance.

See Refs [18, 53].

safety category

See safety categorization.
safety class

See safety classification.

safety classification

For nuclear power plants, the assignment to a limited number of safety classes of systems and components and other items of equipment on the basis of their functions and their safety significance.

safety class. For nuclear power plants, the classes into which systems and components and other items of equipment are assigned on the basis of their functions and their safety significance.

The design is required to ensure in particular that any failure of items important to safety in a system in a lower safety class will not propagate to a system in a higher safety class. Items of equipment that perform multiple functions are required to be classified in a safety class that is consistent with the most important function performed by the items of equipment.

See Requirement 22 of SSR-2/1 (Rev. 1) [18] and para. 2.2 of SSG-30 [53].

safety committee

A group of experts convened by the operating organization to advise on the safety of operation of an authorized facility.

safety culture

The assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, protection and safety issues receive the attention warranted by their significance.

For a more detailed discussion, see Ref. [54].

safety feature (for design extension conditions)

See plant equipment (for a nuclear power plant).

safety function

A specific purpose that must be accomplished for safety for a facility or activity to prevent or to mitigate radiological consequences of normal operation, anticipated operational occurrences and accident conditions. (See SSG-30 [53].)
SSR-2/1 (Rev. 1) [18] establishes requirements on safety functions to be fulfilled by the design of a nuclear power plant in order to meet three general safety requirements:

(a) The capability to safely shut down the reactor and maintain it in a safe shutdown condition during and after appropriate operational states and accident conditions;

(b) The capability to remove residual heat from the reactor core, the reactor and nuclear fuel in storage after shutdown, and during and after appropriate operational states and accident conditions;

(c) The capability to reduce the potential for the release of radioactive material and to ensure that any releases are within prescribed limits during and after operational states and within acceptable limits during and after design basis accidents.

This guidance is commonly condensed into a succinct expression of three fundamental safety functions for nuclear power plants:

(a) Control of reactivity;

(b) Cooling of radioactive material;

(c) Confinement of radioactive material.

In some IAEA publications, ‘basic safety function’ and ‘main safety function’ are also used.

safety group

The assembly of equipment designated to perform all actions required for a particular initiating event to ensure that the limits specified in the design basis for anticipated operational occurrences and design basis accidents are not exceeded.

The term ‘group’ is also used (with various qualifying adjectives, e.g. maintenance group, commissioning group) in the more obvious sense of a group of people involved in a particular area of work. Such terms may need to be defined if there is any chance of confusion with safety group.

safety indicator

A quantity used in assessments as a measure of the radiological impact of a source or of a facility or activity, or of the performance of protection and safety provisions, other than a prediction of dose or risk.

Such quantities are most commonly used in situations where predictions of dose or risk are unlikely to be reliable; for example, long term assessments of repositories.
They are normally either:

(a) Illustrative calculations of dose or risk quantities, used to give an indication of the possible magnitude of doses or risks for comparison with criteria; or
(b) Other quantities, such as radionuclide concentrations or fluxes, that are considered to give a more reliable indication of impact, and that can be compared with other relevant data.

safety issues

Deviations from current safety standards or practices, or weaknesses in facility design or practices as identified by plant events, with a potential impact on safety because of their impact on defence in depth, safety margins or safety culture.

safety layers

Passive systems, automatically or manually initiated safety systems, or administrative controls that are provided to ensure that the required safety functions are achieved.

Often expressed as:

(a) Hardware (i.e. passive and active safety systems);
(b) Software, including personnel and procedures as well as computer software;
(c) Management control, in particular preventing defence in depth degradation (through quality management, preventive maintenance, surveillance testing, etc.) and reacting appropriately to experience feedback from degradations that do occur (e.g. determining root causes, taking corrective actions).

See also defence in depth.

safety limits

See limit.

safety measure

Any action that might be taken, condition that might be applied or procedure that might be followed to fulfil the requirements of Safety Requirements.
safety of radioactive sources

[Measures intended to minimize the likelihood of accidents involving radioactive sources and, should such an accident occur, to mitigate its consequences.] (See Ref. [14].)

safety related item

See plant equipment (for a nuclear power plant).

safety related system

See plant equipment (for a nuclear power plant).

safety standards

Standards issued pursuant to Article III(A)(6) of the Statute of the IAEA [44].

1. Requirements, regulations, standards, rules, codes of practice or recommendations established to protect people and the environment against ionizing radiation and to minimize danger to life and property.

2. Safety standards issued since 1997 in the IAEA Safety Standards Series are designated as Safety Fundamentals, Safety Requirements or Safety Guides.

3. Some safety standards issued prior to 1997 in the (defunct) Safety Series were designated Safety Standards, Codes, Regulations or Rules.

4. Furthermore, some publications issued in the (defunct) Safety Series were not safety standards, notably those designated Safety Practices or Procedures and Data.

5. Other IAEA publications, such as Safety Reports and TECDOCs (most of which are issued pursuant to Article VIII of the Statute), are not safety standards.

safety system

See plant equipment (for a nuclear power plant).

safety system settings

See plant equipment (for a nuclear power plant).

8. “[The Agency is authorized] To establish or adopt, in consultation and, where appropriate, in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, standards of safety for protection of health and minimization of danger to life and property (including such standards for labour conditions).”
safety system support features

See plant equipment (for a nuclear power plant).

safety task

The sensing of one or more variables indicative of a specific postulated initiating event, the signal processing, the initiation and completion of the safety actions required to prevent the limits specified in the design basis from being exceeded, and the initiation and completion of certain services of the safety system support features.

scenario

A postulated or assumed set of conditions and/or events.

1. Most commonly used in analysis or assessment to represent possible future conditions and/or events to be modelled, such as possible accidents at a nuclear facility, or the possible future evolution of a disposal facility and its surroundings. A scenario may represent the conditions at a single point in time or a single event, or a time history of conditions and/or events (including processes).

2. See event.

reference scenario. A hypothetical but possible evolution of a disposal facility and its surroundings on the basis of activities, such as construction work, mining or drilling, that have a high probability of being undertaken by people in the future and that could cause a human intrusion into the disposal facility, and which can be evaluated.

scram

A rapid shutdown of a nuclear reactor in an emergency.

See also anticipated transient without scram (ATWS).

dscreening

A type of analysis aimed at eliminating from further consideration factors that are less significant for protection or safety in order to concentrate on the more significant factors.

1. This is typically achieved by consideration of very pessimistic hypothetical scenarios.

2. Screening is usually conducted at an early stage in order to narrow the range of factors needing detailed consideration in an analysis or assessment.
screening distance value (SDV)

The distance from a facility beyond which, for screening purposes, potential origins of a particular type of external event can be ignored.

screening probability level (SPL)

A value of the annual probability of occurrence of a particular type of event below which, for screening purposes, such an event can be ignored.

seabed disposal

See disposal (3).

sealed source

See source (2).

[secondary limit]

See limit.

secondary waste

See waste.

security

See nuclear security.

segregation

1. See radioactive waste management (1).

2. The physical separation of structures, systems and components by distance or by means of some form of barrier to reduce the likelihood of common cause failures.

3. Separation of transport packages from persons, undeveloped photographic film and dangerous goods and separation of transport packages containing fissile material from each other. (See SSR-6 (Rev. 1) [2].)
seismic qualification

See qualification: equipment qualification.

seismogenic structure

A structure that displays earthquake activity or that manifests historical surface rupture or the effects of palaeoseismicity, and is likely to generate macro-earthquakes within a time period of concern.

seismotectonic model

See model.

self-assessment

See assessment (2).

senior management

The person or persons who direct, control and assess an organization at the highest level.

sensitivity analysis

See analysis.

service conditions

Physical conditions prevailing or expected to prevail during the service life of a structure, system or component.

1. Service conditions include environmental conditions (e.g. conditions of humidity; thermal, chemical, electrical, mechanical and radiological conditions), and operating conditions (conditions in normal operation, error induced conditions) and conditions during and after events.

service life

See life, lifetime.
severe accident

See accident (1).

severe accident management

See accident management.

severe deterministic effect

See health effects (of radiation): deterministic effect.

sheltering

The short term use of a structure for protection from an airborne plume and/or deposited radioactive material.

1. Sheltering is an urgent protective action, used to provide shielding against external exposure and to reduce the intake of airborne radionuclides by inhalation.

shipment

The specific movement of a consignment from origin to destination. (See SSR-6 (Rev. 1) [2].)

short lived waste

See waste classes.

shutdown

The cessation of operation of a facility.

permanent shutdown. The cessation of operation of a facility with no intention to recommence operation in the future.

1. Between the permanent shutdown of the facility and approval of the decommissioning plan, there may be a period of transition.

1. During such a transition period, the authorization for operation of the facility remains in place unless the regulatory body has approved modifications to the authorization on the basis of a reduction in the hazards associated with the facility.

1. During this transition period, some preparatory actions for decommissioning can be performed in accordance with the authorization for operation of the facility or a modified authorization.
shutdown reactivity

See reactivity.

sievert (Sv)

The SI unit of equivalent dose and effective dose, equal to 1 J/kg.

significant transboundary release

A release of radioactive material to the environment that may result in doses or levels of contamination beyond national borders from the release which exceed generic criteria for protective actions and other response actions, including food restrictions and restrictions on trade.

single failure

A failure which results in the loss of capability of a single system or component to perform its intended safety function(s), and any consequential failure(s) which result from it.

single failure criterion

A criterion (or requirement) applied to a system such that it must be capable of performing its task in the presence of any single failure.

1) To ensure that the single failure criterion is met, usually two or more independent (redundant) systems or trains are provided by design to achieve the same safety function.

double contingency principle. A principle applied, for example, in the design of processes for nuclear fuel cycle facilities, such that the design for a process must include sufficient safety features that a criticality accident would not be possible unless at least two unlikely and independent changes in process conditions were to occur concurrently.

site area

See area.
site area emergency

See emergency class.

site boundary

See area: site area.

site characterization

See characterization (2).

site confirmation (in the siting process for a disposal facility)

The final stage of the siting process for a disposal facility, based on detailed investigations on the preferred site which provide site specific information needed for safety assessment.

1. This stage includes the finalization of the design for the disposal facility and the preparation and submission of a licence application to the regulatory body.
2. Site confirmation follows site characterization for a disposal facility.

site evaluation

Analysis of those factors at a site that could affect the safety of a facility or activity on that site.

1. This includes site characterization, consideration of factors that could affect safety features of the facility or activity so as to result in a release of radioactive material and/or could affect the dispersion of such material in the environment, as well as population and access issues relevant to safety (e.g. feasibility of evacuation, location of people and resources).
2. The analysis for a site of the origins of external events that could give rise to hazards with potential consequences for the safety of a nuclear power plant constructed on that site.
3. For a nuclear power plant, site evaluation typically involves the following stages:

(a) Site selection stage. One or more preferred candidate sites are selected after the investigation of a large region, the rejection of unsuitable sites, and screening and comparison of the remaining sites.

(b) Site characterization stage. This stage is further subdivided into:

— Site verification, in which the suitability of the site to host a nuclear power plant is verified mainly according to predefined site exclusion criteria;
— Site confirmation, in which the characteristics of the site necessary for the purposes of analysis and detailed design are determined.
(c) Pre-operational stage. Studies and investigations begun in the previous stages are continued after the start of construction and before the start of operation of the plant, to complete and refine the assessment of site characteristics. The site data obtained allow a final assessment of the simulation models used in the final design.

(d) Operational stage. Appropriate safety related site evaluation activities are carried out throughout the lifetime of the facility, mainly by means of monitoring and periodic safety review.

site personnel

All persons working in the site area of an authorized facility, either permanently or temporarily.

site (seismic) response

The behaviour of a rock column or soil column at a site under a prescribed ground motion load.

site selection

See siting.

site survey

See siting.

site verification

See site evaluation.

siting

The process of selecting a suitable site for a facility, including appropriate assessment and definition of the related design bases.

1 The siting process for a nuclear installation generally consists of site survey and site selection.

site survey. The process of identifying candidate sites for a nuclear installation after the investigation of a large region and the rejection of unsuitable sites.
site selection. The process of assessing the remaining sites by screening and comparing them on the basis of safety and other considerations to select one or more preferred candidate sites.

See also site evaluation.

1 The siting process for a disposal facility is particularly crucial to its long term safety; it may therefore be a particularly extensive process, and is divided into the following stages:

— Concept and planning;
— Area survey;
— Site characterization;
— Site confirmation.

1 The terms siting, design, construction, commissioning, operation and decommissioning are normally used to delineate the six major stages of the lifetime of an authorized facility and of the associated licensing process. In the special case of disposal facilities for radioactive waste, decommissioning is replaced in this sequence by closure.

SL-1, SL-2

Levels of ground motion (representing the potential effects of earthquakes) considered in the design basis for a facility.

1 SL-1 corresponds to a less severe, more likely earthquake than SL-2.

1 In some States, SL-1 corresponds to a level with a probability of $10^{-2}$ per year of being exceeded, and SL-2 corresponds to a level with a probability of $10^{-4}$ per year of being exceeded.

small freight container

See freight container.

somatic effect

See health effects (of radiation).

sorption

The interaction of an atom, molecule or particle with the solid surface at a solid–solution or a solid–gas interface.
Used in the context of radionuclide migration to describe the interaction of radionuclides in pore water or groundwater with soil or host rock, and of radionuclides in surface water bodies with suspended and bed sediments.

A general term which includes absorption (interactions taking place largely within the pores of solids) and adsorption (interactions taking place on solid surfaces).

The processes involved can also be divided into chemisorption (chemical bonding with the substrate) and physisorption (physical attraction, e.g. by weak electrostatic forces).

In practice, sorption may sometimes be difficult to distinguish from other factors affecting migration, such as filtration or dispersion.

source

1. Anything that may cause radiation exposure — such as by emitting ionizing radiation or by releasing radioactive substances or radioactive material — and can be treated as a single entity for purposes of protection and safety.

For example, materials emitting radon are sources in the environment; a sterilization gamma irradiation unit is a source for the practice of irradiation preservation of food and sterilization of other products; an X ray unit may be a source for the practice of radiodiagnosis; a nuclear power plant is part of the practice of generating electricity by nuclear fission, and may be regarded as a source (e.g. with respect to discharges to the environment) or as a collection of sources (e.g. for occupational radiation protection purposes).

A complex or multiple installation situated at one location or site may, as appropriate, be considered a single source for the purposes of application of safety standards.

natural source. A naturally occurring source of radiation, such as the sun and stars (sources of cosmic radiation) and rocks and soil (terrestrial sources of radiation), or any other material whose radioactivity is for all intents and purposes due only to radionuclides of natural origin, such as products or residues from the processing of minerals; but excluding radioactive material for use in a nuclear installation and radioactive waste generated in a nuclear installation.

Examples of natural sources include naturally occurring radioactive material (NORM) associated with the processing of raw materials (e.g. feedstocks, intermediate products, final products, co-products, waste).

radiation generator. A device capable of generating ionizing radiation, such as X rays, neutrons, electrons or other charged particles, that may be used for scientific, industrial or medical purposes.
radiation source. [A radiation generator, or a radioactive source or other radioactive material outside the nuclear fuel cycles of research and power reactors.]

Defined in the 2001 edition of the Code of Conduct on the Safety and Security of Radioactive Sources, but not included in the 2004 edition (see Ref. [14]).

2. Radioactive material used as a source of radiation.
   ① Such as those sources used for medical applications or in industrial instruments. These are, of course, sources as defined in (1), but this usage in (2) is less general.

dangerous source. A source that could, if not under control, give rise to exposure sufficient to cause severe deterministic effects. This categorization is used for determining the need for emergency arrangements and is not to be confused with categorizations of sources for other purposes.
   ① The term dangerous source relates to dangerous quantities of radioactive material (D values) as recommended in Ref. [55].

disused source. A radioactive source that is no longer used, and is not intended to be used, for the practice for which an authorization has been granted. (See Ref. [14].)

Note that a disused source may still represent a significant radiological hazard. It differs from a spent source in that it may still be capable of performing its function: it may be disused because it is no longer needed.

disused sealed source. A radioactive source, comprising radioactive material that is permanently sealed in a capsule or closely bonded and in a solid form (excluding reactor fuel elements), that is no longer used, and is not intended to be used, for the practice for which an authorization was granted.
   ① The definition is provided on the basis of the definition of disused source (see above) and the definition of sealed source (see below).

orphan source. A radioactive source which is not under regulatory control, either because it has never been under regulatory control or because it has been abandoned, lost, misplaced, stolen or otherwise transferred without proper authorization. (See Ref. [14].)

radioactive source
1. A source containing radioactive material that is used as a source of radiation.
2. [Radioactive material] that is permanently sealed in a capsule or closely bonded and in a solid form and which is not exempt from regulatory control. This also includes any radioactive material released if the radioactive source is leaking or broken, but does not include material encapsulated for disposal, or nuclear material within the nuclear fuel cycles of research and power reactors.] (See Ref. [14].) This definition is particular to the Code of Conduct on the Safety and Security of Radioactive Sources [14].

sealed source. A radioactive source in which the radioactive material is (a) permanently sealed in a capsule or (b) closely bonded and in a solid form.

1 The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management definition [5] is radioactive material that is (a) permanently sealed in a capsule or (b) closely bonded and in a solid form, excluding reactor fuel elements.

1 The term special form radioactive material, used in the context of transport of radioactive material, has essentially the same meaning.

1 Disused sealed source: see source: disused source.

spent source. A source that is no longer suitable for its intended purpose as a result of radioactive decay.

! Note that a spent source may still represent a radiological hazard.

unsealed source. A radioactive source in which the radioactive material is neither (a) permanently sealed in a capsule nor (b) closely bonded and in a solid form.

vulnerable source. A radioactive source for which the control is inadequate to provide assurance of long term safety and security, such that it could relatively easily be acquired by unauthorized persons.

source material

Uranium containing the mixture of isotopes occurring in nature; uranium depleted in the isotope 235; thorium; any of the foregoing in the form of metal, alloy, chemical compound, or concentrate; any other material containing one or more of the foregoing in such concentration as the [IAEA] Board of Governors shall from time to time determine; and such other material as the [IAEA] Board of Governors shall from time to time determine. (See Ref. [44].)

See also nuclear material.
source monitoring

See monitoring (1).

source region

A region within the body containing one or more radionuclides.
① Used in internal dosimetry; for example, for radionuclides irradiating a target tissue.

source term

The amount and isotopic composition of radioactive material released (or postulated to be released) from a facility.
① Used in modelling releases of radionuclides to the environment, in particular in the context of accidents at nuclear installations or releases from radioactive waste in repositories.

special arrangement

Those provisions, approved by the competent authority, under which consignments that do not satisfy all the applicable requirements of [the Transport] Regulations may be transported. (See SSR-6 (Rev. 1) [2].)

special facility

A facility for which predetermined facility specific actions need to be taken if urgent protective actions are ordered in its locality in the event of a nuclear or radiological emergency.
① Examples include chemical plants that cannot be evacuated until certain actions have been taken to prevent fire or explosions and telecommunications centres that must be staffed in order to maintain telephone services.
① This is not necessarily a facility within the meaning of the term facilities and activities.

special fissionable material

See nuclear material.

special form radioactive material

Either an indispersible solid radioactive material or a sealed capsule containing radioactive material. (See SSR-6 (Rev. 1) [2].)
special monitoring

See monitoring (1).

special population group

Members of the public for whom special arrangements are necessary in order for effective protective actions to be taken in the event of a nuclear or radiological emergency. Examples include disabled persons, hospital patients and prisoners.

specific activity

See activity (1): specific activity.

spent fuel

1. Nuclear fuel removed from a reactor following irradiation that is no longer usable in its present form because of depletion of fissile material, poison buildup or radiation damage.
   ① The participle ‘spent’ suggests that spent fuel cannot be used as fuel in its present form (e.g. as in spent source). In practice, however (as in (2) below), spent fuel is commonly used to refer to fuel that has been used as fuel but will no longer be used, whether or not it could be used (and that might more accurately be termed ‘disused fuel’).

2. [Nuclear fuel that has been irradiated in and permanently removed from a reactor core.] (See Ref. [5].)

spent fuel management

All activities that relate to the handling or storage of spent fuel, excluding off-site transport. It may also involve discharges. (See Ref. [5].)

spent fuel management facility

Any facility or installation the primary purpose of which is spent fuel management. (See Ref. [5].)

spent source

See source (2).
[stakeholder]

See interested party.

The term stakeholder is used in the same broad sense as interested party and the same provisos are necessary. The term stakeholder has disputed usages and is misleading and too all-encompassing for clear use. In view of the potential for misunderstanding and misrepresentation, use of the term is discouraged in favour of interested party.

To ‘have a stake in’ something, figuratively, means to have something to gain or lose by, or to have an interest in, the turn of events.

The Handbook on Nuclear Law [36] states that: “Owing to the differing views on who has a genuine interest in a particular nuclear related activity, no authoritative definition of stakeholder has yet been offered, and no definition is likely to be accepted by all parties.”

standards dosimetry laboratory

A laboratory, designated by the relevant national authority, that possesses certification or accreditation necessary for the purpose of developing, maintaining or improving primary or secondary standards for radiation dosimetry.

State of destination

A State to which a transboundary movement is planned or takes place. (See Ref. [5].)

State of origin

A State from which a transboundary movement is planned to be initiated or is initiated. (See Ref. [5].)

State of transit

Any State, other than a State of origin or a State of destination, through whose territory a transboundary movement is planned or takes place. (See Ref. [5].)

stochastic analysis

See probabilistic analysis.
stochastic effect

See health effects (of radiation).

storage

The holding of radioactive sources, radioactive material, spent fuel or radioactive waste in a facility that provides for their/its containment, with the intention of retrieval.


Storage is by definition an interim measure, and the term [interim storage] would therefore be appropriate only to refer to short term temporary storage when contrasting this with the longer term fate of the waste.

Storage as defined above should not be described as interim storage.

In many cases, the only element of this definition that is important is the distinction between disposal (with no intent to retrieve) and storage (with intent to retrieve).

1 In such cases, a definition is not necessary; the distinction can be made in the form of a footnote at the first use of the term disposal or storage (e.g. “Use of the term disposal indicates that there is no intention to retrieve the waste. If retrieval of the waste at any time in the future is intended, the term storage is used.”).

1 For storage in a combined storage and disposal facility, for which a decision may be made at the time of its closure whether to remove the waste stored during the operation of the storage facility or to dispose of it by encasing it in concrete, the question of intention of retrieval may be left open until the time of closure of the facility.

1 Contrasted with disposal.

dry storage. Storage in a gaseous medium, such as air or an inert gas.

1 Dry storage facilities include facilities for the storage of spent fuel in casks, silos or vaults.

wet storage. Storage in water or in another liquid.

1 The universal mode of wet storage consists of storing spent fuel assemblies or spent fuel elements in pools of water or other liquids, usually supported on racks or in baskets and/or in canisters that also contain liquid.

1 The liquid in the pool surrounding the fuel provides for heat dissipation and radiation shielding, and the racks or other devices ensure a geometrical configuration that maintains subcriticality.

strombolian eruption

See eruption.
strongly penetrating radiation

See radiation.

structure

See structures, systems and components.

structures, systems and components (SSCs)

A general term encompassing all of the elements (items) of a facility or activity that contribute to protection and safety, except human factors.

1 Human factors may be reflected in structures, systems and components in so far as ergonomics — the study of people’s efficiency in their work setting — is an element in their design.

See also core components.

component. One of the parts that make up a system.

1 A component may be a hardware component (e.g. wires, transistors, integrated circuits, motors, relays, solenoids, pipes, fittings, pumps, tanks, valves) or a software component (e.g. modules, routines, programmes, software functions).

1 A component may be made up of other components.

See also active component, passive component and core components.

structure. A passive element (e.g. buildings, vessels, shielding).

system. A set of components which interact according to a design so as to perform a specific (active) function, in which an element of the system can be another system, called a subsystem.

1 Examples are mechanical systems, electrical systems and instrumentation and control systems.

See also component.

sub-seabed disposal

See disposal (1).
substantiation

See qualification: equipment qualification.

supervised area

See area.

supplier (of a source)

Any person or organization to whom a registrant or licensee assigns duties, totally or partially, in relation to the design, manufacture, production or construction of a source.

1 An importer of a source is considered a supplier of the source.
2 The term supplier (of a source) includes designers, manufacturers, producers, constructors, assemblers, installers, distributors, sellers, importers or exporters of a source.

surface contaminated object (SCO)

A solid object that is not itself radioactive but which has radioactive material distributed on its surfaces. (See SSR-6 (Rev. 1) [2].)

This usage is specific to the Transport Regulations [2], and should otherwise be avoided.

surface faulting

Permanent offsetting or tearing of the ground surface by differential movement across a fault in an earthquake.

surveillance

A type of inspection to verify the integrity of a facility or structure.

1 For example, surveillance is used in the context of a disposal facility for radioactive waste to mean physical inspection of the facility to verify its integrity and the capability to protect and preserve passive barriers.

surveillance testing

Periodic testing to verify that structures, systems and components continue to function or are capable of performing their functions when called upon to do so.
survey

**area survey.** An early stage of the *siting process* for a *disposal facility*, during which a broad region is examined to eliminate unsuitable areas and to identify other areas which may contain suitable sites.

1. *Area survey* is followed by *site characterization*.
2. *Area survey* may also refer to the *siting process* for any other *authorized facility*.

See also *site evaluation*, which includes *site characterization* and is not specific to a *disposal facility* site.

**habit survey.** An evaluation of those aspects of the behaviour of *members of the public* that might influence their *exposure* — such as diet, *food consumption rates* or occupancy of different areas — usually aimed at characterizing the *representative person*.

system

See *structures, systems and components*.

**system code**

A *computational model* that is capable of simulating the transient performance of a complex *system* such as a nuclear power plant.

1. A *system code* typically includes equations for thermohydraulics, neutronics and heat transfer, and must include special *models* for simulating the performance of *components* such as pumps and separators.
2. The *system code* typically also simulates the *control* logic employed in the plant and is able to predict the evolution of *accidents*.

**system code validation**

See *validation* (1).

**system code verification**

See *verification* (1).

**system validation**

See *validation* (2).
tailings

The residues resulting from the processing of ore to extract uranium series or thorium series radionuclides, or similar residues from processing ores for other purposes.

tank

A portable tank (including a tank container), a road tank vehicle, a rail tank wagon or a receptacle that contains solids, liquids or gases, having a capacity of not less than 450 L when used for the transport of gases. (See SSR-6 (Rev. 1) [2].) This usage is specific to the Transport Regulations [2], and should otherwise be avoided.

target tissue or organ

The tissue or organ to which radiation is directed or the radiosensitive tissue or organ for which dose is assessed.

Used in internal dosimetry, normally in relation to a source region.

task related monitoring

See monitoring (1).

technological obsolescence

See ageing: non-physical ageing.

temporary relocation

See relocation.

therapeutic exposure

See exposure categories: medical exposure.

thermodynamic diameter

See activity median aerodynamic diameter (AMAD).
Thorium series

The decay chain of $^{232}$Th.

- Namely, $^{232}$Th, $^{228}$Ra, $^{228}$Ac, $^{228}$Th, $^{224}$Ra, $^{220}$Rn, $^{216}$Po, $^{212}$Pb, $^{212}$Bi, $^{212}$Po (64%), $^{208}$Tl (36%) and (stable) $^{208}$Pb.

[thoron]

Radon-220.

This usage is discontinued in the IAEA safety standards and should be avoided.

[thoron progeny]

The (short lived) radioactive decay products of $^{220}$Rn.

This usage is discontinued in the IAEA safety standards and should be avoided.

- Namely, $^{216}$Po (sometimes called thorium A), $^{212}$Pb (thorium B), $^{212}$Bi (thorium C), $^{212}$Po (thorium C′, 64%) and $^{208}$Tl (thorium C″, 36%). The stable decay product $^{208}$Pb is sometimes known as thorium D.

Through or into

Through or into the countries in which a consignment is transported but specifically excluding countries over which a consignment is carried by air, provided that there are no scheduled stops in those countries (see SSR-6 (Rev. 1) [2]).

This usage is specific to the Transport Regulations [2], and should otherwise be avoided.

time based maintenance

See maintenance: periodic maintenance.

tissue equivalent material

Material designed to have, when irradiated, interaction properties similar to those of soft tissue.

- Used to make phantoms, such as the ICRU sphere.
- The tissue equivalent material used in the ICRU sphere has a density of 1 g/cm$^3$ and an elemental composition, by mass, of 76.2% oxygen, 11.1% carbon, 10.1% hydrogen and 2.6% nitrogen, but materials of various other compositions (e.g. water) are considered suitable for particular applications [23].

The term tissue substitute is also used with the same meaning.
tissue substitute

See tissue equivalent material.

tissue weighting factor, $w_T$

Multiplier of the equivalent dose to a tissue or organ used for purposes of radiation protection to account for the different sensitivities of different tissues or organs to the induction of stochastic effects of radiation [26].

Recommended tissue weighting factors for calculating effective dose are given in the following table:

<table>
<thead>
<tr>
<th>Tissue or organ</th>
<th>$w_T$</th>
<th>$\sum w_T$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone-marrow (red), colon, lung, stomach, breast, remainder tissues&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.12</td>
<td>0.72</td>
</tr>
<tr>
<td>Gonads</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Bladder, oesophagus, liver, thyroid</td>
<td>0.04</td>
<td>0.16</td>
</tr>
<tr>
<td>Bone surface, brain, salivary glands, skin</td>
<td>0.01</td>
<td>0.04</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>The $w_T$ for remainder tissues (0.12) applies to the arithmetic mean dose to these 13 organs and tissues for each sex: adrenals, extrathoracic (ET) region, gall bladder, heart, kidneys, lymphatic nodes, muscle, oral mucosa, pancreas, prostate (male), small intestine, spleen, thymus, uterus/cervix (female).

transboundary exposure

See exposure (1).

transboundary movement

1. Any movement of radioactive material from one State through or into another.

2. [Any shipment of spent fuel or of radioactive waste from a State of origin to a State of destination.] (See Ref. [5].)
transient population group

Those members of the public who are residing for a short period of time (days to weeks) in a location (such as a camping site) that can be identified in advance. This does not include members of the public who may be travelling through an area.

transnational emergency

See emergency.

transport

1. The deliberate physical movement of radioactive material (other than that forming part of the means of propulsion) from one place to another.
   ▪ The term transportation is also used, in particular in US English or where there is a need to distinguish this meaning of transport from meaning (2).

international nuclear transport. [The carriage of a consignment of nuclear material by any means of transportation intended to go beyond the territory of the State where the shipment originates, beginning with the departure from a facility of the shipper in that State and ending with the arrival at a facility of the receiver within the State of ultimate destination.] (See Refs [40–43].)
   ▪ The Final Act of the Convention on the Physical Protection of Nuclear Material and Nuclear Facilities was approved on 8 July 2005.
   ▪ More recent texts use the term transboundary movement for a similar concept.

2. The movement of something as a result of being carried by a medium.
   ▪ A general term used when a number of different processes are involved. The most common examples are heat transport — a combination of advection, convection, etc., in a cooling medium — and radionuclide transport in the environment — which could include processes such as advection, diffusion, sorption and uptake.

transport index (TI)

A number assigned to a package, overpack or freight container, or to unpackaged LSA-I or SCO-I or SCO-III, that is used to provide control over radiation exposure. (See SSR-6 (Rev. 1) [2].)
   ▪ The value of the transport index for a package or overpack is used (together with the surface dose rate) in determining the category (I-WHITE, II-YELLOW or III-YELLOW) to which the package or overpack belongs.
A package or overpack with a transport index higher than 10 can be transported only under exclusive use.

The procedure for calculating a transport index is given in section V of the Transport Regulations [2].

In essence, the transport index is the maximum dose rate at 1 m from the outer surface of the load, expressed in mrem/h (or the value in mSv/h multiplied by 100), and in specified cases multiplied by a factor between 1 (for small sized loads) and 10 (for large sized loads). (See SSR-6 (Rev. 1) [2].)

transportation

See transport (1).

treatment

See radioactive waste management (1).

Type A/B(U)/B(M)/C package

See package.
ultimate heat sink

A medium into which the transferred *residual heat* can always be accepted, even if all other means of removing the heat have been lost or are insufficient.

This medium is normally a body of water or the atmosphere.

ultimate heat transport system

The systems and components needed to transfer residual heat to the ultimate heat sink after shutdown.

unattached fraction

The fraction of potential alpha energy of radon decay products that arises from atoms that are not attached to ambient aerosol particles.

uncertainty

*aleatory uncertainty*. *Uncertainty* inherent in a phenomenon.

1. *Aleatory uncertainty* (or stochastic *uncertainty*) is taken into account by representing a phenomenon in terms of a probability distribution *model*.
2. *Aleatory uncertainty* is of relevance for events or phenomena that occur in a random manner, such as random *failures* of items of equipment [11].

*epistemic uncertainty*. *Uncertainty* attributable to incomplete knowledge about a phenomenon, which affects the ability to model it.

1. *Epistemic uncertainty* is reflected in a range of viable *models*, multiple expert interpretations and statistical confidence.
2. *Epistemic uncertainty* is associated with the state of knowledge relating to a given problem under consideration. In any analysis or analytical *model* of a physical phenomenon, simplifications and assumptions are made. Even for relatively simple problems, a *model* may omit some aspects that are deemed unimportant to the solution.
3. Additionally, the state of knowledge within the relevant scientific and engineering disciplines may be incomplete. Simplifications and incompleteness of knowledge give rise to *uncertainties* in the prediction of outcomes for a specified problem.

uncertainty analysis

See *analysis*.
uniform hazard response spectrum

See response spectrum.

unilateral approval

See approval.

unirradiated thorium

Thorium containing not more than $10^{-7}$ g of $^{233}$U per gram of $^{232}$Th. (See SSR-6 (Rev. 1) [2].)

Although the term unirradiated thorium is used, the issue is not really whether the thorium has been irradiated, but rather whether the content of $^{233}$U (a fissile material) is significantly higher than the trace levels found in naturally occurring thorium.

! This usage is specific to the Transport Regulations [2].

unirradiated uranium

$^{235}$U, not more than $9 \times 10^6$ Bq of fission products per gram of $^{235}$U and not more than $5 \times 10^{-3}$ g of $^{236}$U per gram of $^{235}$U. (See SSR-6 (Rev. 1) [2].)

Although the term unirradiated uranium is used, the issue is not really whether the uranium has been irradiated, but rather whether the content of plutonium (a fissile material) is significantly higher than the trace levels found in naturally occurring uranium.

! This usage is specific to the Transport Regulations [2].

unrestricted linear energy transfer, $L_{\infty}$

See linear energy transfer (LET).

unrestricted use

See use.

unsealed source

See source (2).
uptake

1. A general term for the processes by which radionuclides enter one part of a biological system from another.
   ① Used for a range of situations, in particular for describing the overall effect when there are a number of contributing processes; for example, root uptake, the transfer of radionuclides from soil to plants through the plant roots.

2. The processes by which radionuclides enter the body fluids from the respiratory tract, gastrointestinal tract or through the skin, or the fraction of an intake that enters the body fluids by these processes.
   ① Also, the amount of material transferred from the site of intake to body organs or tissues.

uranium

depleted uranium. Uranium containing a lesser mass percentage of $^{235}$U than is present in natural uranium. (See SSR-6 (Rev. 1) [2].)
   ① This usage is specific to the Transport Regulations [2].

enriched uranium. Uranium containing a higher mass percentage of $^{235}$U than 0.72%. (See SSR-6 (Rev. 1) [2].)
   ① This usage is specific to the Transport Regulations [2].

high enriched uranium (HEU). Uranium containing 20% or more of the isotope $^{235}$U. HEU is considered a special fissionable material and a direct use material. (See Ref. [44].)
   ① That is, 20% or more by mass of the isotope $^{235}$U.

low enriched uranium (LEU). Enriched uranium containing less than 20% of the isotope $^{235}$U. LEU is considered a special fissionable material and an indirect use material. (See Ref. [45].)
   ① That is, less than 20% by mass of the isotope $^{235}$U.

natural uranium. Uranium (which may be chemically separated) containing the naturally occurring distribution of uranium isotopes (approximately 99.28% $^{238}$U and 0.72% $^{235}$U by mass). (See SSR-6 (Rev. 1) [2].)
   ① In all cases, a very small mass percentage of $^{234}$U is present.
   ① The naturally occurring distribution of uranium isotopes including $^{234}$U (approximately 99.285% $^{238}$U, 0.710% $^{235}$U, and 0.005% $^{234}$U by mass) corresponds to approximately 48.9% $^{234}$U, 2.2% $^{235}$U and 48.9% $^{238}$U by activity.
uranium enriched in the isotope uranium-235 or uranium-233

Uranium containing the isotope $^{235}\text{U}$ or $^{233}\text{U}$ or both in an amount such that the abundance ratio of the sum of these isotopes to the isotope $^{238}\text{U}$ is higher than the ratio of the isotope $^{235}\text{U}$ to the isotope $^{238}\text{U}$ occurring in nature (See Refs [40–44]).

1. The Final Act of the Convention on the Physical Protection of Nuclear Material and Nuclear Facilities was approved on 8 July 2005.

uranium series

The decay chain of $^{238}\text{U}$.

1. Namely, $^{238}\text{U}$, $^{234}\text{Th}$, $^{234}\text{Pa}$, $^{234}\text{U}$, $^{230}\text{Th}$, $^{226}\text{Ra}$, $^{222}\text{Rn}$, $^{218}\text{Po}$, $^{214}\text{Pb}$, $^{214}\text{Bi}$, and $^{214}\text{Po}$, $^{210}\text{Pb}$, $^{210}\text{Bi}$, $^{210}\text{Po}$ and (stable) $^{206}\text{Pb}$, plus traces of $^{218}\text{At}$, $^{210}\text{Tl}$, $^{209}\text{Pb}$, $^{206}\text{Hg}$ and $^{206}\text{Tl}$.

urgent protective action

See protective action (1).

urgent protective action planning zone (UPZ)

See emergency planning zone.

urgent response phase

See emergency response phase.

use

**authorized use.** Use of radioactive material or radioactive objects from an authorized facility or activity in accordance with an authorization.

1. Intended primarily for contrast with clearance, in that clearance implies no further regulatory control over the use, whereas the authorization for authorized use may prescribe or prohibit specific uses.

1. A form of restricted use.

**restricted use.** The use of an area or of materials subject to restrictions imposed for reasons of radiation protection and safety.

1. Restrictions would typically be expressed in the form of prohibition of particular activities (e.g. house building, growing or harvesting particular foods) or prescription of particular procedures (e.g. materials may only be recycled or reused within a facility).
unrestricted use. The use of an area or of material without any radiologically based restrictions.

There may be other restrictions on the use of the area or material, such as planning restrictions on the use of an area of land or restrictions related to the chemical properties of a material.

In some situations, these restrictions could, in addition to their primary intended effect, have an incidental effect on radiation exposure, but the use is classified as unrestricted use unless the primary reason for the restrictions is radiological.

Unrestricted use is contrasted with restricted use.
validation

1. The process of determining whether a product or service is adequate to perform its intended function satisfactorily.
   ① Validation (typically of a system) concerns checking against the specification of requirements, whereas verification (typically of a design specification, a test specification or a test report) relates to the outcome of a process.
   ② Validation may involve a greater element of judgement than verification.

computer system validation. The process of testing and evaluating the integrated computer system (hardware and software) to ensure compliance with the functional, performance and interface requirements.

model validation. The process of determining whether a model is an adequate representation of the real system being modelled, by comparing the predictions of the model with observations of the real system.
   ① Usually contrasted with model verification, although verification will often be a part of the broader process of validation.
   ② Modelling the behaviour of an engineered system in a geological disposal facility involves temporal scales and spatial scales for which no comparisons with system level tests are possible: models cannot be ‘validated’ for that which cannot be observed.
   ③ ‘Model validation’ in these circumstance implies showing that there is a basis for confidence in the model(s) by means of detailed external reviews and comparisons with appropriate field and laboratory tests, and comparisons with observations of tests and of analogous materials, conditions and geologies at the process level.
   ④ What is typically required by regulatory bodies is that such models of the behaviour of engineered systems in a geological disposal facility be shown to be ‘fit for purpose’; this is typically called ‘validation’ in national regulations.

system code validation. Assessment of the accuracy of values predicted by the system code against relevant experimental data for the important phenomena expected to occur.

   accuracy. In this context, the known bias between the prediction of a system code and the actual performance in transients of a facility.

2. Confirmation by examination and by means of objective evidence that specified objectives have been met and specified requirements for a specific intended purpose and use or application have been fulfilled.
See also verification.

1. The corresponding status is termed ‘validated’.
2. Validation typically entails the assessment of a final product against its specified objectives and specified requirements.
3. The conditions of use for validation purposes may be real or simulated.

**system validation.** Confirmation by examination and provision of evidence that a system fulfils in its entirety the specification of requirements as intended (e.g. validation of an instrumentation and control system in terms of functionality, response time, fault tolerance and robustness).

3. A means of multilateral approval of a transport package design or shipment, whereby an endorsement on the original certificate or the issuance of a separate endorsement, annex, supplement, etc., is produced by the competent authority of the country through or into which the shipment is made. (See SSR-6 (Rev. 1) [2].)

**vehicle**

A road vehicle (including an articulated vehicle, i.e. a tractor and semi-trailer combination), railroad car or railway wagon. Each trailer shall be considered a separate vehicle. (See SSR-6 (Rev. 1) [2].)

! This usage is specific to the Transport Regulations [2], and should otherwise be avoided.

**vendor**

A design, contracting or manufacturing organization supplying a service, component or facility.

**vent**

An opening in the Earth’s crust where volcanic products (e.g. lava, solid rock, gas, liquid water) are erupted.

1. Vents may be either circular structures (i.e. craters) or elongate fissures or fractures, or small cracks in the ground.

**verification**

1. The process of determining whether the quality or performance of a product or service is as stated, as intended or as required.
Verification is closely related to quality management and quality control.

**Computer system verification.** The process of ensuring that a phase in the computer system life cycle meets the requirements imposed on it by the previous phase.

**Model verification.** The process of determining whether a computational model correctly implements the intended conceptual model or mathematical model.

**System code verification.** Review of source coding in relation to its description in the system code documentation.

See also site evaluation: site verification.

2. Confirmation by examination and by means of objective evidence that specified objectives have been met and specified requirements for specific results have been fulfilled.

   ① The corresponding status is termed ‘verified’.
   ② Verification typically entails the assessment of the results of an individual activity against its inputs.
   ③ Verification may comprise activities such as: performing alternative calculations; comparing a new design specification with a similar proven design specification; undertaking tests and demonstrations; and reviewing documents prior to issue.

See also validation.

**Very low level waste (VLLW)**

See waste classes.

**Very short lived waste**

See waste classes.

**Vessel (for carrying cargo)**

Any sea-going vessel or inland waterway craft used for carrying cargo. (See SSR-6 (Rev. 1) [2].)

This restrictive use of the term vessel in relation to the transport of radioactive material does not apply in other areas of safety; for example, a reactor pressure vessel is a vessel as usually understood.
volcanic activity

A feature or process on a volcano or within a volcanic field that is linked to the presence of magma and heat gases emanating from the Earth and their interaction with nearby crustal rocks or groundwater.

Volcanic activity includes seismicity, fumarolic activity, high rates of heat flow, emission of ground gases, thermal springs, deformation, ground cracks, pressurization of aquifers and ash venting. The term includes volcanic unrest and volcanic eruption.

volcanic earthquake

A seismic event caused by, and directly associated with, processes in a volcano.

Volcanic earthquakes and seismic activity come in many forms and types (e.g. volcano–tectonic earthquakes, long period events, hybrid events, tremors, swarms) before, during and after volcanic eruptions, and their characteristics and patterns are used to infer what is happening within the volcano at different times.

Seismic monitoring is the most fundamental method used for forecasting the onset of a volcanic eruption and for assessing the potential for volcanic eruption.

Increasing seismicity, continuous tremor, shift in hypocentres towards the surface with time and the occurrence of shallow long period (or low frequency) events imply a high possibility that the onset of volcanic eruption is very close. Tremors can also continue through volcanic eruptions.

volcanic eruption

Any process on a volcano or at a volcanic vent that involves the explosive ejection of fragmental material, the effusion of molten lava, the sudden release of large quantities of volcanic gases (e.g. CO₂) or a process by which buried regions of the volcanic systems from various depths, such as the hydrothermal system, are brought to the surface during the collapse of edifices.

Volcanic eruptions are magmatic if newly solidified magma is present in the eruptive products and non-magmatic (phreatic) if they involve only recycled rock fragments. Volcanic eruptions can occur over widely varying timescales (seconds to years).

effusive eruption. A volcanic eruption in which coherent magma is extruded from the volcanic vent to form lava flows.

explosive eruption. A volcanic eruption in which gas bubble expansion or explosive interaction between magma and water is rapid enough to break the magma apart (i.e. to fragment the magma).

Explosive eruptions also occur when pressurized hydrothermal gases and superheated fluids suddenly break the host rock in a volcanic edifice.
Pyroclastic flows, falls and volcano generated missiles are characteristic of explosive eruptions.

**phreatic eruption.** A type of eruption caused by rapid volume expansion of water, or water vaporization, in the subsurface, without magma being erupted at the surface.

- Phreatic eruptions are usually steam explosions that occur when hot water is suddenly depressurized, but may occasionally be non-explosive expulsions of pressurized or heated aquifer waters and/or hydrothermal fluids at a volcano.
- Phreatic eruptions are common where rising magma interacts with groundwater, commonly in the interior of a volcano edifice.
- Although commonly small in scale, phreatic eruptions may be followed by larger scale phreatomagmatic eruptions or magmatic eruptions.
- Phreatic eruptions may generate debris flows and hot lahars.

**phreatomagmatic eruption.** A type of explosive eruption that involves subsurface interaction of magma and water and which produces explosive mixtures of rock, steam and magma that often form pyroclastic flows and surges.

- Surtseyan and phreato-plinian eruptions are phreatomagmatic eruptions involving the interaction of hot pyroclasts and water, as the magma is erupted from the volcanic vent into bodies of water.

**plinian eruption.** An explosive pyroclastic eruption characterized by a sustained eruption column that generally rises to altitudes of 10–50 km.

- Plinian eruptions may produce thick tephra fallout over areas of 500–5000 km² and/or pyroclastic flows and surges that travel tens of kilometres from the volcano.
- The 1991 eruption of Mount Pinatubo, Philippines, is a recent plinian eruption.

**strombolian eruption.** A type of volcanic eruption that is intermediate in explosivity between fire fountain and plinian eruptions.

- Magma is less fragmented in a strombolian eruption than in a plinian eruption and gas is often released in coalesced slugs rather than in a continuous jet.
- Strombolian eruptions are commonly discrete events, punctuated by intervals of relative quiescence lasting from a few seconds to several hours.
- Strombolian eruptions, usually basaltic to andesitic in composition, form weak eruption columns that rarely exceed 5 km in height, and the volume of lava flows is generally equal to, or greater than, the volume of pyroclastic rocks.
- Such eruptions are characteristic of Stromboli volcano, Italy, and Izalco volcano, El Salvador.

**vulcanian eruption.** A type of volcanic eruption characterized by discrete explosions, which produces shock waves and pyroclastic eruptions.

- Vulcanian eruptions typically occur when volcanic gas accumulates in a solidifying shallow conduit or dome, which pressurizes the magma to the point of brittle failure.
Andesitic and dacitic magmas are most often associated with vulcanian eruptions. Examples of recent vulcanian eruptions include Sakurajima volcano, Japan, Soufrière Hills volcano, Montserrat, and Colima volcano, Mexico.

**vulcanic event**

Any occurrence, or sequence of phenomena, associated with volcanoes that may give rise to volcanic hazards.

1. Volcanic events may be formally defined as part of a hazard assessment in order to provide meaningful definition of repose intervals and hazards.
2. Volcanic events may include volcanic eruptions and will typically include the occurrence of non-eruptive hazards, such as landslides.

**vulcanic field**

Any spatial cluster of volcanoes.

Also termed volcano group.

1. Volcanic fields range in size from a few volcanoes to over 1000 volcanoes.
2. Volcanic fields may consist of monogenetic volcanoes (e.g. the Cima volcanic field, United States of America), or both polygenetic and monogenetic volcanoes (e.g. the Kluchevskoy volcano group, Russian Federation).

**vulcanic hazard**

A volcanic process or phenomenon that can have an adverse effect on people or infrastructure.

1. In the more restricted context of risk assessment, it is the probability of occurrence, within a specific period of time in a given area, of a potentially damaging volcanic event of a given intensity value (e.g. thickness of tephra fallout).

**vulcanic unrest**

Variation in the nature, intensity, spatio-temporal distribution and chronology of geophysical, geochemical and geological activity and phenomena as observed and recorded on a volcano, from a baseline level of activity known for this volcano or for other similar volcanoes outside periods of eruptive activity.

1. Volcanic unrest can be precursory and can culminate in a volcanic eruption, although in most cases, rising magma or pressurized fluids that cause unrest do not breach the surface and erupt.
volcanic vent

See vent.

volcano

A naturally occurring vent at the Earth’s surface through which lava, solid rock and associated gases and liquid water can erupt.

The edifice that is built by the explosive or effusive accumulation of these products over time is also a volcano.

**capable volcano.** A volcano that has a credible likelihood of undergoing future activity and producing hazardous phenomena, including non-eruptive phenomena, during the lifetime of a nuclear installation concerned, and which may potentially affect the site.

Hierarchical criteria for determining whether a volcano or volcanic field is a capable volcano or a capable volcanic field are: (i) evidence of contemporary volcanic activity or active near surface processes associated with magmatism for any volcano in the geographical region; (ii) Holocene volcanic activity for any volcano within the geographical region; and (iii) some evidence of potential for activity, such as recurrence rates of volcanism greater than $10^{-7}$ per year, and the potential to produce hazardous phenomena that may affect the site vicinity [57].

**Holocene volcano.** A volcano or volcanic field that has erupted within the past 10,000 years (the Holocene).

Reported historical activity and radiometric dating of volcanic products provide the most direct evidence of volcanic eruptions within the Holocene.

In some circumstances, especially in the early stages of site investigation, the exact age of the most recent volcanic products may be difficult to determine.

In such circumstances, additional evidence may be used to judge a volcano as Holocene (e.g. by following the methods used by the Smithsonian Institution, United States of America).

Such evidence includes: (i) volcanic products overlying latest Pleistocene glacial debris; (ii) youthful volcanic landforms in areas where erosion would be expected to be pronounced after many thousands of years; (iii) vegetation patterns that would have been far richer if the volcanic substrates were more than a few thousand (or hundred) years old; and (iv) ongoing fumarolic degassing, or the presence of a hydrothermal system at the volcano.

In addition, some volcanoes may be denoted as Holocene(?) volcanoes if authorities disagree over the existence of Holocene volcanism, or when the original investigator expresses uncertainty about the most reliable age estimate of the most recent volcanic eruption.

Under these circumstances, it is reasonable to consider such volcanoes to be Holocene and to proceed with the hazard assessment.
volcano explosivity index (VEI)

A classification scheme for the explosive magnitude of a volcanic eruption, primarily defined in terms of the total volume of erupted tephra, but in some cases the height of the eruption column and the duration of continuous explosive eruption are used to determine the VEI value.

1. The VEI varies from VEI 0 (non-explosive eruption, less than $10^4$ m$^3$ tephra ejected) to VEI 8 (largest explosive eruption identified in the geological record, more than $10^{12}$ m$^3$ tephra ejected).
2. A unit of increasing explosivity on the VEI scale generally corresponds to an increase in volume of erupted tephra by a factor of ten.
3. The only exception is the transition from VEI 0 to VEI 1, which represents an increase in the volume of tephra erupted by a factor of one hundred.

volcano generated missile

A pyroclastic particle, often of large size, that is forcefully ejected, follows a high angle trajectory from the volcanic vent to the surface as a result of explosive activity at the vent and falls under gravity.

1. Volcano generated missiles can be of any material, such as rock fragments, trees and structural debris, that is rapidly transported by flow phenomena with significant momentum and that may impact structures, causing considerable damage, even beyond the extent of the main flow itself.

volcano group

See volcanic field.

volcano monitoring

Geophysical, geochemical and geological monitoring to evaluate the potential for a forthcoming volcanic eruption, forecast the onset of eruption, understand an ongoing eruption and evaluate the potential volcanic hazards arising from an eruption.

1. Instruments such as seismometers, global positioning system receivers, tiltmeters, magnetometers, gas sensors, cameras and/or related instruments are installed on and around the volcano to evaluate volcanic activity, identify volcanic unrest and evaluate the potential for volcanic eruption.
2. Remote sensing by satellite is sometimes very effective in monitoring temporal thermal, topographical and geological changes in volcanoes.

volume reduction

See radioactive waste management (1).
vulcanian eruption

See eruption.

vulnerable source

See source (2).
warning point

A designated organization to act as a point of contact that is staffed or able to be alerted at all times for promptly responding to, or initiating a response to, an incoming notification (definition (2)), warning message, request for assistance or request for verification of a message, as appropriate, from the IAEA.

waste

Material for which no further use is foreseen.

exempt waste. Waste from which regulatory control is removed in accordance with exemption principles.

① This is waste that meets the criteria for clearance, exemption or exclusion from regulatory control for radiation protection purposes as described in Refs [13, 58].

! This is therefore not radioactive waste.

[mining and milling waste (MMW)]. Waste from mining and milling.

① This includes tailings from processing, residues from heap leaching, waste rock, sludges, filter cakes, scales and various effluents.

See also [mining and milling].

mixed waste. Radioactive waste that also contains non-radioactive toxic or hazardous substances.

NORM waste. Naturally occurring radioactive material (NORM) for which no further use is foreseen.

secondary waste. Radioactive waste resulting as a byproduct from the processing of primary radioactive waste.

See also radioactive waste.

waste, radioactive

See radioactive waste.
waste acceptance criteria

Quantitative or qualitative criteria specified by the regulatory body, or specified by an operator and approved by the regulatory body, for the waste form and waste package to be accepted by the operator of a waste management facility.

1. Waste acceptance criteria specify the radiological, mechanical, physical, chemical and biological characteristics of waste packages and unpackaged waste.
2. Waste acceptance criteria might include, for example, restrictions on the activity concentration or total activity of particular radionuclides (or types of radionuclide) in the waste, on their heat output or on the properties of the waste form or of the waste package.
3. Waste acceptance criteria are based on the safety case for the facility or are included in the safety case as part of the operational limits and conditions and controls.
4. Waste acceptance criteria are sometimes referred to as ‘waste acceptance requirements’.

waste canister

See waste container.

waste characterization

See characterization (2).

waste classes

![Waste Classes Diagram]

- H/LW: high level waste (deep geological disposal)
- ILW: intermediate level waste (intermediate depth disposal)
- LLW: low level waste (near surface disposal)
- VSLW: very short lived waste (decay storage)
- VLLW: very low level waste (landfill disposal)
- EW: exempt waste (exemption/clearance)
Waste classes are those recommended in GSG-1 [58].

This classification system is organized to take into account matters considered of prime importance for the safety of disposal of radioactive waste.

The term ‘activity content’ is used because of the generally heterogeneous nature of radioactive waste; it is a generic term that covers activity concentration, specific activity and total activity.

The other classes listed below (in square brackets) are sometimes used, for example in national classification systems, and are mentioned here to indicate how they typically relate to the classes in GSG-1 [58].

Other systems classify waste on other bases, such as according to its origin (e.g. reactor operations waste, reprocessing waste, decommissioning waste and defence waste).

exempt waste. See waste.

[heat generating waste (HGW)]. Radioactive waste that is sufficiently radioactive that the decay heat significantly increases its temperature and the temperature of its surroundings.

In practice, heat generating waste is usually high level waste, although some types of intermediate level waste may qualify as heat generating waste.

high level waste (HLW). The radioactive liquid containing most of the fission products and actinides present in spent fuel — which forms the residue from the first solvent extraction cycle in reprocessing — and some of the associated waste streams; this material following solidification; spent fuel (if it is declared as waste); or any other waste with similar radiological characteristics.

Typical characteristics of high level waste are concentrations of long lived radionuclides exceeding the limitations for short lived waste [58].

This is waste with levels of activity concentration high enough to generate significant quantities of heat by the radioactive decay process or waste with large amounts of long lived radionuclides that need to be considered in the design of a disposal facility for such high level waste.

Disposal in deep, stable geological formations usually several hundred metres or more below the surface is the generally recognized option for the disposal of high level waste.

intermediate level waste (ILW). Radioactive waste that, because of its content, in particular its content of long lived radionuclides, requires a greater degree of containment and isolation than that provided by near surface disposal.

Typical characteristics of intermediate level waste are levels of activity concentration above clearance levels.

However, intermediate level waste needs no provision, or only limited provision, for heat dissipation during its storage and disposal [58].
Intermediate level waste may contain long lived radionuclides, in particular, alpha emitting radionuclides that will not decay to a level of activity concentration acceptable for near surface disposal during the time for which institutional controls can be relied upon.

Waste in this class may therefore require disposal at greater (intermediate) depths, of the order of tens of metres to a few hundred metres or more.

Intermediate level waste may be so classified on the basis of waste acceptance criteria for near surface disposal facilities.

**long lived waste.** Radioactive waste that contains significant levels of radionuclides with a half-life greater than 30 years.

Typical characteristics are long lived radionuclide concentrations exceeding the limitations for short lived waste [58].

**low level waste (LLW).** Radioactive waste that is above clearance levels, but with limited amounts of long lived radionuclides.

Low level waste covers a very broad range of waste. Typical characteristics of low level waste are levels of activity concentration above clearance levels.

Low level waste may include short lived radionuclides at higher levels of activity concentration, and also long lived radionuclides, but only at relatively low levels of activity concentration that require only the levels of containment and isolation provided by a near surface disposal facility [58].

Low level waste requires robust containment and isolation for periods typically of up to a few hundred years and is suitable for disposal in engineered near surface disposal facilities.

Low level waste may be so classified on the basis of waste acceptance criteria for near surface disposal facilities.

**short lived waste.** Radioactive waste that does not contain significant levels of radionuclides with a half-life greater than 30 years.

Typical characteristics are restricted long lived radionuclide concentrations (limitation of long lived radionuclides to 4000 Bq/g in individual waste packages and to an overall average of 400 Bq/g per waste package); see para. 2.27 of GSG-1 [58].

**very low level waste (VLLW).** Radioactive waste that does not necessarily meet the criteria of exempt waste, but that does not need a high level of containment and isolation and, therefore, is suitable for disposal in landfill type near surface repositories with limited regulatory control.

Such landfill type near surface repositories may also contain other hazardous waste; typical waste in this class includes soil and rubble with low levels of activity concentration.

Concentrations of longer lived radionuclides in very low level waste are generally very limited [13, 58].

This is a category used in some Member States; in others there is no such category, as no radioactive waste at all may be disposed of in this way, however low level it is.
**very short lived waste.** Radioactive waste that can be stored for decay over a limited period of up to a few years and subsequently cleared from regulatory control according to arrangements approved by the regulatory body, for uncontrolled disposal, use or discharge [13, 58].

   1. This class includes radioactive waste containing primarily radionuclides with very short half-lives often used for research and medical purposes.

waste conditioning

See radioactive waste management (1): conditioning.

waste container

The vessel into which the waste form is placed for handling, transport, storage and/or eventual disposal; also the outer barrier protecting the waste from external intrusions. The waste container is a component of the waste package. For example, molten high level waste glass would be poured into a specially designed container (canister), where it would cool and solidify.

   1. Note that the term waste canister is considered to be a specific term for a container for spent fuel or vitrified high level waste.

waste disposal

See disposal.

waste form

Waste in its physical and chemical form after treatment and/or conditioning (resulting in a solid product) prior to packaging.

   1. The waste form is a component of the waste package.

waste generator

The operating organization of a facility or activity that generates waste.

   1. For convenience, the scope of the term waste generator is sometimes extended to include whoever currently has the responsibilities of the waste generator (e.g. if the actual waste generator is unknown or no longer exists and a successor organization has assumed responsibility for the waste).

waste management, radioactive

See radioactive waste management.
waste management facility, radioactive

See radioactive waste management facility.

waste minimization

See minimization of waste.

waste package

The product of conditioning that includes the waste form and any container(s) and internal barriers (e.g. absorbing materials and liner), as prepared in accordance with requirements for handling, transport, storage and/or disposal.

weakly penetrating radiation

See radiation.

wet storage

See storage.

worker

Any person who works, whether full time, part time or temporarily, for an employer and who has recognized rights and duties in relation to occupational radiation protection.

① A self-employed person is regarded as having the duties of both an employer and a worker.

workers’ health surveillance

Medical supervision intended to ensure the initial and continuing fitness of workers for their intended tasks.

[working level (WL)]

A unit of potential alpha energy concentration (i.e. the potential alpha energy per unit volume of air) resulting from the presence of decay products of $^{222}\text{Rn}$ or $^{220}\text{Rn}$, equal to $1.3 \times 10^8 \text{ MeV/m}^3$ (exactly).

① The term working level is now obsolete and its use is discouraged.

① In SI units, a working level is $2.1 \times 10^{-5} \text{ J/m}^3$ (approximately).
The exposure due to decay products of $^{222}$Rn or $^{220}$Rn that would be incurred during a working month (170 hours) in a constant potential alpha energy concentration of one working level.

The term working level month is now obsolete and its use is discouraged.

In SI units, a working level month is $3.54 \times 10^{-3}$ J·h/m³ (approximately).

**workplace monitoring**

See *monitoring* (1).
REFERENCES


REFERENCES


REFERENCES


[34] INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS, Radiation Quantities and Units, Rep. 33, ICRU, Bethesda, MD (1980).


REFERENCES


It is not intended, or indeed possible, that this glossary cover all terms that might be used in safety related publications. Many terms used in safety related publications originate in other specialized fields, such as computing, geology, meteorology and seismology. For most such technical terms, the reader is referred to specialized glossaries or dictionaries for the relevant fields. Some other safety related glossaries, dictionaries, etc., that may be of use are listed below.


INTERNATIONAL ATOMIC ENERGY AGENCY (Vienna)


INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION (Pergamon Press, Oxford and New York)

Doses to the Embryo and Fetus from Intakes of Radionuclides by the Mother, Publication 88 (2001).

Basic Anatomical and Physiological Data for Use in Radiological Protection: Reference Values, Publication 89 (2002).


INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (Geneva)


Annex

SI UNITS AND PREFIXES

- SI base units
- SI derived units and non-SI units accepted for use with SI
- Additional units accepted for use with SI for the time being

<table>
<thead>
<tr>
<th>Prefixes for SI (and metric units)</th>
<th>Prefixes for SI (and metric units)</th>
</tr>
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<tbody>
<tr>
<td>d (deci) 10^{-1}</td>
<td>da (deca) 10^{1}</td>
</tr>
<tr>
<td>c (centi) 10^{-2}</td>
<td>h (hecto) 10^{2}</td>
</tr>
<tr>
<td>m (milli) 10^{-3}</td>
<td>k (kilo) 10^{3}</td>
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<td>μ (micro) 10^{-6}</td>
<td>M (mega) 10^{6}</td>
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<td>n (nano) 10^{-9}</td>
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<td>p (pico) 10^{-12}</td>
<td>T (tera) 10^{12}</td>
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<tr>
<td>f (femto) 10^{-15}</td>
<td>P (peta) 10^{15}</td>
</tr>
<tr>
<td>a (atto) 10^{-18}</td>
<td>E (exa) 10^{18}</td>
</tr>
</tbody>
</table>

### Length
- m metre
- Å ångström (10^{-10} m)

### Area
- a are (10^{2} m^{2})
- ha hectare (10^{4} m^{2})
- b barn (10^{-28} m^{2})

### Volume
- L litre

### Mass
- kg kilogram
- t tonne (10^{3} kg)
- u unified atomic mass unit
- T tesla

### Time
- s second
- min minute
- h hour
- d day

### Temperature
- K kelvin
- °C degree Celsius

### Pressure
- Pa pascal (N/m^{2})
- bar bar (10^{5} Pa)

### Radiation units
- Bq becquerel (dimensions: s^{-1})
- Gy gray (1 Gy = 1 J/kg)
- Sv sievert
- Ci curie (1 Ci = 37 GBq)
- R röntgen (1 R = 258 µC/kg)
- rad rad (100 rad = 1 Gy)
- rem rem (100 rem = 1 Sv)

### Electricity and magnetism
- A ampere
- C coulomb
- eV electronvolt
- F farad
- H henry
- Hz hertz (cycles per second)
- Ω ohm
- S siemens (ohm^{-1})
- V volt
- W watt
- Wb weber

### Others
- cd candela
- mol mole
- J joule
- lm lumen
- lx lux
- N newton
- rad radian
- sr steradian
- ° degree of angle
- ′ minute of angle
- ″ second of angle
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