Western European
WENRA WGWD
Nuclear Regulators Association

Report

Radioactive Waste Disposal Facilities Safety Reference Levels

22 December 2014

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Executive Summary

The Western European Nuclear Regulators' Association (WENRA) is an international body made up of the Heads and senior staff members of Nuclear Regulatory Authorities of European countries with nuclear power plants. The main objectives of WENRA is to develop a common approach to nuclear safety, to provide an independent capability to examine nuclear safety and to be a network of chief nuclear safety regulators in Europe exchanging experience and discussing significant safety issues.

To accomplish these tasks two working groups within the WENRA have been established - Reactor Harmonisation Working Group (RHWG) and Working Group on Waste and Decommissioning (WGWD).

This document contains the results of the work of WGWD in the area of the safety of disposal facilities for radioactive waste. The objective of this report is to provide safety reference levels for these facilities, which were based on the RHWG report, other WGWD reports and ad hoc IAEA documents (requirements, guidance, etc). Although the IAEA safety standards establish an essential basis for safety of all nuclear installations covering also radioactive waste disposals, the WENRA safety reference levels incorporate more facility specific requirements.

The document was prepared by the task manager on the basis of support by the chairman of the working group, Mr. Stefan Theis, and on the input provided by the members of WGWD listed below:

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WENRA Policy Statement

We, the heads of the national nuclear safety authorities, members of WENRA, commit ourselves to a continuous improvement of nuclear safety in our respective countries.

Nuclear safety and radiation protection are based on the principle of the prime responsibility of the operators. Our role is to ensure that this responsibility is fully secured, in compliance with the regulatory requirements.

In order to work together, we created the Western European Nuclear Regulators' Association (WENRA) with the following main objectives to:

- build and maintain a network of chief nuclear safety regulators in Europe;
- promote exchange of experience and learning from each other's best practices;
- develop a harmonized approach to selected nuclear safety and radiation protection issues and their regulation, in particular within the European Union;
- provide the European Union Institutions with an independent capability to examine nuclear safety and its regulation in applicant countries.

In order to develop a harmonized approach, we are making efforts to:

- share our experience feedback and our vision;
- exchange personnel, allowing an in-depth knowledge of working methods of each other;
- develop common safety reference levels in the fields of reactor safety, decommissioning safety, radioactive waste and spent fuel management facilities in order to benchmark our national practices.

We recognise the IAEA standards to form a good base for developing national regulations. The developed reference levels represent good practices in our counties and we are committed

- by the year of 2010 to adapt at a minimum our national legislation and implementation to the reference levels;
- to influence the revision of the IAEA standards when appropriate;
- to continuously revise the reference levels when new knowledge and experience are available.

We strive for openness and improvement of our work. For that purpose we are making efforts to

- keep the European nuclear safety and radiation protection bodies not belonging to WENRA and the EU Institutions informed of the progress made in our work;
- make the WENRA reports available on the Internet (www.wenra.org);
- invite stakeholders to make comments and suggestions on our reports and the proposed reference levels.

Signed in Stockholm December 2005

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Glossary

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For the purpose of this document, the following definitions have been adopted, although the working group recognizes the possibility of some differences with national and international documents.

Barriers
A natural or engineered obstruction that provides safety functions.

Multiple barriers
Two or more natural or engineered barriers.

Natural barrier (no source)
Barrier provided by the host environment.

Engineered barrier
Barrier provided by engineered components.

Closure (based on 2011/70/Euratom)
'Closure' means the completion of all operations at some time after the emplacement of radioactive waste in a disposal facility, including the final engineering or other work required to bring the facility to a condition that will be safe in the long term.

Commissioning (from IAEA glossary –edition 2007)
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. In this report commissioning means commissioning of the initially constructed part of the disposal facility and newly constructed parts**.**

Computational model
The representation of the conceptual and the mathematical models in a form in which computations can be carried out.

Conditioning (from IAEA glossary –edition 2007)
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.

Construction (from IAEA glossary –edition 2007)
The process of manufacturing and assembling the components of a disposal facility, the carrying out of civil works, the installation of components and equipment and the performance of associated tests. Construction includes any necessary excavation work.

Construction work during operation refers to the civil and underground work carried out by the licensee to develop further the disposal facility (e.g.: create new galleries, create new vaults). Construction includes not only initial construction but may also include construction during operation depending on the national program.

Containment
Provisions of a disposal system that limit the release and the dispersion of radioactive substances.

Control
Function, power or means of directing, regulating or restraining. 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.

Regulatory control
Control or regulation applied to facilities or activities by a regulatory body.

Decommissioning
'In this report, the term decommissioning as applied to a radioactive waste disposal facility includes decontamination, dismantling and removal of ancillary surface facilities, such as waste handling equipment and stores, so that long term protection of the public and the environment is achieved with respect to these facilities. It also includes dismantling and removal of operational equipment from the facility itself, as considered appropriate. Decommissioning is here distinguished from closure which includes all measures necessary to bring a radioactive waste disposal facility to a condition that will be safe in the long term.

Design (based on IAEA glossary – edition 2007)
Development of a concept, detailed plans, supporting calculations and specifications for a facility and its parts.

Design basis
The range of conditions and events taken explicitly into account in the design of a facility, according to established criteria, such that the facility can withstand them without exceeding authorized limits by the planned operation of safety systems.

Disposal (from IAEA – SSR5).
Disposal refers to the emplacement of solid radioactive waste into a facility with no intention of retrieving the waste.

Disposal facility
Any facility the primary purpose of which is radioactive waste disposal. Such a facility may include natural and engineered components. It includes the part of the facility where the waste is emplaced and the auxiliary facilities needed for its construction, operation and closure.

Disposal facility
The disposal system is composed of the part of the facility where the waste is emplaced and those parts of the host environment whose properties and behaviour contribute to post-closure safety.

Experience feedback
Experience feedback should be provided by a system that facilitates the sharing of experiences that have led to significant corrective actions in human performance, hardware or safety management practices, or have revealed vulnerabilities that are not yet fully incorporated into the safety case. In addition, the system should provide safety relevant information arising from research programss, even if the concern was raised for reasons other than an incident at a disposal or other nuclear facility. The key criterion for sharing experience should not be whether a safety event is significant, but rather whether the safety lesson is significant.

Features, events and processes
The general dictionary definitions of these concepts are (1) feature – a distinctive attribute or aspect of something, (2) event – a thing that happens or takes place, especially one of importance, and (3) process – a naturally or artificially induced sequence of events leading to an outcome or product. In this report, which is concerned with safety aspects of a radioactive waste disposal facility, FEPs are these concepts applied to the waste, to engineered aspects of the disposal facility, to the geological environment, and to interactions among any of these, for the purpose of constructing a safety case.

Graded approach (from IAEA glossary –edition 2007)
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 proportionate, to the extent practicable, to the likelihood and possible consequences of, and the level of risk associated with, a loss of control.
2. An application of safety requirements that is proportionate to the characteristics of the practice or source and to the magnitude and likelihood of the exposures.

Host environment
The local geology (rock) within which a radioactive waste disposal facility is directly located.

Isolation
Provisions of a disposal system that ensure that the waste is protected from both natural and human external disturbances.

Licensee
The licensee is the legal or natural person or organization having the overall responsibility for a facility or activity (the responsible organization) for waste disposal as specified in a license.

In this document, the term licensee also covers the prospective licensee, when the SRL refers to actions to be implemented prior to the license application. In such a case, the organization responsible for implementing the SRL is the organization in charge of developing the concept of a disposal facility before the license is applied for.

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. The management system integrates all elements of an organization into one coherent system to enable all the organization's objectives to be achieved. These elements include the organizational structure, resources and processes. Personnel, equipment and organizational culture as well as the documented policies and processes are parts of the management system. 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.

The term management system reflects and includes the evolution in the approach from the initial concept of 'quality control' (controlling the quality of products) through 'quality assurance' (the system to ensure the quality of products) to 'quality management' (the system to manage quality).

Model validation
Model validation is the process of determining whether a conceptual and/or computational model is an adequate representation of the real case being modelled, by comparing the predictions of the model with observations of the real case or with experimental data. Code validation is the assessment of the accuracy of values predicted by the code against relevant experimental data for the important phenomena expected to occur.

Model verification
Model verification is the process of determining that a computational model correctly implements the intended conceptual model or mathematical model; that is, whether the controlling physical equations and data have been correctly translated into the computer code. It includes ensuring that the numerical solutions provided by the computational model are sufficiently accurate for their intended use. System code verification is the review of source coding in relation to its description in the system code documentation.

Monitoring, inspection, surveillance

Monitoring (adapted from IAEA DS357 – version 15/03/11)
Continuous or periodic observation and measurements of environmental, engineering, or radiological parameters to help evaluate the behaviour of components of the waste disposal facility and system, or of the impacts of the waste disposal facility and system on the public and the environment.

Inspection (from IAEA glossary – edition 2007)
An examination, observation, 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.

Surveillance
Overall observation of the disposal facility and system, including monitoring, testing and inspection, during operational phase and, if required, after the closure of the facility.

Passive safety feature
A safety feature which does not depend on an external input and/or continuous supply of media.

Post-closure (based on IAEA SSR-5)
Phase beginning at the time when all the engineered containment and isolation features have been put in place, operational buildings and supporting services have been decommissioned and the disposal system is in its final configuration.

Postulated initiating events (PIE)
An event identified during design as capable of leading to anticipated operational occurrences or accident conditions. The primary causes of postulated initiating events may be credible equipment failures and operator errors (both within and external to the facility) or human induced or natural events.

Protection and Safety
The protection of people and the environment against exposure to ionizing radiation or radioactive materials and the safety of radiation sources, including the means for achieving this, and the means for preventing accidents and for mitigating the consequences of accidents should they occur.

Safety is primarily concerned with maintaining control over sources, whereas radiation protection is primarily concerned with controlling exposure to radiation and its effects. Clearly the two are closely connected: radiation protection is very much simpler if the source in question is under control, so safety necessarily contributes towards protection. Sources come in many different types, and hence safety may be termed nuclear safety, radiation safety, radioactive waste safety or transport safety, but protection (in this sense) is primarily concerned with protecting humans and the environment against exposure, whatever the source, and so also is radiation protection.

Radiation protection
The protection of people ***and the environment*** from the effects of exposure to ionizing radiation, and the means for achieving this.

Nuclear safety
The achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards.

Retrievability
The ability to retrieve waste that has been disposed of.

Reversibility
The ability to reverse waste disposal operations.

Robustness (of a component or a system)
Ability of a component or system to fulfil its assigned safety functions over the timescale required by the safety case despite perturbing internal and external events and processes, and taking into account uncertainties.

Safety

Operational safety
The protection of people and the environment against radiation risks, and the safety of the facility and activities that give rise to radiation risk as a result of operations (such as construction, waste emplacement, decommissioning and closure) with due consideration to potential exposures during normal operation, anticipated operational occurrences and possible accidents.

Post-closure safety
Protection of people and the environment against radiation risks after closure of the disposal system taking into account the various possible ways it might evolve.

Safety case
Collection of scientific and technical arguments and evidence in support of the safety of a disposal facility and system.

Safety assessment
Safety assessment entails evaluating the performance of a disposal system and quantifying its potential radiological impact on human health and the environment. Safety assessment is a major component of the safety case for a disposal facility and should take account of the potential radiological impacts of the facility, both in operation and after closure. Radiological impacts may arise from gradual processes after closure that may cause the facility and its components (e.g. natural and engineered barriers) to degrade, and from discrete disturbing events that could affect the isolation of the waste (e.g. earthquakes, faulting and inadvertent human intrusion). Safety assessment should demonstrate whether the disposal facility complies with applicable regulatory requirements.

Safety functions (based on IAEA SSR5, para 3.32)
Specific function that must be provided for safety, either during operation of the disposal facility (operational safety functions) or after the closure of the disposal system (post-closure safety functions).

> **Operational safety functions**
> are provided by technical systems and control actions.
>
> **Post-closure safety functions**
> are provided by engineered and natural barriers and post-closure control actions (if any). They are achieved by means of physical or chemical properties or processes that contribute to containment and isolation, such as: impermeability to water; limited corrosion, dissolution, leach rate and solubility; and retention.

Scenario (based on IAEA SSG-23)
Scenarios are descriptions of alternative possible evolutions, or alternative possible future states, of the disposal system. The development of scenarios is used to identify and define 'assessment cases' that are consistent with the assessment context. Each assessment case may represent or bound a range of similar possible evolutions or states of the disposal system.

Different types of scenario are usually considered in an assessment, including a 'base case scenario' and 'alternative evolution scenarios', which will include disturbing events and processes, and may explore other uncertainties relating to the base case. The alternative scenarios will have most aspects in common with the base case scenario, but particular aspects will differ between the scenarios, so as to explore the sensitivity of the safety assessment to those aspects.

Two main methods have been used for constructing scenarios. The first may be described as a 'bottom-up' method and is based on screening of features, events and processes. Use of this method requires a comprehensive list of possible or postulated features, events and processes as a starting point. The second may be described as a 'top-down' method and is based on analyses of how the safety functions of the disposal system may be affected by uncertainties and by disturbing events and processes.

Site characterization
Detailed surface and subsurface investigations and activities at a selected site and its environment.

Siting (from IAEA glossary – edition 2007)
The process of selecting a suitable site for a disposal facility, including appropriate assessment and definition of the related design bases. The siting process for a disposal facility is particularly crucial to its post-closure safety; it may therefore be a particularly extensive process, and can be divided into the following stages: concept and planning, area survey, fundamental site characterization, site confirmation.

Standards
Measures of quality or suitability for a specified purpose, recognized by authority or by general consent and expressed in terms of quantitative and/or qualitative rules or criteria. Examples are quality standards and safety standards.

Structures, systems and components (SSCs)
A general term encompassing all of the elements (items) of a facility or activity which contribute to protection and safety, except human factors.

Structures are the passive elements: buildings, vessels, shielding, etc.

A system comprises several components, assembled in such a way as to perform a specific (active) function.

A component is a discrete element of a system or structure.

Uncertainties
Uncertainties are lack of sureness or knowledge in any of several respects about something. Relevant uncertainties in the context of this report are uncertainties that may affect the overall safety of the disposal facility and system.

In the particular context of safety assessment of a waste disposal system, safety demonstration is particularly subject to uncertainties because of the long timescales that may be involved. Relevant uncertainties to be considered relate to data or parameter values considered in the safety assessment; limited understanding of certain mechanisms, modelling difficulties and the general lack of knowledge about the future.

Uncertainty management
Process of accounting for, grading and eliminating, reducing or otherwise dealing with the uncertainties involved with establishing the safety case. This may include uncertainties managed at the level of the safety concept and design as well as those considered in the safety assessment.[1]

Waste acceptance criteria (for disposal)
Criteria applicable to waste packages and unpackaged waste accepted for emplacement in a disposal facility. Such criteria must be fully consistent with the safety case for the disposal facility in operation and after closure. They may include criteria introduced for operational as well as for safety reasons. They may be specified by the regulatory body or by an operator. If specified by an operator, they may be approved by the regulatory body.

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[1] Uncertainties and the way of dealing with them can be divided in various categories:
1. Uncertainties with minor influence on the results of safety assessment need not necessarily further consideration.
2. Reducible uncertainties with substantial influence on the results of safety assessment should be reduced through e.g. further research, improved modelling or design modifications.
   Irreducible uncertainties with substantial influence on the results of safety assessment should be considered through e.g. specific scenarios, conservative assumptions or probabilistic assessments.

Waste form (from IAEA glossary – edition 2007)
Waste in its physical and chemical form after treatment and/or conditioning (resulting in a solid product) prior to packaging. The waste form is a component of the waste package.

Waste package (from IAEA glossary – edition 2007)
The product of conditioning that includes the waste form and any container(s) and internal barriers (e.g. absorbing materials and liners), as prepared in accordance with requirements for handling, transport, storage and/or disposal.

Waste producer (from IAEA glossary – edition 2007)
The operating organization of a facility or activity that generates waste. For this report the scope of the term waste producer is extended to any organization responsible for the management of the waste: either the waste producer himself or a license holder to whom this responsibility has been entrusted by competent authorities.

List of Abbreviations

ALARA	As low as reasonably achievable
EU	European Union
IAEA	International Atomic Energy Agency
NEA	Nuclear Energy Agency (OECD)
OLC	Operational limits and conditions
PIE	Postulated initiating event
PSR	Periodic safety review
R&D	Research and development
RHWG	(WENRA) Reactor Harmonization Working Group
SC	Safety case
SSCs	Structures, systems and components
SRL	Safety reference level
WAC	Waste acceptance criteria
WENRA	Western European Nuclear Regulators' Association
WGWD	(WENRA) Working Group on Waste and Decommissioning

Part 1
Introduction and Methodology

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1.1 Introduction

This report is the result of an effort by the Working Group on Waste and Decommissioning (WGWD) of WENRA, from 2009 to 2014. It presents the safety reference levels (SRLs) for specialized radioactive waste disposal facilities that are thought to be a good basis for future harmonization on a European level.

The SRLs cannot be considered as independent European safety requirements because current legislation in WENRA member states would not allow that due to fundamental differences reflecting the historical development in European countries. The SRLs are a set of requirements against which the situation of each country is assessed and it is each country's responsibility to implement actions to ensure that these levels are reached.

1.1.1 Background

WENRA, which was established in February 1999, is the association of the Heads of nuclear regulatory authorities of European countries with at least one nuclear power plant in construction, operation or decommissioning phase. WENRA was formally extended in 2003 to include new and future European Union (EU) member states. Currently the following countries are members of WENRA: Belgium, Bulgaria, the Czech Republic, Finland, France, Germany, Hungary, Italy, Lithuania, the Netherlands, Romania, Slovenia, the Slovak Republic, Spain, Sweden, Switzerland and the United Kingdom. Recently various other states have been appointed to WENRA meetings with the status of "observers". However such states have not yet been participating in the work of WGWD and have not taken part in the preparation of this report.

The original objectives of the Association were:

- to provide the EU institutions with an independent capability to examine nuclear safety and its regulation in applicant countries,
- to provide the EU with an independent capability to examine nuclear safety and regulation in candidate countries,
- to evaluate and achieve a common approach to nuclear safety and regulatory issues which arise.

The second objective of WENRA has been fulfilled by the preparation of a report on nuclear safety in candidate countries having at least one nuclear power plant. After May 1st, 2004, when most of these candidate countries became regular EU member states, the new WENRA tasks, based on first and third original Association's objectives, became:

- providing the European Union institutions with an independent capability to examine nuclear safety and its regulation in applicant countries and
- developing common approaches to nuclear safety and regulations and to encourage the harmonization of practices.

To perform these tasks two working groups within the WENRA have been established - Reactor Harmonization Working Group (RHWG) and Working Group on Waste and Decommissioning (WGWD). The work of WGWD has started in 2002.

1.1.2 Objective

The objective of this report is to provide SRLs for specialized radioactive waste disposal facilities in line with the safety objectives described by the Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste. This project adopts the position, in accordance with the Directive, that radioactive waste, including spent fuel when considered as waste, requires containment and isolation from humans and the living environment over the long term. Its specific nature (content of radionuclides) requires arrangements to protect human health and the environment against dangers arising from ionizing radiation, including disposal in appropriate facilities as the end point of its management. Although the safety objective is the same whatever the type of disposal facility, the means for reaching it may differ considerably depending on the type of waste to be disposed of. The requirements should accordingly be implemented using a graded approach as stated by the Directive, proportionate to the hazard of the radioactive waste.

The SRLs in this report are oriented toward licensees of the radioactive waste disposal facilities, who are responsible for the safety of such facilities until the termination of the licenses. Prior to a license application, the SRLs require action to be undertaken by the organization responsible for developing a disposal concept. For example, quality assurance programs and a properly structured organization are needed to ensure appropriateness of actions undertaken before the licensing process is started. The SRLs apply particularly to geological disposal facilities, where development of the project is likely to span over several decades and preparatory work - mainly geological investigations and R&D programs - needs to be implemented before the license application. When a requirement applies to a future licensee who is not yet regulated under nuclear regulation, the future licensee will need to demonstrate that it has fulfilled the requirement in order to obtain a license. Some of the SRLs can also be used by the regulatory body for the review and evaluation of the safety of disposal facilities.

According to the WENRA policy statement the harmonization process of the national legal systems in member states should be completed by the year 2010. In 2009 WENRA decided to extend the deadline in case of the disposal SRLs. WENRA also intends to provide, in the future, SRLs for waste processing, to complement the sets of SRLs for radioactive waste management.

1.1.3 Scope

The SRLs are focused on near surface, intermediate depth or deep geological facilities for disposal of radioactive waste in solid form. In the case of geological disposal, this can include spent fuel when it is regarded as radioactive waste. As this document is intended to cover a wide range of facilities, the application of the reference levels to particular facilities will need to be proportionate to the hazards associated with the wastes being disposed of, and to be interpreted in accordance with the type of facility.

This report has been broadly modelled on previous reports prepared by the WENRA WGWD such as the Storage report and the Decommissioning report, but taking into account the particular issues associated with radioactive waste disposal. It has also taken into account a wide range of international and national documents relating to radioactive waste disposal, especially including those listed under “Methodology” below. Certain decisions were taken by the WGWD to limit the scope of the report. These are explained in later paragraphs of this “Scope” section.

In some countries disposal facilities for very low level waste are not regulated under the regulations for nuclear facilities. Even in this case, it is recommended that the requirements developed in this report are taken into consideration in a suitably proportionate manner for these facilities.

Residual materials containing radionuclides of natural origin (NORM - mining and mineral processing waste as referred to in IAEA SSR-5) are not within the scope of this report. Various ways of managing such waste are implemented in different countries, depending on the characteristics and level of activity of the waste. Some of this waste may be managed in radioactive waste disposal facilities with respect to the level of radioactivity, for example as low-level radioactive waste. Other types of waste may be managed either in landfills or even directly on the sites where they were produced, when intrinsic radioactivity is low and there are large amounts of waste. Although not within the scope of this report, it is recommended that in this last case some surveillance may be implemented to confirm the safe management of this waste.

The site selection process is not addressed in the report because this process is specific to each country taking into account societal and political considerations and different regulatory regimes. The SRLs presented here might, however, inform considerations during the site selection process. SRLs in this report start with the disposal facility development covering all aspects of safety once a site has been selected.

Decommissioning aspects of disposal facilities are not regulated in this report. SRLs of the WENRA decommissioning report are to be applied, as appropriate.

After closure, safety of the disposal system is provided by means of passive safety features, possibly accompanied by surveillance, particularly for near surface disposal facilities. The license will be terminated after a period of surveillance under regulatory control, when all the necessary technical, legal and financial requirements have been fulfilled. Thereafter, the assignment of responsibilities is outside the scope of this report.

Because WGWD members do not all regulate the following matters, WGWD has concentrated on relevant nuclear and waste safety requirements and, in particular, it has not taken into account other regulatory requirements such as Environmental Impact Assessment regulation (required by EU directives), discharge authorization, chemical toxicity of radioactive waste disposed of, management of non-radioactive waste, conventional occupational health and safety, physical protection including safeguards, and funding issues. These other regulatory requirements should be treated in accordance with the applicable national regulatory systems.

Article 27 of Council Directive 2011/70/Euratom states that: “Member States should ensure that adequate funding is available for the management of spent fuel and radioactive waste.” As specified in the Directive, the Member State has ultimate responsibility for funding radioactive waste management. However, based on the “polluter pays” principle, within the Member State funding should come from the organization responsible for the waste. The licensee of the disposal facility may also have responsibilities relating to assessing costs for disposal and to ensuring proper funding mechanisms for development, operation and closure of the facility. In some cases the licensee of the disposal facility may be the same as the organization responsible for the waste. Because of the special nature and potential complexity of the funding issue we have not judged it appropriate to deal with it in this report. If WGWD were to specify a requirement on this topic this might be considered in its future reports on waste processing and management. It has to be kept in mind that, in some countries, these matters are addressed by other national regulatory organizations.

With respect to chemical toxicity of the waste, the WGWD recognizes that, although not always in the mandate of its members, protection from the non-radioactive hazardous content of the waste represents an important issue. Therefore the WGWD members stress the need for this issue to be duly handled by the licensee, so as to comply with the appropriate regulatory requirements.

1.1.4 Structure

The report consists of two main parts. Following this introduction, Section B presents the general methodology that was followed to develop the SRLs and to analyze their application in participating countries. Part II of the report presents the specific waste disposal reference levels and the corresponding appendices.

1.2 Methodology

The working methodology of WGWD has gone through several steps and changes since 2002, when the working group was established. A list of topics to be covered by WGWD was defined taking into account the common field of responsibility of WENRA members. Generally for the development of disposal SRLs relevant the following IAEA documents were considered:

- Fundamental Safety Principles, IAEA Safety Fundamentals SF-1, Vienna (2006).
- Governmental, Legal and Regulatory framework for Safety. IAEA General Safety Requirements, GSR Part 1, Vienna (2010).
- Radiation protection and safety of radiation sources: International Basic Safety Standards, IAEA General Safety Requirements, GSR Part 3, Vienna (2011).
- Safety assessment for facilities and activities, IAEA General Safety Requirements, GSR Part 4, Vienna (2009).
- Predisposal Management of Radioactive Waste - Safety Requirements; IAEA General Safety Requirements, GSR Part 5, Vienna (2009).
- Disposal of Radioactive Waste No. SSR-5; IAEA Specific Safety Requirements, Vienna (2011).
- Classification of radioactive waste, IAEA General Safety Guide, GSG-1, Vienna (2009).
- Geological disposal facilities for radioactive waste, IAEA Specific Safety Guide, SSG-14, Vienna (2011).
- The Safety Case and Safety Assessment for the Disposal of Radioactive Waste, IAEA Specific Safety Guide, SSG-23, Vienna (2012).
- Periodic Safety Review for Nuclear Power Plants, IAEA Specific Safety Guide, SSG-25, Vienna (2013).
- Near Surface Disposal of Radioactive Waste, IAEA Specific Safety Guide, SSG-29, Vienna (2014).
- Monitoring and Surveillance of Radioactive Waste Disposal Facilities, IAEA Specific Safety Guide, SSG-31, Vienna (2014).
- Preparedness and Response for a Nuclear or Radiological Emergency, IAEA General Safety Requirements, GS-R-2, Vienna (2002).
- Management Systems for Facilities and Activities, Safety Requirements, IAEA General Safety Requirements, GS-R-3, Vienna (2006).2
- Safety of Nuclear Fuel Cycle Facilities, IAEA Safety Requirements, NS-R-5 (Rev. 1), Vienna (2014).
- The management system for the disposal of radioactive waste, IAEA Safety Guide, GS-G-3.4 , Vienna (2008).

[2] IAEA GS-R-3 is currently being revised

Other international/European standards and recommendations relevant for disposal of spent fuel and radioactive waste:

- Joint convention on the safety of spent fuel management and on the safety of radioactive waste management. INFCIRC/546. 24 December 1997.
- Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste
- Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation
- WENRA - Waste and spent fuel storage safety reference levels report, version 2.2
- WENRA - Decommissioning safety reference levels report, version 2.1.
- The Nature and Purpose of the Post-closure Safety Cases for Geological Repositories, OECD/NEA (2013)

Post-closure Safety Case for Geological Repositories, OECD/NEA (2004)

Part 2
Radioactive Waste Disposal Safety Reference Levels

These reference levels are intended for disposal facilities which will be used to dispose of radioactive waste in solid form.

The reference levels apply to a wide range of facilities and thus have to be applied in a proportionate manner, taking account of the magnitude of the potential hazard of the waste to be disposed of. Such a graded approach should also be applied within a particular facility, so that the provisions made and means of implementation within the facility are proportionate to the hazards identified by the licensee.

Whatever the type of waste to be disposed of, disposal systems should incorporate passive safety features as far as reasonably practical and their post-closure safety, possibly after a period of surveillance, should only rely on passive means.

Compared to other nuclear facilities, radioactive waste disposal facilities present a unique challenge because of the need to demonstrate safety over long periods after closure. Depending on the radiological hazard presented by the waste and the type of facility, these periods may span a few hundred years (for short-lived waste) to several hundred thousand years or more (for long-lived waste). Consideration of radiological hazard over long time periods requires a special focus on post-closure safety.

Containment and isolation are two major safety objectives that have to be fulfilled by the disposal system. Post-closure safety often relies primarily on the intrinsic properties of the site, mainly the ability of the host environment to prevent or delay the release of radionuclides, although any engineered barriers will also contribute to a greater or lesser extent depending on the facility design and construction. Developing the safety case for a disposal system is an important challenge; it requires demonstrating that an acceptable level of safety will be provided over an appropriate timescale. It requires an adequate understanding of the behaviour of the disposal system, in order to achieve confidence in the safety demonstration. The safety demonstration needs to take account of uncertainties in the possible evolution of the disposal system and consider, among other things, reasonably foreseeable events and processes that may disturb the disposal system.

The safety case for a disposal facility in its geological environment presents specific problems compared to the safety case for other types of nuclear facilities: first, it has to address post-closure safety in conjunction with operational safety; second, the safety case matures in the time period during which the disposal concept is developed and the facility is constructed and operated; third, the safety case will have to deal with uncertainties, particularly in the very long term, that have no parallels in other types of facility. The safety case for a disposal facility will often relate to a given stage of facility development.

It is generally recognised that there are key phases that cover the development and implementation of a disposal facility. However, the exact definition of the phases and decision-making points may differ among national programss. As an example, according to the IAEA SSR-5, the following phases can be considered (see Appendix 1):

- The pre-operational phase during which a prospective licensee considers potential sites and design options. A decision regarding the siting of the disposal facility is taken (the prospective licensee will beforehand have identified potentially suitable sites that are compatible with the design concept), the authorization for design and construction of the disposal facility is granted, and design and construction work proceeds.

- The operational phase, during which the licensee emplaces waste packages in the disposal facility. The operational phase begins when waste is first received at the facility. Operations to close parts of the disposal facility are also likely to take place during this phase in parallel with waste emplacement.

- At the end of the operational phase, the licensee will be authorized to decommission parts of the disposal facility that are not needed after closure and to close the disposal facility fully and will proceed to closure.

- The post-closure phase which begins at the time when all the engineered containment and isolation features have been put in place. Follow-up provisions, to reflect the requirements of the post-closure safety case, will be implemented as appropriate.

Consideration should also be given to development of the disposal facility over time. It is possible that construction activities and decommissioning or closure of parts of the facility might take place while it is still in operation. Due attention must be paid to the safe management of any such concurrent activities.

The development of the safety case in parallel with the development of the disposal facility needs to be recognized as an iterative process in which it is strongly recommended that the regulatory body should be involved even prior to licensing. During this pre-licensing phase, it is very important that a dialogue between the prospective licensee of the disposal facility and the regulatory body (and its technical support organization, if any) should take place. The prospective licensee and the regulatory body will both be concerned to ensure that the project is in line with regulatory expectations. At some key decision steps, the regulatory body may even be expected to make a preliminary review of pre-licensing documentation and

to formulate safety recommendations. In some cases, the regulator might be called upon to provide information to the public so as to contribute to better understanding of the safety issues and transparency of the regulatory assessment process. During any pre-licensing process, the regulatory body should be very careful to maintain regulatory independence by not contributing to developing the concept and the design of the facility, and by making sure that the responsibility for the project is seen to lie with the prospective licensee.

Even before a disposal facility exists, the prospective licensee of the facility will be expected to develop a safety strategy including the principle of optimization of protection and a management system to ensure that the activities conducted in preparation for the license application are undertaken under a quality assurance system and are traceable. As an example, it is very important that when research and development activities are conducted in support of the safety case, it can be demonstrated that they have been conducted according to a well-defined and structured program, oriented toward safety demonstration.

Depending on the regulatory requirements the complete description of the management system may or may not be part of the safety case. The regulatory body will have to make sure that the licensee maintains appropriate and adequate means, resources and organizational arrangements throughout the project to develop and maintain the safety case and to ensure the safety of operations.

From the early stages in the development of a disposal facility, both operational safety and post-closure safety will need to be addressed in the safety case. As part of an iterative process, the safety case will evolve and mature, throughout the disposal facility lifetime, as new information and results become available from research, site characterization, and safety assessments.

The safety case may also evolve based on the experience gained during construction and operation as well as implementation of the optimization process. When a modified design for part of the facility is envisaged, experience feedback from previous stages has to be taken into account, as well as experience feedback from other facilities and any evolution in techniques and technologies.

The typical content of a safety case is given in Appendix 3.

At the earliest stages of a disposal facility, there may be many unresolved questions and uncertainties. The safety case should identify key uncertainties that may influence safety and the actions needed to manage them, especially with regard to the R&D programs. By the time a license for constructing the disposal facility is applied for, any uncertainties and open questions that might undermine safety should have been addressed adequately to support the necessary regulatory decisions. At each stage in the development of a facility when a regulatory decision to proceed is required, the key uncertainties should have been addressed to an extent sufficient to establish confidence in the decision.

The licensee will have to pay attention to maintaining knowledge and enabling appropriate transfer of that knowledge throughout the project. Record keeping of important information and data about the disposal facility and its geological environment is an important requirement for the facility that needs to be taken into account by the licensee from the beginning of the project.

Depending on the type of waste and the disposal concept, the characteristics of the waste packages may vary. Some waste packages may be designed only with the aim of allowing handling and emplacing waste in the disposal facility while others will contribute to the safety functions of the disposal system, for example, with respect to containment and isolation.

2.1
Safety area: Safety management

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2.1.1 Safety issue: Responsibility

DI-01:

The licensee shall have the responsibility for ensuring and demonstrating that the facility is safe until termination of the licence, and for demonstrating that the facility will continue to be safe thereafter.

*Related **IAEA** safety standards:*

The operator of a disposal facility for radioactive waste shall be responsible for its safety. The operator shall carry out safety assessment and develop and maintain a safety case, and shall carry out all the necessary activities for site selection and evaluation, design, construction, operation, closure and, if necessary, surveillance after closure, in accordance with national strategy, in compliance with the regulatory requirements and within the legal and regulatory infrastructure. (SSR-5, Requirement 3)

DI-02:

The licensee shall make and implement programss and procedures necessary to maintain safety.

*Related **IAEA** safety standards:*

An essential step in setting the necessary standards for the health and safety of operating personnel and the public and for the protection of the environment are the statements by the operating organization of its safety, health and environmental policies. These policy statements shall be provided to staff as a declaration of the organization's objectives and the public commitment of corporate management. To put these policies into effect, the operating organization shall also specify and put in place organizational structures, standards and management arrangements capable of meeting the organization's objectives and public commitments under the policy. (NS-R-5 (Rev. 1), para 4.6)

Safety shall be paramount within the management system, overriding all other demands. (GS-R-3, para 2.2)

DI-03:

The licensee shall continuously improve safety by, in particular, using experience feedback and advances in science and technology.

*Related **IAEA** safety standards:*

[...] The feedback of operating experience from facilities and activities — and, where relevant, from elsewhere — is a key means of enhancing safety. Processes must be put in place for the feedback and analysis of operating experience, including initiating events, accident precursors, near misses, accidents and unauthorized acts, so that lessons may be learned, shared and acted upon. (SF-1, para 3.17)

Potential non-conformances that could detract from the organization's performance shall be identified. This shall be done: by using feedback from other organizations, both internal and external; through the use of technical advances and research; through the sharing of knowledge and experience; and through the use of techniques that identify best practices.(GS-R-3, para 6.16)

DI-04:

The licensee shall establish and implement its safety policy taking due account of national and international standards and ensure that matters related to safety are given the highest priority.

*Related **IAEA** safety standards:*

4.2. The operating organization:

(a) Shall establish and implement safety, health and environmental policies in accordance with national and international standards and shall ensure that these matters are given the highest priority;
(b) Shall establish an organizational structure to enable these policies to be carried out with a clear definition of responsibilities and accountabilities, lines of authority and lines of communication;
[…]
(NS-R-5 (Rev. 1), para 4.2)

DI-05:

The licensee shall ensure that the resources (including organizational structure, individuals, experience and skills, infrastructure, working environment, information and knowledge, suppliers, materials) for all necessary activities before termination of the licence will be available at the time they are needed.

*Related **IAEA** safety standards:*

The operating organization shall maintain the capability in terms of staffing, skills, experience and knowledge to undertake competently all activities throughout the lifetime of the facility, from its siting to decommissioning. […].(NS-R-5 (Rev. 1), para 4.9)

DI-06:

After closure and until termination of the licence, the licensee shall remain responsible for surveillance of the disposal system in accordance with the safety case and for any remedial action that might be required.

*Related **IAEA** safety standards:*

The operator of a disposal facility for radioactive waste shall be responsible for its safety. The operator shall carry out safety assessment and develop and maintain a safety case, and shall carry out all the necessary activities for site selection and evaluation, design, construction, operation, closure and, if necessary, surveillance after closure, in accordance with national strategy, in compliance with the regulatory requirements and within the legal and regulatory infrastructure. (SSR-5, Requirement 3)

DI-07:

The licensee shall ensure that all activities, including those carried out by contractors, are performed and controlled according to the licensee's management system.

*Related **IAEA** safety standards:*

The operating organization may delegate to other organizations work necessary for discharging its responsibilities, in accordance with the regulatory requirements but the overall responsibility and control shall be retained by the operating organization. (NS-R-5 (Rev. 1), para 4.5)

[…] Where the resources and skills necessary to fulfil any part of these undertakings are provided by an external organization, the operating organization shall nevertheless retain within its organization the capability to assess the adequacy of the external organization's capabilities for ensuring safety. (NS-R-5 (Rev. 1), para 4.9)

DI-08:

The licensee shall ensure that interfaces between its responsibilities and those of other organizations are clearly defined, agreed and documented.

*Related **IAEA** safety standards:*

Interdependences among all steps in the predisposal management of radioactive waste, as well as the impact of the anticipated disposal option, shall be appropriately taken into account. (GSR Part 5, Requirement 6)

The operator is responsible for establishing and implementing the overall strategy for the management of the waste that is generated, […], taking into account interdependences among all steps in waste management, the available options and the national radioactive waste management policy. (GSR Part 5, para 3.17)

2.1.2 Safety issue: Organizational structure

DI-09:

The licensee shall establish an organizational structure to enable its safety policy to be implemented with a clear definition of responsibilities, lines of authority and communication.

*Related **IAEA** safety standards:*

An essential step in setting the necessary standards for the health and safety of operating personnel and the public and for the protection of the environment are the statements by the operating organization of its safety, health and environmental policies. […]To put these policies into effect, the operating organization shall also specify and put in place organizational structures, standards and management arrangements capable of meeting the organization's objectives and public commitments under the policy. (NS-R-5 (Rev. 1), para 4.6)

The operating organization shall clearly specify the responsibilities and accountabilities of all staff involved in conducting or controlling operations that affect safety. […] This applies throughout the lifetime of the facility, from its siting to its decommissioning. (NS-R-5 (Rev. 1), para 4.7)

The management structure shall define clear lines of communication and shall provide the necessary infrastructure for facility operations to be conducted safely. (NS-R-5 (Rev. 1), para 4.8)

DI-10:

The licensee shall establish the capability in terms of staffing, skills, experience and knowledge to build and maintain the competences required to undertake all relevant activities and adapt its organization progressively in accordance with future plans.

*Related **IAEA** safety standards:*

The operating organization shall maintain the capability in terms of staffing, skills, experience and knowledge to undertake competently all activities throughout the lifetime of the facility from siting to decommissioning. Where the resources and skills necessary to fulfil any part of these undertakings are provided by an external organization, the operating organization shall nevertheless retain within its organization the capability to assess the adequacy of the external organization's capabilities for ensuring safety. (NS-R-5 (Rev. 1), para 4.9)

DI-11:

The licensee shall define the necessary qualification, experience and skills for all staff involved with activities that may affect safety.

*Related **IAEA** safety standards:*

The operating organization shall specify the necessary qualifications and experience for all staff involved in activities that may affect safety. […] The operating organization shall additionally ensure that the qualifications and training of contractors are adequate for the activities to be performed and

that adequate control and supervision are in place. Records of the training provided to staff or to contractors shall be maintained (NS-R-5 (Rev. 1), para 4.10)

Senior management shall ensure that individuals are competent to perform their assigned work and that they understand the consequences for safety of their activities. Individuals shall have received appropriate education and training, and shall have acquired suitable skills, knowledge and experience to ensure their competence. [...](GS-R-3, para 4.4)

DI-12:

The licensee shall establish training programs to develop and maintain the professional skills of its staff, and to ensure that personnel are appropriately trained before beginning each activity.

*Related **IAEA** safety standards:*

Minimum qualifications for personnel shall be specified, and these minimum qualifications shall be commensurate with the assigned functional responsibility and authority. The training of personnel working at the facility shall be commensurate with their assigned functional responsibilities, their authorities and their safety related activities. A training program for personnel working at the facility shall be organized, staffed and managed to facilitate planning, direction, evaluation and control for fulfilling the training objectives. The training given shall be graded and shall be based on a competency framework. (NS-R-5 (Rev. 1), para 9.8)

[…] The operating organization shall additionally ensure that the qualifications and training of contractors are adequate for the activities to be performed and that adequate control and supervision are in place. Records of the training provided to staff or to contractors shall be maintained. (NS-R-5 (Rev. 1), para 4.10)

DI-13:

Where any activity related to safety is carried out by a contractor, the licensee shall retain within its organization the capability to assess the adequacy of the contractor's resources and skills for ensuring safety and the quality of the deliverables.

*Related **IAEA** safety standards:*

The operating organization shall maintain the capability in terms of staffing, skills, experience and knowledge to undertake competently all activities throughout the lifetime of the facility from siting to decommissioning. Where the resources and skills necessary to fulfil any part of these undertakings are provided by an external organization, the operating organization shall nevertheless retain within its organization the capability to assess the adequacy of the external organization's capabilities for ensuring safety. (NS-R-5 (Rev. 1), para 4.9)

2.1.3 Safety issue: Management system

DI-14:

The licensee shall establish, document, implement, assess and continuously improve its management system to achieve and enhance safety by bringing together in a coherent manner all the requirements for managing the organization by:

- Describing and implementing the planned and systematic actions necessary to provide adequate confidence that all these requirements are satisfied;
- Ensuring that health, environmental, security, quality and economic requirements are not considered separately from safety requirements, to help preclude their possible negative impact on safety;
- Promoting the development of a safety culture, which includes individual and collective commitment to safety and encourages a proactive, questioning and learning attitude at all levels in the organization;
- Ensuring that the work performed in each process is carried out using approved procedures, instructions, drawings or other appropriate means that are periodically reviewed to ensure their adequacy and effectiveness, and is subject to quality arrangements appropriate to a graded approach.

*Related **IAEA** safety standards:*

To fulfil its prime responsibility for safety throughout the lifetime of a fuel cycle facility, the operating organization shall establish, implement, assess and continually improve a management system that integrates safety, health, environmental, security, quality and economic elements to ensure that safety is properly taken into account in all the activities of an organization. (NS-R-5 (Rev. 1), para 4.1)

A management system shall be established, implemented, assessed and continually improved. It shall be aligned with the goals of the organization and shall contribute to their achievement. The main aim of the management system shall be to achieve and enhance safety by:

- *Bringing together in a coherent manner all the requirements for managing the organization;*
- *Describing the planned and systematic actions necessary to provide adequate confidence that all these requirements are satisfied;*
- *Ensuring that health, environmental, security, quality and economic requirements are not considered separately from safety requirements, to help preclude their possible negative impact on safety.*

(GS-R-3, para 2.1)

The work performed in each process shall be carried out under controlled conditions, by using approved current procedures, instructions, drawings or other appropriate means that are periodically reviewed to ensure their adequacy and effectiveness. (GS-R-3, para 5.9)

DI-15:

The licensee shall ensure that its management system covers normal operation conditions, anticipated operational occurrences and possible accidents.

*Related **IAEA** safety standards:*

For a disposal facility, as for any other operational nuclear facility or facility where radioactive material is handled, used, stored or processed, an operational radiation protection program, commensurate with the radiological hazards, is required to be put in place to ensure that doses to workers during normal operations are controlled and that the requirements for the limitation of radiation doses are met. […] . In addition, emergency plans are required to be put in place for dealing with accidents and other incidents, and for ensuring that any consequent radiation doses are controlled to the extent possible, with due regard for the relevant emergency action levels.(SSR-5, para 2.13)

DI-16:

The licensee shall ensure that its management system takes into account safety in design, construction, commissioning operation, decommissioning, closure and after closure. The licensee shall review its management system at regular intervals to ensure continuing suitability and effectiveness.

*Related **IAEA** safety standards:*

Management systems to provide for assurance of quality shall be applied to all safety related activities, systems and components throughout all the steps of the development and operation of a disposal facility. The level of assurance for each element shall be commensurate with its importance to safety. (SSR-5, Requirement 25)

A management system review shall be conducted at planned intervals to ensure the continuing suitability and effectiveness of the management system and its ability to enable the objectives set for the organization to be accomplished. (GS-R-3, para 6.7)

DI-17:

The licensee shall document in its management system at least the following:

- Its safety policy;
- A description of its management system;
- A description of its organizational structure;
- A description of the functional responsibilities, accountabilities, levels of authority and interactions of those managing, performing and assessing work;
- A description of the licensee's interactions with contractors, including the control of activities carried out by contractors;
- A description of the processes and supporting information that explain how work is to be prepared, carried out, recorded, assessed, reviewed, and improved;
- A description of the provisions to record and review knowledge, information and data about all aspects related to safety of the disposal facility and system and to preserve the records;
- A description of the provisions to ensure appropriate transfer of knowledge to its personnel throughout the different phases until termination of the licence.

*Related **IAEA** safety standards:*

The documentation of the management system shall include the following:

- *The policy statements of the licensee;*
- *A description of the management system;*
- *A description of the functional responsibilities, accountabilities, levels of authority and interactions of those managing, performing and assessing work;*
- *A description of the interactions with relevant external organizations;*
- *A description of the processes and supporting information that explain how work is to be prepared, reviewed, carried out, recorded, assessed and improved.*

(GS-R-3, para 2.8)

2.1.4 Safety issue: Record keeping

DI-18:

The licensee shall ensure that, for any operational activity relating to safety, all documents required to demonstrate that it will be undertaken safely (e.g.: operational procedures, operating instructions) have been prepared before beginning that activity.

*Related **IAEA** safety standards:*

The processes of the management system that are needed to achieve the goals, provide the means to meet all requirements and deliver the products of the organization shall be identified, and their development shall be planned, implemented, assessed and continually improved. (GS-R-3, para 5.1)

The work performed in each process shall be carried out under controlled conditions, by using approved current procedures, instructions, drawings or other appropriate means that are periodically reviewed to ensure their adequacy and effectiveness. (GS-R-3; para 5.9)

DI-19:

The licensee shall establish and conduct an experience feedback program to collect, screen, analyse and document in a systematic way experience important to safety in all phases of facility development until termination of the licence. This program shall cover issues of importance for both operational and post-closure safety. This information shall be used for preventing events and processes adverse to safety, and for improving the design or manner of construction and operation of the facility as necessary. Experience from other facilities shall also be considered as appropriate.

*Related **IAEA** safety standards:*

[…] The feedback of operating experience from facilities and activities — and, where relevant, from elsewhere — is a key means of enhancing safety. Processes must be put in place for the feedback and analysis of operating experience, including initiating events, accident precursors, near misses, accidents and unauthorized acts, so that lessons may be learned, shared and acted upon.(SF-1, para 3.17)

Arrangements shall be made so that available technical information on abnormal occurrences, incidents and accidents that have occurred at the facility or at similar facilities is analysed for the feedback of lessons learned from experience and for preventive actions if necessary. (NS-R-5 (Rev.1), para 9.16)

2.1.5 Safety issue: Records and knowledge keeping

DI-20:

The licensee shall ensure that, during design, construction, commissioning, operation, closure and post-closure until termination of the licence, knowledge and records important to safety are available and updated as appropriate for current activities, safety assessment and long term record keeping on:

- Characterisation of the site
- Design basis
- Design
- As built construction of the disposal facility
- Operation including any operational occurrences and accidents
- Inventory and emplacement of the waste
- State of the disposal system after closure
- All documents relating to the safety case

*Related **IAEA** safety standards:*

The operator has to retain all the information relevant to the safety case and the supporting safety assessment for the disposal facility and has to retain the inspection records that demonstrate compliance with regulatory requirements and with the operator's own specification. Such information and records have to be retained, at least up until the time when the information is shown to be superseded, or until responsibility for the disposal facility is passed on to another organization. This occurs, for example, at closure of the facility, when all relevant information and records have to be transferred to the organization assuming responsibility for the facility and its safety. (SSR-5, para 3.15)

DI-21:

The licensee shall ensure that, at termination of the licence, records on the site and on the as-closed state of the disposal facility are available for continuing preservation, in accordance with the national legal and regulatory framework.

*Related **IAEA** safety standards:*

Disposal facilities may not be closed for several tens of years or more after operations have commenced. Plans for possible future controls and the period over which they would be applied may initially be flexible and conceptual in nature, but plans have to be developed and refined as the facility approaches closure.[…] Arrangements have to be made to be able to pass on information about the disposal facility and its contents to future generations to enable any future decisions on the disposal facility and its safety to be made. (SSR-5, para 5.13)

2.2
Safety area: Disposal facility development

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2.2.1 Safety issue: General requirements

DI-22:
The licensee shall design, construct, operate and decommission a disposal facility, ensure closure and, as appropriate, carry out post-closure surveillance so as to fulfil the objective of protecting people and the environment according to applicable radiological protection criteria, including the ALARA principle. A graded approach shall be adopted proportionate to the hazard presented by the waste.

*Related **IAEA** safety standards:*

The operator of a disposal facility for radioactive waste shall be responsible for its safety. The operator shall carry out safety assessment and develop and maintain a safety case, and shall carry out all the necessary activities for site selection and evaluation, design, construction, operation, closure and, if necessary, surveillance after closure, in accordance with national strategy, in compliance with the regulatory requirements and within the legal and regulatory infrastructure. (SSR-5, Requirement 3)

The safety measures that are applied to facilities and activities that give rise to radiation risks are considered optimized if they provide the highest level of safety that can reasonably be achieved throughout the lifetime of the facility or activity, without unduly limiting its utilization. (SF-1, para 3.21)

To determine whether radiation risks are as low as reasonably achievable, all such risks, whether arising from normal operations or from abnormal or accident conditions, must be assessed (using a graded approach) a priori and periodically reassessed throughout the lifetime of facilities and activities. Where there are interdependences between related actions or between their associated risks (e.g. for different stages of the lifetime of facilities and activities, for risks to different groups or for different steps in radioactive waste management), these must also be considered. Account also has to be taken of uncertainties in knowledge. (SF-1, para 3.22)

A graded approach has to be adopted, depending on the hazard potential of the waste and the complexity of the site and disposal facility design [...] (SSR-5, para 4.28)

DI-23:

The licensee shall ensure that safety is provided by means of multiple safety functions, including use of multiple barriers and controls. The performance of these barriers shall be achieved by diverse physical and chemical means. The overall performance of the disposal system shall not be unduly dependent on any single safety function according to the defence in depth principle.

*Related **IAEA** safety standards:*

The host environment shall be selected, the engineered barriers of the disposal facility shall be designed and the facility shall be operated to ensure that safety is provided by means of multiple safety functions. Containment and isolation of the waste shall be provided by means of a number of physical barriers of the disposal system. The performance of these physical barriers shall be achieved by means of diverse physical and chemical processes together with various operational controls. The capability of the individual barriers and controls together with that of the overall disposal system to perform as assumed in the safety case shall be demonstrated. The overall performance of the disposal system shall not be unduly dependent on a single safety function. (SSR-5, Requirement 7)

Requirements are established […] for ensuring that there is adequate defence in depth so that safety is not unduly dependent on a single element of the disposal facility such as the waste package, or a control measure such as verification of the inventory of waste packages or the fulfilment of a single safety function, such as by containment of radionuclides or retardation of migration; or an administrative procedure such as a procedure for site access control or for maintenance of the facility (SSR-5, para 3.33)

DI-24:

The licensee shall ensure that safety will be achieved entirely by passive means, after closure of the facility and after any subsequent period of active institutional control.

*Related **IAEA** safety standards:*

The operator shall evaluate the site and shall design, construct, operate and close the disposal facility in such a way that safety is ensured by passive means to the fullest extent possible and the need for actions to be taken after closure of the facility is minimized. (SSR-5, Requirement 5)

DI-25:

Throughout the process of development (e.g. design, construction commissioning), operation, decommissioning and closure of a disposal facility, the licensee shall aim for an optimized level of safety considering both operational and the post-closure phases.

*Related **IAEA** safety standards:*

Throughout the process of development and operation of a disposal facility for radioactive waste, an understanding of the relevance and the implications for safety of the available options for the facility shall be developed by the operator. This is for the purpose of providing an optimized level of safety in the operational stage and after closure. (SSR-5, Requirement 4)

DI-26:

The licensee shall design, construct, operate, decommission and close the disposal facility in order to establish a disposal system which provides containment and isolation of the waste for a period of time suited to its radiological hazards.

*Related **IAEA** safety standards:*

The engineered barriers, including the waste form and packaging, shall be designed, and the host environment shall be selected, so as to provide containment of the radionuclides associated with the waste. Containment shall be provided until radioactive decay has significantly reduced the hazard posed by the waste. In addition, in the case of heat generating waste, containment shall be provided while the waste is still producing heat energy in amounts that could adversely affect the performance of the disposal system. (SSR-5, Requirement 8)

The disposal facility shall be sited, designed and operated to provide features that are aimed at isolation of the radioactive waste from people and from the accessible biosphere. The features shall aim to provide isolation for several hundreds of years for short lived waste and at least several thousand years for intermediate and high level waste. In so doing, consideration shall be given to both the natural evolution of the disposal system and events causing disturbance of the facility. (SSR-5, Requirement 9)

DI-27:

The licensee shall ensure that the disposal system provides isolation and containment during normal evolution and shall establish to a high level of confidence that the disposal system can be relied on to provide isolation and containment over the timescales necessary.

*Related **IAEA** safety standards:*

The engineered barriers, including the waste form and packaging, shall be designed, and the host environment shall be selected, so as to provide containment of the radionuclides associated with the waste. Containment shall be provided until radioactive decay has significantly reduced the hazard posed by the waste. […] (SSR-5, Requirement 8)

The disposal facility shall be sited, designed and operated to provide features that are aimed at isolation of the radioactive waste from people and from the accessible biosphere. […] In so doing, consideration shall be given to both the natural evolution of the disposal system and events causing disturbance of the facility. (SSR-5, Requirement 9)

The concept of robustness may be applied to individual components of the disposal system, to the disposal system as a whole and to safety assessment. (SSG-23, para 6.38)

[…]. The assessment of the robustness of a disposal system relies on several elements:

- *Demonstration of the robustness of individual barriers and their safety functions;*
- *Evaluation of the concept of defence in depth, i.e. the presence of multiple diverse safety functions, to ensure that the overall performance of the disposal system does not rely on a single safety function, the failure or unexpected poor performance of which would lead to unacceptable radiological consequences (see paras 6.29–6.37);*
- *Verification that good engineering practices (demonstrability and feasibility) have been applied;*
- *Demonstration that safety is achieved through passive means.*

(SSG-23, para 6.40)

DI-28:

The licensee shall ensure that any provisions to facilitate reversal of disposal operations, or retrieval of waste packages disposed of, have no unacceptable effects on post-closure safety.

*Related **IAEA** safety standards:*

[…] No relaxation of safety standards or requirements could be allowed on the grounds that waste retrieval may be possible or may be facilitated by a particular provision. It would have to be ensured that any such provision would not have an unacceptable adverse effect on safety or on the performance of the disposal system. (SSR-5, para 1.25)

DI-29:

The licensee shall define and implement an appropriate program (e.g. through R&D, investigations, modelling, testing and monitoring activities) with the purpose of providing an understanding of the evolution of the disposal system adequate for the safety case.

*Related **IAEA** safety standards:*

Throughout the process of development and operation of a disposal facility for radioactive waste, an understanding of the relevance and the implications for safety of the available options for the facility shall be developed by the operator. […] (SSR-5, Requirement 4)

A program of monitoring shall be carried out prior to, and during, the construction and operation of a disposal facility and after its closure, if this is part of the safety case. This program shall be designed to collect and update information necessary for the purposes of protection and safety. […] Monitoring shall also be carried out to confirm the absence of any conditions that could affect the safety of the facility after closure. (SSR-5, Requirement 21)

The operator has to conduct or commission the research and development work necessary to ensure that the planned technical operations can be practically and safely accomplished, and to demonstrate this. The operator likewise has to conduct or commission the research work necessary to investigate, to understand and to support the understanding of the processes on which the safety of the disposal facility depends. The operator also has to carry out all the necessary investigations of sites and of materials and has to assess their suitability and obtain all the data necessary for the purposes of safety assessment. (SSR-5, para 3.13)

DI-30:

If construction, operation, decommissioning or closure activities take place concurrently, the licensee shall perform the works so that they will not have an unacceptable effect on operational or post-closure safety.

*Related **IAEA** safety standards:*

Excavation and construction of a disposal facility could continue after the commencement of operation of part of the facility and after the emplacement of waste packages. Such overlapping of construction and operational activities has to be planned and carried out so as to ensure safety, both in operation and after closure. (SSR-5, para 4.34)

DI-31:

The licensee shall ensure that any measures necessary for the purpose of accounting for and control of nuclear material shall not unacceptably affect operational and post-closure safety.

*Related **IAEA** safety standards:*

In the design and operation of disposal facilities subject to agreements on accounting for, and control of, nuclear material, consideration shall be given to ensuring that safety is not compromised by the measures required under the system of accounting for, and control of, nuclear material. (SSR-5, Requirement 23)

2.2.2 Safety issue: Site characterization

DI-32:

The licensee shall prepare and implement a program for site characterization of the selected site. The program shall provide the information necessary to support the safety case.

*Related **IAEA** safety standards:*

An understanding of the site for a disposal facility has to be gained in order to present a convincing scientific description of the disposal system on which the more conceptual descriptions that are used in the safety assessment can be based [...]. (SSR-5, para 4.26)

A detailed program of site characterization should be carried out to provide the site specific data necessary to support the technical basis for safety assessments of the long term isolation and containment of the waste within the excavated portion of the geological disposal facility. […] (SSG-14, para 6.9)

DI-33:

The licensee shall conduct site characterisation of the selected site:

- To establish baseline conditions for the site and the environment;
- To support the understanding of the normal evolution;
- To identify any events and processes associated with the site that might disturb the normal evolution of the disposal system;
- To support the understanding of the effect on safety of any features, events and processes associated with the disposal system.

*Related **IAEA** safety standards:*

The site for a disposal facility shall be characterized at a level of detail sufficient to support a general understanding of both the characteristics of the site and how the site will evolve over time .This shall include its present condition, its probable natural evolution and possible natural events, and also human plans and actions in the vicinity that may affect the safety of the facility over the period of interest. It shall also include a specific understanding of the impact on safety of features, events and processes associated with the site and the facility. (SSR-5, Requirement 15)

2.2.3 Safety issue: Design

DI-34:

The licensee shall design the disposal facility to establish a disposal system which provides operational and post-closure safety. The licensee shall take into account the characteristics of the wastes to be disposed of (e.g.: radioactivity, heat and gas generation), the feasibility of the technical options and the characteristics of the selected site.

*Related **IAEA** safety standards:*

The disposal facility and its engineered barriers shall be designed to contain the waste with its associated hazard, to be physically and chemically compatible with the host geological formation and/or surface environment, and to provide safety features after closure that complement those features afforded by the host environment. The facility and its engineered barriers shall be designed to provide safety during the operational period. (SSR-5, Requirement 16)

DI-35:

The licensee shall establish a design basis for the facility taking into account normal operational conditions, anticipated operational occurrences and possible accidents derived from a relevant set of postulated initiating events (PIEs).

*Related **IAEA** safety standards:*

[…] the operating organization shall establish explicit criteria for the level of safety to be achieved. The operating organization shall set limits on the radiological consequences and associated chemical consequences for the workforce and the public of direct exposures to radiation or authorized discharges of radionuclides to the environment. These limits shall apply to the consequences of operational states and the possible consequences of accident conditions at the facility and shall be set equal to, or below, international and national standards to ensure compliance across the full range of operating conditions and throughput. […] (NS-R-5 (Rev.1), para 6.4)

Design criteria for all relevant parameters shall be specified for each operational state of the facility and for each design basis accident or equivalent. Design criteria for SSCs important to safety may be in the form of engineering design rules. […] Design rules shall provide for safety margins over and above those foreseen for operations to provide reasonable assurance that no significant consequences would occur even if the operational limits were exceeded within the safety margin.(NS-R-5 (Rev.1), para 6.11)

DI-36:

The licensee shall design the disposal facility giving due consideration to both normal evolution of the disposal system after closure and scenarios involving events and processes that might disturb the normal evolution of the disposal system.

*Related **IAEA** safety standards:*

The post-closure safety case should specify a range of credible scenarios for the evolution of the disposal facility and its surroundings over the time period for which the waste represents a potentially significant hazard or as specified in national regulations, some of which prescribe the timescale for the assessment. Consideration should be given to expected scenarios (normal evolution scenarios) and to less likely scenarios.(SSG-29, para 5.18)

DI-37:

The licensee shall design the disposal facility giving due consideration to disturbances of the disposal system during operation whose consequences may affect post-closure safety.

*Related **IAEA** safety standards:*

With regard to safety after closure, the expected range of possible developments affecting the disposal system and events that might affect its performance, including those of low probability, have to be considered in the safety case and supporting assessment by the following means:

(a) By presenting evidence that the disposal system, its possible evolutions and events that might affect it are sufficiently well understood;
(b) By demonstrating the feasibility of implementing the design;
(c) By providing convincing estimates of the performance of the disposal system and a reasonable level of assurance that all the relevant safety requirements will be complied with and that radiation protection has been optimized;
(d) By identifying and presenting an analysis of the associated uncertainties.

(SSR-5, para 4.17)

[…] consideration has to be given to both occupational exposure and public exposure resulting from conditions of normal operation and anticipated operational occurrences over the operating lifetime of the disposal facility. Similarly, consideration also has to be given to accidents with the potential for significant radiological consequences with regard to both the likelihood of occurrence and the magnitude of possible radiation doses. […] (SSG-29, para 5.17)

DI-38:

The licensee shall design the disposal facility to fulfil the following safety functions during the operational and post-closure phases:

- Control of the exposure of people and the environment;
- Containment and isolation of radioactive material;
- Control of sub-criticality, if applicable; If burnup credit is adopted for criticality management, the licensee shall confirm compliance with the limiting minimum burnup level with respect to initial enrichment by administrative and operational controls;
- Heat or gas removal, if applicable.

*Related **IAEA** safety standards:*

The engineered barriers, including the waste form and packaging, shall be designed, and the host environment shall be selected, so as to provide containment of the radionuclides associated with the waste. Containment shall be provided until radioactive decay has significantly reduced the hazard posed by the waste. In addition, in the case of heat generating waste, containment shall be provided while the waste is still producing heat energy in amounts that could adversely affect the performance of the disposal system. (SSR-5, Requirement 8)

Fissile material, when present, has to be managed and has to be emplaced in the disposal facility in a configuration that will remain subcritical. This may be achieved by various means, including the appropriate distribution of fissile material during the conditioning of the waste and the proper design of the waste packages [...]. (SSR-5, para 4.37)

DI-39:

The licensee shall identify and classify engineered structures, systems and components (SSCs) in accordance with their importance for operational and post-closure safety.

*Related **IAEA** safety standards:*

The safety functions and the structures, systems and components (SSCs) important to safety shall be identified in the safety analysis report to the extent appropriate and in accordance with a graded approach. The SSCs important to safety provide means for the prevention of the occurrence of postulated initiating events, the control and limitation of accident sequences and mitigation of the consequences [...]. (NS-R-5 (Rev. 1), para 2.12)

DI-40:

The licensee shall base the design of the facility on applicable standards, appropriately proven techniques and the use of appropriate materials to ensure that the safety requirements will be met, throughout operation and post-closure.

*Related **IAEA** safety standards:*

Design criteria for all relevant parameters shall be specified for each operational state of the facility and for each design basis accident or equivalent. Design criteria for SSCs important to safety may be in the form of engineering design rules. Engineering design rules include requirements in relevant codes and standards, and may be set and required explicitly by the regulatory body by requiring the use of applicable standard engineering practices already established in the State or used internationally. […] (NS-R-5 (Rev. 1), para 6.11)

For SSCs important to safety for which no appropriate established codes or standards exist, an approach derived from existing codes or standards for similar equipment may be applied. In the absence of such codes or standards, lessons learned from experience, tests including tests at pilot plants, analyses and expert committee recommendations or a combination thereof may be applied. Such application shall be justified. (NS-R-5 (Rev. 1), para 6.14)

DI-41:

The licensee shall have a process for identifying any conflicting design requirements from different regulatory regimes, and seeking to resolve them.

*Related **IAEA** safety standards:*

[…] In particular, if different codes and standards are used for different aspects of the same item or system, consistency between them shall be demonstrated [...] (NS-R-5 (Rev. 1), para 6.12)

DI-42:

The licensee shall design the disposal facility so that the engineered components (including barriers) are, to an adequate extent, physically and chemically compatible with each other, with the waste disposed of and with the host environment.

*Related **IAEA** safety standards:*

The disposal facility and its engineered barriers shall be designed to contain the waste with its associated hazard, to be physically and chemically compatible with the host geological formation and/or surface environment, and to provide safety features after closure that complement those

features afforded by the host environment. The facility and its engineered barriers shall be designed to provide safety during the operational period. (SSR-5, Requirement 16)

DI-43:

The licensee shall make design provisions for maintenance, testing, inspection and monitoring of structures, systems and components (SSCs), addressing also their ageing.

*Related **IAEA** safety standards:*

SSCs important to safety shall be designed to facilitate maintenance, inspection and testing for their functional capability over the lifetime of the facility. (NS-R-5 (Rev. 1), para 6.18)

DI-44:

The licensee shall establish design provisions for monitoring the host environment.

*Related **IAEA** safety standards:*

A program of monitoring shall be carried out prior to, and during, the construction and operation of a disposal facility and after its closure, if this is part of the safety case. This program shall be designed to collect and update information necessary for the purposes of protection and safety. Information shall be obtained to confirm the conditions necessary for the safety of workers and members of the public and protection of the environment during the period of operation of the facility. Monitoring shall also be carried out to confirm the absence of any conditions that could affect the safety of the facility after closure. (SSR-5, Requirement 21)

DI-45:

The licensee shall incorporate passive safety features for operational safety into the design of the disposal facility as far as reasonably practicable.

*Related **IAEA** safety standards:*

The operator shall evaluate the site and shall design, construct, operate and close the disposal facility in such a way that safety is ensured by passive means to the fullest extent possible and the need for actions to be taken after closure of the facility is minimized. (SSR-5, Requirement 5)

DI-46:

The licensee shall design the equipment of the disposal facility to take account of radiation protection aspects, ease of maintenance and inspection, and minimization of the probability and consequences of anticipated operational occurrences and, as far as practicable, possible accidents during handling.

*Related **IAEA** safety standards:*

SSCs important to safety shall be designed to facilitate maintenance, inspection and testing for their functional capability over the lifetime of the facility. (NS-R-5 (Rev. 1), para 6.18)

The design and layout of SSCs important to safety shall include provision to minimize exposures arising from maintenance, inspection and testing activities. The term 'maintenance' includes both preventive and corrective actions. (NS-R-5 (Rev. 1), para 6.19)

2.2.4 Safety issue: Information gathering and monitoring

DI-47:

Before starting construction, the licensee shall establish a baseline state of the environment both for supporting the monitoring program and for evaluating the impact of the facility on the environment.

*Related **IAEA** safety standards:*

The site evaluation, with due consideration of the potential hazards posed by the facility, shall constitute the first part of the development of the licensing documentation for a new facility. For the site evaluation, the following requirements apply:

(a) Appropriate radiological monitoring of the site shall be conducted prior to carrying out any site activities in order to establish baseline levels of radiological parameters for assessing the future impact of the facility at the site. Natural and artificial radioactivity at the site in the air, the water and the ground and in flora and fauna shall be investigated and recorded.

[…]

(NS-R-5 (Rev. 1), para 5.5)

Baseline monitoring is concerned with measurement of the initial values of parameters that will continue to be monitored by either continuous or periodic observations. The scope of baseline monitoring includes the determination of conditions and parameters of potential interest for the understanding of basic earth science, engineering and the environment, and for informing the operational safety assessment and the post-closure safety assessment for the disposal facility. For example, baseline monitoring is used to evaluate changes that occur in the rock and the groundwater system during the construction and operational periods and, at the post-closure stage, to evaluate any significant impacts that the presence of the disposal facility may have on natural processes and the environment. In practice, the monitoring program will begin during the site investigation stage. […] (SSG-31, para 6.5)

DI-48:

Before starting construction, the licensee shall define and document a systematic monitoring program to be implemented during construction, commissioning, operation, decommissioning and closure, and as appropriate after closure.

*Related **IAEA** safety standards:*

A program of monitoring shall be carried out prior to, and during, the construction and operation of a disposal facility and after its closure, if this is part of the safety case. This program shall be designed to collect and update information necessary for the purposes of protection and safety. Information shall be obtained to confirm the conditions necessary for the safety of workers and members of the public and protection of the environment during the period of operation of the facility. Monitoring shall also be carried out to confirm the absence of any conditions that could affect the safety of the facility after closure. (SSR-5, Requirement 21)

[…] Plans for monitoring with the aim of providing assurance of safety after closure have to be drawn up before the construction of a geological disposal facility to indicate possible monitoring strategies. […] (SSR-5, para 5.5)

DI-49:

The licensee shall ensure that the monitoring program contributes to:

- Demonstrating adequate protection of people and the environment and demonstrating compliance with the regulatory requirements and licence conditions;
- Confirming that the disposal facility and system behaves and evolves as expected in the safety case;
- Building confidence in and refining the key assumptions and models made in the safety case;
- Enhancing understanding of the environmental conditions and of the functioning of the disposal system;
- Acquiring information for supporting decision-making and;
- Providing background information for any post-closure surveillance program.

*Related **IAEA** safety standards:*

Monitoring has to be carried out at each step in the development and in the operation of a disposal facility. The purposes of the monitoring program include:

(a) Obtaining information for subsequent assessments;
(b) Assurance of operational safety
(c) Assurance that conditions at the facility for operation are consistent with the safety assessment;
(d) Confirmation that conditions are consistent with safety after closure.

(SSR-5, para 5.4)

2.2.5 Safety issue: Construction

DI-50:

The licensee shall construct the disposal facility in accordance with the design as described in the safety case and by application of appropriately proven techniques.

*Related **IAEA** safety standards:*

The disposal facility shall be constructed in accordance with the design as described in the approved safety case and supporting safety assessment. […] (SSR-5, Requirement 17)

DI-51:

The licensee shall construct the disposal facility in such a way as to preserve the post-closure safety functions of the host environment.

*Related **IAEA** safety standards:*

[…] It shall be constructed in such a way as to preserve the safety functions of the host environment that have been shown by the safety case to be important for safety after closure. Construction activities shall be carried out in such a way as to ensure safety during the operational period. (SSR-5, Requirement 17)

DI-52:

In order to refine the assumptions of the safety case, the licensee shall gather information during construction to improve the knowledge of:

- The intrinsic properties of the host environment
- The response of the host environment to the presence of the disposal facility.

*Related **IAEA** safety standards:*

A program of monitoring shall be carried out prior to, and during, the construction and operation of a disposal facility and after its closure, if this is part of the safety case. This program shall be designed to collect and update information necessary for the purposes of protection and safety. Information shall be obtained to confirm the conditions necessary for the safety of workers and members of the public and protection of the environment during the period of operation of the facility. Monitoring shall also be carried out to confirm the absence of any conditions that could affect the safety of the facility after closure. (SSR-5, Requirement 21)

DI-53:

The licensee shall plan, assess, document and implement any modifications of design, construction procedures and methods using arrangements consistent with the importance to safety of the modification. These arrangements shall ensure that the modifications will not have an unacceptable effect on operational and post-closure safety.

*Related **IAEA** safety standards:*

The operating organization shall establish a process whereby its proposals for changes to the design, equipment, feed material characteristics, control or management are subject to a degree of assessment and scrutiny appropriate to the safety significance of the change, so that the direct and wider consequences of the modification are adequately assessed […] .NS-R-5 (Rev. 1), para 9.35)

2.2.6 Safety issue: Operation

DI-54:

The licensee shall operate the facility in accordance with the conditions of the licence and the relevant regulatory requirements so as to maintain safety during the operational phase, and so as to establish and preserve the post-closure safety functions claimed in the safety case.

*Related **IAEA** safety standards:*

The disposal facility shall be operated in accordance with the conditions of the licence and the relevant regulatory requirements so as to maintain safety during the operational period and in such a manner as to preserve the safety functions assumed in the safety case that are important to safety after closure. (SSR-5, Requirement 18)

DI-55:

The licensee shall make and implement arrangements to detect and respond to anticipated operational occurrences and possible accidents. Provisions for doing so shall not unacceptably affect operational or post-closure safety.

*Related **IAEA** safety standards:*

Despite all the precautions that are taken in the design and operation of nuclear facilities and the conduct of nuclear activities, there remains a possibility that a failure or an accident may give rise to an emergency. In some cases, this may give rise to the release of radioactive materials within facilities and/or into the public domain, which may necessitate emergency response actions. […]. (GS-R-1, para 6.2)

Specific design features for emergency planning purposes shall be considered, in accordance with the potential hazards presented by the facility. Such features may include simple escape routes with reliable emergency lighting, reliable means of communication and dedicated instrumentation for monitoring radiation levels and hazardous chemicals. Depending on the potential hazards posed by the facility, consideration shall also be given to providing an on-site emergency control centre in a location separate from the operations area to maintain the chain of command and communication. (NS-R-5 (Rev. 1, para 6.30)

DI-56:

In order to refine the assumptions of the safety case, the licensee shall continue to gather information during operation to improve the knowledge of:

- The intrinsic properties of the host environment
- The response of the host environment to the presence of the disposal facility.

*Related **IAEA** safety standards:*

A program of monitoring shall be carried out prior to, and during, the construction and operation of a disposal facility and after its closure, if this is part of the safety case. This program shall be designed to collect and update information necessary for the purposes of protection and safety. Information shall be obtained to confirm the conditions necessary for the safety of workers and members of the public and protection of the environment during the period of operation of the facility. Monitoring shall also be carried out to confirm the absence of any conditions that could affect the safety of the facility after closure. (SSR-5, Requirement 21)

DI-57:

The licensee shall establish, substantiate, document and implement operational limits and conditions (OLCs) to operate the disposal facility safely, to maintain the waste in a safe state during operation and to ensure compliance with the requirements for post-closure safety.

*Related **IAEA** safety standards:*

The operational limits and conditions are the set of rules that establish parameter limits, the functional capability and the performance levels of equipment and personnel for the safe operation of a facility.(NS-R-5 (Rev. 1), para 2.13)

Operational limits and conditions shall be prepared before operation of the facility commences. (NS-R-5 (Rev. 1), para 9.21)

Operating instructions shall be developed by the operating organization, in cooperation with the designer and manufacturer if necessary. Safety related operating instructions shall be prepared before operations commence. Operating instructions shall clearly describe the methods of operating, including all checks, (NS-R-5 (Rev. 1), para 9.22)

DI-58:

The licensee shall make adequate arrangements for commissioning and operation of the disposal facility including arrangements for receiving, handling and emplacement of waste before these activities are commenced.

*Related **IAEA** safety standards:*

Before the commencement of commissioning, an adequate commissioning program shall be prepared for the testing of a facility to demonstrate that it meets the design objectives and the performance criteria. The commissioning program, agreed as required with the regulatory body, shall cover the organization for and responsibilities for commissioning, the stages of commissioning, the suitable testing of SSCs on the basis of their importance to safety, the test schedule, the commissioning procedures and reports, the methods of reviewing and verification, the treatment of deviations and deficiencies, and the requirements for documentation. (NS-R-5 (Rev. 1), para 8.1)

DI-59:

Before starting the emplacement of any waste, the licensee shall review the plan for decommissioning, closure and post-closure activities.

*Related **IAEA** safety standards:*

The revisions of the safety case that are developed in parallel with the development, operation and closure of the disposal facility should include plans for waste management, facility development, facility closure and institutional control. For example, the closure plans should describe and demonstrate the feasibility of both the closure operations and the time schedule for them. The closure plans should be updated and refined as information is obtained during site characterization, design optimization, construction and operation of the disposal facility. An authorization to commence waste emplacement should include consideration of preliminary closure plans, although these plans may change as operations proceed. (SSG-29, para 5.26)

DI-60:

The licensee shall ensure that any modifications to the disposal facility will not have an unacceptable effect on operational and post-closure safety.

*Related **IAEA** safety standards:*

The safety of existing disposal facilities shall be assessed periodically until termination of the licence. During this period, the safety shall also be assessed when a safety significant modification is planned or in the event of changes with regard to the conditions of the authorization. […] (SSR-5, Requirement 26)

To maintain the assurance of robust safety assessment and safety case, the facility design process should be conducted within a management system providing for configuration change control. Design attributes of the engineered barriers for operational safety and post-closure safety should be classified to ensure application of design requirements is graded in accordance with the safety significance of the barrier. (SSG-14, 6.34)

DI-61:

The licensee shall plan, assess, document and implement any modifications of design, waste acceptance criteria, structures, systems and components (SSCs), operational limits and conditions (OLCs) and operational procedures and methods using arrangements consistent with the importance to safety of the modifications.

*Related **IAEA** safety standards:*

The operating organization shall establish a process whereby its proposals for changes to the design, equipment, feed material characteristics, control or management are subject to a degree of assessment and scrutiny appropriate to the safety significance of the change, so that the direct and wider consequences of the modification are adequately assessed […]. The process shall include a review of possible consequences to ensure that a foreseen modification or change in one facility will not adversely affect the operability or safety of associated or adjacent facilities. (NG-R-5, para 9.35)

DI-62:

The licensee shall prepare and implement an on-site emergency plan to respond to possible accidents requiring protection of the personnel and members of the public. This emergency plan shall be proportionate to the consequences of the possible accidents considered and shall provide for:

- Regaining control of the disposal facility in an emergency;
- Preventing or mitigating the consequences of any such emergency;

If an off-site emergency plan is required, the licensee shall provide the technical basis for its development and implementation.

*Related **IAEA** safety standards:*

All operations and activities important to the safety of a disposal facility have to be subjected to limitations and controls and emergency plans have to be put in place. (SSR-5, para 4.35)

The operating organization shall prepare accident management procedures and on-site emergency procedures, taking into account the potential hazards of the facility, before the introduction of hazardous material. Where necessary, in accordance with the degree of the hazards, the operating organization shall prepare off-site procedures in coordination with the relevant off-site organizations and competent authorities. The off-site procedures shall be consistent with national and international practices. (NS-R-5 (Rev. 1), para 4.21)

DI-63:

For the purposes of emergency planning the licensee shall, as appropriate:

- Establish and implement the necessary organizational structure for clear allocation of responsibilities and authorities,
- Ensure that, based on the on-site emergency plan, appropriate trained and qualified personnel, facilities and equipment needed to control an emergency will be available whenever they might be required, and
- Establish arrangements as necessary for coordinating emergency activities and cooperating with external response organizations throughout all phases of an emergency.

*Related **IAEA** safety standards:*

The operating organization, taking into account the potential hazards of the facility, shall develop an emergency plan in coordination with other bodies having responsibilities in an emergency, including public authorities; shall establish the necessary organizational structure; and shall assign responsibilities for managing emergency response. (NS-R-5 (Rev. 1), para 9.62)

DI-64:

The licensee shall submit the on-site emergency plan to the regulatory body. At regular intervals, the licensee shall carry out emergency exercises, some of which shall be witnessed by the regulatory body. Some of these exercises shall, as appropriate, include the participation of external emergency response organizations. The plan shall be subject to review and updating in the light of the experience gained.

*Related **IAEA** safety standards:*

The emergency plan shall be approved by the regulatory body as appropriate and shall be tested in an exercise before radioactive material is introduced into the facility. There shall thereafter be exercises of the emergency plan at suitable intervals, some of which shall be observed by the regulatory body. Some of these exercises shall be integrated with local, regional and national response organizations, as appropriate, and shall involve the participation of as many as possible of the organizations concerned. The plans shall be subject to review and to updating in the light of the experience gained. (NS-R-5 (Rev. 1), para 9.66)

DI-65:

The licensee shall establish and implement programs for maintenance, periodic testing and inspection, based on written procedures in order to ensure and confirm that structures, systems and components (SSCs) are able to function in accordance with the requirements for operational and post-closure safety.

*Related **IAEA** safety standards:*

All maintenance, calibration, periodic testing and inspection shall be performed in accordance with a program based on approved, written procedures. […] Before operation of the facility commences, the operating organization shall prepare and obtain approval for the programs for maintenance, calibration, periodic testing and inspection of SSCs important to safety. […] (NS-R-5, para 9.29)

DI-66:

The licensee shall record and assess the results of maintenance, periodic testing and inspection, important to safety. Results derived from these programs shall be used to review the adequacy of the design, construction and operation of the disposal facility and to identify any implications for post-closure safety.

*Related **IAEA** safety standards:*

The results of maintenance, testing and inspection shall be recorded and assessed. (NS-R-5, para 9.32)

DI-67:

At regular intervals, the licensee shall review and as necessary revise programs for maintenance, periodic testing and inspection to incorporate the lessons learned from experience.

*Related **IAEA** safety standards:*

The maintenance, calibration, periodic testing and inspection programs shall be reviewed at regular intervals to incorporate the lessons learned from experience. (NS-R-5 (Rev. 1), para 9.33)

2.2.7 Safety issue: Closure of disposal facility

DI-68:

The licensee shall close the disposal facility in such a way as to provide for the safety functions required after closure.

*Related **IAEA** safety standards:*

A disposal facility shall be closed in a way that provides for those safety functions that have been shown by the safety case to be important after closure. […] (SSR-5, Requirement 19)

DI-69:

Before starting decommissioning and closure, the licensee shall define the corresponding program so that it takes into account, as appropriate:

- The state of the facility, as constructed and operated including information on waste inventory and emplacement;
- Dismantling and removal of operational equipment;
- Remaining backfilling and sealing;
- Decommissioning of auxiliary structures, e.g. parts of the facility on the surface;
- Environmental remediation as required;
- Programs for monitoring and surveillance,
- Programs for security and safeguards;
- Plans for preserving knowledge and records about the waste disposed of and the disposal system.

*Related **IAEA** safety standards:*

A disposal facility shall be closed in a way that provides for those safety functions that have been shown by the safety case to be important after closure. Plans for closure, including the transition from active management of the facility, shall be well defined and practicable, so that closure can be carried out safely at an appropriate time. (SSR-5, Requirement 19)

Closure of a geological disposal facility should also include decommissioning of surface facilities and undertaking any environmental restoration necessary, and may include the construction of durable markers. (SSG-14, para 6.59)

DI-70:

The licensee shall perform decommissioning and closure activities in accordance with the national legal and regulatory framework so as to maintain safety during decommissioning and closure, and so as to establish and preserve the post-closure safety functions claimed in the safety case.

*Related **IAEA** safety standards:*

A disposal facility shall be closed in a way that provides for those safety functions that have been shown by the safety case to be important after closure. Plans for closure, including the transition from active management of the facility, shall be well defined and practicable, so that closure can be carried out safely at an appropriate time. (SSR-5, Requirement 19)

DI-71:

The licensee shall plan, assess, document and implement any modifications in the decommissioning and closure procedures and methods using arrangements consistent with the importance to safety of the modifications.

*Related **IAEA** safety standards:*

[…] Plans for closure, including the transition from active management of the facility, shall be well defined and practicable, so that closure can be carried out safely at an appropriate time. (SSR-5, Requirement 19)

Modifications to the design and improvements in processes are inevitable parts of facility operation. A system for configuration control and management should be developed to document and to allow for approval of modifications and to track changes at the facility. […] (SSG-29, para 6.59)

The operating organization shall establish a process whereby its proposals for changes to the design, equipment, feed material characteristics, control or management are subject to a degree of assessment and scrutiny appropriate to the safety significance of the change, so that the direct and wider consequences of the modification are adequately assessed […]. (NS-R-5 (Rev.1), para 9.35)

2.2.8 Safety issue: Post-closure phase and release from regulatory control

DI-72:

After closure and until termination of the licence, the licensee shall implement a post-closure surveillance program, if appropriate. In the event that surveillance demonstrates the need for remedial actions, the licensee shall implement such actions in accordance with the licence.

*Related **IAEA** safety standards:*

The operator of a disposal facility for radioactive waste shall be responsible for its safety. The operator shall carry out safety assessment and develop and maintain a safety case, and shall carry out all the necessary activities for site selection and evaluation, design, construction, operation, closure and, if necessary, surveillance after closure, in accordance with national strategy, in compliance with the regulatory requirements and within the legal and regulatory infrastructure. (SSR-5, Requirement 3)

A program of monitoring shall be carried out prior to, and during, the construction and operation of a disposal facility and after its closure, if this is part of the safety case. […] Monitoring shall also be

carried out to confirm the absence of any conditions that could affect the safety of the facility after closure. (SSR-5, Requirement 21)

Closure of the disposal facility indicates the start of the period of institutional control. This period can be subdivided into active and passive phases, whose durations may be prescribed by regulation. Activities during the active phase of the period of institutional control will include preservation of knowledge, prevention of human intrusion, and monitoring and surveillance. If damage to, or deterioration of, the barriers is detected by means of monitoring or surveillance, remedial measures should be taken to restore any lost safety functionality to the parts of the disposal facility that remain accessible, at a minimum. (SSG-29, para 4.45)

DI-73:

As a condition for the termination of the licence, the licensee shall:

- Demonstrate that the results of any surveillance program are consistent with the assumptions of the safety case, to the satisfaction of the regulatory body;
- Propose any restrictions on land use, suggest and substantiate the way they shall be implemented, or any other measures deemed appropriate for the post-licensing phase.

*Related **IAEA** safety standards:*

After completion of the emplacement operations, but before the final closure of the disposal facility, monitoring and surveillance data should be collected to confirm the continuing performance of key safety functions as identified in the safety case, either through direct evidence (i.e. by means of a measurable parameter) or indirect evidence (i.e. by enhancing the scientific basis used to develop predictive models or through the collection of data from pilot/demonstration disposal facilities). The data obtained should be used to verify that the disposal system is functioning as expected. This means that the key components are fulfilling their functions, as identified in the safety case, or as stipulated by the regulatory body, and that actual conditions are consistent with the key assumptions made for safety after closure. For example, the data obtained may be used to help support a decision to terminate active institutional control, by verifying that the disposal system has remained in a passively safe condition for a specified period of time.(SSG-31, para 8.10)

Plans shall be prepared for the period after closure to address institutional control and the arrangements for maintaining the availability of information on the disposal facility. These plans shall be consistent with passive safety features and shall form part of the safety case on which authorization to close the facility is granted. (SSR-5, Requirement 22)

[...]. Plans for possible future controls and the period over which they would be applied may initially be flexible and conceptual in nature, but plans have to be developed and refined as the facility approaches closure. Consideration has to be given to: local land use controls; site restrictions or surveillance and monitoring; local, national and international records; and the use of durable surface and/or subsurface markers. [...] (SSR-5, para 5.13)

2.3
Safety area: Waste acceptance

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2.3.1 Safety issue: Derivation of waste acceptance criteria

DI-74:

The licensee shall contribute to the safe management of the waste by establishing preliminary waste acceptance criteria at the earliest opportunity. The licensee shall update such preliminary waste acceptance criteria to reflect the development of the disposal project.

*Related **IAEA** safety standards:*

Waste packages and unpackaged waste accepted for emplacement in a disposal facility shall conform to criteria that are fully consistent with, and are derived from, the safety case for the disposal facility in operation and after closure.(SSR-5, Requirement 20)

Waste acceptance criteria have to be developed that specify the radiological, mechanical, physical, chemical and biological characteristics of waste packages and unpackaged waste that are to be processed, stored or disposed of; for example, their radionuclide content or activity limits, their heat output and the properties of the waste form and packaging. (GSR Part 5, para 4.24)

The proposed waste acceptance criteria should be published at the earliest opportunity, to facilitate compatibility of the waste generated and its safe management at the waste generation sites prior to its emplacement in the disposal facility. (SSG-14, para 6.41)

DI-75:

Prior the start of waste emplacement, the licensee shall specify waste acceptance criteria so as to ensure the conformity of individual waste consignments to the safety case and other aspects of the disposal arrangements. The waste acceptance criteria shall be consistent with the operational and post-closure safety case and shall be reported to the regulatory body, for approval if appropriate.

*Related **IAEA** safety standards:*

Waste acceptance requirements and criteria for a given disposal facility have to ensure the safe handling of waste packages and unpackaged waste in conditions of normal operation and anticipated operational occurrences. They also have to ensure the fulfilment of the safety functions for the waste form and waste packaging with regard to safety in long term. […] (SSR-5, para 5.1)

Waste packages and unpackaged waste accepted for emplacement in a disposal facility shall conform to criteria that are fully consistent with, and are derived from, the safety case for the disposal facility in operation and after closure. (SSR-5, Requirement 20)

DI-76:

The licensee shall ensure that waste acceptance criteria specify limits on important parameters such as radionuclide inventories and activity concentrations in individual waste consignments.

Appendix 2 presents further details of the typical content for low and intermediate level waste.

*Related **IAEA** safety standards:*

The waste characteristics important to the safety of the operational and post-closure periods are part of the relevant safety case. Waste acceptance criteria may be developed by means of an iterative dialogue between regulatory body, the operator of the facility and the generator of the waste. The criteria should include the waste characteristics important to safety in the operational period and the period after closure and typically specify the following:

(a) The permissible range of chemical and physical properties of the waste and the waste form;
(b) The permissible dimensions, weight and other manufacturing specifications of each waste package;
(c) Allowable levels of radioactivity in each package;
(d) Allowable amounts of fissile material in each package;
(e) Allowable surface dose rate and surface contamination;
(f) Requirements for accompanying documentation;
(g) Allowable decay heat generation for each package.

(SSG-14, para 6.38)

DI-77:

The licensee shall specify criteria to ensure that waste accepted for disposal is physically and chemically stable over a timescale consistent with the safety case and compatible with other components of the disposal facility.

*Related **IAEA** safety standards:*

Modelling and/or testing of the behaviour of waste forms has to be undertaken to ensure the physical and chemical stability of the different waste packages and unpackaged waste under the conditions expected in the disposal facility, and to ensure their adequate performance in the event of anticipated operational occurrences or accidents. (SSR-5, para 5.2)

2.3.2 Safety issue: Revision of waste acceptance criteria

DI-78:

The licensee shall report changes to waste acceptance criteria to the regulatory body, for approval if appropriate. The licensee shall substantiate the consistency of any changes with the assumptions made in the safety case.

*Related **IAEA** safety standards:*

The waste characteristics important to the safety of the operational and post-closure periods are part of the relevant safety case. Waste acceptance criteria may be developed by means of an iterative dialogue between regulatory body, the operator of the facility and the generator of the waste. The criteria

should include the waste characteristics important to safety in the operational period and the period after closure […] (SSG-14, para 6.38)

2.3.3 Acceptance of waste

DI-79:

The licensee shall ensure that the waste accepted for disposal conforms to waste acceptance criteria. A conformity assessment shall be performed in accordance with written arrangements which include administrative procedures, inspections and/or tests.

*Related **IAEA** safety standards:*

Waste intended for disposal has to be characterized to provide sufficient information to ensure compliance with waste acceptance requirements and criteria. Arrangements have to be put in place to verify that the waste and waste packages received for disposal comply with these requirements and criteria and, if not, to confirm that corrective measures are taken by the generator of the waste or the operator of the disposal facility. The quality control of waste packages has to be undertaken and is achieved mainly on the basis of records, preconditioning testing (e.g. of containers), and control of the conditioning process. (SSR-5, para 5.3)

DI-80:

The licensee shall provide a system for tracing the location in the disposal facility of any waste disposed of.

*Related **IAEA** safety standards:*

The management system for a disposal facility has to provide for the preparation and retention of documentary evidence to illustrate that the necessary quality of data has been achieved; […] that the waste packages and unpackaged waste comply with established requirements and criteria; and that they have been properly emplaced in the disposal facility. […]. (SSR-5, para 5.26)

DI-81:

To provide an adequate level of assurance that waste characteristics conform to the waste acceptance criteria, the licensee shall satisfy itself that the management system of the organization submitting waste for disposal appropriately addresses waste quality issues.

*Related **IAEA** safety standards:*

The waste acceptance process established by the operator should take into account the steps of waste generation and waste processing. Depending on national responsibilities, the waste generator, the waste management organization or the operator of the disposal facility should establish and/or apply waste acceptance criteria and technical specifications and procedures for controlling waste generation, waste processing and waste characterization. This should ensure that there will be mechanisms (e.g. procedures and controls) in place during the process of waste generation and management that will ensure that the waste acceptance criteria for disposal can and will be met. As part of the waste acceptance process, the operator should carry out verifications and controls when waste is received for disposal. The major elements of the waste acceptance process should be presented to the regulatory body for approval, for example as part of the safety case for the application of a licence. (SSG-29, para 6.31)

DI-82:

The licensee shall establish procedures for dealing with waste that does not conform to waste acceptance criteria, and shall not accept such waste unless acceptability with regard to operational and post-closure safety has been demonstrated on a case by case basis.

*Related **IAEA** safety standards:*

Waste intended for disposal is characterized to provide sufficient information to ensure compliance with waste acceptance requirements and criteria. Arrangements will be put in place to verify that the waste and waste packages received for disposal comply with these requirements and criteria, and, if not, to confirm that corrective measures are taken by the generator of the waste or the operator of the disposal facility. Quality control of waste packages has to be undertaken and is achieved mainly on the basis of records, preconditioning testing (e.g. of containers) and control of the conditioning process. Post-conditioning testing and the need for corrective measures have to be limited as far as practicable. (SSR-5, para 5.3)

2.4
Safety area: Safety verification

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2.4.1 Safety issue: Scope and content of the safety case

DI-83:

The licensee shall provide to the regulatory body a safety case substantiating that operational and post-closure safety requirements as specified in the national legal and regulatory framework are met. The licensee shall update the safety case in accordance with regulatory requirements.

*Related **IAEA** safety standards:*

A safety case and supporting safety assessment shall be prepared and updated by the operator, as necessary, at each step in the development of a disposal facility, in operation and after closure. The safety case and supporting safety assessment shall be submitted to the regulatory body for approval. The safety case and supporting safety assessment shall be sufficiently detailed and comprehensive to provide the necessary technical input for informing the regulatory body and for informing the decisions necessary at each step. (SSR-5, Requirement 12)

The safety case for a disposal facility has to address safety both in operation and after closure. […] All aspects of operation relevant to safety are considered, including surface and underground excavation, construction and mining work, waste emplacement, and backfilling, sealing and closing operations. Consideration has to be given to both occupational exposure and public exposure resulting from conditions of normal operation and anticipated operational occurrences over the operating lifetime of the disposal facility. (SSR-5, para 4.15)

DI-84:

The licensee shall provide assurance through the safety case that workers, members of the public and the environment are and will remain adequately protected against the hazards associated with the waste being disposed of.

*Related **IAEA** safety standards:*

The safety case for a disposal facility shall describe all safety relevant aspects of the site, the design of the facility and the managerial control measures and regulatory controls. The safety case and supporting safety assessment shall demonstrate the level of protection of people and the environment provided and shall provide assurance to the regulatory body and other interested parties that safety requirements will be met. (SSR-5, Requirement 13)

DI-85:

The licensee shall include in the safety case, a safety assessment that demonstrates conformity with the safety requirements. The licensee shall also present an evaluation of the technical feasibility of the design and the construction, operation, decommissioning, closure and post-closure activities.

*Related **IAEA** safety standards:*

Safety assessment in support of the safety case has to be performed and updated throughout the development and operation of the disposal facility and as more refined site data become available. Safety assessment has to provide input to ongoing decision making by the operator. Such decision making may relate to subjects for research, development of a capability for assessment, allocation of resources and development of waste acceptance criteria. (SSR-5, para 4.13)

The primary purposes of the safety assessment shall be to determine whether an adequate level of safety has been achieved for a facility or activity and whether the basic safety objectives and safety criteria established by the designer, the operating organization and the regulatory body, in compliance with the requirements for protection and safety as established in the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources [4], have been fulfilled. (GSR part 4, Requirement 4)

DI-86:

The licensee shall include in the safety assessment for the operational and post-closure phases:

- An evaluation of the performance and robustness of the disposal facility and system and its components;
- An evaluation of the radiological impact.

*Related **IAEA** safety standards:*

Robustness of a component of the disposal system means that it will continue to fulfil its expected safety function(s) irrespective of disturbances that may reasonably be expected to occur (see paras 4.33 and 4.51). Sites can be selected, for example, by choosing those that are little affected by natural processes such as flooding and earthquakes. Similarly, the engineered barriers can be designed for robustness, for example, by expanding the dimensioning of certain components beyond the necessary values to ensure their resilience to disturbances and uncertainties. (SSG-23, para 6.39)

Robustness of the disposal system is evaluated through comparison of the results of analyses of the base case with those of a range of scenarios illustrating specific perturbations or uncertainties. Among the different types of perturbation, the most generally considered are those where one component or one of its characteristics is considered to have failed ('what if' scenarios). Scenarios involving such strong perturbations applied to the disposal system are distinguished from scenarios describing degraded behaviour of the disposal system. (SSG-23, para 6.41)

DI-87:

The licensee shall describe in the safety case all safety important aspects of the disposal facility and system including the waste to be disposed of, the design, the construction, operation, closure, decommissioning and post-closure activities. The typical content of a safety case is given in Appendix 3.

*Related **IAEA** safety standards:*

The safety case for a disposal facility shall describe all safety relevant aspects of the site, the design of the facility and the managerial control measures and regulatory controls. The safety case and supporting safety assessment shall demonstrate the level of protection of people and the environment provided and shall provide assurance to the regulatory body and other interested parties that safety requirements will be met. (SSR-5, Requirement 13)

The safety case for a disposal facility has to address safety both in operation and after closure. […. All aspects of operation relevant to safety are considered, including surface and underground excavation, construction and mining work, waste emplacement, and backfilling, sealing and closing operations. Consideration has to be given to both occupational exposure and public exposure resulting from conditions of normal operation and anticipated operational occurrences over the operating lifetime of the disposal facility. (SSR-5, para 4.15)

DI-88:

The licensee shall in the safety case take due consideration to future human actions including inadvertent human intrusion. Such consideration should focus on reducing the likelihood and potential consequences of inadvertent human intrusion. Any measures taken to prevent inadvertent human intrusion must not compromise the operational safety of the disposal facility and the post-closure safety of the disposal system.

*Related **IAEA** safety standards*

The disposal facility shall be sited, designed and operated to provide features that are aimed at isolation of the radioactive waste from people and from the accessible biosphere. … In so doing, consideration shall be given to both the natural evolution of the disposal system and events causing disturbance of the facility. (SSR-5, Requirement 9)

In some cases, it may not be possible to provide sufficient assurance of separation from the accessible biosphere, owing to phenomena such as uplift, erosion and glaciation. In such cases, and if the remaining activity in the waste is still significant at the time such phenomena occur, the possibility of human intrusion has to be evaluated in determining the degree of isolation provided. (SSR-5, para 3.46)

DI-89:

The licensee shall ensure that the safety case provides a clear understanding of the safety arguments, is suitably comprehensive and documented with a content and level of detail appropriate to the step reached in the disposal facility development.

*Related **IAEA** safety standards:*

Disposal facilities for radioactive waste shall be developed, operated and closed in a series of steps. Each of these steps shall be supported, as necessary, by iterative evaluations of the site, of the options for design, construction, operation and management, and of the performance and safety of the disposal system. (SSR-5, Requirement 11)

[…] The safety case and supporting safety assessment shall be sufficiently detailed and comprehensive to provide the necessary technical input for informing the regulatory body and for informing the decisions necessary at each step. (SSR-5, Requirement 12)

The safety case and supporting safety assessment for a disposal facility shall be documented to a level of detail and quality sufficient to inform and support the decision to be made at each step and to allow for independent review of the safety case and supporting safety assessment. (SSR-5, Requirement 14)

DI-90:

The licensee shall ensure that the safety case provides clarity, substantiation and traceability of the assumptions, choices and decisions made.

*Related **IAEA** safety standards:*

The necessary scope and structure of the documentation setting out the safety case and supporting safety assessment will depend on the step reached in the project for the disposal facility and on national requirements. This includes consideration of the needs of different interested parties for information. Important considerations in documenting the safety case and supporting safety assessment are justification, traceability and clarity. (SSR 5, para 4.23)

Justification concerns explaining the basis for the choices that have been made and the arguments for and against the decisions, especially those decisions concerning the main arguments for safety. Traceability concerns the ability of an independent qualified person to follow what has been done. The traceability has to enable technical and regulatory review. Justification and traceability both require a well-documented record of the decisions made and the assumptions made in the development and operation of a disposal facility, and of the models and data used in deriving a particular set of results for safety assessment purposes. (SSR-5, para 4.24)

Clarity concerns good structure and presentation at an appropriate level of detail so as to allow an understanding of the safety arguments. This requires the results of work to be presented in the documents in such a way that interested parties for whom the material is intended can gain a good understanding of the safety arguments and their basis. Different types and styles of document may be necessary to provide material that is useful to different parties. (SSR-5, para 4.25)

DI-91:

The licensee shall ensure that the safety case adequately reflects the factors (e.g. features, events and processes) that influence safety and their significance.

*Related **IAEA** safety standards:*

The operator of a disposal facility shall develop an adequate understanding of the features of the facility and its host environment and of the factors that influence its safety after closure over suitably long time periods, so that a sufficient level of confidence in safety can be achieved. (SSR-5, Requirement 6)

DI-92:

The licensee shall identify all uncertainties significant to safety and shall demonstrate that these uncertainties are adequately taken into account in the safety case. As part of the safety case, the licensee shall describe a program for uncertainty management.

*Related **IAEA** safety standards:*

At any step in the development of a disposal facility, the safety case also has to identify and acknowledge the unresolved uncertainties that exist at that stage and their safety significance, and approaches for their management. (SSR-5, para 4.7)

The safety case for a radioactive waste disposal facility is required to be developed and progressively updated throughout the lifetime of the disposal facility [2]. Confidence in the safety case at any stage will be enhanced if each revision of the safety case includes a plan for further work as necessary to address significant unresolved issues, in particular to reduce significant remaining uncertainties or to reduce their relevance or avoid them entirely by, for example, changes in the design of system components. (SSG-23, para 4.87)

DI-93:

The licensee shall ensure that the safety case shows that the principle of optimization has been addressed in relevant choices and decisions on the disposal system.

*Related **IAEA** safety standards:*

Protection must be optimized to provide the highest level of safety that can reasonably be achieved (SF1, Principle 5).

Throughout the process of development and operation of a disposal facility for radioactive waste, an understanding of the relevance and the implications for safety of the available options for the facility shall be developed by the operator. This is for the purpose of providing an optimized level of safety in the operational stage and after closure. (SSR-5, Requirement 4)

Safety assessment also has to identify key processes relevant to safety and to contribute to the development of an understanding of the performance of disposal facilities. It has to support judgements with regard to alternative management options as an element of optimizing protection and safety. Such an understanding has to provide the basis for the safety arguments presented in the safety case [...]. (SSR-5, para 4.23)

DI-94:

The licensee shall present as part of the safety case the program, plans and provisions for closure of the disposal facility and for any post-closure activities. The program, plans and provisions shall be revised and updated as appropriate.

*Related **IAEA** safety standards:*

[…] Closure has to be considered in the initial design of the facility, and plans for closure and seal or cap designs have to be updated as the design of the facility is developed. Before construction activities commence, there has to be sufficient evidence that the performance of the backfilling, sealing and capping will function as intended to meet the design requirements. (SSR-5, para 4.38)

Disposal facilities may not be closed for several tens of years or more after operations have commenced. Plans for possible future controls and the period over which they would be applied may initially be flexible and conceptual in nature, but plans have to be developed and refined as the facility approaches closure. […] Arrangements have to be made to be able to pass on information about the disposal facility and its contents to future generations to enable any future decisions on the disposal facility and its safety to be made. (SSR-5, para 5.13)

DI-95:

The licensee shall describe in the safety case the management system, including the principles on which it is based, and how it will evolve during future phases of development, operation and closure of the disposal facility.

*Related **IAEA** safety standards:*

The safety case for a disposal facility shall describe all safety relevant aspects of the site, the design of the facility and the managerial control measures and regulatory controls. [...]. (SSR-5, Requirement 13)

The requirements on the management system influence the development of the safety case in two ways. First, the description of the management system applying to the various stages of facility development should represent an important element of the safety case, contributing to the confidence that the relevant requirements and criteria for site selection, design, construction, operation, closure and post-closure safety are met. Second, programs should be set up to ensure the quality of all activities associated with the safety case and safety assessment, such as data collection and modelling. […] (SSG-23, para 4.61)

DI-96:

The licensee shall include in the safety case, subject to a graded approach, a synthesis of multiple lines of reasoning regarding post-closure safety and an evaluation of the level of confidence reached.

*Related **IAEA** safety standards:*

Confidence in the safety case may also be enhanced by the use of multiple lines of reasoning. The use of multiple lines of reasoning may add value to the safety case by providing a range of different arguments that together build confidence in certain data, assumptions and results. Furthermore, certain arguments may be more meaningful to specific audiences.(SSG-23, para 4.85)

Alternative lines of reasoning to complement the results of safety assessment are, for example, natural and anthropogenic analogues; […]. In addition, confidence in the results of modelling in the safety assessment may be enhanced by the presentation of simplified calculations ('scoping calculations') of radionuclide migration or radiological impact. (SSG-23, para 4.86)

DI-97:

The licensee shall update the safety case to reflect current knowledge and submit it to the regulatory body

- in support of applications for major regulatory decisions
- as a result of major changes relevant to safety (e.g. in basic assumptions)
- at least at regular (periodic) intervals as defined in the national legal and regulatory framework

*Related **IAEA** safety standards:*

A safety case and supporting safety assessment shall be prepared and updated by the operator, as necessary, at each step in the development of a disposal facility, in operation and after closure. The safety case and supporting safety assessment shall be submitted to the regulatory body for approval. […]. (SSR-5, Requirement 12)

[…], the development of the safety case should be an iterative process that evolves with the development of the disposal facility. […], the formality and level of technical detail of the safety case will depend on the stage of development of the project, the decision in hand and specific national requirements. The step by step approach adopted for development of disposal facilities provides a basis for decision making relating to the siting, design, excavation and construction, operation and closure of facilities, and should allow the identification of issues that require further attention in order to improve the understanding of aspects influencing the safety of the disposal system and/or to reduce remaining uncertainties by appropriate design choices. (SSG-23, para 4.10)

DI-98:

The licensee shall update the safety case to reflect as a minimum:

- Changes to regulatory requirements and standards;
- Results from surveillance programs;
- Changes to the radioactive waste inventory to be disposed of;
- Results from analysis of operational occurrences and accidents;
- Results of the periodic safety reviews;

as soon as reasonably practicable and in accordance with the safety importance of the improved knowledge.

*Related **IAEA** safety standards:*

A facility specific safety case has to be prepared early in the development of a disposal facility to provide a basis for licensing decisions and to guide activities in research and development, site selection and evaluation and design. The safety case has to be developed progressively and elaborated as the project proceeds. It has to be presented to the regulatory body at each step in the development of the disposal facility. The regulatory body might require an update of, or revision to, the safety case before given steps can be taken, or such an update or revision may be necessary to gain political or public support for taking the next step in the development of the disposal facility or for its operation or closure. The formality and level of technical detail of the safety case will depend on the stage of development of the project, the decision in hand, the audience to which it is addressed and specific national requirements. (SSR-5, para 4.12)

[…] For facilities and activities that continue over long periods of time, the safety assessment needs to be updated as necessary through the stages of the lifetime of the facility or activity, so as to take into account possible changes in circumstances (such as the application of new standards or new scientific and technological developments), changes in site characteristics, and modifications to the design or operation, and also the effects of ageing. (GSR Part 4, para 4.6)

DI-99:

The licensee shall use the safety case as the basis for assessing the safety implications of changes to the disposal facility and system.

*Related **IAEA** safety standards:*

A safety assessment has to be carried out at the design stage for a new facility or activity, or as early as possible in the lifetime of an existing facility or activity. For facilities and activities that continue over long periods of time, the safety assessment needs to be updated as necessary through the stages of the lifetime of the facility or activity, so as to take into account possible changes in circumstances (such as the application of new standards or new scientific and technological developments), changes in site characteristics, and modifications to the design or operation, and also the effects of ageing. (GSR Part 4, para 4.6)

The impact of any modifications to the design that have been implemented during the excavation and/or construction period should be considered in the safety case and associated safety assessment. […]. (SSG-23, para 6.17)

2.4.2 Safety issue: Operational and post-closure safety assessment

DI-100:

The licensee shall consider in the operational safety assessment, both occupational exposure and public exposure resulting from normal operation, and anticipated operational occurrences and possible accidents.

*Related **IAEA** safety standards:*

The safety case for a disposal facility has to address safety both in operation and after closure.[…] All aspects of operation relevant to safety are considered, including surface and underground excavation, construction and mining work, waste emplacement, and backfilling, sealing and closing operations. Consideration has to be given to both occupational exposure and public exposure resulting from conditions of normal operation and anticipated operational occurrences over the operating lifetime of the disposal facility. (SSR-5, para 4.15)

The safety assessment has to address all radiation risks that arise from normal operation (that is, when the facility is operating normally or the activity is being carried out normally) and from anticipated operational occurrences and accident conditions (in which failures or internal or external events have occurred that challenge the safety of the facility or activity). The safety assessment for anticipated operational occurrences and accident conditions also has to address failures that might occur and the consequences of any failures. (GSR Part 4, 4.5)

DI-101:

The licensee shall include in the post-closure safety assessment a scenario analysis that considers the possible features, events and processes that might affect the performance of the disposal system, including events of low probability.

*Related **IAEA** safety standards:*

With regard to safety after closure, the expected range of possible developments affecting the disposal system and events that might affect its performance, including those of low probability, have to be considered in the safety case and supporting assessment by the following means:

(a) By presenting evidence that the disposal system, its possible evolutions and events that might affect it are sufficiently well understood;
(b) By demonstrating the feasibility of implementing the design;
(c) By providing convincing estimates of the performance of the disposal system and a reasonable level of assurance that all the relevant safety requirements will be complied with and that radiation protection has been optimized;
(d) By identifying and presenting an analysis of the associated uncertainties.

(SSR-5, para 4.17)

DI-102:

The licensee shall determine in the assessment whether adequate defence in depth has been provided, as appropriate, through a combination of several layers of protection (e.g. safety function provided by physical barriers, systems to protect the barriers, and administrative procedures) that would have to fail or to be bypassed before there could be any consequences for people or the environment.

*Related **IAEA** safety standards:*

It has to be determined in the safety assessment whether adequate defence in depth has been provided, as appropriate, through a combination of several layers of protection (i.e. physical barriers, systems to protect the barriers, and administrative procedures) that would have to fail or to be bypassed before there could be any consequences for people or the environment. (GSR Part 4, para 4.12)

Assessing the defence in depth is becoming normal practice in preparing the safety case for waste disposal facilities. It involves identifying the various requirements and safety functions of the disposal system, designing the disposal facility and, in particular, the engineered barriers, to fulfil these safety functions, and assessing the performance of the disposal system and the barriers in terms of their ability to fulfil the safety functions. (SSG-23, para 6.31)

DI-103:

The licensee shall substantiate the timescale over which the safety assessment is carried out in the safety case.

*Related **IAEA** safety standards:*

The time frame for the assessment is the longest period considered in the calculations for the radiological impact assessment for the period after closure. The rationale for selecting the assessment time frame should be explained and justified. (SSG-23, para 5.33)

DI-104:

The licensee shall assess the possible evolution of the criticality hazard after closure in the light of long-term uncertainties.

*Related **IAEA** safety standards:*

Fissile material, when present, has to be managed and has to be emplaced in the disposal facility in a configuration that will remain subcritical. This may be achieved by various means, including the appropriate distribution of fissile material during the conditioning of the waste and the proper design of the waste packages. Assessments have to be undertaken of the possible evolution of the criticality hazard after waste emplacement, including after closure. (SSR-5, para 4.37)

DI-105:

In the safety assessment, the licensee shall only use models and computer codes that have undergone verification and, to the extent possible, validation.

*Related **IAEA** safety standards:*

Any calculational methods and computer codes used in the safety analysis shall undergo verification and validation. (GSR Part 4, Requirement 18)

Any calculational methods and computer codes used in the safety analysis have to undergo verification and validation to a sufficient degree. Model verification is the process of determining that a computational model correctly implements the intended conceptual model or mathematical model; that is, whether the controlling physical equations and data have been correctly translated into the computer code. System code verification is the review of source coding in relation to its description in the system code documentation. Model validation is the process of determining whether a mathematical model is an adequate representation of the real system being modelled, by comparing the predictions of the model with observations of the real system or with experimental data. System code validation is the assessment of the accuracy of values predicted by the system code against relevant experimental data for the important phenomena expected to occur. […] (GSR Part-4, para 4.60)

2.4.3 Safety issue: Periodic safety review

DI-106:

The licensee shall carry out at regular intervals a review of the operational and post-closure safety of the facility (periodic safety review - PSR), to confirm compliance with licensing requirements. The frequency of the review shall be established by the national legal and regulatory framework (e.g. every ten years).

*Related **IAEA** safety standards:*

In accordance with the national regulatory requirements, the operating organization shall carry out periodic safety reviews to confirm that the licensing documentation remains valid and that modifications made to the facility, as well as changes in its operating arrangements or utilization, have been accurately reflected in the licensing documentation. In conducting these reviews, the operating organization shall expressly consider the cumulative effects of changes to procedures, modifications to the facility and the operating organization, technical developments, operating experience and ageing. (NS-R-5(Rev.1), para 4.26)

Periodic safety assessment for a disposal facility has to be aimed at providing an overall assessment of the status of protection and safety at the facility. It has to include an analysis of the operational experience acquired and possible improvements that could be made, with account taken of the existing situation and of whatever new technological developments or changes in regulatory control there might be. Periodic safety assessments cannot replace the activities for analysis, control and surveillance that are continuously carried out at disposal facilities. (SSR-5, para 6.2)

DI-107:

The licensee shall define, substantiate and submit to the regulator the scope of the Periodic Safety Review and shall ensure that, as a minimum, the following are taken into account in the PSR:

- Review and analysis of operational experience
- Review of operating experience in radiation protection aspects.
- Review of the waste acceptance criteria and waste quality controls.
- Review of knowledge and experience of aspects affecting post-closure safety.
- Review of the assumptions made in the safety case to confirm that they are still valid.
- Review of compliance with current regulatory requirements.

A guide to the content of the PSR is given in Appendix 4.

*Related **IAEA** safety standards:*

Before the review work is started, a number of prerequisites should be satisfied. The main prerequisite is an agreement between the operating organization and the regulatory body as to the scope and objectives of the PSR, including current national and international standards and codes to be used. This agreement is documented in the 'basis document' for the PSR, which should be developed by the operating organization and made subject to approval and/or confirmation by the regulatory body. (SSG-25, para 4.5)

DI-108:

The licensee shall document the results of the PSR, and derive and implement an action plan for all reasonably practicable improvements to safety.

*Related **IAEA** safety standards:*

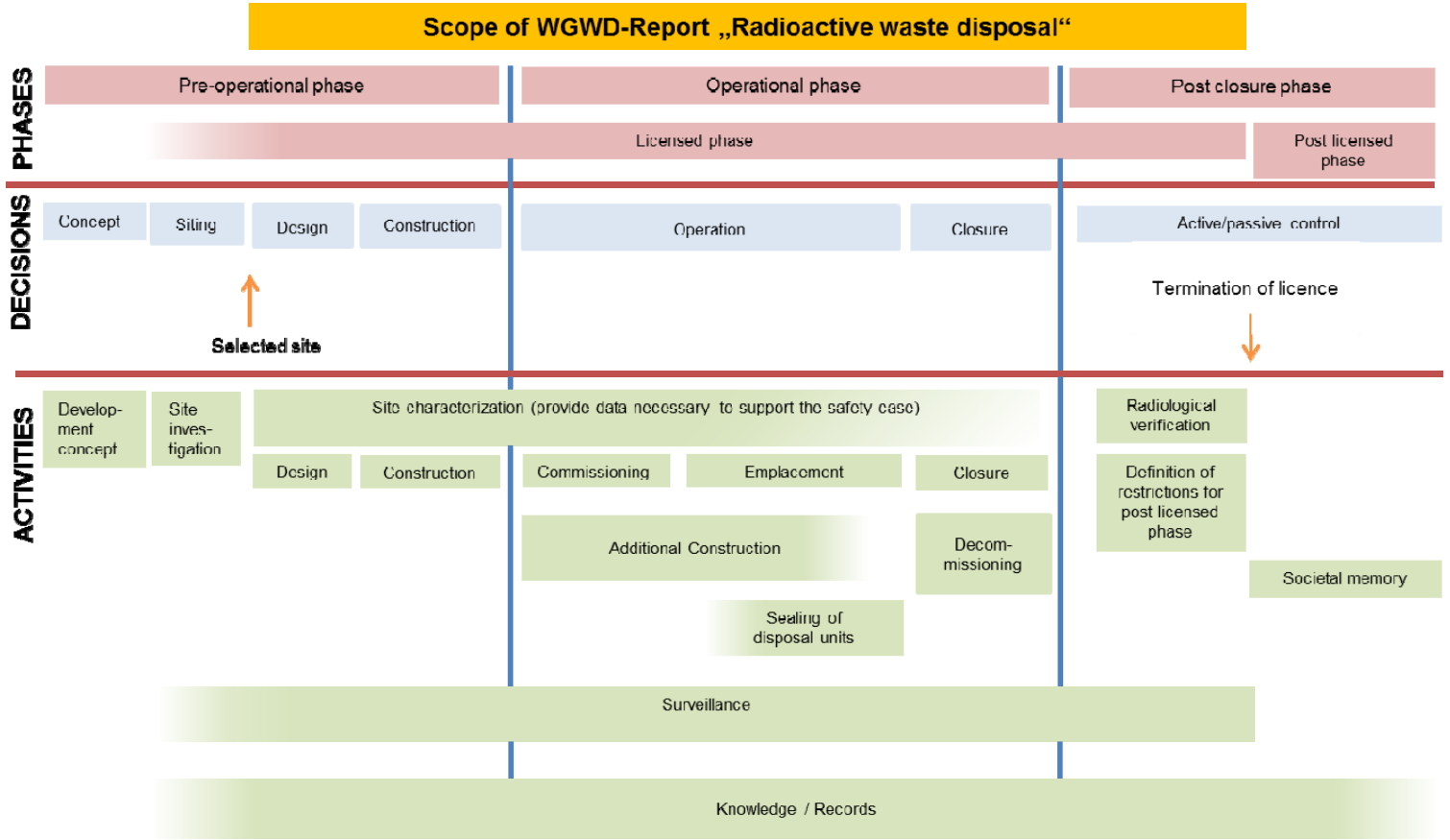
The results of the review should be documented by the operating organization and the documentation should be submitted to the regulatory body either during the PSR or during a structured continuous improvement program, as required. The documentation should include:

- *Reports on the review of each safety factor;*
- *A report documenting the results of the global assessment;*
- *The final PSR report, including information on the proposed safety improvements and integrated implementation plan and a summary of the reports on safety factors and the global assessment.*

[…] (SSG-25, Para 4.28)

Appendix 1

Lifetime of a radioactive waste disposal facility and major decision points – (Schematic diagram)



Appendix 2
Typical content of Waste Acceptance Criteria (WAC) for low- and intermediate level waste

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In general terms, waste acceptance requirements might first describe the general disposal related aspects and requirements of the waste packages and then develop into more specific requirements on the waste forms, on the waste containers, on individual radionuclides and activity, on documentation and record keeping, and finally on the delivery of waste packages[3].

Thus, depending upon the near surface or geological disposal facility, waste acceptance requirements might be structured as follows:

(1) Basic requirements on radioactive waste to be disposed of:

- Prohibition of mixing non-radioactive waste with radioactive waste
- Compliance with the requirements of the site specific safety assessment

(2) General requirements on waste packages:

- Surface dose rate
- Surface contamination
- Hazardous substances content limitation
- Absence of overpressure
- Waste package mass

(3) Requirements on waste forms:

- Basic requirements (e.g. only solid or solidified waste, no free liquid)
- Specific requirements (e.g. stabilization (dispersion inhibition), heterogeneity, chemical restrictions)
- With immobilization binder (e.g. bitumen, polymer or cement)
- Without immobilization binder (e.g. radioactivity and radionuclide restrictions)

[3] Development of specifications for radioactive waste packages. IAEA TECDOC 1515, Vienna, 2001.

(4) Requirements on waste containers:

- Basic requirements (e.g. geometric shape and dimensions, stackability, mechanical handling features)
- Specific requirements (e.g. mechanical stability, thermal resistance, leak tightness, shielding function)
- Inner containers (e.g. surface coating, seals, vents, void space restrictions)

(5) Limitations of activity:

- Permissible activities for individual radionuclides
- Permissible total activity per waste package
- Permissible total alpha and beta/gamma emitter activity
- Declaration of radionuclide-specific activity/total activity per waste package

(6) Delivery of waste packages:

- Compliance with transport regulations
- Permits/documentation including record keeping
- Marking of waste packages
- Requirements on transport containers: Regardless of the requirements for a near surface or geological disposal facility, the regulations on transporting dangerous goods and waste packages with fissile material must be followed.

Appendix 3
Typical Contents of a Safety Case

Introduction

For a disposal facility, the preparation of a safety case including the supporting safety assessment is a step by step development. The safety case is progressively developed and refined as the disposal facility project proceeds. This process continues until the termination of the licence throughout the pre-operational, the operational and the post-closure phases, with integration of operating experience feedback and results of R&D and monitoring.

Safety strategy through the step by step development

An important challenge is to preserve the awareness of the safety objectives throughout the development and implementation of the disposal facility. A safety strategy, which sets out the high-level approach for achieving safe disposal and for managing the activities required to develop the disposal facility, has to be established from the beginning of the pre-operational phase.

The safety strategy describes the processes and methods that will ensure that the disposal facility meets the safety objective. Main components of the safety strategy are:

- The management strategy related to disposal facility development and implementation ensuring that the work focuses on the safety objectives, that adequate resources are available and that activities are correctly carried out and co-ordinated.
- The conceptualization and implementation strategy including approaches and choices for selecting a site, developing a concept, implementing practical engineering solutions and monitoring.
- The safety assessment strategy describing the approach to assessing safety and to building confidence in the assessment results.

The safety strategy is iteratively applied during each program step. At each step, constraints may be imposed by the prevailing circumstances (scientific and technical state of the art, socio-economic situation, national legislation). These constraints and their safety implications should be clearly identified.

The safety strategy should remain consistent during the different phases of disposal facility development. However, the implementation priorities and methods may evolve to take into account experience, technical developments, societal inputs, and new national and international standards and guidance.

Typical content of a safety case

In accordance with the principle of applying a graded approach, the content and the level of detail expected for each element in the safety case should be proportionate to the hazard presented by the waste to be disposed of in the facility concerned and should be appropriate to the regulatory decision step reached.

The safety case should contain the following elements, among others:

1. Purpose and context of the safety case Outline of the disposal program

    - Legal framework
    - Current step or decision point within the program
    - Key decisions that have already been taken or that will need to be taken in the future
    - Objectives of the safety case, in relation to the stage reached in the disposal program

2. Safety Strategy:

    - Identification of the constraints imposed by the prevailing circumstances (scientific, technical, socio-economic, etc.) and of their implications on the safety strategy
    - Management strategy
        - Approach for managing the various activities, ensuring that work focuses on safety objectives and that adequate resources are available (including approach for ensuring quality)
        - Approach for post-closure long-term information management and record-keeping
        - Approach for managing uncertainties (reducing and avoiding uncertainties and mitigating their effects)
        - Approach for implementing the optimization of protection principle
            - consideration of how alternative options will be evaluated.

    - Conceptualization and implementation strategy:
        - Approach to containment and isolation
        - Approach for achieving post-closure safety by passive means
        - Approach for ensuring defence in depth
        - Approach for ensuring reversibility/retrievability if, and to the extent, required
        - Approach for implementing practical engineering solutions and monitoring

    - Safety assessment strategy
        - Approach for assessing the radiological impact and the performance of the disposal system and of its components.
        - Approach for assessing the technical feasibility of the disposal system
        - Approach for building confidence in the assessment

3. Assessment basis

- Analysis tools (assessment methods, models, computer codes and databases) supporting the safety assessment and processes for qualifying them and building confidence in them
- Scientific and technical data and understanding relevant to the safety assessment:
  - Site description (geology, hydrogeology, climate, biosphere, demography, ...)
  - Waste description (waste and container characteristics, inventory and its evolution)
  - Overall description of the disposal system:
    - Design requirements (to meet the safety strategy)
    - Safety functions assigned to the disposal system and to its components post-closure, and evolution with time
    - Understanding of processes
  - Facility description:
    - Design options (reference option and alternatives)
    - Disposal facility characteristics
  - Safety functions assigned to the disposal facility and to its components during operation, and changes with time
  - Plans (for construction, waste package emplacement, for retrievability and reversibility if required, for closure, etc.)
  - As-built description of the part of the disposal facility already implemented
  - Description of any changes to the reference design from the previous phase
- Identification of the uncertainties and their evolution with time
- Technical feasibility of the design options (feasibility studies including demonstration tests)
- Knowledge
  - State of the art
  - Results from research programs
  - Feed-back from experience during construction, operational activities, monitoring
  - Synthesis of process understanding
- Operational issues:
  - Site & engineering assessment basis relevant to operational safety assessment
  - Normal operation and accident conditions, OLC's (including WAC, radiation protection system)
  - Description of facility commissioning
  - Ageing of facility components (periodic inspection and maintenance programs)
  - Activities for the decommissioning of auxiliary facilities
  - Procedures and operating manuals for activities with significant safety implications
  - Operating inspection, maintenance and testing provisions
  - Operating experience feedback
- Monitoring (baseline, disposal system and environmental monitoring program)

4. Operational and post-closure safety assessment

Site and engineering assessment

- Substantiation that the safety requirements are met:
  - Appropriateness of the design
  - Substantiation that there is adequate defence in depth
  - Ability of each component to fulfil its expected role; evolution of its performance with time
- Performance and robustness assessment:
  - Establishment of performance indicators
  - Identification and quantification of the circumstances and phenomena that may affect system performance
  - Scenario and model development to assess performance and robustness
  - Assessment of the performance and robustness of the system and its components,
  - Demonstration that the as-built facilities meet the design basis and requirements
  - Operational safety assessment:
    - Substantiation that facility meets the operational safety requirements and is operated in accordance with the conditions of the licence
    - Safety assessment for possible waste retrieval (in case of a waste package defect)
- Feasibility assessment
- Fault and accident analysis

Radiological and non-radiological impact assessment

- Establishment of safety indicators
- Identification and quantification of the circumstances and phenomena that may affect the radiological impact (includes assessment of radionuclide release and transport)
- Operational/post-closure safety analysis:
  - Scenario and model development to assess radiological and non-radiological impacts
  - Assessment of radiological exposures that might arise during operation /during the post-closure long-term evolution of the facility
  - Substantiation that the estimation of radiological impact is conservative

- Demonstration of the reliability of the safety assessment
  - Reasons for and substantiation of the simplifications
  - Description of how uncertainties are dealt with in the safety assessment.

5. Management system

- Organizational structure for the present phase and organization planned for future phases
- Organization and arrangements for QA of safety-related activities/Audits and verification activities to confirm that implementation is correct, and periodic re-assessment of the management system
- Qualification and training of personnel
- Arrangements for physical protection and safeguards
- Emergency preparedness
- Provisions for information management, conservation of post-closure long-term memory of the disposal facility and record-keeping procedures, ensuring traceability of decisions made
- Program of planned activities through the different phases

6. Integration of safety arguments and evidence

- Integration of the safety arguments and evidence from the assessments.
- Confirmation that the safety strategy and the safety requirements are correctly implemented
- Substantiation that the design has been developed through a process involving optimization of radiological protection
- Argument supporting a decision to proceed to the next phase
- Evaluation of the confidence in the assessment results/Identification of the limitations of the currently available evidence, arguments and analyses
- Methodology for addressing and managing lack of knowledge, unresolved questions and uncertainties that might undermine safety, in respect of:
- development of the design
- data acquisition from research and development programs
- scenario development and modelling

Appendix 4
Expected content of a Periodic Safety Review

Taking into account modifications to the structures, systems and components (SSC) and layout of the facility, to the procedures, and to the organization, and lessons learnt from R&D, monitoring, maintenance, testing, inspection and ageing-management programs, the Periodic Safety Review (PSR) should, as a minimum:

- Review and analyse the operational experience accumulated with equipment, structures, systems and components, including their maintenance, inspection and control; any operational occurrences or accidents that have happened, their root cause analysis and the corrective actions taken; and any modifications of the facility, of the operational procedures and of the organization.
- Review the waste acceptance criteria, taking into account the current state of knowledge and experience in physico-chemical and radiological characterisation; review the waste acceptance process, including how waste production is controlled and how compliance with waste acceptance criteria is confirmed; and assess the overall impact on safety of deviating waste accepted for disposal.
- Review the operating experience in radiological protection aspects for workers and the public, including the control of emissions/release/discharges and the assessment of the radiological impact on the environment.
- Review the knowledge and experience of aspects affecting post-closure safety, including an analysis of the performance and potential evolution of barriers, the site and the biosphere. Review the assumptions made in the safety case to confirm that they are still valid.
- Review compliance with current regulatory requirements (national and international).
  - Identify any significant deviations from applicable current standards and good practice and evaluate their significance for safety;
  - Identify any conflicting requirements between different regulatory regimes.
- Review whether the objectives for operation, closure and post-closure remain achievable.