

**WENRA
WORKING GROUP ON WASTE AND DECOMMISSIONING (WGWD)**

**RADIOACTIVE WASTE DISPOSAL FACILITIES SAFETY REFERENCE
LEVELS
REPORT**

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Explanatory note from the chairman of WENRA-WGWD

This draft report has been published in order to allow -as soon as possible- all concerned parties for a thorough analysis of its technical content as well as for returning their comments to WGWD. In this context the following remarks might already answer some of the upcoming questions:

- *In addressing technical safety aspects this report intentionally **does not cover** the site selection phase of a foreseen repository which commonly includes many other criteria of -inter alia- socio-economical and political importance. The SRLs start in covering the requirements of the characterisation, once a site has been selected. Some of these characterisation exercises –however- may already have been performed as part of the site selection process. In this case the responsible organisations are well advised to consider them even in this earlier stage of the project.*
- *Layout and structure of this document may still be subject to appropriate changes. WGWD is especially aware of the fact that the volume of individual safety areas is still imbalanced. Proposals for improvement on this formal issue are equally welcome.*
- *Whilst WGWD considers the SRLs, explanatory texts, the glossary and annexes as mature texts for the stakeholder involvement, this is not the case for the references given for the individual SRLs. For this reason **the references should not be commented** as they will be updated in a later version of the report. In the final version any reference will directly refer to the original and up-to-date LAEA fundamental or requirement, not -as in many cases today- to reference levels from other WENRA reports. However even today the original references can be traced back in looking at the respective SRL in versions 2.1 of the storage (S-reference levels) or the decommissioning (D-reference levels) report on the WENRA homepage.*

All responses received not later than 30. April 2013 will be evaluated by WGWD in the future editorial process. Depending on volume and significance of the comments WGWD will decide on the need for an additional hearing/workshop, which would be announced on the WENRA homepage before end of May 2013 and which –if necessary- will take place in late June or early July 2013. The following finalization process will be identical to the one used for the storage and the decommissioning report.

Brugg, 18.11.2012

Stefan Theis

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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 in applicant countries 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 harmonized disposal safety reference levels report

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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 countries 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.

Glossary

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 computational science.

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 programme.

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.

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 system

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.

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.

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 organisation having the overall responsibility for a facility or activity (the responsible organization) for waste disposal as specified in a licence.

In this document, the term licensee also covers the prospective licensee, when the SRL refers to actions to be implemented prior to the licence 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 licence 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 mathematical 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. The uncertainties, approximations made in the models, and shortcomings in the models and the underlying basis of data, and how these are to be taken into account in the safety case, all have to be identified and specified in the validation process. In addition, it has to be ensured that users of the code have sufficient experience in the application of the code to the type of facility or activity to be analysed.

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. 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.

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.

Protection and Safety

The protection of people 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 against exposure, whatever the source, and so is always radiation protection.

Radiation protection: The protection of people 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.

Robustness (of a component or a system)

Ability of a component or system to fulfil its assigned safety functions despite perturbing internal and external events and processes.

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 assumed incidents or 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

Systematic analyses of the safety performance of a disposal facility and system and confirming compliance with the safety 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 DS 355)

A postulated or assumed set or sequence of conditions and/or features, events and processes (FEPs) leading to possible future situations and time histories.

A set of scenarios is devised for the purpose of illustrating the range of future behaviours and states of a disposal system after closure. They may be particularly useful if there is uncertainty or lack of knowledge about what assumptions are appropriate.

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 safety assessment.¹

Waste acceptance criteria (for disposal):

Quantitative and/or qualitative criteria, approved by the regulatory body, to ensure that waste accepted for disposal in a specific disposal facility possesses the attributes and quality characteristics required for granting safety during operation, and after closure.

A methodology of waste acceptance (in the disposal facility) needs to be implemented by the licensee in order to guarantee the accomplishment of WAC in waste prior to their disposal.

At the discretion of the disposal facility licensee and/or the regulatory body, the waste acceptance criteria may be broad. For example, the criteria may impose requirements on radionuclide content and on waste package specifications, and may also include requirements for the organization responsible for the waste to provide, or to preserve, records of quality management arrangements, and also records of production, quality checks and storage history for individual waste packages.

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 organisation of a facility or activity that generates waste. For this report the scope of the term waste producer is extended to any organisation responsible for the management of the waste: either the waste producer himself or a licence holder to whom this responsibility has been entrusted by competent authorities.

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.

List of Abbreviations

ALARA	As low as reasonably achievable
EU	European Union
IAEA	International Atomic Energy Agency
LILW	Low and intermediate level waste
NEA	Nuclear Energy Agency (OECD)
NPP	Nuclear power plant
OEF	Operating experience feedback
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 I. Introduction and Methodology

A. Introduction

This report is the result of an effort by the Working Group on Waste and Decommissioning (WGWD) of WENRA, from 2009 to 2012. It presents the safety reference levels (SRLs) for all kind of radioactive waste disposal facilities and practices 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. 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, Slovakia, 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:

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

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

2. Objective

The objective of this report is to provide SRLs for all kind of 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 notably 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 the licensees of the above-mentioned facilities, who are responsible for the safety of the facilities until the termination of the licences. They however also require some actions to be undertaken by the organisation in charge of developing the disposal concept before the licence is applied for. This is mainly the case for geological disposal when the development of the project is likely to span over several decades: in such a case, preparatory work - mainly geological investigations and R&D programmes - needs to be implemented before the licence application. Quality assurance programmes and a properly structured organization are needed to ensure appropriateness of actions undertaken long before the licensing process is started. It is considered in this report that, when a requirement applies to a future licensee which is not yet regulated under nuclear regulation, the licensee shall demonstrate that it has fulfilled the requirement during the pre-licensing activities in order to obtain the licence.

Some of the SRLs can also be used by the regulatory body for the review and evaluation of disposal facilities' safety.

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.

3. Scope

The SRLs are focused on facilities used to dispose of radioactive waste in solid form in either surface, intermediate depth disposal or deep geological facilities. This can include spent fuel when 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.

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 while licensing and regulating these facilities.

With respect to residual materials containing radionuclides of natural origin (NORM - mining and mineral processing waste as referred to in IAEA SSR-5 and TENORM - technologically enhanced natural occurring radioactive materials), various ways of managing this 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. Therefore relating SRLs may not be ready for harmonisation. 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 licence 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 are 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. This last topic is covered by the EU directive on radioactive waste and spent fuel management which is under development. Moreover funding is an issue for the organisation responsible for the waste and not for the licensee of the disposal facility. Therefore, it does not seem appropriate to deal with this issue in this report which sets out requirements binding on the licensee of the disposal facility. 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 recognises that, although not always in the mandate of its members, protection from the non-radioactive hazardous content of the waste represents an important issue with respect to the long term impact of the disposal on people and the environment. 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.

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 analyse their application in participating countries.

Part II of the report presents the specific waste disposal reference levels and the corresponding annexes.

B. 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 IAEA documents were considered, the latest list of which is as follows:

- 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).
- Disposal of Radioactive Waste No. SSR-5; IAEA Specific Safety Requirements, Vienna (2011).
- Siting of near surface disposal facilities, IAEA Safety Guide n° 111-G-3.1, Vienna (1994).
- Siting of geological disposal facilities IAEA, Safety Guide n° 111-G-4.1, Vienna (1994).
- 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).
- Predisposal Management of Radioactive Waste - Safety Requirements; IAEA General Safety Requirements, GSR-Part 5, Vienna (2009).
- Under development during the SRL development work :
 - DS356 - Near Surface Disposal of Radioactive Waste (version 22-08-2008).
 - DS355 - The Safety Case and Safety Assessment for Radioactive Waste Disposal (Version 01-06-2011).
 - DS357 - Monitoring and Surveillance of Radioactive Waste Disposal Facilities (Version 15-03-2011).
- 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).
- The management system for the disposal of radioactive waste, IAEA Safety Guide, GS-G-3.4 (safety guide), Vienna (2008).
- Safety Assessment for near surface disposal of radioactive waste safety guide – IAEA Safety Guide series n° WS-G-1.1, Vienna (1999).

Other international /European standards and recommendations:

- 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
- Draft Euratom Basic Safety Standards Directive, 9/2011
- WENRA - Waste and spent fuel storage safety reference levels report, version 2.1
- WENRA – Decommissioning safety reference levels report, version 2.1.
- European Pilot Group (EPG), Report on the European Pilot Study on the regulatory review of a safety case for geological disposal of radioactive waste, version for consultation 26.11.2010.

Part II. Radioactive Waste Disposal Safety Reference Levels

These reference levels are intended for disposal facilities which will be used to dispose of 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 limited period of surveillance, should only rely on passive means.

As compared to other nuclear facilities, radioactive waste disposal present a unique challenge related to the need to ensure and demonstrate safety after closure. This is due to the persistence of the hazard potential of the waste, for a period that may span over a few hundred years (for short-lived waste) to several hundred thousand years or more (for long-lived waste), depending on the characteristics of waste and the type of facility. Due to this persistence of a radiological hazard there needs to be a special focus on post-closure safety.

Containment and isolation are two major safety functions that have to be fulfilled by the disposal system. Post-closure safety most 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 quite an important challenge. It requires demonstrating that an appropriate level of safety will be provided taking into account reasonably foreseeable perturbing events and despite uncertainties concerning the possible evolution of the disposal system. It requires an adequate understanding of the behaviour of the disposal system, in order to build confidence in the safety demonstration.

The safety case for a disposal facility and system thus presents specific problems compared to the safety case for nuclear facilities of other types: first it has to address post-closure safety in conjunction with operational safety; second, the safety case matures as the disposal concept develops and the facility is constructed and operated. In other words, the safety case for a disposal facility and system 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 programmes. As an example, according to the IAEA SSR-5, the following phases can be considered (see annex 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) and the authorization for design and construction of the disposal facility is granted.
- 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 will be implemented, as appropriate.

Consideration should also be given to the disposal facility development with time and that construction, decommissioning or closure works are likely to take place at the facility during operation. Whenever these situations occur, due attention must be paid to the safe management of these concurrent activities.

The development of the safety case in parallel with the development of the disposal facility needs to be recognised 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. However during this 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 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 licence application are undertaken under a quality assurance system and are traceable. As an example, it is very important for confidence building in the safety case 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 programme, 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. However, the regulatory body will have to make sure that appropriate and adequate means, resources and organization are provided throughout the project to develop 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 the iterative process already mentioned, the safety case will evolve and mature, throughout the disposal facility lifetime, as new information and results from research and safety assessments become available.

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 report of the European Pilot Group on the regulatory review of the safety case for geological disposal [26.11.2010] describes how the safety case will mature throughout the different phases and how the expectations of the regulatory body will grow with the development of the project. The main elements to consider in the safety case are outlined in annex 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 programmes. By the time a licence 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.

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 about the disposal facility and system 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 expected characteristics of the waste packages may vary. Some waste packages may aim only at 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.

1. Safety Area: Safety Management

1.1. Safety issue: Responsibility

SRL 1.1.1. 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.

S-01: The licensee of the radioactive waste or spent fuel storage facility is responsible for the safety of all activities in the facility, and for the implementation of programs and procedures necessary to ensure safety, including the waste or spent fuel stored. In accordance with the graded approach, the programs and procedures necessary to ensure safety shall be commensurate with the scale of the facility and the type of the inventory.

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: Responsibilities of the operator).

SRL 1.1.2. The licensee shall commit itself to maintaining the safety of the facility during operation, decommissioning and closure and to achieving post-closure safety. The licensee shall use experience feedback and advances in science and technology as a basis for continuous safety improvement.

S-03: The licensee shall commit itself to maintain the safety of the facility and, as far as reasonably practicable, improve it on the basis of operating experience.

SRL 1.1.3. To fulfil its overall responsibility for safety and also for continuous safety improvement, the licensee shall at the appropriate time establish and implement its safety policy in line with national and international standards and ensure that matters related to safety are given the highest priority.

S-02: To fulfil its prime responsibility for safety during the lifetime of the facility, the licensee shall establish and implement safety policies and ensure that safety issues are given the highest priority.

SRL 1.1.4. The licensee shall be responsible for implementing programmes and procedures necessary to maintain safety during operation, decommissioning and closure and to achieve post-closure safety. These programmes and procedures shall be proportionate to the hazards presented by the waste.

S-01: The licensee of the radioactive waste or spent fuel storage facility is responsible for the safety of all activities in the facility, and for the implementation of programs and procedures necessary to ensure safety, including the waste or spent fuel stored. In accordance with the graded approach, the programs and procedures necessary to ensure safety shall be commensurate with the scale of the facility and the type of the inventory.

SRL 1.1.5. The licensee shall ensure that the resources² for any foreseen activities before termination of the licence will be available at the time they are needed.

Related IAEA safety standards

Availability of the necessary technical and financial resources to achieve closure has to be assured by means of Requirements 1–3. (SSR-5, para 4.41).

SRL 1.1.6. 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

Responsibilities of the operator. 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).

SRL 1.1.7. The licensee shall ensure that all activities, including those delegated to contractors, are performed and controlled according to quality standards appropriate to the importance to safety of the activities.

S-22: The licensee shall demonstrate that design and construction of the facility are based on applicable standards and appropriate materials especially taking into account the expected lifetime of the facility.

SRL 1.1.8. The licensee shall ensure that interfaces between its responsibilities and those of the organisations responsible³ for the waste are clearly defined, agreed and documented.

S-06: The interface between responsibilities of the licensee of the storage facility and the waste or spent fuel owner shall be clearly defined, agreed and documented.

1.2. **Safety issue: Organizational structure**

SRL 1.2.1. The licensee shall establish an organizational structure to enable its safety policy to be implemented with a clear definition of responsibilities and accountabilities, lines of authority and communication.

S-08: The licensee shall establish an organizational structure to enable its safety policy to be delivered with a clear definition of responsibilities and accountabilities, lines of authority and communication.

² “Resources” includes organisational structure, individuals, experience and skills, infrastructure, the working environment, information and knowledge, and suppliers, as well as material and financial resources.

³ The organisation responsible for the waste is either the waste producer or any organisation to whom the responsibility for the waste has been entrusted by the competent authorities.

SRL 1.2.2. The licensee shall adapt its organization progressively to establish the capability in terms of staffing, skills, experience and knowledge to enable it competently to undertake all relevant activities until termination of the licence.

S-09: The licensee shall maintain the capability in terms of staffing, skills, experience and knowledge to enable it to competently undertake the activities during the lifetime of the facility from siting to decommissioning. Where the resources and skills necessary to deliver any part of these undertakings are provided by an external organization, the licensee shall nevertheless retain within its organisation the capability to assess the adequacy of the external organisations' capabilities of ensuring safety.

SRL 1.2.3. The licensee shall define the necessary qualification, experience and skills for all staff involved with activities that may affect safety.

S-10: The licensee shall specify the necessary qualifications and experiences for all staff involved in activities that may affect safety and establish training programs for developing and maintaining the professional skills of the staff.

SRL 1.2.4. The licensee shall establish training programmes to develop and maintain the professional skills of its staff, and to ensure that personnel are appropriately trained before beginning each activity.

S-09: The licensee shall maintain the capability in terms of staffing, skills, experience and knowledge to enable it to competently undertake the activities during the lifetime of the facility from siting to decommissioning. Where the resources and skills necessary to deliver any part of these undertakings are provided by an external organization, the licensee shall nevertheless retain within its organization the capability to assess the adequacy of the external organizations' capabilities of ensuring safety.

SRL 1.2.5. Where any activity related to safety is provided by a contractor, the licensee shall retain within its organisation the capability to assess the adequacy of the contractor's resources and skills for ensuring safety and the quality of the deliverables.

S-09: The licensee shall maintain the capability in terms of staffing, skills, experience and knowledge to enable it to competently undertake the activities during the lifetime of the facility from siting to decommissioning. Where the resources and skills necessary to deliver any part of these undertakings are provided by an external organization, the licensee shall nevertheless retain within its organization the capability to assess the adequacy of the external organizations' capabilities of ensuring safety.

D-03: The ultimate responsibility for safety shall remain with the licensee, although it is permissible to delegate the performance of specific tasks to a subcontractor. The licensee shall ensure that the work of contractors is appropriately controlled so that it is conducted safely.

Related IAEA safety standards

The control of processes contracted to external organizations shall be identified within the management system. The organization shall retain overall responsibility when contracting any processes. (GS-R-3, para 5.10).

1.3. Safety issue: Management system

Related *IAEA* safety standards

Leadership and management for safety.

Effective leadership and management for safety must be established and sustained in organizations concerned with, and facilities and activities that give rise to, radiation risks. (SS No. SF-1, principle 3).

Leadership in safety matters has to be demonstrated at the highest levels in an organization. Safety has to be achieved and maintained by means of an effective management system. This system has to integrate all elements of management so that requirements for safety are established and applied coherently with other requirements, including those for human performance, quality and security, and so that safety is not compromised by other requirements or demands. The management system also has to ensure the promotion of a safety culture, the regular assessment of safety performance and the application of lessons learned from experience. (SF-1, para 3.12).

SRL 1.3.1. 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 organisation;**
- **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 appropriate quality arrangements.**

***S-11:** 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.

SRL 1.3.2. The licensee shall ensure that its management system covers normal operation conditions, anticipated operational occurrences and possible accidents.

***S-12:** The management system shall cover the full lifetime of a facility and the entire duration of activities in normal, transient and emergency situations. For a storage facility, these phases usually include siting, design, construction, commissioning, operation and decommissioning.*

SRL 1.3.3. The licensee shall ensure that its management system encompasses all activities related to safety in design, construction, operation, decommissioning, closure and after closure. The level of assurance for each activity shall be consistent with its importance to safety.

Related IAEA safety standards

Management systems

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).

SRL 1.3.4. The licensee shall ensure that its management system describes how the waste is checked to ensure compliance with waste acceptance criteria.

Related IAEA safety standards

Waste acceptance in a disposal facility

Waste intended for geological disposal has to be characterized to provide sufficient information to ensure that the waste packages received for disposal comply with the waste acceptance criteria or, if not, that corrective measures are taken by the generator of the waste or the operator of the disposal facility. The decision on acceptance of waste packages is based mainly on records, preconditioning tests and control of the manufacturing and conditioning processes. Owing to the risk of potentially high doses from waste packages, "post-conditioning testing and the need for corrective measures have to be limited as far as practicable". (SSG-14, para 6.39).

The management systems for records should be structured to accommodate the information associated with waste acceptance, including the data indicated in the previous paragraph, and records on waste generation and processing. (SSG-14, para 6.40).

SRL 1.3.5. The licensee shall document in its management system the following:

- Its safety policy;
- A description of its management system;
- A description of its organisational 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 delegated to 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 system and facility 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.

S-14: *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 organisations;*

- *A description of the processes and supporting information that explain how work is to be prepared, reviewed, carried out, recorded, assessed and improved.*

SRL 1.3.6. The licensee shall ensure that all documents required for an activity under the national regulatory system (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).

SRL 1.3.7. The licensee shall establish and conduct an experience feedback programme 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 programme 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 modifying the design or manner of construction and operation of the facility as necessary. Relevant experience from other facilities shall also be considered as appropriate.

S-45: The licensee shall establish and conduct an Operating Experience Feedback (OEF) programme to collect, screen, analyse and document operating experience and events at the facility in a systematic way. Relevant operational experience and events reported by other facilities shall also be considered as appropriate.

2. Safety area: Disposal facility development

2.1. Safety issue: General requirements

SRL 2.1.1. 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 the ALARA principle. A graded approach shall be adopted proportionate to the hazard presented by the waste.

SRL 2.1.2. 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

Multiple safety functions

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).

Defence in depth

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).

SRL 2.1.3. The licensee shall ensure that long term safety will be achieved by passive means.

Related IAEA safety standards

Passive means for the safety of the disposal facility

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).

SRL 2.1.4. Throughout the process of development, 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).

SRL 2.1.5. Taking into account the selected host environment, the licensee shall design, construct, operate, decommission and close the disposal facility and system so as to provide containment and isolation of the waste for a period of time suited to its hazardous properties.

Related IAEA safety standards

Containment of radioactive waste

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).

Isolation of radioactive waste

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).

SRL 2.1.6. The licensee shall provide for isolation and containment during normal evolution and shall ensure robustness of the disposal system.

Related IAEA safety standards

Isolation and containment

The purpose of this demonstration is to establish to a high level of confidence that the disposal facility and its host environment can be relied on to provide the necessary containment and isolation over the timescales necessary (SSR-5, para 3.27).

Scope of the safety case and safety assessment

The consequences of unexpected events and processes may be explored to test the robustness of the disposal system. In particular, the resilience of the disposal system has to be assessed. [...] (SSR-5, para 4.20).

SRL 2.1.7. The licensee shall ensure that any provisions to facilitate reversal of disposal operations, or retrieval of waste packages disposed of, have no unacceptable adverse effects on post-closure safety.

Related IAEA safety standards

(...) In some States, post-closure retrievability is a legal requirement and constitutes a boundary condition on the options available, which must always satisfy the safety requirements for disposal. 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).

SRL 2.1.8. The licensee shall define and implement an appropriate programme (e.g. through R&D, investigations, modelling, testing and monitoring activities) to improve and confirm the understanding of the evolution of the disposal system.

Related IAEA safety standards:

Importance of safety in the process of development and operation of a disposal facility

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)

Understanding of a disposal facility and confidence in safety.

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)

SRL 2.1.9. If construction, operation, decommissioning or closure activities take place concurrently, the licensee shall perform the works so that they will not have an unacceptable adverse 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)

Safeguards and security

SRL 2.1.10. The licensee shall ensure that, from design until closure of disposal facility, any measures necessary for the purpose of accounting for and control of nuclear material are part of an integrated approach to safety, security and accounting. In particular, the licensee shall ensure that safety is not unacceptably affected by measures for any other purpose.

Related IAEA safety standards:

Consideration of the State system of accounting for, and control of, nuclear material

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 [21–23].(SSR-5, requirement 23).

2.2. Safety issue: Site characterization

SRL 2.2.1. The licensee shall prepare and implement a programme for site characterization of the selected site. The programme shall provide the data necessary to support the safety case, both during operation and after closure.

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).

Ultimately, knowledge gained from site characterization will be required to provide a credible scientific description of the natural systems at the site and a demonstration of understanding concerning safety significant processes (relating to geology, hydrology, geochemistry, meteorology, etc.). This knowledge will be necessary to support confidence in the technical basis for safety assessments of the near surface disposal system (DS356, para 6.9).

SRL 2.2.2. The licensee shall conduct site characterisation of the selected site so that it includes data:

- **To establish baseline conditions for the site and the environment;**
- **To support the understanding of the normal evolution;**
- **To support the identification of possible disturbing features, events and processes associated with the site and the disposal facility;**
- **To support the understanding of the effect on safety of any features, events and processes.**

Related **IAEA** safety standards:

Site characterisation

The site characterization program should identify the site conditions to be monitored during the pre-construction, construction and operational phases and should establish the level of measurement detail required (e.g. accuracy and precision) to ensure a suitable baseline record of the natural systems of the site. This baseline then provides a reference against which future site monitoring can be compared to determine any changes brought about by the construction and operation of the facility (DS356, para 6.14).

Site characterization for a disposal facility

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).

2.3. **Safety issue: Design**

SRL 2.3.1. The licensee shall design the disposal facility and system and its engineered barriers to provide operational and post-closure safety with due consideration of 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:

Design of a disposal facility

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).

SRL 2.3.2. The licensee shall design the facility on the basis of normal operational conditions, anticipated operational occurrences and possible accidents derived from a relevant set of postulated initiating events (PIEs). The licensee shall clearly and systematically define and document the design basis.

SRL 2.3.3. The licensee shall design the disposal facility giving due consideration to both normal evolution of the disposal system after closure and scenarios involving disturbing features, events and processes.

SRL 2.3.4. 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.

S-23: *The radioactive waste and spent fuel storage facility shall be designed on the basis of assumed conditions for its normal operations and assumed incidents or accidents. The design basis shall be clearly and systematically defined and documented.*

S-28: *The design of the facility shall take into account all relevant postulated initiating events (PIEs), depending on the storage characteristics. A list of potential PIE is provided in the appendix.*

SRL 2.3.5. The licensee shall design the disposal facility to fulfil the following safety functions during the operational phase:

- Control of the exposure of operating personnel, the general public 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.

These safety functions shall be achieved during normal operation, and during anticipated operational occurrences and possible accidents.

S-19: *The storage facility shall be designed to fulfil the fundamental applicable safety functions:*

- control of sub-criticality,
- removal of heat,
- radiation shielding
- confinement of radioactive material,
- retrievability,

during normal operation, anticipated operational occurrences and design basis accident conditions.

S-29: *The criticality safety shall be achieved by design as far as practicable. If burnup credit is adopted, compliance with the limiting burnup level shall be verified by administrative and operational controls.*

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 (...). (SSR-5, para 4.37).

SRL 2.3.6. The licensee shall identify and classify engineered structures, systems and components (SSCs) in accordance with their importance for operational and post-closure safety.

S-24: *The licensee shall identify and classify structures, systems and components important to safety (SSCs) applying a graded approach.*

SRL 2.3.7. 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 the foreseeable operational phase including closure, as well as after closure.

S-22: *The licensee shall demonstrate that design and construction of the facility are based on applicable standards and appropriate materials especially taking into account the expected lifetime of the facility.*

SRL 2.3.8. The licensee shall identify any interfering design requirements between different regulatory regimes, which may impair safety and propose an appropriate way to manage them.

SRL 2.3.9. The licensee shall design the disposal facility so that the engineered components (including barriers) are physically and chemically compatible with each other, with the waste disposed of and with the host environment.

Related IAEA safety standards

Design of a disposal facility

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).

SRL 2.3.10. The licensee shall make provisions for maintenance, testing, inspection and monitoring of structures, systems and components (SSCs), addressing also their ageing.

S-25: The licensee shall address the ageing of SSCs and safety features of facilities for the storage of spent fuel and waste by establishing, if necessary, provisions for their maintenance, testing and inspection. Results derived from this program shall be used to review the adequacy of the design at appropriate intervals.

SRL 2.3.11. The licensee shall establish appropriate provisions for monitoring the host environment.

Related IAEA safety standards:

Monitoring programmes at a disposal facility.

A programme 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 programme 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).

SRL 2.3.12. The licensee shall incorporate passive operational safety features into the design of the disposal facility as far as reasonably practicable.

Related IAEA safety standards:

The operator shall site, design, construct, operate and close the disposal facility in such a way that safety is ensured by passive means to the extent possible and that the need for actions to be taken after the closure of the facility is minimized (SSR5 and DS 356, requirement 5).

SRL 2.3.13. The licensee shall design the handling equipment to take account of radiation protection aspects, ease of maintenance, and minimization of the probability and consequences of anticipated operational occurrences and possible accidents during handling.

S-31: *The handling equipment shall be designed particularly to take account of radiation protection aspects, ease of maintenance and minimization of the probability and consequences of associated incidents and accidents.*

SRL 2.3.14. The licensee shall make provisions in the design of the disposal facility and system to enable surveillance.

Related IAEA safety standards:

An appropriate level of surveillance and control shall be applied to protect and preserve the passive safety features, to the extent that this is necessary, so that they can fulfil the functions that they are assigned in the safety case for safety after closure. (SSR-5, requirement 10).

2.4. Safety issue: Information gathering and monitoring

SRL 2.4.1. Before starting construction, the licensee shall establish a baseline state of the environment both for supporting the monitoring programme and for evaluating the impact of the facility on the environment.

D-16: The licensee shall undertake a baseline survey, including radiological conditions of the site before construction, for comparison with the proposed end-state after decommissioning. For those practices for which such a baseline survey has not been done in the past, data from analogous, undisturbed areas with similar characteristics can be used instead of pre-operational baseline data.

SRL 2.4.2. Before starting construction, the licensee shall define and document a systematic monitoring programme to be implemented during construction, operation, decommissioning and closure, and as appropriate after closure.

Related IAEA safety standards:

Monitoring programmes at a disposal facility

A programme 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 programme 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).

Monitoring has to be carried out at each step in the development and in the operation of a disposal facility. [...] (SSR-5, para 5.4)

SRL 2.4.3. The licensee shall ensure that the objectives of the monitoring programme are to:

- **Contribute to demonstrating adequate protection of people and the environment and demonstrating compliance with the regulatory requirements and licence conditions;**
- **Confirm that the disposal facility and system behaves and evolves as expected in the safety case;**
- **Identify any deviations from the expected behaviour of the disposal system;**
- **Contribute to confirming and refining the key assumptions and models made in the safety case;**

- Enhance understanding of the environmental conditions and of the functioning of the disposal system;
- Acquire data for supporting decision-making and;
- Provide background information for any post-closure surveillance programme.

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 programme 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)*

[...] 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)

2.5. Safety issue: Construction

General requirements

SRL 2.5.1. 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.

SRL 2.5.2. 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:

Construction of a disposal facility: The disposal facility shall be constructed in accordance with the design as described in the approved safety case and supporting safety assessment. 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).

SRL 2.5.3. During construction, the licensee shall gather information in particular to improve the knowledge of:

- **The properties of the host environment and to refine the assumptions of the safety case;**
- **The geomechanical response of the host environment, and the effect on geochemical and hydrogeological conditions of the perturbations induced by the disposal facility.**

Related **IAEA** safety standards:

Monitoring programmes at a disposal facility

A programme 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 programme 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).

Modifications of the disposal facility during construction

SRL 2.5.4. 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.

S-42: Modifications of design, equipment, storage conditions, waste or spent fuel characteristics, control or management, especially changes of SSCs, OLCs or operational procedures in a spent fuel- or radioactive storage shall be subject to planning, assessment, review and authorisation processes commensurate to the importance to safety of the modification. These processes shall ensure that the modifications will not impact adversely the safety of the facility or associated facilities or the further management of spent fuel or waste.

2.6. Safety issue: Operation

General requirements

SRL 2.6.1. 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:

Operation of a disposal facility

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).

SRL 2.6.2. The licensee shall detect and respond to anticipated operational occurrences and possible accidents. Provisions for doing so shall not jeopardize post-closure safety.

S-37: Based upon an assessment of reasonably foreseeable events and situations that may require protective measures the licensee shall provide arrangements for responding effectively to events requiring protective measures at the scene for:

- (a) regaining control of any emergency arising at the site, including events related to combinations of non-nuclear and nuclear hazards;*
- (b) preventing or mitigating the consequences at the scene of any such emergency and*
- (c) co-operating with external emergency response organizations in preventing adverse health effects in workers and the public.*

Operational limits and conditions

SRL 2.6.3. 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.

S-26: *The licensee shall establish operational limits and conditions (OLCs) in order to maintain the storage facility and waste and spent fuel packages or unpackaged spent fuel elements in a safe state during facility operation.*

S-27: *The defined OLCs (see S-26) shall consider, in particular, and as appropriate:*

- *environmental conditions within the store (e.g. temperature, humidity, contaminants...);*
- *the effects of heat generation from waste or spent fuel, covering both each individual waste and spent fuel packages or unpackaged spent fuel element as well as the whole store;*
- *potential aspects of gas generation from waste or spent fuel, in particular the hazards of fire ignition, explosion, waste and spent fuel package or unpackaged spent fuel element deformations and radiation protection aspects;*
- *criticality prevention, covering both each individual waste and spent fuel package or unpackaged spent fuel element as well as the whole store (including operational occurrences and accidental conditions)*
- *suitability for handling and retrieval.*

Commissioning and start of operation

SRL 2.6.4. The licensee shall plan, assess, review and make adequate implementation arrangements before commissioning of the disposal facility and start of operation including arrangements for receiving, handling and emplacement of waste.

S-43: *Before introducing a modification according to S-42, personnel shall, as appropriate, have been trained according to the new operating procedures and all relevant documents necessary for facility operation shall have been updated.*

Preparation for end of operation

SRL 2.6.5. Before starting the operational phase, the licensee shall plan for closure, decommissioning and post-closure activities.

Related **IAEA** safety standards:

Closure of a disposal facility

[...] 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 disposal facility during operation

SRL 2.6.6. The licensee shall ensure that any modifications will not have an unacceptable effect on operational and post-closure safety.

SRL 2.6.7. 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.

S-42: *Modifications of design, equipment, storage conditions, waste or spent fuel characteristics, control or management, especially changes of SSCs, OLCs or operational procedures in a spent fuel or radioactive storage shall be subject to planning, assessment, review and authorisation processes commensurate to the importance to*

safety of the modification. These processes shall ensure that the modifications will not impact adversely the safety of the facility or associated facilities or the further management of spent fuel or waste.

Emergency preparedness

SRL 2.6.8. The licensee shall prepare and implement an emergency plan to respond to possible accidents requiring protection of the personnel and/or members of the public. This emergency plan shall be proportionate to the consequences of the possible accidents considered. For facilities with low potential for radioactive releases, an off-site emergency plan may not be required.

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).

SRL 2.6.9. The licensee shall define an emergency plan to respond, as appropriate, to events for:

- Regaining control of the disposal facility in an emergency;**
- Preventing or mitigating the consequences of any such emergency; and**
- Co-operating with external emergency response organizations in preventing adverse health effects to the public.**

S-37: *Based upon an assessment of reasonably foreseeable events and situations that may require protective measures the licensee shall provide arrangements for responding effectively to events requiring protective measures at the scene for:*

- (a) Regaining control of any emergency arising at the site, including events related to combinations of non-nuclear and nuclear hazards;*
- (b) Preventing or mitigating the consequences at the scene of any such emergency; and*
- (c) Co-operating with external emergency response organizations in preventing adverse health effects in workers and the public.*

SRL 2.6.10. The licensee shall, as appropriate:

- Establish and implement the necessary organizational structure for clear allocation of responsibilities, authorities, and arrangements for coordinating emergency activities and cooperating with external response agencies throughout all phases of an emergency; and**
- 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.**

S-38: *The licensee shall:*

- prepare an on-site emergency plan as basis for preparation and conduct of emergency measures (an example for the contents of such emergency plan is given in app.2),*
- establish the necessary organizational structure for clear allocation of responsibilities, authorities, and arrangements for coordinating facility activities and cooperating with external response agencies throughout all phases of an emergency and*
- ensure, that based on the on-site emergency plan trained and qualified personnel, facilities and equipment need to control an emergency are available, appropriate, reliable and available at the time.*

SRL 2.6.11. 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 include the participation of external emergency response organizations. The plan shall be subject to review and updating in light of the experience gained.

S-39: The on-site emergency plan shall be submitted to the regulatory body. At regular intervals there shall be emergency exercises, some of which shall be witnessed by the regulatory body. Some of these exercises shall be integrated and shall include the participation of all organizations concerned. The plan shall be subject to review and updating in light of the experience gained.

Maintenance, periodic testing, inspection

SRL 2.6.12. The licensee shall establish and implement programmes 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:

Surveillance and control of passive safety features

An appropriate level of surveillance and control shall be applied to protect and preserve the passive safety features, to the extent that this is necessary, so that they can fulfil the functions that they are assigned in the safety case for safety after closure. (SSR-5, requirement 10).

S-44: A maintenance, periodic testing and inspection program shall be conducted according to written procedures in order to ensure that SSCs are able to function in accordance with the design intents and safety requirements.

S-45: The extent of the programme for maintenance, periodic testing or inspection of SSCs shall be in accordance with the facility safety case.

SRL 2.6.13. The licensee shall record and assess the results of maintenance, periodic testing, and inspection. Results derived from these programmes 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.

S-46: The result of maintenance, periodic testing and inspection shall be recorded and assessed.

SRL 2.6.14. At regular intervals, the licensee shall review and as necessary revise programmes for maintenance, periodic testing and inspection to incorporate the lessons learned from experience.

S-47: The maintenance, periodic testing and inspection programmes shall be reviewed at regular intervals to incorporate the lessons learned from experience.

S-48: The licensee shall develop an inspection program for the verification of the continuing compliance of waste and spent fuel packages or unpackaged spent fuel stored with the limits specified in the safety case to ensure continued functionality of safety features on which safety case is based. This program shall address:

- *the required environmental conditions within the storage facility,*
- *the state of waste and spent fuel packages or unpackaged spent fuel elements.*

2.7. **Safety issue: Record and knowledge keeping**

SRL 2.7.1. The licensee shall establish and maintain records of waste receipt, inventory and emplacement, combined with the information on waste acceptance.

S-15: *The licensee shall develop and maintain a record system on the location and characteristics of every waste and spent fuel package or unpackaged spent fuel element in storage, including information on its ownership and origin.*

S-17: *The licensee shall implement an adequate system to provide up-to-date information on the radioactive inventory within the storage facility.*

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. (...). 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).

Records of waste receipt and disposal should be structured to accommodate the information associated with waste acceptance (DS356, para 6.34).

Management systems for disposal facilities provide for the production and retention of documentary evidence to illustrate that the necessary quality of data has been achieved; that components have been supplied and used in accordance with the relevant specifications; and that the waste packages and unpackaged waste comply with established requirements and criteria and have been properly emplaced in the disposal facility. It also ensures the collation of all the information recorded at all steps of the development and operation of the facility, and the preservation of that information which could be important to safety and for any reassessment of the facility in the future (DS356, para 6.78).

SRL 2.7.2. The licensee shall ensure that knowledge and records important to safety are kept up to date and retained until termination of the licence and then are handed on to the corresponding successor authority/ies in accordance with national regulations.

Related **IAEA** safety standards

The period after closure and institutional controls.

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).

(...) 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).

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).

In meeting the requirements, it is necessary that the operator retain all information relevant to the safety case and the supporting safety assessments of the geological disposal facility, and the records that demonstrate compliance with regulatory requirements. Such information and records have to be retained by the operator unless or until such time as another organization assumes responsibility for the facility, at which time the records should be transferred to the organization that assumes that responsibility. (SSG-14, para 3.12).

2.8. **Safety issue: Closure of disposal facility**

SRL 2.8.1. The licensee shall close the disposal system in such a way as to provide for the safety functions required after closure.

Related IAEA safety standards:

Closure of a disposal facility

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).

SRL 2.8.2. The licensee shall ensure that structures, systems and components that are not needed after closure are safely dismantled and decommissioned as required.

SRL 2.8.3. Before starting decommissioning and closure, the licensee shall define the corresponding programme 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;**
- **Programmes for surveillance, security and safeguards;**
- **Plans for preserving knowledge and records about the waste disposed of and the disposal system.**

SRL 2.8.4. The licensee shall perform decommissioning and closure activities in accordance with the conditions of the licence and the relevant regulatory requirements 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:

Responsibilities of the regulatory body

The regulatory body shall establish regulatory requirements for the development of different types of disposal facility for radioactive waste and shall set out the procedures for meeting the requirements for the various stages of the licensing process. It shall also set conditions for the development, operation and closure of each individual disposal facility and shall carry out such activities as are necessary to ensure that the conditions are met (SSR-5, requirement 2).

Closure of a disposal facility

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).

SRL 2.8.5. The licensee shall plan, assess, document and implement any modifications in the authorized decommissioning and closure procedures and methods using arrangements consistent with the importance to safety of the modifications.

Related IAEA safety standards:

Closure of a disposal facility

[...] 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).

The period after closure and institutional controls

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).

SRL 2.8.6. After completion of the closure operations, the licensee shall prepare a report that documents the state of the disposal system including as built records of the means of closure as actually implemented.

D-58: The licensee shall prepare a final decommissioning report to demonstrate, that the decommissioning has been completed and the proposed end state of the facility or site has been achieved.

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

SRL 2.9.1. After closure and until termination of the licence, the licensee shall implement an appropriate post-closure surveillance programme. 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:

Monitoring programmes at a disposal facility

A programme 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 programme 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).

SRL 2.9.2. Before the licensee is relieved of further responsibility (i.e., by termination of the licence and any other permits the licensee holds), the licensee shall:

- **Demonstrate that the results of surveillance programme 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.**

D-60: *Before a facility or site can be released from regulatory control, the licensee shall perform a final survey to demonstrate that the end-state, as approved by the regulatory body, has been met.*

D-62: *In the case of restricted use the licensee shall provide a long term impact assessment, an appropriate surveillance regime and any proposed land use restrictions.*

Related **IAEA** safety standards:

[...]. 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).

3. Safety area: Waste acceptance

3.1. Safety issue: Derivation of Waste Acceptance Criteria

SRL 3.1.1. 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:

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).

SRL 3.1.2. Prior the start of waste emplacement, the licensee shall specify waste acceptance criteria so as to ensure the conformity of the waste 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.

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).

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).

Waste acceptance in a disposal facility

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).

SRL 3.1.3. The licensee shall establish and implement, as necessary, limits on important parameters such as radionuclide inventories and activity concentrations in individual waste packages, in specific parts of the disposal facility and in the facility as a whole.

Related IAEA safety standards:

The operator should develop technical specifications to ensure that the disposal facility is constructed, operated and closed in accordance with the regulatory requirements and the safety case. This includes the development and use of waste acceptance criteria and other controls and limits to be applied during construction, operation and closure (DS356, para 3.17).

SRL 3.1.4. The licensee shall specify criteria to ensure that waste accepted for disposal is physically and chemically stable and compatible with other components of the disposal facility.

Related IAEA safety standards:

Containment is most important for more highly concentrated radioactive waste, such as intermediate level waste and vitrified waste from fuel reprocessing, or for spent nuclear fuel. Attention also has to be given to the durability of the waste form. The most highly concentrated waste has to be emplaced in a containment configuration that is designed to retain its integrity for a long enough period of time to enable most of the shorter lived radionuclides to decay and for the associated generation of heat to decrease substantially (...). (SSR-5, para 3.42).

SRL 3.1.5. The licensee shall ensure that waste acceptance criteria as a minimum specify:

- Limits on raw waste composition;**
- Limits on the waste form;**
- Limits on the waste container for packaged waste;**
- Limits on the waste package (where relevant).**

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

Related IAEA safety standards:

Waste acceptance criteria may be developed as part of an iterative dialogue between the regulator, operator and waste producer. The criteria should include the waste characteristics important to the safety of the operational and post-closure period, and typically specify the:

- permissible range of chemical and physical properties of the waste and the waste form;*
- permissible waste package dimensions, weight, and other manufacturing specifications;*
- allowable levels of radioactivity in each package;*
- allowable levels of fissile material in each package;*
- allowable surface dose rate and surface contamination; and*
- requirements for the accompanying documentation.*

(DS356, para 6.32).

3.2. Safety issue: Revision of waste acceptance criteria

SRL 3.2.1. 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.

3.3. Acceptance of waste

SRL 3.3.1. The licensee shall check that the waste accepted for disposal conforms to waste acceptance criteria. A conformity check 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).

SRL 3.3.2. The licensee shall ensure that each waste package consigned for disposal is traceable by a unique means of identification.

S-16: *The licensee shall ensure that each waste and spent fuel package or unpackaged spent fuel element can be uniquely identified with a marking system that will last for the storage period.*

SRL 3.3.3. The licensee shall review the quality of information supplied by the organization responsible for the waste together with its management system so as to provide an adequate level of assurance that the waste characteristics conform to the waste acceptance criteria. The licensee's arrangements for this may include audits and checks on operations and processes at other facilities.

Related IAEA safety standards:

The quality assurance programme shall recognize that the safety of the repository with respect to waste acceptance depends on both activities undertaken by the operator and activities undertaken by the waste generators. (WS-R-1, para 12.6).

Waste generators shall provide the documentation necessary to comply with the operator's requirements with respect to the nature and the proper performance of any treatment, determination of radionuclide content, preparation of consignment documentation or other actions that could affect the safety of disposal. (WS-R-1, para 12.7).

The operator shall review the quality of information supplied by the waste generator and the quality assurance programme of the waste generator so as to provide an adequate level of assurance of the acceptable characteristics of the waste. This may include audits and checks on operations and processes that produce or treat waste. (WS-R-1, para 12.8).

SRL 3.3.4. The licensee shall establish procedures for dealing with waste packages that do not conform to waste acceptance criteria, and shall not accept such waste packages unless acceptability with regard to 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).

S-49: *The licensee's procedures for the receipt of waste and spent fuel packages or unpackaged spent fuel elements shall contain provisions to deal safely with those that fail to meet the acceptance criteria, e.g. returning to the owner, taking remedial actions.*

4. Safety area: Safety Verification

4.1. Safety issue: Scope and content of the safety case

Related **IAEA** safety standards:

Assessment of safety over the lifetime of a facility or activity: The safety assessment shall cover all the stages in the lifetime of a facility or activity in which there are possible radiation risks. (GSR-Part 4, requirement 12).

In the case of a repository for radioactive waste in significant quantities, radiation risks have to be considered for the post-closure phase. Radiation risks following closure of the repository may arise from gradual processes, such as the degradation of barriers, and from discrete events that could affect isolation of the waste, such as inadvertent human intrusion or abrupt changes in geological conditions. (GSR-Part 4, para 4.43).

The Safety Requirements publication on Geological Disposal of Radioactive Waste [5] requires that, in view of the uncertainties inherent in predicting events, reasonable assurance of compliance with the safety requirements relating to long term hazards be obtained by the use of multiple lines of reasoning. Reasonable assurance of compliance is obtained by supplementing the quantitative estimates of repository performance with qualitative evidence that the repository as designed will provide isolation of the waste. (GSR-Part 4, para 4.44).

Documentation of the safety assessment: The results and findings of the safety assessment shall be documented. (GSR Part 4, requirement 20).

The results and findings of the safety assessment are to be documented, as appropriate, in the form of a safety report that reflects the complexity of the facility or activity and the radiation risks associated with it. The safety report presents the assessments and the analyses that have been carried out for the purpose of demonstrating that the facility or activity is in compliance with the fundamental safety principles and the requirements established in this Safety Requirements publication, and any other safety requirements as established in national laws and regulations. (GSR Part 4, para 4.62).

The quantitative and qualitative outcomes of the safety assessment form the basis for the safety report. The outcomes of the safety assessment are supplemented by supporting evidence for and reasoning about the robustness and reliability of the safety assessment and its assumptions, including information on the performance of individual components of systems as appropriate. (GSR Part 4, para 4.63).

4.64. The safety report has to document the safety assessment in sufficient scope and detail to support the conclusions reached and to provide an adequate input into independent verification and regulatory review. The safety report includes:

- a) A justification for the selection of the anticipated operational occurrences and accidents considered in the analysis;
- b) An overview and necessary details of the collection of data, the modelling, the computer codes and the assumptions made;
- c) Criteria used for the evaluation of the modelling results;
- d) Results of the analysis covering the performance of the facility or activity, the radiation risks incurred and a discussion of the underlying uncertainties;
- e) Conclusions on the acceptability of the level of safety achieved and the identification of necessary improvements and additional measures. (GSR Part 4, para 4.64).

The safety report is to be updated as necessary. The safety report has to be retained until the facility has been fully decommissioned and dismantled or the activity has been terminated and released from regulatory control. For a repository for radioactive waste, the safety report has to be retained for an extended period of time after closure of the repository. (GSR Part 4, para 4.65).

SRL 4.1.1. The licensee shall provide to the regulatory body a safety case substantiating that safety requirements as specified in the national legal and regulatory framework are met. 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:

Scope of the safety case and safety assessment

(...) 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).

SRL 4.1.2. 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).

Purpose of the safety assessment

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).

SRL 4.1.3. The licensee shall include in the safety assessment:

- **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:

The performance of the disposal system under expected and less likely evolutions and events, which can be outside the design performance range of the disposal facility, has to be analysed in the safety assessment. A judgement of what is to be considered the expected evolution and less likely evolutions has to be discussed between the regulatory body and the operator. If necessary, sensitivity analyses and uncertainty analyses would be undertaken to gain an understanding of the performance of the disposal system and its components under a range of evolutions and events. (SSR5 – para 4.19).

All safety functions associated with a facility or activity shall be specified and assessed. (GSR part 4 – Requirement 7).

It shall be determined in the safety assessment for a facility or activity whether adequate measures are in place to protect people and the environment from harmful effects of ionizing radiation. (GSR part 4 – Requirement 9).

It shall be determined in the safety assessment whether a facility or activity uses, to the extent practicable, structures, systems and components of robust and proven design. (GSR part 4 – Requirement 10).

The performance of a facility or activity in all operational states and, as necessary, in the post-operational phase shall be assessed in the safety analysis. (GSR part 4 – Requirement 14).

SRL 4.1.4. The licensee shall update the safety case to reflect its current knowledge and submit it to the regulator for review before each major regulatory decision.

Related IAEA safety standards:

Preparation, approval and use of the safety case and safety assessment for a disposal facility.

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. (DS355 – para 4.10).

The safety case provides a basis for decision making and is presented to the relevant decision makers for their review and consideration. The parties interested in the safety case may include regulators, the general public and other interested parties. These parties will decide for themselves the extent to which they are convinced by the reasoning that is presented, and whether they share the confidence of the operator developing the safety case. The confidence of the interested parties in the findings of the safety case should, however, be enhanced if the arguments and evidence are presented in a manner that is open and transparent, and all relevant results are fully disclosed and subject to quality control and independent review. (DS355 – para 7.2).

SRL 4.1.5. The licensee shall describe in the safety case all safety important aspects related to the disposal facility and system and more particularly the waste to be disposed of, the design, the construction, operation, closure, decommissioning and post-closure activities. An illustrative guide to the content of the safety case is given in Annex 3.

Related IAEA safety standards:

Scope of the safety case and safety assessment

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).

SRL 4.1.6. The licensee shall ensure that the safety case provides a clear understanding of the safety arguments, is comprehensive and documented with a content and level of detail appropriate to the step reached in the disposal facility development.

Related IAEA safety standards:

Understanding of a disposal facility and confidence in safety

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).

Preparation, approval and use of the safety case and safety assessment for a disposal facility

(...) 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).

Step by step development and evaluation of disposal facilities

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).

Documentation of the safety case and safety assessment.

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).

SRL 4.1.7. 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).

Traceability and transparency of the documentation of the safety case and safety assessment (DS355, para. 7.12 to 7.17).

SRL 4.1.8. The licensee shall ensure that the safety case adequately reflects the factors that influence safety and their significance.

Related IAEA safety standards:

Understanding of a disposal facility and confidence in safety.

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).

SRL 4.1.9. The licensee shall identify all uncertainties significant to safety and shall demonstrate that these uncertainties are adequately taken into account in the safety case. The licensee shall describe a programme 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).

[...] Safety assessment has to include quantification of the overall level of performance, analysis of the associated uncertainties and comparison with the relevant design requirements and safety standards. [...] (SSR-5, para 4.10).

Uncertainty and sensitivity analysis

Uncertainty and sensitivity analysis shall be performed and taken into account in the results of the safety analysis and the conclusions drawn from it. (GSR part 4 – Requirement 17).

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. (DS 355, 4.87).

Management of uncertainties

In view of the complexity of radioactive waste disposal systems, efforts should be undertaken in the assessment to understand the significance of uncertainties and to reduce or bound uncertainties. (DS 355, 5.54).

SRL 4.1.10. The licensee shall ensure that the safety case shows that design, engineering and operational choices and decisions on the disposal system derive from a process involving optimization of radiological protection.

Related **IAEA** safety standards:

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

The optimization of protection (that is, the process of determining measures for protection and safety to make exposures, and the probability and magnitude of potential exposures, “as low as reasonably achievable, economic and social factors being taken into account”) is considered in the design of the disposal facility and in the planning of all operations [3]. (SSR-5, para 2.9).

Importance of safety in the process of development and operation of a disposal facility

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).

SRL 4.1.11. The licensee shall present in the safety case the programme, plans and provisions for closure of the disposal facility and for the post-closure activities. The programme, plans and provisions shall be revised and updated as appropriate.

Related **IAEA** safety standards:

The safety case for a disposal facility has to address safety both in operation and after closure. It may also address safety in transport, for which requirements are established in Ref. [17]. 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 (...). (SSR – 5, para 4.15).

SRL 4.1.12. The licensee shall describe in the safety case the management system, including the principles on which it is based, and how it will evolve with the forthcoming phases.

Related **IAEA** safety standards:

Management systems.

Management systems to provide for the 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).

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).

SRL 4.1.13. 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:

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).*

The safety case may include the presentation of multiple lines of reasoning based, for example, on studies of natural analogues and palaeohydrogeological studies, suitable characteristics of the site, properties of the host geological formation, engineering considerations, operational procedures and institutional assurances. (SSR-5, para 4.18).

SRL 4.1.14. The licensee shall update the safety case to reflect:

- **Changes to regulatory requirements and standards;**
- **Results from the surveillance programmes;**
- **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 practicable and in accordance with the safety importance of the improved knowledge.

SRL 4.1.15. The licensee shall use the safety case as the basis for assessing the safety implications of changes to the disposal facility and system.

S-58: *The licensee shall update the safety case to reflect*

- *modifications and new regulatory requirements and relevant standards;*
- *results of the periodic safety review;*
- *results from analysis of incidents*

as soon as practicable and in accordance with safety relevance of the modification after the new information is available and applicable.

4.2. Safety issue: Operational and post-closure safety assessment

Related **IAEA** safety standards:

The safety case for a disposal facility has to address safety both in operation and after closure. It may also address safety in transport, for which requirements are established in Ref. [17]. 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. [...] (SSR-5 para 4.15).

SRL 4.2.1. 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:

[...] 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).

SRL 4.2.2. The licensee shall present 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 and human actions.

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).

SRL 4.2.3. 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 (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.

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).

SRL 4.2.4. The licensee shall substantiate the timescale over which the safety assessment is carried out in the safety case.

SRL 4.2.5. If nuclear criticality cannot be ruled out due to long-term uncertainties, the licensee shall substantiate that in case of nuclear criticality occurring after closure, there would be no unacceptable adverse effect on post-closure safety.

Related **IAEA** safety standards:

[...] Assessments have to be undertaken of the possible evolution of the criticality hazard after waste emplacement, including after closure. (SSR-5, para 4.37).

SRL 4.2.6. 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:

Use of computer codes.

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

Any calculational methods and computer codes used in the safety analysis have to undergo verification and validation to a sufficient degree (...). (GS-R-4, para 4.60).

4.3. **Safety issue: Periodic safety review**

SRL 4.3.1. The licensee shall carry out at regular intervals a review of the operational and post-closure safety of the facility (periodic safety review - PSR), at a frequency which shall be established by the national regulatory framework (e.g. every ten years).

S-59: The licensee shall carry out at regular intervals a review of the safety of the facility (PSR). The review shall be made periodically, at a frequency which shall be established by the national regulatory framework (e. g. every ten years).

SRL 4.3.2. The licensee shall define, substantiate and submit to the regulator the scope of the Periodic Safety Review and shall ensure that the following are taken into account in the PSR:

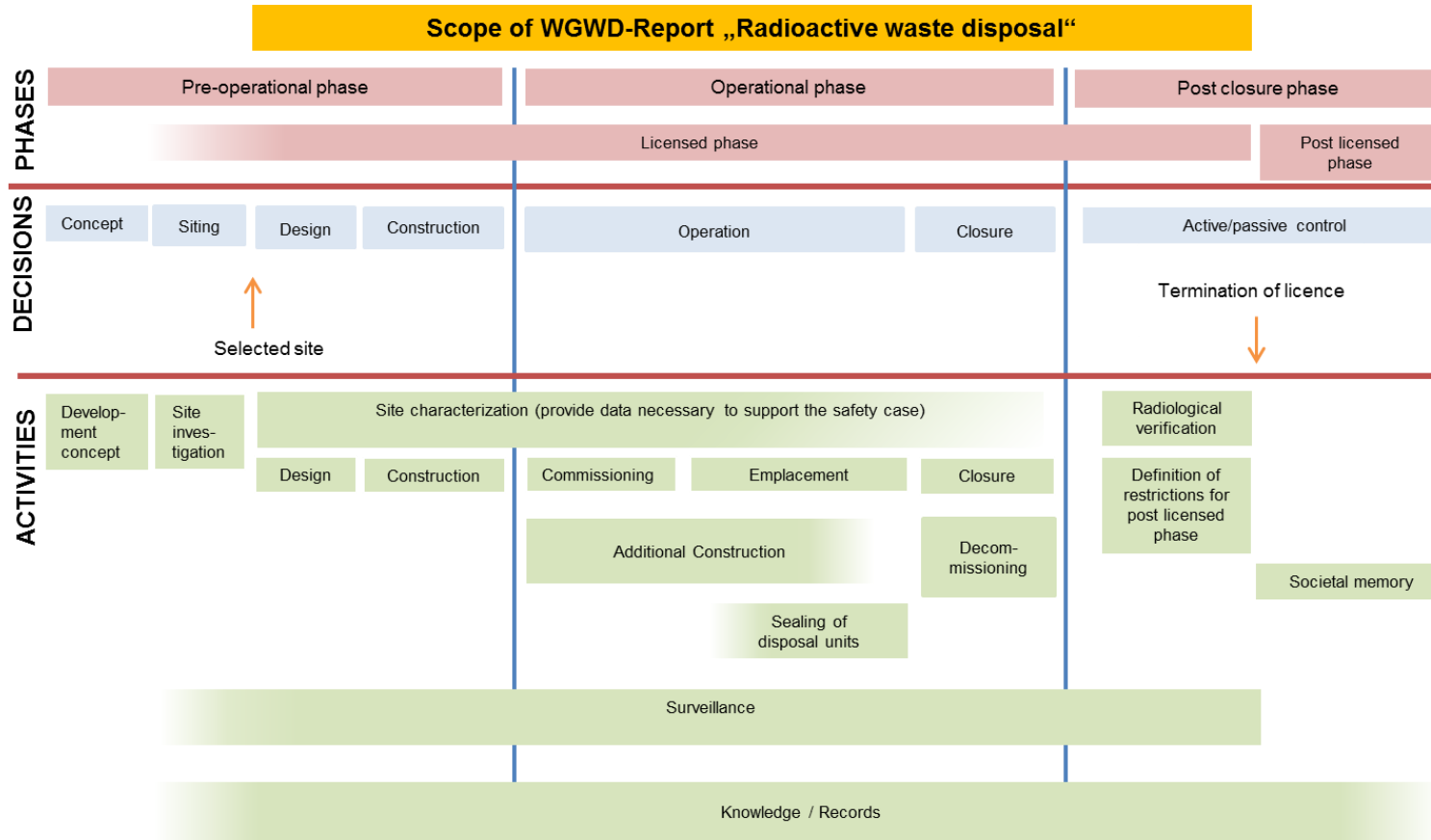
- Evaluation of operational experience accumulated with equipments, structures, systems and components, their maintenance, inspections and controls; anticipated operational occurrences, possible accidents and corrective actions; modifications of the facility, of the operational procedures and of the organization.
 - Review of the radiological protection aspects, with an analysis of the occupational doses, effluents and doses to the public as well as the environmental radiological survey results.
 - Review of the waste acceptance, considering waste quality controls.
 - Review of experience with respect to aspects with influence in the post-closure safety, with an analysis of the understanding of the performance and potential evolution of the disposal system. 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 Annex 4.**

S-60: The scope and methodology of the PSR shall be clearly defined and justified. The PSR shall confirm the compliance with the licensing requirements. It shall also identify and evaluate the safety significance of differences from applicable current safety standards and good practices and take into account the cumulative effects of changes to procedures, modifications to the facility and the operating organization, technical developments, operational experience accumulated and ageing of SSCs. It shall include consideration of the acceptance criteria for waste and spent fuel packages and unpackaged spent fuel elements and any deviation from these criteria during storage.

SRL 4.3.3. The licensee shall document the results of the PSR, and prepare and implement an action plan for all reasonably practicable improvements.

S-61: The results of the PSR shall be documented. All reasonably practicable improvement measures shall be subject to an action plan.

Annex 1: Lifetime of a radioactive waste disposal facility and major decision points – (Schematic diagram)



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

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.

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)
- (4) Requirements on waste containers:
 - Basic requirements (e.g. geometric shape and dimensions, stackability)
 - 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.

⁴ Development of specifications for radioactive waste packages. IAEA TECDOC 1515, Vienna, 2001

Annex 3: Elements 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 (based on NEA Post-closure safety case for geological repositories - <http://www.oecd-nea.org/rwm/reports/2004/nea3679-closure.pdf>):

- 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 programme 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. Fundamental aspects of the strategy are not, in general, expected to change over the course of the project; however, they may be re-interpreted and the implementation priorities and methods may evolve to take into account experience, technical developments, societal inputs, and new national and international standards and guidance.

. Illustrative content of a safety case

The present Illustrative content of the safety case is in line with the scope of this document (see chapter I.3) and therefore does not specifically address items such as the requirements of the European Directive on Environmental Impact Assessment, physical protection including safeguards, etc. It is based on the information provided in the EPG report.

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 (SC)

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

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 RD & D programme
 - 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 programmes)
 - Activities for the decommissioning of auxiliary facilities
 - Procedures and operating manuals for activities with significant safety implications [based on similar items for Storage]
 - Operating inspection, maintenance and testing provisions [based on similar items for Storage]
 - Operating experience feedback [based on similar items for Storage]
- Monitoring (baseline, disposal system and environmental monitoring programme)

4. Safety Assessment

- Site and engineering assessment

- Substantiation that the design basis/safety requirements/rules are met:
 - Appropriateness of the design relating to the design basis

- 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
- 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

- Organisational 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
- Programme 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 an optimization process
- 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
 - RD&D and data acquisition
 - scenario development and modelling

Annex 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 programmes, 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.