

IAEA Safety Standards

for protecting people and the environment

Storage of Spent Nuclear Fuel

Specific Safety Guide

No. SSG-15



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IAEA SAFETY STANDARDS

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

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RELATED PUBLICATIONS

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

Other safety related IAEA publications are issued as **Radiological Assessment Reports**, the International Nuclear Safety Group's **INSAG Reports**, **Technical Reports** and **TECDOCs**. The IAEA also issues reports on radiological accidents, training manuals and practical manuals, and other special safety related publications.

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This publication has been superseded by SSG-15 (Rev. 1).

STORAGE OF SPENT NUCLEAR FUEL

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

This publication has been superseded by SSG-15 (Rev. 1).

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STORAGE OF SPENT NUCLEAR FUEL

SPECIFIC SAFETY GUIDE

INTERNATIONAL ATOMIC ENERGY AGENCY
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FOREWORD

by Yukiya Amano
Director General

The IAEA's Statute authorizes the Agency to "establish or adopt... standards of safety for protection of health and minimization of danger to life and property" — standards that the IAEA must use in its own operations, and which States can apply by means of their regulatory provisions for nuclear and radiation safety. The IAEA does this in consultation with the competent organs of the United Nations and with the specialized agencies concerned. A comprehensive set of high quality standards under regular review is a key element of a stable and sustainable global safety regime, as is the IAEA's assistance in their application.

The IAEA commenced its safety standards programme in 1958. The emphasis placed on quality, fitness for purpose and continuous improvement has led to the widespread use of the IAEA standards throughout the world. The Safety Standards Series now includes unified Fundamental Safety Principles, which represent an international consensus on what must constitute a high level of protection and safety. With the strong support of the Commission on Safety Standards, the IAEA is working to promote the global acceptance and use of its standards.

Standards are only effective if they are properly applied in practice. The IAEA's safety services encompass design, siting and engineering safety, operational safety, radiation safety, safe transport of radioactive material and safe management of radioactive waste, as well as governmental organization, regulatory matters and safety culture in organizations. These safety services assist Member States in the application of the standards and enable valuable experience and insights to be shared.

Regulating safety is a national responsibility, and many States have decided to adopt the IAEA's standards for use in their national regulations. For parties to the various international safety conventions, IAEA standards provide a consistent, reliable means of ensuring the effective fulfilment of obligations under the conventions. The standards are also applied by regulatory bodies and operators around the world to enhance safety in nuclear power generation and in nuclear applications in medicine, industry, agriculture and research.

Safety is not an end in itself but a prerequisite for the purpose of the protection of people in all States and of the environment — now and in the future. The risks associated with ionizing radiation must be assessed and controlled without unduly limiting the contribution of nuclear energy to equitable and sustainable development. Governments, regulatory bodies and operators everywhere must ensure that nuclear material and radiation sources are used beneficially, safely and ethically. The IAEA safety standards are designed to facilitate this, and I encourage all Member States to make use of them.

NOTE BY THE SECRETARIAT

The IAEA safety standards reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from harmful effects of ionizing radiation. The process of developing, reviewing and establishing the IAEA standards involves the IAEA Secretariat and all Member States, many of which are represented on the four IAEA safety standards committees and the IAEA Commission on Safety Standards.

The IAEA standards, as a key element of the global safety regime, are kept under regular review by the Secretariat, the safety standards committees and the Commission on Safety Standards. The Secretariat gathers information on experience in the application of the IAEA standards and information gained from the follow-up of events for the purpose of ensuring that the standards continue to meet users' needs. The present publication reflects feedback and experience accumulated until 2010 and it has been subject to the rigorous review process for standards.

Lessons that may be learned from studying the accident at the Fukushima Daiichi nuclear power plant in Japan following the disastrous earthquake and tsunami of 11 March 2011 will be reflected in this IAEA safety standard as revised and issued in the future.

THE IAEA SAFETY STANDARDS

BACKGROUND

Radioactivity is a natural phenomenon and natural sources of radiation are features of the environment. Radiation and radioactive substances have many beneficial applications, ranging from power generation to uses in medicine, industry and agriculture. The radiation risks to workers and the public and to the environment that may arise from these applications have to be assessed and, if necessary, controlled.

Activities such as the medical uses of radiation, the operation of nuclear installations, the production, transport and use of radioactive material, and the management of radioactive waste must therefore be subject to standards of safety.

Regulating safety is a national responsibility. However, radiation risks may transcend national borders, and international cooperation serves to promote and enhance safety globally by exchanging experience and by improving capabilities to control hazards, to prevent accidents, to respond to emergencies and to mitigate any harmful consequences.

States have an obligation of diligence and duty of care, and are expected to fulfil their national and international undertakings and obligations.

International safety standards provide support for States in meeting their obligations under general principles of international law, such as those relating to environmental protection. International safety standards also promote and assure confidence in safety and facilitate international commerce and trade.

A global nuclear safety regime is in place and is being continuously improved. IAEA safety standards, which support the implementation of binding international instruments and national safety infrastructures, are a cornerstone of this global regime. The IAEA safety standards constitute a useful tool for contracting parties to assess their performance under these international conventions.

THE IAEA SAFETY STANDARDS

The status of the IAEA safety standards derives from the IAEA's Statute, which authorizes the IAEA to establish or adopt, in consultation and, where appropriate, in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, standards of safety for protection of health and minimization of danger to life and property, and to provide for their application.

With a view to ensuring the protection of people and the environment from harmful effects of ionizing radiation, the IAEA safety standards establish

fundamental safety principles, requirements and measures to control the radiation exposure of people and the release of radioactive material to the environment, to restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation, and to mitigate the consequences of such events if they were to occur. The standards apply to facilities and activities that give rise to radiation risks, including nuclear installations, the use of radiation and radioactive sources, the transport of radioactive material and the management of radioactive waste.

Safety measures and security measures¹ have in common the aim of protecting human life and health and the environment. Safety measures and security measures must be designed and implemented in an integrated manner so that security measures do not compromise safety and safety measures do not compromise security.

The IAEA safety standards reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from harmful effects of ionizing radiation. They are issued in the IAEA Safety Standards Series, which has three categories (see Fig. 1).

Safety Fundamentals

Safety Fundamentals present the fundamental safety objective and principles of protection and safety, and provide the basis for the safety requirements.

Safety Requirements

An integrated and consistent set of Safety Requirements establishes the requirements that must be met to ensure the protection of people and the environment, both now and in the future. The requirements are governed by the objective and principles of the Safety Fundamentals. If the requirements are not met, measures must be taken to reach or restore the required level of safety. The format and style of the requirements facilitate their use for the establishment, in a harmonized manner, of a national regulatory framework. Requirements, including numbered ‘overarching’ requirements, are expressed as ‘shall’ statements. Many requirements are not addressed to a specific party, the implication being that the appropriate parties are responsible for fulfilling them.

Safety Guides

Safety Guides provide recommendations and guidance on how to comply with the safety requirements, indicating an international consensus that it is necessary to take the measures recommended (or equivalent alternative measures). The Safety

¹ See also publications issued in the IAEA Nuclear Security Series.

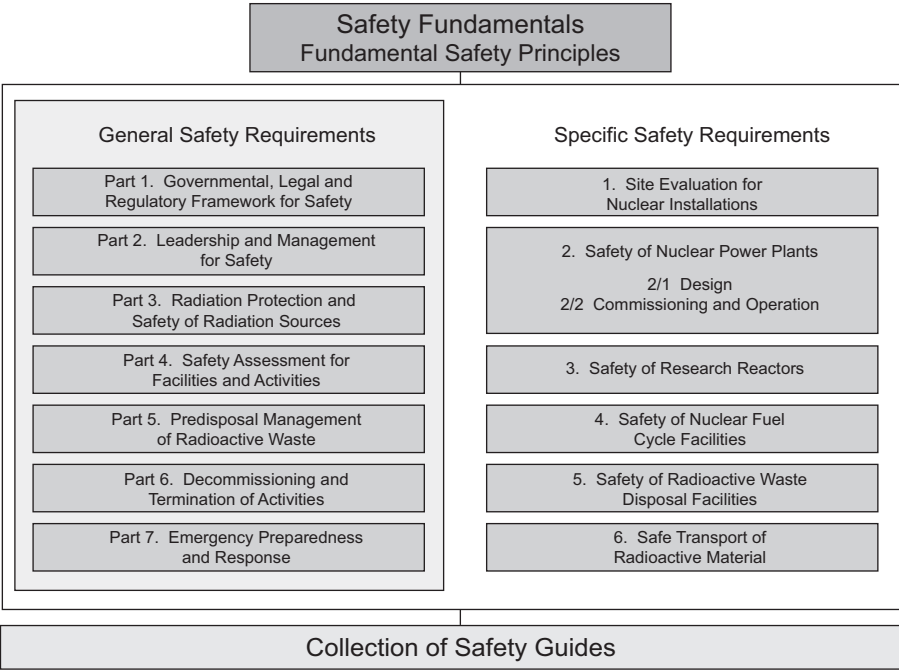


FIG. 1. The long term structure of the IAEA Safety Standards Series.

Guides present international good practices, and increasingly they reflect best practices, to help users striving to achieve high levels of safety. The recommendations provided in Safety Guides are expressed as ‘should’ statements.

APPLICATION OF THE IAEA SAFETY STANDARDS

The principal users of safety standards in IAEA Member States are regulatory bodies and other relevant national authorities. The IAEA safety standards are also used by co-sponsoring organizations and by many organizations that design, construct and operate nuclear facilities, as well as organizations involved in the use of radiation and radioactive sources.

The IAEA safety standards are applicable, as relevant, throughout the entire lifetime of all facilities and activities — existing and new — utilized for peaceful purposes and to protective actions to reduce existing radiation risks. They can be used by States as a reference for their national regulations in respect of facilities and activities.

The IAEA's Statute makes the safety standards binding on the IAEA in relation to its own operations and also on States in relation to IAEA assisted operations.

The IAEA safety standards also form the basis for the IAEA's safety review services, and they are used by the IAEA in support of competence building, including the development of educational curricula and training courses.

International conventions contain requirements similar to those in the IAEA safety standards and make them binding on contracting parties. The IAEA safety standards, supplemented by international conventions, industry standards and detailed national requirements, establish a consistent basis for protecting people and the environment. There will also be some special aspects of safety that need to be assessed at the national level. For example, many of the IAEA safety standards, in particular those addressing aspects of safety in planning or design, are intended to apply primarily to new facilities and activities. The requirements established in the IAEA safety standards might not be fully met at some existing facilities that were built to earlier standards. The way in which IAEA safety standards are to be applied to such facilities is a decision for individual States.

The scientific considerations underlying the IAEA safety standards provide an objective basis for decisions concerning safety; however, decision makers must also make informed judgements and must determine how best to balance the benefits of an action or an activity against the associated radiation risks and any other detrimental impacts to which it gives rise.

DEVELOPMENT PROCESS FOR THE IAEA SAFETY STANDARDS

The preparation and review of the safety standards involves the IAEA Secretariat and four safety standards committees, for nuclear safety (NUSSC), radiation safety (RASSC), the safety of radioactive waste (WASSC) and the safe transport of radioactive material (TRANSSC), and a Commission on Safety Standards (CSS) which oversees the IAEA safety standards programme (see Fig. 2).

All IAEA Member States may nominate experts for the safety standards committees and may provide comments on draft standards. The membership of the Commission on Safety Standards is appointed by the Director General and includes senior governmental officials having responsibility for establishing national standards.

A management system has been established for the processes of planning, developing, reviewing, revising and establishing the IAEA safety standards. It articulates the mandate of the IAEA, the vision for the future application of the

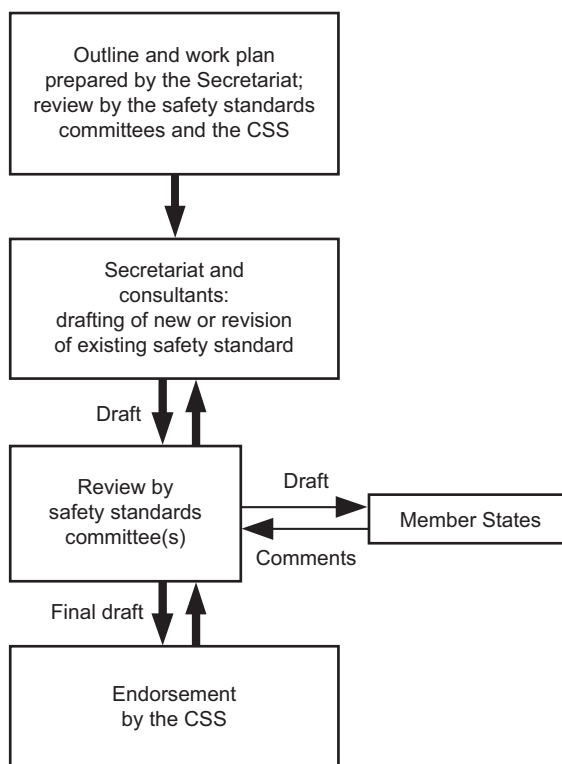


FIG. 2. The process for developing a new safety standard or revising an existing standard.

safety standards, policies and strategies, and corresponding functions and responsibilities.

INTERACTION WITH OTHER INTERNATIONAL ORGANIZATIONS

The findings of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the recommendations of international expert bodies, notably the International Commission on Radiological Protection (ICRP), are taken into account in developing the IAEA safety standards. Some safety standards are developed in cooperation with other bodies in the United Nations system or other specialized agencies, including the Food and Agriculture Organization of the United Nations, the United Nations Environment Programme, the International Labour Organization, the OECD Nuclear Energy Agency, the Pan American Health Organization and the World Health Organization.

INTERPRETATION OF THE TEXT

Safety related terms are to be understood as defined in the IAEA Safety Glossary (see <http://www-ns.iaea.org/standards/safety-glossary.htm>). Otherwise, words are used with the spellings and meanings assigned to them in the latest edition of The Concise Oxford Dictionary. For Safety Guides, the English version of the text is the authoritative version.

The background and context of each standard in the IAEA Safety Standards Series and its objective, scope and structure are explained in Section 1, Introduction, of each publication.

Material for which there is no appropriate place in the body text (e.g. material that is subsidiary to or separate from the body text, is included in support of statements in the body text, or describes methods of calculation, procedures or limits and conditions) may be presented in appendices or annexes.

An appendix, if included, is considered to form an integral part of the safety standard. Material in an appendix has the same status as the body text, and the IAEA assumes authorship of it. Annexes and footnotes to the main text, if included, are used to provide practical examples or additional information or explanation. Annexes and footnotes are not integral parts of the main text. Annex material published by the IAEA is not necessarily issued under its authorship; material under other authorship may be presented in annexes to the safety standards. Extraneous material presented in annexes is excerpted and adapted as necessary to be generally useful.

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1. INTRODUCTION

BACKGROUND

1.1. Spent nuclear fuel is generated from the operation of nuclear reactors of all types and needs to be safely managed following its removal from the reactor core. Spent fuel is considered waste in some circumstances or a potential future energy resource in others and, as such, management options may involve direct disposal (as part of what is generally known as the ‘once through fuel cycle’) or reprocessing (as part of what is generally known as the ‘closed fuel cycle’). Either management option will involve a number of steps, which will necessarily include storage of the spent fuel for some period of time. This time period for storage can differ, depending on the management strategy adopted, from a few months to several decades. The time period for storage will be a significant factor in determining the storage arrangements adopted. The final management option may not have been determined at the time of design of the storage facility, leading to some uncertainty in the storage period that will be necessary, a factor that needs to be considered in the adoption of a storage option and the design of the facility. Storage options include wet storage in some form of storage pool or dry storage in a facility or storage casks built for this purpose. Storage casks can be located in a designated area on a site or in a designated storage building. A number of different designs for both wet and dry storage have been developed and used in different States.

1.2. Irrespective of the consideration of spent fuel (either waste or an energy resource), the safety aspects for storage remain the same as those for radioactive waste, which are established in GSR Part 5 [1].

1.3. The safety of a spent fuel storage facility, and the spent fuel stored within it, is ensured by: appropriate containment of the radionuclides involved, criticality safety, heat removal, radiation shielding and retrievability. These functions are ensured by the proper siting, design, construction and commissioning of the storage facility, its proper management and safe operation. At the design stage, due consideration also needs to be given to the future decommissioning of the facility.

1.4. Spent fuel is generated continually by operating nuclear reactors. It is stored in the reactor fuel storage pool for a period of time for cooling and then may be transferred to a designated wet or dry spent fuel storage facility, where it will await reprocessing or disposal (if it is considered to be radioactive waste). The

spent fuel storage pools of some reactors have sufficient capacity to accommodate all the spent fuel that will be generated during the lifetime of the reactor.

1.5. The basic safety aspects for storage of spent fuel are applicable for the storage of spent fuel from research reactors as well as from power reactors. An approach should be adopted that takes account of the differences between the fuel types (e.g. lower heat generation, higher enrichment and cladding materials that are less corrosion resistant) when considering containment, heat removal, criticality control, radiation shielding and retrievability.

1.6. Many spent fuel storage facilities at reactors were intended to serve for a limited period of time (a few years) as a place to keep spent fuel between unloading from the reactor and its subsequent reprocessing or disposal. In view of the time being taken to develop disposal facilities and the limited reprocessing programmes that have been developed, storage periods are being extended from years to decades. This conceptual change in the management of spent fuel has been accompanied by other developments, for example increase in enrichment, increase of burnup, use of advanced fuel design and mixed oxide (MOX) fuel, re-racking, use of burnup credit and, in some cases, extension of storage periods beyond the original design lifetime of the storage facility. Nevertheless, storage cannot be considered the ultimate solution for the management of spent fuel, which requires a defined end point such as reprocessing or disposal in order to ensure safety. The design lifetime of nuclear installations is generally of the order of decades and experience with the storage of spent fuel of up to around fifty years has accrued. While design lifetimes of up to one hundred years have been considered and adopted for certain spent fuel storage facilities, in view of the rate of industrial and institutional change, periods beyond around fifty years are deemed to be ‘long term’ in the context of this Safety Guide (see also Annex I).

1.7. This Safety Guide supersedes the Safety Series publication numbers 116, 117 and 118, which were published in 1994 and covered the design, operation and safety assessment of spent fuel storage facilities, respectively. It additionally incorporates recommendations addressing the impact of the new developments described in para. 1.6. It complements the Safety Guide on storage of radioactive waste [2].

OBJECTIVE

1.8. The objective of this Safety Guide is to provide up-to-date guidance and recommendations on the design, safe operation and assessment of safety for the different types of spent nuclear fuel storage facility (wet and dry), by considering different types of spent nuclear fuel from nuclear reactors, including research reactors, and different storage periods, including storage beyond the original design lifetime of the storage facility. This Safety Guide presents guidance and recommendations on how to meet the requirements established in the following IAEA Safety Requirements publications: Predisposal Management of Radioactive Waste [1], Safety of Nuclear Fuel Cycle Facilities [3], Safety Assessment for Facilities and Activities [4] and The Management System for Facilities and Activities [5].

SCOPE

1.9. This Safety Guide covers spent nuclear fuel storage facilities that may be either collocated with other nuclear facilities (such as a nuclear power plant, research reactor or reprocessing plant) or located on their own sites. However, it is not specifically intended to cover the storage of spent nuclear fuel as long as it remains a part of the operational activities of a nuclear reactor or a spent fuel reprocessing facility.

1.10. The scope of this Safety Guide includes the storage of spent nuclear fuel from water moderated reactors and can, with due consideration, also be applied to the storage of other types of nuclear fuel, such as those from gas cooled reactors and research reactors and also to the storage of spent fuel assembly components and degraded or failed nuclear fuel¹ that may be placed in canisters.

1.11. The Safety Guide does not provide comprehensive and detailed recommendations on physical protection of nuclear material and nuclear facilities. Recommendations and guidelines on physical protection arrangements at nuclear facilities, including risk assessment, threat definition, designing, maintaining and operation of physical protection systems, evaluation of effectiveness and inspection of physical protection systems, are provided in

¹ The terms ‘degraded fuel’ or ‘failed fuel’ can cover a broad range of conditions, ranging from minor pinholes to cracked cladding to broken fuel pins. The nature and extent of failure is an important consideration.

Refs [6] and [7] and in publications in the IAEA Nuclear Security Series. The Safety Guide considers physical protection and accounting for and control of nuclear material only to highlight their potential implications for safety.

STRUCTURE

1.12. Section 2 of this Safety Guide addresses the application of the fundamental safety objective and principles and criteria to the storage of spent nuclear fuel. The roles and responsibilities of the organizations involved in the storage of spent nuclear fuel are set out in Section 3. Section 4 provides recommendations on the management systems necessary to provide assurance of safety. Section 5 provides recommendations on safety assessment and Section 6 provides recommendations on safety considerations in respect of design, construction, operation and decommissioning of spent fuel storage facilities, including considerations for long term storage. Appendix I addresses considerations specific to wet and dry storage of spent nuclear fuel and Appendix II addresses considerations in respect of spent fuel with particular characteristics. Annex I provides explanations of the concepts of short term and long term storage. Annex II summarizes safety considerations for wet and dry spent fuel storage facilities. Annex III provides an example of the sections that may be included in the operating procedures for a spent fuel storage facility. Annex IV provides an overview of related IAEA safety standards. Annexes V–VII provide listings of events for consideration in a safety assessment for a spent fuel storage facility.

1.13. For convenience, the text of each safety requirement of Ref. [1] that is applicable to the storage of spent nuclear fuel is reproduced in this Safety Guide, followed by the related recommendations.

2. PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

2.1. National requirements for radiation protection are required to be established, keeping in view the fundamental safety objective and fundamental safety principles set out in Ref. [8] and in compliance with the International Basic Safety Standards [9]. In particular, doses to persons as a consequence of the

storage of spent fuel are required to be kept within specified dose limits and radiation protection is required to be optimized within dose constraints.

2.2. If several nuclear installations (e.g. nuclear power plants, spent fuel storage facilities, reprocessing facilities) are located at the same site, the dose constraints for public exposure should take into account all sources of exposure that could be associated with activities at the site, leaving an appropriate margin for foreseeable future activities at the site that may also give rise to exposure. Particularly in such cases, the regulatory body should require the operating organization(s) of the nuclear installation(s) on the site to develop constraints, subject to regulatory approval. Alternatively, the regulatory body may establish the dose constraint(s). Requirements on dose constraints are established in Ref. [9] and recommendations are provided in Ref. [10].

2.3. The design of a spent fuel storage facility and the storage of spent fuel must be such that workers, the public and the environment, present and future, will be protected from harmful effects of radiation exposure from all sources associated with current activities with spent fuel at the site, with sufficient margins [8, 9].

2.4. Discharges to the environment from spent fuel storage facilities should be controlled in accordance with the conditions imposed by the national regulatory body and should be included when estimating doses to workers and to the public.

2.5. The adequacy of control measures taken to limit the radiation exposure of workers and the public should be verified by monitoring and surveillance, both inside and outside the facility.

2.6. In the generation and storage of spent fuel, as well as in subsequent management steps, a safety culture that encourages a questioning and learning attitude to protection and safety and that discourages complacency should be fostered and maintained [3, 5, 9, 11, 12].

3. ROLES AND RESPONSIBILITIES

GENERAL

Requirement 1 of GSR Part 5 (Ref. [1]): Legal and regulatory framework

The government shall provide for an appropriate national legal and regulatory framework within which radioactive waste management activities can be planned and safely carried out. This shall include the clear and unequivocal allocation of responsibilities, the securing of financial and other resources, and the provision of independent regulatory functions. Protection shall also be provided beyond national borders as appropriate and necessary for neighbouring States that may be affected.

Requirement 6 of GSR Part 5 (Ref. [1]): Interdependences

Interdependences among all steps in the predisposal management of radioactive waste, as well as the impact of the anticipated disposal option, shall be appropriately taken into account.

3.1. Storage of spent fuel should be undertaken within an appropriate national legal and regulatory framework that provides for a clear allocation of responsibilities [13], including responsibilities for meeting international obligations and for verifying compliance with these obligations, and which ensures the effective regulatory control of the facilities and activities concerned [1, 3]. The national legal framework should also ensure compliance with other relevant national and international legal instruments, such as the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [14].

3.2. The management of spent fuel may entail the transfer of spent fuel from one operating organization to another and various interdependences exist between the various steps in the management of spent fuel. The legal framework should include provision to ensure a clear allocation of responsibility for safety throughout the entire process, in particular with regard to storage of spent fuel and its transfer between operating organizations. Continuity of responsibility for safety should be ensured by means of a system of authorization by the regulatory

body. For transfers between States, authorizations from the respective national regulatory bodies are required [14, 15].

3.3. The responsibilities of the regulatory body², the operating organization and, when appropriate, the spent fuel owner in respect of spent fuel management should be clearly specified and functionally separate.

3.4. A mechanism for providing adequate financial resources should be established to cover any future costs, in particular, the costs associated with the spent fuel storage and decommissioning of the storage facility and also the costs of managing radioactive waste. The financial mechanism should be established before licensing and eventual operation and should be updated as necessary. Consideration should also be given to provision of the necessary financial resources in the event of premature shutdown of the spent fuel storage facility.

RESPONSIBILITIES OF THE GOVERNMENT

Requirement 2 of GSR Part 5 (Ref. [1]): National policy and strategy on radioactive waste management

To ensure the effective management and control of radioactive waste, the government shall ensure that a national policy and a strategy for radioactive waste management are established. The policy and strategy shall be appropriate for the nature and the amount of the radioactive waste in the State, shall indicate the regulatory control required, and shall consider relevant societal factors. The policy and strategy shall be compatible with the fundamental safety principles [8] and with international instruments, conventions and codes that have been ratified by the State. The national policy and strategy shall form the basis for decision making with respect to the management of radioactive waste.

3.5. The government is responsible for establishing a national policy and corresponding strategies for the management of spent fuel and for providing the legal and regulatory framework necessary to implement the policy and strategies. The policy and strategies should cover all types of spent fuel and spent fuel

² The regulatory body may be one regulatory authority or a number of regulatory authorities with responsibility for the facility or activity.

storage facility in the State, with account taken of the interdependences between the various stages of spent fuel management, the time periods involved and the options available.

3.6. The government is responsible for establishing a regulatory body independent from the owners of the spent fuel or the operating organizations managing the spent fuel, with adequate authority, power, staffing and financial resources to discharge its assigned responsibilities [13].

3.7. The government should consult interested parties (i.e. those who are involved in or are affected by spent fuel management activities) on matters relating to the development of policies and strategies that affect the management of spent fuel.

3.8. In the event that circumstances change and storage is required beyond the period originally envisaged in the national strategy, a re-evaluation of the national storage strategy should be initiated.

RESPONSIBILITIES OF THE REGULATORY BODY

Requirement 3 of GSR Part 5 (Ref. [1]): Responsibilities of the regulatory body

The regulatory body shall establish the requirements for the development of radioactive waste management facilities and activities and shall set out procedures for meeting the requirements for the various stages of the licensing process. The regulatory body shall review and assess the safety case and the environmental impact assessment for radioactive waste management facilities and activities, as prepared by the operator both prior to authorization and periodically during operation. The regulatory body shall provide for the issuing, amending, suspension or revoking of licences, subject to any necessary conditions. The regulatory body shall carry out activities to verify that the operator meets these conditions. Enforcement actions shall be taken as necessary by the regulatory body in the event of deviations from, or non-compliance with, requirements and conditions.

3.9. Regulatory responsibilities may include contributing to the technical input for the establishment of policies, safety principles and associated criteria, and for establishing regulations or conditions to serve as the basis for regulatory

activities. The regulatory body should also provide guidance to operating organizations on how to meet requirements relating to the safe storage of spent fuel.

3.10. Since spent fuel may be stored for long periods of time prior to its retrieval for reprocessing or disposal, the regulatory body should verify that the operating organization is providing the necessary personnel and the technical and financial resources for the lifetime of the spent fuel storage facility, to the extent that such confirmation is within the statutory obligations of the regulatory body.

3.11. The regulatory review of the decommissioning plans for spent fuel storage facilities should follow a graded approach, particularly considering the phases in the lifetime of the storage facility. The initial decommissioning plan should be conceptual and should be reviewed by the regulatory body for its overall completeness rather than for specific decommissioning arrangements, but should include specifically how financial and human resources and the availability of the necessary information from the design, construction and operational phases will be ensured when the decommissioning takes place. The decommissioning plan should be updated regularly by the licensee and updates should be reviewed by the regulatory body. If a facility is shut down and no longer to be used for its intended purpose, a final decommissioning plan should be submitted to the regulatory body for review and approval.

3.12. General recommendations for regulatory inspection and enforcement actions relating to spent fuel storage facilities are provided in Ref. [16]. The regulatory body should periodically verify that the key aspects of the operation of the storage facility meet the requirements of the national legal system and facility licence conditions, such as those relating to the keeping of records on inventories and material transfers, compliance with acceptance criteria for storage, maintenance, inspection, testing and surveillance, operational limits and conditions, physical protection of nuclear material and arrangements for emergency preparedness and response. Such verification may be carried out, for example, by routine inspections of the spent fuel storage facility and audits of the operating organization. The regulatory body should verify that the necessary records are prepared and that they are maintained for an appropriate period of time. A suggested list of records is included in Ref. [17].

3.13. The regulatory body should set up appropriate means of informing interested parties, such as persons living in the vicinity, the general public, information media and others, about the safety aspects (including health and environmental aspects) of the spent fuel storage facility and about regulatory

processes and should consult these parties, as appropriate, in an open and inclusive manner. The need for confidentiality (e.g. for security reasons) should be respected.

3.14. The regulatory body should consider the licensing strategy to be adopted, for example:

- (a) A licence issued for the entire lifetime of the storage system and/or facility, which encompasses the whole anticipated operating period, including periodic review of safety assessments, as elaborated in Section 5; or
- (b) A licence issued for a specified time period with the possibility for its renewal after expiry.

3.15. If the regulatory body consists of more than one authority, effective arrangements should be made to ensure that regulatory responsibilities and functions are clearly defined and coordinated, in order to avoid any omissions or unnecessary duplication and to prevent conflicting requirements being placed on the operating organization. The main regulatory functions of review and assessment and inspection and enforcement should be organized in such a way as to achieve consistency and to enable the necessary feedback and exchange of information.

RESPONSIBILITIES OF THE OPERATING ORGANIZATION³

Requirement 4 of GSR Part 5 (Ref. [1]): Responsibilities of the operator

Operators shall be responsible for the safety of predisposal radioactive waste⁴ management facilities or activities. The operator shall carry out safety assessments and shall develop a safety case, and shall ensure that the necessary activities for siting, design, construction, commissioning, operation, shutdown and decommissioning are carried out in compliance with legal and regulatory requirements.

³ The operating organization is assumed to be the licensee. If the facility is operated under contract, the interface between responsibilities of the licensee and those of the contracted operational management should be clearly defined, agreed on and documented.

⁴ As indicated in para. 1.1.1, no distinction is made in respect of safety between spent fuel considered waste or considered a resource material.

3.16. The operating organization is responsible for the safety of all activities associated with the storage of spent fuel (including activities undertaken by contractors) and for the specification and implementation of the programmes and procedures necessary to ensure safety. The operating organization should maintain a high level of safety culture and demonstrate safety. In some instances, the operating organization may be the owner of the spent fuel and in other cases the owner may be a separate organization. In the latter instance, consideration should be given to interdependences, including any activity carried out prior to receipt of the spent fuel at a storage facility, such as its characterization or packaging, or subsequent transport of the spent fuel from the facility, to ensure that conditions for safety will be met.

3.17. The responsibilities of the operating organization of a spent fuel storage facility typically include:

- (a) Application to the regulatory body for permission to site, design, construct, commission, operate, modify or decommission a spent fuel storage facility;
- (b) Conduct of appropriate safety and environmental assessments in support of the application for a licence;
- (c) Operation of the spent fuel storage facility in accordance with the requirements of the safety case, the licence conditions and the applicable regulations;
- (d) Development and application of acceptance criteria for the storage of spent fuel, as approved by the regulatory body;
- (e) Providing periodic reports as required by the regulatory body (e.g. information on the actual inventory of spent fuel, any transfers of spent fuel into and out of the facility, any events that occur at the facility and which have to be reported to the regulatory body) and communicating with interested parties and the general public.

3.18. Prior to authorization of a spent fuel storage facility, the operating organization should provide the regulatory body with a safety case⁵ that demonstrates the safety of the proposed activities and also demonstrates that the proposed activities will be in compliance with the safety requirements and criteria set out in national laws and regulations. The operating organization should use

⁵ The safety case is a collection of arguments and evidence in support of the safety of a facility or activity. This collection of arguments and evidence may be known by different names (such as safety report, safety dossier, safety file) in different States and may be presented in a single document or a series of documents (see Section 5).

the safety assessment to establish specific operational limits and conditions. The operating organization may wish to set an operational target level below these specified limits to assist in avoiding any breach of approved limits and conditions (see para. 6.106).

3.19. At an early stage in the lifetime of a spent fuel storage facility, the operating organization should prepare preliminary plans for its eventual decommissioning. For new facilities, features that will facilitate decommissioning should be taken into consideration at the design stage. Such features should be included in the decommissioning plan, together with information on arrangements regarding how the availability of the necessary human and financial resources and information will be ensured, for presentation in the safety case.

3.20. For existing facilities without a decommissioning plan, such a plan should be prepared as soon as possible. Requirements on decommissioning are established in Ref. [18] and recommendations are provided in Ref. [19].

3.21. The operating organization should establish the requirements for training and qualification of its staff and contractors, including for initial and periodic refresher training. The operating organization should ensure that all concerned staff members understand the nature of the spent fuel, its potential hazards and the relevant operating and safety procedures pertaining to it. Supervisory staff should be competent to perform their activities and should therefore be selected, trained, qualified and authorized for that purpose. A radiation protection officer should be appointed to oversee the application of radiation protection requirements.

3.22. The operating organization should carry out pre-operational tests and commissioning tests to demonstrate compliance of the storage facility and storage activities with the requirements of the safety assessment and with the safety requirements established by the regulatory body.

3.23. The operating organization should ensure that discharges of radioactive material and other potentially hazardous material to the environment are in accordance with the conditions of licence. Discharges should be documented.

3.24. The operating organization should prepare plans and implement programmes for personnel monitoring, area monitoring, environmental monitoring and for emergency preparedness and response (see para. 6.44).

3.25. The operating organization should establish a process on how to authorize and make modifications to the spent fuel storage facility, storage conditions, or the spent fuel to be stored, which is commensurate with the significance of the modifications. As part of the process, the potential consequences of such modifications should be evaluated, including consequences for the safety of other facilities and also for the retrieval, reprocessing or disposal of spent fuel.

3.26. The operating organization is required to put in place appropriate mechanisms for ensuring that sufficient financial resources are available to undertake all necessary tasks throughout the lifetime of the facility, including its decommissioning [13].

3.27. The operating organization should develop and maintain a records system on spent fuel data and on the storage system, which should include the radioactive inventory, location and characteristics of the spent fuel, information on ownership and origin and information about its characterization. An unequivocal identification system should be established, with markings that will last for the duration of the storage period. Such records should be preserved and updated, to enable the implementation of the spent fuel management strategy, whether disposal or reprocessing.

3.28. The operating organization should draw up emergency plans on the basis of the potential radiological impacts of accidents [20] and should be prepared to respond to accidents at all times, as indicated in the emergency plans (see paras 6.73 and 6.74).

RESPONSIBILITIES OF THE SPENT FUEL OWNER

Requirement 6 of GSR Part 5 (Ref. [1]): Interdependences

Interdependences among all steps in the predisposal management of radioactive waste, as well as the impact of the anticipated disposal option, shall be appropriately taken into account.

3.29. There should be clear and unequivocal ownership of the spent fuel stored in the facility. The interface between the responsibilities of the operating organization and the spent fuel owner, if they differ, should be clearly defined, agreed upon and documented. The spent fuel owner, namely, a body having legal

title to the spent fuel, including financial liabilities (usually the spent fuel producer), should be responsible for the overall strategy for the management of its spent fuel. In determining the overall strategy, the owner should take into account interdependences between all stages of spent fuel management, the options available and the overall national spent fuel management strategy. The owner should analyse the available options, justify the reasons for the approach chosen and provide the regulatory body with plans for the management of the spent fuel beyond the anticipated storage period (which should be in line with approved national policy), together with justification for the plans. These plans should be periodically updated as necessary and specifically before the end of the storage period.

3.30. Information about any changes in ownership of the spent fuel or changes in the relationship between the owner and the operating organization of a spent fuel storage facility should be provided to the regulatory body.

ACCOUNTING FOR AND CONTROL OF NUCLEAR MATERIAL AND PHYSICAL PROTECTION SYSTEMS

Requirement 21 of GSR Part 5 (Ref. [1]): System of accounting for and control of nuclear material

For facilities subject to agreements on nuclear material accounting, in the design and operation of predisposal radioactive waste management facilities the system of accounting for and control of nuclear material shall be implemented in such a way as not to compromise the safety of the facility.

Requirement 5 of GSR Part 5 (Ref. [1]): Requirements in respect of security measures

Measures shall be implemented to ensure an integrated approach to safety and security in the predisposal management of radioactive waste.

3.31. The operating organization will be required to establish, maintain and implement a system for nuclear material accounting and control as an integrated part

of the State system of accounting for and control (SSAC)⁶ of nuclear material. In addition, physical protection systems for deterrence and detection of the intrusion of unauthorized persons and for protection against sabotage from within and outside the facility will be designed and installed during the construction and operation of the spent fuel storage facility. The implications of such systems and arrangements for the safety of the facility should be assessed and it should be ensured that no safety function would be compromised nor would the overall level of safety at the facility be significantly reduced on account of such systems and arrangements.

4. MANAGEMENT SYSTEM

GENERAL

Requirement 7 of GSR Part 5 (Ref. [1]): Management systems

Management systems shall be applied for all steps and elements of the predisposal management of radioactive waste.

4.1. The requirements on management systems for all stages in the lifetime of a spent fuel storage facility are established in Ref. [5]. Recommendations on management systems related to the storage of spent fuel are provided in Ref. [21].

4.2. A management system is required to be established, implemented, assessed and continually improved by the operating organization [5] and it should be applied to all stages of the storage of spent fuel that have a bearing on safety. It should be aligned with the goals of the operating organization and should contribute to their achievement. The management system should make provision for siting, design, commissioning, operation, maintenance and decommissioning of the spent fuel storage facility. The management system should be designed to ensure that the safety of the spent fuel and of the spent fuel storage facility is maintained, and that

⁶ Safeguards agreements between the IAEA and non-nuclear-weapon States party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) contain the obligation of the State to establish and maintain a national system of accountancy for, and control of, nuclear material. The IAEA document describing the structure and content of such NPT safeguards agreements, INFCIRC/153(Corr.), also known as the 'Blue Book', sets out the basic requirement for a State's system of accounting for and control of nuclear material.

the quality of the records and of subsidiary information on spent fuel inventories is preserved, with account taken of the duration of the storage period and the consecutive management steps, for example, reprocessing or disposal. The management system should also include provision to ensure that the fulfilment of its goals can be demonstrated.

4.3. The long term nature of spent fuel management operations means that particular consideration should be given to establishing and maintaining confidence that the performance of the spent fuel storage facilities and activities will meet the safety requirements over the lifetime of the facility to the end of its decommissioning (e.g. by creation of the funding arrangements that will be necessary to manage the spent fuel in the long term).

SPENT FUEL MANAGEMENT

4.4. National and international policies and principles for spent fuel management that currently constitute an accepted management arrangement can evolve over the lifetime of the facility. Policy decisions (e.g. regarding spent fuel reprocessing) and technological innovations and advances (e.g. in partitioning and transmutation) can lead to fundamental changes in the overall spent fuel management strategy. However, the operating organization retains its responsibility for all activities at all times and continuous commitment by the organization remains a prerequisite to ensuring safety and the protection of human health and the environment.

4.5. For the plans, goals and objectives that define the strategy for achieving an integrated approach to safety, interactions with all interested parties should be considered, as well as long term aspects such as:

- (a) Provision of adequate resources (the adequacy of resources for maintenance of facilities and equipment may need to be periodically reviewed over operational periods that may extend over decades);
- (b) Preservation of technology and knowledge and transfer of such knowledge to people joining the programme or the organization in the future;
- (c) Retention or transfer of ownership of spent fuel and spent fuel management facilities;
- (d) Succession planning for the programme's or the organization's technical and managerial human resources;
- (e) Continuation of arrangements for interacting with interested parties.

RESOURCE MANAGEMENT

4.6. Spent fuel management activities will require financial and human resources and the necessary infrastructure at the site where the spent fuel storage facility is located. Senior management should be responsible for making arrangements to provide adequate resources for spent fuel management activities, to satisfy the demands imposed by the safety, health, environmental, security, quality and economic aspects of the full range of activities involved in the management of spent fuel and the potentially long duration of such activities.

4.7. Arrangements for funding of future spent fuel management activities should be specified and responsibilities, mechanisms and schedules for providing the funds should be established in due time. The generator of the spent fuel should establish an appropriate funding mechanism.

4.8. Management systems for spent fuel management activities should include provision to deal with several funding challenges:

- (a) For various reasons (e.g. bankruptcy, cessation of business), it may not be feasible to obtain the necessary funds from the spent fuel generator, especially if funds were not set aside at the time the benefits were received from the activity, or if ownership of the spent fuel has been transferred to other parties.
- (b) If funds are to come from public sources, this will compete with other demands for public funding and it may be difficult to gain access to adequate funds on a timely basis.
- (c) It may be difficult to make realistic estimates of costs for spent fuel management activities that are still in the planning stage and for which no experience has been accumulated.
- (d) It may be difficult to estimate anticipated costs for activities that will only begin in the long term, because they will depend strongly on assumptions made about future inflation rates, interest rates and technological developments.
- (e) It may be difficult to determine appropriate risk and contingency factors to be built into estimates of future costs, owing to the uncertainties associated with future changes in societal demands, political imperatives, public opinion and the nature of unplanned events that may require resources for dealing with them.

- (f) If several organizations are involved in spent fuel management activities, the necessary financial arrangements may be complex and may vary over the lifetime of the facility. It may be problematic to establish an adequate degree of confidence in all the arrangements so that the necessary continuity of funding throughout the entire series of activities is ensured.

4.9. Accumulated experience, including lessons learned from incidents and events, should be reviewed periodically and should be used in revising training programmes and in future decision making.

4.10. In the design of facilities for long term spent fuel management, consideration should be given to the incorporation of measures that will facilitate operation, maintenance of equipment and eventual decommissioning of the facility. For long term spent fuel management activities, future infrastructural requirements should be specified and plans should be made to ensure that these will be met. In such planning, consideration should be given to the continuing need for support services, spare parts for equipment that may eventually no longer be manufactured and equipment upgrades to meet new regulations and operational improvements, and to the evolution and inevitable obsolescence of software. Consideration should also be given to the need to develop monitoring programmes and inspection techniques for use during extended periods of storage.

PROCESS IMPLEMENTATION

4.11. Consideration should be given to the possible need to relocate spent fuel casks if problems arise after they have been placed in storage (e.g. threats to the integrity of casks or problems associated with criticality or decay heat). The availability of any specialized equipment that may be necessary over a long time period while spent fuel is in storage or that may be necessary in the future should be assessed.

4.12. Records concerning the spent fuel and its storage that need to be retained for an extended period should be stored in a manner that minimizes the likelihood and consequences of loss, damage or deterioration due to unpredictable events such as fire, flooding or other natural or human initiated occurrences. Storage arrangements for records should meet the requirements prescribed by the national authorities or the regulatory body and the status of the records should be periodically assessed. If records are inadvertently destroyed, the status of surviving records should be examined and the importance of their retention and their necessary retention periods should be re-evaluated.

4.13. Management systems should be reassessed whenever the relationship between the owner of the spent fuel and the operating organization of the facility changes (e.g. public organizations are privatized, new organizations are created, existing organizations are combined or restructured, responsibilities are transferred between organizations, operating organizations undergo internal reorganization of the management structure, or resources are reallocated).

5. SAFETY CASE AND SAFETY ASSESSMENT

GENERAL

Requirement 13 of GSR Part 5 (Ref. [1]): Preparation of the safety case and supporting safety assessment

The operator shall prepare a safety case and a supporting safety assessment. In the case of a step by step development, or in the event of the modification of the facility or activity, the safety case and its supporting safety assessment shall be reviewed and updated as necessary.

Requirement 14 of GSR Part 5 (Ref. [1]): Scope of the safety case and supporting safety assessment

The safety case for a predisposal radioactive waste management facility shall include a description of how all the safety aspects of the site, the design, operation, shutdown and decommissioning of the facility, and the managerial controls satisfy the regulatory requirements. The safety case and its supporting safety assessment shall demonstrate the level of protection provided and shall provide assurance to the regulatory body that safety requirements will be met.

Requirement 22 of GSR Part 5 (Ref. [1]): Existing facilities

The safety at existing facilities shall be reviewed to verify compliance with requirements. Safety related upgrades shall be made by the operator in line with national policies and as required by the regulatory body.

5.1. In demonstrating the safety of the spent fuel storage facility and related activities, a safety case should be developed as development of the facility progresses and the supporting safety assessment should be carried out in a structured and systematic manner. Proposed facilities, processes, operations, activities, and the like, should be examined to determine whether they can be implemented safely and whether they meet all requirements regarding safety. If storage casks are to be used, there may be one or separate safety cases and/or safety assessment(s) for the storage casks, the storage building or facility and the subsequent transport arrangements if the cask will be used eventually for transport as well as for storage. This will depend on the national regulatory approach. However, irrespective of the approach taken, the interdependences should be taken into consideration to ensure that an integrated approach to safety is adopted and that safety is optimized. The safety case and supporting safety assessment should provide the primary input to the licensing documentation required to demonstrate compliance with regulatory requirements [4].

5.2. The various stages in the lifetime of the spent fuel storage facility (i.e. siting, design, construction, commissioning, operation and decommissioning) should be taken into account in the safety case. The safety case should be periodically reviewed in accordance with regulatory requirements and should be revised as necessary.

5.3. The prime responsibility for safety throughout the lifetime of a facility lies with the operating organization [8]. This includes responsibility for both ensuring and demonstrating the safety of a facility in the safety case.

5.4. Long term storage (see para. 1.6 and Annex I) may involve a period of time that exceeds the normal design lifetime of civil structures, including short term storage facilities, and this will have implications for the selection of construction materials, operating methods, and quality assurance and quality control requirements, etc. Specific issues that should be given particular consideration in the safety case for a facility for long term storage of spent fuel include the anticipated lifetime of the facility, the importance of passive safety features, retrievability and management systems. Consideration should also be given to the provision of support services when the spent fuel storage facility remains in operation after other facilities at the site have been closed, in particular for storage facilities at reactor sites.

5.5. The rationale for selection of the assessment time frame should be explained and justified. Depending on the purpose of the assessment (for design studies, licensing, etc.), for ease of modelling or presentation it might be

convenient to divide the overall time frame of the safety assessment into shorter ‘time windows’ with various end points.

5.6. In determining the assessment time frame, account should be taken of the characteristics of the particular storage facility or activity, the site and the spent fuel to be stored. Other factors that should be considered include the following:

- (a) For most long term storage systems (including storage casks, engineered constructions and the surrounding environment), potential health and environmental impacts may increase for a period of time after commissioning of the facility. In the long term, depending on the nature of the facility, potential impacts may decrease, in particular through decay of the radionuclide inventory of the spent fuel. The safety assessment calculations should consider the maximum, or peak, dose or risk associated with the facility or activity.
- (b) A further consideration that may influence decisions on assessment time frames is the return period of natural external hazards, such as extreme meteorological events or earthquakes.
- (c) Several factors that can significantly affect the results of the safety assessment may change with time, including external hazards from human activities such as the construction of other facilities nearby, natural events such as changes in water levels, and changes in the availability of support facilities and infrastructure due to shutdown and decommissioning of collocated facilities. Potential changes such as these should be considered in the safety assessment. As a means to assess the possible evolution of the long term storage, one or more scenarios postulated to reflect different evolution paths may be considered in the safety assessment. Assessment time windows may be defined, as appropriate, to reflect potential changes at the storage facility.
- (d) The location, habits and characteristics of the reference person in radiological impact assessment may be changed over time. Consequently, the reference person should be considered hypothetical, but individuals and populations in the future should be afforded at least the same level of protection as that required currently. The habits and characteristics assumed for the reference person should be chosen on the basis of reasonably conservative and plausible assumptions, considering current lifestyles as well as the available site or regional environmental conditions.

5.7. The operating organization should demonstrate as soon as possible that, to the extent possible, passive safety features are applied. In the assessment of long term safety, the degradation of passive barriers over time should be taken into account.

5.8. The complementary performance of the different elements providing safety functions should be evaluated. Each element should be independent of the others, to the extent possible, to ensure that they are complementary and cannot fail through a single failure mode. The safety case should explain and justify the functions provided by each element and should identify the time periods over which they are expected to perform their various safety functions and also the alternative or additional safety functions that operate if a barrier does not fully perform.

5.9. As in the case of disposal of radioactive waste, the environment may also offer additional protective functions (e.g. underlying clay layers which would provide a sorption capacity for contaminants in the event of any leakages from the facility). Such aspects should be taken into account during the siting of the facility and should be considered in the safety case.

5.10. Storage is, by definition, an interim measure, but it can last for several decades. The intention in storing spent fuel is that it can be retrieved for reprocessing or processing and/or disposal at a later time. In the safety case, a plan for the safe handling of the spent fuel, following the period of storage, should be considered and the potential effects of degradation of the spent fuel and/or any elements of the containment on the ability to retrieve and handle the spent fuel should be assessed (see also Section 6).

5.11. The possibility of inadvertent human intrusion normally would not be considered relevant when assessing the safety of a storage facility because the facility will require continued surveillance and maintenance not only during, but also after the spent fuel emplacement phase. Prevention of intentional human intrusion requires adequate security arrangements and these should be addressed in the safety case.

5.12. As storage is an interim measure, the safety case should describe the provisions for the regular monitoring, inspection and maintenance of the storage facility to ensure its continued integrity over the anticipated lifetime of the facility.

5.13. Because of the long time frames potentially involved, a plan for adequate record keeping over the expected time frame for storage should be considered in the safety case.

5.14. Periodically, the safety case should be reviewed to assess the continuing adequacy of the storage capacity; account should be taken of the predicted spent fuel arising, the expected lifetime of the storage facility and the availability of reprocessing or disposal options.

5.15. It may be necessary to reassess the anticipated impacts of decommissioning after operational experience has been gained.

5.16. The requirement to perform safety assessment derives from national programme requirements and the realization that the safety assessment can contribute directly to safety, as through this appropriate measures are identified that can be put in place to protect workers, the public and the environment. Safety assessment is undertaken in conjunction with the planning and design of a proposed facility or activity, rather than its being a separate activity. The results of the safety assessment can be used to determine any necessary changes in the plans or design so that compliance with all requirements is ensured. The results are also used to establish controls and limitations on the design, construction and operation of the facility.

5.17. Safety assessment is typically an iterative process used to ensure that a spent fuel storage facility can be operated safely and it should be commenced early in the design process. Generally, in the control of radiation hazards, reliance should be placed principally on design features rather than on operating procedures.

5.18. Postulated initiating events that may influence the design of the spent fuel storage facility and the integrity and safety of the spent fuel should be identified. The primary causes of postulated initiating events may be credible equipment failure and operator error or human induced or natural events (both within and external to the facility). In identifying the relevant postulated initiating events, generic lists should be consulted (see Annexes III, IV and V). Such lists should not be relied on solely, since site specific environmental conditions and phenomena and the design and operation of the facility will also influence the decision as to which postulated initiating events need to be evaluated in the safety assessment.

5.19. Safety assessment should cover the storage facility and the type of spent fuel to be stored and the storage arrangements. In this regard, the types, quantities, initial enrichment, burnup, integrity, heat production, storage mode (wet or dry storage) and physical and chemical characteristics of the spent fuel represent basic elements that need to be included in the safety assessment of spent fuel storage facilities.

5.20. Safety assessment for a spent fuel storage facility should cover the expected operational period of the facility. The storage of spent fuel for long periods of time would require events of lower likelihood to be evaluated in the safety

assessment than would storage for a shorter duration. Similarly, processes that may not be relevant for a shorter duration of storage may become significant for a longer duration of storage (e.g. generation of gas, general corrosion, stress corrosion, radiation or hydride induced embrittlement of cladding material, natural processes such as vermin infestation and possible change of nuclear reactivity over a long time).

5.21. A facility specific safety case and supporting assessment should generally include aspects such as:

- (a) A description of the site and facility (including the maximum expected inventory of spent fuel and its acceptance criteria, the storage facility and its characteristics, structures, systems and components, including the characteristics of items important to the safety of the spent fuel storage facility, in accordance with the requirements of its licence) and a specification of applicable regulations and guidance.
- (b) A description of spent fuel handling and storage activities and any other operations at the facility.
- (c) Systematic identification of hazards and scenarios associated with operational states and accident conditions and external events (e.g. fires, handling accidents and seismic events).
- (d) An evaluation of hazards and scenarios, including screening of their combinations that may result in a release of radioactive material, to eliminate those of low likelihood or low potential consequences.
- (e) Assessment of the probabilities and potential consequences of the release(s) of radioactive material identified in the hazard evaluation by quantitative analysis and comparison of the results of the assessment with regulatory limitations.
- (f) Establishment of operational limits, conditions and administrative controls based on the safety assessment. If necessary, the design of the spent fuel storage facility should be modified and the safety assessment should be updated. Such controls should include acceptance criteria for spent fuel casks, including canisters containing failed fuel.
- (g) Documentation of safety analyses and the safety assessment for inclusion in the documentation supporting the licensing of the facility.
- (h) The commissioning programme.
- (i) Organizational control of operations.
- (j) Procedures and operational manuals for activities with significant safety implications.
- (k) A programme for periodic maintenance, inspection and testing.