

IAEA Safety Standards

for protecting people and the environment

Safety of Nuclear Fuel Cycle Facilities

Specific Safety Requirements No. SSR-4



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International Atomic Energy Agency



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IAEA SAFETY STANDARDS AND RELATED PUBLICATIONS

IAEA SAFETY STANDARDS

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

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

Information on the IAEA's safety standards programme is available on the IAEA Internet site

<http://www-ns.iaea.org/standards/>

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

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

RELATED PUBLICATIONS

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

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

Other safety related IAEA publications are issued as **Emergency Preparedness and Response** publications, **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.

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

The **IAEA Nuclear Energy Series** comprises informational publications to encourage and assist research on, and the development and practical application of, nuclear energy for peaceful purposes. It includes reports and guides on the status of and advances in technology, and on experience, good practices and practical examples in the areas of nuclear power, the nuclear fuel cycle, radioactive waste management and decommissioning.

SAFETY OF NUCLEAR FUEL CYCLE FACILITIES



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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".

IAEA SAFETY STANDARDS SERIES No. SSR-4

SAFETY OF NUCLEAR FUEL CYCLE FACILITIES

SPECIFIC SAFETY REQUIREMENTS

This publication includes a CD-ROM containing the IAEA Safety Glossary:
2007 Edition (2007) and the Fundamental Safety Principles (2006),
each in Arabic, Chinese, English, French, Russian and Spanish versions.

The CD-ROM is also available for purchase separately.

See: <http://www-pub.iaea.org/books>

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2017

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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.

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.

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

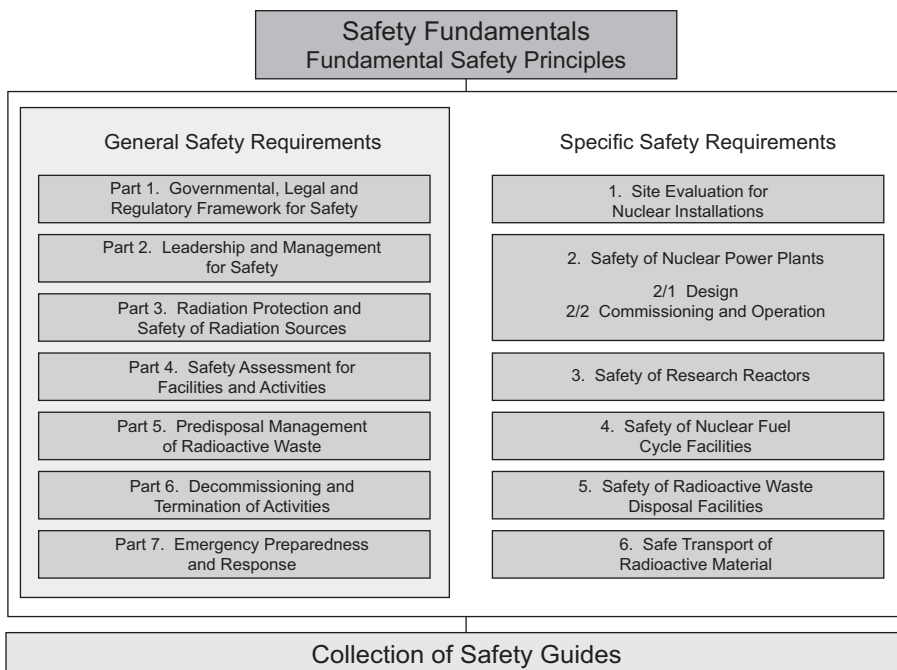


FIG. 1. The long term structure of the IAEA Safety Standards Series.

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 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 five safety standards committees, for emergency preparedness and response (EPReSC) (as of 2016), 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

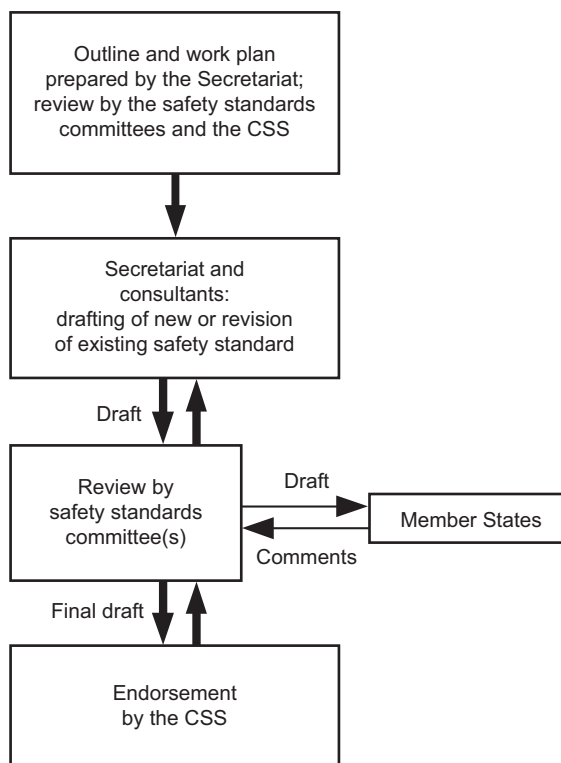


FIG. 2. The process for developing a new safety standard or revising an existing standard.

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 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. This Safety Requirements publication establishes requirements for all the important areas of safety in all stages of the lifetime of a nuclear fuel cycle facility, including design and operation and all activities performed to achieve the purpose for which the facility was constructed. These activities include maintenance, in-service inspection and other associated activities, as well as the processing of radioactive material from its introduction to the facility to its exit from the facility. This publication supersedes the Safety Requirements publication, IAEA Safety Standards Series No. NS-R-5, Safety of Nuclear Fuel Cycle Facilities, issued in 2008 and revised and reissued with additional appendices in 2014.¹

1.2. Requirements for nuclear safety are intended to ensure the highest level of safety that can reasonably be achieved for the protection of workers, the public and the environment from harmful effects of ionizing radiation arising from nuclear facilities [1]. It is recognized that technology and scientific knowledge advance, and that nuclear safety and the adequacy of protection against radiation risks need to be considered in the context of the present state of knowledge. This Safety Requirements publication reflects the present international consensus and the experience of IAEA Member States from using the previous edition.

1.3. In this publication, nuclear fuel cycle facilities are nuclear installations, other than nuclear power plants, research reactors and critical assemblies, in which nuclear material and radioactive material are processed, handled, stored and prepared for disposal, in quantities or concentrations that pose potential hazards to personnel, the public and the environment. Nuclear fuel cycle facilities include facilities for:

- (a) Mining and processing of uranium and thorium ores;
- (b) Conversion and enrichment of uranium;
- (c) Reconversion and fabrication of nuclear fuels of all types;
- (d) Interim storage of fissile material and fertile material before and after irradiation;
- (e) Production of nuclear energy for power, research and other purposes;

¹ INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Fuel Cycle Facilities, IAEA Safety Standards Series No. NS-R-5 (Rev. 1), IAEA, Vienna (2014).

- (f) Reprocessing of spent nuclear fuel and breeder materials from thermal reactors and fast reactors;
- (g) Associated waste conditioning, effluent treatment and facilities for interim storage of waste that allow for retrieval of the waste for later disposal;
- (h) Separation of radionuclides from irradiated thorium and uranium;
- (i) Related research and development.

Requirements for nuclear power plants, research reactors and critical assemblies, facilities for the mining and processing of natural ore and waste disposal facilities are established in other IAEA safety standards and therefore are not addressed in this publication.

1.4. Nuclear fuel cycle facilities employ many diverse technologies and processes. Radioactive material is often processed through a series of interconnected units and consequently can be found throughout an entire facility. The physical and chemical forms of the processed material may also vary within a single facility. Some of the processes use hazardous chemical substances and gases, which may be toxic, corrosive, combustible or reactive and consequently may give rise to the need for specific requirements in addition to requirements for nuclear safety. For example, the reactive chemicals used in many nuclear fuel cycle facilities can cause exothermic reactions that may need to be controlled to prevent effects such as overheating, fire or explosion. A further feature specific to nuclear fuel cycle facilities is that they are often characterized by frequent changes in the mode of operation, in equipment and in processes. Operations at nuclear fuel cycle facilities generally require more operator intervention than operations at nuclear reactors, which may result in specific hazards for personnel. On the other hand, the overall hazard to the public from many nuclear fuel cycle facilities can be low. The nature and diversity of the processes associated with nuclear fuel cycle facilities result in a broad range of hazardous conditions and possible accidents that need to be considered in the safety analysis. In view of the wide range of facilities and hazards, requirements established in this publication are to be applied using a graded approach where stated [1].

OBJECTIVE

1.5. The objective of this publication is to establish a basis for safety and for safety assessment for all stages in the lifetime of a nuclear fuel cycle facility by establishing requirements for site evaluation, design, construction, commissioning, operation and preparation for decommissioning that must be satisfied to ensure safety.

1.6. This publication is intended for use by organizations involved in the design, manufacture, construction, modification, maintenance, operation and decommissioning of nuclear fuel cycle facilities, in safety analysis, verification and review and in the provision of technical support, as well as by regulatory bodies. Particular emphasis is given to safety requirements for design and operation including commissioning.

1.7. This publication also provides references to other IAEA Safety Requirements publications on aspects relating to regulatory supervision, management of safety, and site evaluation for nuclear fuel cycle facilities. This publication is intended to be used in conjunction with these related IAEA Safety Requirements publications and with IAEA Safety Guides, which provide recommendations on meeting these requirements for specific facility types and specific activities.

SCOPE

1.8. This Safety Requirements publication applies to nuclear fuel cycle facilities of all types and sizes, including facilities for the processing, refining, conversion, enrichment, and fabrication of fuel, the storage of spent nuclear fuel and the reprocessing of spent nuclear fuel, nuclear fuel cycle research and development facilities and supporting ancillary facilities in which radioactive material is handled. The scope of this publication extends from uranium refining and conversion to the storage of radioactive waste prior to disposal. Facilities for the mining and processing of natural ore, nuclear power plants, research reactors, critical assemblies and waste disposal facilities are outside the scope of this publication. The types of radioactive material covered by these requirements include nuclear material used as fissile or fertile fuel in thermal and fast reactors. In addition to processed uranium, such materials include plutonium, MOX (mixed uranium oxide, UO_2 , and plutonium oxide, PuO_2) fuel, thorium breeder material and other types of experimental fuel. Facility specific requirements for the predisposal management of waste and the management of effluents containing radioactive material and associated hazardous chemicals are also included. The processes and hazards at facilities that produce isotopes by chemical separation from nuclear material can be similar to the processes and hazards at facilities for the processing and reprocessing of nuclear fuel. The requirements of this publication relating to criticality safety and confinement can also be applied to these processes, in accordance with a graded approach.

1.9. The safety requirements established in this publication are to be applied for new nuclear fuel cycle facilities and are also to be applied to existing nuclear fuel cycle facilities to the extent practicable.

1.10. In view of the broad diversity of facilities and operations covered, the requirements established in this publication are to be applied in a manner that is commensurate with the potential hazard for each facility, in accordance with a graded approach. Each case in which the application of the requirements is to be graded shall be identified, with account taken of the nature and possible magnitude of the hazards presented by the given facility and the activities conducted (see Section 2).

1.11. This publication does not address:

- (a) Requirements that are specifically covered in other IAEA Safety Requirements publications (e.g. Refs [2–6]), except in requiring a graded approach to the application of some of these other requirements.
- (b) Matters relating to nuclear security (other than requirements on the interfaces between nuclear safety and nuclear security, which are established in Section 11) or to the State system of accounting for, and control of, nuclear material.
- (c) Conventional industrial safety matters that under no circumstances could interfere with the nuclear safety of the nuclear fuel cycle facility. (For instance, a diesel spillage during transfer of diesel generator fuel is not addressed if it could not affect the nuclear safety of the facility, but a release of HF due to the escape and hydrolysis of UF_6 is addressed.)

1.12. If a particular nuclear fuel cycle facility or activity involving radioactive material does not conform exactly to the scope or description provided in para. 1.8, the safety requirements established in this publication still apply as a basis for establishing specific requirements.

1.13. Terms in this publication are to be understood as defined and explained in the IAEA Safety Glossary [7], unless otherwise stated (see Definitions).

STRUCTURE

1.14. Section 2 of this publication, which draws on IAEA Safety Standards Series No. SF-1 [1], Fundamental Safety Principles, introduces the general safety objective, concepts and principles for the safety of nuclear installations, with emphasis on the radiation safety and nuclear safety aspects of nuclear fuel cycle facilities. Section 3, which draws on IAEA Safety Standards Series No. GSR Part 1 (Rev. 1), Governmental, Legal and Regulatory Framework for Safety [3], establishes the general requirements on the legal and regulatory infrastructure as far as these are relevant for nuclear fuel cycle facilities. Section 4 establishes the requirements relating to the management and verification of safety. This section is based on IAEA Safety Standards Series No. GSR Part 2, Leadership and Management for Safety [4]. Section 5 establishes the requirements for site evaluation for new and existing nuclear fuel cycle facilities. This section is based on IAEA Safety Standards Series No. NS-R-3 (Rev. 1), Site Evaluation for Nuclear Installations [5]. Section 6 establishes the requirements for safety assessment for the safe design of all types of nuclear fuel cycle facility. It applies to new facilities and can also be applied in reviewing the safety of existing facilities. Section 7 establishes the requirements for construction of a nuclear fuel cycle facility. Section 8 establishes the requirements for the commissioning process. It also establishes requirements for a phased transition from inactive commissioning to active commissioning, when the requirements for operation first apply. Sections 7 and 8 can also be applied to modifications of existing facilities, in accordance with a graded approach.

1.15. Section 9 establishes the requirements for the safe operation of a nuclear fuel cycle facility, including maintenance, utilization and modification. It also covers requirements for records and reports for a nuclear fuel cycle facility, which are also applicable at other stages in the lifetime of a facility. Section 10 establishes the requirements for the preparation for the safe decommissioning of a nuclear fuel cycle facility on the basis of IAEA Safety Standards Series No. GSR Part 6, Decommissioning of Facilities [8], while Section 11 establishes the requirements for the interfaces between safety and security. The Appendix provides lists of postulated initiating events to be considered in the safety analysis for a nuclear fuel cycle facility. The Annex provides information on establishing risk criteria for safety.

2. APPLYING THE SAFETY OBJECTIVE, CONCEPTS AND PRINCIPLES FOR NUCLEAR FUEL CYCLE FACILITIES

GENERAL

2.1. SF-1 [1] establishes the fundamental safety objective and ten safety principles that provide the basis for requirements and measures to protect workers, the public and the environment from harmful effects of ionizing radiation and for the safety of facilities and activities that give rise to radiation risks. Restricting the likelihood of events that might lead to a loss of control of subcriticality or loss of confinement of radioactive material, or radiation exposures of people, also requires control over chemical hazards and other non-radiological hazards of nuclear fuel cycle facilities.

FUNDAMENTAL SAFETY OBJECTIVE

2.2. The fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation. Paragraph 2.1 of SF-1 [1] states that:

“This fundamental safety objective of protecting people — individually and collectively — and the environment has to be achieved without unduly limiting the operation of facilities or the conduct of activities that give rise to radiation risks. To ensure that facilities are operated and activities conducted so as to achieve the highest standards of safety that can reasonably be achieved, measures have to be taken:

- (a) To control the radiation exposure of people and the release of radioactive material to the environment;
- (b) 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;
- (c) To mitigate the consequences of such events if they were to occur.”

2.3. Paragraph 2.2 of SF-1 [1] states that:

“The fundamental safety objective applies for all facilities and activities and for all stages over the lifetime of a facility or radiation source, including planning, siting, design, manufacturing, construction, commissioning and operation, as well as decommissioning and closure. This includes the associated transport of radioactive material and management of radioactive waste.”

This objective applies in all facility states². In this publication, ‘manufacturing’ refers to the manufacture of components important for the safety of the facility, and ‘transport’ includes transport on the site. IAEA safety requirements for off-site transport are established in IAEA Safety Standards Series No. SSR-6, Regulations for the Safe Transport of Radioactive Material [9]. Requirements for the closure of a waste repository are established in IAEA Safety Standards Series No. SSR-5, Disposal of Radioactive Waste [10].

2.4. In the context of nuclear fuel cycle facilities, non-radiological hazards associated with the radioactive material in the facility also need to be controlled, in order to minimize risks to workers, the public and the environment. Events initiated by chemical hazards and the toxic chemicals that are used in the facility can have a significant bearing on achieving the fundamental safety objective. Industrial hazards associated with radioactive material need to be considered in the design, commissioning and operation of the facility. Activities at nuclear fuel cycle facilities may also include industrial processes that pose additional hazards to safe nuclear operations, site personnel and to the environment. Purely industrial hazards also need to be considered where these can interfere with the nuclear safety of the facility.

FUNDAMENTAL SAFETY PRINCIPLES

2.5. Paragraph 2.3 of SF-1 [1] states that:

“Ten safety principles have been formulated, on the basis of which safety requirements are developed and safety measures are to be implemented in order to achieve the fundamental safety objective. The safety principles form a set that is applicable in its entirety; although in practice different

² See Definitions.

principles may be more or less important in relation to particular circumstances, the appropriate application of all relevant principles is required.”

2.6. The requirements presented in this publication are derived from the fundamental safety objective of protecting people and the environment, and the related safety principles [1]:

Principle 1: Responsibility for safety

The prime responsibility for safety must rest with the person or organization³ responsible for facilities and activities that give rise to radiation risks.

Principle 2: Role of government

An effective legal and governmental framework for safety, including an independent regulatory body, must be established and sustained.

Principle 3: 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.

Principle 4: Justification of facilities and activities

Facilities and activities that give rise to radiation risks must yield an overall benefit.

Principle 5: Optimization of protection

Protection must be optimized to provide the highest level of safety that can reasonably be achieved.

Principle 6: Limitation of risks to individuals

Measures for controlling radiation risks must ensure that no individual bears an unacceptable risk of harm.

³ For nuclear fuel cycle facilities, this is the operating organization.

Principle 7: Protection of present and future generations

People and the environment, present and future, must be protected against radiation risks.

Principle 8: Prevention of accidents

All practical efforts must be made to prevent and mitigate nuclear or radiation accidents.

Principle 9: Emergency preparedness and response

Arrangements must be made for emergency preparedness and response for nuclear or radiation incidents.

Principle 10: Protective actions to reduce existing or unregulated radiation risks

Protective actions to reduce existing or unregulated radiation risks must be justified and optimized.

The requirements derived from these principles must be applied to minimize and control the radiation risks to workers and site personnel, the public and the environment.

RADIATION PROTECTION

2.7. In order to satisfy the safety principles, it is required to ensure that for all operational states (normal operation and anticipated operational occurrences) of a nuclear fuel cycle facility, doses from exposure to radiation within the facility or exposure due to radioactive discharges are kept within operational limits and below the dose limits and as low as reasonably achievable (protection and safety is required to be optimized [2]).

2.8. To apply the safety principles, nuclear fuel cycle facilities are required to be designed and operated so as to keep all sources of radiation and all nuclear material under strict technical and administrative control (see Requirement 57). However, these principles do not preclude limited exposures or the release of authorized amounts of radioactive materials to the environment from the facility in operational states. Such exposures and radioactive releases are required to be

strictly controlled, to be measured or estimated, to be recorded and to be kept as low as reasonably achievable, in compliance with regulatory and operational limits as well as radiation protection requirements.

2.9. Although measures are taken to limit radiation exposure in all operational states to levels that are as low as reasonably achievable and to minimize the likelihood of an event that could lead to the loss of normal control over the source of radiation, there will remain a probability — albeit very low — that an accident could happen. Therefore, emergency arrangements are required to be in place to ensure that the consequences of any accident that does occur are mitigated. Such measures and arrangements include: engineered safety features; safety features for design extension conditions⁴; on-site emergency arrangements established by the operating organization; and, where necessary, off-site emergency arrangements established by the appropriate authorities in accordance with IAEA Safety Standards Series No. GSR Part 7, Preparedness and Response for a Nuclear or Radiological Emergency [6].

CONCEPT OF DEFENCE IN DEPTH

2.10. The primary means of preventing accidents at a nuclear fuel cycle facility and mitigating the consequences of accidents if they do occur is the application of the concept of defence in depth (SF-1 [1], Principle 8). This concept is applied to all safety related activities, whether organizational, behavioural or design related, in all operational states, and including activities with chemical hazards. This is to ensure that all safety related activities are subject to independent layers of protection (or barriers), so that if a failure were to occur in any one of these layers, it would be detected and compensated for or corrected through the successful application of measures in the other layers.

2.11. Application of the concept of defence in depth throughout design and operation provides protection against transients, anticipated operational occurrences and accidents, including those resulting from equipment failure or human action within the installation, and events induced by external hazards.

⁴ See Requirement 21 and Definitions.

2.12. Paragraph 3.31 of SF-1 [1] states that:

“Defence in depth is implemented primarily through the combination of a number of consecutive and independent levels of protection that would have to fail before harmful effects could be caused to people or to the environment. If one level of protection or barrier were to fail, the subsequent level or barrier would be available.... The independent effectiveness of the different levels of defence is a necessary element of defence in depth.”

A graded approach is applied to the concept of defence in depth in nuclear fuel cycle facilities. There are five levels of defence:

- (1) The purpose of the first level of defence is to prevent deviations from normal operation and the failure of items important to safety. This leads to requirements that the facility be soundly and conservatively sited, designed, constructed, maintained, operated and modified in accordance with a management system and appropriate and proven engineering practices. To meet these requirements, careful attention is paid to the selection of appropriate design codes and materials, and to the quality control of the manufacture of components and construction of the facility, as well as to its commissioning. Design options, including the selection of processes, that reduce the potential for internal hazards also contribute to the prevention of accidents at this level of defence. Attention is also paid to the processes and procedures involved in design, manufacture, construction and in-service inspection, maintenance and testing, to the ease of access for these activities, and to the way the facility is operated and to how operating experience is utilized. This process is supported by a detailed analysis that determines the requirements for operation and maintenance of the facility and the requirements for quality management for operational and maintenance practices.
- (2) The purpose of the second level of defence is to detect and control deviations from operational states in order to prevent anticipated operational occurrences at the facility from escalating to accident conditions⁵. This is in recognition of the fact that postulated initiating events are likely to occur over the operating lifetime of a nuclear fuel cycle facility, despite the care taken to prevent them. This second level of defence necessitates the provision of specific systems and features in the design, the confirmation of their effectiveness through safety analysis, and the establishing of operating

⁵ See Definitions.

procedures to prevent such initiating events, or else to minimize their consequences, and to return the facility to a safe state.

- (3) For the third level of defence, it is assumed that, although very unlikely, the escalation of certain anticipated operational occurrences or postulated initiating events might not be controlled at a preceding level and that an accident could occur. In the design of the facility, such accidents are postulated to occur. This leads to the requirement that inherent and/or engineered safety features, fail-safe design and procedures be provided to control the consequences of such accidents. Such engineered safety features will be capable of preventing extensive damage to the facility or significant off-site releases and returning the facility to a safe state, and maintaining at least one physical barrier for the confinement of radioactive material. This barrier may be provided by a combination of a 'static' barrier with a complementary 'dynamic' barrier (e.g. a ventilation system), which together provide effective confinement of radioactive material. The most important objective for this level is to prevent releases of radioactive material and associated hazardous material or radiation levels that require off-site protective actions.
- (4) The purpose of the fourth level of defence is to mitigate the consequences of accidents that result from failure of the third level of defence in depth. The most important objective for this level is to ensure that the confinement function is maintained, thus ensuring that radioactive releases are kept as low as reasonably achievable.
- (5) The purpose of the fifth level of defence is to mitigate the radiological consequences and associated chemical consequences of releases or radiation levels that could potentially result from accidents. This requires the provision of adequately equipped emergency response facilities and emergency plans and emergency procedures for on-site and off-site emergency response.

2.13. In the application of the concept of defence in depth, the chemical hazards associated with the radioactive material (i.e. dangerous properties arising from the chemistry of radioactive materials or as a consequence of activities at the facility) need to be taken into account at every level of defence. The potential interaction of multiple facilities or multiple accidents on the same site also needs to be considered at the fourth and fifth levels of defence where applicable.

2.14. The safety philosophy that is followed to fulfil the objective and principles stated in SF-1 [1] relies on the concept of defence in depth and on the adoption of measures for the management and verification of safety over the entire lifetime of the nuclear fuel cycle facility. In addition to automatic control, many nuclear

fuel cycle facilities rely on operator actions to maintain and control the safety of radioactive material throughout the facility. The safety philosophy addresses the means with which the organization supports individuals and groups in performing their tasks safely, taking the interactions between humans, technology and organizational aspects into account. The awareness by individuals of safety matters and the commitment of individuals to safety, and where appropriate the effective leadership and management of safety, are therefore essential to the proper application of the concept of defence in depth.

GRADED APPROACH

2.15. Nuclear fuel cycle facilities are of diverse natures and types. Their design and operating characteristics may differ significantly and present a variety of different hazards. Where certain hazards are demonstrated to be non-existent or very small, application of some features or procedures required for other higher hazard facilities may be less relevant or important. Because nuclear fuel cycle facilities present a greater range of hazards than do power reactors, a graded approach can be used in the application of certain identified requirements of this publication (see Requirement 11).

3. REGULATORY SUPERVISION FOR NUCLEAR FUEL CYCLE FACILITIES

LEGISLATIVE AND REGULATORY INFRASTRUCTURE

3.1. According to SF-1 [1], the government is responsible for the adoption of legislation that assigns the prime responsibility for safety to the operating organization and for the establishment of a regulatory body responsible for systems of authorization and inspection⁶, for the regulatory control of nuclear activities and for the enforcement of the legislation, regulations and conditions of the authorization. These principles are established in section 3 (Principles 1 and 2) of SF-1 [1].

⁶ See Requirements 23, 27 and 28 of GSR Part 1 (Rev. 1) [3].

3.2. General requirements to fulfil these principles are established in GSR Part 1 (Rev. 1) [3], which covers the essential aspects of the governmental and legal framework for establishing a regulatory body and for taking actions necessary to ensure the effective regulatory control of facilities and activities — existing and new — utilized for peaceful purposes. Other responsibilities and functions are also covered, such as liaison within the global safety regime and liaison for providing the necessary support services for the purposes of safety (including radiation protection), emergency preparedness and response, and the interfaces with nuclear security⁷ (see GSR Part 1 (Rev. 1) [3] and Ref. [11]) and with the State system of accounting for and control of nuclear material. These general requirements apply to the general legal and governmental infrastructure for the safety of nuclear fuel cycle facilities during site evaluation, design, construction, commissioning, operation, modification and preparation for decommissioning. A graded approach commensurate with the potential hazards of the facility shall be used in the application of these requirements (see para. 2.15).

AUTHORIZATION PROCESS

3.3. Different types of authorization are required to be obtained for the different stages in the lifetime of a facility [3]. The authorization process may differ among States but the stages in the lifetime of a nuclear fuel cycle facility usually include the following:

- (1) Site evaluation;
- (2) Design;
- (3) Construction;
- (4) Commissioning;
- (5) Operation, including utilization and modification;⁸
- (6) Shutdown;
- (7) Decommissioning;
- (8) Release from regulatory control.

⁷ The IAEA issues guidance on nuclear security in the IAEA Nuclear Security Series.

⁸ Although the utilization and modification of nuclear fuel cycle facilities are activities that are normally included under operation, in some cases they are considered separate stages in the authorization process, since their safety implications give rise to a large amount of review and assessment activities that are repeated a number of times over the lifetime of the facility (see Requirement 5).

3.4. In some cases, several stages may be authorized by a single licence, with conditions attached to control the subsequent stages. Other stages, such as the termination of operation, could be required by the regulatory body.

Requirement 1: Licensing documentation

The operating organization shall demonstrate the safety of its facility through a set of documents known as the licensing documentation (or safety case). The licensing documentation shall provide a basis for the safety of the facility at all stages of its lifetime and shall be updated periodically, to take account of modifications made to the facility and other changes. The licensing documentation shall be considered by the regulatory body in determining whether the authorizations necessary under national legislative and regulatory requirements are to be granted.

3.5. The licensing documentation shall include an adequate safety analysis report and the operational limits and conditions, as well as any other information required by the regulatory body. The licensing documentation shall provide a detailed demonstration of the safety of the facility and shall form the basis of all decisions relating to the safety of the facility that are made by the operating organization; thus it forms an important link between the operating organization and the regulatory body.

3.6. The safety analysis report shall describe all activities with safety significance in appropriate detail, including any restrictions on inputs to and outputs from the facility. It shall describe the application of the safety principles and criteria in the design for the protection of workers, the public and the environment. The safety analysis report shall contain an analysis of the hazards associated with the operation of the facility and shall demonstrate compliance with the regulatory requirements and criteria. It shall also contain analyses of accidents and of the safety features incorporated in the design for preventing accidents or minimizing the likelihood of their occurrence and for mitigating their consequences in accordance with the concept of defence in depth.

3.7. The safety functions, associated safety limits and items important to safety shall be identified in the safety analysis report, which shall also provide details about the operating organization, the conduct of operations and the management system throughout the lifetime of the nuclear fuel cycle facility. The licensing documentation shall provide details of the emergency arrangements for the facility.

3.8. The level of detail in the information to be presented in the safety analysis report shall be determined using a graded approach. The safety analysis report shall cite additional references that may be necessary for its thorough review and assessment. The referenced material shall be made readily available to the regulatory body. In all cases, the safety analysis report shall cover all the topics identified in paras 3.6 and 3.7.

3.9. The licensing documentation shall specify the required intervals for periodic testing and inspection of items important to safety. Consideration of the application of the principle of optimization of protection (Principle 5 of SF-1 [1]) in the design and operation of the facility shall be included in the licensing documentation.

3.10. The operating organization shall give adequate notice to the regulatory body of its intent to move from one stage to another in the lifetime of the facility. Decisions on the need for authorization shall be documented by the regulatory body, which shall assess the licensing documentation prior to granting an authorization. The operating organization shall submit the licensing documentation to the regulatory body in support of its application for authorization of the facility or activity. A schedule for the submission of documents for review and assessment for the stages in the authorization process shall be agreed between the regulatory body and operating organization.

3.11. The regulatory body shall base subsequent authorization for stages in the lifetime of the facility on relevant objectives, principles and associated criteria for safety to ensure that the facility presents no undue radiation risks to the personnel at the site, the public and the environment. The regulatory body shall take account of associated chemical hazards and security advice when making its assessment. The specific objectives of the regulatory review and assessment are provided in GSR Part 1 (Rev. 1) [3]. The review and assessment by the regulatory body shall be commensurate with the potential magnitude of the hazard associated with the facility in accordance with a graded approach.

Criteria for judging safety

3.12. Each State shall develop its approach to criteria for judging safety, in accordance with its particular legal and regulatory infrastructure. The criteria for judging safety shall be based on principles for safe design and operation and shall be made available to the operating organization, ideally before the nuclear

fuel cycle facility project commences. The Annex to this publication illustrates the concept of criteria for judging safety, expressed in terms of the relationship between the likelihood of an event occurring and the consequences of the event.

INSPECTION AND ENFORCEMENT

3.13. Paragraph 2.5 of GSR Part 1 (Rev. 1) [3] states that the governmental, legal and regulatory framework for safety “shall set out ... Provision for the inspection of facilities and activities, and for the enforcement of regulations, in accordance with a graded approach”.

3.14. Paragraph 4.50 of GSR Part 1 (Rev. 1) [3] states that:

“The regulatory body shall develop and implement a programme of inspection of facilities and activities, to confirm compliance with regulatory requirements and with any conditions specified in the authorization. In this programme, it shall specify the types of regulatory inspection (including scheduled inspections and unannounced inspections), and shall stipulate the frequency of inspections and the areas and programmes to be inspected, in accordance with a graded approach.”

3.15. Requirement 30 of GSR Part 1 (Rev. 1) [3] states that:

“The regulatory body shall establish and implement an enforcement policy within the legal framework for responding to non-compliance by authorized parties with regulatory requirements or with any conditions specified in the authorization.”

3.16. If there is evidence of non-compliance or if risks are identified, including risks unforeseen in the authorization process, enforcement actions as described in para. 4.55 of GSR Part 1 (Rev. 1) [3] shall be taken.

4. MANAGEMENT AND VERIFICATION OF SAFETY FOR A NUCLEAR FUEL CYCLE FACILITY

RESPONSIBILITY FOR SAFETY

Requirement 2: Responsibilities in management for safety

The operating organization shall have the prime responsibility for the safety of a nuclear fuel cycle facility over its lifetime. This responsibility includes ensuring that the design meets all applicable safety requirements.

4.1. The operating organization and all other organizations engaged in activities important to the safety of a nuclear fuel cycle facility shall be responsible for ensuring that safety matters are given the highest priority. The operating organization shall possess the necessary competence to ensure that the facility meets all applicable safety requirements and shall retain responsibility for safety when contracting out any processes, including the design or other analysis.

4.2. In order to ensure rigour and thoroughness by individuals at all levels in the achievement and maintenance of safety in all activities, the operating organization:

- (a) Shall clearly define responsibilities and accountabilities for safety with corresponding lines of authority and communication and shall ensure that individuals are not given other business roles that conflict with their responsibilities for safety;
- (b) Shall ensure that it has sufficient qualified individuals with appropriate experience at all levels;
- (c) Shall foster a strong safety culture and shall strictly adhere to sound procedures for all activities that may affect safety, ensuring that managers and supervisors promote and support good safety practices and correct poor safety practices;
- (d) Shall review, monitor and audit⁹ all safety related matters on a regular basis and shall implement appropriate corrective actions where necessary;

⁹ Independent assessments such as audits or surveillance are carried out to determine the extent to which the requirements for the management system are met, to evaluate the effectiveness of the management system and to identify opportunities for improvement. They can be conducted by or on behalf of the organization itself for internal purposes, by interested parties such as customers, by the regulatory body (or by other persons on its behalf), or by independent external organizations.

- (e) Shall allocate adequate financial resources to ensure safety, including provision for financial resources for decommissioning where these are not provided by the government.

4.3. The operating organization shall prepare a detailed demonstration of safety, which shall include an adequate safety analysis, at each stage in the lifetime of the facility. The safety analysis at each stage shall include an adequate demonstration of how the operating organization intends to discharge its responsibility for safety at all subsequent stages in the lifetime of the nuclear fuel cycle facility.

4.4. In a timely manner, the operating organization shall submit to the regulatory body any information that it has requested. The operating organization shall inform the regulatory body of any additional new information and of significant changes to information submitted previously. All information provided by the operating organization to the regulatory body shall be complete and accurate. The format and content of the safety documentation submitted to the regulatory body by the operating organization in support of the application for authorization shall be consistent with the requirements established in this publication.

Requirement 3: Safety policy

The operating organization shall establish and implement safety, health and environmental policies that give protection and safety the overriding priority warranted by their significance.

4.5. The safety policy established and implemented by the operating organization shall give safety the utmost priority, overriding all other demands, including those of facility production and project schedules or research and development programmes. The safety policy shall promote a strong safety culture, including a questioning attitude and a commitment to excellent performance in all activities important to safety. Managers shall promote an attitude of safety consciousness among individuals in the organization (see Ref. [12]).

4.6. The safety policy shall stipulate clearly the leadership role of the highest level of management in safety matters. Senior management¹⁰ shall be responsible for communicating and implementing the provisions of the safety policy throughout the organization. All individuals in the organization shall be made

¹⁰ Senior management is the person or group assigned by the organization that directs, controls and assesses an organization at the highest level [7].

aware of the safety policy and of their responsibilities for ensuring safety. The behavioural expectations of senior management shall be clearly communicated to all individuals, including external support organizations and contractors, and it shall be ensured that such expectations are understood by all those who are expected to meet them.

4.7. The safety policy of the operating organization shall include a commitment to achieving enhancements in operational safety. The strategy of the operating organization for enhancing safety and for finding more effective ways of meeting safety standards shall be continuously monitored, periodically revised and supported by means of a clearly specified programme with clear objectives and targets.

MANAGEMENT SYSTEM

Requirement 4: Management system

The operating organization shall establish, implement, assess and continuously improve an integrated management system for ensuring that all safety requirements are met at all stages of the lifetime of the nuclear fuel cycle facility.

4.8. The operating organization shall establish and apply a single coherent management system in which all the constituents of the organization, including its structure, resources and processes, are integrated to enable the organization's objectives to be achieved.¹¹ The requirements for an integrated management system for facilities and activities are established in GSR Part 2 [4]. These requirements and the associated objectives and principles shall be taken into account in the development and implementation of the management system for a nuclear fuel cycle facility on the basis of the importance to safety of each item, service or process. The extent of development and application of the management system shall be determined in accordance with a graded approach for a particular nuclear fuel cycle facility.

4.9. The operating organization shall ensure through the establishment and application of the management system that the nuclear fuel cycle facility is sited,

¹¹ This system integrates all elements of management, including safety, health, environmental, security, quality, human-and-organizational-factor, societal and economic elements, so that safety is not compromised.

designed, constructed, commissioned, operated and decommissioned in a safe manner and within operational limits and conditions identified in the licensing documentation such as the safety analysis report.

4.10. Management arrangements shall be developed and established in a timely manner before transitions between major stages in the lifetime of the nuclear fuel cycle facility. In particular, activities for site investigation, which are usually initiated a long time before the establishment of a project, shall be covered by the management system.

4.11. The management system shall include all the elements of management so that processes and activities important to safety are established and conducted coherently with other requirements, including those relating to leadership, human performance, security, quality, protection of health and protection of the environment. The management system shall implement the safety policy.

4.12. The management system shall identify and include the following requirements:

- (a) The relevant statutory and regulatory requirements of the State;
- (b) Any requirements agreed with interested parties;
- (c) Relevant IAEA safety standards on matters not addressed by points (a) and (b).

4.13. The documentation of the management system shall be reviewed and made subject to approval¹² at appropriate levels of management in the operating organization and shall be submitted for review and assessment by the regulatory body if so required.

4.14. The provisions of the management system shall be based on four functional categories: management responsibility; resource management; process implementation; and measurement, assessment and improvement.

Management responsibility

4.15. Management responsibility includes planning, implementing and providing the means and support necessary to achieve the organization's objectives. Before

¹² In this publication, approval can be mean either approval by the management of the operating organization or approval by the regulatory body, unless otherwise specified.

major decisions affecting safety are taken, management shall seek independent advice and the agreement of the regulatory body where necessary. In this regard, the management system shall include provisions for ensuring effective communication and clear assignment of responsibilities, in which accountabilities are unambiguously assigned to individual roles within the organization and to suppliers, to ensure that processes and activities important to safety are controlled and performed in a manner that ensures that safety objectives are achieved.

Resource management

4.16. Resource management includes measures to ensure that the resources essential to the implementation of safety policy and the enhancement of safety and the achievement of the organization's objectives are identified and made available. The management system shall ensure that:

- (a) The operating organization is resourced with sufficient qualified personnel for the safe operation of the facility.
- (b) Suppliers, manufacturers and designers of items important to safety have an effective management system in place.
- (c) External personnel (including suppliers of both materials and services) are adequately qualified and are performing their activities under the same controls and to the same standards as the facility personnel.
- (d) Equipment, tools, materials, hardware and software necessary to operate the facility at all stages of its lifetime in a safe manner are specified, supplied, checked, verified and maintained in accordance with the management system.

Process implementation

4.17. Process implementation includes the actions and tasks necessary to achieve an appropriate level of quality, in accordance with a graded approach. Such actions and tasks include identification of the processes of the management system, and determination of the sequences in and interaction between those processes.

4.18. The management system shall include provisions to ensure that the design, including subsequent changes, modifications or safety improvements, construction, commissioning, operational activities, and decommissioning of the nuclear fuel cycle facility are carried out in accordance with established codes,

standards, specifications, procedures and administrative controls¹³. Means of detecting and correcting deficiencies in any of these activities shall be provided. Items and services important to safety shall be specified and controlled to ensure their proper use, maintenance and configuration. The use of computer codes for the justification of the safety of the facility, and their validation and verification (e.g. tests and experiments), shall be covered by the management system.

4.19. For the manufacturing, installation and construction of items important to safety for the nuclear fuel cycle facility, processes shall be established to ensure that the relevant regulations and safety requirements are met and that the construction work is properly carried out. The processes shall be such as to allow the operating organization to ensure that the fabrication and construction of items important to safety are performed in accordance with the design intent and regulatory requirements (see Requirement 13).

4.20. As part of the management system, processes for the control of modifications shall be established, and graded in accordance with the safety significance of the modification. These processes shall cover the design, review, assessment and approval, fabrication, testing and implementation of a modification project. Relevant procedures describing the processes shall be put into effect by the operating organization before the commissioning stage of the nuclear fuel cycle facility. For nuclear fuel cycle research and development facilities, the activities of the utilization programme (including new experiments) shall be subjected to the same requirements as those for modifications.

4.21. Where a nuclear fuel cycle facility imports nuclear, toxic or flammable materials or generates products, waste or effluents, any safety implications of these materials and of any on-site transfer of these materials shall be covered by the processes of the management system, in accordance with a graded approach. The requirements for the transport of radioactive material off the site are established in SSR-6 [9].

4.22. The management system shall ensure that items and services under procurement meet established design, quality and performance criteria. Suppliers shall be evaluated and selected on the basis of specified criteria, which shall be periodically reviewed and the suppliers then re-evaluated. Requirements for reporting deviations from procurement specifications shall be specified in

¹³ In this publication, administrative controls are instructions for modifying the actions of individuals and groups of personnel for the purposes of maintaining or enhancing safety.

the procurement documents. Evidence that purchased items and services meet procurement specifications shall be made available for verification before the items are used or the services are provided.

Measurement, assessment, evaluation and improvement

4.23. Measurement, assessment and evaluation provide an indication of the effectiveness of management processes and work performance. The effectiveness of the management system shall be periodically assessed through audits. Weaknesses in processes and performance shall be identified and corrective actions shall be taken in a timely manner. The operating organization shall evaluate the results of such audits and shall determine and implement the necessary actions for continuous improvement.

VERIFICATION OF SAFETY

Requirement 5: Safety assessment and periodic safety review

The adequacy of the design of the nuclear fuel cycle facility shall be verified by means of comprehensive safety assessment that results in a safety analysis report and that defines the operational limits and conditions required for safety. The safety of the facility or activity for all facility states shall be assessed in the safety analysis and shall be independently reviewed. The operating organization shall conduct systematic safety assessments of the facility, in accordance with regulatory requirements, throughout the lifetime of the facility. On the basis of the results of such periodic safety reviews, the operating organization shall implement any necessary corrective actions and shall consider the need for modifications to enhance safety.

4.24. Requirements for safety assessment for facilities and activities are established in IAEA Safety Standards Series No. GSR Part 4 (Rev. 1), Safety Assessment for Facilities and Activities [13]. The adequacy of the design of the nuclear fuel cycle facility, including design tools and design inputs and outputs, shall be verified, validated and approved using a systematic safety assessment process. The safety assessment process shall be undertaken by individuals or groups independent from those who originally carried out the design work. Verification, validation and approval of the facility design shall be completed as early as is practicable in the design and construction processes, and in any case before commissioning of the facility is commenced. The verification that takes

place before validation under active conditions shall be sufficiently rigorous to support decisions of safety significance.

4.25. Safety assessment shall be part of the design process, with iterations made between the design activities and the confirmatory analytical activities and with increasing scope and level of detail of the safety assessment as the design progresses. The basis for the safety assessment in the design stage shall be the information derived from the safety analysis (see Section 6) as well as information from other sources such as research and operating experience at other facilities. If non-permanent equipment is important for safety, it shall be included in the analysis.

4.26. In accordance with national regulatory requirements, the operating organization shall carry out systematic periodic safety reviews of the nuclear fuel cycle facility throughout its lifetime, with account taken of ageing, modifications, human and organizational factors, operating experience, technical developments, new information on site evaluation and other information relating to safety from other sources. The operating organization shall verify by analysis, surveillance, testing and inspection that the physical state of the facility, including any modifications, is as described in the safety analysis report and other safety documents and that the facility was commissioned and is operated in accordance with the safety analysis and operational limits and conditions.

4.27. The periodic safety review shall confirm that the safety analysis report and other documents (such as the operational limits and conditions and documentation on maintenance and training) remain valid in view of current regulatory requirements, or shall indicate where improvements may be necessary. In such reviews, changes in the site characteristics, changes in the utilization programme (particularly for research and development facilities), the cumulative effects of ageing and modifications, changes to procedures, feedback from operating experience and technical developments shall be considered. It shall also be verified that items and software important to safety comply with the design requirements.

4.28. The findings of safety assessments and periodic safety reviews shall be considered by the safety committee (see Requirement 6). The operating organization shall report to the regulatory body as required, in a timely manner, the confirmed findings of the periodic safety review that have implications for safety. Any modifications that arise from these findings shall be implemented in a timely manner, in accordance with the safety categorization of the modification.

Requirement 6: Safety committee

An independent safety committee (or an advisory group) shall be established to advise the management of the operating organization on all safety aspects of the nuclear fuel cycle facility.

4.29. The operating organization shall establish one or more internal safety committees (or advisory groups) to advise the management of the operating organization on safety issues relating to the commissioning, operation and modification of the facility. The safety committee shall have among its membership experts with the necessary breadth of knowledge and experience to provide appropriate advice. The committee shall be independent of the regulatory body and its membership shall, to the extent practicable, be independent of the operations management.¹⁴

4.30. The functions, responsibilities, composition and terms of reference of the safety committee shall be documented and, if required, shall be submitted to the regulatory body. For a new facility, the safety committee¹⁵ shall be fully functioning before active commissioning commences.

4.31. A list of items that the safety committee is required to review shall also be established. The list shall include, for example, the following:

- (a) Proposed changes in any operational limits and conditions for the facility;
- (b) Proposed new tests, equipment, systems or procedures that have significance for safety;
- (c) Commissioning plans and results;
- (d) Proposed modifications (temporary or permanent) to processes, structures, systems or components that may have significance for safety;
- (e) Where applicable, violations of operational limits and conditions, of the licence and of procedures that are significant to safety;
- (f) Events that are required to be reported or that have been reported to the regulatory body, other than occasional false alarms;
- (g) The findings of periodic reviews of the operational performance and safety performance of the facility;

¹⁴ The membership of the safety committee may differ with facility type and the chairperson could be the facility manager.

¹⁵ In some States a different advisory group (or another safety committee) is established to advise management of the operating organization on the safety aspects of the day-to-day operation of the facility.

- (h) Reports on routine releases of radioactive material to the environment;
- (i) Reports on radiation exposure of personnel at the facility and of the public;
- (j) The decommissioning plan;
- (k) Safety reports to be provided to the regulatory body;
- (l) Reports on regulatory inspections for safety.

4.32. The management system shall include provisions to ensure that relevant aspects of the facility design, changes to the design, operating procedures, organizational structure and safety assessment are subject to an appropriate level of review by the safety committee.

4.33. Where the volume of work or a multifacility site requires that more than one safety committee be established, the management system shall include provisions to ensure that the committees' considerations and advice are complementary, consistent and coherent and that safety is not compromised. The scope of the agenda and frequency of meetings by the safety committee shall be established in accordance with a graded approach.

5. SITE EVALUATION FOR NUCLEAR FUEL CYCLE FACILITIES

SITE EVALUATION

5.1. The main safety objective in site evaluation for a nuclear fuel cycle facility is the protection of the public and the protection of the environment against the radiological and associated chemical hazards arising from normal and accidental releases of radioactive material (see NS-R-3 (Rev. 1) [5]). This requires the identification and assessment of site characteristics affecting, or potentially affecting, the facility and the effects that the facility has, or may have, on its surroundings. Information shall be collected in sufficient detail to support the safety analysis to demonstrate that the facility can be safely operated at the site. The site evaluation may constitute the first part of the development of the licensing documentation for a new facility, or it may form part of a safety reassessment for redevelopment or for licence renewal. The results of the site evaluation shall be documented and presented in sufficient detail to permit an independent assessment by the regulatory body.

5.2. In the evaluation of the suitability of a site for a nuclear fuel cycle facility, the following aspects shall be considered:

- (a) The effects of external events occurring in the region of the particular site (external events could be of natural origin or human induced and may originate on the site, see NS-R-3 (Rev. 1) [5]);
- (b) The characteristics of the site and its environment that could influence the transfer to persons and to the environment of radioactive material that has been released;
- (c) The population density and population distribution and other characteristics of the surrounding area, for specifying off-site emergency planning zones and emergency planning distances, as specified in GSR Part 7 [6], and the need to evaluate the risks to individuals and to the population;
- (d) The interface between nuclear security and nuclear safety;
- (e) For facilities handling self-heating materials, the capability for an ultimate heat sink;
- (f) Other factors determined by the government, which may include public acceptability.

5.3. The site evaluation shall be graded such that the amount of detail required for facilities where the intrinsic hazard is low (e.g. a natural uranium fuel fabrication facility) can be substantially less than the amount of detail required for a medium or high hazard facility (e.g. a light water reactor fuel fabrication facility or a reprocessing facility). The area covered by the site evaluation and the amount of detail in the evaluation shall provide sufficient factual evidence to define safety performance criteria for the facility. For the site evaluation, the following requirements apply:

- (a) Environmental characteristics of the area that may potentially be affected by the radiological impact and the associated chemical impact¹⁶ of the facility in all facility states shall be investigated. An appropriate monitoring system shall be designed to verify the predicted environmental impact.
- (b) The possible locations near the facility where radioactive material and other hazardous material could be discharged or could otherwise pass into the environment shall be investigated. Hydrological and hydrogeological investigations shall be carried out to assess, to the extent necessary, the dilution and dispersion characteristics of water bodies. The models used

¹⁶ In this publication, the radiological and associated chemical or toxicological impact on the environment are collectively termed the ‘environmental impact’.