

IAEA Safety Standards

for protecting people and the environment

Safety of Research Reactors

Specific Safety Requirements No. SSR-3



IAEA

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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.

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

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

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SAFETY OF RESEARCH REACTORS



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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-3

SAFETY OF RESEARCH REACTORS

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, 2016

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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.

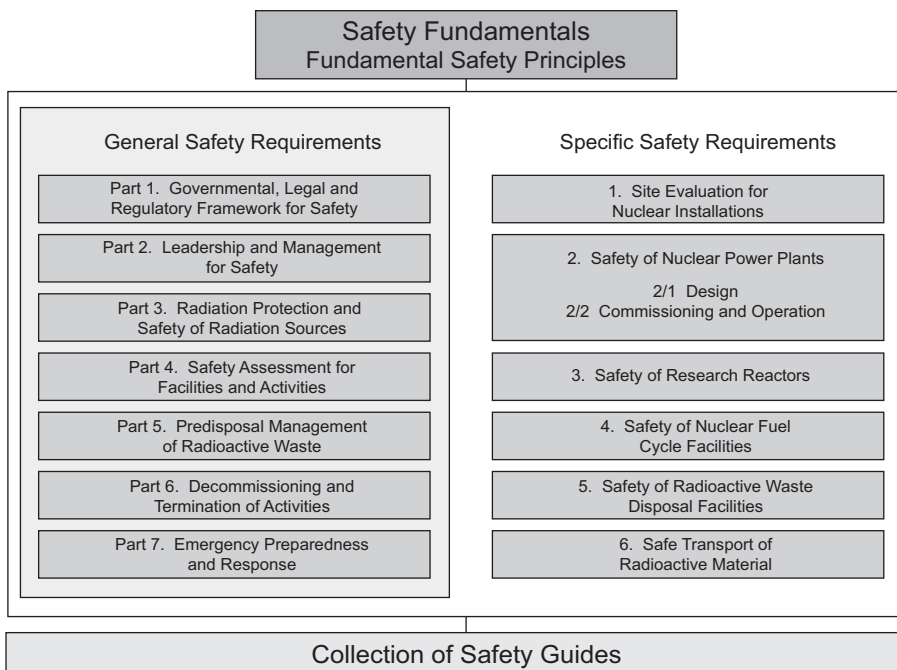


FIG. 1. The long term structure of the IAEA Safety Standards Series.

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

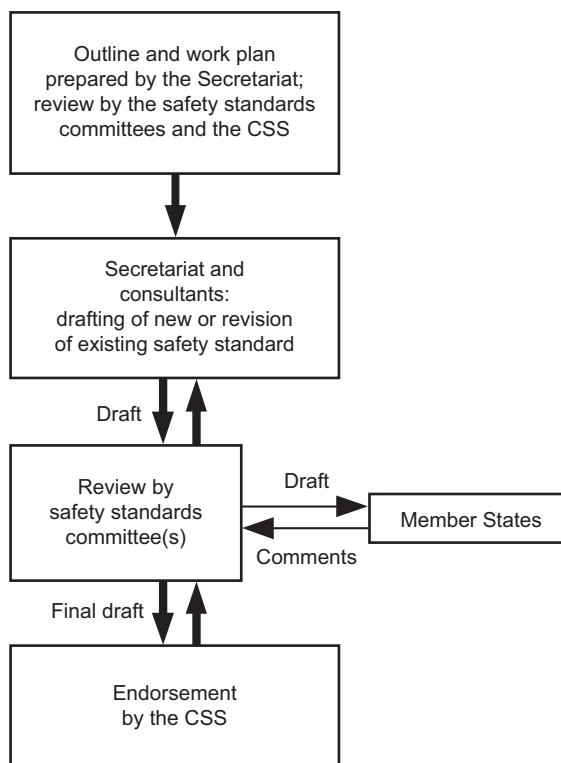


FIG. 2. The process for developing a new safety standard or revising an existing standard.

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 publication supersedes the Safety Requirements publication Safety of Research Reactors,¹ which was issued in 2005 as IAEA Safety Standards Series No. NS-R-4. Account has been taken of IAEA Safety Standards Series No. SF-1, Fundamental Safety Principles [1], published in 2006. Requirements for nuclear safety are intended to ensure the highest level of safety that can reasonably be achieved for the protection of workers and other on-site personnel, and the public, and the protection of the environment from harmful effects of ionizing radiation arising from nuclear facilities. 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. Safety requirements will change over time; this Safety Requirements publication reflects the present international consensus.

1.2. This Safety Requirements publication establishes requirements for all the important areas of the safety of research reactors, with particular emphasis on requirements for design and operation².

1.3. A number of requirements for the safety of nuclear research reactors are the same as, or similar to, those for nuclear power reactors. In view of the important differences between power reactors and research reactors and between the different types of research reactor,³ including critical assemblies and

¹ INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Research Reactors, IAEA Safety Standards Series No. NS-R-4, IAEA, Vienna (2005).

² The important areas of research reactor safety include all activities performed to achieve the purpose for which the research reactor was designed and constructed or modified. This includes: maintenance, testing and inspection; fuel handling and handling of radioactive material (including the production of radioisotopes); the installation, testing and operation of experimental devices; the use of neutron beams; research and development work and education and training using the research reactor systems; and other associated activities.

³ A research reactor is a nuclear reactor used mainly for the generation and utilization of neutron flux and ionizing radiation for research and other purposes, including experimental facilities associated with the reactor and storage, handling and treatment facilities for radioactive materials on the same site that are directly related to safe operation of the research reactor. Facilities commonly known as critical assemblies and subcritical assemblies are included.

subcritical assemblies, these requirements are to be applied in accordance with the potential hazards associated with the reactor by means of a graded approach (see paras 2.15–2.17 and IAEA Safety Standards Series No. SSG-22, Use of a Graded Approach in the Application of the Safety Requirements for Research Reactors [2]).

OBJECTIVE

1.4. The main objective of this Safety Requirements publication is to provide a basis for safety and for safety assessment for all stages in the lifetime of a research reactor by establishing requirements on aspects relating to regulatory supervision, management for safety, site⁴ evaluation, design, manufacture, construction, commissioning, operation, including utilization and modification, and planning for decommissioning.

1.5. Technical and administrative requirements for the safety of research reactors are established in accordance with this objective. This publication is intended for use by organizations involved in the design, manufacture, construction, operation, modification, maintenance and decommissioning of research reactors, in safety analysis, verification and review, and in the provision of technical support, as well as by regulatory bodies.

SCOPE

1.6. The safety requirements established in this publication are applicable for the site evaluation, design, manufacture, construction, commissioning, operation, including utilization and modification, and decommissioning of research reactors, including critical assemblies and subcritical assemblies. The safety requirements established in this publication are also to be applied to existing research reactors to the extent practicable.

⁴ Within this context, the site area is the geographical area that contains an authorized facility, authorized activity or radiation source, and within which the management of the authorized facility or authorized activity may directly initiate emergency actions. The site boundary is the perimeter of the site area.

1.7. For the purposes of this publication, a research reactor is a nuclear reactor (including critical assemblies and subcritical assemblies) used for nuclear research and for the generation and utilization of radiation for research and other purposes. This definition excludes nuclear reactors used for the production of electricity, naval propulsion, desalination or district heating. The term covers the reactor core, radioactive sources used, experimental devices⁵, all systems needed for their operation, installations managed by the facility that contain nuclear material (irradiated or not), and radioactive waste management facilities and all other facilities relevant to either the reactor or its associated experimental facilities and devices located on the reactor site.

1.8. Research reactors with power levels in excess of several tens of megawatts, fast reactors and reactors using experimental devices such as high pressure and temperature loops and cold or hot neutron sources may require the application of supplementary measures or even the application of requirements for power reactors and/or additional safety measures (e.g. in the case of reactors used for testing hazardous material). For such facilities, the requirements (and engineering standards) to be applied, the extent of their application and any additional safety measures that may need to be taken are required to be proposed by the operating organization and to be subject to approval by the regulatory body. Homogeneous reactors and accelerator driven systems are out of the scope of this publication.

1.9. All the requirements established here are to be applied unless it can be justified that, for a specific research reactor, critical assembly or subcritical assembly, the application of certain requirements may be graded. Each case in which the application of requirements is 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. Hereafter, subcritical assemblies will be mentioned separately only if a specific requirement is not relevant for, or is applicable only to, subcritical assemblies. Paragraph 2.17 sets out factors to be considered in deciding whether the application of certain requirements established here may be graded.

⁵ For the purposes of this safety standard, the term experimental devices includes devices installed in or around a reactor to utilize the neutron flux and ionizing radiation from the reactor for research, development, isotope production or any other purpose.

1.10. This publication does not address:

- (a) Requirements that are specifically covered in other IAEA Safety Requirements publications (e.g. Refs [3–7]);
- (b) Matters relating to nuclear security (other than the interfaces between nuclear safety and nuclear security, addressed in Section 9) or to the State system of accounting for, and control of, nuclear material;
- (c) Conventional industrial safety matters that under no circumstances could affect the safety of the research reactor;
- (d) Non-radiological impacts arising from the operation of the research reactor facility.

1.11. Terms in this publication are to be understood as defined and explained in the IAEA Safety Glossary [8], unless otherwise stated (see Definitions).

STRUCTURE

1.12. This Safety Requirements publication follows the relationship between the safety objective and safety principles, and between requirements for nuclear safety functions and design criteria and operational criteria for safety. It consists of nine sections, two appendices and two annexes. Section 2, which draws on SF-1 [1], introduces the general safety objectives, concepts and principles for the safety of nuclear installations, with emphasis on the radiation safety and nuclear safety aspects of research reactors. Section 3, which draws on IAEA Safety Standards Series No. GSR Part 1 (Rev. 1), Governmental, Legal and Regulatory Framework for Safety [3], deals with the general requirements on legal and regulatory infrastructure as far as these are relevant for research reactors. Section 4 deals with requirements on topics 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 requirements regarding the evaluation and selection of the research reactor site and deals with the evaluation of new sites and the sites of existing research reactor 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 requirements for the safe design of all types of research reactor, with account taken of the considerations mentioned in paras 1.8 and 1.9. Coherence is ensured with the Safety Requirements publication on the same subject for nuclear power plants, IAEA Safety Standards Series No. SSR-2/1 (Rev. 1), Safety

of Nuclear Power Plants: Design [9]. Section 7 establishes requirements for the safe operation of research reactors, including commissioning, maintenance, utilization and modification. Coherence is likewise ensured with the Safety Requirements publication on the same subject for nuclear power plants, IAEA Safety Standards Series No. SSR-2/2 (Rev. 1), Safety of Nuclear Power Plants: Commissioning and Operation [10]. Section 8 establishes requirements for the preparation of the safe decommissioning of research reactors on the basis of IAEA Safety Standards Series No. GSR Part 6, Decommissioning of Facilities [11], while Section 9 establishes requirements for the interfaces between safety and security. Appendix I provides a list of the selected postulated initiating events to be considered in the safety analysis for a research reactor. Appendix II deals with the operational aspects warranting particular consideration. Annex I lists selected safety functions of the safety systems for research reactors and of other safety related items usually included in the design of research reactor. Annex II provides an overview of the application of the safety requirements to subcritical assemblies.

2. APPLYING THE SAFETY OBJECTIVE, CONCEPTS AND PRINCIPLES FOR RESEARCH REACTOR FACILITIES

GENERAL

2.1. SF-1 [1] establishes the fundamental safety objective and ten fundamental safety principles that provide the basis for requirements and measures to protect people and the environment from harmful effects of ionizing radiation and for the safety of facilities and activities that give rise to radiation risks.

FUNDAMENTAL SAFETY OBJECTIVE

2.2. The fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation. This fundamental safety objective has to be achieved, and the ten safety principles have to be applied, without unduly limiting the operation of facilities or the conduct of activities that give rise to radiation risks. To ensure that research reactors are operated and activities are conducted to achieve the highest standards of safety that can reasonably be

achieved, measures have to be taken to achieve the following (see para. 2.1 of SF-1 [1]):

- “(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 [and utilization], as well as decommissioning and closure. This includes the associated transport of radioactive material and management of radioactive waste.”

FUNDAMENTAL SAFETY PRINCIPLES

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

2.5. 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 organization⁶ 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.

Principle 7: Protection of present and future generations

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

⁶ For research reactor facilities, this is the operating organization.

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 other personnel, the public and the environment.

RADIATION PROTECTION

2.6. In order to satisfy the safety principles, it is required that, for all operational states of a research reactor and for any associated activities including experiments, doses from exposure to radiation within the research reactor facility or exposure due to any planned radioactive release from the facility be kept below the dose limits and kept as low as reasonably achievable (protection and safety is required to be optimized [7]).

2.7. To apply the safety principles, it is also required that research reactors be designed and operated so as to keep all sources of radiation under strict technical and administrative control. However, these principles do not preclude limited exposures or the release of authorized amounts of radioactive substances to the environment from the research reactor facility in operational states. Such exposures and radioactive releases are required to be strictly controlled, 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.

2.8. 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. Emergency arrangements shall therefore be applied to ensure that the consequences of any accident that do occur are mitigated. Such measures and arrangements include: engineered safety features; safety features for design extension conditions; on-site emergency plans and procedures established by the operating organization; and possibly off-site emergency intervention measures put in place 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].

2.9. The safety philosophy that is followed to meet the 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 research reactor facility. The safety philosophy addresses the means with which the organization supports individuals and groups to perform their tasks safely, with account taken of the interactions between humans, technology and organizational aspects.

CONCEPT OF DEFENCE IN DEPTH

2.10. The primary means of preventing accidents in a research reactor facility and mitigating the consequences of accidents if they do occur is the application of the concept of defence in depth. This concept is applied to all safety related activities, whether organizational, behavioural or design related, in all operational states.

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

2.12. Application of the concept of defence in depth in the design of a research reactor provides a series of levels of defence (based on inherent features, equipment and procedures) that are aimed at preventing accidents and ensuring adequate protection of people and the environment against harmful effects of radiation and mitigation of the consequences in the event that an accident does occur. Paragraph 3.31 of SF-1 [1] states that “The independent effectiveness of the different levels of defence is a necessary element of defence in depth.”

However, the concept of defence in depth shall be applied with account taken of the graded approach. 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 the requirement that the research reactor facility shall be soundly and conservatively sited, designed, constructed, operated and maintained, in accordance with the management system and proven engineering practices, such as the application of redundancy, independence and diversity. To meet this objective, careful attention is paid to the selection of appropriate design codes and materials, and control of the fabrication of components and control of the construction, commissioning, operation and maintenance of the research reactor.
- (2) The purpose of the second level of defence is to detect and control deviations from normal operational states in order to prevent anticipated operational occurrences from escalating to accident conditions. This is in recognition of the fact that some postulated initiating events are likely to occur at some point over the operating lifetime of the research reactor, despite the precautions taken to prevent them. This level of defence necessitates the provision of specific systems and features in the design, as determined in the safety analysis, and the establishment of operating procedures to prevent or minimize damage resulting from such postulated initiating events.
- (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 of defence and a more serious event may develop. These unlikely events are anticipated in the design basis for the research reactor, and inherent safety features, fail-safe design, additional equipment and procedures are provided to control their consequences and to achieve stable and acceptable states of the research reactor facility following such events. This leads to the requirement that engineered safety features be capable of transferring the research reactor first to a controlled state and subsequently to a safe state. The radiological objective is to have no, or only a minor, off-site radiological impact.
- (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. 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 and final level of defence is to mitigate the radiological consequences of radioactive releases that could potentially result from accidents. This requires the provision of adequately equipped emergency response facilities and emergency plans and procedures for on-site and, if necessary, off-site emergency response.

2.13. A relevant aspect of the application of the concept of defence in depth for a research reactor is to include in the design a series of physical barriers, as well as a combination of active, passive and inherent safety features that contribute to the effectiveness of the physical barriers in confining radioactive material at specified locations. The number of barriers that will be necessary will depend upon the potential source term in terms of the amount and the isotopic composition of the radionuclides, the effectiveness of the individual barriers, the possible internal and external hazards, and the potential consequences of barrier failures.

2.14. The defence in depth concept is applied mainly through the safety analysis and the use of sound engineering practices based on research and operating experience. This analysis is carried out in the design to ensure that the safety objectives are met. It includes a systematic critical review of the ways in which the research reactor structures, systems and components could fail and identifies the consequences of such failures. The safety analysis examines: all planned normal operational modes of the research reactor facility; and its performance in anticipated operational occurrences, design basis accident conditions and if necessary, event sequences that may lead to design extension conditions (see Requirement 22 and paras 6.64–6.68). Requirements for the safety analysis of the design are presented in paras 6.119–6.125. These analyses are independently reviewed by the operating organization and by the regulatory body (see paras 3.1–3.3).

GRADED APPROACH

2.15. Research reactors are used for special and varied purposes, such as research, training, education, radioisotope production, neutron radiography and materials testing. These purposes call for different design features and different operational regimes. Design and operating characteristics of research reactors may vary significantly, since the use of experimental devices may affect the performance of reactors. In addition, the need for flexibility in their use requires a different approach to achieving and managing safety.

2.16. Most research reactors give rise to fewer potential hazards to the public than nuclear power plants, but they may pose greater potential hazards to operators, researchers and other users owing to the relative ease of access to radiation or radioactive materials. Qualitative categorization of the facility shall be performed on the basis of the potential hazard associated with the research reactor (see SSG-22 [2]).

2.17. The factors to be considered in deciding whether the application of certain requirements established here may be graded include:

- (a) The reactor power;
- (b) The potential source term;
- (c) The amount and enrichment of fissile and fissionable material;
- (d) Spent fuel elements, high pressure systems, heating systems and the storage of flammable materials, which may affect the safety of the reactor;
- (e) The type of fuel elements;
- (f) The type and the mass of moderator, reflector and coolant;
- (g) The amount of reactivity that can be introduced and its rate of introduction, reactivity control, and inherent and additional safety features (including those for preventing inadvertent criticality);
- (h) The quality of the containment structure or other means of confinement;
- (i) The utilization of the reactor (experimental devices, tests and reactor physics experiments);
- (j) The site evaluation, including external hazards associated with the site and the proximity to population groups;
- (k) The ease or difficulty in changing the overall configuration.

3. REGULATORY SUPERVISION FOR RESEARCH REACTOR FACILITIES

LEGAL AND REGULATORY INFRASTRUCTURE

3.1. GSR Part 1 (Rev. 1) [3] requires the government to ensure that an adequate legal infrastructure for a research reactor facility is established. This shall provide for the regulation of nuclear activities and for the clear assignment of responsibilities for safety in all stages in the lifetime of the facility. The government is responsible for the adoption of legislation that assigns the prime responsibility for safety to the operating organization and establishes a regulatory

body. The regulatory body is responsible for the establishment of regulations that results in a system of authorization⁷ for the regulatory control of nuclear activities and for the enforcement of the regulations. These principles are established in section 3 (Principles 1 and 2) of SF-1 [1].

3.2. General safety requirements to fulfil these principles are established in GSR Part 1 (Rev. 1) [3]. GSR Part 1 (Rev. 1) [3] 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, nuclear security⁸, and the State system of accounting for, and control of, nuclear material. These general safety requirements apply to the legal and governmental infrastructure for the safety of research reactors during site evaluation, design, construction, commissioning, operation, including utilization and modification, and decommissioning. The application of a graded approach that is commensurate with the potential hazards of the facility is essential and shall be used in the determination and application of adequate safety requirements (see paras 2.15–2.17).

3.3. GSR Part 1 (Rev. 1) [3] requires the government to establish and maintain an effectively independent regulatory body for the regulatory control of facilities and activities (see Requirements 3 and 4 of GSR Part 1 (Rev. 1) [3]). To be effective, the regulatory body shall be provided with the statutory legal authority and resources necessary to ensure that it can fulfil its responsibilities and fulfil its functions. This includes the authority to review and assess safety related information submitted by the operating organization during the authorization process and to apply the relevant regulations (e.g. by issuing, amending or revoking authorizations or their conditions), including carrying out compliance inspections and audits, taking enforcement actions and providing other competent authorities and the public with information, as appropriate.

⁷ Authorization to operate a facility or to conduct an activity may be granted by the regulatory body or by another governmental body to an operating organization or to a person. ‘Authorization’ includes approval, written permission, licensing, certification or registration. See Ref. [8] and Requirement 23 of GSR Part 1 (Rev. 1) [3].

⁸ The IAEA issues guidance on nuclear security in the IAEA Nuclear Security Series publications.

AUTHORIZATION PROCESS

3.4. The authorization process is ongoing, starting at the site evaluation stage and continuing up to and including the release of the facility from regulatory control. The authorization process may vary among States, but the major stages of the authorization process for nuclear research reactors shall include the following:

- (a) Site evaluation;
- (b) Design;
- (c) Construction;
- (d) Commissioning;
- (e) Operation, including utilization and modification⁹;
- (f) Decommissioning;
- (g) Release from regulatory control.

3.5. In some cases, several stages may be authorized by a single licence, but conditions are attached to it to control the subsequent stages. Despite these differences between national practices, a detailed demonstration of safety in the form of a safety analysis report that includes an adequate safety analysis shall be submitted by the operating organization to the regulatory body for review and assessment as part of the authorization process.

Requirement 1: Safety analysis report

A safety analysis report shall be prepared by the operating organization for a research reactor facility. The safety analysis report shall provide a justification of the site and the design and shall provide a basis for the safe operation of the research reactor. The safety analysis report shall be reviewed and assessed by the regulatory body before the research reactor project is authorized to progress to the next stage. The safety analysis report shall be periodically updated over the research reactor's operating lifetime to reflect modifications made to the facility and on the basis of experience and in accordance with regulatory requirements.

⁹ Although the utilization and modification of research reactors are activities that are normally included under operation, they may be considered separate stages in the authorization process, since their safety implications give rise to a large number of review and assessment activities that are repeated many times over the lifetime of the reactor facility (see paras 7.98–7.106).

3.6. The safety analysis report is one of the main documents for the authorization of the research reactor facility and an important link between the operating organization and the regulatory body. The safety analysis report shall contain a detailed description of the reactor site, the reactor facility and experimental devices, and shall include all other facilities and activities with safety significance. It shall describe in detail the general safety principles and criteria applied to the design for the safety of the reactor, the protection of operating personnel¹⁰ and the public, and the protection of the environment. The safety analysis report shall contain the analyses of the potential hazards from the operation of the reactor. The safety analysis report shall include safety analyses of accident sequences and shall describe the safety features incorporated in the design to avoid or to minimize the likelihood of occurrence of accidents, or to mitigate their consequences in accordance with the defence in depth concept.

3.7. The safety analyses in the safety analysis report shall form the basis for the operational limits and conditions for the reactor. The safety analysis report shall provide details about the operating organization, the conduct of operations and the management system throughout the lifetime of the research reactor facility. The safety analysis report shall also provide information on emergency arrangements for the research reactor, although this does not preclude the need for detailed emergency arrangements, in accordance with Requirement 81.

3.8. The safety analysis report shall include information to demonstrate compliance with national legislation and requirements issued by the regulatory body. The level of detail of the information to be presented in the safety analysis report shall be determined using a graded approach. For reactors with high power levels, the safety analysis report will usually require more detail in discussions such as those of reactor design and accident scenarios. For some reactors (e.g. research reactors with low potential hazard, critical or subcritical assemblies), the requirements for the safety analysis report content may be much less extensive. However, in all cases, the safety analysis report shall cover every topic in paras 3.6–3.7.

3.9. The safety analysis report shall cite references that may be necessary for its thorough review and assessment. This reference material shall be readily available to the regulatory body and shall not be subject to any classification or limitation that would prevent its adequate review and assessment.

¹⁰ The operating personnel comprise the reactor manager, the shift supervisors, the operators, the maintenance staff and the radiation protection staff.

Review and assessment by the regulatory body

3.10. A review and assessment of the information (usually in the form of a safety analysis report) submitted by the operating organization in support of its application for authorization shall be performed by the regulatory body. The specific objectives of the regulatory review and assessment are provided in GSR Part 1 (Rev. 1) [3]. The review and assessment shall be commensurate with the magnitude of the potential radiation risk associated with the research reactor facility in accordance with a graded approach. If necessary, the regulatory body may request additional information depending on national practices.

3.11. A schedule for the submission of documents for review and assessment for the stages in the authorization process shall be established early in the research reactor project and made available to the operating organization.

Acceptance criteria

3.12. Each State shall develop its own approach to acceptance criteria depending upon its particular legal and regulatory infrastructure. Acceptance criteria based on principles for safe design and operation shall be made available to the operating organizations.

INSPECTION AND ENFORCEMENT

3.13. Paragraph 2.5 (10) of GSR Part 1 (Rev. 1) [3] states that “an effective governmental, legal and regulatory framework for safety...shall set out...[p]rovision 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 a deterioration in the level of safety, or in the event of serious violations that, in the judgement of the regulatory body, could pose an imminent radiological hazard to workers and other personnel, the public or the environment, the regulatory body shall require the operating organization to curtail its activities and to take any further actions necessary to restore an adequate level of safety. In the event of continual, persistent or extremely serious non-compliance, the regulatory body shall direct the operating organization to cease its activities and may suspend or revoke the authorization.

4. MANAGEMENT FOR SAFETY AND VERIFICATION OF SAFETY FOR RESEARCH REACTOR FACILITIES

Requirement 2: Responsibilities in the management for safety

The operating organization for a research reactor facility shall have the prime responsibility for the safety of the research reactor over its lifetime, from the beginning of the project for site evaluation, design, construction, commissioning, operation, including utilization and modification, and decommissioning, until its release from regulatory control.

4.1. In order to ensure rigour and thoroughness at all levels of the staff in the achievement and maintenance of safety, the operating organization:

- (a) Shall establish and implement safety policies and shall ensure that safety matters are given the highest priority;
- (b) Shall clearly define responsibilities and accountabilities with corresponding lines of authority and communication;
- (c) Shall ensure that it has sufficient staff with appropriate qualifications and training at all levels;

- (d) Shall develop and strictly adhere to sound procedures for all activities that may affect safety, ensuring that managers and supervisors promote and support good safety practices, while correcting poor safety practices;
- (e) Shall review, monitor and audit¹¹ all safety related matters on a regular basis, and shall take appropriate corrective actions where necessary;
- (f) Shall develop and sustain a strong safety culture, and shall prepare a statement of safety policy and safety objectives, which is disseminated to and understood by all staff.

4.2. Whenever a change of stage in the lifetime of a research reactor is to be initiated by the operating organization, it shall submit a detailed demonstration of safety, which shall include an adequate safety analysis, for review and assessment by the regulatory body before the project is authorized to progress to the next stage.

4.3. The operating organization shall submit to the regulatory body in a timely manner any information that it has requested. The operating organization shall be responsible for making arrangements with vendors and suppliers to ensure the availability of any information that has been requested by the regulatory body. The operating organization shall also be responsible for informing the regulatory body of any additional new information on the research reactor and of any 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 documents submitted to the regulatory body by the operating organization in support of the authorization shall be based on the requirements presented in paras 3.6–3.9. The functions and responsibilities of the operating organization for ensuring safety at each stage of the lifetime of the research reactor are presented in Section 3 (see Requirement 1) and here in Section 4 as well as in the relevant paragraphs of Sections 5 to 9.

Requirement 3: Safety policy

The operating organization for a research reactor facility shall establish and implement safety policies that give safety the highest priority.

¹¹ Independent assessments such as audits or surveillance are carried out to determine the extent to which the requirements for the management system are fulfilled, to evaluate the effectiveness of the management system and to identify opportunities for improvement. They can be conducted by, or on behalf of, the organization itself for internal purposes, by interested parties such as customers and regulators (or by other persons on their behalf), or by independent external organizations.

4.4. The safety policy established and implemented by the operating organization shall give safety the highest priority, overriding all other demands, including the demands of production and of reactor users. 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.

4.5. The safety policy shall stipulate clearly the leadership role of the highest level of management in safety matters. Senior management¹² shall be responsible for communicating and implementing the provisions of the safety policy throughout the organization. All personnel in the organization shall be made aware of the safety policy and of their responsibilities for ensuring safety. The expectations of management for safety performance shall be clearly communicated to all personnel, and it shall be ensured that such expectations are understood and followed within the organization.

4.6. 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 applying and, where feasible, improving existing 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: Integrated management system

The operating organization for a research reactor facility shall establish, implement, assess and continuously improve an integrated management system.

¹² ‘Senior management’ means the person who, or group of people that, is accountable for meeting the terms established in the licence and directs, controls and assesses an organization at the highest level. Many different terms are used, including, for example: board of directors, chief executive officer, director general, executive team, plant manager, top manager, chief regulator, site vice-president, managing director and laboratory director.

4.7. The requirements for an integrated management system¹³ 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 establishment and implementation of the management system for the research reactor by means of a graded approach on the basis of the importance to safety of each item, service or process. The level of detail of the management system that is required for a particular research reactor or experiment shall be governed by the potential hazard of the reactor and the experiment (see paras 2.15–2.17 on the graded approach and SSG-22 [2]).

4.8. The operating organization shall ensure through the establishment and use of an integrated management system that the research reactor is sited, designed, constructed, commissioned, operated and utilized (including the associated activities such as those mentioned in Appendix II), and decommissioned, in a safe manner and within the limits and conditions that are specified in the operational limits and conditions and established in the authorization.

4.9. The management system shall be developed and established at a time consistent with the schedule for accomplishing activities at all stages in the lifetime of the research reactor. 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.

4.10. The management system shall include all the elements of management so that processes and activities important to safety are established and conducted in accordance with relevant requirements, including those relating to leadership, protection of health, human performance, emergency preparedness and response, protection of the environment, security and quality.

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

- (a) The statutory and regulatory requirements of the State;
- (b) The relevant IAEA safety standards;

¹³ An integrated management system is a single coherent management system in which all constituents of an organization are integrated to enable the organization's objectives to be achieved. Such constituents include the organizational structure, resources and organizational processes. 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.

- (c) Any requirements formally agreed with interested parties.

4.12. The documentation of the management system shall be reviewed and made subject to approval at appropriate levels of management in the operating organization and shall be submitted to the regulatory body for review and assessment as requested.

4.13. The provisions of the management system shall be based on four functional categories:

- (a) Management responsibility;
- (b) Management of resources;
- (c) Management of processes and activities;
- (d) Measurement, assessment and improvement of the management system.

Management responsibility

4.14. Management shall be responsible for providing the means and support needed to achieve the organization's objectives. In this regard, the management system shall include provisions for effective communication and clear assignment of responsibilities 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

4.15. Resource management shall ensure that the resources¹⁴ essential to the implementation of the organizational strategy and the achievement of the organization's objectives are identified and made available. The management system shall ensure that:

- (a) Suppliers, manufacturers and designers of structures, systems and components important to safety have an effective integrated management system in place, with audits to confirm its effectiveness;
- (b) External personnel (including suppliers and experimenters) are adequately trained and qualified and perform their activities under the same controls and to the same standards as the reactor personnel;

¹⁴ Resources includes individuals, infrastructure, the working environment, information and knowledge, and suppliers, as well as material and financial resources.

- (c) The equipment, tools, materials, hardware and software necessary to conduct the work in a safe manner are identified, provided, checked, and verified and maintained.

Process implementation

4.16. The management system shall include provisions for the implementation of processes to ensure that the design, including subsequent changes, modifications or safety improvements, construction, commissioning, operation and utilization, and decommissioning of the reactor are performed in accordance with established codes, standards, specifications, procedures and administrative controls. Items and services important to safety shall be specified and controlled to ensure their proper use, maintenance and configuration.

4.17. In the manufacturing and construction of structures, systems and components of the research reactor, including its associated experimental facilities and devices and modification projects, processes shall be established to ensure that the relevant regulations and safety requirements are met and that the construction work is properly implemented. Such processes shall enable the operating organization to ensure that the manufacturing and construction of items important to safety are performed in accordance with the design requirements and the regulatory requirements.

4.18. As part of the management system, processes for utilization and modification shall be established and shall be graded on the basis of their safety significance. Such processes shall include the design, review, assessment and approval, fabrication, testing and implementation of a utilization and modification project. Relevant procedures describing the processes shall be put into effect by the operating organization early in the reactor operation stage.

4.19. The management system shall ensure that items and services under procurement meet established requirements and perform as specified. Suppliers shall be evaluated and selected on the basis of specified criteria. Requirements for reporting deviations from procurement specifications shall be specified in 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.

Assessment and improvements

4.20. The effectiveness of the management system shall be regularly measured and assessed through independent assessments and self-assessments. Weaknesses in processes shall be identified and corrected. The operating organization shall evaluate the results of such assessments and shall determine and take the necessary actions for continuous improvements.

VERIFICATION OF SAFETY

Requirement 5: Safety assessment

The adequacy of the design of the research reactor shall be verified in accordance with the management system by means of comprehensive deterministic safety analysis and complementary probabilistic analysis as appropriate and shall be validated by independent verification by individuals or groups independent from those who originally performed the design work. The safety assessment shall be continued throughout all the stages of the reactor's lifetime (in periodic safety reviews) and shall be conducted in accordance with the potential magnitude and nature of the hazards associated with the particular facility or activity.

4.21. Verification, validation and approval of the reactor design shall be completed as soon as practicable in the design and construction processes, and in any case before commissioning of the facility is commenced.

4.22. Safety assessment¹⁵ shall be part of the design process, with iterations made between the design activities and the confirmatory analytical activities and with increases in the scope and the level of detail of the safety assessment as the design progresses.

4.23. Safety assessment shall commence at an early stage in the design process. Deterministic safety analysis shall be the primary tool for safety assessment of research reactors. Probabilistic safety analysis may be used as a complementary tool for detecting potential weaknesses and improving the safety assessment.

¹⁵ 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 [12].

4.24. The safety assessments (and periodic safety reviews) shall be documented to facilitate their evaluation.

4.25. Systematic periodic safety reviews of the research reactor in accordance with the regulatory requirements shall be performed throughout its operating lifetime, with account taken of operating experience, the cumulative effects of ageing, applicable safety standards and safety information from all relevant sources. The operating organization shall verify by analysis, surveillance, testing and inspection that the physical state of the reactor facility, including experimental devices and facilities, is as described in the safety analysis report and other safety documents, and that the facility is commissioned and operated in accordance with safety requirements and the safety analysis and operational limits and conditions.

4.26. Activities for systematic periodic safety reassessments include, among others, periodic safety reviews such as self-assessments and peer reviews¹⁶ to confirm that the safety analysis report and other selected documents (such as documentation for operational limits and conditions, maintenance, training and qualification) for the facility remain valid in view of current regulatory requirements, or, if necessary, to update or make improvements to the extent practicable. In such reviews, changes in the site characteristics, changes in the utilization programme, cumulative effects of ageing and modifications, changes to procedures, the use of feedback from operating experience and technical developments shall be considered. It shall be verified that selected structures, systems and components and software comply with the design requirements. Specific design requirements are established in Section 6 and functional requirements are established in Section 7.

Requirement 6: Safety committee

A safety committee (or an advisory group) that is independent from the reactor manager shall be established to advise the operating organization on all the safety aspects of the research reactor.

¹⁶ A peer review is a review conducted by a team of independent experts with technical competence and experience in the areas of evaluation. Judgements are based on the combined expertise of the team members. The objectives, scope and size of the review team are tailored to the review that is to be conducted. A review is neither an inspection nor an audit against specific standards. Instead, it consists of a comprehensive comparison of the practices applied by organizations with internationally accepted good practices, and an exchange of expert judgement.

4.27. The safety committee (or advisory group) shall advise the operating organization on: (i) the safety assessment of design, commissioning and operational issues; and (ii) relevant aspects of the safety of the reactor and the safety of its utilization.¹⁷ Members of the safety committee shall be experts in different fields associated with the design and operation of research reactors. The safety committee shall be fully functioning before the design of the research reactor begins. The list of items that the safety committee is required to consider, provide advice on, or recommend approval of shall also be established. Such a list shall include, among other things, the following:

- (a) The design of structures, systems and components and in particular the design and qualification of nuclear fuel elements¹⁸ and reactivity control elements;
- (b) Safety documents and their modifications;
- (c) Proposed new tests, experiments, equipment, systems or procedures that have significance for safety;
- (d) Proposed modifications to items important to safety and changes in experiments that have implications for safety;
- (e) Violations of the 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;
- (g) Periodic reviews of the operational performance and the safety performance of the research reactor facility;
- (h) Reports on routine radioactive discharges to the environment;
- (i) Reports on radiation doses to the personnel at the facility and to the public;
- (j) Reports to be provided to the regulatory body;
- (k) Reports on regulatory inspections.

¹⁷ In some States, an additional safety committee (or advisory group) is established to advise the reactor manager on the safety aspects of the day to day operation and utilization of the reactor (see para. 7.26).

¹⁸ The nuclear fuel elements are the elements containing fissionable and fissile nuclear material that are used in the core of a research reactor for the purpose of generating neutrons. Adequate design and safety margins are established to take into account unknown behaviour of experimental fuel that is not yet qualified.

5. SITE EVALUATION FOR RESEARCH REACTOR FACILITIES

5.1. The main safety objective in evaluating the site for a research reactor is the protection of the public and the protection of the environment against the radiological consequences of normal and accidental releases of radioactive material (see NS-R-3 (Rev. 1) [5]). Information shall be collected in sufficient detail to support the safety analysis to demonstrate that the research reactor facility can be safely operated at the proposed site. For research reactors with low potential hazard and critical and subcritical assemblies, the amount of detail to be provided can be substantially reduced below that required for a medium power research reactor or high power research reactor (see also paras 1.6–1.9). 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 particular site for a research reactor, the characteristics of the site, which may affect aspects of the safety of the research reactor and associated emergency arrangements, shall be investigated and assessed by the operating organization. The objective of the assessment is to demonstrate how these site characteristics will influence the design criteria and operating criteria for the facility and to demonstrate the adequacy of the site characteristics in terms of the effects on safety and on emergency preparedness and response.

5.3. The site evaluation shall establish the boundaries of the site area, including exclusion and monitoring areas satisfying the main safety objective (see para. 5.1) and the exact location of the reactor and associated facilities (the operations area), which is under the control of the reactor management¹⁹ and its legal rights within the site area. Any activities that are unrelated to the operation of the research reactor within these boundaries shall be evaluated and justified.

5.4. In the evaluation of the suitability of a site for a research reactor, the following aspects shall be considered:

- (a) The effects of natural and human induced external events (e.g. seismic events, fire or flooding) that may occur in the region of the site;

¹⁹ The reactor management comprises the members of the operating organization to whom the responsibility and the authority for directing the operation of the research reactor facility have been assigned.