IAEA Safety Standards

for protecting people and the environment

Operational Limits and Conditions and Operating Procedures for Research Reactors

Specific Safety Guide

No. SSG-83

IAEA

International Atomic Energy Agency

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

https://www.iaea.org/resources/safety-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.

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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.

OPERATIONAL LIMITS AND CONDITIONS AND OPERATING PROCEDURES FOR 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. SSG-83

OPERATIONAL LIMITS AND CONDITIONS AND OPERATING PROCEDURES FOR RESEARCH REACTORS

SPECIFIC SAFETY GUIDE

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Marketing and Sales Unit, Publishing Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
fax: +43 1 26007 22529
tel.: +43 1 2600 22417
email: sales.publications@iaea.org
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FOREWORD

by Rafael Mariano Grossi
Director General

The IAEA's Statute authorizes it to "establish…standards of safety for protection of health and minimization of danger to life and property". These are standards that the IAEA must apply to its own operations, and that States can apply through their national regulations.

The IAEA started its safety standards programme in 1958 and there have been many developments since. As Director General, I am committed to ensuring that the IAEA maintains and improves upon this integrated, comprehensive and consistent set of up to date, user friendly and fit for purpose safety standards of high quality. Their proper application in the use of nuclear science and technology should offer a high level of protection for people and the environment across the world and provide the confidence necessary to allow for the ongoing use of nuclear technology for the benefit of all.

Safety is a national responsibility underpinned by a number of international conventions. The IAEA safety standards form a basis for these legal instruments and serve as a global reference to help parties meet their obligations. While safety standards are not legally binding on Member States, they are widely applied. They have become an indispensable reference point and a common denominator for the vast majority of Member States that have adopted these standards for use in national regulations to enhance safety in nuclear power generation, research reactors and fuel cycle facilities as well as in nuclear applications in medicine, industry, agriculture and research.

The IAEA safety standards are based on the practical experience of its Member States and produced through international consensus. The involvement of the members of the Safety Standards Committees, the Nuclear Security Guidance Committee and the Commission on Safety Standards is particularly important, and I am grateful to all those who contribute their knowledge and expertise to this endeavour.

The IAEA also uses these safety standards when it assists Member States through its review missions and advisory services. This helps Member States in the application of the standards and enables valuable experience and insight to be shared. Feedback from these missions and services, and lessons identified from events and experience in the use and application of the safety standards, are taken into account during their periodic revision.

I believe the IAEA safety standards and their application make an invaluable contribution to ensuring a high level of safety in the use of nuclear technology. I encourage all Member States to promote and apply these standards, and to work with the IAEA to uphold their quality now and in the future.

THE IAEA SAFETY STANDARDS

BACKGROUND

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

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

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

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

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

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

THE IAEA SAFETY STANDARDS

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

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

Safety measures and security measures[1] have in common the aim of protecting human life and health and the environment. Safety measures and security measures must be designed and implemented in an integrated manner so that security measures do not compromise safety and safety measures do not compromise security.

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

Safety Fundamentals

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

Safety Requirements

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

Safety Guides

Safety Guides provide recommendations and guidance on how to comply with the safety requirements, indicating an international consensus that it

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

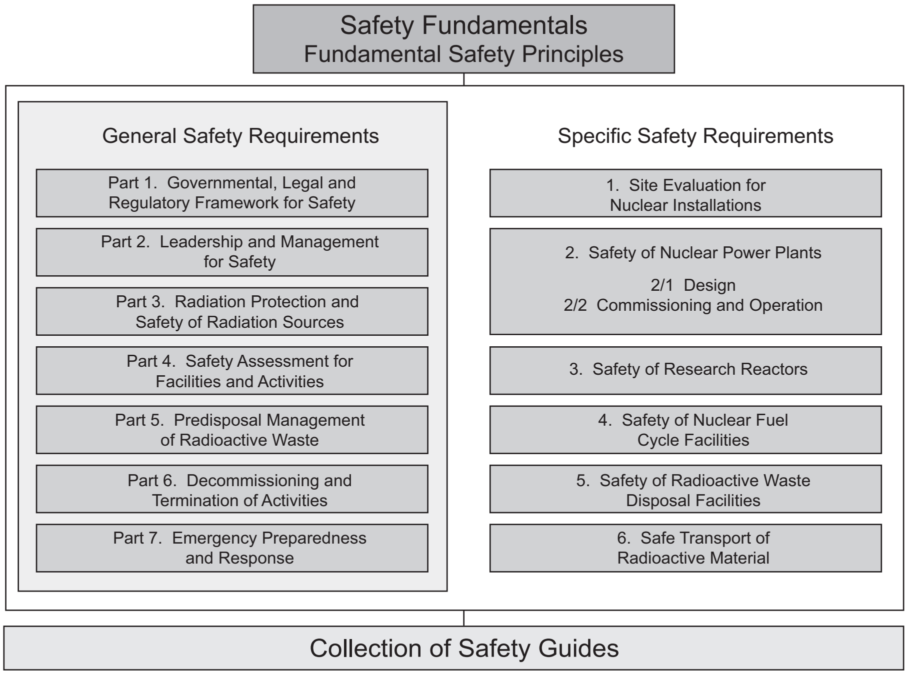

FIG. 1. The long term structure of the IAEA Safety Standards Series.

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 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.

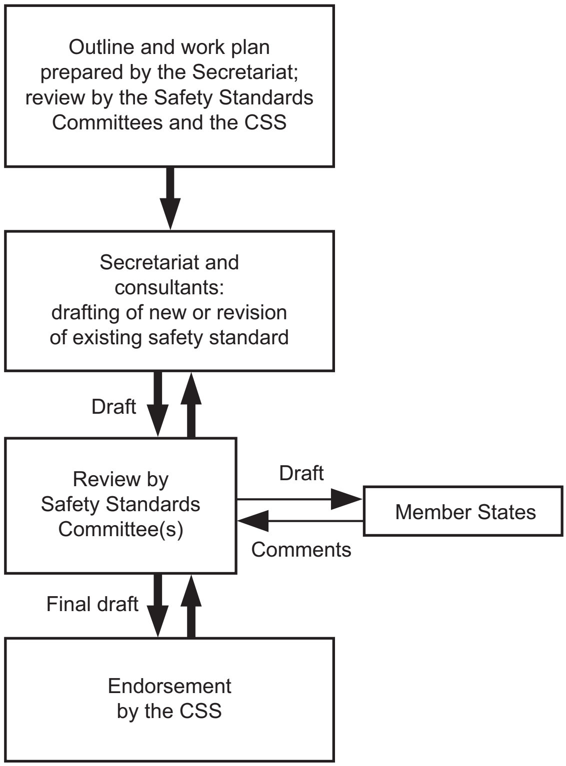

FIG. 2. The process for developing a new safety standard or revising an existing standard.

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 Nuclear Safety and Security Glossary (see https://www.iaea.org/resources/publications/iaea-nuclear-safety-and-security-glossary). 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.

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. Requirements for the safety of research reactors, with particular emphasis on their design and operation, are established in IAEA Safety Standards Series No. SSR-3, Safety of Research Reactors [1].

1.2. This Safety Guide provides recommendations on operational limits and conditions (OLCs)[1] and operating procedures for research reactors.

1.3. This Safety Guide was developed in parallel with seven other Safety Guides on the safety of research reactors, as follows:

(a) IAEA Safety Standards Series No. SSG-80, Commissioning of Research Reactors [2];
(b) IAEA Safety Standards Series No. SSG-81, Maintenance, Periodic Testing and Inspection of Research Reactors [3];
(c) IAEA Safety Standards Series No. SSG-82, Core Management and Fuel Handling for Research Reactors [4];
(d) IAEA Safety Standards Series No. SSG-84, The Operating Organization and the Recruitment, Training and Qualification of Personnel for Research Reactors [5];
(e) IAEA Safety Standards Series No. SSG-85, Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors [6];
(f) IAEA Safety Standards Series No. SSG-10 (Rev. 1), Ageing Management for Research Reactors [7];
(g) IAEA Safety Standards Series No. SSG-37 (Rev. 1), Instrumentation and Control Systems and Software Important to Safety for Research Reactors [8].

[1] The terms ‘safety specifications’ or ‘technical specifications (‘tech specs’) for safe operation’ and ‘general operating rules’ are sometimes used to mean OLCs. These terms usually include safety limits; safety system settings; limiting conditions for safe operation; requirements for maintenance, periodic testing and inspection; and administrative requirements. In some States, the term ‘operating rules’ is used to mean the equivalent of safety limits, safety system settings and limiting conditions for safe operation but does not include requirements for maintenance, periodic testing and inspection or administrative requirements.

1.4. Additional recommendations on the safety of research reactors are provided in IAEA Safety Standards Series Nos SSG-20 (Rev. 1), Safety Assessment for Research Reactors and Preparation of the Safety Analysis Report [9], and SSG-24 (Rev. 1), Safety in the Utilization and Modification of Research Reactors [10].

1.5. The terms used in this Safety Guide are to be understood as defined and explained in the IAEA Nuclear Safety and Security Glossary [11].

1.6. This Safety Guide supersedes IAEA Safety Standards Series No. NS-G-4.4, Operational Limits and Conditions and Operating Procedures for Research Reactors[2].

OBJECTIVE

1.7. The objective of this Safety Guide is to provide recommendations on developing, formulating and presenting OLCs and operating procedures for research reactors, to meet the relevant requirements established in SSR-3 [1], in particular Requirements 71 and 74.

1.8. The recommendations provided in this Safety Guide are aimed at operating organizations of research reactors, regulatory bodies and other organizations involved in a research reactor project.

SCOPE

1.9. This Safety Guide is primarily intended for use for heterogeneous, thermal spectrum research reactors that have a power rating of up to several tens of megawatts. For research reactors of higher power, specialized reactors (e.g. fast spectrum reactors) and reactors that have specialized facilities (e.g. hot or cold neutron sources, high pressure and high temperature loops), additional guidance may be needed. For such research reactors, the recommendations provided in IAEA Safety Standards Series No. SSG-70, Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants [12], might be more suitable. Homogeneous reactors and accelerator driven systems are outside the scope of this publication.

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[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Operational Limits and Conditions and Operating Procedures for Research Reactors, IAEA Safety Standards Series No. NS-G-4.4, IAEA, Vienna (2008).

1.10. Some research reactors, critical assemblies and subcritical assemblies with a low hazard potential might need less comprehensive OLCs and operating procedures. While all recommendations in this Safety Guide are to be considered, some might not be applicable to such research reactors, critical assemblies and subcritical assemblies (see Requirement 12 and paras 2.15–2.17 of SSR-3 [1], as well as IAEA Safety Standards Series No. SSG-22 (Rev. 1), Use of a Graded Approach in the Application of the Safety Requirements for Research Reactors [13]).

1.11. In this Safety Guide, subcritical assemblies will be mentioned separately only if a specific recommendation is not relevant for, or is applicable only to, subcritical assemblies.

STRUCTURE

1.12. Section 2 provides recommendations on the management system for a research reactor as it relates to OLCs and operating procedures. Section 3 describes the relationship between the OLCs and the fundamental safety objective of protecting people and the environment from harmful effects of ionizing radiation, and provides recommendations on the concept of OLCs, the need for OLCs and their development, the roles and responsibilities of the operating organization and the regulatory body in the preparation and review of OLCs, and the attributes of OLCs. Section 4 provides recommendations on the OLC documentation as well as the safety parameters and systems that should be covered by the OLCs, including requirements for maintenance, periodic testing and inspection for these parameters. Section 4 also provides recommendations on administrative requirements that should be covered by the OLCs. Section 5 provides recommendations on the development of operating procedures, including the functions and responsibilities of the operating organization, the operating personnel, the radiation protection personnel, the reactor safety committee, the reactor manager[3] and the regulatory body in developing and implementing procedures. Section 6 provides recommendations on the format and content of various types of operating procedure, and on specific topics to be addressed in procedures of each category. Section 7 provides recommendations on the training of personnel in the use of procedures. Section 8 provides recommendations on

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[3] The reactor manager is the member of the reactor management to whom direct responsibility and authority for the safe operation of the reactor are assigned by the operating organization and whose primary duties constitute the discharge of this responsibility.

how to ensure compliance with OLCs and operating procedures, including the need to retain records of compliance.

1.13. Appendix I provides a list of factors that should generally be considered in establishing the limiting conditions for safe operation and surveillance requirements. Appendix II provides a list of typical operating procedures for the categories identified in Section 6.

2. APPLICATION OF THE MANAGEMENT SYSTEM FOR A RESEARCH REACTOR TO OPERATIONAL LIMITS AND CONDITIONS AND OPERATING PROCEDURES

2.1. A management system that integrates safety, health, environmental, security, quality, human-and-organizational-factor, societal and economic elements, for the research reactor project is required to be developed (see Requirement 4 of SSR-3 [1]). The documentation of the management system should describe the system that controls the development and implementation of OLCs and operating procedures. Approval of the management system (or parts thereof) by the regulatory body may be required (see para. 4.12 of SSR-3 [1]).

2.2. In accordance with paras 4.13–4.20 of SSR-3 [1], the management system is required to cover four functional categories, as follows:

(a) Management responsibility: includes providing the means and management support needed to achieve the organization’s objectives (see paras 2.7 and 2.8 of this Safety Guide).
(b) Resource management: includes the measures needed to ensure that resources essential to the implementation of strategy and the achievement of the organization’s objectives are identified and made available (see paras 2.9–2.12 of this Safety Guide).
(c) Process implementation: includes those actions and tasks needed to achieve the goals of the organization (see paras 2.13 and 2.14 of this Safety Guide).
(d) Measurement, assessment and improvement of the management system: includes activities conducted to evaluate the effectiveness of management processes and work performance (see paras 2.15–2.19 of this Safety Guide).

General requirements for the management system are established in IAEA Safety Standards Series No. GSR Part 2, Leadership and Management for Safety [14]. Specific recommendations are provided in IAEA Safety Standards Series Nos GS-G-3.1, Application of the Management System for Facilities and Activities [15], and GS-G-3.5, The Management System for Nuclear Installations [16].

2.3. As part of the management system, the arrangements for the management of OLCs and operating procedures should be established. These arrangements should apply to all items, services and processes important to safety and should provide confidence that activities are performed safely in accordance with established codes, standards, specifications, procedures and administrative controls, as required by para. 4.16 of SSR-3 [1]. The management system should also include provisions to ensure that changes to OLCs and operating procedures are planned, performed and controlled in a manner that ensures effective communication and clear assignment of responsibilities.

2.4. In establishing the management system, a graded approach in accordance with the relative importance to safety of each item or process is required to be used (see para. 4.7 of SSR-3 [1]).

2.5. The objective of the management system as applied to OLCs and operating procedures should be to ensure that the research reactor meets the following:

(a) Regulatory requirements;
(b) Design requirements and assumptions;
(c) The safety assessment and safety analysis report (see Requirement 1 of SSR-3 [1]);
(d) The OLCs for the research reactor (used for the development of operating procedures) (see Requirement 71 of SSR-3 [1]);
(e) Administrative requirements associated with management of the research reactor.

2.6. The management system is required to support the development, implementation and enhancement of a strong safety culture (see paras 1.5(b) and 4.9 of GSR Part 2 [14]). This safety culture should be applied in all aspects of development and implementation of OLCs and operating procedures.

MANAGEMENT RESPONSIBILITY FOR OPERATIONAL LIMITS AND CONDITIONS AND OPERATING PROCEDURES FOR A RESEARCH REACTOR

2.7. The operating organization has responsibility for preparing and issuing OLCs and operating procedures for the safe operation of the research reactor, in accordance with Requirements 71 and 74 of SSR-3 [1], respectively. The reactor manager should be an active participant in the implementation and evaluation of these activities.

2.8. The management of the operating organization should ensure that the processes for development and implementation of OLCs and operating procedures describe how these activities are to be assessed, managed, authorized and performed to ensure that the objectives of the OLCs and operating procedures are met and that safe operation of the research reactor, including experimental facilities, is ensured. These processes should be documented and should include descriptions of the organizational structure, functional responsibilities, levels of authority and interfaces for those assessing, managing, authorizing, performing, controlling or supervising these activities. The documentation should also cover other management measures, including planning and scheduling of activities, resource allocation and human factors.

RESOURCE MANAGEMENT FOR OPERATIONAL LIMITS AND CONDITIONS AND OPERATING PROCEDURES FOR A RESEARCH REACTOR

2.9. The operating organization is required to provide adequate resources to implement the OLCs and operating procedures (see para. 4.15 of SSR-3 [1]). This should be achieved by the following actions:

(a) Determining the necessary competences and providing training, where appropriate, in accordance with Requirement 70 of SSR-3 [1], to ensure that the personnel of the operating organization are competent to perform their assigned work;
(b) Supervising external personnel (including experimenters, suppliers and contractors) who perform safety related activities and ensuring that these personnel are adequately trained and qualified.

2.10. Paragraph 4.15(b) of SSR-3 [1] states:

> "The management system shall ensure that: …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".

Personnel who are not directly working for the research reactor, and personnel of contracting organizations who are involved in implementing the OLCs and operating procedures, should be appropriately trained and qualified for the work they are to perform. Operating personnel should review the work of external personnel who are involved in implementing the OLCs and operating procedures during preparation for work, at the job site during performance of the work, and during acceptance testing and inspection.

2.11. Paragraph 4.15(a) of SSR-3 [1] states:

> "The management system shall ensure that: …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".

The management system of the operating organization should be extended to include arrangements with suppliers, manufacturers and designers.

2.12. Paragraph 4.15(c) of SSR-3 [1] states that "The management system shall ensure that: ...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 FOR OPERATIONAL LIMITS AND CONDITIONS AND OPERATING PROCEDURES FOR A RESEARCH REACTOR

2.13. Activities relating to the OLCs of a research reactor should be performed and recorded in accordance with approved procedures and instructions. The management system should specify the processes for the development, implementation and modification of OLCs and operating procedures to ensure that they have been correctly conceived and implemented.

2.14. The management system should specify the means of detecting and correcting any deviations from OLCs and any failures to comply with operating procedures. This may be done by means of periodic review and assessment by the operating organization.

MEASUREMENT, ASSESSMENT AND IMPROVEMENT OF THE MANAGEMENT SYSTEM IN RELATION TO OPERATIONAL LIMITS AND CONDITIONS AND OPERATING PROCEDURES

2.15. Paragraph 4.20 of SSR-3 [1] states:

> "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."

2.16. Assessment measures, including review and verification, should be established to ensure that OLCs and operating procedures are developed and implemented in accordance with the design intent. These measures should include the following:

(a) Review of the OLCs and operating procedures;
(b) Verification of the implementation of OLCs and operating procedures;
(c) Review and verification of records, results and reports relating to the OLCs and operating procedures, including those on the status of non-conformances and corrective actions;
(d) Use of feedback from operating experience;
(e) Verification of the adequacy and timeliness of corrective actions.

2.17. The items to be assessed and the maximum interval between assessments should be stated and may include the following:

(a) The conduct of operations at the research reactor in terms of conformance with the OLCs and compliance with any licence conditions;
(b) The response by the operating organization to violations of the OLCs (see paras 7.41–7.43 of SSR-3 [1]);
(c) The implementation of licensing procedures;
(d) Events reported to the regulatory body;

(e) The emergency plans (including drills and exercises) and emergency procedures for the research reactor (see paras 6.53–6.57 of this Safety Guide);
(f) The training programme for operating personnel (see Section 7);
(g) The updating of documents.

2.18. The effective implementation of the management system in relation to OLCs and operating procedures for a research reactor should be assessed by qualified personnel who are not directly involved in the development and implementation of these OLCs and operating procedures.

2.19. An organizational unit should be established that has responsibility for conducting independent assessments of OLCs and operating procedures on behalf of the operating organization. Such an assessment could be performed by the reactor safety committee, as described in para. 7.19 of SSR-3 [1]. The operating organization should evaluate the results of such independent assessments and should determine and take the necessary actions to implement recommendations and suggestions for improvement.

3. DEVELOPMENT OF OPERATIONAL LIMITS AND CONDITIONS FOR A RESEARCH REACTOR

3.1. Paragraph 7.33 of SSR-3 [1] states:

> "The set of operational limits and conditions important to reactor safety, including safety limits, safety system settings, limiting conditions for safe operation, requirements for surveillance, testing and maintenance, and administrative requirements, shall be established and submitted to the regulatory body for review and assessment and approval before the commencement of operation."

The submission of OLCs for review and approval by the regulatory body is an important part of the licensing process, on the basis of which the operating organization is authorized to operate the research reactor.

3.2. The OLCs should form an envelope or boundary for reactor parameter values and system conditions, within which the operation of the research reactor has been demonstrated in the safety analysis report to be safe, and the site personnel, the public and the environment are adequately protected against radiation hazards.

3.3. Paragraph 7.32 of SSR-3 [1] states:

> "The operational limits and conditions shall form an important part of the basis for the authorization of the operating organization to operate the research reactor facility. The facility shall be operated within the operational limits and conditions to prevent situations arising that could lead to anticipated operational occurrences or accident conditions, and to mitigate the consequences of such events if they do occur. The operational limits and conditions shall be developed to ensure that the reactor is being operated in accordance with the design assumptions and intent, as well as in accordance with its licence conditions."

3.4. Paragraph 3.7 of SSR-3 [1] states that "The safety analyses in the safety analysis report shall form the basis for the operational limits and conditions for the reactor." To meet this requirement, the safety analysis report should be developed so as to identify clearly the OLCs needed for safe operation of the research reactor.

3.5. Paragraph 7.34 of SSR-3 [1] states:

> "The operational limits and conditions shall be adequately defined, clearly established and appropriately substantiated (e.g. by clearly stating for each operational limit or condition its objective, its applicability and its specification; i.e. its specified limit and its basis)."

A clear statement of the objective, applicability, specification and justification of each OLC, as appropriate, should be included in the documentation on OLCs to increase the awareness of operating personnel of the application and observance of OLCs.

3.6. The technical aspects of the OLCs should cover the limitations to be observed, as well as the operational requirements, to ensure that the structures, systems and components important to safety are able to perform their intended functions as assumed in the safety analysis report for the research reactor.

3.7. Safe operation depends on operating personnel as well as on equipment and procedures; consequently, OLCs are also required to include actions to be taken and limitations to be observed by the operating personnel (see paras 7.37 and

7.40–7.43 of SSR-3 [1]). This includes requirements for maintenance, periodic testing and inspection (see paras 7.38 and 7.39 of SSR-3 [1]) and corrective or complementary actions necessary to supplement the functioning of equipment involved in maintaining the established OLCs. Some OLCs may involve combinations of automatic functions and actions by operating personnel.

3.8. The OLCs at a research reactor are required to include the following items (see paras 7.35–7.40 of SSR-3 [1]):

(a) Safety limits (see paras 4.5–4.14 of this Safety Guide);
(b) Safety system settings (see paras 4.15–4.19 of this Safety Guide);
(c) Limiting conditions for safe operation (see paras 4.20–4.29 of this Safety Guide);
(d) Requirements for maintenance, periodic testing and inspection (see paras 4.30–4.35 of this Safety Guide);
(e) Administrative requirements (see paras 4.36–4.45 of this Safety Guide).

3.9. The development of the OLCs should take into account the reactor design, the safety analysis and the information in the safety analysis report concerning the conduct of operations. The OLCs should be defined in such a way that the independence of the levels of defence in depth and their adequate reliability are ensured. The content and the format of the OLCs should be appropriate for their main purpose, and the following aims should also be taken into account:

(a) To facilitate verification that the operation of the research reactor is in compliance with the approved OLCs;
(b) To facilitate understanding and awareness among operating personnel of the application of and need for compliance with the OLCs.

3.10. The operating organization is responsible for the preparation of the OLCs and for their submission to the regulatory body as part of the application for an authorization (see paras 7.33 and 7.34 of SSR-3 [1]). The objective is to verify that each OLC is well founded, provides an adequate safety margin in relation to accidents analysed in the safety analysis report and complies with regulatory requirements. The operating organization should consult the designer in preparing the OLCs and should ensure that the operating personnel know the OLCs and adhere to them. Proposed OLCs should be reviewed by the reactor safety committee before their submission to the regulatory body. When specific restrictions are placed on operation by the regulatory body, the operating organization is required to ensure that the OLCs are revised appropriately (see para. 7.34 of SSR-3 [1]).

3.11. The operating organization should prepare OLCs for each stage of reactor operation that may require a regulatory authorization (see para. 3.4 of SSR-3 [1]). For example, specific OLCs are usually needed for the commissioning stage of the reactor; such OLCs may be revised after completion of this stage. Further recommendations on OLCs in the commissioning stage are provided in SSG-80 [2]. Similarly, special OLCs may be needed for operation of the reactor under special conditions, such as the conduct of a particular experiment or the undertaking of a reactor modification. Further recommendations are provided in SSG-24 (Rev. 1) [10]. Other reasons for a change in the OLCs may be the observed inadequacy of existing parameter values or conditions, operating experience gained during reactor operation, technological progress, or extended shutdown or decommissioning.

3.12. The operating organization should conduct a periodic review of the OLCs, in association with a review of the safety analysis report, so as to make revisions on the basis of operating experience and any technological developments. The operating organization is responsible for the timely submission of any additions or changes to the existing OLCs to the regulatory body for review and approval, as required. This periodic review, in association with a review of the safety analysis report, should be performed even if the facility has not been modified.

3.13. Requirement 71 of SSR-3 [1] states that "**The operating organization for a research reactor facility shall ensure that the research reactor is operated in accordance with the operational limits and conditions.**" In this context, the operating organization should ensure that adequate records are kept to facilitate audits and inspections to verify that the operation of the research reactor is in compliance with the OLCs. In addition, the operating organization is required to establish procedures to be followed in the event of a violation of limiting conditions for safe operation or of exceeding a safety limit (see paras 7.42 and 7.43 of SSR-3 [1], respectively).

3.14. The regulatory body should conduct regulatory inspections that include the operating organization and the reactor management, as well as operations at the research reactor, to verify compliance with the approved OLCs. Further recommendations on regulatory inspections are provided in IAEA Safety Standards Series No. GSG-13, Functions and Processes of the Regulatory Body for Safety [17].

ATTRIBUTES OF OPERATIONAL LIMITS AND CONDITIONS FOR A RESEARCH REACTOR

3.15. The way in which OLCs are presented may vary from State to State, depending on national regulations and practices and on the particular research reactor. It may range from a short list of limits and limiting conditions to a set of detailed specifications together with the objective, applicability statement and basis (see para. 3.4) for each of the specifications. Ideally, a longer format, consisting of a brief description of the objective, applicability, specification and basis for each of the safety limits, safety system settings and limiting conditions for safe operation, should be adopted as good practice. The presentation format should, if appropriate, also include a statement describing actions to be taken (and the allowed completion time) in the event of deviations from the OLCs or in the event of violation of an OLC (see para. 4.45).

3.16. The presentation format adopted for the OLCs may also be used in an appropriate manner to present the associated requirements for maintenance, periodic testing and inspection (see paras 4.30–4.35) and administrative requirements (see paras 4.36–4.45). The requirements for maintenance, periodic testing and inspection may be included in the section of the document on the limiting conditions for safe operation or may be specified in a separate section of the OLC document. The requirements for maintenance, periodic testing and inspection should include operability checks and calibrations, as applicable, and should clearly establish the frequency and scope of the tests needed to verify that the performance levels for safe operation, as established by the OLCs, are met.

3.17. Clear presentation and avoidance of ambiguity are necessary for the reliable use of OLCs, and advice on human factors should be sought at an early stage in the development of the OLC documentation that will be presented to operating personnel. The meaning of terms should be explained to help prevent misinterpretation.

3.18. All modifications to the research reactor are required to be reviewed to determine whether they necessitate changes to the OLCs (see paras 7.99 and 7.100 of SSR-3 [1]). Any changes to the OLCs should be subject to review by the reactor safety committee and to assessment and approval by the regulatory body, as required. Further recommendations are provided in SSG-24 (Rev. 1) [10].

3.19. Whenever it is necessary to change the OLCs on a temporary basis, for example to perform tests or experiments, particular care should be taken to ensure that the effects of the change are analysed. The modified state, although temporary, requires at least the same level of approval as a permanent modification (see para. 7.101 of SSR-3 [1]). Any reasonable alternative approach, if available, should be preferred to temporary changes to an OLC (see also para. 7.104 of SSR-3 [1]).

3.20. Consideration may be given to the application of a probabilistic safety assessment in the optimization of OLCs. Probabilistic assessment methods together with operating experience may be used in the justification and revision of OLCs.

Objective of the specification of operational limits and conditions

3.21. The OLCs should be meaningful to the responsible operating personnel. The objective of the specification of the OLCs should be clearly stated, and the OLCs should be specified in terms of measurable or directly identifiable values of parameters. This is important because the objective might not be evident from the specification itself. For example, if the objective of a particular OLC is to ensure the integrity of the fuel cladding, a temperature level may be specified. However, if there is no instrument for measuring the cladding temperature, it may be necessary to instead specify a reactor power level, a coolant flow rate through the core, a coolant inlet temperature and a height of water above the fuel. It is not self-evident from these four specifications that the final objective is to ensure the integrity of the cladding. The relationship of a limiting parameter to other measurable parameters should be indicated by means of tables or diagrams, as appropriate. The limit or condition should be stated in such a way that it is clear whether a violation has or has not occurred in any situation.

Specification of the applicability of operational limits and conditions

3.22. The applicability of an OLC should be specified in a statement that indicates the operating mode of the reactor (e.g. startup, normal operation, refuelling) and the parameters, components, systems and administrative requirements to which the specification applies. Such a statement of applicability should be included to help ensure a clear and proper understanding of the scope of each OLC specification; for example, the cooling modes (e.g. natural, forced) in which a given OLC is applicable may be specified.

Specification of operational limits and conditions

3.23. The specification of an OLC consists of a statement of the value of a particular parameter or the values of a group of parameters, either as a single value or as a range of possible values. The specification may concern a structure, a system, a component, an operation, a requirement for maintenance, periodic testing and inspection, or an administrative requirement. The specification should be stated in a clear and concise manner and should not conflict with other specifications. Specifications may be derived from the design, from the safety analysis report or from operating experience.

Bases for the specification of operational limits and conditions

3.24. Paragraph 7.34 of SSR-3 [1] states:

> "The selection of, and the values for, the operational limits and conditions shall be based on the safety analysis, on the reactor design or on aspects relating to the conduct of operations, and shall be demonstrably consistent with the updated safety analysis report, shall reflect the present status of the reactor and shall correspond to the licence conditions imposed by the regulatory body."

To help ensure that this requirement is met, the bases for the selection of the values within the OLC specifications should be stated. These may be simple conservative statements made on the basis of operating experience or experimental results. Reference to the relevant sections of the safety analysis report, with a brief summary, should be included. The aim should be to demonstrate that the values in the specifications are conservatively selected for normal operation. Appropriate consideration should be given to factors such as calibration errors, measurement accuracy and system response times and/or the response times of operating personnel.

4. CONTENT OF THE DOCUMENTATION ON OPERATIONAL LIMITS AND CONDITIONS FOR A RESEARCH REACTOR

4.1. The content and the order of presentation of OLCs for a research reactor may differ from State to State. However, all items relevant to safe operation should be included in the OLCs. The content of the OLC documentation may be arranged in the following manner: table of contents; definitions; introduction; safety limits; safety system settings; limiting conditions for safe operation; requirements for maintenance, periodic testing and inspection; and administrative requirements. Each of these is considered in this section.

TABLE OF CONTENTS

4.2. The table of contents should provide sufficient detail to allow easy reference to a specific OLC.

DEFINITIONS

4.3. Definitions should be given of specific terms used in the OLC documentation. In addition, the definitions of any terms particular to the research reactor should be provided.

INTRODUCTION

4.4. The introduction should contain general information about the operating organization of the research reactor and the authorship of the OLC documentation, including its historical development, if necessary. The introduction should also include a statement of any restrictions placed on the OLCs. An example would be stating that the OLCs are only applicable during the commissioning stage of the research reactor. Finally, there should be a statement that all operations at the research reactor are to be conducted in accordance with the OLCs.

SAFETY LIMITS FOR A RESEARCH REACTOR

4.5. Safety limits are limits on process parameter values, within which the operation of the research reactor has been shown to be safe. Safety limits are necessary to protect the integrity of the principal physical barrier that guards against uncontrolled radioactive releases or exposure over regulatory limits in all operational states and design basis accidents. For many research reactors, this principal physical barrier is the cladding of the fuel elements, whose temperature is maintained below a certain limit by cooling so that the integrity of the cladding is ensured. For some research reactors, the principal physical barrier is the primary coolant boundary.

4.6. Safety limits should be established by means of a conservative approach that ensures that all the uncertainties associated with the safety analyses are taken into account. This implies that the exceeding of a single safety limit does not always lead to unacceptable consequences.

4.7. Paragraph 7.43 of SSR-3 [1] states:

> "If a safety limit is exceeded, the reactor shall be shut down and maintained in a safe state and inspections on challenged items important to safety shall be performed. Under such circumstances, the regulatory body shall be promptly notified, an investigation of the cause shall be carried out by the operating organization and a report shall be submitted to the regulatory body for assessment before the reactor is returned to operation."

Normal operation should be restored only after an appropriate evaluation has been performed and approval for restarting has been given in accordance with established procedures.

4.8. The fuel temperature may be used as the basis for a safety limit if there are means of measuring it. If the temperature is measured in only one location in the core, the measured temperature should be correlated to the maximum fuel temperature in the core.

4.9. In some research reactors there may be no provision for measuring the fuel temperature. In this case, the safety limit may still be a maximum fuel temperature derived from the characteristics of the fuel; however, the safety limit is often expressed in terms of other related parameters that are measured, such as the neutron flux, thermal power level, coolant flow through the core, coolant inlet temperature or outlet temperature, coolant pressure and height of coolant above the core. If the core can be cooled by either forced or natural convection, safety limits should be developed for each mode of cooling.

4.10. The selection of the safety limits is of paramount importance and should be given careful consideration. For example, the onset of nucleate boiling, which is often used to establish safety limits, represents an undesirable but not unsafe condition for a research reactor. Departure from nucleate boiling and flow instability, however, are conditions that, if approached too closely, would have significance for safety, and these conditions may therefore be used to establish safety limits. For this reason, reactor operation is limited to a power level such that the maximum heat flux in a fuel element is only a fraction of the burnout heat flux. In some instances (e.g. for low power research reactors), the safety limits may be set very conservatively.

4.11. The maximum allowable surface temperature for the fuel cladding should be set as a safety limit. This safety limit should be applied to the hottest reactor channel, and it should not be exceeded even during pump failure accompanied by reactor shutdown. Some research reactors that are cooled by forced convection utilize downward coolant flow; in the event of pump failure and reactor shutdown, the reactor may be cooled by natural convection, which involves a reversal of the direction of flow. The safety limit should not be exceeded even in such cases.

4.12. It should be shown in the safety analysis report or other associated document that the safety limits will not be exceeded in any operational state.

4.13. The specification of a safety limit should be clear and precise, and the parameters to which it applies and the objective of the limit should be stated. The basis for the safety limit should provide sufficient information to help ensure that operating personnel and the regulatory body have a clear understanding of its safety significance.

4.14. Although the integrity of the containment or the means of confinement (if any) is important in limiting the radiological consequences of an accident, the loss of integrity of the containment or the means of confinement does not in itself lead to damage to the fuel cladding. The integrity of the containment or the means of confinement is therefore not included in the safety limits, but it should be included under the limiting conditions for safe operation.

SAFETY SYSTEM SETTINGS FOR A RESEARCH REACTOR

4.15. Requirement 50 of SSR-3 [1] states that "**A protection system shall be provided for a research reactor to initiate automatic actions to actuate the safety systems necessary for achieving and maintaining a safe state.**" The protection system monitors the parameters for which a safety limit is assigned, and the set points for the automatic actions are defined as the safety system settings.

4.16. Some safety system settings are provided to initiate the operation of engineered safety systems to limit the course of anticipated operational occurrences in such a way that either safety limits are not exceeded or the consequences of postulated accidents are mitigated.

4.17. Safety system settings should be established to ensure the automatic actuation of safety systems within the parameter values assumed in the safety analysis report, despite possible errors that could occur in adjusting the nominal set point. Appropriate alarms should be provided to enable operating personnel to initiate corrective actions before safety system settings are reached.

4.18. Safety system settings should be established for all operational states of the research reactor. The process uncertainties and measurement uncertainties, the response of instrumentation, and uncertainties associated with calculations should all be taken into account when determining a safety system setting.

4.19. The specification of any safety system setting should be clear and precise and should state the parameters to which it applies and the objective of the safety system setting. The basis for the safety system setting should contain sufficient information to help ensure that operating personnel and the regulatory body have a clear understanding of its safety significance.

LIMITING CONDITIONS FOR SAFE OPERATION OF A RESEARCH REACTOR

4.20. Paragraph 7.37 of SSR-3 [1] states:

> "Limiting conditions for safe operation shall be established to ensure that there are acceptable margins between normal operating values and the safety system settings. Limiting conditions for safe operation shall include limits on operating parameters, requirements relating to the minimum availability of operable equipment and minimum staffing levels, and prescribed actions to be taken by operating personnel to preserve the settings of the safety system."

4.21. Limiting conditions for safe operation are administrative constraints on equipment and on operating parameter values, to be adhered to during the startup, operation, shutting down and shutdown of a research reactor to provide assurance of safe operation in compliance with regulatory requirements and licence conditions. The limiting conditions for safe operation should also ensure that safety systems and additional safety features perform their functions in all facility states for which they are necessary.

4.22. The limiting conditions for safe operation should be consistent with and, to the extent possible, derived from the safety analysis report. Limiting conditions for safe operation should be complied with in all operational states of the reactor. Compliance with limiting conditions for safe operation prevents safety system settings from being reached, addresses other factors that might give rise to risks to the public, and ensures the fulfilment of safety functions in all operational states and accident conditions.

4.23. The limiting conditions for safe operation should include unavailability rules for systems and the time allowed to attain the safety fallback state (i.e. a state in which the given equipment is not necessary for safety, such as reactor shutdown or reduced reactor power) if these rules are not met. In describing the actions to be taken by operating personnel (see para. 4.20), the time allowed to complete these actions should also be included.

4.24. Operability requirements should state for the various operating modes of the research reactor the number of systems or components important to safety that should be either in an operating condition or in a standby condition. These operability requirements define the minimum safe facility configuration for each mode of normal operation. The independence of the levels of defence in depth implemented in the research reactor should be maintained when defining the minimum safe configuration. The actions to be taken if operability requirements cannot be met should be specified, and the time allowed to complete these actions should also be stated.

4.25. The operability requirements for startup of the reactor should be more stringent than those set for purposes of operational flexibility during operation of the reactor. The structures, systems and components needed to be operable for startup should be specified.

4.26. For the operability requirements for safety related equipment, the design provisions for redundancy and reliability of equipment (see Requirements 23–28 of SSR-3 [1]) and the period over which equipment may be allowed to be inoperable without an unacceptable increase in risk should be taken into consideration. The basis for determining what constitutes an unacceptable increase in risk should be clearly documented in the OLCs.

4.27. The objective, applicability and specification of each limiting condition for safe operation should be clearly and precisely stated, and its basis should contain sufficient information to help ensure that operating personnel and the regulatory body have a clear understanding of its safety significance.

4.28. The number of limiting conditions for safe operation may be large, even for a low power research reactor. For this reason, the limiting conditions should be grouped by topic. An example of such a grouping is as follows:

(a) Fuel, fuel elements and assemblies;
(b) Fuel handling and storage of fresh fuel and irradiated fuel;
(c) The reactor core configuration;

(d) Reactivity and reactivity control systems;
(e) Reactor protection systems and reactor shutdown systems;
(f) Fuel loading, reactor startup and operation;
(g) Cooling systems and connected systems;
(h) Containment systems or means of confinement, including ventilation;
(i) Operational radiation protection and radioactive waste management;
(j) Instrumentation and control systems;
(k) Experimental devices;
(l) Electrical power supply systems;
(m) Auxiliary systems and equipment;
(n) Other limitations.

4.29. A list of selected factors to be considered when establishing limiting conditions for safe operation is provided in Appendix I.

REQUIREMENTS FOR MAINTENANCE, PERIODIC TESTING AND INSPECTION AS PART OF THE OPERATIONAL LIMITS AND CONDITIONS FOR A RESEARCH REACTOR

4.30. To ensure that safety system settings and limits and conditions for safe operation are observed at all times, the relevant systems and components should be monitored, inspected, checked, calibrated and tested in accordance with an approved maintenance, periodic testing and inspection programme. Recommendations on the maintenance, periodic testing and inspection of research reactors are provided in SSG-81 [3].

4.31. The design of a research reactor is required to allow for appropriate functional testing and inspection of all items important to safety (see Requirement 31 of SSR-3 [1]). Consequently, all items subject to safety system settings and limiting conditions for safe operation should undergo some form of periodic testing. The testing programme should specify the frequency and scope of tests and the acceptance criteria to show that the performance requirements associated with the items subject to safety system settings and limiting conditions for safe operation are met. The test frequency is required to be prescribed in terms of the average intervals, with a maximum interval that is not to be exceeded (see para. 7.39 of SSR-3 [1]), to provide operational flexibility in the scheduling of the inspection, operability check or calibration.

4.32. The requirements for maintenance, periodic testing and inspection should be specified in procedures that include clear acceptance criteria to ensure that the requirements for system operability and component operability are clearly understood by operating personnel. The relationship between the acceptance criteria and the OLC being confirmed should be documented.

4.33. The requirements for maintenance, periodic testing and inspection may be presented by grouping them either in accordance with the systems to which they refer or in a mixed way, for example in groups of requirements for major systems (e.g. the reactivity control system, the reactor pool or tank, the containment and/or confinement systems) or in groups of requirements covering related activities (e.g. tests before startup, monthly tests, quarterly tests, routine monitoring, personal dosimetry).

4.34. Requirements for maintenance, periodic testing and inspection should also include activities intended to detect ageing and other types of deterioration due to corrosion, fatigue and other mechanisms, as appropriate: further recommendations are provided in SSG-10 (Rev. 1) [7]. Such activities will include non-destructive examination of passive systems and of systems explicitly covered by limits and conditions for safe operation. If degraded conditions are found, the effect on the operability of systems should be assessed and acted on, as appropriate.

4.35. Some of the OLCs, including requirements for maintenance, periodic testing and inspection, might not apply during extended periods of shutdown of the research reactor. For example, the calibration of a power measuring channel may be deferred but should be performed before the next reactor startup. Some additional requirements for maintenance, periodic testing and inspection may be necessary during an extended shutdown period, such as during major maintenance or modifications. For these reasons, the requirements for maintenance, periodic testing and inspection for extended shutdown periods may be specified separately.

ADMINISTRATIVE REQUIREMENTS ASSOCIATED WITH OPERATIONAL LIMITS AND CONDITIONS FOR A RESEARCH REACTOR

4.36. Paragraph 7.40 of SSR-3 [1] states:

> "The operational limits and conditions shall include administrative requirements or controls concerning organizational structure and the responsibilities for key positions for the safe operation of the reactor, staffing, the training and retraining of facility personnel, review and audit

procedures, modifications, experiments, records and reports, and required actions following a violation of the operational limits and conditions."

4.37. A list of safety related procedures could also be included in the OLC documentation. These safety related procedures should be reviewed by the reactor safety committee and may be subject to approval by the regulatory body.

Organizational structure

4.38. The organizational structure of the facility should be presented in an organizational chart, with a brief description of the functions of each part of the organization. The chart should show the key personnel of the operating organization who have responsibility for the safety of the research reactor under the terms of the licence or authorization, including the reactor manager, shift supervisor and reactor operators.

Staffing

4.39. The minimum staffing of the various disciplines for all operational states of the research reactor should be specified by the operating organization. The necessary staffing will vary with the complexity and power level of the research reactor. The minimum qualifications for operating personnel performing safety related functions should also be specified.

Training and retraining of facility personnel

4.40. The administrative requirements should include a statement that the reactor manager, shift supervisors, reactor operators, radiation protection personnel, experimenters, maintenance personnel, emergency workers and others who frequently work in the research reactor should be properly trained. The personnel requiring certification or licensing (see para. 7.5 of SSR-3 [1]) should be specified. If appropriate, the period of validity of this certification or licence should also be stated. Recommendations on training are provided in SSG-84 [5].

Review and audit procedures

4.41. The requirement for reviews by the reactor safety committee should be stated. The items that should be reviewed by the reactor safety committee include the following:

(a) Proposed changes to the OLCs or to the authorization for the research reactor;
(b) Proposed changes to tests, experiments, equipment, systems or procedures, and new tests, experiments, equipment, systems or procedures that have safety significance;
(c) Safety related modifications to the research reactor;
(d) Violations of the OLCs or the licence conditions, or failures to follow procedures that have safety significance;
(e) Events that are required to be reported, or have been reported, to the regulatory body;
(f) Routine radioactive discharges and exposures of personnel and the public;
(g) Periodic reviews of the operation and safety performance of the research reactor.

Utilization and modifications

4.42. Administrative requirements for the safe utilization and modification of the research reactor should be included in the OLCs. Guidance for deciding which experiments or modifications are to be referred to the regulatory body should be included in the administrative requirements. Further recommendations on the utilization and modification of a research reactor are provided in SSG-24 (Rev. 1) [10].

Records and reports

4.43. As part of the administrative requirements, the operating organization should make periodic summary reports to the reactor safety committee and, if required, to the regulatory body on matters relating to the safety of the research reactor. The format and frequency of reports should be specified.

4.44. An administrative requirement for the preparation and availability of records and reports should be included in the OLCs. Records important for the safe operation of the research reactor and for demonstrating compliance with the OLCs are required to be prepared and retained (see Requirement 82 of SSR-3 [1]). The records to be maintained by the facility and the time period for which the records are to be retained should be specified. Typical records to be retained include the following:

(a) The safety analysis report for the research reactor and changes to the safety analysis report;
(b) The authorization for the research reactor, the licence conditions and the OLCs;
(c) The emergency plans (including drills and exercises), the security plan and other relevant plans (e.g. associated with the management system, training of personnel);
(d) Records of discharges of effluents to the environment;
(e) Records of radioactive waste;
(f) Records important to decommissioning, such as records of spills, as-built drawings and records of modifications to structures;
(g) Records of radiation exposures;
(h) Records of significant contamination events;
(i) Facility drawings;
(j) Fuel receipt, transport and inventory records;
(k) Routine operating data, such as log books and recording charts;
(l) Procedures and changes to procedures;
(m) Records of events reported to the regulatory body;
(n) Records relating to research reactor experiments, such as application forms and collected data;
(o) Records of dose rate and contamination surveys;
(p) Records pertaining to the reactor safety committee, such as meeting minutes and review reports;
(q) Records of non-compliance;
(r) Records of maintenance, periodic testing and inspection.

Actions in the event of a violation of operational limits and conditions

4.45. The actions to be taken by the operating organization and operating personnel if a limiting condition for safe operation is violated (or cannot be met) or if a safety limit is exceeded, including the time allowed to recover from these situations, should be included in the OLCs. The responsibilities for responding to violations of OLCs and for ensuring compliance should be defined.

5. DEVELOPMENT OF OPERATING PROCEDURES FOR A RESEARCH REACTOR

5.1. Requirement 74 of SSR-3 [1] states:

> "**Operating procedures for the research reactor shall be developed that apply comprehensively (for the reactor and its associated facilities) for normal operation, anticipated operational occurrences and accident conditions, in accordance with the policy of the operating organization and the requirements of the regulatory body.**"

5.2. Paragraph 7.57 of SSR-3 [1] states that "Procedures shall be developed for normal operation to ensure that the reactor is operated within the operational limits and conditions."

5.3. Operating procedures should provide instructions for the safe conduct of operations in all operating modes, such as startup, low and nominal power operation, shutting down, shutdown, maintenance, testing, and refuelling. For anticipated operational occurrences, design basis accidents and design extension conditions without significant fuel degradation, the operating procedures should provide instructions for the return to a safe state.

5.4. Operating procedures are sometimes bound in several volumes or manuals (e.g. operations manual, testing manual, maintenance manual). For low power research reactors, the operating procedures may be collected into a single volume under the general title of 'operating instructions'.

5.5. The organizations involved in ensuring the safety of research reactors have a number of interrelated responsibilities, including the performance of the safety analysis and the preparation of other safety related documents for review and assessment by the reactor safety committee and approval by the regulatory body, as required. Operating procedures that have safety significance should be included in such documents.

5.6. Operating procedures should be verified and validated by authorized persons to ensure that they are administratively and technically correct, are easy to understand and use, and will function as intended. Special attention should be paid to ensuring that the content of operating procedures is compatible with the environment in which they are intended to be used. The operating procedures should be validated in the form in which they will be used.

ROLES AND RESPONSIBILITIES FOR THE DEVELOPMENT OF OPERATING PROCEDURES FOR A RESEARCH REACTOR

Operating organization

5.7. The operating organization of the research reactor is responsible for establishing a set of operating procedures, including administrative and organizational arrangements, taking into account operating experience, if applicable. These general operating rules should be supplemented by specific written operating procedures, as appropriate. The assistance of external consultants may also be sought.

Operating personnel

5.8. Paragraph 7.59 of SSR-3 [1] states:

> "Operating procedures shall be developed by the reactor operating personnel, in cooperation whenever possible with the designer and manufacturer and with other staff of the operating organization, including radiation protection staff."

5.9. Operating personnel should be knowledgeable about the application of the operating procedures relevant to their tasks in the research reactor.

5.10. Operating personnel should operate the research reactor in accordance with valid operating procedures and should provide feedback to the reactor manager on the application of the procedures.

Radiation protection personnel

5.11. Operating procedures relating to radiation protection should be reviewed by a radiation protection officer. The head of the radiation protection group (see para. 7.23 of SSR-3 [1]) should be responsible for the preparation of procedures for radiation protection personnel.

Reactor safety committee

5.12. The reactor safety committee should review and assess operating procedures important to safety and make recommendations to the reactor manager before submitting such procedures to the regulatory body for approval, if such approval is required.

5.13. The reactor safety committee should establish a process for reviewing urgently needed new procedures or changes to existing procedures that cannot await a review during a regularly scheduled reactor safety committee meeting. For example, minor modifications to the operating procedures may be made with the approval of the reactor manager followed by a review by the reactor safety committee at its next meeting, provided that the general operating rules are observed.

Reactor manager

5.14. The reactor manager should determine the need for operating procedures, including those procedures required by the regulatory body (see para. 5.19), and identify the operating personnel and other persons with appropriate competence and experience to be involved in the development of the procedures.

5.15. The reactor manager should ensure the timely development and implementation of the operating procedures. Alternatively, the reactor manager may appoint a staff member, normally a relevant group leader, to oversee the development and implementation of procedures.

5.16. The reactor manager should be responsible for the approval of all operating procedures, including those reviewed by the reactor safety committee.

5.17. In accordance with para. 7.15 of SSR-3 [1], the reactor manager is responsible for the training and retraining of staff in the procedures. The reactor manager should ensure that the latest revision of the procedures is used in the training or retraining.

5.18. The reactor manager should ensure that the latest approved operating procedures are readily available close to the location where the work is done. Usually, one full set of operating procedures is kept in the control room and another full set in the office of the reactor supervisor (see Section 3 of SSG-84 [5]). There may be an additional selection of appropriate procedures, kept in other locations near relevant operations areas that are remote from the control room.

Regulatory body

5.19. The regulatory body may require that specific operating procedures be established for the research reactor. Operating procedures should be made available to the regulatory body, when requested.

CATEGORIZATION OF OPERATING PROCEDURES FOR A RESEARCH REACTOR

5.20. Paragraph 7.58 of SSR-3 [1] states (footnotes omitted):

> "Operating procedures shall be developed for all safety related operations that may be conducted over the entire lifetime of the facility, including for:
>
> (a) Commissioning;
> (b) Operation in normal operational states;
> (c) The maintenance of major components or systems that could affect reactor safety;
> (d) Periodic inspections, calibrations and tests of structures, systems and components that are essential for the safe operation of the reactor;
> (e) Radiation protection activities;
> (f) The review and approval process for operation and maintenance and the conduct of irradiation and experiments that could affect reactor safety or the reactivity of the core;
> (g) The reactor operator's response to anticipated operational occurrences and design basis accidents, and, to the extent feasible, to design extension conditions;
> (h) Emergencies;
> (i) Handling of radioactive waste and monitoring and control of radioactive releases;
> (j) Utilization;
> (k) Modifications;
> (l) The management system."

This list is not intended to be comprehensive; additional procedures (e.g. for security, for extended shutdown, for administrative purposes) may be appropriate. Some of the listed procedures might not be appropriate for some research reactors, critical assemblies and subcritical assemblies with low hazard potential, and the list might be incomplete for high power facilities. Appendix II provides an indicative list of operating procedures.

5.21. Other approaches to the categorization of operating procedures may also be appropriate. A categorization system may be established on the basis of the review and approval route for the procedures, for example procedures that are required and approved by the regulatory body, administrative procedures (reviewed by the operating organization) and other safety related procedures (reviewed by the reactor safety committee and approved by the reactor manager).

GENERAL CONSIDERATIONS FOR THE DEVELOPMENT OF OPERATING PROCEDURES FOR A RESEARCH REACTOR

5.22. The need for special quality management measures should be taken into account when developing procedures for operational activities that have an influence on or relate to the following:

(a) The reactor core configuration;
(b) Reactivity and criticality;
(c) Thermal safety;
(d) Safety of experiments;
(e) Repair actions;
(f) Modification of existing systems or components;
(g) Safety measures for visitors;
(h) New installations;
(i) Manipulation of special components and radioactive material;
(j) Maintenance, periodic testing and inspection of equipment;
(k) Inspection programmes;
(l) Steps for the approval of different safety related actions (e.g. replacements, repairs, modifications, new installations);
(m) Training and qualification of operating personnel and experimenters.

5.23. A planned and systematic approach should be applied to the development of a set of operating procedures. This may be facilitated by using a prescribed format and standard outline of the content to be incorporated (see Section 6). All the procedures should be developed in accordance with established requirements and recommendations of the management system for the research reactor.

5.24. Each procedure should be sufficiently detailed for a qualified individual to be able to perform the activities without direct supervision; however, each procedure is not expected to provide a complete description of all the processes involved in the operation of the research reactor.

5.25. Human factors should be taken into account to help ensure that operating procedures are safe, reliable and effective. Consideration should be given to the layout, the general design of the facility, the staffing needs, the time needed for operator action, the physical environment, the level of stress and operating experience at the research reactor.

STEPS IN THE PREPARATION OF AN OPERATING PROCEDURE FOR A RESEARCH REACTOR

5.26. The first step in the development of an operating procedure should be to define the objectives of the procedure. The next step is to evaluate the possible methods and staffing for fulfilling the objectives of the procedure and to select the methods best suited to achieving the desired goal.

5.27. If possible (and if considered necessary), the methods selected should be simulated by the technical and administrative personnel who will be performing the task covered by the procedure. A draft procedure should be used for the simulation. The simulation should cover all conceivable technical and human errors that could occur during the performance of the task. The procedure should be finalized on the basis of the results of the simulation.

5.28. If the procedure has significance for radiation protection, it should be reviewed by a radiation protection officer and modified as necessary.

5.29. The draft procedure may be improved by means of a further review by personnel with experience in the subject of the procedure.

5.30. The reactor manager should be responsible for ensuring that draft procedures are reviewed to determine whether they are sufficiently detailed to meet their objectives and are consistent with other relevant procedures. Also, the reactor manager should ensure that implementation of the procedure would not violate any OLCs.

5.31. The reactor manager should forward the final drafts of safety related procedures to the reactor safety committee for review and comment prior to their approval. Procedures that have significance for the safety of the reactor should be specified as such and, if required by national regulations, be subject to approval by the regulatory body.

5.32. The procedure may be released by the reactor manager for a trial period or a period of restricted use and subsequently revised if necessary. Following this validation period, use of the procedure should be subject to final approval by the reactor manager.

5.33. Paragraph 7.60 of SSR-3 [1] states that “The operating procedures shall be reviewed and updated periodically on the basis of lessons learned from operating experience, or in accordance with predetermined internal procedures.”

Review and updating should follow the same steps as those in the preparation of the original procedure. The reactor manager should specify the process for this review and updating.

5.34. Safety significant revisions of procedures should be treated in accordance with para. 5.30. Other revisions of procedures may be approved directly by the reactor manager.

6. FORMAT AND CONTENT OF OPERATING PROCEDURES FOR A RESEARCH REACTOR

6.1. All operating procedures should have a standard format, as specified by the operating organization. The procedures should follow a suitable sequential presentation, should have a clear, concise and logical text, and should cover all relevant issues.

6.2. To ensure consistency in format and content, operating procedures should be prepared in accordance with the management system and the administrative procedures that govern the development, review and control of such documents. Provision should be made for periodic review of operating procedures, as described in para. 5.33. There should be a mechanism to easily verify that a procedure has been approved (e.g. by means of a signature) and that it is current (e.g. through a list of the latest revision dates).

6.3. Operating procedures should generally contain step by step instructions for performing tasks, except in the case of routine activities that are capable of being performed by qualified personnel without special instructions. More than one procedure may be necessary to accomplish certain tasks. In this case, the order in which the procedures need to be performed should be specified in the procedures themselves.

6.4. There should be a clear differentiation in a procedure between the introduction, guidance and essential steps.

6.5. The following is an example of the content to be considered for inclusion in an operating procedure:

(a) Identification number: A unique number that identifies the procedure as one of a series of operating procedures.
(b) Revision number and date: The current revision number and date, included at the head of each page of an operating procedure to ensure that personnel are aware of the revision that is in use (e.g. Revision 3: day, month and year).
(c) Date of expiry: The date of the next revision or an indication of indefinite validity until the withdrawal of the procedure.
(d) Title: A concise description of the content of the procedure (e.g. reactor startup, control rod calibration).
(e) Scope and purpose: A statement of the scope and purpose of the procedure.
(f) Definitions: Definitions of terms used in the procedure that are necessary for understanding and performing the procedure.
(g) References: References that support the procedure and that are referred to in the text.
(h) Responsibilities: Specification of the roles and responsibilities of personnel performing the procedure.
(i) Prerequisites: List of specific conditions for the reactor, systems, equipment and personnel necessary to perform the procedure.
(j) Additional measures: Specification and/or description of special tools, support services, radiation protection measures, special safety precautions, possible effects on the reactor during the implementation of the procedure, measures to prevent damage to fuel and equipment, training of personnel, conditions of applicability, and preparations relating to the performance of the procedure.
(k) Warnings and cautions: The highlighting of specific risks. These warnings and cautions should be positioned in the text immediately prior to the relevant steps in the procedure.
(l) Instructions: Specific step by step instructions for performing a task. The level of detail should be such that qualified personnel can follow the instructions without further directions. Where appropriate, hold points for inspection and verification should be specified. Instructional steps should begin with verbs (i.e. actions such as turn, record, energize, set, note, check, lift, press, test or insert). Safety significant steps should be clearly differentiated such that they attract attention. Caution should be exercised to ensure that the steps in the instructions are complete, that all necessary actions have been considered and that there are no instruction steps contained in the procedure as prerequisites, special measures, warnings or cautions

that could be overlooked while performing the procedure. Consideration should be given to providing checklists on which each step is initialled by operating personnel as it is completed. Where necessary, instructions should be provided for closing activities, such as restoring the system to its normal configuration.

(m) Basis for measurements and calculations: For some procedures that involve measurements and calculations, documentation of the basis for the measurements and calculations may be provided to assist operating personnel in understanding the steps performed in the procedure. Relevant limits and conditions for safe operation from risk analysis should be included in procedures, as appropriate.

(n) Documentation: While completion of some procedures may be indicated by a simple entry in the reactor log book, more complicated procedures may be documented by means of appropriate checklists, data tables and reports. Such documentation should include the name of the person recording the data, the time and the date. The level of detail for documenting a procedure should be commensurate with the relative complexity of the operation and the risks associated with failure to conduct the operation properly.

6.6. Operating procedures should include arrangements for collecting, tabulating and reporting data and test results. Methods of analysis should be stated and presented in a manner that allows for further verification. Test data should be evaluated against predefined performance parameter values and acceptance criteria in which account is taken of the uncertainties assumed in the safety analysis.

6.7. Procedures should be prepared for the procurement and acceptance of new components or equipment (e.g. fuel elements, ion exchange resins) in accordance with the management system for the research reactor. The procedures should include the need for a valid calibration certificate for test equipment used in the procedure.

6.8. Procedures should specify who has the authority to permit deviations from the procedure and the circumstances under which deviations are permitted. Such deviations, if permitted, should be made within the bounds of the relevant OLCs.

COMMISSIONING PROCEDURES FOR A RESEARCH REACTOR

6.9. Commissioning procedures may be subdivided into those that are derived directly from operating procedures and those that will be needed during commissioning only. The latter are sometimes referred to as ‘test procedures’.

A commissioning procedure should be prepared for each commissioning test or activity. The procedure may also be used as a guide for assessing and documenting the results of the test.

6.10. Recommendations on commissioning procedures, including procedures for tests of equipment and systems, are provided in SSG-80 [2]. In preparing such procedures, special attention should be paid to the following:

(a) Summary of the purpose of each commissioning test, the equipment to be tested and the relationship to the commissioning programme;
(b) Prerequisites and initial conditions (see para. 6.13);
(c) Precautions, including stopping of the test;
(d) List of equipment and instruments needed to perform the test;
(e) List of data to be recorded and checklists;
(f) Methods for analysis of data and results;
(g) Acceptance criteria;
(h) Provisions for corrective actions to address possible non-conformances;
(i) Certification of the completion of the test.

6.11. The commissioning test procedures should follow the normal operating procedures for the research reactor, to the extent practicable, to verify these procedures and to provide an opportunity for operating personnel to become familiar with the normal operating procedures.

6.12. Certain commissioning activities may only need generic procedures or lists of instructions.

6.13. Commissioning procedures should include prerequisites, where applicable, for system tests that have to be completed prior to performing the step by step instructions, including commissioning of support systems (e.g. checking that the flow measurement channel is operable prior to testing of the primary cooling system, checking that there is an operable electrical power supply prior to commissioning tests of pumps).

6.14. In addition to operating procedures, supporting documentation, including manufacturer manuals and construction drawings, may be needed for commissioning test procedures for some components and systems.

6.15. If necessary, the procedure should include hold points for the notification and involvement of outside agencies, manufacturers and the regulatory body.

6.16. Commissioning procedures should state all the changes to the normal operating configuration that are necessary to perform testing. In such cases, configuration checks should be undertaken to ensure that these changes are made correctly before the start of the tests and that all the components or systems are restored to their normal status after the testing.

6.17. Consideration should be given during the preparation of commissioning procedures to possible interactions between the reactor and experimental devices.

6.18. Commissioning procedures should be prepared for experimental devices, whether they undergo commissioning at the same time as the reactor or later.

6.19. Commissioning procedures should contain provisions for dealing with unexpected results, deliberate changes to the design, programmes or tests that may become necessary, and incidents that might occur during the commissioning process.

6.20. In practice, many of the commissioning procedures will become operating procedures (e.g. procedures for fuel loading, startup, calibration of reactivity control mechanisms and determination of the thermal power level).

6.21. The results of commissioning tests should be analysed, and the need for modifications to the OLCs or the operating procedures should be considered.

OPERATIONAL PROCEDURES FOR A RESEARCH REACTOR

6.22. Operational procedures should be prepared for all activities performed by operating personnel in all operational states of the research reactor and, where appropriate, for activities performed during experiments and for the handling of fuel assemblies or other core components or reflector components, including experimental devices.

6.23. Procedures are normally performed one at a time. If this is not the case, the safety significance of the simultaneous performance of several procedures should be taken into account by specifying special precautions in the relevant procedures.

6.24. Operating procedures are required to be reviewed periodically (see para. 7.60 of SSR-3 [1]) and should also be reviewed whenever a change is made in the configuration of the research reactor systems or components. For operations that are performed infrequently, the existing operating procedures should be reviewed before each use, and revisions should be made as appropriate.

6.25. Operational procedures should specify the actions necessary in the case of an unexpected event or unexpected results during the performance of the procedure, as necessary.

6.26. Operational procedures should include the arrangements for work permits, if used.

MAINTENANCE PROCEDURES FOR A RESEARCH REACTOR

6.27. Paragraph 7.69 of SSR-3 [1] states that "All maintenance, periodic testing and inspection of systems or items important to safety shall be performed by following approved written procedures." A plan should be prepared to assist in the timely completion of preventive maintenance activities that are conducted on a regular (e.g. weekly, monthly, quarterly, semi-annual, annual) basis. Procedures for corrective maintenance activities should also be prepared, as necessary. Further recommendations are provided in SSG-81 [3].

6.28. In the preparation of maintenance procedures, particular attention should be paid to the effects of the procedure on safety systems and on reactor operation. Paragraph 7.70 of SSR-3 [1] states that "Non-routine inspections or corrective maintenance of systems or items important to safety shall be performed to a specially prepared plan and procedures." Some maintenance procedures with no impact on reactor safety may be performed during reactor operation; other procedures may necessitate the shutdown of the reactor. The maintenance process should not reduce the safety of the research reactor, and the OLCs should not be violated.

6.29. Paragraph 7.69 of SSR-3 [1] states:

> "In accordance with the requirements of the management system, a system of work permits shall be used for maintenance, periodic testing and inspection, including appropriate procedures and checklists before and after the conduct of the work. These procedures shall include acceptance criteria."

The aim is to ensure that all work is conducted with the knowledge and permission of the person in operational control of the research reactor and that both the safety of the reactor and the safety of the personnel doing the work have been considered, with approval of the work permit as a prerequisite for performing maintenance.

6.30. Paragraph 7.69 of SSR-3 [1] states that “The procedures shall specify the measures to be taken for any changes from the normal reactor configuration and shall include provisions for the restoration of the normal configuration on the completion of the activity.” This could include, for example, procedures for changes to valve line-ups and procedures for taking mechanical and electrical equipment out of service and for restoring it to service. A generic procedure should be developed, or special provisions should be made in individual procedures, to ensure configuration control.

6.31. References to drawings, manufacturer manuals and manufacturer recommendations should be included in the maintenance procedures. It should be ensured that the current versions of drawings and manuals are used.

6.32. Maintenance procedures should specify that the results of maintenance, periodic testing and inspection should be assessed by qualified personnel in accordance with para. 7.75 of SSR-3 [1]. Comparison should be made, where appropriate, with the results of previous inspections and tests to determine latent failures and to permit timely corrective action.

6.33. Maintenance procedures should specify that the resumption of normal operation should be permitted only after an authorized person has approved the results of the maintenance.

6.34. Special procedures should be prepared for the control of maintenance work performed by contractors. These procedures should include prerequisites for the work, arrangements for supervision of contractors in accordance with para. 7.1 of SSR-3 [1], contractor qualification criteria and arrangements for work coordination.

INSPECTION, CALIBRATION AND PERIODIC TESTING PROCEDURES FOR A RESEARCH REACTOR

6.35. Periodic testing is performed to fulfil the requirements for maintenance, periodic testing and inspection specified in the OLCs and is intended to ensure compliance with the OLCs. The maintenance, periodic testing and inspection programme should be adequately specified to ensure the inclusion of all aspects of the limits or conditions.

6.36. Periodic testing procedures, which include calibration, inspection and operability checks, should be prepared for structures, systems and components important to safety at a research reactor. A plan for scheduling calibrations, inspections and operability checks should be prepared to assist in their completion with the required frequency. Procedures should provide for independent verification that a component or system is returned to its operational state (including verification that it is not bypassed or disabled) after an inspection, operability check, calibration or any other associated maintenance activity.

6.37. The frequency of the periodic testing and inspection activities should be stated in the associated procedures and should take into account the following:

(a) Analyses, including insights from probabilistic safety assessment, where available;
(b) The recommendations of the supplier;
(c) Experience gained from previous periodic testing and inspection results;
(d) Operating experience from the facility or relevant experience from other facilities;
(e) Engineering judgement.

6.38. Periodic testing procedures should be consistent with the reactor operating procedures. When developing periodic testing procedures, the recommendations on the format and content of operational procedures and maintenance procedures (see paras 6.22–6.34) should also be taken into account.

6.39. Each periodic testing procedure should provide for a final acceptance (including a signature) by a person qualified and authorized to assess the results of the procedure and to verify compliance with the OLCs.

6.40. Periodic testing procedures should have provisions for resolving non-conformances with the OLCs.

6.41. Acceptance criteria should be provided within periodic testing procedures, and these criteria should take into account any uncertainties associated with measurements. Providing a range of acceptable values for parameters is generally better than specifying single values.

6.42. The procedures should specify that instruments used for calibrations are certified in accordance with the management system.

RADIATION PROTECTION PROCEDURES FOR A RESEARCH REACTOR

6.43. Radiation protection procedures should be prepared within the framework of the radiation protection programme for the research reactor (see Requirement 84 of SSR-3 [1]).

6.44. Radiation protection procedures should contain instructions for implementing the radiation protection programme, such as instructions for periodic measurements (e.g. for bioassay, contamination surveys, stack effluents and source inventory). The procedures should contain acceptance criteria and should identify the person responsible for reviewing the results. An overarching radiation protection procedure should be prepared to ensure that all radiation protection activities are completed with the necessary frequency.

6.45. The provisions for radiation protection for reactor operators, and for personnel conducting maintenance, periodic testing and inspection or performing experiments, should be included in each of the relevant procedures and, if necessary, in the associated work permits.

6.46. In developing radiation protection procedures, compliance with the OLCs for reactor operation and with regulatory requirements should be verified.

PROCEDURES FOR THE AUTHORIZATION OF OPERATION, MAINTENANCE AND UTILIZATION OF A RESEARCH REACTOR

6.47. Procedures for the authorization of operation, maintenance and utilization (conduct of irradiations or performance of experiments) that could affect the safety of the reactor should be prepared, and these procedures should define the conditions, the levels of responsibility and the means of authorization.

6.48. Paragraph 7.103 of SSR-3 [1] states that "The reactor manager shall establish a procedure, in accordance with accepted engineering practice, for the review and approval of proposals for experiments and modifications and for the control of their performance."

6.49. Proposals for experiments should include the following:

(a) A description of the purpose and intended conduct of the experiment;
(b) The means of integrating the experimental device with the reactor systems;

(c) The selection and justification of the criteria employed in the design of the experimental device;
(d) A safety assessment of the experimental device, including the experiment itself, and of its effects on the safety of the reactor and personnel;
(e) Any needs for the production and validation of special documentation for operation and maintenance;
(f) Any special training needs for operating personnel, maintenance personnel and experimenters;
(g) The arrangements for commissioning and functional testing;
(h) Requirements for transport, if necessary;
(i) A decommissioning plan for the experimental device;
(j) The quality management programme;
(k) The suggested means of disposal of the radioactive waste generated in the experiments and of the experimental devices after their final use (see IAEA Safety Standards Series No. SSR-5, Disposal of Radioactive Waste [18]);
(l) Considerations relating to alarms and interlocks;
(m) Procedures to ensure adequate means of communication between the reactor operators and experimenters.

6.50. Procedures should be prepared for the authorization of irradiations and isotope production. The procedures should include information concerning the means by which new types of irradiation (e.g. irradiation of new materials or of greater quantities of the usual materials) should be authorized.

PROCEDURES FOR RESPONDING TO ANTICIPATED OPERATIONAL OCCURRENCES AND ACCIDENT CONDITIONS AT A RESEARCH REACTOR

6.51. In accordance with Requirement 74 of SSR-3 [1], operating procedures are required to be prepared to guide the response of operating personnel to anticipated operational occurrences and design basis accidents and, to the extent feasible, to design extension conditions. These procedures should be periodically exercised. The procedures should be reviewed periodically, depending on their safety significance, and modified on the basis of operating experience and the performance of the exercises.

6.52. The procedures for dealing with experiments, including the irradiation of targets for isotope production, should be included with the operational procedures for the reactor. On the basis of the safety analysis report, the procedures should contain the duties of the operating organization for all anticipated operational occurrences. The instructions in these procedures should be clear and brief, and particularly so for those dealing with anticipated operational occurrences.

EMERGENCY PROCEDURES FOR A RESEARCH REACTOR

6.53. Emergency procedures are required be prepared as part of the operating organization’s emergency arrangements for preparedness for and response to a nuclear or radiological emergency (see Requirement 81 and para. 7.90 of SSR-3 [1]). The emergency arrangements are also required to be in accordance with the requirements established in IAEA Safety Standards Series No. GSR Part 7, Preparedness and Response for a Nuclear or Radiological Emergency [19].

6.54. The development of emergency procedures should take into account the evaluation and analysis of all aspects of possible accidents in the safety analysis report as well as those additionally postulated in the hazard assessment undertaken for the purpose of emergency preparedness and response. The emergency procedures should describe in detail the actions to be taken by emergency workers in the case of an emergency. They should refer to the emergency response facilities, emergency services, response organizations and emergency equipment associated with the research reactor.

6.55. Emergency drills and exercises are required to be periodically conducted (see para. 7.92 of SSR-3 [1] and para. 6.31 of GSR Part 7 [19]). In accordance with para. 7.92 of SSR-3 [1], the emergency procedures are required to be reviewed on the basis of experience gained from the performance of the drills and exercises. In addition, the procedures, including the list of organizations and individuals to be informed in the event of an emergency, are required to be reviewed at specified periods and amended, if necessary, to improve their execution and to ensure that the lessons learned are taken into account

6.56. In preparing emergency procedures in which the services of off-site organizations such as hospitals, police forces, fire departments and ambulance services are utilized, formal letters of agreement should be obtained by the operating organization from the other organizations involved in the emergency response. Formal letters of agreement and lists of contact points should be maintained and periodically updated. In addition, emergency procedures, including emergency actions to be taken by off-site organizations, should include clear and detailed instructions that have been agreed with the off-site organizations.

6.57. Experts should be consulted in preparing emergency procedures for a research reactor (e.g. specialized personnel from fire departments, hospital emergency units and ambulance crews) and in implementing the requirements of GSR Part 7 [19]. Further recommendations are provided in IAEA Safety Standards Series No. GS-G-2.1, Arrangements for Preparedness for a Nuclear or Radiological Emergency [20].

NUCLEAR SECURITY PROCEDURES FOR A RESEARCH REACTOR

6.58. Security procedures (e.g. physical protection and computer security procedures) should be prepared and should be a component of the nuclear security contingency plan. The plan should be approved by the competent authorities as specified in the legal framework of the State. The plan and procedures should be kept confidential and should be revealed only to those with a valid need to know.

6.59. Security procedures should be developed on the basis of the evaluation and analysis of all aspects of security. The instructions for security procedures should be brief but should give sufficient details of the essential steps for coping with security matters.

6.60. If the security procedures involve the services of off-site organizations such as police forces and army units, formal letters of agreement and lists of contact points should be obtained, and these should be periodically updated.

6.61. Experts (e.g. security specialists, including physical security specialists, computer security specialists and specialized personnel from the police and army) should be consulted in preparing security procedures. Further guidance is provided in the IAEA Nuclear Security Series [21–24].

PROCEDURES FOR THE HANDLING OF RADIOACTIVE WASTE AND THE MONITORING AND CONTROL OF RADIOACTIVE DISCHARGES AT A RESEARCH REACTOR

6.62. Requirements for the procedures for the handling of radioactive waste and the monitoring and control of radioactive discharges are established in IAEA Safety Standards Series No. GSR Part 5, Predisposal Management of Radioactive Waste [25]. These procedures may be included as part of the radiation protection procedures (see paras 6.43–6.46) or may form a group within the operational procedures (see paras 6.22–6.26).

6.63. At some research reactors, the operating personnel and radiation protection personnel handle, collect, process, account for and store radioactive waste. In such cases, the procedures for radioactive waste are usually considered to be radiation protection procedures. Further recommendations on the predisposal management of radioactive waste are provided in IAEA Safety Standards Series No. SSG-40, Predisposal Management of Radioactive Waste from Nuclear Power Plants and Research Reactors [26].

6.64. Procedures for controlling radioactive discharges play an important part in environmental protection and in gaining public acceptance of the research reactor. These factors should be taken into account in the development of the procedures. Further recommendations are provided in IAEA Safety Standards Series No. GSG-9, Regulatory Control of Radioactive Discharges to the Environment [27].

PROCEDURES FOR EXTENDED SHUTDOWN OF A RESEARCH REACTOR

6.65. Procedures are required to be prepared for the management of extended shutdown of a research reactor and for the provision of adequate resources for ensuring the safety of activities during such a shutdown (see Requirement 87 of SSR-3 [1]). During an extended shutdown, modifications of the procedures for preventive maintenance and periodic testing may be introduced, consistent with any modification of the OLCs, as discussed in Section 3 of this Safety Guide. During an extended shutdown, some exemptions from procedures for activities that are a function of operating time or energy generation might be appropriate (see also paras 6.67–6.69).

6.66. Special procedures should be developed for those inspections that could indicate degradation of mechanical and electrical systems and components (see also para. 7.123 of SSR-3 [1]).

6.67. Procedures for extended shutdown should be derived from the procedures for normal operation. The effects of giving exemptions for activities to be conducted during extended shutdown should be carefully investigated, as some activities could cause significant degradation in the systems, which could prevent the future operation of the reactor.

6.68. Maintenance, periodic testing and inspection procedures to be used during extended shutdown periods for the reactor should be derived from the maintenance, periodic testing and inspection procedures for an operating reactor, with exemptions given for certain activities but procedures strengthened for others.

6.69. If operating procedures are modified for the extended shutdown, the original versions of the operating procedures should be kept for use in the possible future operation of the reactor.

6.70. Procedures should be developed for disconnecting, dismantling and preserving the systems that are to be taken out of operation or temporarily dismantled.

PROCEDURES FOR UTILIZATION AND FOR MODIFICATION OF A RESEARCH REACTOR

6.71. Procedures should be prepared for controlling any utilization and modification of the reactor that has safety significance to ensure that the design, manufacture, installation, conduct and testing of experiments and modifications are properly executed and are in accordance with Requirement 83 of SSR-3 [1].

6.72. The utilization and modification of the reactor should be performed in accordance with approved procedures that contain provisions for meeting all the OLCs.

6.73. The following should be included in procedures for modification of a research reactor:

(a) Description and drawings of the proposed modification;
(b) Justification of the need for the modification;
(c) Design requirements and criteria;
(d) Results of the safety assessment supporting the modification, including influences on other systems;
(e) Manufacturing processes for the modification;
(f) Installation processes for the modification;
(g) Commissioning process for the modification;
(h) Review and modification of existing operating procedures and the need for new procedures;
(i) Updating of documentation (e.g. drawings, training materials);
(j) Training needs for reactor operators and other personnel (including requalification and relicensing, if necessary);
(k) Quality management;
(l) Arrangements for the optimization of protection and safety;
(m) Arrangements for security;
(n) Arrangements for radioactive waste management.

6.74. A procedure should be prepared for the categorization of experiments and modifications on the basis of their safety significance, as required by para. 7.100 of SSR-3 [1]. Three categories for experiments and modifications should be considered: those that fall outside the existing OLCs (major safety significance); those that are within the existing OLCs (moderate safety significance); and those that have no safety significance. Recommendations on categorization, safety assessment and approval routes for experiments and modifications are provided in SSG-24 (Rev. 1) [10].

6.75. In the preparation of procedures for utilization and modification, particular attention should be paid to the consequences for safety systems and for reactor operation. The safety of the reactor during or as a result of the modification or utilization should not be reduced below the limits set in the OLCs.

6.76. The procedures should include a system of work permits for modification and utilization and for pre-operational testing, including appropriate checks before and after the work. This is to ensure that all work is conducted with the knowledge and permission of the reactor operator, to ensure the protection and safety of the personnel doing the work and the safety of the reactor, and to ensure that work is undertaken in accordance with the management system.

6.77. Procedures for modification and utilization of the research reactor should specify any changes to the normal reactor operating configuration (e.g. valve line-ups) and should include provisions for restoration of the normal configuration.

6.78. Procedures for modification and utilization of the research reactor should include assessment of the results of the modification or utilization by properly qualified persons to verify compliance with the design requirements and intent and with the OLCs. The procedures should involve comparisons, where appropriate, with the pre-modification conditions to determine possible failures and to permit timely corrective action.

6.79. Modification procedures should ensure that the resumption of normal operation of the research reactor will be permitted only after the person who is responsible for coordinating the modification work has approved the results, including the updating of documentation.

6.80. Special procedures should be prepared to control modification work performed by contractors. These procedures should include criteria for contractor qualifications and training and for the coordination of work, as well as provisions for supervision of the contractors in accordance with para. 7.1 of SSR-3 [1]. The procedures should list any activities prohibited from being performed by contractors (e.g. activities causing the generation of dust, use of the reactor power supply).

ADMINISTRATIVE PROCEDURES FOR A RESEARCH REACTOR

6.81. Administrative procedures should be developed for all operations that are of an administrative nature and that might have an effect on the safety of the reactor (e.g. training and retraining of personnel, transport of radioactive material, fuel management, safety measures for visitors).

6.82. Administrative procedures that are consistent with the management system are required to be developed for the generation, collection, retention and archiving of records and reports (see para. 7.95 of SSR-3 [1]).

6.83. Administrative procedures may be used as implementing procedures for the management system.

6.84. Administrative procedures for the transport of radioactive material should be based on regulatory requirements for the transport of radioactive material and should be in accordance with the requirements established in IAEA Safety Standards Series No. SSR-6 (Rev. 1), Regulations for the Safe Transport of Radioactive Material [28].

7. TRAINING OF PERSONNEL IN THE USE OF OPERATING PROCEDURES AT A RESEARCH REACTOR

7.1. To ensure that operating procedures will be properly executed, operating personnel and other persons are expected be knowledgeable in these procedures and have the necessary training, retraining and qualification in accordance with Requirement 70 of SSR-3 [1].

7.2. Training of operating personnel and other persons who are intended to implement procedures should be conducted before these procedures are used. Training may take the form of oral or written instructions, demonstrations, drills, training classes and/or comprehensive training courses and, where applicable, involve the use of mock-ups.

7.3. Retraining (see para. 7.30 of SSR-3 [1]) in the use of procedures should be included in the training programme for operating personnel and other persons, and the frequency of retraining should be specified. Retraining should be conducted in accordance with a plan, and special attention should be paid to emergency procedures, including infrequently performed procedures and procedures for design extension conditions. Examples of the activities for which retraining should be provided include the following:

(a) Operation of the emergency core cooling systems;
(b) Operation of the air cleaning system for the containment or the means of confinement;
(c) Testing of the leak rate of the reactor building containment or means of confinement;
(d) Handling of highly radioactive material under abnormal conditions;
(e) Fuel transport;
(f) Emergency actions, such as responses to a fire alarm or an evacuation alarm in the reactor building, to a personal injury, to the release of airborne radioactive material or to extreme weather warnings;
(g) Use of personal protective equipment.

7.4. The operating personnel and other persons at the research reactor should be able to demonstrate their knowledge and understanding of the operating procedures they follow in discharging their responsibilities.

7.5. Paragraph 7.31 of SSR-3 [1] states that "Procedures shall be put in place for the validation of the training to verify its effectiveness and the qualification of the staff."

7.6. Further recommendations on training of personnel are provided in SSG-84 [5].

8. COMPLIANCE WITH OPERATIONAL LIMITS AND CONDITIONS AND OPERATING PROCEDURES FOR A RESEARCH REACTOR

8.1. The operating organization has the primary responsibility for ensuring compliance with the OLCs. The provision of operating procedures and training in using operating procedures consistently with the OLCs is a major contribution to ensuring compliance with the OLCs. Some OLCs may be directly stated in procedures or other documents; if this is the case, it should be clearly indicated in the relevant document. To ensure compliance with the OLCs, all persons responsible for such compliance should always have available a copy of the OLCs currently in force and should be adequately trained in their application.

8.2. If possible, OLCs should be legibly indicated on instruments and displays to facilitate compliance. Similarly, operating procedures should be immediately available to operating personnel and to others who need to refer to them.

8.3. If an OLC cannot be met or a procedure cannot be followed, this should be reported and the causes should be analysed. This may lead to the modification of an OLC or procedure in accordance with established procedures that allow for changes to be made in a controlled manner and approved as required by the regulatory body.

8.4. Records of operation of the research reactor and demonstrations of compliance with the OLCs and operating procedures are required to be kept (see para. 7.96 of SSR-3 [1]) and should be stored in accordance with the management system. Reports of non-compliance should be investigated to ensure that corrective action is taken and to help prevent such non-compliance in the future.

Appendix I

FACTORS TO BE CONSIDERED IN ESTABLISHING LIMITING CONDITIONS FOR SAFE OPERATION OF A RESEARCH REACTOR

I.1. The following list of operating parameters and equipment should be considered in establishing limiting conditions for the safe operation of a research reactor. These limiting conditions for safe operation may be constraints on operating parameter values or administrative limitations imposed on each of the listed items. The operating organization should look at the entire list and select the appropriate items in accordance with the type of research reactor, critical assembly or subcritical assembly, and the conditions of operation. All the items should be considered in establishing OLCs, unless it can be justified that certain items listed are not applicable for a specific research reactor, critical assembly or subcritical assembly; such a justification will depend on the design and potential hazards associated with the facility. The grouping of items by systems or activities of a common nature has been done only for convenience. However, presenting the limiting conditions for safe operation by groups in the OLC documentation would provide a logical arrangement and give clarity to the documentation.

(a) Fuel and fuel elements and assemblies:
- Uranium enrichment;
- Uranium content;
- Materials used;
- Geometry;
- Burnup limits;
- Fuel failure criteria (e.g. maximum allowed activity of the cooling water);
- Inspection and testing of fresh fuel and in-service elements and assemblies.

(b) Fuel handling and storage of fresh and spent fuel:
- Storage of fresh fuel;
- Storage of irradiated fuel;
- Storage of failed fuel;
- Capability to unload and store core components;
- Fuel movements (e.g. staffing, tools, measurements, interlocks);
- Preparation of fuel for off-site transport.

(c) Reactor core configuration:
- Permissible internal or peripheral cavities;
- Maximum and minimum number of fuel elements;

— Conditions of reflection (e.g. type of reflector and configuration);
— Number of control elements, including fuel followers;
— Mixed cores (e.g. cores containing fuel of different enrichments);
— Permissible configurations;
— Arrangements for determining new configurations;
— Reactor power;
— Average and peak fuel element power;
— Maximum allowed fuel temperature and cladding temperature;
— Departure from nucleate boiling ratio, critical heat flux ratio or flow instability.

(d) Reactivity and reactivity control systems:
— Maximum excess reactivity;
— Maximum effective neutron multiplication factor (k_{eff}) for subcritical assemblies;
— Minimum shutdown margin during operation and during fuel movement;
— Reactivity worth of the reactivity control mechanisms (e.g. regulating, shim, safety, pulse rods or blades);
— Reactivity addition rates by means of reactivity control mechanisms, experiments and fuel elements;
— Total reactivity worth of all experiments;
— Maximum reactivity worth of specific types of experiment (e.g. experiments fixed or not fixed to the reactor structure);
— Reactivity worth of backup shutdown system (if any);
— Reactivity balance (e.g. pattern of withdrawal levels of the reactivity control mechanisms, fuel burnup distribution in the core);
— Type and number of control rods (including material and configuration).

(e) Protection systems and reactor shutdown systems:
— Type and minimum number of neutronic measuring equipment items necessary to monitor the reactor and trigger the scram of the reactor in each mode of operation;
— Type and minimum number of other measuring equipment items (e.g. for temperature, flow, height of water above the fuel, radiation level) necessary to scram the reactor, and alarm and scram limits for the equipment;
— Interlocks and trips, including inadvertent bypass;
— Bypassing channels, which might be inadvertent or part of operation;
— Other safety instrumentation;
— Reactor shutdown delay time (e.g. rod drop time, response time of the protection or control system).

(f) Reactor startup and operation:
- Minimum operability of structures, systems and components;
- Completion and review of checklists;
- Visual inspections of reactor core, beam tube shutters and shielding;
- Additional conditions for startup following a reactor scram.

(g) Cooling systems and connected systems:
- Coolant chemistry (content of solids and dissolved gases; pH; conductivity);
- Temperature, pressure (in lines, across filters) and flow;
- System configuration for different modes of operation (e.g. how many and which pumps should be operable, which main valves should be open or closed);
- Changeover conditions to and from the natural convection mode of cooling, if applicable;
- Coolant or moderator level;
- Emergency core cooling;
- Leak detection and loss of coolant alarm limits;
- Radionuclide content in the coolant;
- Content of fission products in the coolant;
- Coolant availability;
- Ultimate heat sink;
- Moderator chemistry (e.g. necessary properties and characteristics).

(h) Containment or means of confinement, including ventilation:
- Temperature, humidity and airflow in different areas of the reactor;
- Pressure drop across filters;
- Containment pressure relative to the atmosphere (normal and under emergency conditions);
- Isolation of the containment or the means of confinement and starting of emergency ventilation;
- Operations that involve containment or confinement;
- Configuration and minimum equipment for ventilation;
- Leak rate from the containment or the means of confinement;
- Hazardous materials inside the containment or the means of confinement;
- Efficiencies of filters and iodine traps.

(i) Operational radiation protection and radioactive waste management:
- Type (e.g. gaseous, particulate, gamma, neutron) and location of radiation monitoring instruments;
- Alarm setting for radiation monitoring instruments (including monitoring instruments for initiating scrams, if any);

— Limits on the concentration of radionuclides or other limits on the liquid or gaseous effluents that may be discharged in a given time period, such as maximum annual discharges (site limits may apply where more than one facility is located at the same site);
— Dose control values for operation, such as annual dose limits;
— Operating limits for surface contamination;
— Dose constraints (individual and collective);
— Criteria for respiratory protection and protective clothing;
— Criteria for bioassay or whole body counting;
— Storage capacity for liquid waste and solid waste.

(j) Instrumentation and control systems:
— Type and minimum number of items of measuring equipment associated with safety systems;
— Startup instrumentation;
— Display monitors;
— Data acquisition systems;
— Calibration of instrumentation and its periodic control, including updating of the related documentation.

(k) Experimental devices:
— Suitability of materials for use in the ambient conditions, provisions for encapsulation of irradiation samples and use of fissile materials;
— Explosive and other hazardous materials;
— Prohibited materials;
— Interlocks needed for experiments.

(l) Electrical power supply systems:
— Emergency power supplies for all operational states (e.g. configuration of distributors and list of equipment connected to a distributor; startup and operation of fixed and non-permanent diesel generators; batteries for the uninterruptible power supply system);
— Testing of emergency power supplies.

(m) Auxiliary systems and equipment:
— Fire protection systems;
— Communication systems;
— Cranes (e.g. limitation of manipulation and loading; interlocks);
— Emergency lighting systems;
— Compressed air systems;
— Emergency equipment relating to design extension conditions.

(n) Other limitations:
— Other design features;
— Site features;
— Administrative controls.

Appendix II

INDICATIVE LIST OF OPERATING PROCEDURES FOR A RESEARCH REACTOR

II.1. For research reactors, critical assemblies and subcritical assemblies with low hazard potential, all the procedures provided here should be considered, unless it can be justified that certain procedures listed are not applicable for a specific research reactor, critical assembly or subcritical assembly; such a justification will depend on the design and potential hazards associated with the facility.

(a) Commissioning procedures:
- — Cleaning procedures for the cooling system and ventilation systems;
- — Commissioning tests and acceptance tests for mechanical, electrical and instrumentation systems and components;
- — Tests prior to fuel loading;
- — Fuel handling;
- — Fuel loading, initial criticality tests and low power tests;
- — Control rod calibration;
- — Calibration of reactor safety channels and other neutron detection channels;
- — Determination of shutdown margin and core excess reactivity;
- — Power ascension tests and power tests;
- — Determination of thermal power level;
- — Reactor emergency procedures;
- — Radiation protection procedures;
- — Control of discharges to the environment and monitoring of radioactive material;
- — Procedures for control (exclusion), identification and removal of foreign material;
- — Verification of shielding;
- — Handling of non-conformances.

(b) Operational procedures:
- — Reactor startup, operation, power level changes and shutdown;
- — Determination of core reactivity to meet the OLCs (e.g. shutdown margin and excess reactivity; set point calculations);
- — Determination of thermal power level;
- — Routine loading, unloading, handling and movement of fuel elements, fuel assemblies and other core components and reflector components;

— Special fuel handling (e.g. handling of failed fuel, preparation for and transport of spent fuel);
— Reactivity determination, loading, unloading, irradiation, handling and safety evaluation for experimental devices;
— Routine checks on reactor operation, the status of systems and the condition of the facility;
— Operation of the mechanical and electrical support systems and equipment of the reactor;
— Shift turnover entries and entries in the reactor log books;
— Acceptance testing of new fuel elements;
— Ion exchange replacement or regeneration;
— Operation of hoisting devices.

(c) Maintenance procedures:
— Equipment replacement and repair;
— Preventive maintenance of reactor equipment and reactor support system equipment;
— Repair or replacement of reactivity control mechanisms;
— Cleaning of the heat exchanger and tube plugging;
— Replacement of seals;
— Replacement of filters;
— Routine maintenance on the overhead crane;
— Routine maintenance on the auxiliary power supply;
— In-service inspection;
— Inventories of spare parts.

(d) Inspection, calibration and periodic testing procedures:
— Inspection and dimensional checking of fuel and preparation of the fuel inventory;
— Inspection and calibration of the reactivity control mechanism;
— Release and drop time measurements for safety rods and control rods;
— Calibration of reactor measuring channels and protection channels;
— Calibration and testing of fixed and portable radiation monitors, airborne radioactivity monitors and personal dosimeters;
— Calibration and testing of process systems (e.g. for temperature, flow, emergency power and ventilation);
— Performance checks for emergency core cooling systems;
— Efficiency and flow rate measurements for the emergency ventilation system;
— Flow rate measurements for the operational ventilation system;
— In situ periodic testing of built-in filters in the ventilation system;
— Measurements in the primary coolant system;

— In-service inspection of the reactor vessel, pool liner and core components;
— Performance checks for the secondary cooling system;
— Testing of the leak rate of the reactor building containment or confinement envelope;
— Testing of pneumatic tube systems;
— Testing of the emergency power supply system;
— Testing of emergency equipment;
— Checking of the fire protection system.

(e) Radiation protection procedures:
— Radiation surveys and air sampling;
— Control of the contamination of surfaces, personnel and equipment, including the use of decontamination facilities;
— Administrative measures for controlling access to and residence times in radiation areas;
— Control of occupational exposures, such as procedures for monitoring external exposures and internal exposures of operating personnel, temporary personnel and visitors;
— Issue, selection, use and maintenance of personal protective equipment;
— Monitoring of radioactive material and the packaging and transport of radioactive material;
— Control of discharges to the environment and monitoring of radioactive material;
— Analysis of the reactor coolant;
— Inventory, handling and leak testing of sealed radioactive sources;
— Control and periodic review of operations to ensure that radiation exposures are as low as reasonably achievable.

(f) Procedures for the authorization of operation, maintenance, irradiation or experiments:
— Authorization for operation;
— Authorization for maintenance (e.g. work permits);
— Authorization for modifications;
— Authorization for experiments;
— Authorization for irradiation;
— Authorization for isotope production.

(g) Procedures for the response of operating personnel to anticipated operational occurrences:
— Response to alarms, loss of electrical power supplies, instrument failures, pipe leakage;
— Response to failures of experiments, experimental systems or equipment;

— Response to abnormal radioactive releases;
— Response to spread of contamination.

(h) Emergency procedures:
  — For high airborne radioactivity levels or area radiation levels;
  — For fire or internal flooding;
  — For tornadoes, hurricanes, typhoons, flooding, precipitation or other weather related emergency;
  — For earthquakes;
  — For injury of personnel, with or without radioactive contamination;
  — For credible reactor accidents, including design basis accidents (e.g. loss of primary coolant, abnormal release of radioactive material, rapid insertion of positive reactivity, significant fuel failure) and design extension conditions;
  — For aircraft crash, sabotage or attempted sabotage.

(i) Security procedures:
  — Surveillance and alarm system tests for fuel storage areas;
  — Surveillance and alarm system tests for facility access points;
  — Patrols and inspections during reactor operation and when the reactor is shut down;
  — Control of access to the facility (e.g. identification badges, door locks, closed circuit television monitoring systems, electronic card keys);
  — Prevention of and/or coping with an unauthorized intruder;
  — Coping with an attack;
  — Coping with a civil disturbance.

(j) Procedures for the handling of radioactive waste and control of radioactive releases:
  — Monitoring, handling, storage and disposal of solid radioactive waste;
  — Collection, monitoring, processing and disposal of liquid radioactive waste;
  — Monitoring of gaseous and particulate airborne radioactive releases.

(k) Procedures for extended shutdown:
  — Disconnection and dismantling of systems taken out of service;
  — Protection of systems or components against deterioration;
  — Prevention of undesired use of systems or components that have been taken out of service (e.g. electrical power supply, isolation valves).

(l) Procedures to support preparation for decommissioning:
  — Updating of the initial decommissioning plan and associated documentation;
  — Handling, dismantling and disposal of experimental devices;
  — Dismantling and handling of activated and radioactively contaminated components, and handling of radioactive waste.

(m) Procedures for utilization and for modification of the reactor:
   - Proposals for experiments or modifications;
   - Determination of the safety significance of an experiment or a modification, for purposes of review and approval;
   - Review and approval of a new or modified experiment or modification;
   - Conduct of an experiment, including commissioning and decommissioning;
   - Conduct of a modification, including commissioning of modified systems and updating of the facility documentation.

(n) Administrative procedures:
   - Accountancy and control of nuclear material;
   - Reporting of the fuel inventory;
   - Transport of spent fuel;
   - Testing and certification of packages used for the transport of radioactive material;
   - Qualification, training and retraining of personnel;
   - Generation, collection and retention of records;
   - Isolation and tagging of equipment;
   - Instructions to personnel concerning possible health effects of radiation exposure and associated legal requirements;
   - Instructions for internal communications;
   - Arrangements for on-call personnel;
   - Quality management;
   - Operating experience feedback;
   - Purchase of items important to safety.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Research Reactors, IAEA Safety Standards Series No. SSR-3, IAEA, Vienna (2016).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Commissioning of Research Reactors, IAEA Safety Standards Series No. SSG-80, IAEA, Vienna (2023).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Maintenance, Periodic Testing and Inspection of Research Reactors, IAEA Safety Standards Series No. SSG-81, IAEA, Vienna (2023).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Core Management and Fuel Handling for Research Reactors, IAEA Safety Standards Series No. SSG-82, IAEA, Vienna (2023).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, The Operating Organization and the Recruitment, Training and Qualification of Personnel for Research Reactors, IAEA Safety Standards Series No. SSG-84, IAEA, Vienna (2023).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors, IAEA Safety Standards Series No. SSG-85, IAEA, Vienna (2023).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Ageing Management for Research Reactors, IAEA Safety Standards Series No. SSG-10 (Rev. 1), IAEA, Vienna (2023).

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Instrumentation and Control Systems and Software Important to Safety for Research Reactors, IAEA Safety Standards Series No. SSG-37 (Rev. 1), IAEA, Vienna (2023).

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Assessment for Research Reactors and Preparation of the Safety Analysis Report, IAEA Safety Standards Series No. SSG-20 (Rev. 1), IAEA, Vienna (2022).

[10] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety in the Utilization and Modification of Research Reactors, IAEA Safety Standards Series No. SSG-24 (Rev. 1), IAEA, Vienna (2022).

[11] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Nuclear Safety and Security Glossary: Terminology Used in Nuclear Safety, Nuclear Security, Radiation Protection and Emergency Preparedness and Response, 2022 (Interim) Edition, IAEA, Vienna (2022).

[12] INTERNATIONAL ATOMIC ENERGY AGENCY, Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants, IAEA Safety Standards Series No. SSG-70, IAEA, Vienna (2022).

[13] INTERNATIONAL ATOMIC ENERGY AGENCY, Use of a Graded Approach in the Application of the Safety Requirements for Research Reactors, IAEA Safety Standards Series No. SSG-22 (Rev. 1), IAEA, Vienna (2023).

[14] INTERNATIONAL ATOMIC ENERGY AGENCY, Leadership and Management for Safety, IAEA Safety Standards Series No. GSR Part 2, IAEA, Vienna (2016).

[15] INTERNATIONAL ATOMIC ENERGY AGENCY, Application of the Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-G-3.1, IAEA, Vienna (2006).

[16] INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for Nuclear Installations, IAEA Safety Standards Series No. GS-G-3.5, IAEA, Vienna (2009).

[17] INTERNATIONAL ATOMIC ENERGY AGENCY, Functions and Processes of the Regulatory Body for Safety, IAEA Safety Standards Series No. GSG-13, IAEA, Vienna (2018).

[18] INTERNATIONAL ATOMIC ENERGY AGENCY, Disposal of Radioactive Waste, IAEA Safety Standards Series No. SSR-5, IAEA, Vienna (2011).

[19] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL CIVIL AVIATION ORGANIZATION, INTERNATIONAL LABOUR ORGANIZATION, INTERNATIONAL MARITIME ORGANIZATION, INTERPOL, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, PREPARATORY COMMISSION FOR THE COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, UNITED NATIONS OFFICE FOR THE COORDINATION OF HUMANITARIAN AFFAIRS, WORLD HEALTH ORGANIZATION, WORLD METEOROLOGICAL ORGANIZATION, Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSR Part 7, IAEA, Vienna (2015).

[20] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR OFFICE, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS OFFICE FOR THE COORDINATION OF HUMANITARIAN AFFAIRS, WORLD HEALTH ORGANIZATION, Arrangements for Preparedness for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GS-G-2.1, IAEA, Vienna (2007). (A revision of this publication is in preparation.)

[21] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Revision 5), IAEA Nuclear Security Series No. 13, IAEA, Vienna (2011).

[22] INTERNATIONAL ATOMIC ENERGY AGENCY, Physical Protection of Nuclear Material and Nuclear Facilities (Implementation of INFCIRC/225/Revision 5), IAEA Nuclear Security Series No. 27-G, IAEA, Vienna (2018).

[23] INTERNATIONAL ATOMIC ENERGY AGENCY, Security During the Lifetime of a Nuclear Facility, IAEA Nuclear Security Series No. 35-G, IAEA, Vienna (2019).

[24] INTERNATIONAL ATOMIC ENERGY AGENCY, Developing a Nuclear Security Contingency Plan for Nuclear Facilities, IAEA Nuclear Security Series No. 39-T, IAEA, Vienna (2019).

[25] INTERNATIONAL ATOMIC ENERGY AGENCY, Predisposal Management of Radioactive Waste, IAEA Safety Standards Series No. GSR Part 5, IAEA, Vienna (2009).

[26] INTERNATIONAL ATOMIC ENERGY AGENCY, Predisposal Management of Radioactive Waste from Nuclear Power Plants and Research Reactors, IAEA Safety Standards Series No. SSG-40, IAEA, Vienna (2016).

[27] INTERNATIONAL ATOMIC ENERGY AGENCY, UNITED NATIONS ENVIRONMENT PROGRAMME, Regulatory Control of Radioactive Discharges to the Environment, IAEA Safety Standards Series No. GSG-9, IAEA, Vienna (2018).
[28] INTERNATIONAL ATOMIC ENERGY AGENCY, Regulations for the Safe Transport of Radioactive Material, 2018 Edition, IAEA Safety Standards Series No. SSR-6 (Rev. 1), IAEA, Vienna (2018).

CONTRIBUTORS TO DRAFTING AND REVIEW

Abou Yehia, H.	International Atomic Energy Agency
D'Arcy, A.	Consultant, South Africa
Hardesty, D.	Nuclear Regulatory Commission, United States of America
Hargitai, T.	Consultant, Hungary
Hirshfeld, H.	Israel Atomic Energy Commission, Israel
Kennedy, W.	International Atomic Energy Agency
McIvor, A.	Consultant, Canada
Naseer, F.	International Atomic Energy Agency
Perrin, C.D.	Nuclear Regulatory Authority, Argentina
Rao, D.V.	International Atomic Energy Agency
Sears, D.F.	International Atomic Energy Agency
Shaw, P.	International Atomic Energy Agency
Shim, S.	International Atomic Energy Agency
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