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Operational Limits and Conditions and Operating Procedures for Research Reactors (Revision of NS-G-4.4)

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DRAFT SPECIFIC SAFETY GUIDE

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1. INTRODUCTION

BACKGROUND

1.1. This ~~publication supersedes the~~ Safety Guide on Operational Limits and Conditions and Operating Procedures for Research Reactors that was issued in 2008 as Safety Guide No. NS-G-4.4~~was developed under the IAEA work programme for safety standards for research reactors~~¹. It supplements and elaborates upon the safety requirements for operational limits and conditions (OLCs) and operating procedures for research reactors that are established in Section 7 (paras 7.29-7.41, 7.51-7.55) of the IAEA ~~publication on the~~ Safety Standards Series No. SSR-3, Safety of Research Reactors [1].

1.2. For a research reactor to be operated safely, the provisions made in the final design and any subsequent modifications to the design must be taken into account in specifying the limits on operating parameters and the requirements on the equipment and personnel of the reactor facility. Under the responsibility of the operating organization, these limits on operating parameters and requirements should be developed in the evaluation of the design safety as a set of OLCs². A

¹ 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).

² The terms ‘safety specifications’ or ‘technical specifications (tech specs) for safe operation’ and ‘general operating rules’ are sometimes used to mean OLCs. These terms are used by operating organizations and regulatory bodies for nuclear reactors. These expressions usually cover safety limits, safety system settings, limiting conditions for safe operation, and ~~surveillance~~ requirements for maintenance, periodic testing and inspection and administrative requirements. In addition, in some Member States the term ‘operating rules’ is used to mean the equivalent of safety limits, safety system settings and limiting conditions for safe operation, and this does not then include ~~surveillance~~ requirements for maintenance, periodic testing and inspection and administrative requirements.

³ ~~Defence in depth is a hierarchical deployment of different levels of diverse equipment and procedures to prevent the escalation of anticipated operational occurrences and to maintain the effectiveness of the physical barriers placed between a radiation source or radioactive material and workers, members of the public, or the environment, in operational states and, for some barriers, under accident conditions. The objectives of defence in depth are (a) to compensate for potential human and component failures, (b) to maintain the effectiveness of the barriers by averting damage~~

major contribution to compliance with the OLCs is made by the development and utilization of operating procedures that are consistent with the OLCs. Establishment of OLCs and operating procedures is essential to achieving the objectives of the defence in depth concept.²

~~The Safety Requirements publication on the Safety of Research Reactors [1] establishes the basic requirements in all the relevant areas associated with the safety of research reactors, including site evaluation, design, operation, decommissioning, regulatory oversight and the management system. This Safety Guide provides recommendations on fulfilling the basic requirements in all relevant areas associated with the safety of research reactors. In making use of this publication and the other Safety Guides that provide recommendations on means of fulfilling the basic requirements established in Ref. [1], the particular characteristics of research reactors should be taken into account. These characteristics include the wide variety of designs, the wide range of power levels, the different modes of operation and purposes of utilization, the particularities of siting and the differences among the operating organizations for research reactors. These characteristics require flexibility in setting objectives and applying the basic requirements when dealing with some specific topics.~~

~~4.4.1.3.~~ The organizations involved in ensuring the safety of research reactors and the protection of site personnel, the public and the environment have a number of responsibilities that are interrelated. Some of the more important of these are the performance of the safety analysis and the development of the OLCs and safety related documents for review and assessment by the regulatory body. Documented operating procedures having safety significance are part of such documentation. The OLCs are a set of operating rules that normally includes: safety limits and safety system settings on relevant variables and parameters of the reactor; ~~surveillance~~ requirements ~~for maintenance, periodic testing and inspection~~; and administrative requirements. This set ~~should needs to~~ satisfy the ~~basic r~~Requirements ~~71~~ for the OLCs as established in ~~Ref.SSR-3 [1], paras 7.29–7.41.~~

~~4.5.1.4.~~ There is an international consensus on the need for the establishment of and compliance with OLCs for the safe operation of nuclear reactors. However, the OLCs are presented in various formats, depending on the structure of the mandatory safety documentation as stipulated in the legal framework established

~~to the facility and to the barriers themselves, and (c) to protect workers, members of the public and the environment from harm under accident conditions in the event that the barriers are not fully effective.~~

by the State for the operation of research reactors. Thus, some States include the OLCs, together with requirements of other kinds, as an essential part of the reactor licence for operation, while others make reference to a separate document containing the OLCs. In this regard, the structure of the present Safety Guide is oriented to the development of the OLCs as a separate document, which may or may not be attached to the reactor licence and appropriately referenced in the safety analysis report. In the case that the safety analysis report does not include the OLCs, a summary should be presented in the safety analysis report and reference should be made to the separate document. This summary should be prepared in accordance with the recommendations provided in [IAEA Safety Standards Series No. SSG-20, Safety Assessment for Research Reactors and Preparation of the Safety Analysis Report Ref. \[2\], paras A.1701–A.1708.](#)

OBJECTIVE

~~4.6.1.5.~~ The purpose of this Safety Guide is to provide [operating organizations, regulatory bodies and other relevant organizations with](#) recommendations on all important aspects of developing, formulating and presenting the OLCs and the operating procedures for research reactors. In particular, detailed recommendations are provided on the development, content and implementation of OLCs and operating procedures for the operation of research reactors as well as for experiments ~~(see Ref. [3], para. 303).~~ ~~This Safety Guide is directed at both operating organizations and regulatory bodies.~~ [In addition the application of the recommendations of this safety guide will support the fostering of a strong safety culture.](#)

SCOPE

~~4.7.1.6.~~ This Safety Guide covers the concept of OLCs, their content as it applies to research reactors, and the responsibilities of the operating organization ~~in respect of~~ [regarding](#) their establishment, modification and documentation, and with regard to compliance with them. The operating procedures necessary to facilitate full compliance with the OLCs and to ensure their observance are also within the scope of this Safety Guide.

~~4.8.1.7.~~ The recommendations provided in this Safety Guide are intended to be applicable to most types of research reactor, [including critical and subcritical assemblies having power levels of up to a few tens of megawatts.](#) Research reactors [with power levels in excess of several tens of megawatts, of higher power levels](#)

~~and specialized reactors (e.g. homogeneous reactors, fast reactors) and reactors using experimental devices such as high pressure and temperature loops and cold or hot neutron sources may require the provision of additional guidance that is beyond the scope of this Safety Guide provided in IAEA Safety Guides for power reactors. All the guidance provided should be applied unless it can be justified that, for a specific research reactor, critical assembly or subcritical assembly, the application of certain guidance may be graded. Each case in which the application of guidance is graded should be identified with account taken of the nature and possible magnitude of the hazards presented by the given facility (see IAEA Safety Standards Series No. SSG-22, Use of Graded Approach in the Application of the Safety Requirements for Research Reactors [3]). Some flexibility in the application of the recommendations provided in this Safety Guide is warranted on the basis of the specific characteristics of research reactors (see para. 1.11) or the relevant regulations of States.~~ Because of the differences in the approaches to the preparation of OLCs and operating procedures in different States, the level of detail required in the application of the guidelines should be agreed upon by the operating organization and the regulatory body to develop a set of OLCs and operating procedures acceptable to the regulatory body.

~~1.9. Research reactors are used for various purposes, including research, training, radioisotope production, neutron therapy, neutron radiography and material tests, and therefore they have differing design features and operational regimes. Design and operating characteristics may vary significantly, since experimental devices may affect the performance of reactors. In addition, the need for greater flexibility in the use of research reactors may require an approach to achieving or managing safety different from that for nuclear power plants.~~

~~1.11.1.8. Low risk R~~Research reactors with a low risk potential having a power rating of up to tens of kilowatts, critical assemblies and subcritical assemblies may need less comprehensive OLCs and operating procedures than those outlined here. While all recommendations in this Safety Guide should be considered, some may not apply to these low risk reactors. For these reasons, the recommendations and guidance provided in this Safety Guide should be graded for applicability to a particular research reactor (see Ref.SSR-3 [1], paras ~~12.1415–12.1417~~).

~~The factors to be considered in deciding whether certain recommendations provided here may be waived in applying a graded approach to the application of safety requirements include (but are not limited to):~~

~~(a) Reactor power levels;~~

- ~~(a) The radiological source term;~~
- ~~— The amount and enrichment of fissile and fissionable material;~~
- ~~(b) Spent fuel elements, high pressure systems, heating systems, fuel accumulators, and other systems and components that may affect the safety of the reactor;~~
- ~~(b) The type of fuel element;~~
- ~~(b) The type and mass of moderator, reflector and coolant;~~
- ~~(b) The amount of reactivity that can be introduced and its rate of introduction, reactivity control, and inherent and engineered safety features;~~
- ~~(c) The quality of the containment or the means of confinement;³~~
- ~~(c) Utilization of the reactor (experimental devices, tests, reactor physics experiments);~~
- ~~(d) The presence of personnel in the installation during the operation of the reactor;~~
- ~~(d) The type of operation of the facility (e.g. whether permanent or only for short experiments);~~
- ~~(d) Siting of the reactor;~~
- ~~(d) Proximity of the reactor to population groups.~~

4.13.1.9. The OLCs represent an envelope of parameters. Compliance with the OLCs will protect the reactor, and will protect the staff, the general public and the environment from undue radiation exposure. In addition, establishing the OLCs forms an important part of meeting the requirements for the issuing by the regulatory body of the authorization to operate the facility. Therefore the requirement to develop the OLCs and to operate the facility in accordance with them should not be waived. However, the number of OLCs may vary depending on the factors listed in para. 4.14.1.7 of SSR-3 [1].

4.14.1.10. The development and use of operating procedures make a major contribution to the safe operation of the reactor. The operating procedures facilitate full compliance with the OLCs, and therefore the preparation and use of operating procedures should not be waived in any case. Since the operating procedures are required to be consistent with the OLCs (see Requirement 74 of SSR-3 [1]), the number and the complexity of the procedures may vary depending on the factors

³~~The means of confinement is a barrier surrounding the main parts of a reactor containing radioactive material that is designed to prevent or mitigate the uncontrolled release of radioactive material to the environment in operating states or in design basis accidents. If the design is also able to fulfil this function under overpressure conditions after an accident, it is often called a containment.~~

listed in para. ~~4.14~~2.17 of SSR-3 [1].

STRUCTURE

~~4.15-1.11.~~ 1.11. This Safety Guide consists of eight sections and two appendices. Section 2 provides guidance on management system for OLCs and operating procedures. Section ~~2-3~~ describes the relationship between the OLCs and the fundamental safety objective of protecting people and the environment from harmful effects of ionizing radiation, and discusses: the concept of OLCs; the need for OLCs; their development; the roles and responsibilities of the operating organization and the regulatory body in their preparation and review; and the presentation of each operational limit or condition. Section ~~3~~ 4 discusses the content of the OLCs document⁴ and provides a list of the safety parameters and systems that should be covered by the OLCs, including ~~surveillance~~-requirements for maintenance, periodic testing and inspection for these parameters. This section also provides guidance on administrative requirements that should be covered by the OLCs. Section ~~4-5~~ covers the development of operating procedures. It describes the functions and responsibilities of the operating organization, operating personnel, the safety committee, the reactor manager and the regulatory body in developing and implementing procedures, and discusses general considerations regarding their categorization and other issues. Section ~~5-6~~ provides guidance on the format and content of procedures of various types to achieve consistency and completeness in developing the operating procedures. In addition, it describes specific topics to be addressed in procedures of each category. Section ~~6-7~~ provides guidance on the training of personnel in the use of procedures. Section ~~7-8~~ provides guidance on how to ensure compliance with OLCs and operating procedures, including the need to retain records of such compliance. ~~Section 8 provides guidance on quality assurance pertaining to the OLCs and on the quality assurance practices applied to the development and implementation of the operating procedures.~~ Appendix I provides a list of selected factors that should generally be considered in establishing the limiting conditions for safe operation and the ~~surveillance~~-requirements for maintenance, periodic testing and inspection. Appendix II provides a list of typical procedures for the categories identified in Section ~~56~~.

⁴ ~~OLCs are a set of rules setting forth parameter limits, and the functional capability and performance levels of equipment and personnel approved by the regulatory body for safe operation of an authorized facility. The document that contains the OLCs as a whole is referred to as the 'OLCs document'~~

2. MANAGEMENT SYSTEM FOR OPERATIONAL LIMITS AND CONDITIONS AND OPERATING PROCEDURES

GENERAL

2.1. The IAEA Safety Standards Series No. GSR Part 2 Leadership and Management for Safety, [4] and Requirement 4 of SSR-3 [1], requires that the operating organization for a research reactor establishes and implements a management system that integrates safety, health, environmental, security, quality, human and organizational factor, societal and economic elements, so that safety is not compromised. 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. The management system should include four functional categories: management responsibility; resource management; process implementation; and measurement, assessment and improvement. In general:

- Management responsibility includes the support and commitment of management necessary to achieve the objectives of the operating organization.
- Resource management includes measures necessary to ensure that the resources essential to the implementation of strategy and the achievement of the objectives of the operating organization are identified and made available.
- Process implementation includes the activities and tasks necessary to achieve the goals of the organization.
- Measurement and assessment provide an indication of the effectiveness of management processes and work performance compared with objectives or benchmarks. It is through measurement and assessment that opportunities for improvements are identified.

Further guidance is provided in IAEA Safety Standards Series No. GS-G-3.1, Application of the Management System for Facilities and Activities [5] and IAEA Safety Standards Series No. GS-G-3.5, The Management System for Nuclear Installations [6].

2.2. The management system should cover all processes important to safety, and should include a means of establishing controls over OLCs and operating procedures, thereby providing confidence that they are performed safely in accordance with established requirements. 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.

2.3. The objective of the management system is to ensure that the research reactor meets the requirements for safety as derived from:

- National laws and regulations;
- The requirements of the regulatory body;
- Design requirements and assumptions;
- The safety assessment and safety analysis report (SAR);
- Operational limits and conditions (as applied to the development of operating procedures);
- The administrative requirements of the reactor management

2.4. The management system should support the development, implementation and enhancement of a strong safety culture in all aspects of development and implementation of OLCs and operating procedures.

MANAGEMENT RESPONSIBILITY

2.5. It is the responsibility of management to 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 in order to ensure that the objectives of the OLCs and operating procedures are met, and safe operation of the research reactor including experimental facilities is ensured. The documentation should also include descriptions of the organizational structure, functional responsibilities, levels of authority and interfaces for those assessing, managing, authorizing, performing, controlling or supervising these activities. It should also cover other management measures, including planning and scheduling of activities, resource allocation and human factors.

2.6. The operating organization has the responsibility for preparing and issuing OLCs and operating procedures for safe operation of the research reactor. The reactor manager should be an active participant in the implementation and evaluation of these activities.

RESOURCE MANAGEMENT

2.7. The operating organization should provide adequate resources to implement the OLCs and operating procedures by:

- Determining the required competences and providing training, where appropriate, to ensure that the personnel of the operating organization are competent to perform their assigned work;
- Supervising external personnel (including experimenters, suppliers and

contractors) who perform safety related activities and ensuring that these personnel are adequately trained and qualified.

2.8. 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. Such external personnel should perform their activities under the same controls, and to the same work standards, as reactor personnel. Operating personnel should review the work of these external personnel during preparation for work, at the job site during performance of the work, and during acceptance testing and inspection.

2.9. The management system of the operating organization should be extended to include suppliers. The operating organization should ensure that the suppliers, manufacturers and designers have an effective management system in place.

2.10. The equipment, tools, materials, hardware and software necessary to conduct the work in a safe manner and to ensure that the requirements are met should be determined, provided, checked and verified, and maintained.

PROCESS IMPLEMENTATION

2.11. Activities related to the OLCs and operating procedures of a research reactor should be performed and recorded in accordance with approved procedures and instructions.

2.12. The management system should specify the system for the development, implementation and modification of OLCs and operating procedures to ensure that they have been correctly conceived and implemented.

2.13. The management system should specify the means of detecting and correcting non-conformances in the OLCs and operating procedures. This may be done by means of periodic review and assessment by the operating organization.

MEASUREMENT, ASSESSMENT AND IMPROVEMENT

2.14. Measures should be established for assessment, review and verification to ensure that OLCs and operating procedures are developed and implemented as per the design intent. Such measures should include:

- Review of the OLCs and operating procedures;
- Verification of the implementation of OLCs and operating procedures;
- 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.

- Assessments of the relevant processes, procedures and documentation;
- Use of feedback and operating experience;
- Follow-up of the adequacy and timeliness of corrective actions.

2.15. The operating organization should ensure, through self-assessments and independent assessment, that the assigned activities are carried out in compliance with the management system.

2.16. The items to be assessed and the maximum interval between assessments should be stated and may include, for example:

- Facility operations for conformance with the OLCs and the facility licence;
- The response by the operating organization to violations of the OLCs;
- The implementation of licensing procedures;
- Events that should be reported to the regulatory body;
- The facility emergency plans (including drills and exercises) and procedures;
- The training programme for reactor operators;
- The updating of documents.

2.17. Effective implementation of the management system for the OLCs and operating procedures of a research reactor should be assessed by qualified personnel who are not directly involved in performing these activities.

2.18. 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. Operational safety of the research reactor facility and experiments should be subjected to periodic review by the reactor safety committee.

2.3. DEVELOPMENT OF OPERATIONAL LIMITS AND CONDITIONS

GENERAL

~~2.1.3.1.~~ To prevent situations from arising that might lead to accident conditions and to mitigate the consequences of accident conditions if they do arise, “~~A-~~The set of OLCs—operational limits and conditions important to reactor safety, including safety limits, safety system settings, limiting conditions for safe operation, requirements for inspection surveillance, ~~periodic~~—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” (Ref.SSR-3 [1], Requirement 71 para. 7.2933).⁵

~~2.2.3.2.~~ Thus—the OLCs 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. Thus, adherence to the OLCs contributes to the prevention of accident conditions and ~~to~~ mitigation of the consequences of accidents if they do occur.

~~2.3.3.3.~~ Requirement 71 para 7.32 of SSR-3 reiterates that “The OLCs operational limits and conditions are required to shall be developed to ensure that the reactor facilities are being operated in accordance with the design assumptions and intent, as well as in accordance with its licence conditions”. In order to achieve this requirement, the safety analysis report should be developed so as to identify clearly the OLCs ~~that must be met~~ needed for safe operation of the reactor. “The safety analyses in the safety analyses report shall form the basis for the operational limits and conditions for the reactor” as stated in Requirement 1, para 3.7 of SSR-3[1].

~~2.4.3.4.~~ The OLCs should be submitted for the review and approval of the regulatory body as an important part of the licensing process, on the basis of which the operating organization is authorized to operate the facility.

~~2.5.3.5.~~ Paragraph 7.34 of SSR-3 [1] states that: “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).” ~~The important function of the OLCs in the operation of the research reactor requires that they be adequately selected, clearly established and appropriately substantiated by means of a written statement of the reasons for their adoption.~~ When reviewed and approved by the regulatory body, the OLCs represent an accepted basis for the operation of the research reactor facility.

~~2.6.3.6.~~ The technical aspects of the OLCs cover the limitations to be observed, as well as the operational requirement that structures, systems and components important to the safety of the research reactor be able to perform their intended functions as assumed in the safety analysis report.

⁵ See also para. 510 of the IAEA Safety Fundamentals publication on The Safety of Nuclear Installations, Safety Series No. 110, IAEA, Vienna (1993)

Safe operation depends on operating personnel as well as on equipment and procedures; OLCs should therefore also cover actions to be taken and limitations to be observed by operating personnel.

2.7.3.7. Regarding the functions of operating personnel, the OLCs include those principal requirements for maintenance, periodic testing and inspection surveillance and corrective or complementary actions that are 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.

2.8.3.8. The OLCs at research reactor facilities ~~should~~ are required to include the following items (see SRR-3 [1], para 7.35-7.40):

- (a) Safety limits (see paras 34.5–34.13);
- (b) Safety system settings (see paras 34.14–34.18);
- (c) Limiting conditions for safe operation (see paras 34.19–34.26);
- (d) ~~Surveillance~~ Requirements for maintenance, periodic testing and inspection (see paras 34.27–34.32);
- (e) Administrative requirements (see paras 34.33–34.44).

Each OLC's ~~should be supported by a~~ clear statement of its objective, applicability, specification and justification, as appropriate. ~~These items~~ should be included in the documentation on OLCs to increase the facility personnel's consciousness of the OLCs' their application and observance.

2.9.3.9. The development of the OLCs is based on the reactor design, on the safety analysis and on the information in the safety analysis report concerning the conduct of operations. The style and the format of the OLCs should be appropriate for their main purpose (see para. 2.3.1), and the following aims should also be taken into account:

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

2.10.3.10. The operating organization is ~~required to be~~ responsible for the preparation of the OLCs and for their submission to the regulatory body, as one of the requirements for the granting of a licence (see paras 3.41–47 and 7.29–33 of Ref.SSR-3 [1]). 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. In addition, the

proposed OLCs should be reviewed by the safety committee⁶ before their submission to the regulatory body. When specific restrictions are placed on operation by the regulatory body, the operating organization should ensure that the ~~approved~~ OLCs are revised appropriately.

~~2.11.3.11.~~ The operating organization should prepare OLCs for each stage of reactor operation that may require a regulatory licence. For example, the commissioning stage of the reactor usually requires specific OLCs, which may be revised after completion of this stage. Similarly, operation of the reactor under special conditions, such as the conduct of a particular experiment or the undertaking of a reactor modification, may require special OLCs (for further guidance, see IAEA Safety Standards Series No. SSG-24, Safety in the Utilization and Modification of Research Reactors [7]). Other reasons for a change in the OLCs may be an observed inadequacy of present parameter values or requirements, operating experience gained during reactor operation, technological progress, and extended shutdown or decommissioning. The OLCs are therefore normally reviewed and changed as necessary over the reactor's lifetime.

~~2.12.3.12.~~ In line with its overall responsibility, the operating organization is responsible for conducting 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. Accordingly, the operating organization is also responsible for the timely submission of any additions or changes to the existing OLCs to the regulatory body for review and approval.

~~2.13.3.13.~~ In accordance ~~with para. 2.10~~ Requirement 71 of SSR-3 [1], ~~t~~he operating organization is responsible for ensuring compliance with the approved OLCs. To assist in discharging this responsibility, safety limits, safety system settings and ~~surveillance~~ requirements for maintenance, periodic testing and inspection are required to be established in the OLCs (see ~~Ref. SSR-3~~ [1], para. 7.2935-7.39). In this context, the operating organization is responsible for keeping adequate records to facilitate audits and inspections to verify that the operation of the facility is in compliance with the OLCs. In addition, the operating organization is responsible for establishing procedures to be followed in the event of a violation of a safety limit or limiting conditions for safe operation.⁷

~~2.14.3.14.~~ The operating organization should submit the OLCs to the

⁶ See Ref. [1], para. 4.15

⁷ See paras 7.39-7.41 of Ref. [1], and paras 7.3 and 7.4 of this Safety Guide.

regulatory body for review, assessment and approval⁸. 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 the applicable regulations.

~~2.15.3.15.~~ The regulatory body should conduct regulatory inspections of the operating organization, reactor management and operations of the reactor facility to verify compliance with the approved OLCs. Further guidance on regulatory inspections is provided in [Ref. IAEA Safety Standards Series No. GS-G-13, Functions and Processes of the Regulatory Body for Safety](#) [48].

ATTRIBUTES OF OPERATIONAL LIMITS AND CONDITIONS

~~2.16.3.16.~~ The presentation adopted for the OLCs may vary from State to State depending on national regulations and practices and on the particular 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. ~~23~~.8) for each of the specifications. The facility personnel should be made fully aware of the importance of OLCs and compliance with them. The latter 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 given consideration as a good practice. The presentation ~~may should, if appropriate,~~ also include a statement describing actions to be taken, with the allowed completion time, in the event of deviations from the established OLCs (see para. ~~34~~.20) or in the case of violation of an operational limit or condition (see para. ~~34.4344~~).

~~2.17.3.17.~~ The presentation adopted for the OLCs may also be used in an appropriate manner for ~~surveillance~~-requirements [for maintenance, periodic testing and inspection](#) (see paras ~~34.2728–34.3233~~) and administrative requirements. The ~~surveillance~~-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 OLCs document. The ~~surveillance~~-requirements [for maintenance, periodic testing and inspection](#) should include the requirements for [inspection](#), operability checks and calibrations, as applicable, and should clearly establish the frequency and scope of the tests required to verify that the performance levels for safe operation as set in the OLCs are met.

⁸ Approval is not required in some Member States

~~2.18.3.18.~~ Clear presentation and avoidance of ambiguity are important factors in reliability in the use of OLCs, and advice on human factors should be sought at an early stage in the development of the documentation in which the OLCs will be presented to the operating personnel. The meaning of terms should be explained to help prevent misinterpretation.

~~2.19.3.19.~~ Whenever modifications to the OLCs become necessary, the approach outlined in para. ~~2.3.18~~ should be followed. All modifications to the facility should be reviewed to determine whether they necessitate modifications to the OLCs. Any modification to the OLCs should be subject to review by the safety committee and to assessment and approval by the regulatory body, as required. [For further guidance see SSG-24 \[37\]](#).

~~2.20.3.20.~~ Whenever it is necessary to modify 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, necessitates at least the same level of approval as a permanent modification. Any reasonable alternative approach, if available, should be preferred to the temporary modification of an OLC.

~~2.21.3.21.~~ Periodic reviews should be undertaken to ensure that the OLCs remain applicable for their intended purpose, and, where necessary, the OLCs should be modified in the light of operating experience and technological developments. This periodic review, in association with a review of the safety analysis report, should be carried out even if the facility has not been modified.

~~2.22.3.22.~~ Consideration may be given to the application of probabilistic safety assessment in the optimization of OLCs. Probabilistic assessment methods together with operating experience may be used in the justification and modification of OLCs.

Objective of the specification of OLCs

~~2.23.3.23.~~ 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 may not be evident from the specification itself. For example, if the objective of a particular operational limit or condition is stated as to ensure the integrity of the fuel cladding, a temperature may be specified. However, if there is no instrument for measuring the cladding temperature, it may be necessary

to specify a reactor power level, coolant flow rate through the core, coolant inlet temperature and 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 with 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.

Applicability of the specification of OLCs

2.24-3.24. The applicability of an operating limit or condition is specified in a statement that indicates the operational state (e.g. startup, normal operation, refueling), the variables, the components, the systems and the administrative requirements to which the specification applies. Such a statement of applicability should be included to ensure a clear and proper understanding of the scope of the specifications; for example, the specific cooling modes (natural, forced, etc.) in which a given limit is applicable may be specified.

Statement of the specification of OLCs

2.25-3.25. The specification of the OLCs provides 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, or a surveillance requirement for maintenance, periodic testing and inspection or 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 and from operating experience.

Bases for the specification of OLCs

2.26-3.26. Reasons should be given for the selection of the specifications, to help ensure that the SSR-3 [1], para 7.34 requirement that “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” is met. ~~These reasons should be based on the safety analysis report, on the reactor design or on aspects relating to the conduct of operations.~~ These reasons or bases may be simple ~~but~~ conservative

statements made on the basis of operational experience or experimental results. Reference to the relevant sections of the safety analysis report with a brief summary should be included in the bases.

2.27-3.27. The bases should show that the specification is conservatively selected for normal operation. Appropriate consideration should be given to factors such as calibration errors, measurement accuracy and system response times or operator response times.

3.4. CONTENT OF THE OPERATIONAL LIMITS AND CONDITIONS DOCUMENT

3.1.4.1. Just as the format of the OLCs may differ between States, so may the content and the order of presentation. However, all items relevant to safe operation should be included in the OLCs. The content and presentation of the OLCs document may be arranged in the following manner: table of contents; definitions; introduction; safety limits; safety system settings; limiting conditions for safe operation; ~~surveillance~~ requirements for maintenance, periodic testing and inspection; administrative requirements.

TABLE OF CONTENTS

3.2.4.2. The table of contents should provide sufficient detail to allow for easy reference to a specific operational limit or condition.

DEFINITIONS

3.3.4.3. Definitions of specific terms used in the OLCs document should be given. In addition, the definitions of terms particular to the research reactor should be provided. (See the definitions in the IAEA Safety Glossary [59].)

INTRODUCTION

3.4.4.4. The introduction should contain general information about the research reactor operating organization and the authorship of the OLCs

document, including its historical development, if necessary. It should also include a statement of any restrictions placed on the OLCs. An example ~~would be stating is: “ that T~~ these OLCs are applicable during the commissioning stage of the reactor only²². Finally, there should be a statement that all operations of the reactor should be in accordance with the OLCs.

SAFETY LIMITS

~~3-5.4.5.~~ Safety limits are limits on process variables within which the operation of the research reactor facility 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 in all operational states and design basis accidents.⁹ 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 reactors, the principal physical barrier is the primary coolant boundary.

~~3-6.4.6.~~ The safety limits should be established by means of a conservative approach that ensures that all the uncertainties of the safety analyses are taken into account. This implies that the exceeding of a single safety limit does not always lead to unacceptable consequences. ~~“I~~ Nevertheless, if any a safety limit is exceeded, the reactor ~~should~~ shall be shut down and maintained in a safe state and inspections on challenged items important to safety shall be performed” as required by para 7.43 of SSR-3 [1]. The normal operation should be restored only after an appropriate evaluation has been performed and the evaluation report has been submitted to the regulatory body for assessment and approval for restarting has been given in accordance with established procedures.

~~3-7.4.7.~~ The fuel temperature may be used to establish a safety limit if there is a provision for 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.

~~3-8.4.8.~~ 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 based on the characteristics of the fuel;

~~⁹ Those safety limits that might be exceeded in the event of a design basis accident should be justified on the basis of careful analyses~~

however, the safety limit is often expressed in terms of other related parameters that are measured, such as the 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.

3.9.4.9. 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 the 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.

3.10.4.10. Similarly, the maximum allowable surface temperature for the 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. It should be noted that 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.

3.11.4.11. It should be shown in the safety analysis report or other associated document that the safety limits are not violated in any operational state.

3.12.4.12. The specification of the 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 allow a clear understanding of its safety significance on the part of the operating personnel and the regulatory body.

3.13.4.13. Although the integrity of the containment or the means of confinement (if any) is important in limiting the radiological consequences of an accident, a loss of containment or loss of the integrity of 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

3.14.4.14. For each parameter for which a safety limit is required, and for other important safety related parameters⁴⁰, the safe design of the reactor requires the installation of a reactor protection system that monitors the parameter and provides a signal that can be utilized in an automatic mode to prevent the value of that parameter from exceeding the safety limit (see SSR-3 [1], para 7.35). The set point for this protective action is defined as the safety system setting.

3.15.4.15. 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.

3.16.4.16. Established safety system settings should 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 the operating personnel to initiate corrective actions before safety system settings are reached.

3.17.4.17. Safety system settings should be established for all operational states of the reactor. In determining a safety system setting, the process uncertainties and measurement uncertainties, the response of instrumentation and uncertainties in calculations should be taken into account (see Ref.SSR-3 [1], para. 7.3436).

3.18.4.18. 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 specification. The basis for the safety system setting should contain sufficient information to allow a clear understanding of its safety significance on the part of the operating personnel and the regulatory body.

⁴⁰ ~~For example, a limiting condition for safe operation may be the concentration of radioactive material in the exhaust ventilation, which requires monitoring and action to prevent releases exceeding a set value~~

LIMITING CONDITIONS FOR SAFE OPERATION

3.19.4.19. Limiting conditions for safe operation are administratively established constraints on equipment and operational parameters that must be adhered to during the startup, operation, shutting down and shutdown of a research reactor to provide acceptable assurance of safe operation within the reactor licence conditions and within applicable regulations. The limiting conditions for safe operation should be consistent with and, to the extent possible, should be derived from the safety analysis report. Where established, limiting conditions for safe operation should be complied with in all operational states of the reactor. In (see Ref.SSR-3 [1], para. 7.3537 of Requirement 71): requires states that “limiting conditions for safe operation shall be established to ensure that there are acceptable margins between normal operating values and safety system settings”. Compliance with limiting conditions for safe operation prevents safety system settings from being reached, addresses other factors that, if not controlled, might give rise to risks to the health and safety of the public, and ensures full capability for performing other necessary safety functions in all operational states and under accident conditions.

3.20.4.20. The limiting conditions for safe operation should include limits on operating parameters, requirements for minimum operable equipment with systems unavailability rules 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) in the event that these unavailability rules are not met, and any prescribed actions to be taken by the operating personnel in the event of deviations from the established OLCs as well as the time allowed to complete these actions.

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

3.22.4.22. Given the higher associated risk during startup of the reactor, the operability requirements for this mode should be more stringent than those set for purposes of operational flexibility in power operation. Systems, structures and components that are required to be operable for startup

should be specified.

~~3.23.4.23.~~ For the operability requirements of safety related equipment, the provisions in the design for redundancy, the reliability of the equipment 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 an unacceptable increase in risk should be clearly documented in the OLCs.

~~3.24.4.24.~~ The objective and applicability of each limiting condition should be stated, its specification should be clear and precise, and its basis should contain sufficient information for it to be fully understood by the operating personnel and ~~easily~~ assessed by the regulatory body.

~~3.25.4.25.~~ 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 one such grouping is as follows:

- (a) Fuel, fuel elements and assemblies;
- (b) Fuel handling and storage of fresh and spent fuel;
- (c) Reactor core configuration;
- (d) Reactivity and reactivity control systems;
- (e) Protection systems and reactor shutdown systems;
- (f) Fuel loading, reactor startup and operation;
- (g) Coolant systems and connected systems;
- (h) Containment systems or means of confinement, including ventilation;
- (i) Operational radiation protection;
- (j) Instrumentation and control systems;
- (k) Experimental devices;
- (l) Electric power supply systems;
- (m) Auxiliary systems and equipment;
- (n) Other limitations.

~~4.26.~~ A list of selected factors to be considered when establishing limiting conditions for safe operation is provided in Appendix I.

~~3.26.4.27.~~ The OLCs should also define operational requirements to ensure that safety systems and additional safety features perform their functions in all facility states for which they are necessary.

~~SURVEILLANCE~~ REQUIREMENTS FOR MAINTENANCE, PERIODIC TESTING AND INSPECTION

~~3.27.4.28.~~ 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 surveillance maintenance, periodic testing and inspection programme.

~~3.28.4.29.~~ It should be an important design requirement for research reactors to allow for appropriate functional testing and inspection of all items important to safety (see ~~para. 6.43 of Ref.SSR-3~~ [1]). This means that all items subject to safety system settings and limiting conditions for safe operation should undergo some form of ~~surveillance or periodic~~ testing. Surveillance-Testing requirements should specify the frequency and scope of tests and the acceptance criteria (~~for further guidance see paras 3.18–3.23 of IAEA Safety Standards Series No. NS-G-4.2, Maintenance, Periodic Testing and Inspection of Research Reactors—Ref.—[610]~~) to show that the performance requirements associated with the items subject to safety system settings and limiting conditions for safe operation are met.⁴⁴ The specification of the ~~surveillance-test~~ frequency should give average intervals with a minimum frequency that is to be achieved or a maximum interval that is not to be exceeded in order to provide operational flexibility in scheduling the inspection, operability check or calibration.

~~3.29.4.30.~~ The ~~surveillance—requirements~~ for maintenance, periodic testing and inspection should be specified in procedures with clear acceptance criteria so that there can be no doubts concerning system operability or component operability. The relationship between these acceptance criteria and the limit or condition being confirmed should be available in written form.

~~3.30.4.31.~~ The ~~surveillance~~-requirements for maintenance, periodic testing and inspection may be presented either by grouping them according to the systems to which they refer or in a mixed way; for example, in groups of requirements for major systems (such as the reactivity control system, the reactor pool or tank and the containment and/or confinement systems) or in groups of requirements covering related activities (e.g. tests before startup, monthly tests, quarterly tests, routine~~ing~~, monitoring and personal dosimetry).

~~3.31.4.32.~~ ~~Limiting conditions for safe operation concerning the~~

⁴⁴~~Surveillance requirements are met by using procedures that are normally part of the maintenance, periodic testing and inspection programme (see Section 5).~~

~~surveillance~~ Requirements for maintenance, periodic testing and inspection ~~should~~ could also ~~cover~~ include activities to detect ageing and other types of deterioration due to corrosion, fatigue and other mechanisms. Further guidance is provided in IAEA Safety Standards Series No. SSG-10 Aging Management for Research Reactors [11] 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 upon appropriately.

3.32.4.33. Some of the OLCs, including ~~surveillance~~ requirements for maintenance, periodic testing and inspection, may not apply during extended periods of shutdown of the reactor. For example, calibration of a power measuring channel may be deferred but should be performed before the next reactor startup. Some additional special ~~surveillance~~ 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 ~~surveillance~~ requirements for maintenance, periodic testing and inspection for extended shutdown periods may be specified separately.

ADMINISTRATIVE REQUIREMENTS

General

3.33.4.34. This section of the OLCs document specifies the administrative requirements for the reactor facility.¹² These administrative requirements consist of administrative controls concerning organizational structure and responsibilities, minimum staffing requirements, and required actions following violation of an operational limit or condition.

3.34.4.35. A list of safety related procedures could also be included in the OLCs document. These safety related procedures should be reviewed by the safety committee and may be subject to approval by the regulatory body.

¹²~~In some Member States, administrative requirements may be part of the quality assurance programme.~~

Organization

~~3.35.4.36.~~ The organizational structure of the facility should be presented in an organizational chart with a brief description of functions. The chart should show the key personnel of the operating organization who have responsibility for the facility under the terms of the licence, including the reactor manager, shift supervisor and reactor operators.

Staffing

~~3.36.4.37.~~ It should be an important requirement relating to operational safety to determine and specify the minimum staffing requirements of the various disciplines for all operational states of the reactor. These requirements will vary with the complexity and power level of the reactor. The minimum qualifications for ~~key~~-operating personnel performing safety related functions should also be specified.

Training and retraining

~~3.37.4.38.~~ The administrative requirements should include a statement that reactor manager, shift supervisors, reactor operators, radiation protection ~~staff~~personnel, experimenters, maintenance personnel, emergency workers and others who frequent the reactor facility should be properly trained. The staff requiring certification or licensing should be specified. If appropriate, the period of validity of the certification or licence should also be stated.

Review

~~3.38.4.39.~~ The requirement for specified reviews by a safety committee⁴² should be stated. The items that should be reviewed by the safety committee may include the following:

- (a) Proposed changes to the OLCs or the facility licence;
- (b) Proposed changes to existing tests, experiments, equipment, systems or procedures, and new tests, experiments, equipment, systems or procedures having safety significance;
- (c) Safety related modifications to the reactor facility;
- (d) Violations of the OLCs, the licence conditions and procedures having safety significance;
- (e) Events that are required to be reported, or have been reported, to the

⁴² See paras 7.25-7.26 of Ref. [1].

- regulatory body;
- (f) Routine radioactive releases and exposures of personnel and the public;
 - (g) Periodic reviews of the operation and safety performance of the facility.

Utilization and modifications

[3.39.4.40.](#) Administrative requirements for the safe utilization and modification of the facility should be included in the OLCs. Guidance for deciding which experiments or modifications have to be referred to the regulatory body should be included in the administrative requirements. Further guidance on utilization and modification of the facility is provided in [Ref.SSG-24 \[37\]](#).

Records and reports

[3.40.4.41.](#) An administrative requirement for the preparation and availability of various records and reports should be included in the OLCs.

[3.41.4.42.](#) The administrative requirements should state that the operating organization should make periodic summary reports to the safety committee and, if required, to the regulatory body on matters relating to the safety of the facility. The content and frequency of reports should be specified.

[3.42.4.43.](#) Records that are important for the safe operation of the reactor and for demonstrating compliance with the OLCs should be prepared and retained (see [Ref.SSR-3 \[1\]](#), [para. 7.83](#)). The records to be maintained by the facility and the time period for which the records are required to be retained should be specified. Typical records to be retained include the following:

- (a) The safety analysis report for the facility and changes to the safety analysis report;
- (b) The facility licence, the licence conditions and the OLCs;
- (c) Required plans such as the emergency plan, the security plan, the ~~quality assurance management system~~ plans, and the reactor operator and staff training plan;
- (d) Records of releases 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, shipment and inventory records;
- (k) Routine operating data such as log books and recording charts;
- (l) Procedures and changes to procedures;
- (m) Records of events that are required to be reported to the regulatory body;
- (n) Records relating to reactor experiments, such as application forms and collected data;
- (o) Facility radiation records and contamination survey records;
- (p) Records pertaining to the safety committee, such as meeting minutes and review reports;
- ~~(p)~~(q) Records of non-compliance;
- ~~(q)~~(r) Surveillance and, Maintenance, periodic testing and inspection records.

Action required in the event of a violation of OLCs

~~3.43-4.44.~~ Actions that are required to be taken by the operating organization including time allowed in the event that a safety limit or limiting condition for safe operation is violated or cannot be met should be included in the OLCs. The responsibilities to carry out the necessary compliance controls and for responding to violations of OLCs should be defined.⁴³

4.5. DEVELOPMENT OF OPERATING PROCEDURES

GENERAL

~~4.1.5.1.~~ All safety related activities should be performed in conformance with documents issued in accordance with approved operating procedures. The availability and correct use of written operating procedures is an important contribution to the safe operation of a research reactor. ~~The IAEA Safety Requirements publication on the Safety of Research Reactors (Ref. Requirement 74 of SSR-3 [1], para. 7.518)~~ states that “Operating procedures shall be developed for all safety related operations that may be conducted over the entire lifetime of the facility”, and this includes normal operation, anticipated operational occurrences and emergencies accident conditions.

⁴³ See paras 7.39-7.41 of Ref. [1]

4.2.5.2. The operating procedures for normal operation should be developed to ensure that the research reactor is operated in compliance with the OLCs and should provide instructions for the safe conduct of operation in all modes, such as startup, shutdown, power level changes, fuel loading and handling, normal operation and anticipated operational occurrences facility states. For anticipated operational occurrences, design basis accidents and design extension conditions without significant core degradation the operating procedures should provide instructions for the return to a safe state.

4.3.5.3. In this Safety Guide the term ‘operating procedures’ also covers other activities that are conducted by means of written instructions and step by step descriptions of operations, such as commissioning, maintenance, experiments and modifications, activities in emergencies and radiation protection services. Operating procedures are sometimes bound in several volumes called manuals (e.g. operation 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.

4.4.5.4. The organizations involved in ensuring the safety of research reactors and the protection of site personnel, the public and the environment have a number of responsibilities that are interrelated. Among these responsibilities are the performance of the safety analysis as well as the preparation of other safety related documents for review and assessment by the safety committee and approval by the regulatory body, as required. Operating procedures having safety significance are part of such documents.

4.5.5.5. Operating procedures should be verified and validated by authorized persons to ensure that they are administratively and technically correct, are easy to understand and to use, and will function as intended. Special attention should be paid to ensuring that operating procedures are compatible with operation in 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

Operating organization

4.6.5.6. To achieve the objective of safe operation of a reactor, the operating organization should establish administrative controls. These

controls will usually be in the form of procedures to be followed by all personnel involved in their implementation.

~~4.7.5.7.~~ The operating organization is responsible for establishing a set of OLCs, including administrative and organizational requirements. These general operating rules¹⁴ should be supplemented by specific written operating procedures.

~~4.8.5.8.~~ When possible, operating procedures, especially for a new reactor, should be developed in cooperation with the reactor designer, equipment manufacturers, ~~and vendors and with other staff of the operating organization, including radiation protection staff.~~ The assistance of external consultants may also be sought, ~~and operating experiences should be taken into account, if applicable.~~

Operating personnel

~~4.9.5.9.~~ The operating personnel may initiate and should participate in the process of developing the operating procedures.

~~4.10.5.10.~~ The operating personnel should be knowledgeable about the application of the operating procedures relevant to their tasks in the facility.

~~4.11.5.11.~~ The operating personnel should operate the reactor in accordance with valid operating procedures and should provide feedback to the reactor manager on the application of the procedures.

~~4.12.5.12.~~ Those procedures that are directly related to radiation protection should be reviewed by a radiation protection officer. The radiation protection manager is responsible for the preparation of all the radiation protection procedures for the tasks carried out by radiation protection personnel.

Safety committee

~~4.13.5.13.~~ The safety committee should review and assess the OLCs and ~~the submitted~~ operating procedures important to safety, and make recommendations before submission to the regulatory body for approval, as required. The safety committee should establish a process for review of urgently needed new procedures or changes to existing procedures that

¹⁴ ~~These general operating rules are frequently compiled in a document called an operation manual~~

cannot await a review during a regularly scheduled safety committee meeting. For example, minor modifications to the operating procedures may possibly be made with the approval of the reactor manager followed by a review by the safety committee at its next meeting, provided that the general operating rules are observed.

Reactor manager

4.14-5.14. In addition to those procedures required by the regulatory body (see para. 4.19), the reactor manager should determine the need for operating procedures that may be initiated by the operating personnel or others.

4.15-5.15. The reactor manager should ensure the development and implementation of the operating procedures. Alternatively, the reactor manager may appoint a staff member, normally a relevant group leader, to develop procedures.

4.16-5.16. The reactor manager is responsible for the approval of all operating procedures, including those reviewed by the safety committee.

4.17-5.17. 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.

4.18-5.18. The reactor manager should ensure that latest approved operating ~~general~~ procedures are readily available for reference close to the point where the work is done, or operations are carried out. Usually, one full set of operational procedures is kept in the control room and another full set in the reactor supervisor's office. There may be an additional selection of appropriate procedures kept in a location near relevant operations areas that are remote from the control room.

Regulatory body

4.19-5.19. The regulatory body should review, assess and approve the OLCs and the submitted operating procedures, as required. The regulatory body may require that some specific procedures be established.

4.20-5.20. The operating procedures should be made available to the regulatory body, ~~when requested for its consideration~~.

CATEGORIZATION AND LIST OF OPERATING PROCEDURES

~~4.21-5.21.~~ Procedures should be developed for all safety related operations that may be conducted over the entire lifetime of the research reactor. For this reason, it is convenient to categorize procedures according to their purpose and content. One such categorization is as follows:

- (a) Commissioning procedures;
- (b) Operational procedures;
- (c) Maintenance procedures of major components or systems that could affect reactor safety;
- (d) Inspection, calibration and periodic testing procedures of structures systems and components that are essential for safe operation of the reactor;
- (e) Radiation protection procedures;
- (f) Procedures for the authorization of operation, maintenance, irradiation or experiments that could affect reactor safety or the reactivity of the core;
- (g) Procedures for reactor operator's response to anticipated operational occurrences and design basis accidents, and, to the extent feasible, to design extension conditions;
- (h) Emergency procedures;
- (i) Physical protection procedures;
- (j) Procedures for the handling of radioactive waste, monitoring and control of radioactive releases;
- ~~(k) Decommissioning procedures;~~
- (k) Procedures for extended shutdown
- (l) Procedures for utilization and for modification of the reactor;
- (m) Administrative procedures.

This list is not intended to be comprehensive. Some items may not be appropriate for low power facilities including critical assemblies and subcritical assemblies, and the list may be incomplete for high power facilities. Appendix II presents selected operating procedures listed on the basis of this categorization.

~~4.22-5.22.~~ The categorization has been selected for consistency with the topics developed in ~~the IAEA Safety Requirements publication on the Safety of Research Reactors SSR-3~~ [1]. Categorizations on the basis of other criteria may also be valid. A categorization system may be based on the review and approval route for the procedures; for example, safety related procedures (required and approved by the regulatory body), administrative procedures (reviewed by the operating organization) and other safety related procedures (reviewed by the safety committee and approved by the reactor manager). In other categorizations, only the area of application may be

considered.

GENERAL CONSIDERATIONS FOR THE DEVELOPMENT OF OPERATING PROCEDURES

4.23-5.23. Paragraphs ~~45.24-25-45.29-30~~ present general considerations relating to the different types of procedures presented in para. ~~45.24-22~~. In addition, where possible, a reference is provided to IAEA publications that provide additional information.

4.24-5.24. The need for special quality assurance measures should be taken into account when developing procedures for operational activities that have an influence on or that relate to the following, as appropriate:

(a) Reactor core configuration;

~~(a)~~(b) Reactivity and criticality;

~~(b)~~(c) Thermal safety;

~~(c)~~(d) Safety of experiments;

~~(d)~~(e) Repair actions;

~~(e)~~(f) Modification of existing systems or components;

~~(f)~~(g) Safety measures for visitors;

~~(g)~~(h) New installations;

~~(h)~~(i) Manipulation of special components and radioactive material;

~~(i)~~(j) Surveillance-Maintenance, periodic testing and inspection of equipment;

~~(j)~~(k) Inspection programmes;

~~(k)~~(l) Steps for the approval of different safety related actions (e.g. replacements, repairs, modifications, new installations);

~~(l)~~(m) Accreditation-Training and qualification of operating personnel and experimenters.

4.25-5.25. To develop a set of procedures for use in operation, a planned and systematic process should be applied. This may be facilitated by using a prescribed format and standard outline of the content to be incorporated.

4.26-5.26. Each procedure should be sufficiently detailed for a qualified individual to be able to perform the required activities without direct supervision, but the procedure should not provide a complete description of the facility processes involved.

4.27-5.27. The format of the procedures may vary, but the procedures should be developed in accordance with established requirements and recommendations relating to quality assurance of the management system.

4.28-5.28. Persons with appropriate competence and experience should be designated to prepare and verify procedures.

4.29-5.29. Human factors should be taken into account to develop safe, reliable and effective operating procedures. Consideration should be given to the layout, the general design of the facility, staffing requirements, time required for operator action, physical environment, level of stress and operating experience at the research reactor concerned.

STEPS IN THE PREPARATION OF A PROCEDURE

4.30-5.30. Once the objectives of the procedure have been defined, the first step in the development of an operating procedure is to evaluate the possible methods and staff requirements for fulfilling the objectives of the procedure and to select the methods best suited for achieving the desired goal.

4.31-5.31. If it is possible and considered necessary, the methods selected should be simulated by the staff and the relevant 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 procedures should be finalized on the basis of the results of the simulation.

4.32-5.32. If the procedure has significance for radiation protection, it should be reviewed by a radiation protection officer and should be modified as recommended.

4.33-5.33. The draft of the procedure may be improved by means of a review by staff members with experience in the subject of the procedure and by those staff members who will use the procedure.

4.34-5.34. The reactor manager should be responsible for a review of a draft of the procedure to determine whether the procedure is sufficiently detailed for its intended objectives and is consistent with other relevant procedures. Also, the reactor manager should ensure that implementation of the procedure would not violate any OLCs.

4.35-5.35. The reactor manager should forward the final drafts of safety related procedures to the safety committee for review and comment prior to their approval. Procedures having significance for the safety of the reactor should be specified as such and should be subject to

approval by the regulatory body, as required.

~~4.36-5.36.~~ 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.

~~4.37-5.37.~~ Experience gained in the use of a procedure may indicate a need for its review and updating. Review and updating should, in principle, follow the same steps as those in the preparation of a procedure as outlined here. The reactor manager should specify the process for this review and updating.

~~4.38-5.38.~~ Safety significant revisions of procedures should be treated in accordance with para. ~~4~~5.35. Other revisions of procedures may be approved directly by the reactor manager.

5.6. FORMAT AND CONTENT OF OPERATING PROCEDURES

GENERAL

~~5-1-6.1.~~ All operating procedures should have a standard format as specified by the operating organization. They should follow a suitable sequential presentation, should have a clear, concise and logical text, and should cover all relevant issues. The following guidance will facilitate meeting these objectives.

~~5-2-6.2.~~ To ensure consistency in format and content, operating procedures should be prepared in accordance with ~~a—general—quality assurance management system~~ procedure ~~or—administrative procedure~~ that governs the development, review and control of such documents. Provision should be made in this general procedure or elsewhere for periodic review. There should be a mechanism to verify conveniently 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).

~~5-3-6.3.~~ Operating procedures should generally direct the step by step performance of all activities except for 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 of performance of the procedures should be specified in the procedures themselves.

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

5.5.6.5. The following is a typical 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 should be 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: ~~16 July 2003~~day, month and year).
- (c) Date of expiry: This may be the date of the next revision or it may be indefinite 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.⁴⁵
- (g) References: References on the basis of which the procedure was developed and that are referred to in the text.
- (h) Responsibilities: Specification of the requirements on and responsibilities of personnel performing the procedure.
- (i) Prerequisites: Specific conditions for the reactor, systems, equipment and personnel required to perform the procedure.
- (j) Additional requirements: 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 (education) of personnel, conditions of applicability and preparations relating to the performance of the procedure.
- (k) Instructions: Specific step by step instructions for performing a procedure. 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, insert). Caution should be exercised to ensure that the steps in the instructions are complete, and

⁴⁵~~In general, use of terminology requiring definitions should be avoided. If this is not possible, a definition needs to be incorporated into the procedure.~~

that all required actions have been considered and there are no instruction steps contained in the procedure as prerequisites and special requirements that could be overlooked while performing the procedure. Consideration should be given to setting up instructions in the form of checklists on which each step is initiated 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.

- (l) Basis for measurements and calculations: For some procedures that require 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.
- (m) Documentation: While completion of some procedures may be indicated by a simple entry in the reactor logbook, more complicated procedures may be documented by means of appropriate checklists, data tables and reports. Such data sheets 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 inherent risks associated with failure to conduct the operation properly.

5-6-6.6 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 parameters and acceptance criteria in which account is taken of the uncertainties assumed in the safety analysis.

5-7-6.7 On the basis of the quality assurance management system requirements, procedures should be prepared for the procurement and acceptance of new components or equipment (e.g. fuel elements, ion exchange resins). The procedures should require a valid calibration certification for test equipment that is used in the procedure.

5-8-6.8 Procedures should specify the authority for permitting 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.

5-9-6.9 In addition to the general recommendations provided here for consideration in developing all procedures, the following sections are intended to provide additional recommendations for the various types of operating procedure.

COMMISSIONING PROCEDURES

5.10-6.10. The content of commissioning procedures for tests of equipment and systems should be defined in accordance with para. 56.5 (for further guidance see IAEA Safety Standards Series No. NS-G-4.1, Commissioning of Research Reactors [12]), with special attention paid to the following:

- Summary of purpose, equipment to be tested and relationship to the commissioning programme;
- Prerequisites and initial conditions;
- Precautions, including stopping of the test;
- List of required equipment and instruments;
- List of data to be recorded and checklists;
- Analysis of data and results;
- Acceptance criteria;
- Provisions for corrective actions concerning possible non-conformances;
- Certification of completion of the test.

5.11-6.11. Commissioning procedures may be subdivided into those that are derived directly from operating procedures and those that will be required during commissioning only. The latter are sometimes referred to as test procedures.

5.12-6.12. 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.

5.13-6.13. The test procedures should follow the normal facility operating procedures to the extent practicable, to verify these procedures and to provide an opportunity for operating personnel to become familiar with the normal facility operating procedures.

5.14-6.14. Certain commissioning activities may simply require generic procedures or lists of instructions.

5.15-6.15. Commissioning procedures should include prerequisites, where applicable, for system tests that must be completed prior to performing the step by step instructions established by these procedures, including commissioning of support systems (e.g. operable flow measurement channel prior to testing of the primary coolant system, operable electric power supply prior to commissioning tests of pumps).

5.16-6.16. In addition to operational procedures, supporting documentation, including manufacturers' manuals and construction drawings,

may be required for commissioning test procedures for some components and systems.

5.17-6.17. If necessary, the procedure should include hold points for the notification and involvement of outside agencies, manufacturers and the regulatory body.

5.18-6.18. Procedures should state all the necessary changes to the normal operating configuration that are required for testing. However, in this case, configuration checks should be undertaken to ensure that these deviations 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.

5.19-6.19. Consideration should be given during the preparation of the procedure to interactions between the reactor and experimental devices.

5.20-6.20. Commissioning procedures should be prepared for experimental devices in any case, whether they will undergo commissioning at the same time as the reactor or later.

5.21-6.21. The commissioning procedure should contain provisions for dealing with unexpected results of commissioning, deliberate changes to the design, programmes or tests that may become necessary, and incidents that may occur during the commissioning process.

5.22-6.22. In practice, many of the commissioning procedures become operational procedures (e.g. procedures for fuel loading, startup, calibration of reactivity control mechanisms and determination of the thermal power level).

OPERATIONAL PROCEDURES

5.23-6.23. The operating organization should ensure that all reactor operation is in accordance with approved operational procedures. These procedures should be prepared for all activities performed by the operating personnel for all operational states of the reactor and, where appropriate, for experiments and for the handling of fuel assemblies or other core and reflector components, including experimental devices.

5.24-6.24. Normally, procedures are 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 in the procedure by specifying

special precautions.

~~5.25-6.25.~~ Operating procedures are reviewed periodically and also whenever a change is made in the configuration of the reactor system or components concerned. For operations that are performed infrequently, the existing procedures should be reviewed in any case before use, and revisions should be made as appropriate.

~~5.26-6.26.~~ Operational procedures should specify the actions required in the case of an unexpected event or unexpected results during the performance of the procedure, as necessary.

~~5.27-6.27.~~ Operational procedures should include requirements for work permits, if necessary.

MAINTENANCE PROCEDURES

~~5.28-6.28.~~ A plan for preventive maintenance should be prepared to assist in the timely completion of those maintenance activities that are required to be completed on a regular (e.g. weekly, monthly, quarterly, semi-annual, annual) basis.¹⁶ Requirement 77, para 7.69 of SSR-3 requires that “All maintenance, periodic testing and inspection of systems or items important to safety shall be performed by following approved written procedures”. Procedures for corrective maintenance activities should be prepared as required. Further guidance on this topic is provided in NSG-4.2 [10].

~~5.29-6.29.~~ In the preparation of maintenance procedures, particular attention should be paid to the effects of the procedure on safety systems and on reactor operation. “Non-routine inspections or corrective maintenance of systems or items important to safety shall be performed to a specially prepared plan and procedures” as per para 7.70 of SSR-3 [1]. Some procedures with no impact on reactor safety may be performed during reactor operation; other procedures may require shutdown of the reactor. The maintenance process should not reduce the safety of the reactor, and the OLCs should not be violated.

~~5.30-6.30.~~ Requirement 77, para 7.69 of SSR-3 [1] states that “In accordance with the requirements of the management system, A system of

~~¹⁶ Ageing management activities are generally part of a preventive maintenance programme. Procedures include inspections to evaluate the effects of ageing of equipment and the need for the replacement of equipment~~

work permits ~~should~~shall be used for maintenance, periodic testing and inspection, including appropriate procedures and checklists ~~check-offs, during-before~~ and after the conduct of the work. These procedures shall include acceptance criteria.” ~~in accordance with the quality assurance programme~~. This is to ensure that all work is conducted with the knowledge and permission of the person in operational control of the reactor and that both the safety of the reactor and the safety of the personnel doing the work have been considered. Therefore, maintenance procedures ~~should~~ may incorporate the requirement of a work permit as a prerequisite to performing the maintenance.

5.31-6.31. Maintenance procedures should specify any changes to the normal reactor operating configuration (e.g. valve line-ups) and should have provisions for the restoration of the normal configuration after maintenance (e.g. procedures for taking mechanical and electrical equipment out of service and for restoring it to service). A generic procedure should therefore be developed, or special provisions should be made in individual procedures to achieve configuration control.

5.32-6.32. Reference to drawings, manufacturer’s manuals to be used and manufacturer’s recommendations to be followed should be included in the procedures. It should be ensured that the updated-current versions of drawings and manuals are used.

5.33-6.33. Maintenance procedures should specify that the results of maintenance, periodic testing and inspection should be assessed by properly qualified personnel. Comparison should be made, where appropriate, with the results of previous inspections and tests to determine potential failures and to permit timely corrective action.

5.34-6.34. 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.

5.35-6.35. Special procedures should be prepared to control contractor maintenance work. These procedures should include prerequisites to the work, requirements for supervision of the contractor, contractor qualification and work coordination.

INSPECTION, CALIBRATION AND PERIODIC TESTING PROCEDURES

5.36-6.36. Periodic testing is performed to fulfil ~~surveillance~~ 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~~surveillance~~ programme should be adequately specified to ensure the inclusion of all aspects of the limits or conditions.

5.37-6.37. Periodic testing procedures, which include calibration, inspection and operability checks, should be prepared for structures, systems and components that are important for safe operation of the reactor. A plan for scheduling calibrations, inspections and operability checks should be prepared to assist in their completion at the required frequencies. 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.

5.38-6.38. The frequency of the ~~surveillance and periodic testing and inspection~~ activities should be stated and should be based on:

- Analyses, including insights from probabilistic safety assessment, where available;
- The recommendations of the supplier;
- ~~Experience gained from previous surveillance and periodic testing and inspection~~ results;
- Operating experience from the facility or relevant experience from other facilities;
- Engineering judgement.

5.39-6.39. Periodic testing procedures should be consistent with the reactor operating procedures. In addition, when developing periodic testing procedures, the considerations for developing operational and maintenance procedures (see paras ~~56.23–56.35~~) should also be taken into account.

5.40-6.40. Each periodic testing procedure should provide for a final acceptance (including signature) by a person qualified and authorized to assess the results of the procedure and to verify compliance with the OLCs.

5.41-6.41. Periodic testing procedures should have provisions for resolving non-conformances with the OLCs.

5.42-6.42. Acceptance criteria (for which consideration has been given to the uncertainties of measurements) should be provided within periodic testing procedures. Providing a range of acceptable values for parameters is therefore generally better than giving single values.

~~5.43-6.43.~~ The procedures ~~may~~ should require that instruments used for calibrations be certified in accordance with the requirements of the ~~quality assurance programme~~ management system.

RADIATION PROTECTION PROCEDURES

~~5.44-6.44.~~ Radiation protection procedures should be prepared within the framework of the radiation protection programme for the facility.

~~5.45-6.45.~~ 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, source inventory). The procedures should contain acceptance criteria and should identify the person responsible for reviewing the results. A master radiation protection procedure should be prepared to ensure that all activities are completed at the required frequencies.

~~5.46-6.46.~~ Radiation protection provisions for those personnel operating the reactor, conducting maintenance ~~and~~ periodic testing, inspection or performing experiments should be included in each of the relevant procedures and, if necessary, in the work permits for their implementation.

~~5.47-6.47.~~ In developing radiation protection procedures, compliance with the OLCs for reactor operation and with regulatory body requirements should be verified.

PROCEDURES FOR THE AUTHORIZATION OF OPERATION, MAINTENANCE AND UTILIZATION

~~5.48-6.48.~~ 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, to define the conditions, the levels of responsibility and the means of authorization.

~~5.49-6.49.~~ A procedure for dealing with proposals for experiments should be established. The procedure should require that the proposals include:

- (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) The requirements for the production and validation of any special documentation for operation and maintenance;
 - (f) The requirements for any special training of operating and maintenance personnel and experimenters;
 - (g) The requirements for commissioning and functional testing;
 - (h) Special requirements for transport, if necessary;
 - (i) A decommissioning plan for the experimental device;
 - (j) The quality assurance programme used;
 - (k) The suggested means of disposal of the radioactive waste generated in the experiments and of the experimental devices after their final use;
 - (l) Considerations relating to alarms and interlocks;
 - (m) Procedures to ensure adequate means of communication between operators and experimenters.

5.50-6.50. 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 OPERATOR RESPONSE TO ANTICIPATED OPERATIONAL OCCURRENCES AND ACCIDENT CONDITIONS

5.51-6.51. Procedures for guiding the response of the operator to anticipated operational occurrences, and design basis accidents ~~and, to the extent feasible, beyond design basis accident conditions, and, to the extent feasible, to design extension conditions~~ should be prepared and should be periodically exercised. To improve their execution, the procedures should be reviewed periodically depending upon their safety significance and modified on the basis of operational experience and the performance of the exercises.

5.52-6.52. The procedures ~~mentioned in para. 5.49~~ for dealing with proposals for experiments 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 for all operating procedures should be clear and brief, and particularly so for those dealing with

anticipated operational occurrences.

EMERGENCY PROCEDURES

~~5.53-6.53.~~ Emergency procedures should be prepared, and they should be a component of the operating organization's emergency arrangements plan for preparedness for and response to a nuclear or radiological emergency as required by Requirement 81 of SSR-3 [1] and in accordance with IAEA Safety Standards Series No. GSR Part 7, Preparedness and Response for a Nuclear or Radiological Emergency [13]. Their development should be based on the evaluation and analysis of all aspects of possible ~~emergencies~~accidents in the safety analysis report as well as those additionally postulated for the purpose of emergency preparedness and response depending upon the hazard assessment. The emergency procedures should describe in detail the actions to be taken by emergency workers in case of an emergency~~specify the methods and duties of intervention staff and the emergency actions that are necessary to mitigate the possible consequences of the emergency~~. They should refer to the emergency response facilities, emergency services, response organizations and emergency equipment.

~~5.54-6.54.~~ Emergency drills and exercises should be periodically conducted. On the basis of experience gained from the performance of the drills and exercises, the procedures, including the list of organizations and individuals to be called or informed in the event of an emergency, should be reviewed at specified periods and amended, if necessary, to improve their execution and to ensure that the lessons learned are taken into account.

~~5.55-6.55.~~ 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 agreements should be obtained from the organizations concerned. 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.

~~5.56-6.56.~~ Experts should be consulted in preparing emergency procedures (e.g. specialized personnel from fire departments, hospital emergency units, ambulance crews, etc.) in implementing the requirements of GSR Part 7 [713]. Further guidance is provided in IAEA Safety Standards Series No. GS-G-2.1, Arrangements for Preparedness for a Nuclear or Radiological Emergency, [814].

PHYSICAL PROTECTION PROCEDURES

~~5.57-6.57.~~ Physical protection procedures should be prepared and should be a component of a physical protection 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 on a need to know basis only.

~~5.58-6.58.~~ Physical protection procedures should be developed on the basis of the evaluation and analysis of all aspects of security. The instructions for physical protection procedures should be brief but should give sufficient details of the essential steps for coping with security matters.

~~5.59-6.59.~~ If the services of off-site organizations such as police forces and army units are required by physical protection procedures, formal letters of agreement should be obtained and these should be periodically updated.

~~5.60-6.60.~~ Experts should be consulted in preparing security procedures (e.g. security specialists, specialized personnel from the police and army).

PROCEDURES FOR THE HANDLING OF RADIOACTIVE WASTE, MONITORING AND CONTROL OF RADIOACTIVE RELEASES

~~5.61-6.61.~~ Requirements covering the procedures for handling radioactive waste and for the monitoring and control of radioactive releases are established in IAEA Safety Standards Series No. GSR Part 5, Predisposal Management of Radioactive Waste~~Ref. [915]~~. These procedures may be included as part of the radiation protection procedures or may form an individual group within the operating procedures.

~~5.62-6.62.~~ At some research reactor facilities, the operating personnel and radiation protection staff handle, collect, process, account for, store radioactive waste and is responsible that the waste is disposed of safely~~radioactive waste~~.¹⁷ In this case the procedures for radioactive waste are usually considered to be radiation protection procedures. Further guidance on the predisposal management of radioactive waste is provided in other Safety Guides IAEA Safety Standards Series No. SSG-40, Predisposal

¹⁷~~Further guidance is provided in the IAEA safety standards relating to radioactive waste.~~

Management of Radioactive Waste from Nuclear Power Plants and Research Reactors [4016,14].

5.63-6.63. Procedures for controlling radioactive discharges play an important part in environmental protection and also in gaining public acceptance of the facility. The sensitivity of this matter should be taken into account in the development of these procedures. Further guidance is provided in IAEA Safety Standards Series No. GS-G-9, Regulatory Control of Radioactive Discharges to the Environment Ref. [4217].

PROCEDURES FOR EXTENDED SHUTDOWN

5.64-6.64. Procedures should be prepared for the management of extended shutdown and for the provision of adequate resources for ensuring the safety of activities during extended shutdown, in implementing the Requirement 87, para 7.124 of SSR-3 [1]. During the extended shutdown period, modifications of the procedures for preventive maintenance and periodic testing may be introduced consistent with any modification to the OLCs as discussed in section 3 of this Safety Guide. Relief from the procedures is possible in those activities that are a function of operating time or energy generation.

5.65-6.65. Special procedures should be developed for those inspections that could indicate degradation of mechanical and electrical systems and components.

5.66-6.66. 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 recommissioning of the reactor.

5.67-6.67. Maintenance, periodic testing and inspection Surveillance procedures to be used during extended shutdown periods for the reactor should be derived from the maintenance, periodic testing and inspectionsurveillance procedures for an operating reactor, with exemptions given for certain activities or strengthening of the procedures for others.

5.68-6.68. If the operating procedures are modified for the extended shutdown state of the facility, the original version of the operating procedures should be kept for possible future operation of the reactor.

~~5.69-6.69.~~ 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 THE REACTOR

~~5.70-6.70.~~ Procedures should be prepared for controlling utilization or modification of the reactor¹⁸ having safety significance, to ensure that the design, manufacture, installation, conduct and testing of experiments and modifications are properly executed.

~~5.71-6.71.~~ The utilization and modification of the reactor should be performed in accordance with approved procedures that contain provisions for ensuring that all OLCs are met.

~~5.72-6.72.~~ The following considerations should be addressed in the modification procedure:

- (a) Description and drawings of the proposed modification;
- (b) Justification of the need for the modification;
- (c) Design requirements and criteria;
- (d) Safety assessment supporting the modification, including influences on other systems;
- (e) Manufacturing processes;
- (f) Installation processes;
- (g) The commissioning process;
- (h) Review and modification of existing operating procedures and the need for new procedures;
- (i) Updating of documentation (drawings, training materials, etc.);
- (j) Training requirements for reactor operators and support staff (including requalification and relicensing, if necessary);
- (k) Quality assurance requirements;
- (l) Requirements for the optimization of radiation protection;
- (m) Requirements for physical protection;
- (n) Requirements for radioactive waste disposal.

~~5.73-6.73.~~ A procedure should be prepared for the categorization of experiments and modifications on the basis of their safety significance. Generally, three categories for experiments and modifications are

¹⁸ ~~For further details, see Ref. [3].~~

utilized: those that fall outside the approved OLCs (major safety significance); those that are within the OLCs (moderate safety significance); and those having no safety significance. An extensive discussion of categorization, safety assessment and approval routes for experiments and modifications is provided in ~~section 3 of RefSSG-24~~. [37].

~~5.74-6.74.~~ In the preparation of procedures for utilization or modification, particular attention should be paid to the consequences for safety systems and for reactor operation. The safety level of the reactor during or as a result of the modification or utilization should not be reduced below the limits set in the OLCs.

~~5.75-6.75.~~ The procedures ~~may~~should include a system of work permits for use for modification or utilization and when performing pre-operational testing, including appropriate checks before and after the conduct of the work in accordance with the ~~quality assurance program~~management system. This is to ensure that all work is conducted with the knowledge and permission of the person in operational control of the reactor, and to ensure the protection and safety of the personnel doing the work as well as the safety of the reactor.

~~5.76-6.76.~~ Procedures for modification and utilization 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.

~~5.77-6.77.~~ Procedures for modification and utilization should include assessment of the results of the modification or utilization by properly qualified persons to verify compliance with the approved design and with the OLCs. The procedures should require comparisons, where appropriate, with the pre-modification conditions to determine possible failures and to permit timely corrective action.

~~5.78-6.78.~~ Modification procedures should ensure that the resumption of normal operation will be permitted only after the person who is responsible for coordinating the modification work has approved the results, including the updating of documentation.

~~5.79-6.79.~~ Special procedures should be prepared to control modification work performed by contractors. These procedures should include requirements for contractors' qualifications and training and for the coordination of work, as well as provisions for surveillance of the contractors. The procedures should list activities of the contractor that are prohibited (e.g. activities causing the generation of dust, use of the reactor power

supply).

ADMINISTRATIVE PROCEDURES

~~5.80-6.80.~~ Administrative procedures should be developed for all operations that are of an administrative nature and that may have an effect on the safety of the reactor (e.g. personnel training and retraining, transport of radioactive material, fuel management and safety measures for control of visitors).

~~5.81-6.81.~~ Administrative procedures that are consistent with the quality assurance programme management system should be developed for the generation, collection, and retention and archiving of records and reports.

~~5.82-6.82.~~ Administrative procedures may be used as implementing procedures for the quality assurance programme management system.

~~5.83-6.83.~~ Administrative procedures should be based on national standards or national regulatory requirements. Where appropriate, as for the transport of radioactive material, the administrative procedures should be in accordance with international standards, agreements or practices.

6.7. TRAINING OF PERSONNEL IN THE USE OF PROCEDURES

~~6.1-7.1.~~ To ensure that procedures will be properly executed, operating personnel and others should be knowledgeable in the current procedures relating to the tasks for which they are responsible.

~~6.2-7.2.~~ Before a procedure is used, training of operating personnel and others who are intended to implement the procedure should be conducted. Training may take the form of oral or written instructions, demonstrations, drills, training classes or comprehensive training courses and, where applicable, the use of mock-ups.

~~6.3-7.3.~~ Retraining in the use of procedures should be included in the continuing retraining programme for operating personnel and others, and the frequency of the continuing retraining programme should be specified. Retraining should be conducted according to a plan, and special attention should be paid to emergency procedures including those for design

extension conditions and infrequently performed procedures. Typical examples of these are:

- Operation of the emergency core cooling systems;
- Operation of the air cleaning system for the containment or the means of confinement;
- Testing ~~the leak rate of the leaktightness~~ of the reactor building containment / confinement;
- Handling of highly radioactive material under abnormal conditions;
- Fuel shipment;
- Emergency actions such as responses to a fire alarm or evacuation alarm in the reactor building, a personal injury, the release of airborne radioactive material and weather warnings;
- Use of personal protective equipment.

6.4.7.4. The operating personnel and others should be required to demonstrate their knowledge and understanding of the operating procedures that they follow in discharging their responsibilities.

6.5.7.5. Procedures should be developed for validation of the training, to verify its effectiveness and the qualifications of the staff. Further guidance is provided in IAEA Safety Standards Series No. NS-G-4.5, The Operating Organization and the Recruitment, Training and Qualification of Personnel for Research Reactors [18].

7.8. COMPLIANCE WITH OPERATIONAL LIMITS AND CONDITIONS AND OPERATING PROCEDURES

7.1.8.1. The operating organization has the primary responsibility for ensuring compliance with the OLCs. Relevant controls should be established to discharge this responsibility.⁴⁹ The provision of and training in operating procedures consistent with the OLCs is a major contribution to ensuring compliance with the OLCs. Some OLCs may be directly stated in procedures or other documents, and if so this should be clearly indicated in the implementation document.

7.2.8.2. To ensure compliance with OLCs, all persons who are responsible for such compliance should always have available a copy of the OLCs currently in force and should be adequately trained in their application. If possible, operational limits should be legibly indicated on instruments and

⁴⁹ Further guidance is provided in Ref. [6]

displays to facilitate compliance. Similarly, the current operating procedures should be immediately available to the control room personnel and to others who need to use them or refer to them.

~~7.3.8.3.~~ 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. Results of routine or commissioning tests also necessitate analyses and consideration of the need for modifications to the OLCs and/or the operating procedures.

~~7.4.8.4.~~ Records of operation of the research reactor and demonstrations of compliance with the OLCs and operating procedures should be kept and should be stored in accordance with the quality assurance requirements. Reports of non-compliance should be investigated to ensure that corrective action is taken and to help prevent such non-compliance in the future.

~~1. QUALITY ASSURANCE~~

~~GENERAL~~

~~8.6. A quality assurance²⁰ programme based on specific quality standards for the operation and utilization of a research reactor should be established, managed, applied and evaluated for ensuring safety.²¹ The senior management should establish, implement and maintain the quality assurance programme, which should cover all processes of the organization, including the operational processes, the interfaces at different operational phases, and the development and implementation of operating procedures. The extent of the quality assurance programme that is required for the operating organization of a particular research reactor will depend on the safety significance of the activities and processes relating to the reactor and on the legal requirements established by the regulatory body. For further guidance on the format and~~

²⁰ The IAEA has revised the requirements and guidance in the subject area of quality assurance for new safety standards on management systems for the safety of nuclear facilities and activities involving the use of ionizing radiation [13, 14]. Aspects of managing a nuclear facility, including the safety, health, environmental and quality requirements, are to be integrated into one coherent management system

²¹ See Ref. [1], paras 4.5–4.9.

content of the quality assurance programme, see Ref. [13].

~~8.8. The quality assurance programme should be reviewed and approved at the appropriate levels of management within the operating organization and, where necessary, by the regulatory body.~~

~~8.10. The quality assurance programme 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.~~

~~8.12.8.1. The management should ensure that an approved quality assurance programme is documented and distributed to staff for implementation of its requirements and should ensure its effective implementation.~~

~~SPECIFIC QUALITY ASSURANCE ARRANGEMENTS FOR OPERATIONAL LIMITS AND CONDITIONS~~

~~8.12. To provide assurance that the selection, development, implementation and modification of the OLCs have been correctly conceived, the overall quality assurance programme for operation of the reactor should specify the system for controlling the establishment of the OLCs and the management responsibilities for this process. This process should also be applied to the development of any additional operating rules and other technical requirements referred to in the OLCs. This quality assurance programme refers to other documents that define the processes in detail.~~

~~8.12. The items to be audited and the maximum interval between audits should be stated and may include, for example:~~

- ~~— Facility operations for conformance with the OLCs and the facility licence;~~
- ~~— The response by the operating organization to violations of the OLCs;~~
- ~~— The implementation of licensing procedures;~~
- ~~— Events that should be reported to the regulatory body;~~
- ~~— The facility emergency plan and procedures;~~
- ~~— The training programme for reactor operators;~~
- ~~— The updating of documents.~~

~~For requirements and guidance on auditing, see Refs [13, 14], and also Safety Guide No. 50 C/SG Q: Q5.²³~~

~~QUALITY ASSURANCE FOR OPERATING PROCEDURES~~

~~8.12. The quality assurance programme should specify the system for the development, implementation and modification of operating procedures to ensure that they have been correctly conceived and implemented.~~

~~For requirements and guidance, see Refs [13, 14] and Safety Guides No 50 C/SG Q: Q3, Q13 (see footnote 23)²².~~

~~8.12. The quality assurance programme should specify the means of detecting and correcting non-conformances in the operating procedures. This may be done by means of periodic review and auditing by the operating organization.~~

²² ~~INTERNATIONAL ATOMIC ENERGY AGENCY, Quality Assurance for Safety in Nuclear Power Plants and other Nuclear Installations: Code and Safety Guides Q1-Q14, Safety Series No. 50 C/SG Q, IAEA, Vienna (1996).~~

Appendix I

FACTORS TO BE CONSIDERED IN ESTABLISHING LIMITING CONDITIONS FOR SAFE OPERATION

I.1. The following list of operational parameters and equipment should be considered in establishing limiting conditions for safe operation of research reactors. These limiting conditions for safe operation may be operational constraints or administrative limitations imposed on each of the listed items. The user should look at the entire list and select the appropriate items in accordance with the type of research reactor, critical assemblies or subcritical assemblies and the conditions of operation, ~~critical assemblies and subcritical assemblies~~. All the items should be considered in establishing OLCs unless it can be justified that, for a specific research reactor, critical or subcritical assembly, some of the operational parameters and equipment mentioned in this Appendix may not be applicable depending on the design and potential hazards associated with the facility. The grouping of items by systems or activities of a common nature has been made only for convenience. However, the presentation of limiting conditions for safe operation by groups in the OLCs document provides for a logical arrangement and gives clarity to the document.

I.2. FUEL AND FUEL ELEMENTS AND ASSEMBLIES

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

I.3. FUEL HANDLING AND STORAGE OF FRESH AND SPENT FUEL

- (a) Storage of fresh fuel;
- (b) Storage of spent fuel;
- (c) Storage of failed fuel;
- (d) Capability to unload and store core components;
- (e) Requirements for fuel movements (e.g. staffing, tools, measurements);
- (f) Requirements for preparation of fuel for off-site shipment.

I.4. REACTOR CORE CONFIGURATION

- (a) Permissible internal or peripheral cavities;
- (b) Maximum and minimum number of fuel elements;
- (c) Conditions of reflection (e.g. type of reflector and configuration);
- (d) Number of control elements, including fuel followers;
- (e) Mixed cores (e.g. cores containing fuel of different enrichments);
- (f) Permissible configurations;
- (g) Requirements for determining new configurations;
- (h) Reactor power;
- (i) Average and peak fuel element power;
- (j) Maximum allowed fuel temperature and cladding temperature;
- (k) Departure from nucleate boiling ratio, critical heat flux ratio or flow instability.

I.5. REACTIVITY AND REACTIVITY CONTROL SYSTEMS

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

I.6. PROTECTION SYSTEMS AND REACTOR SHUTDOWN SYSTEMS

- (a) Type and minimum number of neutronic measuring equipment items necessary to scram the reactor in each mode of operation;
- (b) Type and minimum number of other measuring equipment items (temperature, flow, radiation level, etc.) necessary to scram the reactor;
- (c) Alarm and scram limits for the aforementioned equipment;
- (d) Interlocks and trips, including inadvertent bypass;
- (e) Bypassing channels, inadvertently or as part of operation;
- (f) Other safety instrumentation;
- (g) Reactor shutdown delay time (e.g. rod drop time, response time of the

protection or control system).

I.7. REACTOR STARTUP AND OPERATION

- (a) Minimum operability requirements of structures, systems and components;
- (b) Completion and review of checklists;
- (c) Visual inspections of reactor core, beam tube shutters and shielding;
- (d) Additional conditions for startup following a ~~#ip~~reactor scram.

I.8. COOLANT SYSTEMS AND CONNECTED SYSTEMS

- (a) Coolant chemistry (content of solids and dissolved gases, pH and conductivity);
- (b) Temperature, pressure (in lines, across filters, ~~etc.~~) and flow;
- (c) 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, ~~etc.~~);
- (d) Changeover conditions to and from the natural convection mode of cooling, if applicable;
- (e) Coolant or moderator level;
- (f) Emergency core cooling;
- (g) Leak detection and loss of coolant alarm limits;
- (h) Radionuclide content in the coolant;
- (i) Content of fission products in the coolant;
- (j) Coolant availability;
- (k) Ultimate heat sink;
- (l) Moderator chemistry (e.g. required properties and characteristics).

I.9. CONTAINMENT SYSTEMS OR MEANS OF CONFINEMENT, INCLUDING VENTILATION

- (a) Temperature, humidity and air flow in different areas of the reactor;
- (b) Pressure drop across filters;
- (c) Containment pressure relative to the atmosphere (normal and under emergency conditions);
- (d) Isolation of the containment or the means of confinement and starting of emergency ventilation;
- (e) Operations that require containment or confinement;
- (f) Configuration and minimum equipment for ventilation;
- (g) Leak rate from the containment or the means of confinement;
- (h) Hazardous materials inside the containment or the means of confinement;
- (i) Efficiencies of filters and iodine traps.

I.10. OPERATIONAL RADIATION PROTECTION AND RADIOACTIVE WASTE MANAGEMENT

- (a) Type (gaseous, particulate, gamma, neutron, etc.) and location of radiation monitoring instruments;
- (b) Alarm setting for monitoring instruments for radiation (including monitoring instruments for initiating scrams, if any);
- (c) Limits on the concentration of radionuclides or other limits on the liquid or gaseous effluents that may be released in a given time period, such as maximum annual releases (site limits may apply where more than one facility is located at the same site);
- (d) Dose control values for operation, such as annual dose limits;
- (e) Operating limits for surface contamination;
- (f) Dose ~~targets~~ constraints (individual and collective);
- (g) Criteria for respiratory protection and special protective clothing;
- (h) Criteria for bioassay or whole body counting;
- (i) Storage capacity for liquid and solid waste.

I.11. INSTRUMENTATION AND CONTROL SYSTEMS

- (a) Type and minimum number of items of measuring equipment associated with safety systems;
- (b) Startup instrumentation;
- (c) Display monitors;
- (d) Data acquisition systems;
- (e) Requirements for the calibration of instrumentation and its periodic control, including updating of the related documentation.

I.12. EXPERIMENTAL DEVICES

- (a) Suitability of materials for use in the ambient conditions, provisions for encapsulation of irradiation samples, ~~with~~ fissile materials, ~~etc.~~;
- (b) Explosive and other hazardous materials;
- ~~(b)~~ (c) Prohibited materials;
- ~~(c)~~ (d) Interlocking requirements for experiments.

I.13. ELECTRIC POWER SUPPLY SYSTEMS

- (a) 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, etc.);
- (b) Testing of emergency power supplies.

I.14. AUXILIARY SYSTEMS AND EQUIPMENT

- (a) Fire protection systems;
- (b) Communication systems;
- (c) Cranes (e.g. limitation of manipulation and loading);
- (d) Emergency lighting systems;
- (e) Compressed air systems;
- (f) Emergency equipment related to design extension conditions.

I.15. OTHER LIMITATIONS

- (a) Other design features;
- (b) Site features;
- (c) Administrative controls.

Appendix II

INDICATIVE LIST OF OPERATING PROCEDURES

II.1. For low power research reactors, critical assemblies and subcritical assemblies, all the procedures provided here should be considered unless it can be justified that, for a specific research reactor, critical or subcritical assembly, some of these procedures may not be applicable depending on the design and potential hazards associated with the facility.

II.1.2. COMMISSIONING PROCEDURES

- (a) Cleaning procedures for the cooling and ventilation systems;
- (b) Commissioning and acceptance tests for mechanical, electrical and instrumentation systems and components;
- (c) Tests prior to fuel loading;
- (d) Fuel handling;
- (e) Fuel loading, initial criticality tests and low power tests;
- (f) Control rod calibration;
- (g) Calibration of reactor safety channels and other neutron detection channels;
- (h) Determination of shutdown margin and core excess reactivity;
- (i) Power ascension tests and power tests;
- (j) Determination of thermal power level;
- (k) Reactor emergency procedures;
- (l) Radiation protection procedures;
- (m) Control of discharges to the environment and monitoring of radioactive material;
- ~~(n)~~ Procedures for identification and removal of foreign material;
- ~~(o)~~ Verification of biological shielding;
- ~~(p)~~ Handling of non-conformances.

II.2.3. OPERATIONAL-OPERATING PROCEDURES

- (a) Reactor startup, operation, power level changes and shutdown;
- (b) Determination of core reactivity to meet the OLCs (e.g. shutdown margin and excess reactivity, set point calculations, etc.);
- (c) Determination of thermal power level;
- (d) Routine loading, unloading, handling and movement of fuel elements, fuel assemblies and other core components and reflector components;
- (e) Special fuel handling (e.g. handling of failed fuel, preparation for and shipment of spent fuel);
- (f) Reactivity determination, loading, unloading, irradiation, handling and

- safety evaluation for experimental devices;
- (g) Performance of routine checks on reactor operation, the status of systems and the condition of the facility;
- (h) Operation of the mechanical and electrical support systems and equipment of the reactor;
- (i) Shift turnover entries and entries in the reactor logbooks;
- (j) Acceptance testing of new fuel elements;
- (k) Ion exchange replacement or regeneration;
- (l) Operation of hoisting devices.

H.3-II.4. MAINTENANCE PROCEDURES

- (a) Equipment replacement and repair;
- (b) Preventive maintenance of reactor equipment and reactor support system equipment;
- (c) Repair or replacement of reactivity control mechanisms;
- (d) Cleaning of the heat exchanger and tube plugging;
- (e) Replacement of seals;
- (f) Replacement of filters;
- (g) Routine maintenance on the overhead crane;
- (h) Routine maintenance on the auxiliary power supply;
- (i) In-service inspection;
- (j) Inventories of spare parts.

H.4-II.5. INSPECTION, CALIBRATION AND PERIODIC TESTING PROCEDURES

- (a) Inspection and dimensional checking of fuel and preparation of the fuel inventory;
- (b) Inspection and calibration of the reactivity control mechanism;
- (c) Release and drop time measurements for safety rods and control rods;
- (d) Calibration of reactor measuring channels and protection channels;
- (e) Calibration and testing of fixed and portable radiation monitors, airborne radiation monitors and personal monitors;
- (f) Calibration and testing of process systems (e.g. for temperature, flow, emergency power and ventilation);
- (g) Performance check for emergency core cooling systems;
- (h) Efficiency and flow rate measurements for the emergency ventilation system;
- (i) Flow rate measurements for the operational ventilation system;
- (j) In situ periodic testing of built-in filters in the ventilation system;
- (k) Measurements in the primary cooling system;
- (l) In-service inspection of the reactor vessel, pool liner and core

components;

- (m) Performance checks for the secondary cooling system;
- (n) Measurement of the leak tightness of the building Testing of the integrity of the reactor building containment / confinement envelope;
- (o) Testing of pneumatic tube systems;
- (p) Testing of the emergency power supply system;
- ~~(p)~~(q) Testing of emergency equipment;
- ~~(q)~~(r) Checking of the fire protection system.

II-5-II.6. RADIATION PROTECTION PROCEDURES

- (a) Radiation surveys and air sampling;
- (b) Control of the contamination of surfaces, personnel and equipment, including the use of decontamination facilities;
- (c) Administrative measures for controlling access to or residence time in radiation areas;
- (d) Control of occupational radiation exposure, such as procedures for monitoring external and internal exposures of the operating personnel, temporary personnel and visitors;
- (e) Issue, selection, use and maintenance of protective equipment;
- (f) Monitoring of radioactive material and the packaging and shipment of radioactive material;
- (g) Control of discharges to the environment and monitoring of radiative material;
- ~~(g)~~(h) Analysis of the reactor coolant;
- ~~(h)~~(i) Inventory, handling and leak testing of stored sealed radioactive sources;
- ~~(i)~~(j) Control and periodic review of operations to ensure that radiation exposures are as low as reasonably achievable.

II-6-II.7. PROCEDURES FOR THE AUTHORIZATION OF OPERATION, MAINTENANCE, IRRADIATION OR EXPERIMENTS

- (a) Authorization for operation;
- (b) Authorization for maintenance (work permit);
- (c) Authorization for modification;
- (d) Authorization for experiments;
- (e) Permit for irradiation;
- (f) Procedures for isotope production.

II-7-II.8. PROCEDURES FOR OPERATOR RESPONSE TO ANTICIPATED OPERATIONAL OCCURRENCES

- (a) Operator response to alarms, loss of electric power supplies, instrument

- failures, pipe leakage, etc.;
- (b) Operator response to failures of experiments, experimental systems or equipment;
 - (c) Response to abnormal radioactive releases;
 - (d) Response to spread of contamination.

H.8-II.9. EMERGENCY PROCEDURES

- (a) High airborne radiation levels or area radiation levels;
- (b) Fire, internal flooding;
- (c) Tornado, hurricane, typhoon, flood, precipitation or other weather related emergency;
- (d) Earthquake;
- (e) Injury of personnel, with and without radioactive contamination;
- (f) Credible reactor accident, including design basis accident (e.g. loss of primary coolant, abnormal release of radioactive material, rapid insertion of positive reactivity, significant fuel failure) and design extension conditions;
- (g) Aircraft crash, sabotage or attempted sabotage.

H.9-II.10. PHYSICAL PROTECTION PROCEDURES

- (a) Surveillance and alarm system tests for fuel storage areas;
- (b) Surveillance and alarm system tests for facility access points;
- (c) Required patrols and inspections during reactor operation and when the reactor is shut down;
- (d) Control of access to the facility (e.g. identification badges, door locks, closed circuit television monitoring systems, electronic card keys);
- (e) Preventing and/or coping with an unauthorized intruder;
- (f) Coping with an attack;
- (g) Coping with a civil disturbance.

H.10-II.11. PROCEDURES FOR THE HANDLING OF RADIOACTIVE WASTE AND CONTROL OF RADIOACTIVE RELEASES

- (a) Monitoring, handling, storage and disposal of solid radioactive waste;
- (b) Collection, monitoring, processing and disposal of liquid radioactive waste;
- (c) Control of monitoring for gaseous and particulate airborne radioactive releases.

H.11-II.12. PROCEDURES FOR EXTENDED SHUTDOWN

- (a) Disconnecting and dismantling of systems that have to be taken out of service;
- (b) Protecting systems or components against deterioration;
- (c) Preventing undesired use of systems or components that have been taken out of service (e.g. electric power supply, isolation valves).

~~II.12.~~ II.13. ~~DECOMMISSIONING PROCEDURES TO SUPPORT PLANNING REPAIRATION FOR DECOMMISSIONING~~

- (a) Procedures for updating the initial decommissioning plan and associated documentation
- ~~(a)~~ (b) Procedures for handling, dismantling and disposal of experimental devices;
- ~~(b)~~ (c) Dismantling and handling of activated and radioactively contaminated components, and handling of radioactive waste;
- ~~(c) Radiation protection during and after decommissioning.~~

~~II.13.~~ II.14. PROCEDURES FOR UTILIZATION AND FOR MODIFICATION OF THE REACTOR

- (a) Proposals for experiments or modifications;
- (b) Determination of the safety significance of an experiment or a modification, for purposes of review and approval;
- (c) Review and approval of a new or modified experiment or modification;
- (d) Conduct of an experiment, including commissioning and decommissioning;
- (e) Conduct of a modification, including commissioning of modified systems and updating of the facility documentation.

~~II.14.~~ II.15. ADMINISTRATIVE PROCEDURES

- (a) Control and accountability of nuclear material;
- (b) Reporting of the fuel inventory;
- (c) Shipment of spent fuel;
- (d) Testing and certification of packages used for the shipment of radioactive material;
- (e) Qualification, training and retraining of personnel;
- (f) Generation, collection and retention of records;
- (g) Isolation and tagging of equipment;
- (h) Instructions to personnel concerning possible health effects of radiation exposure, legal requirements, etc.;
- (i) Instructions for internal communications;
- (j) Requirement for on-call personnel;
- (k) Quality assurance;

~~(k)~~(l) Operating experience feedback;

~~(k)~~(m) Purchase of safety related components.

REFERENCES

- [1] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Research Reactors, IAEA Safety Standards Series No. ~~NS-R-4SSR-3~~, IAEA, Vienna (~~2005~~2016).
- [2] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Assessment of Research Reactors and Preparation of the Safety Analysis Report, IAEA Safety Standards Series No. ~~35-G+SSG-20~~, IAEA, Vienna (~~1994~~2012).
- [3] 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, IAEA, Vienna (2012).
- [4] INTERNATIONAL ATOMIC ENERGY AGENCY, Leadership and Management for Safety, IAEA Safety Standards Series No. GSR Part 2, IAEA, Vienna (2016).
- [54] 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).
- [6] INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for Nuclear Installations, IAEA Safety Standards Series No. GS-G-3.5, IAEA, Vienna (2009).
- [73] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety in the Utilization and Modification of Research Reactors, IAEA Safety Standards Series No. ~~35G2SSG-24~~, IAEA, Vienna (~~1994~~2012).
- [84] INTERNATIONAL ATOMIC ENERGY AGENCY, ~~Regulatory Inspection of Nuclear Facilities and Enforcement by the~~ Functions and Processes of the Regulatory Body, IAEA Safety Standards Series No. GS-G-~~1.3~~13, IAEA, Vienna (~~2002~~2018).
- [59] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Safety Glossary: Terminology Used in Nuclear Safety and Radiation Protection, ~~2007-2018~~ Edition, IAEA, Vienna (~~2007~~2019).
- [106] INTERNATIONAL ATOMIC ENERGY AGENCY, Maintenance, Periodic Testing and Inspection of Research Reactors, IAEA Safety Standards Series No. NS-G-4.2, IAEA, Vienna (2006).
- [11] INTERNATIONAL ATOMIC ENERGY AGENCY, Ageing Management for Research Reactors, IAEA Safety Standards Series No. SSG-10, IAEA, Vienna (2010).
- [12] INTERNATIONAL ATOMIC ENERGY AGENCY, Commissioning of Research Reactors, IAEA Safety Standards Series No. NS-G-4.1, IAEA, Vienna (2006).
- [713] 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, ~~GS-R-2~~, IAEA, Vienna (~~2002~~)(2015).
- [814] 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).

[915] INTERNATIONAL ATOMIC ENERGY AGENCY, Predisposal Management of Radioactive Waste, ~~Including Decommissioning~~, IAEA Safety Standards Series No. ~~WS-R-2GSR Part 5~~, IAEA, Vienna (2009).

[169] INTERNATIONAL ATOMIC ENERGY AGENCY, Predisposal Management of ~~Low and Intermediate Level~~ Radioactive Waste from Nuclear Power Plants and Research Reactors, IAEA Safety Standards Series No. ~~WS-G-2.SSG-40~~, IAEA, Vienna (~~2003~~2016).

~~[11] INTERNATIONAL ATOMIC ENERGY AGENCY, Predisposal Management of High Level Radioactive Waste, IAEA Safety Standards Series No. WS-G-2.6, IAEA, Vienna (2003).~~

[4217] INTERNATIONAL ATOMIC ENERGY AGENCY, Regulatory Control of Radioactive Discharges to the Environment, IAEA Safety Standards Series No. ~~WSGS-G-2.39~~, IAEA, Vienna (~~2000~~2018).

~~[13] INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-R-3, IAEA, Vienna (2006).~~

[18] INTERNATIONAL ATOMIC ENERGY AGENCY, The Operating Organization and the Recruitment, Training and Qualification of Personnel for Research Reactors, IAEA Safety Standards Series No. NS-G-4.5, IAEA, Vienna (2008).

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