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Safety in the Utilization and Modification of Research Reactors (Revision of SSG-24)

DS 510

DRAFT SPECIFIC SAFETY GUIDE

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. This publication supersedes the Safety Guide on Safety in the Utilization and Modification of Research Reactors that was issued in 2012 as Specific Safety Guide No. SSG-24[1]. ~~This Safety Guide was developed under the IAEA programme for safety standards, which covers all of the important areas of research reactor safety.~~ The IAEA Safety Standards Series No. SF-1, Fundamental Safety Principles ~~publication~~ [1], establishes principles for ensuring the protection of workers, the public and the environment from harmful effects of ionizing radiation. This Safety Guide directly addresses four of these principles, i.e. responsibility for safety, optimization of protection, limitation of radiation risks to individuals and the environment and prevention of accidents[2]. In addition, this Safety Guide provides recommendations on meeting the safety requirements on utilization and modification that are established in the IAEA Safety ~~Requirements~~ Standards Series No. SSR-3, ~~publication on the~~ Safety of Research Reactors [2], for ensuring adequate safety at all stages of the lifetime of a research reactor~~. In particular, recommendations are provided on which analyses, verifications and evaluations should be performed to fulfil the safety requirements for the operating organization that are established in paras 2.15, 2.18–2.20, 3.6–3.12 and 4.14 of Ref. [2]~~.

1.2. ~~This publication supersedes Safety Series No. 35-G2~~. The main changes and adaptations in this Safety Guide relate to consistency with SSR-3 ~~Ref.~~ [2], and the other recently published ~~Safety Guides for research reactors and other relevant~~ safety standards and incorporation of recent experiences from

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[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety in the Utilization and Modification of Research Reactors, IAEA Safety Standards Series No. ~~35-G2~~SSG-24, IAEA, Vienna (~~1994~~2012).

[2] These are principles 1, 5, 6 and 8 (see ~~Ref.~~SF-1 [1]):

— "Principle 1: Responsibility for safety: The prime responsibility for safety must rest with the person or organization responsible for facilities and activities that give rise to radiation risks."

— "Principle 5: Optimization of protection: Protection must be optimized to provide the highest level of safety that can reasonably be achieved."

— "Principle 6: Limitation of risks to individuals: Measures for controlling radiation risks must ensure that no individual bears an unacceptable risk of harm."

— "Principle 8: Prevention of accidents: All practical efforts must be made to prevent and mitigate nuclear or radiation accidents."

IAEA Member States in the areas of utilization and modification of research reactors. The feedback from the application of Safety Series No. 35-G2 is also incorporated into the present publication.

1.3. Owing to the particular characteristics of research reactors, safety aspects relating to design and operation have been given special emphasis and have been incorporated into SSR-3Ref. [2]. These characteristics include the large variety of designs; the wide range of reactor power levels; the different modes of operation and different purposes of utilization; the particularities of siting and the major differences in types of research reactors; and arrangements of operating organizations. These characteristics require a graded approach[3] in the application of the requirements (paras 1.112.15–1.142.17 of SSR-3Ref. [2]), i.e. flexibility in the implementation of objectives and the fulfilment of basic requirements when dealing with certain specific topics, such as utilization and modification of research reactors. Further guidance on the graded approach is provided in IAEA Safety Standards Series No. SSG-22, Use of Graded Approach in the Application of the Safety Requirements for Research Reactors [3].

1.4. 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. Most important are the performance of the safety analysis by the operating organization, and the review and assessment of the safety analysis report by the regulatory body, as well as the preparation, submission and evaluation of other important safety related documents during the initial licensing process, periodic licensing renewals or other occasions, such as a periodic safety review or major modification(s) of the research reactor. The recommendations on safety analysis and related documentation, provided in IAEA Safety Standards Series No. SSG-20, Safety Assessment for Research Reactors and Preparation of the Safety Analysis Report Ref. [4], and on the review and assessment of nuclear facilities by the regulatory body, provided in IAEA Safety Standards Series No. GSG-13, Functions and Processes of the Regulatory Body for Safety Ref. [5], have been taken into account in the preparation of the present Safety Guide. In addition, this Safety Guide discusses other aspects of experiments and modifications, such as commissioning of research reactors and provisions for radiation protection, for which detailed recommendations are provided in IAEA Safety Standards Series No. NS-G-4.1, Commissioning of Research Reactors [6], and IAEA Safety Standards Series No. NS-G-4.6, Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors Refs [6, 7]. The

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[3] Further guidance on the graded approach is provided in Ref. [3].

IAEA Safety Glossary [8] defines and explains the safety related ~~words and~~ terms used in the present publication.

OBJECTIVE

1.5. The objective of this Safety Guide is to provide recommendations on meeting the requirements on the safety related aspects of the utilization and modification of research reactors, such that these projects can be implemented without undue radiation risks to the site personnel, the public or the environment. The present Safety Guide develops the general concepts in these areas, which are presented in ~~paras 7.85–7.92~~Requirement 83 of SSR-3~~Ref.~~ [2] relating to utilization and modification. Therefore, this Safety Guide should be read in conjunction with SSR-3 ~~Ref.~~ [2].

1.6. This Safety Guide provides recommendations to the operating organization, including external users of the research reactor (i.e. experimenters), technical support organizations and other persons involved in utilization and modification projects. It provides recommendations only on the safety implications of the utilization and modification of research reactors. The reason for presenting the areas of utilization and modification together in a single volume is to avoid duplication, since most experiment and modification projects have similar treatments in common areas, such as categorization, safety review and assessment, project implementation and commissioning.

SCOPE

1.7. The recommendations provided in this Safety Guide apply to the utilization of research reactors and to all modifications of research reactors. For some specific research reactors with power level in excess of several tens of megawatts, fast reactors and reactors using~~,~~ highly complex experimental devices such as high pressure and temperature loops and cold or hot neutron sources, additional guidance may be necessary that is provided in IAEA Safety Guides for power reactors. The amount of detail required for specific research reactors, critical assemblies and subcritical assemblies should be justified and documented using graded approach. Nevertheless, when using a graded approach, all recommendations included in this Safety Guide should be addressed. Hereafter, subcritical assemblies will be mentioned separately only if a specific recommendation is not relevant for, or is applicable only to, some of subcritical assemblies. This Safety Guide does not cover experiments in prototype power reactors or experiments performed in operating or decommissioned nuclear power plants.

1.8. In the context of this Safety Guide, utilization is the use of the research reactor or of an experiment or an experimental device during reactor operation. The experiment or experimental device may be situated in the reactor core, the reactor reflector, the shielding or the experimental facilities[4] connected to the reactor, but may also be located outside the biological shielding or outside the reactor building.

1.9. In the context of this Safety Guide, a modification is a deliberate change[5] in, or an addition to, an existing reactor, a structure, system or component, or item of software important to safety, an experiment or an experimental device. A modification may also involve a change in safety systems, safety related items, safety documentation including operational limits and conditions, operating procedures, documentation, or and operating conditions for the research reactor as well as for experiments Organizational changes are considered modifications because these changes can affect safety.

1.10. The requirements for the utilization or modification (i.e. the experiment or modification project) established in Ref.SSR-3 [2] depend on the type of reactor and the safety significance of the task. However, in all cases, the preparation and implementation of a project for utilization or modification should follow the logical sequence outlined in this Safety Guide. In small projects, the individual stages may be very simple but none of the stages should be omitted.

1.11. Modifications to structures, systems and components with security aspects should follow the logical sequence outlined in this Safety Guide but will also be subject to confidentiality requirements and security review., which are notManageing the interface between nuclear safety and security in modification projects is discussed in this Safety Guide.

1.12. In the case of modifications that concern only changes to documentation, the recommendations presented in Section 6 of this Safety Guide are not fully applicable. For such modifications, the additional guidance provided in Ref.SSG-20 [4] should be considered and followed, as applicable.

1.13. The Fundamental Safety Principles Reference SF-1[1] states that “Safety measures and security measures have in common the aim of protecting human life and health and the environment.” This Safety Guide addresses nuclear

[4] An experimental facility includes any device installed in or around a reactor to utilize the neutron flux and ionizing radiation from the reactor for research, development, isotop production or any other purpose.

[5] Experiments and experimental facilities that have been approved in the past or that have been analyzed as part of the safety analysis report are not considered to be modifications in the context of the present Safety Guide.

security considerations only briefly in paras 3.35–3.37–41and indicates the actions that need to be taken to incorporate security elements progressively into an effective nuclear security regime for a nuclear power programme. Safety measures and security measures are designed and applied in an integrated manner, and as far as possible in a complementary manner, so that security measures do not compromise safety and safety measures do not compromise security. In dealing with interfaces between nuclear safety and nuclear security, it is borne in mind that nuclear safety and nuclear security are likewise important, and measures to be taken are mutually acceptable in both areas. Nuclear security matters are covered in IAEA Nuclear Security Series publications. The scope of this Safety Guide includes consideration of the interface between nuclear safety and nuclear security (see Ref.INSAG-24 [9] for further information on this issue).

STRUCTURE

1.14. This Safety Guide consists of ten eleven sections and three five annexes. In most of these sections, the safety aspects of both the utilization and modification of research reactors are described together. Section 2 provides recommendations on the management system for the utilization, and modifications including organizational changes, of a research reactor. Categorization of the experiment or modification provides a basis for selecting the review and approval route; recommendations on these topics are provided in Section 3. Recommendations on the design of experiments or modifications are provided in Section 4, which should be read in conjunction with the relevant requirements of Ref.SSR-3 [2]. Sections 5, 6 and 7 provide recommendations on the activities that should be considered in the various stages of a typical utilization or modification project. Section 8 covers additional recommendations for operational safety of experiments, and Section 9 provides recommendations on the handling, dismantling, post-irradiation examination and disposal of experimental devices. Section 10 provides recommendations on the safety of out- of-reactor-core experimental devices and modifications. Section 11 deals with safety related aspects of organizational changes. Annexes I and II outline and provide information on example of a checklist for categorization of an experiment or modification, and the content of the safety analysis report for an experiment at a research reactor. Annexes-III and IV provide examples of modifications that can result in interface issue, and safety focused questions and security focused questions. Annex V provides examples of reasons for a modification at a research reactor.

2. MANAGEMENT SYSTEM FOR THE UTILIZATION AND MODIFICATION OF A RESEARCH REACTOR

GENERAL

2.1. The IAEA Safety Standards Series No. GSR Part 2 Leadership and Management for Safety, [10], requires that the operating organization of a research reactor establishes and implements aA documented management system that integrates safety, health, environmental, security, quality, human and organizational factor, societal and economic elements, so that safety is not compromisedobjectives of the operating organization of a research reactor is required to be in place [10]. The documentation of the management system should describe the system that controls the planning and implementation of all activities at the research reactor throughout its lifetime, including utilization and modification projects. 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; resource management; 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.
— 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.
— 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 improvement are identified.

The requirements for the integrated management system are established in Requirement 4 paras 4.5–4.13 of Ref.SSR-3 [2], and in Ref.GSR Part 2 [10], and further recommendations are provided in IAEA Safety Standards Series No. GS-

G-3.1, Application of the Management System for Facilities and Activities [11] and IAEA Safety Standards Series No. GS-G-3.5, The Management System for Nuclear Installations,Refs [11, 12].

2.2. Processes for modifications and utilization and modifications should be established as part of the integrated management system. These processes should include the design, review, assessment and approval, fabrication, testing and implementation of a utilization and modification project. Relevant procedures describing the processes should be put into effect by the operating organization early in the utilization or modification project. The management system should cover all structures, systems and components, and processes important to safety, and should include a means of establishing controls over utilization and modification activities, thereby providing confidence that they are performed safely in accordance with established requirements. The management system should also include provisions to ensure that modification or utilization and modification activities are planned, performed and controlled in a manner that ensures effective communication and clear assignment of responsibilities. In establishing the management system, a graded approach based on the relative importance to safety of each item or process may be applied.

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 analysis report;
— Operational limits and conditions;
— The administrative requirements established by the management of the research reactor.

2.4. The management system should support the development, implementation and enhancement of a strong safety culture in all aspects of modification projects and the utilization programme.

MANAGEMENT RESPONSIBILITY

2.5. It is the responsibility of management to ensure that the procedures for utilization and modification describe how these activities are to be assessed, managed, authorized and performed in order to ensure that the objectives of the experiment or modification are met, and safe operation of the research reactor and its safe utilization are ensured. The documentation of the management system for utilization and modification should include descriptions of the organizational structure, functional responsibilities, levels of authority and interfaces for those assessing, managing, authorizing, performing, controlling or supervising these activities. 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 specifications and procedures for utilization and modification of the research reactor. The reactor manager[6] should be an active participant in the implementation and evaluation of utilization and modification activities. The detailed responsibilities of the reactor manager are set out in paras 2.23 and 2.24 of this Safety Guide, and the detailed responsibilities of the project manager in paras 2.18–2.22.

RESOURCE MANAGEMENT

2.7. The operating organization should provide adequate resources to execute the ~~modification or~~ utilization or modification by:

— Determining the required ~~staff~~ competences and providing periodic training, where appropriate, to ensure that the personnel of the operating organization are competent to perform their assigned work;
— Supervising external personnel (including suppliers) 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 the modification project or utilization 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. Reactor supervisors 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

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

to include suppliers. The operating organization should ensure that the suppliers, manufacturers and designers have an effective management system in place. The operating organization should ensure, through audits, that the assigned activities are carried out in compliance with the management system.

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.

IMPLEMENTATION FOR A UTILIZATION OR MODIFICATION PROJECT

~~2.7.~~2.11. Activities relating to the utilization or modification of a research reactor should be performed and recorded in accordance with approved procedures and instructions.

~~2.8.~~2.12. For successful implementation of a utilization or modification project, consideration should be given to the following aspects:

- — Planning and prioritization of work;
- — Addressing all relevant regulatory requirements and demonstrating that the overall level of safety will not be reduced;
- — Addressing the requirements derived from the operational limits and conditions;
- — Evaluation of the feedback of operational experience from similar utilization or modification projects;
- — Addressing the maintenance requirements for the experiment or the modified system or component;
- — Ensuring the availability of qualified personnel with suitable skills;
- — Establishing appropriate operating procedures, including those for assessing and correcting non-conforming items;
- — Performing and documenting the required inspections and tests, including those required for commissioning an experiment or modification;
- — Performing and documenting the required training and instruction.

~~2.9.~~2.13. The management system should include measures to control records essential to the performance and verification of utilization and modification activities, including justification and safety assessment, through a system for their identification, approval, review, filing, retrieval and disposal.

~~2.10.~~2.14. Documents such as the procedures, specifications and drawings for the utilization and modification project, including the operating procedures, should be controlled. In particular, measures should be established for their preparation, identification, review, updating, validation as required, as well as their approval, issue, distribution, revision and archiving.

~~RESOURCE MANAGEMENT~~

~~2.11.1.1. The operating organization should provide adequate resources to execute the modification or utilization by:~~

- ~~Determining the required staff 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 suppliers) who perform safety related activities and ensuring that these personnel are adequately trained and qualified.~~

~~2.12.1.1. Personnel who are not directly working for the research reactor and personnel of contracting organizations who are involved in the modification project or utilization 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. Reactor supervisors 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.~~

~~2.13.1.1. 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. The operating organization should ensure, through audits, that the assigned activities are carried out in compliance with the management system.~~

~~2.14.1.1. 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.~~

MEASUREMENT, ASSESSMENT AND IMPROVEMENT

2.15. Measures should be established for assessment, review and verification to determine whether and to ensure that utilization or modification activities are accomplished as specified in the design. Such measures should include:

- Review of the design and the design procedures;
- Verification of the implementation of activities by inspection and

witnessing;
- Review and verification of records, results and reports relating to the design, the implementation of projects and the operation of the reactor, including those on the status of non-conformances and corrective actions;
- Audits of the relevant processes, procedures and documentation;
- Follow-up of the adequacy and timeliness of corrective actions.

2.16. Effective implementation of the management system for the utilization and modification of a research reactor should be assessed by qualified personnel who are not directly involved in performing these activities.

2.17. 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 experiments should be subjected to periodic review by the reactor safety committee.

RESPONSIBILITIES OF THE PROJECT MANAGER

2.18. The operating organization should assign a person, normally a dedicated project manager with understanding of research reactor facility and applicable regulatory framework, to be responsible for the implementation of the project objectives. These responsibilities should include development of a project definition, determination of measures to ensure adherence to established safety criteria, evaluation of the options and management of detailed design, project implementation, commissioning and decommissioning, if relevant.

2.19. The project manager should be responsible for determining the impact of the project on the existing safety analysis report and on the operational limits and conditions. This involves making proposals for the categorization of the modification or experiment and providing the safety documentation in order to enable the operating organization to submit the project for review and approval, as necessary, by the safety committee(s) or the regulatory body. The advice of external specialists and consultants may be sought to support the project manager in performing ~~these~~ his duties.

2.20. The project manager should ensure that any contractor or supplier involved in the preparation or implementation of a ~~modification or~~ utilization or modification project is made aware of and complies with the appropriate requirements and regulations.

2.21. The project manager should be responsible for ensuring that adequate precautions are in place to provide protection against radiological and other hazards that may arise during or as a result of the project.

2.22. Possible interactions between different utilization or modification projects that are being implemented or proposed should be considered and analyzed.

RESPONSIBILITIES OF THE REACTOR MANAGER

2.23. The reactor manager has direct responsibility for the safety aspects of reactor operation. In this respect, he or she should ensure that any proposal for utilization or modification of the reactor has been demonstrated to be safe, and additional review, and approval, if required, has been carried out by an appropriate body[7] before implementation of the project commences.

2.24. The reactor manager should be responsible for ensuring that the scheduling of the implementation of the utilization or modification project does not affect safety.

[7] The appropriate body could be an expert in the relevant field of specialization, the safety committee(s) or the regulatory body.

3. CATEGORIZATION, SAFETY ASSESSMENT AND APPROVAL OF AN EXPERIMENT OR MODIFICATION

3.1. All utilization and modification projects including organizational changes should be subjected to a screening process in order to determine their implications for safety and the related safety category of the experiment or modification. The screening process should be documented and the selection of the safety category should be justified. Experiments of a repetitive[8] nature that have been assessed and approved earlier, and for which no changes in the safety analysis report, operational limits and conditions or operating procedures are required, could be considered as modifications with a minor effect on safety (see para. 3.9).

3.2. The categorization of the experiment or modification should provide the basis for determining the detail and the extent of the safety analysis and the review to be performed. The categorization should also provide the basis for the review and approval route to be followed for the modification or utilization or modification project. A checklist could facilitate the categorization process. An example of such a checklist is provided in Annex I.

3.3. For modification projects, the safety class of the relevant structures, systems and components (as required in accordance with paras 6.12 and 6.13Requirement 16 of Ref.SSR-3 [2]) should be used as a first step in the safety categorization in order to determine the safety impact of the modification. This is described in paras 3.7–3.34 on the categorization process.

3.3.3.4. For utilization of a research reactorprojects, the relevant experimental devices should be classified in accordance with the structures, systems and components (SSCs) classification system. a safety classification system should be developed, based on the possible safety implications of the utilization. This classification should also be used as a first step in the safety categorization of the utilization project, in order to determine the safety impact of the utilization. In developing a safety classification categorization system

[8] A repetitive experiment is an experiment that had been approved earlier and has only minor changes compared with the original design that would not affect the safety analyses originally performed. Isotope production using a target material with the same physical and chemical behaviour and using the same irradiation facility within the approved maximum neutron flux would also be regarded as a repetitive experiment.

for utilization of a research reactorproject the potential impact on main safety functions and the potential for challenging safety functions should be considered. In addition, at as a minimum, the following aspects should be taken into account:

— Criticality aspects;
— Reactivity aspects;
— In-core and out-of-core irradiation;
— Experiments within or outside the biological shielding or containment;
— Physical conditions and behaviour of components;
— Chemical conditions and behaviour of components;
— Heat generation and thermal characteristics;
— Mechanical and thermal stresses and behaviour of components;
— The potential for a significant dose to site personnel;
— The potential for a (significant) off-site dose to members of the public.

3.4.3.5. The review and approval route for a utilization project should be based on the safety category determined for the experiment, for which the nature of the experiment, i.e. a new experiment, a repetitive experiment or isotope production, should be taken into account (see also paras 3.29 and 3.30 for recommendations relating to repetitive experiments).

3.5.3.6. The proposal for the classification and categorization process for modification and utilization projects, including the proposed review and approval routes, should be submitted to the safety committee(s) for review approval and, following approval by the reactor manager, the proposal should be submitted to the regulatory body for review and approval, in accordance with the regulatory requirements.

CATEGORIZATION PROCESS

3.6.3.7. A more detailed and comprehensive safety assessment should be carried out for those experiments or modifications with a safety class having a potential impact on safety. The result of the detailed safety analysis should indicate the extent of the implications for safety (see paras 3.11–3.32). The results of the safety analysis for each experiment could should be incorporated in the safety analysis report of the research reactor or might be described in a separate document (i.e. safety analysis report for the experiment). An example of the content of the safety analysis report for an experiment is presented in Annex II.

3.7.3.8. Modifications and new experiments should be subjected to the categorization process described in this Safety Guide.

~~3.8.~~3.9. For repetitive experiments, it should be proven that they can utilize earlier approved safety analyses that were performed according to the requirements of the management system.

~~3.9.~~3.10. In determining the potential effect on safety, the consequences of each experiment or modification for the reactor itself and the interactions with other systems should also be taken into account.

~~3.10.~~3.11. The safety significance or effect on safety of each modification or experiment, as defined in the following, as well as the potential for design errors or incorrect implementation of a project, should be taken into account in determining the safety category of the utilization or modification project, the safety analyses to be performed and the documentation to be prepared:

— Major effect on safety: modifications or experiments that:
  - Could affect the design function or the ability of structures, systems and components to perform their intended safety function as described in the safety analysis;
  - Are beyond the licence conditions or beyond the existing (i.e. approved) safety analysis[9];
  - Could introduce hazards that have not been previously addressed.

— Significant effect on safety: modifications or experiments that are within the approved licence conditions and safety analysis, but which require adaptation of the operational limits and conditions~~[10]~~, and not of the remaining chapters of the safety analysis report, or could significantly reduce the margin to criticality or which need an adaptation of the safety related operating procedures. Recommendations on operational limits and conditions for research reactors are provided in IAEA Safety Standards Series No. NS-G-4.4, Operational Limits and Conditions and Operating Procedures for Research Reactors [13].

— Minor effect on safety: modifications or experiments that are within the approved licence conditions, safety analysis and operational limits and conditions, still having significant margins and no effect on the safety system settings and which do not require a change in the safety related operating procedures.

[9] A modification beyond the licence conditions or beyond the approved safety analysis is implicitly also beyond the operational limits and conditions.

~~[10] Recommendations on operational limits and conditions for research reactors are provided in Ref. [13].~~

— No effect on safety: modifications or experiments that present no hazard and have no impact on safety.

3.11.3.12. The classification and categorization process for modifications and experiments having an effect on safety significance should be documented in detail, together with the justification for the proposed safety category.

Modifications or experiments with a major effect on safety

3.12.3.13. Modifications or experiments with a major effect on safety should be subjected to safety analysis and to the same design, construction and commissioning procedures as applied for the research reactor, in order to ensure that they meet the same requirements as the existing structures, systems and components or existing experimental facilities.

3.13.3.14. An assessment of radiation exposure of the staff of site personnel expected during or as a result of the project should be prepared. Measures to reduce exposures based on the principle of optimization of protection and safety[11] should be determined for all reactor states (i.e. normal operation, anticipated operational occurrences and accident conditions), and any potentially necessary mitigation measures should be identified. Recommendations on applying the principle of optimization of protection and safety are provided in NS-G-4.6 [7].

3.14.3.15. The safety documentation for the project should cover the responsibilities and duties of the operating personnel, the experimenters and others involved in the project.

3.15.3.16. A list of all new or modified items important to safety and their classification should be included in the safety documentation. Information required for accident analysis and for determining mitigation measures under accident conditions should also be defined.

3.16.3.17. The safety documentation for the project should be reviewed by the reactor manager with respect to safety, operability and compatibility with other experiments in the research reactor and with reactor systems.

[11] Recommendations on applying the principle of optimization of protection and safety are provided in Ref. [7]

~~3.17.~~3.18. Modifications and experiments having a major effect on safety should be reviewed by the safety committee(s). After the review by the safety committee it should be ~~and~~ submitted to the regulatory body for review and ~~approval~~ licensing in accordance with the same procedures as those applied for the research reactor itself.

~~3.18.~~3.19. If the modification or experiment will affect the operating licence or the licence documentation, an appropriate re-licensing or licence amendment process should be applied.

~~3.19.~~3.20. The operating procedures, including emergency procedures, should be reviewed to ascertain whether they need to be revised as a result of the modification or experiment, and should be revised, reviewed and made subject to approval as appropriate.

Modifications or experiments with a significant effect on safety

~~3.20.~~3.21. The safety documentation for such projects, which may include complex experiments, experimental facilities and modifications, should include a comprehensive and detailed description of the experiment or modification and its design and construction.

~~3.21.~~3.22. The safety analysis should cover all operational states, as well as accident conditions. The analysis should demonstrate that the licence conditions and the original safety limits would not be affected and that the radiological consequences of the experiment or modification are within the accepted limits.

~~3.22.~~3.23. An assessment of radiation exposure of the ~~staff~~ site personnel expected during or as a result of the project should be prepared. Measures to reduce radiation exposures based on the principle of optimization of protection and safety[12] should be described for all reactor states, and any potentially necessary mitigation measures should be identified.

~~3.23.~~3.24. The safety documentation for the project should cover the responsibilities and duties of the operating personnel, experimenters and others involved in the project.

~~[12] Recommendations on applying the principle of optimization of protectionare provided in Ref. [7].~~

~~3.24.~~3.25. A list of all new or modified items important to safety and their classification should be included in the safety documentation. Information required for accident analysis and for determining mitigation measures under accident conditions should also be defined.

~~3.25.~~3.26. The safety documentation for the project should be reviewed and approved by the reactor manager with respect to safety, operability and compatibility with other experiments in the reactor and with reactor systems.

~~3.26.~~3.27. Modifications and experiments having a significant effect on safety should be reviewed by the safety committee(s) ~~and~~ before ~~submitted~~ submission to the regulatory body for review and approval in accordance with the regulatory requirements.

~~3.27.~~3.28. The operating procedures, including emergency procedures, should be reviewed as to whether they need to be revised as a result of the ~~modification or~~ utilization or modification, and should be revised, reviewed and approved as appropriate.

Modifications or experiments with minor safety significance

~~3.28.~~3.29. Many experiments and modifications are considered to have minor safety significance. Such modifications include small modifications to structures, systems or components. Research reactors are, by their nature, often used for repetitive sample irradiations or for repetitive experiments with minor modifications. Criteria should be defined for repetitive experiments, isotope production or modifications having only minor changes from the original design, for which approval by the reactor manager would be sufficient without the need for re-submission to the safety committee(s) or to the regulatory body. The recommendations provided in Sections 5, 6 and 7 should be applied using a graded approach.

~~3.29.~~3.30. Clear criteria should be defined according to which irradiation may be regarded as a repetitive experiment. The type and quantity of the samples for isotope production or activation analyses should be defined, and the irradiation facility and the irradiation position (maximum allowable neutron flux) should be specified. The information and documentation to be prepared in support of a request to conduct an irradiation experiment, as well as the review and approval route, should also be specified. This proposed method of application to conduct an experiment or implement a modification with minor safety significance should be submitted to the safety committee(s) for review.

3.30.3.31. Records of experiments and modifications with minor safety significance approved by the reactor manager should be periodically reviewed by the safety committee(s) in order to ensure that there are no disagreements in the interpretation of the criteria for approval and that there has been no change in the original categorization due to, for example, ageing.

Modifications or experiments with no effect on safety

3.31.3.32. Careful consideration should be given to any proposed change before categorizing it as a modification or experiment with no effect on safety. Such consideration should be based on a description of the modification or experiment, together with an assessment of its implications, and these should be submitted to the reactor manager for approval.

3.32.3.33. Records of all such approvals should be retained, together with the related documentation.

3.33.3.34. The safety committee(s) should periodically review the records of modifications and experiments with no effect on safety, in order to ensure that there are no disagreements in the interpretation of the criteria for approval.

SECURITY AND PHYSICAL PROTECTION ASPECTSINTERFACE BETWEEN NUCLEAR SAFETY AND NUCLEAR SECURITY

3.34.3.35. The operating organization should ensure that the interface between nuclear safety and nuclear security is duly taken into account and is managed within the context of a modification. As part of the integrated management system described in section 2 of this safety guide, all modifications or experiments should be designed and carried out with due care to nuclear security matters. Annex III provides examples of such modification projects. Modifications of systems for protection of the site and installation against sabotage and unauthorized removal of fissile material and radioactive material should be carried out in accordance with the requirements of the relevant national security authorities and the guidance provided in publications in the IAEA Nuclear Security Series (see Refs [14–21]).

3.35.3.36. Modifications of systems for protection of the site and installation against sabotage and unauthorized removal of fissile material and radioactive material should be carried out in accordance with the requirements of the relevant national security authorities and the guidance provided in publications in the IAEA Nuclear Security Series (see Refs [14–21]).

Guidance on the security aspects of modifications to instrumentation and control systems and software important to safety for research reactors is provided in Ref. [14].

3.37. Modifications carried out on ~~physical protection systems (or other security sensitive~~ any equipment, including safety structures, systems and components, and nuclear security measures~~)~~ should be screened and assessed for potential impacts on safety and security, and the results may need to be described in a separate document and ~~may need to~~ be kept confidential.

3.38. It should be acknowledged that some nuclear security measures may be needed to allow access for external workers and personnel. These accesses may need prior trustworthiness checks and other measures that can need significant time to perform. The importance of these measures should not be underestimated as they aim to face insider threat, which is a major concern, in particular in nuclear research. Further guidance is provided in IAEA Nuclear Security Series No. NSS-8, Preventive and Protective Measures against Insider Threat [17].

3.39. The reactor manager should ensure that the security organization is involved in the modification project. The reactor manager should also ensure effective communication and coordination to ensure that safety measures and security measures do not compromise one another and that potential issues related to interface between nuclear safety and nuclear security have been addressed. This should be done for all phases in the implementation of an experiment or modification.

3.40. To assess potential adverse impact on facility safety and security, the proposed modification or experiment should be reviewed. When reviewing the modification, consideration should also be given to the possibilities to enhance safety and security by design. The modification should be reviewed in conjunction with the elements such as:

— The physical layout of the facility;
— The layout of security layers in the facility surrounding security targets, including access controlled points;
— The configuration and purpose of structures, systems, and components important to safety and systems and equipment important to security at the facility;
— Integrated management system requirements and quality procedures;
— Facility operating procedures;
— Security plan and procedures;
— The operating programme of the facility;

— The safety analyses and the operational limits and conditions;
— Facility licence conditions and licensing process;
— Emergency and contingency plans and preparedness;
— Programmes for radiation protection and waste management;
— Engineering;
— Maintenance;
— Work management (control and planning);
— Training and qualification of personnel;
— Fire protection;
— Environmental protection;
— Conventional health and safety (including chemical safety).

3.41. Examples of safety focused questions on proposed modifications to the physical protection system, and of security focused questions on proposed modifications important to safety are provided in Annex IV.

4. SAFETY CONSIDERATIONS FOR THE DESIGN OF AN EXPERIMENT OR MODIFICATION

GENERAL CONSIDERATIONS

4.1. The design of an experiment or modification should demonstrate that:

— It can fulfill the task for which it is intended.
— It can be installed and operated without compromising the safety of the research reactor.
— The experiment can be removed or decommissioned without compromising the safety of the research reactor.
— In all operational states, the radiation exposure of site personnel and members of the public will remain within the dose limits and, moreover, in accordance with the principle of optimization of protection.
— Any equipment can be stored or disposed of safely during its operational lifetime and after decommissioning.
— The amount of radioactive waste is limited, to the extent possible, by means of, for example, appropriate selection of materials.

4.2. The design of an experiment or modification should be such as to minimize additional demands on the reactor shutdown system. In the case of experiments, consideration should be given to providing the means for placing the experiment in a safe condition without the need for activation of the reactor shutdown system.

4.3. In addition to the reactor operations, such as startup, steady state, pulsed operation and shutdown, other reactor conditions should be considered for their effects on the experiment or modification. These conditions include unscheduled shutdown followed by immediate restart, maintenance, extended shutdown, refuelling, low power operation, changes in core configuration, and failure of electrical power and other services. The operational states and accidents conditions considered in the design of the research reactor should also be considered for their effects on the experiment or modification. Similarly, the effects of all states of the experiment or modification on the reactor should be considered.

4.4. The design requirements for a utilization or modification project should be defined early in the project and should be selected on the basis of the safety significance of the project.

4.4.4.5. Modifications aiming to continuously improve nuclear safety such as modifications to design features or equipment used for design extension conditions, including non-permanent equipment should be performed in accordance with the approved facility modification processes, procedures and required safety assessment.

4.5.4.6. The operating organization's safety policy towards modifications should be based on the principle of continuous improvement. For each modification adverse effects challenging: the protection of the barriers to radioactive release; the independence between the levels of the defence in depth and an adequate reliability of each level during operation, as a consequence of all modifications and related operational activities should be avoided. The influence of human and organizational factors, on one, several or all barriers and levels of defence in depth, should be considered in all activities, including design related to utilization and modifications. The operating organization's safety policy towards modifications should be reviewed regularly in order to allow for a continuous improvement.

4.6.4.7. The interfaces between safety and security should be considered to be part of the design process. These interfaces should be considered in such a way that the impacts of safety measures on security and the impacts of security measures on safety are taken into account from the design stage and an appropriate balance is achieved.

SPECIFIC CONSIDERATIONS

Reactivity

~~4.7.~~4.8. If the experimental device or modified system, or its failure, could lead to an increase in the reactivity of the reactor core, the experiment or modification should be designed so as to limit the positive reactivity effects to those that can safely be accommodated by the reactor control and shutdown systems.

~~4.8.~~4.9. If modification of the reactor control and shutdown systems is necessary to accommodate an increase in the reactivity of the reactor core, then this modification should be treated as a separate modification with a major effect on safety and should be implemented before the originally proposed modification or experiment is implemented.

4.10. The reactivity worth of an experiment or reactor modification should be determined for all situations (e.g. insertion of the experiment into the reactor core, removal of the experiment and potential failure modes). A calculated, or otherwise determined, reactivity worth should usually be checked by measurement, by carrying out a critical experiment or by an equivalent method. ~~The design basis accidents for the reactor should also be considered in the evaluation.~~

~~4.9.~~4.11. For subcritical assemblies, any potential for criticality because of the reactivity worth of an experiment should be covered as a design extension condition and it should be assessed to identify whether the existing safety provisions remain effective or additional safety features to prevent or mitigate the consequences of such event need to be implemented.

Radiation protection~~[13]~~

~~4.10.~~4.12. An experiment or modification should not significantly affect the radiation protection programme for the research reactor. The original design of the research reactor facility, including experimental devices, will typically have been based on a combination of shielding, ventilation filtration and decay to reduce radioactive releases, with associated monitoring instrumentation for radiation and airborne radioactive substances, for all operational states and for accident conditions. If the experiment or modification would otherwise affect the radiation protection measures, then additional measures should be taken to reduce the dose to site personnel and the public during the installation of the project, the operation, handling and dismantling of an experiment, or the implementation of a

~~[13] The safety requirements for radiation protection are established in Ref. [22].~~

modification project to levels as low as reasonably achievable (in accordance with the principle of optimization of protection). Such measures may include the removal of sources that generate high radiation fields, the provision of additional shielding, and/or the provision of remote handling devices and/or measures for controlling or mitigating the consequences of accident conditions. The safety requirements for radiation protection are established in IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources [22].

4.11.4.13. If the failure of the experimental device or modified system could lead to degradation of either the original system or the additional system of barriers to the release of radioactive substances, the effects of such an accident should be considered in the design of the experiment or modification.

4.12.4.14. The potential for an uncontrolled release of radioactive substances should be limited and the amounts of such material released should be minimized by measures such as the use of delay tanks, inert purge gas, filters or recirculation. This applies for all stages of the project, (including the installation, construction, commissioning, operation and decommissioning)stage, ; for all operational states (i.e. normal operation and anticipated operational occurrences) ; for accident conditions; and for removal, storage and shipment of experimental devices or modified systems.

Safety devices

4.13.4.15. Whenever possible, experiments and modifications should be designed considering the use of to minimize the need for active safety devices (e.g. by the use of inherent safety features, passive systems and fail-safe design).

4.14.4.16. If safety devices are interconnected with the reactor protection system, they should be designed so as to maintain the quality and effectiveness of the reactor protection system. The potential for detrimental interactions with the reactor protection system should be assessed and be demonstrated to be acceptable.

4.15.4.17. If an experiment might pose a hazard to the research reactor or to personnel, the protection and control system of the experiment should be connected to the reactor systems, so that the reactor power level would be reduced or the reactor would be shut down in the event of failure of the experimental device. The method of effecting this connection should receive special attention and the connection should be classified and qualified as a safety system. Separate annunciators or other devices should be provided in the control room to notify the operating personnel whenever a safety action is initiated when a safety system setting of the experiment is reached. The research reactor systems should not be used to control the experiment, nor to provide an indication of the progress of the experiment.

~~4.16.~~4.18. If a safety device is to be used only to protect the experiment itself or if the experimental device can be permitted to fail without causing a hazard to the research reactor or to personnel, then the safety device may be assigned a lower safety ~~category~~classification. Such safety devices should not be connected to reactor control and protection systems.

~~4.17.~~4.19. Annunciators should operate at an alarm level below the safety limit of the experiment parameters to allow~~. This will enable~~ operating personnel to take predefined actions to correct the situation.

Heat generation and cooling

~~4.18.~~4.20. Special consideration should be given to the possibility of an experiment or modification that could affect~~ing~~ the capability for heat removal from the reactor core.

~~4.19.~~4.21. A dominant cause of failure for many irradiation experiments is related to either excessive heat generation or insufficient cooling. Thus, adequate heat removal under all conditions considered in the design of the experiment and of the research reactor itself should be one of the main aspects addressed in the safety analysis for the experiment. In addition, the effect of the presence or absence of an experimental device on the power distribution in the reactor core should be carefully addressed, as this may influence the safety margins of the research reactor. Particular attention should be given to the calculation of the power distribution in the experimental device, in which all material compositions and the neutron and gamma heat deposition should be taken into account. Such calculations should be performed for all operational states. Adequate cooling should be provided to keep the temperature within acceptable limits. To avoid excessively high temperatures in all circumstances, means to place the experiment in a safe configuration should be provided. Means to reduce the reactor power or to shut down the reactor, as discussed in paras ~~4.6–4.8~~4.17, should be analysed and ensured.

~~4.20.~~4.22. In addition to the above considerations, particular consideration should be given to irradiation of fissile material or moderating material with respect to the potential for inadvertent criticality and to cooling provisions during and after irradiation to prevent overheating of the target material.

Pressure

~~4.21.~~4.23. Possible effects of high or low pressure in the experimental device or modified system on the reactor should be assessed and appropriate means to keep the pressure within acceptable limits should be ensured.

~~4.22.~~4.24. Special precautions should be taken in the design for irradiating material, including their enclosures. Such material can readily decompose or otherwise change state, or its chemical reactivity may be enhanced, producing an overpressure, or gases that may be flammable and/or explosive. It should be ensured that pressures within the enclosures and chemical concentrations of the target material do not adversely affect the safety of ~~endanger~~ the reactor or the experiment.

Selection of materials

~~4.23.~~4.25. In the design of experiments, the selection of materials should take into account material compatibility, corrosion, changing of material properties due to irradiation (e.g. creep, embrittlement, radiolytic decomposition, activation), including transmutation of material, differential thermal expansion, ageing effects and ease of decontamination, dismantling and final ~~disposal~~disposition.

4.26. In the design of experiments, particular consideration should be given to the ~~irradiation of corrosive~~ selection of materials for irradiation~~, (e.g. mercury, rhenium, magnesium) or materials whose corrosive properties may become enhanced as a result of irradiation~~. For example:~~,~~

- materials such as copper and cadmium should not be used without cladding;
- irradiation of materials whose corrosive properties may become enhanced as a result of irradiation (e.g. mercury, rhenium, magnesium) should be avoided;
- plastics and other organic or synthetic compounds will disintegrate under irradiation;
- cadmium, beryllium, silver, cobalt, boron compounds (e.g. B_4C), and alloys containing these materials, should be used with extreme caution owing to their neutronic properties;
- chemical compounds which decompose upon irradiation and give off-gases;
- explosive chemical and materials should be used with extreme caution and in limited quantities;

- galvanic effects, in particular those due to interactions between water and aluminium, should also be considered;.
- In particular, the use of mercury should be excluded in research reactors with aluminium components owing to the extremely corrosive interactions between these elements.

4.24.4.27. Furthermore, certain activated corrosion products (such as silver) tend to plate out (i.e. form a coating) on cooling circuit surfaces, thus creating contamination and the potential –for radiation– exposure during handling -and maintenance.

4.25.4.28. In the design of experiments, particular consideration should be given to the provision of additional barriers to contain toxic material that could pose a hazard if released; for example, beryllium is particularly toxic if ingested.

Neutron fFlux perturbations

4.26.4.29. Consideration should be given to the effects of interactions of neutrons from an experiment or modified system with core components, fuel or other experiments. Perturbations in the neutron flux should be evaluated, especially in the vicinity of safety related devices (e.g. neutron detectors). Where experiments can be inserted, withdrawn or otherwise relocated while the reactor is at power, the effects on the power distribution in fuel assemblies and on the controllability of reactivity changes should be carefully assessed.

Protection against external and internal hazards

4.27.4.30. At each stage of the project, the design of the experiment or modification should include measures to withstand or mitigate the effects of external and internal events, e.g. earthquakes, floods, fires and explosions, that have been taken into account for the research reactor. Experiments and modifications should be designed such as, that in case of external events exceeding the design basis external events the design has a sufficient margin to avoid event sequences leading to unacceptable radiological releases. The design should be reviewed by the appropriate experts and the implementation of the recommendations made should be documented.

4.28.4.31. If temporary equipment is to be used in the construction and installation stages, the proper measures should be taken to protect the structures, systems and components of the research reactor as well as the temporary equipment against external and internal hazards, e.g. anchoring them, fire protection measures.

Mechanical interaction of experiments and the reactor

~~4.29.~~4.32. The possible vibration of experimental devices or modified components due to coolant flow should be considered. Particular consideration should be given to avoiding vibrations at resonance frequency.

Testability and ageing management

~~4.30.~~4.33. In the design, particular consideration should be given to the proper testability of the modification or experiment during commissioning as well as during operation. If necessary for the ability to execute a commissioning programme successfully, special measuring and testing provisions should be made available to ensure accessibility of the modified system or experiment for measurements.

4.34. Particular consideration should be given to providing appropriate features to support the same degree of ageing management and in-service inspection as for the original system, taking into consideration the ~~envisaged duration~~lifetime of the utilization project or modification.

5. PRE-IMPLEMENTATION PHASE OF A UTILIZATION OR MODIFICATION ~~OR UTILIZATION~~ PROJECT

GENERAL

5.1. Sections 5, 6 and 7 provide detailed recommendations for the various phases of a typical ~~modification or~~ utilization or modification project. These recommendations should be followed for a project with a major effect on safety. For projects with lesser safety implications, the recommendations should be applied using a graded approach. Figure 1 shows a flow chart for a project with a major effect on safety and the relationship between the operating organization and the regulatory body throughout the execution of the project. Other organizations could also be involved in the utilization or modification project, e.g. a design organization or sub-contractors. For the design of a modification, the operating organization should consult the designer to the extent possible. However, the overall responsibility remains with the operating organization. The following paragraphs provide a detailed discussion of each aspect of Fig. 1.

5.2. The extent of the involvement of the safety committee(s) and the regulatory body depends on the safety category of the experiment or modification; recommendations for determining the safety category are provided in Section 3 of this Safety Guide.

5.3. The implementation of projects with a minor effect on safety should follow the same steps, but using a graded approach, especially regarding the extent and detail of the safety analysis, the documentation to be prepared, and the review and approval route to be followed.

5.4. Each phase of the project should be clearly defined and should be understood by all persons involved. In particular, the transition points between phases should be formally acknowledged and recorded.

5.5. Early in the project, the need to develop a mock-up should be considered to facilitate the development of procedures for the implementation of the project, operating procedures, training of operating personnel and workability within a confined space, or to ensure the feasibility of the ~~modification or~~ utilization or modification project.

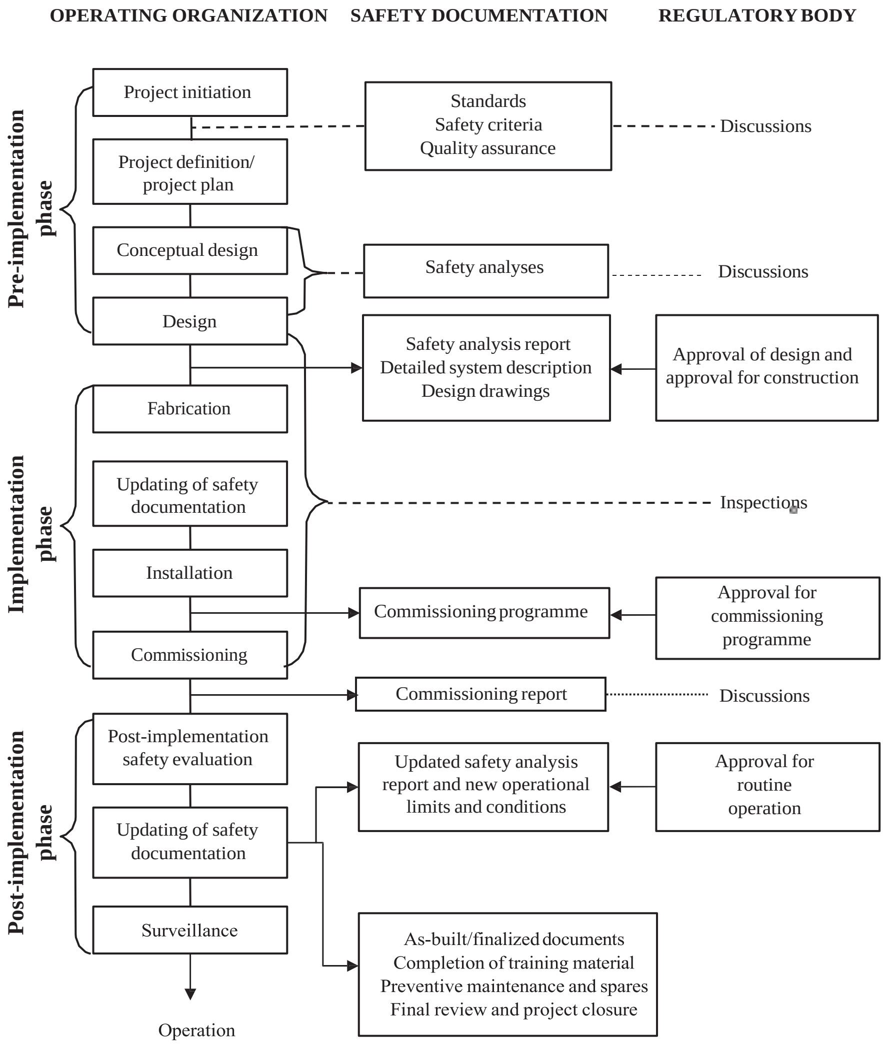

FIG. 1. Phases of a utilization or modification project with a major effect on safety.

PROJECT INITIATION

5.6. The need for a modification or experiment can arise from different groups of persons, such as the reactor management, the regulatory body, experimenters or equipment suppliers. Modifications can be necessary for the continuous improvement of nuclear safety involvinge changes to safety systems, safety related items, operational limits and conditions, procedures, documentation, or operating conditions for the reactor as well as for experiments. Modifications may be also necessary to adapt the research reactor facility to changing needs from science and research (e.g. high neutron flux density, new irradiation facility, modified or new experimental facilities). Whatever the reason for a modification or an experiment, the general concept should be discussed by the reactor management and the regulatory body early in the project. It may also be appropriate to include other groups, such as the safety committee(s), experimenters, equipment suppliers and independent consultants.

5.7. Modifications and experiments at research reactors may also arise from a variety of considerations. These considerations are discussed in Annex IIIV.

PROJECT DEFINITION

5.8. The project definition stage involves development of the specific objectives and the scope of the proposed modification or experiment and, thus, provides the starting point for the technical design. Limiting conditions, safety criteria and quality requirements with regard to the implementation of the project should also be developed at this stage.

5.9. General organizational and administrative arrangements for the subsequent project steps should also be dealt with at the project definition stage.

Categorization and selection of safety codes and standards

5.10. The process of categorization of the experiment or modification, as discussed in Section 3, should be applied at this stage in order to determine the safety implications of the project and the review and approval route to be applied.

5.11. The applicability of relevant existing safety codes and national and international standards to the structures, systems and components should be evaluated, and in some cases, development of some additional codes and standards may be necessary (see also paras 6.14 and 6.15Requirement 13 of Ref.SSR-3 [2]).

Data collection

5.12. The use of relevant technical data and information on performance and material properties and process characteristics as input in the design stage is essential to ensure the quality and safety of modifications and experiments. Considerations such as those provided in paras 4. 1720–4.25 28should also form part of such design inputs.

5.13. The existing documentation for the research reactor, component or software, including all modifications, should be provided to establish a pre-design database. A review of this documentation should be made to verify that it is up to date. This may require inspection of the equipment affected by the modification or experiment, and an evaluation of the operating and maintenance history of this equipment to verify that the documentation is up to date and that the existing equipment is capable of performing its intended function.

5.14. The establishment of the pre-design database may also require specific measurements or tests to be carried out on relevant reactor systems, in order to complete or update the information. Verification of historical data may be necessary, and the data should be carefully authenticated. Historical information on repeated failures or generic common cause failures should also be collected.

5.15. Inclusion of information on similar modifications or experiments carried out at other research reactors may provide an important contribution to the pre-design database. Operating experience, including information on ageing effects, should also be collected.

Pre-design appraisal

5.16. The design process is usually an iterative process. For each experiment or modification, several technical options should be evaluated. This appraisal will provide the basis for subsequent evaluation of the safety and the technical and financial feasibility of the modification or experiment, and for justification for the chosen option. The appraisal of options should cover not only the hardware for the modification or experiment (i.e. equipment, materials) but also the implementation and operational aspects, including surveillance requirements, as well as decommissioning and disposal aspects. These may determine the degree of interference with the research reactor under normal operation, anticipated operational occurrences or accident conditions, the required radiation protection measures and the projected volume of radioactive waste, and thus will affect the safety, effectiveness and costs of the project. A technical description and a preliminary safety analysis should be provided for each option. The review scheme used for carrying out comparisons between the available options and for selection of the optimum solution should be documented and provided. Reasons for the rejection of other options should also be documented.

5.17. Depending on the safety category of the modification or experiment, the pre-design appraisal should be discussed with the regulatory body and, if applicable, the safety codes and design standards that have been selected for the project should be submitted to the regulatory body for assessment and review, and the associated time schedule should be discussed with the regulatory body at the pre-design stage.

5.18. The pre-design appraisal may lead to a decision not to execute the modification or experiment.

DESIGN

5.19. At the design stage, the selected option should be developed into a fully documented and justified design for the modification or experiment. Thus, project plans, specifications, design assessments, safety analyses, detailed drawings for manufacture and the installation of the modification or experiment and all associated documentation should be prepared at this stage. Requirements for commissioning, post-implementation safety evaluation and surveillance should also be determined at the design stage (see paras 7.2 and 7.5).

5.20. Management system criteria for design control and continuous improvement should be established and implemented, covering all aspects of the design, including inspection and testing methods, and construction. Measures should be established and documented to ensure that the applicable codes, standards and regulatory requirements are correctly incorporated into design documents for safety related items. Measures should also be provided for verification of the adequacy of design. This verification should be performed by qualified individuals other than those who developed the original design. Further recommendations are provided in Section 2.

5.21. Detailed safety analysis should be carried out to the extent necessary for the potential hazards. The analyses should be capable of demonstrating that the design is safe and, in particular, of showing that:

- Any new system or component complies with all relevant safety standards and that it will function safely for all operational states.
- New systems will not adversely affect the safety characteristics of other items important to safety under any operational states, or the safety relevant characteristics of the research reactor.

— The experiment or modification can be carried out without significantly increasing the dose to staff site personnel and members of the public; this should be determined in accordance with the principle of optimization of protection, or with the risk of an accident.
— The modification or experiment can be carried out without adversely affecting the safety of reactor operation.
— Any new hazards introduced by the modification or experiment can be safely managed at any stage of the project.

Care should be taken that up to date safety documents and data are used in these analyses.

5.22. It should be demonstrated and documented that:

— The introduction of the new system would not adversely affect the consequences, in terms of radiological hazards or other hazards, for any operational states.
— The failure of the new system would not result in any new event scenario with significantly increased risks (different failure modes may have to be considered).

5.23. The technical and operational relationship of the proposed modified system or experiment should be evaluated for each of the accident sequences considered in the safety analysis report for the research reactor. The implications of the modification or experiment for the management of potential accidents and for their consequences should be analysed.

5.24. Furthermore, each credible failure mode of the changed system should be considered as a postulated initiating event for a new event scenario, and its consequences should be analysed by appropriate evaluation methods. Care should be taken to include in the assessment not only direct effects on the research reactor, but also the effect on items important to safety, such as systems for accident prevention and for mitigation of the consequences of accidents.

5.25. At the end of this analysis, an updated version of the research reactor safety documentation should be produced, which may include an update of the safety analysis report and the operational limits and conditions.

5.26. The safety documentation should be written and maintained according to the requirements established in Ref.SSR-3 [2] and recommendations provided in SSG-20Ref. [4]. Attention should be paid to the review and updating, as necessary, of the documentation covering the design, operational limits and conditions, operating procedures, and other safety documentation, to be used as a basis for approval for normal operation of the experiment or modified research reactor.

5.27. Testing of experimental devices and equipment prior to their installation in the research reactor should be considered. Tests should be planned as part of the design and the commissioning of the experiment or modification.

5.28. The output from the design stage should also include the following:

- A statement of the objectives to be met.
- Details of the structure of the organization set-up for the project and the responsibilities of the parties involved.
- A description of the activities, techniques and procedures to be employed, including those for the implementation programme.
- A safety evaluation of the specific procedures and techniques to be used.
- A description of the expected state of the research reactor at the various phases of the project.
- The necessary design calculations, drawings and specifications for the complete project.
- The training programme designed to enable ~~staff~~ site personnel to cope with anticipated operational occurrences during the implementation of the project. (~~Staff~~ Site personnel should also be informed about the special safety considerations and provisions that apply during the various stages of the project.)
- Documentation, such as procedures for the modified state of the research reactor, including any new or temporary emergency procedures and the associated training programme.
- A plan for commissioning to verify that the design objectives have been achieved.
- An outline of the preliminary decommissioning plan.
- A special surveillance programme, including ageing management and in-service inspection requirements, if necessary (see para. 7.5). Such surveillance should be used to demonstrate the continued safety of the research reactor systems.
- An overview of the safety related spare parts that should be available before implementation of the ~~modification or~~ utilization or modification project.

5.29. For ageing management, the relevant recommendations in IAEA Safety Standards Series No. SSG-10, Ageing Management for Research Reactors ~~Ref.~~ [23] should be followed.

5.30. For decommissioning, dismantling and removal of major reactor components, the relevant recommendations in IAEA Safety Standards Series No. SSG-47, Decommissioning of Nuclear Power Plants, Research Reactors and

Other Nuclear Fuel Cycle Facilities Ref. [24] should be followed.

5.31. The need for approval of the experiment, approval of the design and approval for construction of the modification or the need for formal licensing as referred to in para. 3.18-3.19 should be considered at this stage.

6. IMPLEMENTATION PHASE OF A UTILIZATION OR MODIFICATION OR UTILIZATION PROJECT

GENERAL

6.1. This section covers the fabrication, installation and commissioning stages of the implementation phase of the modification or utilization or modification project. For some projects, Nnot all of the recommendations provided are relevant for some projects, for example in cases where the project involves only changes to procedures.

6.2. Irregularities encountered at a particular stage should be dealt with immediately, rather than at a subsequent stage.

6.3. Nevertheless, if the outcome of a certain stage could place a constraint or a requirement on a subsequent stage, procedures to ensure that such constraints or requirements are satisfied should be put in place.

FABRICATION

6.4. For the fabrication stage of the project, measures should be established for the control of procurement of materials, development, revision and use of documents and drawings, and for processing of materials as well as for the inspection of such activities.

6.5. New components or existing components that have to be modified are generally fabricated or modified by suppliers in accordance with the detailed specifications that have been established in the design phase. Before selecting a supplier, the project manager should ensure that the supplier has gained the necessary experience for the work and is aware of all of the particular constraints of the project, including management system criteria (see para. 5.20). Preliminary visits to the supplier are generally indispensable.

6.6. The project manager should also ensure that the suppliers involved have an appropriate management system.

6.7. During fabrication, technical audits and quality audits should be conducted in order to check and handleverify all aspects of fabrication, such as deviations from specifications, quality control and the schedule and deadlines. The regulatory body should define which inspections will be conducted during fabrication to verify that it is in compliance with applicable requirements, codes and standards. In particular, regulatory inspections during fabrication is important for that equipment which cannot be thoroughly inspected during installation.

INSTALLATION

6.8. Measures should be established for the control of the installation of equipment, and any potential hazards, for example, radiation, chemical and industrial hazards, should be taken into consideration.

6.9. The installation of the experiment or the modification should not commence until all approvals have been obtained and the relevant staff site personnel involved in the installation have been trained satisfactorily.

6.10. The schedule for the installation of the experiment or for the modification should be prepared in consultation with the reactor manager, in order to ensure that the research reactor is placed in a safe state before commencing the activity.

Management

6.11. Management of the installation stage of the project should cover at least the following:

- Clear identification of all responsibilities, including those relating to management system procedures and radiation protection.
- Frequent meetings to inform on progress and exchange information with all staff (i.e. technical, operational and health physics staff) and interested parties involved in or affected by the project.
- Coordinating with the security personnel to identify any additional security measures or any potential impacts on existing security measures during and after the installation.
- Clear procedures with respect to the control (i.e. reporting, assessment and disposition) of deviations from approved methods and specifications, or from expected behaviour.
- Clear procedures to ensure that no foreign objects, e.g. assembly or

installation tools and equipment, have been left in the area around the modification.

— Measurement and registration of all characteristics of the system as built; this is required for updating relevant technical documents, drawings and procedures.

— Training and provision of information to operating personnel and external personnel with respect to the conduct of the experiment or modification, methods to be used, safety aspects and safe working practices.

— Contingencies in the project plans to accommodate unforeseen events and operational deviations that may require a revision of the working practices and the project planning.

Safety aspects

6.12. The designer should carry out a sufficiently detailed safety evaluation of the installation process, which should be based on a detailed installation plan, describing activities, methods, hazards and temporary provisions, and the technical or administrative measures or precautions that should be implemented to minimize risk during the installation activities.

6.13. If temporary equipment has to be installed, the external and internal events that have been taken into account for the research reactor should be taken into account for the design and installation of temporary equipment (see also para. 4.~~28~~31).

6.14. Specific safety topics that should be considered for the installation stage are related to:

— Identification of the hazards and the steps to be taken to control the hazards in order to minimize the risk to personnel, the research reactor and ~~the reactor~~its systems and the environment;

— Management of radioactive waste, including transport, decontamination and dismantling aspects, as applicable;

— External exposure to radiation;

— Provisions required to prevent the spread of contamination and internal exposure to radiation;

— Emergency preparedness and response (The safety requirements for emergency preparedness and response are established in IAEA Safety Standards Series No. GSR Part 7, Emergency Preparedness and Response for a Nuclear or Radiological Emergency [25]);

— Safe storage of the fuel, radioactive material and other radiation sources and chemicals during the modification period;

— Industrial hazards, such as high voltage, vacuum, working in high places or confined spaces, fire, local flooding, and the use of chemicals and of potentially dangerous tools.

6.15. All temporary adaptations (such as connections, procedures or arrangements) that are necessary for implementation of a modification or experiment should be documented and should be made subject to approval by the reactor manager before they are applied.

6.16. Special temporary emergency procedures should be drafted as required, made subject to approval and exercised (see para. 5.28) in cases where potentially hazardous situations have been identified in connection with the installation of the experiment or the modification at the research reactor. These temporary procedures should be formally withdrawn once the installation is completed (see also para. 6.21).

COMMISSIONING

6.17. Commissioning~~[14]~~ of an approved ~~modification or~~ utilization or modification project, which may include pre-installation tests of experimental devices and equipment, as discussed in para. 5.27, should be aimed at demonstrating the functionality and safety of the project. Additional recommendations for the commissioning process and for the various stages of commissioning for large modifications are provided in NS-G-4.1[6].

6.18. The reactor manager should be given the responsibility to ensure that a review of the commissioning plan is conducted in accordance with established procedures.

6.19. The safety of a modification or experiment that is to be implemented should be verified through a commissioning programme involving tests and checks, and measurements and evaluations prior to and during implementation of the modification or experiment. The requirement~~s~~ 73 ~~in paras 7.42–7.50~~ of ~~Ref.~~SSR-3 [2] ~~are~~ is also applicable for the commissioning of a modification or experiment. The regulatory body should define appropriate witness and hold points to inspect the commissioning of the utilization or modification project.

6.20. The adequacy of the commissioning programme for each modification or experiment should be reviewed with respect to the following objectives:

~~[14] Additional recommendations for the commissioning process and for the various stages of commissioning for large modifications are provided in Ref. [6].~~

— Determination (by measurement under realistic conditions met in normal operation conditions and in anticipated operational occurrences to the extent possible) of all reactor characteristics relevant to safety with respect to the modified system;
— Demonstration that the structures, systems and components of the research reactor that have not been modified (in particular all items important to safety) will not be compromised;
— Verification (on the basis of measured data) of the relevant safety parameters and proper performance of all safety functions;
— Provision of additional information and data from commissioning, in order to update the safety documentation, the technical documentation and the operating procedures;
— Provision of opportunities and time for familiarization and training of operating and maintenance personnel;
— Adjustment of the reactor systems affected by the modification or experiment for optimum performance.

6.21. Special temporary safety provisions or procedures should be developed and exercised whenever necessary throughout the commissioning process.

6.22. The completion of the commissioning process should include a check to confirm that all temporary adaptations (such as connections, procedures or arrangements) that were necessary for implementation have been removed or cancelled and that the research reactor has been returned to full operational status.

6.23. The operating organization should submit the commissioning results to the regulatory body ~~need~~ for formal approval ~~of the commissioning results~~ and permission for operation ~~with~~ of the experiment or with the modified system ~~should be considered at this stage~~as required in the licence conditions.

7. POST-IMPLEMENTATION PHASE OF A UTILIZATION OR MODIFICATION PROJECT

POST-IMPLEMENTATION SAFETY EVALUATION AND APPROVAL FOR ROUTINE OPERATION

7.1. The basis for final approval of the experiment or modification for routine operation should be the successful completion of all stages of commissioning, and the verification of all information and experience against the requirements as specified in the design. The results of the commissioning tests and the as-built drawings and documentation should be reviewed in accordance with existing procedures, to demonstrate that the modification or experiment has been built in a manner that conforms to the approved specifications and to ensure safe operation.

7.2. A final commissioning report should be produced in which the results of commissioning are presented and assessed. The report should be subject to approval in accordance with established procedure.

UPDATING OF SAFETY DOCUMENTATION

7.3. Revision of the safety documentation and the safety analysis report, as mentioned in para. 5.26, should be carried out as appropriate, to include the as-built description of the utilization or modification, and to take into account the results of the commissioning process. The project manager should be responsible for such revisions. The time schedule for the revision of the documentation should be made subject to approval by the reactor manager, in accordance with the regulatory requirements.

7.4. If the safety documentation has been revised, the approval and distribution of the documentation should be carried out in accordance with the approved procedures on the basis of the safety significance of the experiment or modification. This could require involvement of the safety committee(s) and review and approval by the regulatory body, as appropriate. Obsolete safety documentation should be removed from service and archived.

SPECIAL SURVEILLANCE

7.5. The justification for certain modifications and experiments may be dependent on technical or material characteristics that may be affected in long term reactor operation by irradiation embrittlement, corrosion or other ageing effects. In cases where such effects cannot be predicted with sufficient accuracy from previous experience or by analysis, a safety surveillance programme should be defined for monitoring the behaviour of the relevant characteristics. Any special surveillance requirements determined at the design stage (see paras 5.16 and 5.28) should be implemented.

8. OPERATIONAL SAFETY OF EXPERIMENTS AT A RESEARCH REACTOR

8.1. Although the recommendations provided in the following paragraphs are, in principle, applicable for both modifications and experiments, for modification projects and for major utilization projects the recommendations for a new research reactor should be followed where applicable (see Refs [3, 4, 6, 7, 13, 23, 2~~5~~6]).

RADIATION PROTECTION

8.2. Experiments at research reactors can present significant radiological hazards for persons conducting the experiment, for operating personnel and, in some cases, for ~~persons outside the research reactor~~other site personnel and members of the public. In addition to the design, which should be such as to minimize radiological hazards and which is supported by the commissioning process, the experimenters and persons involved in the operation of the experiment should be trained and should follow approved procedures for the performance of their tasks.

8.3. Every experiment should be performed using approved operating procedures that describe the responsibilities of those involved in the experiment and that include operating instructions for the experiment.

8.4. In addition to general training in radiation protection, specific training should be provided for all experiments. Such specific training should cover:

— Operating procedures for the experiment;
— Rules and instructions for radiation protection associated with the performance of the experiment;
— Emergency plans and procedures.

8.5. Areas in which there can be significant radiation levels during research reactor operation and during reactor shutdown, such as areas close to open beam tubes, reactor loops or irradiated materials, should be determined before reactor startup. Such areas should be categorized as controlled and supervised areas in accordance with SSR-3 [2] and Ref~~s~~. [~~2,~~ 21]. After reactor startup, a radiation survey (of alpha, gamma and neutron radiation) should be made that especially covers the area around the experiment. The actual radiation fields should be measured, displayed and, where appropriate, recorded. Where necessary, such areas should be cordoned off or physically secured to prevent inadvertent or unauthorized access, and appropriate radiation warning signs should be exhibited.

INFORMATION NECESSARY FOR SAFE PERFORMANCE OF

EXPERIMENTS

8.6. In addition to the information in the safety analysis report, experimenters should prepare for the operating personnel: a detailed description of the experimental device; a list of credible possible hazards posed by the experiment; the boundary conditions for operation of the experiment; and a list of all connections to the reactor protection system that may cause the research reactor to shut down.

8.7. The reactor manager should be made responsible for the coordination necessary (e.g. to take into account the reactor shutdown periods needed for maintenance) for the conduct of experiments.

8.8. For every experiment, the operating personnel and experimenters should have the necessary information available for the safe performance of the experiment, and the information that may be needed in the event of a safety related problem or operating difficulties. The required information should list any operational limits and conditions for the experiment, such as maximum temperatures and pressures. The actions to be taken in the event that these limits are approached or exceeded should be clearly stated in written instructions. These actions should be provided mainly in the form of procedures for all operational states and for emergencies. A tabulation of the expected radiation levels or other hazards associated with the experiment should be provided, as well as a list of the personnel allowed to run the experiment and of those persons associated with the experiment who can be called upon for advice if difficulties arise. This information should be regularly reviewed and updated.

8.9. The limiting conditions for safe operation (where appropriate, as a part of operational limits and conditions covering experiments both for the reactor and for the experiment to ensure safe operation, as well as the procedures for handling and operation of the experiment), should be subject to approval by the reactor manager. Particular consideration should be given to the approval of limiting conditions for safe operation and procedures relating to the startup of the reactor or the experiment, anticipated operational occurrences, and emergency situations.

8.10. Records should be kept of material, samples, equipment and devices inserted into the reactor core, and such items should be retrieved and accounted for at the end of their irradiation. These records should also include the measured or estimated activity of each item.

COOPERATION BETWEEN EXPERIMENTERS AND OPERATING

PERSONNEL

8.11. To ensure safe operation of experimental devices, the experimenter and the operating personnel will need to work closely together. Special arrangements should be considered for startup of the research reactor or the experimental device, such as any special handling necessary by the operating personnel or the experimenter or operation outside the normal schedule of either the experimental device or the research reactor. Procedures should be prepared, made subject to approval and implemented to ensure adequate communication between experimenters and operating personnel. The following aspects should be considered for these procedures:

— The need to announce, through a public address system, that the reactor is starting up or that the experiment will commence;
— The need for the reactor manager to check all experiments and the locations of all experimenters;
— The use of warning lights, ~~or~~ other visible signs or audible indications in experimental areas to indicate that the reactor is operating;
— The use of dedicated communication provisions;
— Contact details of persons who can be contacted after working hours if special actions are required.

Such communication needs should be considered in addition to any interlock or other safety devices provided in the design.

8.12. The activities of experimenters and the operating personnel should also be coordinated during routine operation. If an experiment involves operations that may influence reactor parameters (e.g. displacement of a fuel test rig), a method of direct vocal communication between the experimenter and the operating personnel should be available at all times, and the actual status of the experiment should always be known to the operating personnel. These provisions should be put in place in addition to design provisions.

8.13. The operating instructions should clearly define the tasks and responsibilities of the operating personnel and experimenters, so as to avoid conflicts of interest between the progress of experiments and the safe operation of the experiments or the research reactor. These responsibilities should be reviewed by the safety committee(s) and made subject to approval by the reactor manager.

OPERATIONAL CHANGES IN EXPERIMENTS

8.14. For some experiments, it might be necessary to change the operating conditions in some manner, such as changing the experimental set-up, or the safety system setting of the experiment, or the operating sequence agreed to when the experiment was originally approved. Such proposed changes should be treated as a modification, and the guidance given in this Safety Guide should be followed.

RESPONSIBILITY FOR SAFE OPERATION OF EXPERIMENTS

8.15. The reactor manager has direct responsibility for the safety of the reactor operation. Accordingly, the reactor manager or a designated member of the reactor manager's staff should be given the authority to assume control of any necessary operation of the experimental equipment to ensure the safety of the reactor and the personnel, including stopping any experiment that the manager considers hazardous and placing it in a safe condition. See section 2 on the management system for the utilization and modification of a research reactors of this Safety Guide.

8.16. Experimenters should promptly report any deviation from normal operation of their experiment directly to the operating personnel.

8.17. ~~As part of his or her responsibility for safety, including all safety aspects of experiments, t~~The reactor manager should enforce any safety rule or any limitations to experiments, if necessary, to ensure the safe operation of both the experiment and the research reactor, as well as to ensure the safety of ~~staff~~operating personnel and experimenters.

8.18. Within the approved procedures and within the approved operational limits for their experiment, the experimenters should assume responsibility for the safe operation of the equipment of their experiment.

8.19. The responsibilities of the operating personnel and the experimenters should be clearly defined and made subject to approval by the reactor manager.

9. SAFETY CONSIDERATIONS IN THE HANDLING, DISMANTLING, POST-IRRADIATION EXAMINATION AND DISPOSAL OF EXPERIMENTAL DEVICES

GENERAL RECOMMENDATIONS

9.1. The handling, dismantling and disposal of experimental devices or other irradiated equipment that requires storage and eventual disposal in connection with the project should be carried out in accordance with approved procedures.

9.2. The procedures should take into account the safety evaluation of all operations connected with the handling, dismantling, post-irradiation examination, transport and storage or disposal of irradiated equipment. The activity and contamination of irradiated equipment should be evaluated in advance, under each of two assumptions:

— The most probable course of the experiment;
— The worst possible combination of equipment failures and human errors.

9.3. Radiological hazards should be assessed for all relevant conditions. The radiation protection measures (e.g. shielding, cleaning of air, decontamination procedures and the use of movable provisions such as shielding and ventilation provisions to facilitate handling operations) should be demonstrated to be adequate to deal with the worst possible situation.

9.4. The equipment to be used for the handling, dismantling and safe storage or disposal of irradiated materials and devices should be procured and tested in advance.

9.5. The operations should be planned such that the exposures of personnel are as low as reasonably achievable, and the amounts of radioactive substances released are minimized. Measures necessary to prevent contamination of equipment and personnel should be developed and put in place.

9.6. If the irradiated equipment can give rise to airborne contamination, a handling process to prevent this should be developed and put in place (e.g. by keeping the equipment in leaktight containers -or by -providing a -system of negative pressures and filters). Criteria for items important to safety (e.g. single failure criterion, to ensure that no single failure or single maintenance action or any other single human action could disable a safety function, redundancy) should be used in planning such a process. The requirements are established in ~~Ref.~~SSR-3 [2].

9.7. Decontamination schemes should be developed for all surfaces that may be contaminated by the experiment. The safe storage or disposal of decontaminants used should be ensured.

Training

9.8. All documentation describing the sequence of operations and the instructions for operating the equipment should be known to the operating personnel and should be available during the handling, dismantling, post-irradiation examination and storage of the irradiated equipment or components until their ~~final~~ disposal.

9.9. The personnel performing the handling, dismantling, post-irradiation examination and storage of experimental devices should be given the necessary training in all aspects of these operations, including, if necessary, exercises using mock-ups, before work with irradiated objects is commenced. A method for determining the effectiveness of training should be put in place.

Storage

9.10. If the irradiated equipment of the dismantled experiment, experimental facility or system is to be stored on-site, the volume and the characteristics of the materials to be stored, including their measured or estimated activities, should be evaluated and the safe storage of such equipment should be demonstrated.

10. SAFETY ASPECTS OF OUT-OF-REACTOR-CORE INSTALLATIONS

10.1. The out-of-reactor-core experimental devices or modifications (installations) include two groups: (i) those that utilize the radiation produced by the reactor core but are located outside the reactor (biological) shielding (e.g. a neutron spectrometer); and (ii) those that are at or near the reactor core and which do not utilize the radiation produced by the reactor core, but which constitute a potential hazard (e.g. a cryostat containing liquid nitrogen or cold neutron sources containing hydrogen or deutrium).

10.2. Both groups of installations should be subjected to the categorization process as described in paras 3.7–3.34.

10.3. For the out-of-reactor-core installations that constitute a potential hazard, in addition to an analysis of ‘conventional’ safety (e.g. fire, explosion, chemical hazards), analyses should be performed to identify the potential hazards and determine the safety provisions to be implemented to reduce the hazards to the extent possible.

10.4. In addition to the review by the safety committee(s), if required, the safety analysis should be reviewed in accordance with management system procedures by appropriate specialists, e.g. in the field of occupational hazards, chemical hazards and electrical hazards.

10.5. The proposal for an out-of-reactor-core installation should be subject to approval by the reactor manager, including the safety analysis for its implementation. Based on its effect on safety (i.e. major, significant), the proposal should be submitted to the safety committee(s) and to the regulatory body for review and approval of the analysis, as appropriate.

11. CHANGES TO THE OPERATING ORGANIZATION

ORGANIZATIONAL CHANGES

11.1. The operating organization should set up its organizational structure for the safe operation of research reactor before the commencement of operation.

11.2. Requirements 68, para 7.11 of SSR-3[2] requires that "the proposed organizational changes to the structure and associated arrangements, which might be of importance to safety, shall be analysed in advance by the operating organization and submitted to the regulatory body for approval". Changes to the operating organization should be considered as modifications and should be categorized according to their safety significance. They should also follow the same modification categorization process in place at the research reactor. Benchmarking and analyses of the operating experience feedback concerning organizational changes in the nuclear installations and other industries should support this process for organizational development and continuous improvement of nuclear safety. Additional guidance may also be found in IAEA Safety Standards Series No. NS-G-2.3, Modifications to Nuclear Power Plant [27].

11.3. Changes to the operating organization should be carefully evaluated in order to avoid frequent modification to the operational structure which may pose a threat to the stability of the organization. Whenever organizational restructure is undertaken at any level, the modified structure should be such as to ensure that all the responsibilities of the operating organization as defined in SSR-3 [2] continue to be carried out.

11.4. If there are safety implications arising from an organizational change, an independent internal review should also be provided to demonstrate that the provisions for the management of safety, including the provision for adequate control and supervision, will not be compromised. Proposed organizational changes should be reviewed by the safety committee before submitting to the regulatory body for review and assessment, if needed.

11.5. Special attention should be paid to the review, and revision as necessary, of training programme for all site and designated external personnel to ensure in advance that they have an understanding of the new tasks and functions that will follow the organizational changes. In particular, it should be ensured that adequate provisions have been made to maintain a suitable level of trained and qualified staff in all areas important to safety, and that any new organizational structure has been documented with clear and well understood roles, responsibilities and interfaces. All needs for retraining should be identified by, for example, carrying out an analysis of training needs for each of the new roles, and planning retraining of staff where this is found to be necessary.

IMPLEMENTATION OF ORGANIZATIONAL CHANGES

11.6. During periods of organizational change, the adequacy of safety arrangements, should be maintained. Proposed organizational changes should be clearly defined and their safety implications should be assessed. Organizational changes should be properly planned well in advance.

11.7. An acceptable level of safety should be maintained during the transition phase, starting from existing organizational structure to before new organizational arrangements have become fully established. The possible need for additional resources to cope with any increased workload during the transition phase should be considered.

11.8. Involvement of personnel in any restructuring process should be considered at an early stage in order to avoid undue uncertainty and concern with regard to the planned organizational changes.

11.9. Large organizational changes should be implemented stepwise, if appropriate. The implementation, specifically the completion of each step, should be followed and monitored in order to assess the achievement of the objective of the change.

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Annex I

EXAMPLE OF A CHECKLIST FOR CATEGORIZATION OF AN EXPERIMENT OR MODIFICATION AT A RESEARCH REACTOR

Form to be completed by the designated project manager			
Document No.		Rev.	

Part 1 — Description of the modification or experiment
Describe the modification or experiment *Describe the modification or experiment to be undertaken, or refer to other documentation, e.g. project initiation document.*

Part 2 — Safety screening				
Screening questions ***(tick the appropriate box)***				
No.	Question	Answer		Justification
1	Does the proposed modification or experiment involve a change to, or an effect on, a structure, system or component that could affect its design function or its ability to perform its design function as described in the safety analysis report?	☐ Yes	☐ No	
2	Does the proposed modification or experiment involve a change to a procedure that could affect how the design functions of structures, systems and components described in the safety analysis report are performed or controlled?	☐ Yes	☐ No	
3	Does the proposed modification or experiment involve revising or replacing an evaluation methodology	☐ Yes	☐ No	

	described in the safety analysis report, used in establishing the design bases or used in the safety analyses?			
4	Does the proposed modification or experiment involve a test, experiment or activity not described in the safety analysis report, where a structure, system or component is utilized or controlled in a manner that is outside the reference bounds of the design for that structure, system or component, or the modification or experiment is inconsistent with analyses or descriptions in the safety analysis report?	☐ Yes	☐ No	
5	Does the proposed change require a change to any of the following other than an editorial or typographic change: • Licence? • Safety analysis report? • Operational limits and conditions? • Safety related operating procedures?	☐ Yes	☐ No	

Result of the safety screening *(tick the appropriate box)*			
1	All the questions have been answered with "NO".		☐
	1A	If the proposed modification or experiment falls within the lowest safety ~~classification~~categorization, then Safety category 4 'no effect on safety' is recommended. Go to Part 4, Safety categorization.	☐
	1B	If the proposed modification or experiment falls within a higher safety ~~classification~~categorization, then Safety category 3 'minor effect on safety' is recommended. Go to Part 4, Safety categorization.	☐
2	At least one question has been answered with "YES". A safety evaluation (Part 3) is required to evaluate the safety implications of the project prior to assigning a safety category. Go to Part 3, Safety evaluation.		☐

Part 3 — Safety evaluation
Evaluation questions *(tick the box for the appropriate answer)*

Effect in relation to accidents and malfunctions previously evaluated in the safety analysis report				
No.	Question	Answer		Justification
1	Could the proposed change affect the frequency of occurrence of ~~a design basis~~ accident conditions previously evaluated in the safety analysis report?	☐ Yes	☐ No	
2	Could the proposed change affect the consequences of ~~a design basis~~ accident conditions previously evaluated in the safety analysis report?	☐ Yes	☐ No	
3	Could the proposed change affect the likelihood of occurrence of a malfunction of a structure, system or component important to safety previously evaluated in the safety analysis report?	☐ Yes	☐ No	
4	Could the proposed change affect the consequences of a malfunction of a structure, system or component important to safety previously evaluated in the safety analysis report?	☐ Yes	☐ No	
Potential for occurrence of a new type of event not previously evaluated				
5	Could the proposed change create a possibility for an accident of a different type than any previously evaluated in the safety analysis report?	☐ Yes	☐ No	
6	Could the proposed change create a possibility for a malfunction of a structure, system or component important to safety with a different result than any previously evaluated in the safety analysis report?	☐ Yes	☐ No	
Impact on fission product barriers as described in the safety analysis report				
No.	Question	Answer		Justification
7	Could the proposed change result in a design basis limit for a fission product barrier as described in the safety analysis report being exceeded or altered?	☐ Yes	☐ No	
Impact on evaluation methodologies described in the safety analysis report				
No.	Question	Answer		Justification
8	Does the proposed change result in a departure from a method of evaluation described in the safety analysis report used in establishing the design basis or in the safety analyses?	☐ Yes	☐ No	

Changes to safety documentation				
No.	Question	Answer		Justification
9	Does the proposed change require a change to the safety analysis report, other than an editorial or typographic change, that impacts the safety case in a way not considered in questions 1 – 8 above?	☐ Yes	☐ No	
10	Does the proposed change require a change to the operational limits and conditions, other than an editorial or typographic change?	☐ Yes	☐ No	
11	Does the proposed change require a change to licensing basis documents, other than an editorial or typographic change, that impacts the safety case in a way not considered in questions 1 – 8 above?	☐ Yes	☐ No	
12	Does the proposed change require a change to the reactor procedures, other than an editorial or typographic change, that impacts the safety case in a way not considered in questions 1 – 8 above?	☐ Yes	☐ No	

Result of the safety evaluation *(tick the appropriate box)*	
All the questions have been answered with "NO". The proposed change will have a significant effect on safety. Safety category 2 'significant effect on safety' is recommended. Go to Part 4, Safety categorization.	☐
At least one question has been answered with "YES". The proposed change will have a major effect on safety. Safety category 1 'major effect on safety' is recommended. Go to Part 4, Safety categorization.	☐

Part 4 — Safety categorization				
Category requested *(tick the appropriate category)*	1 ☐ Major effect on safety	2 ☐ Significant effect on safety	3 ☐ Minor effect on safety	4 ☐ No effect on safety
Justification				
References				

Part 5 — Review and approval					
Prepared by (project manager)					
Name		Signature		Date	
~~***Section manager approval***~~					
~~Name~~		~~Signature~~		~~Date~~	
Reactor manager approval					
Name		Signature		Date	
Review and approval by the regulatory body required			Yes ☐	No ☐	
Approved safety category *(tick the appropriate category)*		1 ☐	2 ☐	3 ☐	4 ☐
Comments					
Name		Signature		Date	
Original to be retained in the project file					

Annex II

EXAMPLE OF THE CONTENT OF THE SAFETY ANALYSIS REPORT FOR AN EXPERIMENT AT A RESEARCH REACTOR

GENERAL

II–1. The following list of topics sets out the minimum requirement for the table of contents of the safety analysis report for an experiment. The topics are to be discussed using a graded approach based on the safety category of the experiment, as defined in Section 3 of this Safety Guide. The topics that are not relevant for the safety analysis report of the utilization project should be need to be indicated with the remark 'not applicable'. The list of topics may be modified depending on the type and purpose of the research reactor.

II–2. The layout of the safety analysis report is to be such that the main chapters contain only technical descriptions, summaries of calculation and analysis methods used, the main results and conclusions. Evaluations with detailed descriptions and calculations may be incorporated in the appendices if necessary.

II–3. Furthermore, the safety analysis report for the utilization project has to include figures, sketches and/or flow diagrams indicating overall dimensions, masses, temperatures and pressures. All computer codes used are to be fully verified, validated and benchmarked for their specific application and valid references have to be given. A summary has to be provided at the beginning of the safety analysis report.

STRUCTURE OF THE SAFETY ANALYSIS REPORT

1. Introduction

Short description of:

— Purpose of the utilization project;
— General nature of the irradiation target;
— General nature of the irradiation facility;
— If applicable, reference to earlier experiments or periodic review of the safety analysis report for the utilization project.

2. Experimental requirements

Specification of required:

- Nuclear conditions (fluence, radiation heating, linear power);
- Process conditions (target environment, temperature distribution, pressure characteristics);
- On-line measurements;
- Off-line measuring or inspection possibilities.

3. Irradiation target

- Detailed description (materials, composition, dimensions, special features);
- Codes and standards applied (e.g. ASME, RCC-M, RCC-MR, etc.);
- Thermal and mechanical characteristics;
- Design drawing;
- Fabrication method and quality procedures[1].

4. Irradiation facility

When a standard irradiation facility is used for the irradiation, a brief description will be sufficient, complemented by reference to document(s) in which the facility is described in detail.

4.1. In-core/out-of-core irradiation

- Functional description of the experimental facility and all in-core and out-of-core components (e.g. thermocouples, heaters);
- Sketches, showing vertical and horizontal cross-sections;
- Detailed assembly drawing (including parts list, list of materials used and material specifications).

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[1] A detailed description of the quality control procedures that are applied is necessary for irradiation targets containing fissionable materials, actinides or other potentially hazardous materials, in order to ensure that these are manufactured in conformity with specifications and that the acceptance criteria are met. The acceptance criteria (tolerances) for materials and dimensions that are important for determining uncertainty factors in the safety analyses have to be specified.

Remarks:

(a) General assembly drawings (two sets) and sufficient information about all components need to be submitted to the reactor manager.
(b) A complete description of all joints, penetrations, etc. that are part of the containment(s) has to be provided.

4.2. Radiation shielding

— ~~Functional description~~ Description of the ~~experimental facility~~radiation shielding including calculations (thickness optimization and justification), shielding material, thickness, dose rates, sketches, and drawings;~~, including all components (e.g. thermocouples, heaters);~~
— Description of the procedures for installation of radiation shielding;
— Verification of radiation shielding;
— Description of procedures for disassembling of shielding after completion of the experiments ~~Sketches, showing vertical and horizontal cross-sections;~~
~~— Detailed assembly drawing (including parts list, list of materials used and material specifications).~~

~~Remarks:~~

~~(a) General assembly drawings (two sets) and sufficient information of all components need to be submitted to the reactor manager.~~
~~(b) A complete description of all joints, penetrations, etc. that are part of the safety containment(s) has to be provided.~~

4.3. External system(s)

— Functional description of all components, classified into subsystems, such as:
4.3.1. Cooling system
4.3.2. Gas supply and circulation system
— Flow sheet, block schemes of external systems;
— Functional characteristics and design requirements of major components (i.e. pumps, valves).

4.4. Instrumentation

4.4.1. General

— General description of the different groups of instrumentation.

4.4.2. Safety instrumentation (essential to ensure safe operation of the experiment)

- Design of the safety instrumentation;
- Connection/interference with the reactor protection system, and interlock instrumentation;
- Connections with the experiment;
- Components and diagrams.

4.4.3. Process instrumentation

- Objective of the process instrumentation;
- Components and diagrams.

4.4.4. Scientific instrumentation

- Objective of the scientific instrumentation;
- Components and diagrams.

4.4.5. Additional experimental instrumentation

- Instrumentation not covered by the previous categories.

4.5. Data registration and control systems

- Functional description of data acquisition and evaluation systems;
- Block schemes illustrating entire set-up.

4.6. Service and supply systems

Functional description of all external supply systems that have fixed connections to the irradiation facility, subdivided into:

4.6.1. Electrical power supply systems
4.6.2. (Make-up) water supply system
4.6.3. (Service) gas supply systems

Each description has to indicate anticipated consumption rates (of power, water, air, gases, etc.).

4.7. Waste systems

Functional description of all systems for waste retrieval that are permanently connected to the irradiation facility, subdivided into:

4.7.1. Off-gas system
4.7.2. Water disposal system(s)

Each description has to include a specification of the anticipated amount and category of radioactive waste of waste to be generated from the experiment and description of pre-disposal plans for storage or disposition and activity of the effluents disposed under:

— Normal operation;
— Specific measures or actions;
— Emergency ~~situations~~.

4.8. Shielding

Description of shielding provisions and specifications of anticipated radiation levels in service areas during:

— Normal operation including post-irradiation handling;
— Specific measures or actions;
— Emergency ~~situations~~.

5. Characteristics[2]

5.1. Nuclear characteristics

— Specification of anticipated fluence values;
— Description of (or reference to) measurements and/or calculations made to verify fluence characteristics:
  (a) Prior to irradiation;
  (b) During irradiation (dosimetry).
— Reference to or summary of calculated and applied nuclear data.

[2] The main section of the report is to contain mostly the results (tables, graphs) of the various calculations. Detailed calculations are to be reported either in appendices to the safety report or in separate reports, which will be referred to in the safety analysis report of the utilization project.

5.2. Reactivity and criticality characteristics

Specification (based upon calculation and/or measurement) of:

- Criticality aspects;
- Total reactivity worth of the experiment;
- Reactivity effect of the in-core experimental facility for non-fixed experiments;
- Reactivity effect associated with voids which can be filled with water in case of leakage;
- Reactivity aspects in case of fast movement of the experimental facility;
- Effect on the reactivity worth of the control and safety systems.

5.3. Radioactivity characteristics

Inventory of radioisotopes generated and ~~C~~calculation of total activity of radionuclides produced in:

- Irradiation target (if fissionable, specify all noble gases, halogens, actinides and other dangerous nuclides);
- Gases or liquids that may escape as a result of containment failure;
- Structural parts of in-pile assembly.

All calculations to be relevant for the end of the anticipated irradiation period:

- Calculation of the decrease in activity owing to decay of the major activity contributors at the end of irradiation and 10 h, 10 d and 100 d after the end of irradiation.

5.4. Thermohydraulic characteristics

- Calculation of specific heating rates (due to nuclear fission and radiation heating) of all in-core materials;
- Calculation of:
  - Radial and axial heat flux density and temperature distribution;
  - Coolant temperature increase.
- Calculation of temperature control margin that can be achieved by the available control systems (heaters, mixed gas systems);

— Calculation of the margins to the thermohydraulic critical phenomena under the worst possible operating conditions (i.e. maximum power, minimum cooling, etc.), applying all relevant uncertainty (hot spot) factors. A justification of the correlation(s) used has to be provided.

Remark:

All calculations are to be made for all operational states and cooling conditions as well as for accident conditions and reactor shutdown conditions.

5.5. Mechanical and thermal stress characteristics

The calculation methods and the applied criteria are to be described for all safety related mechanical components. The tensile, thermal and admissible stresses are to be presented and particular consideration is to be given to:

— Transient behaviour;
— Containment lids;
— Cryogenic material behaviour;
— Standard gas supply pressures.

6. Fabrication, assembly and commissioning

6.1. Fabrication

6.2. Assembly

6.3. Commissioning

Summarized description of the quality programme, with, inter alia, inspection of incoming goods, inspection and testing during assembling and final inspection and testing to which the irradiation facility will be subjected prior to operation. The detailed management system programme is to be documented separately, i.e. in a quality assurance or quality control report and a commissioning report.

7. Operation, maintenance and periodic testing

7.1. General

Outline of the startup, operation, special measurements and emergency procedures: The detailed operation and handling are to be specified in a separate ‘operations and handling manual’. Special periodic testing requirements and maintenance procedures to be performed by the project engineer are to be described. In case of extensive programmes, reference could be made to a special document.

7.2. Operational experience

Summary of the relevant operational experience during the execution of comparable irradiation experiments in the past: Aspects to be mentioned are reactor behaviour during operation, experience in loading and unloading of experimental devices and which improvements were implemented or could be introduced.

8. Handling, dismantling, transport and disposal

Outline of the various handling procedures, for both normal conditions and abnormal conditions (e.g. target failure) with a description of (or reference to) special tools or containers that have to be used; specification of the transport container, and means to be used for transport within or off the site, and summary of specific container criteria required by national legislation and international regulations.

9. Post-irradiation examination

Description (summary) of post-irradiation examination of targets (i.e. dismantling mode, scientific measurements) and/or the irradiation facility. Specification as to whether the post-irradiation examination is scheduled to be performed at the research reactor itself or ~~at another research institute~~at an off-site facility.

10. Safety analysis

In this section, the postulated initiating events for the experiment are to be presented and the consequences, including effects of experiment failures on the reactor, of the postulated initiating events are to be analysed for all operational states and accident conditions of the reactor~~, in which analysis the single failure criterion is to be applied~~. The safety analysis for the experiment also needs to include an analysis of the damage that would be caused to the experimental devices by the postulated initiating events of the reactor and the overall consequences (i.e. combined consequences of the reactor accident and resulting experiment failure). The postulated initiating events are not to be restricted to the experimental facility, but also possible internal and external hazards that affect both the experimental facility and the reactor (e.g. internal flooding or seismic events). ~~as defined for the reactor itself or~~ Postulated initiating events for similar experiments at other research reactors are also considered and ~~to be~~ analysed.

The safety analyses need to be such as to demonstrate adequate fulfilment of the safety functions and prove that neither conduct of the experiment nor any failure would result in unacceptable conventional hazards and/or radiological hazards to site personnel and the public, in major disturbances to the operation of the reactor and (other) experimental facilities, in damage to the reactor or experimental facilities or in reduced access to the reactor, experimental facilities or the reactor building.

For the purpose of design basis accidents, the single failure criterion applied to the safety systems and safety support systems are to be considered in the analysis. For design extension conditions, additional failures may be assumed.

The safety analysis is to include at least the following subjects:

- — Target failure;
- — Failure of (some) containment(s);
- — Cooling (system) failure;
- — Electrical power failure;
- — Failures of instruments;
- — Failures of services (e.g. electricity supply);
- — Failures of (other) components;
- — Operating errors;
- — Handling errors;
- — Applicable internal and external events.

Annex III
EXAMPLES OF MODIFICATIONS THAT CAN RESULT IN INTERFACE ISSUES

III–1. The following list provides some examples of modifications that could potentially result in an adverse impact on either facility safety or security if not adequately reviewed or properly managed. The listing is not all-inclusive, but provides some pointers to the types of activities that can result in interface issues:

— Modifications that could cause a loss of power to systems relied upon for safety or security;
— Modifications resulting in the installation or removal of a barrier that could adversely impact safety, security, emergency or contingency response;
— Modifications involving the placement of heavy equipment, industrial materials or temporary structures that could:
  - Obstruct detection, assessment or response functions;
  - Aid or otherwise provide advantage to an adversary in the completion of a malicious act;
  - Increase the response times of security personnel or those involved in emergency response;
  - Prevent operator access to equipment important to facility safety or prevent timely completion of manual operator actions credited in safety analyses;
  - Prevent access of mobile emergency equipment (e.g. fire truck or ambulance).
— Modifications involving the installation of a chemical or hazardous material plant or storage facilities adjacent to or intersecting with:
  - A security central alarm station or other security post;
  - A protected security response position;
  - A security or emergency pathway;
  - Facility equipment important to safety;
  - Facility equipment important to security.
— Construction activities associated with a modification that remove or degrade physical barriers, thus allowing established access controls to be bypassed;
— Modifications involving addition to, removal from or relocation of theft or sabotage targets (nuclear/ radioactive materials or equipment relied on for safety).

Annex IV
EXAMPLES OF SAFETY FOCUSED QUESTIONS AND SECURITY FOCUSED QUESTIONS

IV–1. The following are examples of safety focused questions on proposed modifications to the physical protection system, and of security focused questions on proposed modifications important to safety:

Safety focused questions

- Could the proposed change result in an increase in the frequency of occurrence of an accident previously evaluated in the facility safety analysis?
- Could the proposed change result in an increase in the likelihood of occurrence of a malfunction or failure of a structure, system, or component important to safety previously evaluated in the facility safety analysis?
- Could the proposed change result in an increase in the consequences of an accident previously evaluated in the facility safety analysis?
- Could the proposed change result in an increase in the consequences of a malfunction of a structure, system or component important to safety previously evaluated in the facility safety analysis?
- Could the proposed change create a possibility for an accident of a different type than from any previously evaluated in the facility safety analysis?
- Could the proposed change create a possibility for a malfunction of a structure, system or component important to safety with a different result than from any previously evaluated in the facility safety analysis?
- Could the proposed change result in a design basis limit for a fission product barrier being exceeded or altered (e.g. changes to security measures aimed at preventing sabotage to the fuel cladding, reactor tank, pressure vessel, or confinement or containment structures)?
- Could the proposed change result in a departure from the method of evaluation used in establishing the design bases or in the facility safety analyses?
- Could the proposed change increase the risk of exposure to workers and public?
- Could the proposed change or activity obstruct the mobility of operations or emergency workers to carry out actions for which credit is given in the safety assessment?
- Could the proposed change or activity result in/lead to non-compliance with regulatory authority safety requirements?

Security Focused Questions

— Could the proposed change or activity decrease the reliability or availability of a security system to perform its intended functions?
— Could the proposed change or activity increase the likelihood of malfunctions or failure of security equipment or systems?
— Could the proposed change or activity decrease the effectiveness of security plan or invalidate the site protective strategy (e.g. communications, response timelines and pathways, equipment and systems, or protected response positions)?
— Could the proposed change or activity interfere with detection (i.e. interior and exterior sensors, zone of detection and field of view, alarm communications, or access control systems) and assessment functions?
— Could the proposed change or activity increase the response times of security personnel? (e.g. manmade or natural vehicle barriers, vehicle access control and channelling barriers).
— Could the proposed change or activity decrease delay times for adversaries (e.g. manmade or natural vehicle barriers, vehicle access control and channelling barriers, access delay systems, exterior or interior delay barriers?
— Could the proposed change or activity increase the numbers of, change the configurations of, or create a new theft or sabotage target from those previously evaluated?
— Could the proposed change or activity result in/lead to noncompliance with regulatory authority security requirements?

Annex ~~III~~V

EXAMPLES OF REASONS FOR A MODIFICATION AT A RESEARCH REACTOR

PERIODIC SAFETY REVIEW

~~III~~V–1. Routine reviews of operation (including modifications to hardware and procedures, significant events, operating experience, management and personnel competence) and special reviews following events of major safety significance are the ~~–~~primary means of safety verification. In addition, systematic safety reassessment, termed periodic safety review, is performed to assess the cumulative effects of ~~plant~~ facility ageing and ~~plant~~ facility modifications, operating experience, technical developments and siting aspects. Such reviews include an assessment of the design and operation of the reactor against current safety standards and practices in order to take into account advances in knowledge, and they have the objective of ensuring a high level and continuous improvement of safety throughout the operating lifetime of the research reactor. They are complementary to routine and special safety reviews and do not replace them. Such reviews could lead to an indication that a modification of the existing reactor systems or procedures is necessary to meet current safety standards.

OPERATING EXPERIENCE FROM OTHER FACILITIES

~~III-2.~~V–2. Operating experience from other research reactors, nuclear or non-nuclear facilities using similar structures, systems, components or processes, could be applicable to the design or operation of the research reactor facility. In addition to operating experience assessed during periodic safety reviews, there may be a need to make modifications on a shorter timescale in response to emergent safety considerations.

AGEING

~~III~~V–3~~2~~. Ageing of structures, systems and components or of an experimental facility, obsolescence of equipment, problems relating to spare parts, or experience from maintenance and operation may call for modification of reactor systems and operating procedures. Another incentive for modification may be the availability of new materials or improved components.

UPGRADING

IIIV–43. Reactor systems or reactor operating conditions may be upgraded in response to the need for improved irradiation conditions, more experimental capacity or improved reactor availability.

NEW EXPERIMENTS

IIIV–45. A major reason for modifications is the need to cater for new experiments or to extend existing experiments. Such modifications can entail new hazards.

ADDITIONAL REASONS FOR A MODIFICATION

IIIV–65. The need for modifications may also arise from considerations of reactor economy, fuel availability, human factors or physical protection at the reactor.

IIIV–76. The relevance of these or other considerations for a particular reactor will depend strongly on the reactor type, its age and utilization, and on national safety criteria.

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BODIES FOR THE ENDORSEMENT OF IAEA SAFETY STANDARDS

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