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Safety in the Utilization and Modification of Research Reactors

DRAFT SAFETY GUIDE
DS397

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CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. This Safety Guide was developed under the IAEA programme for safety standards for research reactors, which covers all the important areas of research reactor safety. The Fundamental Safety Principles publication [1] establishes principles for ensuring the protection of workers, the public and the environment. This Safety Guide directly addresses four of these principles, i.e.: responsibility for safety, optimization of protection, limitation of radiation risks to individuals and prevention of accidents[1]. ~~Also~~In addition, ~~the present~~this Safety Guide provides ~~guidance~~ recommendations on ~~implementing~~ meeting the requirements established in the IAEA Safety Requirements on the Safety of Research Reactors~~, NS-R-4~~ [2], for ensuring adequate safety at all stages of the lifetime of a research reactor. In particular, ~~guidance is given~~recommendations are provided on which analyses, verifications and evaluations should be performed to fulfil the safety ~~objectives of the~~ 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~~e present~~ publication supersedes ~~IAEA~~ Safety Series No. 35-G2[2]~~; it is harmonized with the body of IAEA Safety Standards and with the publications being developed within the framework of the IAEA programme on research reactor safety~~. The main changes and adaptations relate to consistency with Ref. [2], the other recently published Safety Guides for research reactors and other relevant safety standards. The feedback from application of ~~the~~ Safety Series No. 35-G2 are also incorporated in the present publication.

1.3. Owing to the particular characteristics of research reactors, ~~the~~ safety aspects relating~~ed~~ to design and operation have been given special emphasis and have been incorporated into Ref. [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

[1] These are p~~P~~rinciples 1, 5, 6 and 8 (see Ref. [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.”

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety in the Utilization and Modification of Research Reactors, Safety Series No. 35-G2, IAEA, Vienna (1994).

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 (Ref. [2], paras 1.11.–1.14), 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.

1.4. The organizations involved in ensuring the safety of research reactors and the protection of site personnel, the public~~, site personnel~~ and the environment have a number of responsibilities ~~which~~ that are interrelated. Most important are the ~~preparation~~ performance of the safety analysis by the operating organization and the ~~safety analysis report by the operating organization and its~~ review and assessment of the safety analysis report by the regulatory body, as well as the ~~production~~ 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 ~~information~~ recommendations on safety analysis and related documentation provided in Ref. [4] and on the review and assessment of nuclear facilities by the regulatory body provided in Ref. [5] ~~has~~ have been taken into account in the preparation of the present Safety Guide. In addition, ~~the present~~this Safety Guide discusses other aspects of experiments and modifications, such as commissioning of research reactors and provisions for radiation protection ~~provisions~~, for which detailed ~~guidance is~~recommendations are provided in Refs [6] and [7]. The 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 ~~publication~~ Safety Guide is to provide ~~practical guidance~~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 ~~and~~ the environment. The present Safety Guide develops the general concepts in these areas, which are presented in ~~the~~ para~~sgraphs~~ 7.85 to 7.92 of Ref. [2] relat~~inged~~ to utilization and modification ~~in the Safety Requirements for Research Reactors [2]~~. Therefore, this Safety Guide should be read in conjunction with Ref. [2].

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

1.6. This Safety Guide ~~gives guidance~~provides recommendations to the operating organization, including external users of ~~a utilization provision~~the research reactor (~~e.g.~~ i.e experimenters)~~, and~~ technical support organizations and other persons involved in utilization and modification projects. It provides ~~guidance~~ recommendations only on the safety implications of ~~research reactor~~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 ~~guidance~~ recommendations provided in this Safety Guide apply~~ies~~ to the utilization of research reactors and to all modifications of research reactors. For some specific, highly complex experimental devices, additional guidance may be necessary. This Safety Guide does not cover experiments in prototype power reactors or experiments performed in ~~operational~~ operating or decommissioned nuclear power plants.

1.8. In the context of this Safety Guide, ~~research reactor~~ 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 connected to the reactor, but may also be located outside the biological shielding or ~~containment or confinement~~outside the reactor building.

1.9. In the context of this Safety Guide, a modification is a deliberate change[4] in, or an addition to, an existing reactor, a ~~reactor~~ structure, system or component or item of~~, piece of equipment,~~ software important to safety, an experiment or an experimental device~~, with potential safety implications~~. ~~It~~ A modification may also involve ~~–~~a change in ~~of~~ safety systems, safety related items, operational limits and conditions, procedures, documentation, or operating conditions for the reactor as well as for experiments.

1.10. The requirements for the utilization or modification~~s~~ (i.e. the experiment or modification project) ~~given~~ established in Ref. [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 ~~as~~ outlined in this Safety

[4] Experiments and experimental facilities ~~that~~ have been approved ~~over time~~in the past~~,~~ or ~~which~~ that have been analysed as a part of the safety analysis report are not considered to be modifications ~~in~~ in the context of the present Safety Guide.

Guide. In ~~minor~~ small ~~-~~projects the ~~particular~~ individual stages may be very simple, but none of ~~them~~ the stages should be omitted.

1.11. Modifications to systems with security aspects should follow the logical sequence outlined in this Safety Guide, but ~~are~~ will also be subject to confidentiality requirements, which are not discussed in this Safety Guide.

1.12. In the case of modifications ~~which~~ that ~~only~~ concern only changes to documentation, the ~~guidance~~ recommendations presented in Section 6 of this ~~publication~~ Safety Guide are not fully applicable. For such modifications, the additional guidance provided in ~~the Safety Guide on the Safety Assessment of Research Reactors and Preparation and Content of the Safety Analysis Report~~Ref. [4] should be considered and followed, as applicable.

1.13. ~~Fundamentals Safety Principles~~Reference [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 security considerations only briefly in paras 3.35 – 3.37 and indicates the actions that need to be taken to incorporate security elements progressively into an effective nuclear security regime for a nuclear power programme. ~~Considerations of N~~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[5] (see Ref. [9] for further information on this issue).

STRUCTURE

~~1.12.~~1.14. This Safety Guide consists of ten sections and three a~~A~~nnexes. In most of these sections, the safety aspects of both the ~~research reactor~~ utilization and modification of research reactors are described together. Section 2 provides ~~guidance~~ recommendations on the management system for the ~~modifications and~~ utilization and modification of a research reactor. Categorization of the experiment or modification provides a basis for selecting the review and approval route; ~~guidance~~ recommendations on these topics ~~is given~~are provided in Section 3. ~~Guidance~~ Recommendations on the design ~~is~~ of experiments or modifications are provided in Section 4, which should be read in conjunction with the relevant requirements of

[5] ~~INTERNATIONAL ATOMIC ENERGY AGENCY "Interface Between Safety and Security in Nuclear Power Plants; INSAG 24; Vienna 2010, gives further information on this issue.~~

Ref. [2]. Sections 5, 6 and 7 provide ~~guidance~~ recommendations on the ~~various~~ activities that should be considered ~~during~~ in the various stages of a typical utilization or modification project. Section 8 covers ~~the~~ additional ~~guidelines~~ recommendations for operational safety of experiments, and Section 9 ~~gives guidance~~provides recommendations on the handling, dismantling, post-irradiation examination and disposal of experimental devices. Section 10 provides ~~guidance~~ recommendations on~~to ensure~~ the safety of out-of-reactor-core experimental devices and modifications.

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

GENERAL

2.1. A documented management system that integrates safety, health, environmental, security[6], quality and economic ~~related~~ objectives ~~for~~ of the operating organization of a research reactor ~~project should be~~ is required to be in place [10]. The documentation of the management system ~~documentation~~ should describe the system that controls the ~~development~~ planning and implementation of all ~~aspects~~ activities at~~of~~ the research reactor ~~project~~throughout its lifetime, including ~~the~~ 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; process implementation; resource management; and measurement, assessment and improvement. In ~~G~~general~~ly~~:

- ~~–~~ Management responsibility includes ~~providing the means and~~the support and commitment of management necessary~~needed~~ to achieve the ~~organization's~~ objectives of the operating organization;
- 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 ~~organization's~~ objectives of the operating organization are identified and made available;

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~~Guide.~~

- Measurement and, assessment and improvement 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.

Further The requirements for the management system requirements are provided established in Ref. [2], paras 4.5–4.13 and in Ref. [910], and further recommendations are. Additional guidance on management systems is provided in Refs [101] and [112].

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

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

- National laws and regulations;
- The requirements of the Rregulatory body requirements;
- Design requirements and assumptions;
- The safety analysis report,
- The oOperationalg limits and conditions;
- The Aadministrative requirements of reactorestablished 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 ~~the~~ 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~~s~~ how these activities are to be assessed, managed, authorized and performed in order to ensure that the objectives of the ~~utilization~~ experiment or modification~~s~~ are met, and safe operation of the research reactor and its safe utilization are ensured. The documentation of the management system ~~description~~ for utilization and modification should ~~cover~~ 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 ~~address~~ cover other management measures, including planning and~~,~~ scheduling of activities, resource allocation and human factors.

2.6. The operating organization has the responsibility ~~to~~ for prepar~~ing~~e and issu~~ing~~e specifications and procedures for ~~the~~ utilization and modification of the research reactor. The reactor manager[7] should be an active participant in the ~~executing~~ implementation and evaluati~~ng~~on ~~the~~ of utilization and modification activities. The detailed responsibilities of the reactor manager are ~~presented~~ set out in paras 2.23~~30~~ and 2.24~~31~~ of this Safety Guide.

IMPLEMENTATION OF ~~THE~~ A UTILIZATION OR MODIFICATION PROJECT

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

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

- Planning and prioritization of work;
- Addressing all relevant regulatory requirements;
- Addressing the requirements derived from the operational limits and conditions;
- Evaluation of the feedback of operational experience from similar utilization or modification projects;

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

– Addressing the maintenance requirements for the ~~utilization~~experiment or the modified system or component;

– Ensuring the availability ~~Providing~~ 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. The management system should include measures to control records essential to the performance and verification of utilization and modification activities through a system for their identification, approval, review, filing, retrieval and disposal.

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

~~2.11. Records essential to the performance and verification of modification or utilization should be controlled through a system for their identification, approval, review, filing, retrieval and disposal.~~

RESOURCE MANAGEMENT

~~2.12.~~2.11. 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~~ing~~ safety related activities and ensuring that these personnel are adequately trained and qualified.

~~2.13.~~2.12. Personnel who are not directly working for the research reactor ~~facility~~ and personnel of contracting organizations who are involved in the utilization ~~and~~ or modification project should be appropriately trained and qualified for the work they are to perform.

~~Contractors~~ Such external personnel ~~-~~should perform their activities under the same controls, and to the same work standards, as ~~facility~~ reactor personnel. ~~Facility~~ Reactor supervisors should review the work of these ~~contractor~~ external personnel during preparation for work, at the job site during performance of the work, and during acceptance testing and inspection.

2.13. The management system of the operating organization ~~on the site~~ should be extended to include suppliers. The operating organization should ensure that the suppliers, manufacturers and designers have in place an effective ~~acceptable~~ management system ~~implemented~~. The operating organization should ensure through audits that the assigned activities are carried out in compliance ~~they comply~~ with the management system~~.~~.

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

MEASUREMENT, ASSESSMENT AND IMPROVEMENT

2.15. Measures should be established for assessment~~s, to determine whether, and for~~ review and verification to determine whether and to ensure that ~~the~~, utilization ~~and~~ or modification activities are accomplished as specified ~~during~~ in the design. ~~These~~ 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 or the reactor ~~records, results and reports~~, including those on the status of non-conformances ~~control~~ 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 ~~the~~ such independent assessments and should ~~define~~ determine and take the necessary actions to implement recommendations and suggestions for improvement.

RESPONSIBILITIES~~Y~~ OF THE PROJECT MANAGER

2.18. The operating organization should assign a~~n individual~~ person, normally a dedicated project manager, 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 ~~the~~ 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 ~~obtain~~ submit the project for~~any necessary~~ review~~s~~ and approval~~s~~, as necessary, by~~from~~ the safety committee(s) or the regulatory body. The ~~A~~advice of ~~outside~~ external specialists and consultants may be ~~used~~ sought in performing these duties.

2.20. The project manager should ensure that any contractor or supplier involved in the preparation or ~~the~~ implementation of ~~the~~ a modification or utilization 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 ~~arising~~ that may arise during or as a result of ~~-~~the project.

2.22. ~~The~~ ~~P~~possible interactions between different utilization or modification projects~~,~~ ~~which~~ that are being implemented or proposed~~,~~ should be considered and analysed.

RESPONSIBILITIES~~Y~~ 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 ~~proposal~~ of the reactor has been demonstrated to be safe, and additional review,

and approval, if required, has been carried out by an appropriate body[8] ~~has been carried out~~ before ~~the~~ implementation of the project commences.

2.24. The reactor manager should be responsible for ensuring that the~~proper~~ scheduling of the implementation of the utilization or modification project does not affect safety~~in a safe manner~~.

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

3.1. All utilization and modification projects should be subjected to a screening process ~~categorization process~~ in order to determine their safety implication and the related safety category of the ~~utilization~~experiment or modification. The screening process should be documented and the selection~~ed~~ of the safety category should be justified~~.~~ Experiments ~~with~~ of a repetitive[9] nature~~, which~~ 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 ~~a change~~modifications with 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 ~~be~~ provide the basis for the ~~authorization~~ review and approval route to be followed for the modification or utilization project. A checklist could facilitate the categorization process. An example of such a checklist is ~~given~~ provided in Annex ~~I~~I.

3.3. For modification projects, the approved safety class~~ification~~ of the relevant structures, systems and components , ~~which is a requirement in~~ (as required in accordance with Ref. [2], paras 6.12 and 6.13) should be used as a first step ~~for~~ in the safety categorization, in order to determine the safety impact of the modification. This is ~~as~~ described in ~~the paragraphs~~paras 3.7 to 3.34 ~~related to~~on the c~~C~~ategorization p~~P~~rocess~~, see below~~.

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

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

3.4. For utilization of a research reactor, 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 ~~for~~ in the safety categorization, in order to determine the safety impact of the utilization. ~~For~~ In ~~the~~ developing~~ment of~~ a safety classification system for ~~the~~ utilization of a research reactor, at ~~least~~ a minimum the following aspects should be taken into account:

- Criticality aspects;
- Reactivity aspects;
- In-core and~~/~~ out of core irradiation;
- Experiments ~~iIn site~~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 ~~P~~potential ~~to lead to~~for a (significant) off-site dose to members of the public.

3.5. The review and approval route for a utilization project should be based on the safety categor~~yization~~ determined for the ~~utilization~~experiment, ~~by~~ for which the nature of the experiment, i.e. a new experiment, a repetitive experiment or isotope production, should be taken into account.~~,~~ ~~s~~See also paras 3.2~~7~~9~~2~~–3.30~~28~~3 for recommendations relating to repetitive experiments.

3.6. The proposal for the classification and categorization ~~of~~ process for modification~~s~~ and utilization projects, including the proposed review and approval route~~s~~ should be submitted to the safety committee(s) for approval ~~-~~and, following ~~after~~ approval by the reactor manager, the proposal should be submitted to the regulatory body for review and approval.

CATEGORIZATION PROCESS

3.7. A more detailed and comprehensive safety assessment should be carried out for those experiments or modifications with a safety class~~ification~~ having potential impact on safety. The result of the detailed safety analysis should indicate the extent of the implications for safety ~~implication,~~ (see paras 3.11~~9~~–3.32~~25~~). The results of the safety analys~~e~~is for ~~the utilization~~ each experiment could be incorporated in the safety analysis report of the research

reactor or might be described in a separate safety analysis report. An example of the content ~~a~~ of the safety analysis report for an experiment is presented in Annex II.

3.8. Modifications and n~~N~~ew experiments should be subjected to the categorization process described in this Safety Guide.

3.9. For repetitive experiments it should be proven that they can utilize earlier approved safety analyses.

3.10. ~~For the determination of~~In determining the potential effect on safety, the consequences ~~on~~ for the reactor itself and the ~~relation~~ interactions with other systems should also be taken into account ~~too~~.

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

– Major effect on safety ~~significance~~: modifications or ~~new~~ experiments~~, which~~that:
  - C~~c~~ould affect the design function or the ability of structures, systems~~,~~ and components to perform its design function as described in the safety analysis; A~~a~~re beyond the licence conditions or beyond the approved safety analysis [10];
  - C~~c~~ould introduce hazards~~, which~~ that have~~are~~ not ~~earlier~~ been previously addressed.

– Significant effect on safety: modifications or experiments~~, which~~ that are within the approved licence conditions and~~,~~ safety analysis ~~and safety analysis report~~, but which require~~s~~ adaptation of the operational limits and conditions [11] and not of the remaining chapters of the safety analyses report, or which need an adaptation of the safety related operating procedures.

– Minor effect on safety: modifications or experiments~~, which~~ that are within the approved licence conditions, safety analysis~~, safety analyses report~~ and~~,~~ operational limits and conditions, ~~and~~ still having significant margins and no effect on the safety

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[10] A modification beyond the licence conditions or beyond the approved safety analysis ~~report~~ ~~are~~ is implicitly also beyond the operational limits and conditions.

[11] ~~Guidance~~ Recommendations on operational limits and conditions ~~is~~ for research reactors are provided in Ref. [1~~2~~3].

system settings and which do not require a change in the safety related operating procedures.

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

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3.12. The classification and categorization process ~~of~~ for modifications and experiments having safety significance should be documented in detail, together with the justification for the ~~proposal~~proposed safety category.

~~Changes~~ Modifications or experiments with a major effect on safety ~~significance~~

3.13. ~~Changes~~ Modifications or experiments with a major effect on safety ~~significance~~ 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 ~~satisfy~~ meet the same requirements as the existing structures, systems and components or existing experimental facilities.

3.14. An assessment of radiation exposure ~~to~~ of the staff expected during or as a result of the project should be prepared. Measures to reduce ~~the~~ exposures based on the principle of optimization of protection~~principle~~[12] should be ~~described~~ determined for all ~~–~~reactor states (i.e. normal operation~~s~~, anticipated operational occurrences and accident conditions), and any potentially necessary mitigation measures should be considered.

3.15. The completed safety documentation for the project should cover the responsibilities and duties of the operating personnel, the ~~the experimental staff~~experimenters and others involved in the project.

3.16. A list of all new or modified safety devices should be included in the safety documentation. Information required for accident ~~evaluation~~ analysis and for determining mitigation measures under ~~emergency~~ accident conditions should also be defined.

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.

3.18. Modifications and experiments having a major effect on safety ~~significance~~ should be reviewed by the ~~reactor~~ safety committee(s) and submitted~~send~~ to the regulatory body for

[12] ~~Guidance~~ Recommendations on~~for~~ applying the ~~optimization~~ principle ~~is~~ of optimization of protection are provided in Ref. [7].

review and approval ~~following~~ in accordance with the same procedures as those applied for the reactor itself.

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

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

~~C~~hanges ~~Modifications or experiments~~ with a significant effect on safety

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

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

3.23. An assessment of radiation exposure ~~to~~ of the staff expected during or as a result of the project should be prepared. Measures to reduce ~~the~~ exposures based on the principle of optimization ~~principle~~of protection[13] should be described for all reactor states~~–~~ and any potentially necessary mitigation measures should be considered.

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

3.25. A list of all new or modified safety devices ~~connected to the reactor~~ should be included in the safety documentation. Information required for accident ~~evaluation~~ analysis and for determining mitigation measures under ~~emergency~~ accident conditions should also be defined.

[13] ~~Guidance~~ Recommendations on~~for~~ applying the principle of optimization ~~principle~~ of protection are~~is~~ provided in Ref. [7].

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

3.27. Modifications and experiments having a significant~~tee~~ effect on safety should be reviewed by the ~~reactor~~ safety committee(s) and ~~send~~ submitted to the regulatory body for review and approval ~~following~~ in accordance with approved procedures.

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

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~~Changes~~ Modifications or experiments with minor safety significance

~~3.28.~~3.29. Many experiments and modifications ~~fall into this category~~are considered to have minor safety significance. ~~Besides the~~Such modifications include small modifications to structures, systems and components.~~,~~ ~~r~~Research reactors are, by their nature, often used for repetitive sample irradiations or for repetitive experiments with minor modifications. ~~The~~ C~~c~~riteria should be defined for repetitive experiments, isotope production or modifications having only minor changes from the original approved design~~,~~ for which ~~might be~~ approval~~ed~~ by the reactor manager would be sufficient without the need for re-submission to the safety committee(s) or to the regulatory body~~, should be defined~~. The ~~guidance given~~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 ~~of large number of samples, (e.g~~for~~. for~~ isotope production or activation analyses should be defined and the ~~) may be regarded as a repetitive experiment. The~~ irradiation facility and the irradiation position (maximum allowable flux) should be specified. The information and documentation ~~, which should~~to be prepared ~~to~~ in support of ~~the~~ a request to conduct an irradiation ~~request~~experiment, as well as ~~and~~ the review and approval route, should also be specified ~~in the procedure~~. 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 ~~minor~~ modifications with minor safety significance approved by the reactor manager should be periodically reviewed by the safety

committee(s) to ensure that there are no disagreements in the interpretation of the criteria for approval.

~~Changes~~ 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 ~~utilization~~ experiment with no effect on safety. Such consideration should be based on a description of the ~~change~~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 ~~kept~~retained, together with the related documentation.

~~3.33.~~3.34. The safety committee(s) should periodically review the ~~approved~~dal ~~-~~records of modifications and experiments with no effect on safety~~-~~, in order to ensure that there are no disagreements ~~exists~~ in the interpretation of the criteria for approval.

SECURITY AND PHYSICAL PROTECTION ASPECTS

~~3.34.~~3.35. Modifications of systems ~~to~~ for protection of the site and installation against sabotage and unauthorized removal of fissile and radioactive material should ~~follow~~ be carried out in accordance with the requirements ~~from~~of the relevant national security authorities ~~of the country~~ and the ~~recommendations~~ guidance ~~given~~ provided in publications in the IAEA Nuclear Security Series[14].

~~3.35.~~3.36. Guidance on the security aspects of modifications ~~on~~ to instrumentation and control systems and software important to safety for research reactors is provided in Ref. [1~~3~~4].

~~3.36.~~3.37. ~~The m~~Modifications carried out on physical protection systems may be described in a separate document and ~~should~~ may need to be kept confidential.

4. GENERAL AND SPECIFIC SAFETY CONSIDERATIONS FOR THE DESIGN OF ~~THE~~ AN ~~UTILIZATION~~ EXPERIMENT OR MODIFICATION

GENERAL CONSIDERATIONS

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

[14] ~~Guidance on nuclear security is presented in the IAEA Nuclear Security Series~~See Refs [1~~3~~ 20~~19~~].

– I~~i~~t can fulfil ~~a necessary~~the task for which it is intended;

– I~~i~~t can be installed and operated without compromising the safety of the research reactor;

– T~~t~~he experiment can be removed or decommissioned without compromising the safety of the research reactor;

– In~~during~~ all operational states the radiation exposure of ~~the~~ site personnel and members of the public will remain~~s~~ within the dose limits and, moreover, in accordance with the principle of optimization ~~principle~~of protection;

– A~~a~~ny equipment can be stored or disposed of safely during its operational lifetime and after decommissioning; ~~and~~

– T~~t~~he amount of radioactive waste is limited to the extent possible ~~and entailed~~ by means of, for example, ~~the~~ appropriate selection of materials.

4.2. The ~~objective of 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~~e~~ the means for placing the experiment in a safe condition without the need for ~~involving~~ activation of the reactor shutdown system.

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

4.4. The design requirements for a utilization or modification project should be defined ~~in an~~ early ~~stage of~~ in the project and should be selected ~~based~~ on the basis of the safety significance of the project. For utilization or modification projects with a major effect on safety ~~significance~~, the design requirements ~~as~~ established for the reactor itself should be taken as the basis.

4.5. The interfaces between ~~nuclear~~ safety and ~~nuclear~~ security should be considered as 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

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

4.7. If modification of the reactor control and shutdown systems ~~is~~ would be 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 ~~significance~~ and should be implemented before the originally proposed modification or experiment is implemented.

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4.8.

~~4.9.~~ 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 ~~using~~ carrying out a critical experiment ~~procedure~~ or by an equivalent method. The design basis accidents for the reactor should also be considered in the evaluation. ~~The reactivity worth of experiments or modified systems should be within the approved operational limits and conditions.~~

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Radiation protection[15]

~~4.10.~~4.9. An ~~utilization~~ experiment or modification should not significantly affect the ~~overall~~ radiation protection programme for the research reactor ~~facility., particularly where doses have already been reduced to levels that are as low as reasonably achievable (optimization principle).~~ The original design 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 ~~–~~, ~~and~~ for all operational states and for accident conditions. If the experiment or modification would otherwise affect the ~~overall~~ radiation protection measures ~~–~~, then additional measures ~~may~~

[15] The ~~basic safety standards~~safety requirements for radiation protection ~~can be found~~are established in Ref. [2~~0~~1]

should be takennecessary to reduce the dose to personnel during the installation of the project, the operation, handling and dismantling of an experiment, or the implementation of a modification project to levels as low as reasoanablye achievable (principle of optimization principleof protection). These Such measures may include the removal of sources of that generate high radiation fields-, the provision of additional shielding and/or the provision of remote handling devices.

4.11.4.10. If the failure of the experimental device or the 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.

4.12.4.11. 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, filters or recirculation. This applies for all stages of the project, including the installation phasestage, for all operational states (i.e. normal operation and, anticipated operational occurrences) and, for removal, storage and shipment of experimental devices or modified systems.

Safety devices

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

4.14.4.13. 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 possibility ofpotential for deleterious detrimental interactions with the reactor protection system should be assessed.

4.15.4.14. If an experiment might create pose a hazard to the reactor or to personnel, the protection and control system of the experiment should be connected to the reactor systems, in order to reduceso that the reactor power level would be reduced or to shut down the reactor shutdown in the event of failure of the experimental device-. The method of effecting this connection should receive special attention and the connection should be qualified as a safety related system. Separate annunciators or other devices should be provided in the control room to notify the operating personnel whenever a safety action occurs is initiated when a safety

system setting of the experiment ~~has been~~is reached. The reactor systems should not be used to control the experiment nor to provide an indication of the progress of the experiment.

~~4.16.~~4.15. If a safety device is ~~only~~ to be used only to protect the experiment itself, or if the experimental device can be permitted to fail without ~~creating~~ causing a hazard to the reactor or to personnel, then the safety device may be assigned ~~have~~ a lower ~~level of~~ safety category~~yization –~~. Such safety devices should not be connected to reactor control and protection systems.

~~4.17.~~4.16. ~~The a~~Annunciators ~~provided~~ should operate at an alarm level below the safety limit of the experiment. This will ~~–~~enable ~~the reactor operator~~operating personnel ~~–~~to take predefined actions to correct the situation.

Heat generation and cooling

~~4.18.~~4.17. Special consideration should be given to the possibility of an experiment or modification affecting the capability ~~of~~ for heat removal from the reactor core.

~~4.19.~~4.18. A dominant cause of failure ~~potential of~~ for many irradiation experiments is related ~~to the possibility of~~ to either excessive heat generation or insufficient cooling. Thus, adequate heat removal under all design basis conditions for the experiment and ~~the design basis accident conditions of~~for the reactor itself~~,~~ should be one of the main aspects ~~to be~~ addressed in ~~any~~ 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 safety margins of the reactor. Particular attention should be given to the calculation of the power distribution in the experimental device, ~~by~~in which all ~~-~~material compositions and the neutron and gamma heat deposition ~~have to~~should be taken into account. ~~These~~Such calculations should be performed for all operational states. ~~Heat generation due to neutron and gamma deposition needs to be considered.~~ Adequate cooling should be provided to ~~limit~~ 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 t~~T~~o reduce the reactor power or ~~shutting~~ to shut down the reactor, as discussed in paras 4.6~~11~~ –4.8~~12~~ –, should be analysed and ~~as~~ensured.

~~4.20.~~4.19. In addition to the above considerations, particular consideration should be given to irradiation of fissile material or moderating material ~~r~~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.~~4.20. Possible effects of high or low pressure in the experimental device~~s~~ or modified system~~s~~ on the reactor should be assessed and appropriate means to ~~limit~~ keep the pressure within acceptable limits should be ensured.

~~4.22.~~4.21. Special precautions should be taken in the design for irradiating material, including their enclosures. Such material~~, that~~ can readily decompose or otherwise change state, or ~~whose~~ its chemical reactivity may be enhanced, producing an overpressure, or gases ~~which~~ that may be flammable and/or explosive.~~,~~ It should be ~~in order to~~ ensured that pressures within the enclosures and chemical concentrations of the target material do not endanger the reactor or~~n~~ the experiment.

Selection of materials

~~4.23.~~4.22. ~~Selection of materials during~~In the design of experiments, the selection of materials should ~~be~~ take~~n~~ into account material compatibility, corrosion, changing of material properties due to irradiation (e.g. creep, embrittlement, radiolytic decomposition), including transmutation of material, differential thermal expansion, ageing effects and ease of decontamination, dismantling and final disposal ~~aspects~~.

~~4.24.~~4.23. ~~Special safety consideration for~~In the design of experiments, particular consideration should be given to the irradiation of corrosive materials (e.g. mercury, rhenium, magnesium) or materials ~~that may have enhanced~~whose corrosive properties may become enhanced as a result of irradiation. For example: materials such as copper~~,~~ and ~~lead,~~ cadmium should not be used without cladding; plastics and other organic or synthetic compounds will disintegrate under irradiation; cadmium, beryllium, silver, boron compounds (e.g. B_4C), and alloys containing these materials, should be used with extreme caution ~~due~~ owing to their neutronic properties. Galvanic effects, in particular those due to interactions ~~-~~between water and aluminium, should also be considered. In particular, the u~~U~~se of mercury should be ~~particularly~~ excluded in ~~facilities~~ research reactors ~~-~~with aluminium components ~~due~~ owing to the extremely corrosive interactions between these elements.

~~4.25.~~4.24. 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.

4.26.4.25. In the design of experiments, Special particular consideration should be given for design of experiments to the provisionde of additional barriers to contain toxic material that could pose a hazard if released; e.g. beryllium is particularly toxic if ingested.

Flux perturbations

4.27.4.26. Consideration should be given to Tthe effects of neutron interactions of neutrons from of an experiment or modified system on with core components, fuel or other experiments. should be considered. Perturbations in the Nneutron flux perturbations 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 must should be carefully assessed.

Protection against external and internal hazards

4.28.4.27. At each stage of the project, Tthe design of the experiments and or modifications should include measures during each stage of the project to withstand or mitigate the effects of external and internal events, e.g. earthquakes, floods, fires and explosions,– as that have been taken into account for the reactor. The design should be reviewed by the appropriate specialist experts and the implementation of the recommendations made should be documented.

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

Mechanical interaction of experiments and the reactor

4.30.4.29. The possible vibration of experimental devices or modified components due to coolant flow should be considered. Special attentionParticular consideration should be paid given to avoiding resonance frequency vibrations at resonance frequency.

Testability and ageing management

4.31.4.30. During In the design, particular consideration special attention should be given to the proper testability of the modification or experiment during the 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.

4.32.4.31. Special attentionParticular consideration should be given to providing appropriate features to support the same level degree of ageing management and Iin Sservice iInspection programme as of for the original system.

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

GENERAL

5.1.Sections 5, 6 and 7 give provide detailed guidance recommendations for the various phases in of a typical modification or utilization project. These guidance recommendations should be followed for a project with a major effect on safety implications. For projects with lesser safety implications, the guidance recommendations should be used withapplied using a graded approach as a basis for development of less restrictive requirements. Figure 1 is shows a flow chart for a project with a major effect on safety implications and shows the relationship between the operating organization and the regulatory body during 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 extentwhere possible. However, the overall responsibility remains at with the operating organization. The following paragraphs provide a detailed discussion of each aspect of Fig.ure 1.

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

5.3. The implementation of Pprojects with minor effect on safety should follow the same steps, but with 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 appliedfollowed.

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

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

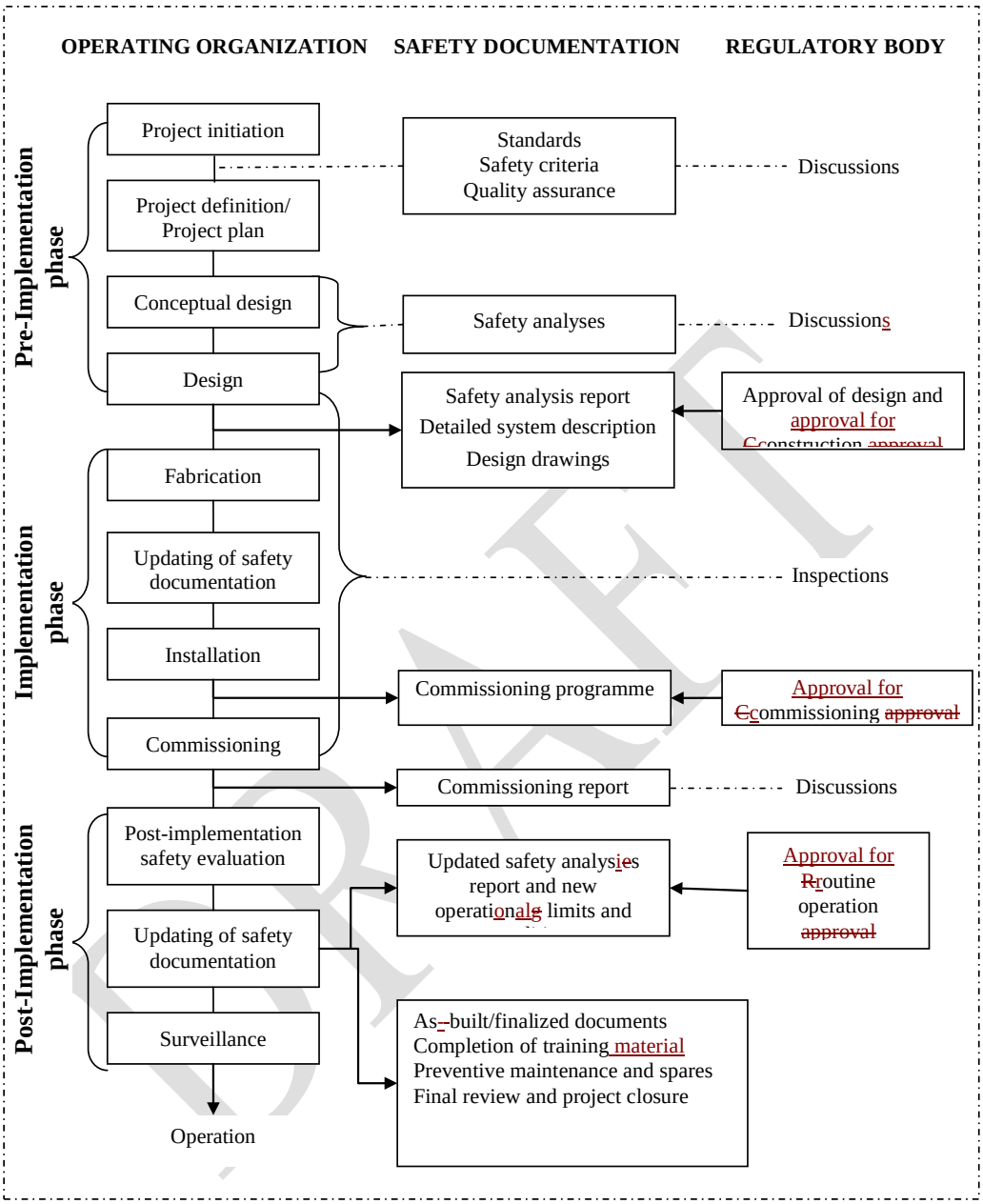

FIG. 1. ~~Stages~~ Phases of a modification or utilization project with a major effect on safety ~~implications~~.

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, ~~external users (~~experimenters~~)~~ ~~and~~ or

equipment suppliers. Modifications can involve changes to safety systems, safety related items, operational limits and conditions, procedures, documentation, or operating conditions for the reactor as well as for experiments~~equipment, reactor operating conditions or procedures~~. Whatever the ~~source of the need~~reason for a modification or an experiment~~utilization~~~~an experiment~~, ~~it is extremely important that~~ the general concept should be discussed by the reactor management and the regulatory body ~~at an~~ early ~~phase of~~in the project. It may also be appropriate to include other groups, such as the safety committee(s), ~~external users (~~experimenters~~)~~, equipment suppliers and independent consultants.

5.7.~~The reasons for M~~modifications ~~to~~ and experiments ~~with~~ at research reactors may also arise from a variety of considerations. These considerations are discussed in Annex III.

PROJECT DEFINITION

5.8.The project definition stage involves ~~the~~ 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 ~~during~~ at this stage.

5.9.~~The project definition stage should also deal with g~~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 ~~during~~ at this stage in order to determine the safety implications ~~of the safety aspects~~ of the project and ~~to determine~~ the ~~authorization~~ review and approval route to be applied.

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

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 given provided in paras 4.1719–4.252, should also form part of such design inputs.

5.13. The existing documentation for the facilityresearch reactor, component or software, including all modifications, is requiredshould be provided to for establishing a pre-design database. A review of this documentation should be made to ensure 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 operational operating and maintenance history of this equipment to verify that the documentation is up to date and that the existing equipment is capable tooof 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 of importancenecessary, 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 elsewhere at other research reactors may provide an important contribution to the pre-design database. Operational Operating experiences, including information on ageing effects, should also be collected.

Pre-design appraisal

5.16. The design process is usually an iterative operationprocess. For each experiments or modifications, several technical options should be evaluated. This appraisal will provide the basis for a subsequent evaluation of the safety and the technical and financial feasibility of the modification or experiment, and for a 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 the operational aspects, including surveillance requirements, as well as decommissioning and disposal aspects. These may determine the degree of interference with normal the reactor under normal operation, anticipated operational occurrences or accident conditions, the required radiological safetyradiation protection precautionsmeasures 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. TheA 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 ~~the~~ other ~~solutions~~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~~, which~~ that have been selected for the project should be ~~sent~~ submitted to the regulatory body for assessment and review, and the associated time ~~-~~schedule should be discussed with the regulatory body ~~in this~~ 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. ~~During~~ At the design stage, the ~~chosen~~ selected option should be developed into a fully documented and justified design ~~of~~ 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 ~~produced~~ prepared at this stage. Requirements for ~~C~~commissioning, post-implementation safety evaluation and surveillance ~~requirements~~ should also be determined ~~during~~ at the design stage (see paras 7.2 and 7.~~6~~5~~6~~).

5.20. Management system criteria ~~on~~ for design control should be established and implemented, covering all aspects of the design, including inspection and testing methods, and construction. ~~For the design, m~~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 individuals other than those who ~~made~~ developed the original design. Further recommendations ~~and guidance~~ are ~~given~~ provided in Section 2.

5.21. Detailed safety analyses should be ~~provided~~ carried out to the extent necessary for the potential hazards. The analyses should be capable of demonstratinge that ~~determine whether~~ the design ~~will be~~is safe, and in particular of showing that:

– Anya new system or component complies with all relevant safety standards and that it will function safely~~,~~ for all ~~conditions of~~ operational states ~~-~~;

– N~~n~~ew systems will not adversely affect the safety characteristics of other items important to safety under any ~~conditions of~~ operational states~~.~~, or the safety relevant characteristics of the reactor;

– The~~an~~ experiment or modification can be carried out without significantly increasing the dose~~s~~ to staff ~~personnel~~ and members of the public; this should be determined in accordance with the principle of optimization of ~~radiation~~ protection ~~optimization principle~~, or with the risk of an accident;

– The~~a~~ modification or experiment can be carried out without adversely affecting the safety of reactor operation;~~,~~ ~~and~~

– ~~a~~Any new hazards introduced by the modification or experiment can be safely managed ~~it will not introduce new hazards~~ at any stage of the project.

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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~~:

– The introduction of the new system ~~does~~ would not adversely affect the consequences, in terms of radiological hazards or other hazards, for any ~~conditions of reactor~~ operational states; ~~and that~~

– The failure of the new system ~~does~~ 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 ~~with~~ for each of the accident sequences considered in the safety analysis report for the reactor~~, should be evaluated~~. The implications of the modification or experiment for the management of potential accidents and ~~of~~ 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 ~~the~~ direct effects on the reactor, but also the effect on ~~the~~ 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 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 ~~of~~ established in Ref. [2] and ~~guidance~~ recommendations provided in Ref. [4]. Attention should be paid to the review and updating~~e~~, 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 ~~facility~~research reactor~~.~~.

5.27. Testing of experimental devices and equipment prior to their installation in the 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 ~~output~~ should also include the following:

- A statement of the objectives to be ~~achieved~~met;~~.~~
- Details of the structure of the organization set up for the project and the responsibilities of the ~~involved~~ 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 reactor at the ~~different~~ various phases of the project;~~.~~
- The necessary design calculations, drawings and specifications for the complete project;~~.~~
- The ~~staff~~ training programme designed to enable staff to cope with anticipated operational occurrences during the implementation of the project. (~~The s~~Staff should also be informed about the special safety considerations and provisions that apply~~ing~~ during the various stages of the project.)
- ~~The preparation of all d~~Documentation, such as procedures for the ~~amended~~ modified state of the reactor, including any new or temporary emergency procedures and the associated ~~staff~~ training programme;~~.~~

– A plan for commissioning ~~plan~~ to verify that the design objectives have been achieved;~~.~~

– An outline of the ~~-~~preliminary decommissioning plan;~~.~~

– A special surveillance programme, including ageing management and i~~I~~n ~~-~~s~~S~~ervice i~~I~~nspection requirements, if necessary (see para. 7.5~~6~~). ~~It should be demonstrated that the system is safe during s~~Such surveillance should be used to demonstrate the continued safety of the reactor systems;

– An overview of the safety related spare parts ~~which~~ that should be available before ~~the~~ implementation of the modification or utilization project.

5.29. For ageing management, ~~the project should follow~~ the relevant ~~guidance~~ recommendations in Ref. [22]~~in the IAEA Safety Standards~~ should be followed.[16]

5.30. For decommissioning, dismantling and removal of major reactor components, ~~the project should follow~~ the relevant ~~guidance~~ recommendations in Ref. [23]~~in the IAEA Safety Standards Series~~ should be followed.[17]

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. 3.1~~9~~3 should be considered at this stage.

6. IMPLEMENTATION PHASE OF A MODIFICATION OR UTILIZATION PROJECT

GENERAL

6.1. This section covers the fabrication, installation and commissioning stages of the implementation phase of the approved modification or utilization project. Not all recommendations provided will be~~are~~ relevant for some projects, for example in cases where the project ~~only~~ involves only changes to procedures.

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

[16] ~~Further guidance on ageing management is given in Ref. [21].~~

[17] ~~For further guidance, see the IAEA safety standards on radioactive waste management, in particular Decommissioning of Nuclear Power Plants and Research Reactors, Safety Series No. WS-G-2.1, IAEA, Vienna (1999) [22].~~

6.3. Nevertheless, if the outcome of a certain stage could places 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 controlled procurement of materials, for the controlled development, revision and use of documents and drawings, for the controlled processing of materials, and for the inspection of such activities.

6.5. New components or existing components ones that have to be modified are generally fabricated or modified by suppliers in accordance with the detailed specifications that have been established during 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 particular constraints of the project, including management system criteria (see para. 5.20). Preliminary visits to the supplier are generally indispensable.

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

6.7. During fabrication, technical audits and quality audits should be conducted in order to check and handle all aspects of fabrication, such as deviations from specifications, quality control and deadlines.

INSTALLATION OF THE UTILIZATION OR MODIFICATION PROJECT

6.8. Measures should be established for the control of the installation of equipment, and for any potential hazards, e.g. 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 has have been obtained and before the relevant staff involved in the installation has 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 reactor is placed in a safe state before commencing the activity.

Management

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

- Clear identification of all responsibilities, including those relating~~ed~~ to ~~the~~ management system procedures and ~~radiological~~ radiation protection~~.~~;
- Frequent meetings to inform on progress~~/~~ and exchange information ~~meetings~~ with all staff (i.e. technical, operational and health physics~~)~~ staff) involved in or affected by the ~~implementation~~project;~~.~~
- Clear procedures with respect to the control (i.e. reporting, assessment and disposition) of deviations from approved methods and specifications or from ~~the~~ expected behaviour;~~.~~
- Clear procedures to ensure that no foreign objects, e.g. assembly or ~~/~~installation tools and equipment, have been left ~~inside the boundary for~~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 and procedures;~~.~~
- Training and provision of information to operating personnel and external ~~staff~~ 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 ~~which~~ that may require a revision of the working practices and the project planning.

Safety aspects

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

6.13. If temporary equipment ~~have~~ has to be installed, the external and internal events ~~which~~ 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~~s~~ 4.28~~4 and 4.25~~).

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

- External exposure to radiation;
- Identification of the hazards and the steps to be taken to control the hazards in order to minimize the risk to personnel, the reactor and ~~its~~ the reactor systems and the environment;~~.~~
- ~~Radioactive waste~~ M~~m~~anagement of radioactive waste, including transport, decontamination and dismantling aspects, as applicable;
- Provisions required to prevent the spread of contamination and internal exposure to radiation;
- Safe storage of the fuel, radioactive materials , 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)~~,~~ ~~which~~ that are necessary for implementation of a modification or experiment~~,~~ should be documented and should be made subject to approval~~ed~~ by the reactor manager before they ~~will be~~are applied.

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

COMMISSIONING[18]

6.17. Commissioning of an approved modification or utilization 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.

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

6.19. The safety of a~~n implemented~~ modification or experiment that is to be implemented should be verified through a commissioning programme involving tests and checks, measurements and evaluations prior to and during implementation of the modification or experiment. The requirements of ~~NS-R-4 (~~Ref. [2], paras 7.42–7.50~~,)~~ are also applicable for the commissioning of a modification or experiment.

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

- Determination (by measurement under realistic conditions ~~during~~ met in normal operation as well as under transient conditions to the extent possible) of all reactor characteristic relevant to safety with respect to the ~~changed~~ modified system;
- Demonstration that the ~~unchanged~~ reactor systems that have not been modified (in particular all items important to safety) ~~are~~ will not be compromised;
- Verification (on the basis of measured data) of the relevant safety parameters ~~,~~and proper ~~operation~~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 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 ~~ever~~ necessary ~~during~~ throughout the commissioning process.

[18] Additional ~~guidance~~ recommendations for the commissioning process and for the ~~different~~ various stages of commissioning ~~stages~~ for large modifications ~~can be found~~are provided in Ref. [6].

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

6.23. The need for ~~a~~ formal approval of the commissioning results and permission for operation with the experiment or with the modified system should be considered ~~in~~ at this stage.

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 ~~utilization~~ experiment or modification for routine operation should be the successful completion of all stages of ~~the~~ commissioning ~~stage~~, and the verification of all information and experience against the requirements as specified ~~for~~ in the design. The results of the commissioning tests and the as-built drawings and documentation should be reviewed in accordance with ~~standing~~ existing procedures, to demonstrate that the modification or experiment has been built in a manner that conforms to the approved specifications and to ~~assure~~ 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~~ed~~ in accordance with established procedure.

UPDATING OF SAFETY DOCUMENTATION

7.3. ~~The r~~Revision of the safety documentation and the safety analysis report, as mentioned in ~~Section~~ para. 5.26, should be ~~reviewed and revised~~carried out as appropriate, to include the as-built description of the utilization or modification, taking 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~~ed~~ by the reactor manager.

7.4. If the safety documentation has been revised, the approval and distribution of the documentation should ~~follow~~ be carried out in accordance with the approved procedures on

the basised ofn the safety significance of the utilization experiment or modification. This could require involvement of the reactor 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 safety justification for certain modifications and experiments may be dependent on technical or material characteristics that may be affected by in long term reactor operation through 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 to for monitoring the behaviour of the relevant characteristics. Any special surveillance requirements determined during at the design stage (see paras 5.16 and 5.28) should be implemented.

8. OPERATIONAL SAFETY GUIDELINES FOROF EXPERIMENTS AT A RESEARCH REACTOR

8.1. Although the guidance recommendations presented provided in the following paragraphs are in principle applicable for both modifications as well as forand experiments, for modification projects or and for major utilization projects the guidance recommendations for a new research reactor facility should be followed where applicable, (see Refs [3] [4] [6] [7] [132] [212] and [234]).

RADIATION PROTECTION

8.2. Experiments at research reactors can present significant radiological hazards for persons conducting the experiments, for operating personnel and, in some cases, for persons outside the facilityresearch reactor. In addition to the design, which should be such as to minimize these radiological hazards and which is supportedbacked up 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 experiments and that include operating instructions for the experimentm.

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

- Operating procedures for ~~the~~se experiments;
- Rules and instructions for ~~radiological~~ radiation protection associated with the performance of the experiment ~~in the facility~~; and
- Emergency plans and procedures.

8.5. ~~The a~~Areas in which there can be significant radiation levels during reactor operation and during reactor shutdown ~~down~~, such as ~~the radiation fields created~~areas close to ~~by~~ open beam tubes, reactor loops or ~~handling of~~ irradiated materials, should be determined before reactor startup. Such areas should be categorized as controlled and supervised areas in accordance with Ref [2, 20]~~.~~. After reactor startup, a radiation survey (of alph~~f~~a, gamma and neutron radiation) should be made~~,~~ ~~which~~ that covers especially the area ~~of~~ around the experiment. The actual radiation fields should be measured, displayed and, where~~n~~ appropriate, recorded. Where necessary, ~~the~~ such areas should be cordoned off or physically secured to prevent inadvertent or unauthorized access, and appropriate radiation warning signs should be placed.

INFORMATION NECESSARY FOR SAFE PERFORMANCE OF EXPERIMENTS

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

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

8.8. For every experiment the ~~reactor~~ operating personnel and experimenters should have available the necessary information ~~available necessary~~ 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 ~~of~~ that these limits ~~being~~ are approached or exceeded ~~-~~should be clearly

stated in written instructions. These actions should~~will~~ 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 ~~which~~ who can~~will~~ be called upon for advice if difficulties arise.

8.9. The limiting conditions –both for the reactor ~~as well as~~and for the experiment to ~~as~~ensure safe operation, as well as the procedures for handling and operation of the experiment, should be subject to approval~~ed~~ by the reactor manager. ~~Special attention~~Particular consideration should be given to the approval of limiting conditions and procedures relating to the startup of the reactor or the experiment, transient conditions and emergency situations.

8.10. Records should be kept of material, samples, equipment and devices ~~put~~ inserted into the reactor, and ~~they~~ 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 ~~OPERATORS~~OPERATING PERSONNEL

8.11. To ensure safe operation of ~~the~~ experimental devices, ~~requires that~~ the experimenter and the operating personnel will need to work closely together. Special arrangements should be considered for startup of the reactor or the experimental device, such as –any special handling~~s~~ ~~required~~ necessary by the operating personnel or the experimenter~~,~~ or operation outside the normal schedule of either the experimental device or the reactor. Procedures should be prepared, made subject to approval~~ed~~ 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 in experimental areas to indicate that the reactor is operating;~~,~~
- The use of dedicated communication provisions;

– Contact details of persons ~~to be~~who can be contacted after working hours if special actions are required.

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

8.12. ~~Coordination between T~~the activities of experimenters and the ~~reactor~~ operating personnel should be ~~maintained~~ coordinated also 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 ~~operator~~ operating personnel should be available at all times, and the actual status of the experiment should always be known to the operat~~or~~ing personnel. These ~~needs~~ provisions ~~are~~ should be put in place in addition~~al~~ to ~~the~~ design provisions.

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

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OPERATIONAL CHANGES IN EXPERIMENTS

~~8.12.~~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 modifications, and the ~~guidance~~ recommendations given in this Safety Guide should be followed.

RESPONSIBILITY FOR SAFE OPERATION OF EXPERIMENTS

~~8.13.~~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 ~~have~~ 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 ~~stoppage of~~stopping any experiment ~~which~~ that the manager considers hazardous and placing~~e~~ it in a safe condition.

~~8.14.~~8.16. Experimenters should report any deviation from normal operation of their experiment directly to the operating personnel.

8.15.8.17. ~~In~~ As part of his or her responsibility for ~~all~~ safety ~~issues~~, including all safety aspects of experiments, the reactor manager should enforce any safety rule or any limitations to ~~the~~ experiments if necessary to ensure the safe operation of both the experiment and the reactor, as well as to ensure the safety of ~~the~~ staff.

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

8.17.8.19. The responsibilities of the operating personnel and the experimenters should be clearly defined and made subject to approval~~ed~~ 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 ~~as per~~ 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~~ation~~ and storage or disposal of irradiated equipment. The activity and contamination of irradiated equipment should be evaluated in advance, under each of two assumptions:

- T~~t~~he most probable course of the experiment; ~~and~~
- T~~t~~he worst possible combination of equipment failures and human errors.

9.3. ~~The r~~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 ~~(i.e.~~ 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, ~~exposures~~ 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 ~~release~~ give rise to airborne contamination, a handling process to prevent this ~~release~~ should be developed and put in place~~,~~ (e.g. by keeping the ~~material~~ equipment in leak tight 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 ~~presented~~ established in Ref. [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.

SPECIFIC ~~RECOMMENDATIONS~~GUIDANCE~~RECOMMENDATIONS~~

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 ~~throughout the time of~~during the handling, dismantling, post-irradiation examination and storage of the irradiated equipment or ~~elements~~ 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 ~~with~~ using mock-ups, before work with irradiated objects is ~~undertaken~~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, ~~of the materials to be stored~~ 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 ~~group of out-of-reactor-core installations includes two categories~~: those ~~which~~ that utilize the radiation produced by the reactor but are located~~which are~~ outside the reactor (biological) shielding (e.g. a neutron spectrometer)~~;~~ and those ~~which~~ that are at or near the reactor and which do not utilize the radiation produced by the reactor, but which constitute a potential hazard (e.g. a cryostat ~~for the generation of~~containing liquid nitrogen).

10.2. Both groups of installations should be subjected to the categorization process as described in paras 3.7–3.~~25~~34.

10.3. For the out-of-reactor core installations ~~which~~that constitute a potential hazard, in addition an analysis of '~~"~~conventional~~"~~' safety ~~impact~~, analyses should be performed~~,~~ to identify~~ing~~ 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 ~~reactor~~ safety committee(s), if required, the safety analysis should be reviewed in accordance~~ing to~~ with management system procedures by appropriate specialists, e.g. in the field of occupational hazards, chemical hazards and~~,~~ electrical hazards~~, etc.~~.

10.5. The ~~reactor manager should approve 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 ~~significance,~~ (i.e. major, significant) the proposal should be submitted to the ~~reactor~~ safety committee(s) and to the regulatory body for review and approval of the analysis, as appropriate.

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ANNEX I

EXAMPLE OF A CHECKLIST FOR ~~THE~~ CATEGORIZATION OF AN EXPERIMENT OR MODIFICATION ~~OR UTILIZATION PROJECT~~ AT A RESEARCH REACTOR

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Form ~~should~~ to be completed by the designated p~~P~~roject m~~M~~anager			
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Part 1 - Description of the Modification or ~~Utilization~~Experiment

Describe the Modification or ~~Utilization~~Experiment

Describe the modification or ~~activity~~ experiment to be undertaken, or refer to other documentation, e.g. p~~P~~roject i~~I~~nitiation ~~D~~document.

Part 2 - Safety Screening

Screening Questions *(tick the appropriate box)*

No.	Question	Answer		Justification
1	Does the proposed modification or ~~utilization activity~~experiment involve a change to, or an effect on, a structure, system or component (SSC) 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 ~~utilization activity~~ involve a change to a procedure that could affect how the design functions of ~~structures, systems and components~~SSCs described in the safety analysis report are performed or controlled?	☐ Yes	☐ No	

3	Does the proposed modification or experiment ~~utilization activity~~ involve revising or replacing an evaluation methodology described in the safety analysis report, used in establishing the design bases or used in the safety analyses?	☐ Yes	☐ No	
4	Does the proposed modification or experiment ~~utilization activity~~ involve a test, experiment or activity not described in the safety analysis report, where an SSC is utilized or controlled in a manner that is outside the reference bounds of the design for that SSC, 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? • S~~s~~afety analysis report? • O~~perating Limits and Conditions (o~~perational 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 "NO".** ~~The proposed change does have minor effect on safety.~~			☐
	1A	If the proposed modification or experiment ~~utilization~~ falls within the lowest safety classification, ~~than~~then Safety Category 4 '~~"~~n~~N~~o effect on s~~S~~afety~~"~~' ~~should be~~is recommended. Go to Part 4 Safety Categorization.		☐
	1B	If the proposed modification or experiment ~~utilization~~ falls within a higher safety classification, ~~than~~then Safety Category 3 '~~"~~m~~M~~inor effect on ~~S~~safety'~~"~~ ~~should be~~is recommended. Go to Part 4 Safety Categorization.		☐
2	**At least one question has been answered "YES".** A ~~S~~safety ~~E~~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**.			☐

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Part 3 - Safety Evaluation				
Evaluation Questions *(tick the box for the appropriate answer)*				
Effect ~~on~~ 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 previously evaluated in the safety analysis report?	☐ Yes	☐ No	
2	Could the proposed change affect the consequences of a design basis accident previously evaluated in the safety analysis report?	☐ Yes	☐ No	
3	Could the proposed change affect the likelihood of occurrence of a malfunction of an SSC important to safety previously evaluated in the safety analysis report?	☐ Yes	☐ No	
4	Could the proposed change affect the consequences of a malfunction of an SSC important to safety previously evaluated in the safety analysis report?	☐ Yes	☐ No	
Potential for ~~Creation~~ 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 an SSC 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 S~~s~~afety A~~a~~nalysis R~~r~~eport				
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 S~~s~~afety A~~a~~nalysis ~~r~~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 bas~~e~~is 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 ~~q~~Questions 1 to 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, ~~which~~ that impacts the safety case in a way not considered in Questions 1 to 8 above?	☐ Yes	☐ No	
12	Does the proposed change require a change to the reactor Procedures, other than an editorial or typographic change, ~~which~~ that impacts the safety case in a way not considered in Questions 1 to 8 above?	☐ Yes	☐ No	
Result of the Safety Evaluation *(tick the appropriate box)*				
All the questions have been answered "NO". The proposed change will have a significant effect on safety. Safety Category 2 '"~~s~~Significant effect on ~~S~~safety'" ~~should be~~is recommended. **Go to Part 4 Safety Categorization**.				☐
At least one question has been answered "YES". The proposed change ~~does~~ will have a major effect on safety. Safety Category 1 '"m~~M~~ajor effect on s~~S~~afety'" ~~should be~~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 ~~A~~ THE SAFETY ANALYSIS REPORT FOR AN EXPERIMENT AT A RESEARCH REACTOR

GENERAL

II-1. The following list of topics ~~is~~ sets out the minimum requirement for the table of contents of ~~a~~the safety analysis report ~~Safety Analysis Report~~ for an experiment. The topics ~~should~~ are to be discussed using a graded approach based on the safety category~~ization~~ of the experiment, as defined in ~~chapter~~ Section 3 of this Safety Guide. The topics ~~which~~ that are not relevant for the safety analysis report of the utilization project should be ~~mentioned~~ indicated with the remark “not applicable”.

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

~~II-1.~~II-3. Furthermore, the safety analysis report for the utilization project ~~should~~ has to include figures, sketches and/or flow diagrams indicating overall dimensions, masses–, temperatures and pressures. All computer codes used ~~should~~ are to be fully validated and benchmarked for their specific application and valid references ~~must~~ have to be given. A summary has to be provided at the beginning of the safety analysis report.

1. INTRODUCTION

Short description of:

- ~~p~~Purpose of the utilization project;
- G~~g~~eneral nature of the irradiation target;
- G~~g~~eneral nature of the irradiation facility;
- I~~i~~f applicable, reference to earlier experiments or periodic review of the safety analysis report for the utilization project.

2. EXPERIMENTAL REQUIREMENTS

Specification of required:

- N~~n~~uclear conditions (fluence-, radiation -heating, linear power);

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- Pprocess conditions (target environment, temperature distribution, pressure characteristics);
- Oon-line measurements;
- Ooff-line measuring or inspection possibilities.

3. IRRADIATION TARGET

- Detailed description (materials, composition, dimensions, special features);
- The cCodes and standards applied (e.g. ASME, RCC-M, RCC-MR, etc.);
- Thermal and mechanical characteristics;
- Design drawing;
- Fabrication method and quality procedures[19].

4. IRRADIATION FACILITY

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

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, giving showing vertical and horizontal cross sections;
- Detailed assembly drawing (including parts list, list of used materials used and material specifications).

Remarks

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

4.2. Radiation shielding

- Functional description of the experimental facility, including all components (e.g. thermocouples, heaters);
- Sketches, giving 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 must need to be submitted to the rReactor Mmanager.

[19] A detailed description of the quality control procedures that are applied, is needed 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 which that are of importance for the determination ofimportant for determining uncertainty factors in the safety analyses must have to be specified.

b. A complete description of all joints, penetrations, etc. that~~which~~ are part of the safety containment(s) ~~must~~ has to be provided.

4.3. External system(s)

- Functional description of all components, classified into sub-systems, 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
- G~~g~~eneral description of the different groups of instrumentation.

4.4.2. Safety instrumentation (essential to ensure safe operation of the experiment)
- D~~d~~esign of the safety instrumentation;
- C~~c~~onnection/interference with the reactor protection system, and (i~~I~~nterlock instrumentation~~)~~;
- C~~c~~onnections with the experiment;
- C~~c~~omponents and diagrams.

4.4.3. Process instrumentation
- O~~o~~bjective of the process instrumentation;
- C~~c~~omponents and diagrams.

4.4.4~~5~~. Scientific instrumentation
- O~~o~~bjective of the scientific instrumentation;
- Ceomponents and diagrams.

4.4.5~~6~~. Additional experimental instrumentation
- ~~i~~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 ~~total~~ entire set-up.

4.6. Service and s~~S~~upply s~~S~~ystems

Functional description of all external supply systems ~~which~~ 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 ~~should~~ has to indicate anticipated consumption rates (of power, water, air, gasses, etc.~~helium~~) ~~consumption rate~~.

4.7. Waste systems

Functional description of all systems for waste retrieval~~,~~ ~~which~~ 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 ~~should~~ has to include a specification of the anticipated amount and radioactivity content of the effluents disposed under:

- N~~n~~ormal operation;
- S~~s~~pecific measures or actions;
- E~~e~~mergency situations.

4.8. Shielding

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

- N~~n~~ormal operation including post irradiation handling;
- S~~s~~pecific measures or actions;
- E~~e~~mergency situations.

5. CHARACTERISTICS[20]

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.

5.2. Reactivity and criticality characteristics

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

a. ~~c~~Criticality aspects;~~,~~
b. Total reactivity worth of the experiment;
c. R~~r~~eactivity effect of the ~~entire~~ in-core experimental facility for non-fixed e~~E~~xperiments
d R~~r~~eactivity effect associated with voids which can be filled with water in case of leakage;~~,~~
e~~d~~. R~~r~~eactivity aspects in case of fast movement of the experimental facility~~,~~
f~~e~~. E~~e~~ffect on the -reactivity worth of the control and safety systems.

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5.3. Radioactivity characteristics

Calculation of total activity of radio-nuclides produced in:

- I~~i~~rradiation target (if fissionable, specify all noble gases, halogens, actinides and other dangerous nuclides);
- G~~g~~ases~~,~~ or liquids~~,~~ ~~which~~ that may escape ~~due~~ as a result of~~to~~ containment failure;
- S~~s~~tructural parts of in-pile assembly.

[20] The main section of the report ~~should~~ is to contain mostly ~~contain~~ the results (tables, graphs) of the various calculations. Detailed calculations ~~should~~ are to ~~either~~ 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.

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

- Ccalculation of the decrease in radioactivity due owing to decay of the major activity contributors at the end of irradiation, and 10 hours, 10 days and 100 days after the end of irradiation.

5.4. Thermalhydraulic characteristics

- Calculation of specific heating rates (due to nuclear fission and radiation nuclear heating) of all in-core materials.;
- Calculation of:
  a. Rradial and axial heat flux density and temperature distribution;
  b. Ccoolant temperature increase.
- Calculation of temperature control margin which that can be achieved by the available control systems (heaters, mixed gas systems);.
- Calculation of the margins to the thermalhydraulic 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 must has to be givenprovided.

Remark:
All calculations are to be made for nominal reactor power,all operational states and cooling conditions as well as during for accident conditions and reactor shutdown powerconditions.

5.5. Mechanical and thermal stress characteristics

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

- Ttransient behaviour;
- Ccontainment lids;
- Ccryogenic material behaviour;
- Sstandard 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 aliaamongst others, inspection of incoming goods inspection, 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 must is to be documented separately be documented, 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 ~~must~~ are to be specified in a separate '~~"~~o~~O~~perations and h~~H~~andling m~~M~~anual'~~"~~.
In this section, 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 ~~E~~experience

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

8. HANDLING, DISMANTLING, TRANSPORT AND DISPOSAL

Outline of the various handling procedures, ~~both~~ for both normal conditions and abnormal ~~(e.g. target failure)~~ conditions (e.g. target failure) with description of (or reference to) special tools or~~,~~ containers ~~which must~~that have to be ~~applied~~used.
Specify~~y~~ication of the transport container and ~~facilities~~ means –to be used for ~~internal or external~~ transport within or off the site and summary~~ize~~ of specific container criteria required by ~~(inter-)~~national legislation and international regulations.

9. POST IRRADIATION EXAMINATION

Description (summary) of post irradiation examination of targets (i.e. dismantling mode, scientific measurements) ~~of targets~~ and/or the irradiation facility. ~~Indicate if~~Specification whether the post irradiation examination~~PIE~~ is scheduled to be ~~done~~ performed at the ~~institute~~ research reactor itself or ~~in~~ at another research institute.

10. SAFETY ANALYSIS

~~10.1. Failure analysis~~

In this section the ~~consequences~~ postulated initiating events ~~(PIEs)~~ for the experiment ~~should~~are to be presented and the consequences of the ~~PIE's~~ postulated initiating events ~~should~~are to be analysed for all operational states of the reactor, by which ~~a~~the single failure ~~principle~~criterion is to ~~should~~ be applied. The ~~PIEs should~~postulated initiating events are not be restricted to the experimental facility, but also possible internal and external hazards as defined for the reactor itself or ~~from~~for ~~other~~similar experiments at other reactors ~~should~~are to be analysed.
~~.~~The safety~~failure~~ analyses ~~should~~need to be such as to prove ~~must show~~ that neither conduct ~~operation~~ of the experiment nor any ~~such~~ failure ~~will~~ would ~~not~~ result in ~~intolerable~~ unacceptable conventional and/or radiological hazards to personnel, in major disturbances ~~in~~ to the operation of reactor and (other) experimental facilities, in damage to the reactor or

experimental facilities or in reduced access to reactor, experimental facilities or reactor building.

The ~~failure~~ safety analyses ~~will should~~is to include at least ~~treat~~ the following subjects:

- Target failure;
- Failure of (some) ~~safety~~ containment(s);
- Cooling (system) failure;
- Electrical power failure;
- ~~Instrumentation f~~Failures of instruments;
- ~~Utility f~~Failures of services (e.g. electricity supply);
- ~~(other) Component F~~failures of (other) components;
- Operating errors;
- Handling errors;
- Applicable internal and external events.

~~10.2. Enveloping Design Base Accident~~

~~In this section the consequences are treated of the worst combination of two simultaneously occurring but mutually independent failure-failure (or failure-human error) situations. All other systems and components not directly affected by the postulated failure, may be assumed to be functioning correctly. In this analysis, the total and sudden failure of structural components, which have been designed and are operating under conditions within the safety limits of accepted (and applicable) mechanical codes, are supposed to occur but each failure mode or human error must be "credible". The design basis accident as considered for the research reactor should be taken into account for the analyses.~~

~~The enveloping design basis accident analysis must prove that the postulated double failure does not result in intolerable health hazards to personnel or in damage to reactor core or reactor systems. The results must remain within the envelope of the Safety Analysis of the reactor.~~

ANNEX III:
EXAMPLES OF REASONS FOR A MODIFICATION AT A RESEARCH REACTOR

PERIODIC SAFETY REVIEW

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

AGEING

III-2. Ageing of ~~SSC~~ structures, systems or components or of an experimental facility, obsolescence of equipment, problems relating~~ed~~ to spare parts, or experience from maintenance and operation may call for modification of reactor systems and operati~~o~~ng~~al~~ procedures. Another incentive for ~~such~~ modification may be the availability of new materials or improved components.

UPGRADING

III-3. 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

III-4. 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

III-5. The need for modifications may also arise from considerations of reactor economy, fuel availability, human factors~~, and~~ or physical security at the reactor.

III-6. The relevance of these or other considerations ~~to~~ for a particular reactor will depend~~s~~ strongly on the reactor type, its age and utilization, and on national safety criteria.

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