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SAFETY
STANDARDS
SERIES

Modifications to
Nuclear Power Plants

SAFETY GUIDE

No. NS-G-2.3

INTERNATIONAL
ATOMIC ENERGY AGENCY
VIENNA

IAEA SAFETY RELATED PUBLICATIONS

IAEA SAFETY STANDARDS

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MODIFICATIONS TO
NUCLEAR POWER PLANTS

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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

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FOREWORD

By Yukiya Amano
Director General

One of the statutory functions of the IAEA is to establish or adopt standards of safety for the protection of health, life and property in the development and application of nuclear energy for peaceful purposes, and to provide for the application of these standards to its own operations as well as to assisted operations and, at the request of the parties, to operations under any bilateral or multilateral arrangement, or, at the request of a State, to any of that State's activities in the field of nuclear energy.

The following advisory bodies oversee the development of safety standards: the Commission for Safety Standards (CSS); the Nuclear Safety Standards Committee (NUSSC); the Radiation Safety Standards Committee (RASSC); the Transport Safety Standards Committee (TRANSSC); and the Waste Safety Standards Committee (WASSC). Member States are widely represented on these committees.

In order to ensure the broadest international consensus, safety standards are also submitted to all Member States for comment before approval by the IAEA Board of Governors (for Safety Fundamentals and Safety Requirements) or, on behalf of the Director General, by the Publications Committee (for Safety Guides).

The IAEA's safety standards are not legally binding on Member States but may be adopted by them, at their own discretion, for use in national regulations in respect of their own activities. The standards are binding on the IAEA in relation to its own operations and on States in relation to operations assisted by the IAEA. Any State wishing to enter into an agreement with the IAEA for its assistance in connection with the siting, design, construction, commissioning, operation or decommissioning of a nuclear facility or any other activities will be required to follow those parts of the safety standards that pertain to the activities to be covered by the agreement. However, it should be recalled that the final decisions and legal responsibilities in any licensing procedures rest with the States.

Although the safety standards establish an essential basis for safety, the incorporation of more detailed requirements, in accordance with national practice, may also be necessary. Moreover, there will generally be special aspects that need to be assessed on a case by case basis.

The physical protection of fissile and radioactive materials and of nuclear power plants as a whole is mentioned where appropriate but is not treated in detail; obligations of States in this respect should be addressed on the basis of the relevant instruments and publications developed under the auspices of the IAEA. Non-radiological aspects of industrial safety and environmental protection are also not explicitly considered; it is recognized that States should fulfill their international undertakings and obligations in relation to these.

The requirements and recommendations set forth in the IAEA safety standards might not be fully satisfied by some facilities built to earlier standards. Decisions on the way in which the safety standards are applied to such facilities will be taken by

IAEA, while not legally binding, are developed with the aim of ensuring that the peaceful uses of nuclear energy and of radioactive materials are undertaken in a manner that enables States to meet their obligations under generally accepted principles of international law and rules such as those relating to environmental protection. According to one such general principle, the territory of a State must not be used in such a way as to cause damage in another State. States thus have an obligation of diligence and standard of care.

Civil nuclear activities conducted within the jurisdiction of States are, as any other activities, subject to obligations to which States may subscribe under international conventions, in addition to generally accepted principles of international law. States are expected to adopt within their national legal systems such legislation (including regulations) and other standards and measures as may be necessary to fulfill all of their international obligations effectively.

EDITORIAL NOTE

An appendix, when included, is considered to form an integral part of the standard and to have the same status as the main text. Annexes, footnotes and bibliographies, if included, are used to provide additional information or practical examples that might be helpful to the user.

The safety standards use the form 'shall' in making statements about requirements, responsibilities and obligations. Use of the form 'should' denotes recommendations of a desired option.

The English version of the text is the authoritative version.

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1. INTRODUCTION

BACKGROUND

1.1. This Safety Guide was prepared under the IAEA's programme for safety standards for nuclear power plants. It supplements Section 4 (Requirements 10 and 11) of Ref. Safety of Nuclear Power Plants: Commissioning and Operation, Safety Standards Series No. SSR-2/2 (Rev. 1) [1] and section 4 (Requirement 6: Integration of the management system, 4.13) of Ref. Leadership and Management for Safety GST Part 2 [4], which establishes the safety requirements for the modification of nuclear power plants including changes of the operating organization. This publication is a revision of the IAEA Safety Guide on Modifications to Nuclear Power Plants issued in 2001 as IAEA Safety Standards Series No. NS-G-2.3.

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1.2. The reasons for carrying out modifications to nuclear power plants may include:

1. maintaining, or strengthening existing safety provisions and thus maintaining consistency with or improving on the current design;
2. recovering from plant faults;
3. improving the thermal performance or increasing the power rating of the plant;
4. increasing the maintainability of the plant or modifying the maintenance strategy
5. reducing the radiation exposure of personnel;
6. addressing the findings of periodic safety reviews;
7. extending the design life of the plant.

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1.2 A Most modifications, made on the basis of operating experience, are intended to improve the design, or improve operational performance and flexibility. Some modifications are rendered necessary by reviews of the adequacy of the design against changes in internal and external hazards, new regulatory requirements, ageing of the plant, obsolescence, lack of spare parts for equipment, advances in knowledge, or improvements in technology. However, the benefits of regularly updating the plant design can be jeopardized if modifications are not kept under rigorous control throughout the lifetime of the plant.

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1.3. The need to reduce costs and improve efficiency without compromising safety of the plant, in combination with changes to the structure of the electricity generation sector of the economy in many countries, has led many companies to make changes to the structure of the operating organization for nuclear power plants. Organizational

changes should be treated as modifications as they can affect safety.

OBJECTIVE

1.4. The objective of this Safety Guide is to provide guidance and recommendations on controlling activities relating to modifications at nuclear power plants in order to reduce risk and to ensure that the configuration of the plant is at all times under control and that the modified configuration conforms to the approved basis for granting a nuclear power plant operating license. The main purpose of the recommendations concerning organizational changes is to give general guidance on performing those changes, in such a way that the safety of the plant is not compromised. In addition the application of the recommendations of this safety guide will support the fostering of a strong safety culture.

SCOPE

1.5. This Safety Guide deals with the intended modification of structures, systems and components, structure and components of the operating organization, safety related documentation (e.g. operational limits and conditions), software, and the management systems for the operation of a nuclear power plant. The recommendations made cover the whole modification process, from conception to completion with consideration of human and organizational factors.

1.6. The modifications made during the design phase are outside the scope of this Safety Guide.

1.7. The modification and/or refurbishment of nuclear power plants for the purpose of extending the design lifetime could necessitate many major design modifications and special re-evaluation of plant safety, Ref. Periodic Safety Review of Operational Nuclear Power Plants, Safety Standards Series No. SSG-25 [2], and is therefore outside the scope of this publication.

1.7.A The relationship and obligations of the licensee to the regulator are outside the scope of this guide. The extent of the regulatory body's involvement in the modification process should depend on the safety significance of the modification, consistent with the relevant national regulations. Ref. Governmental, Legal and Regulatory Framework for Safety Standards Series No. GSR part 1 (Rev. 1) [5].

STRUCTURE

1.8. Section 2 gives guidance on the general methods for the management of modifications that could be implemented at nuclear power plants. Section 3

identifies the roles and responsibilities of various organizations involved in the modification process. Sections 4 and 5 give guidance on the different types of modification and their assessment in respect of safety aspects. Section 6 deals with aspects of temporary modifications. Sections 7 and 8 give guidance on implementation of different types of modifications. Sections 9, 10 and 11 give recommendations on the application of the management system, training and management of documentation. Appendix I provides recommendations for the criteria to categorize modifications based on their importance to safety. Appendix II provides recommendations for the overall modification process.

2. MODIFICATION PROGRAMME

2.1. Requirement 11 of Ref.[1] states “The operating organization shall establish and implement a programme to manage modifications. Throughout its lifetime, the operating organization should regularly inspect, test and maintain the plant, in accordance with approved procedures, to ensure that the plant continues to meet the design requirements and remains consistent with the assumptions and results of the safety analysis.

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2.2. The management of plant modifications should be consistent with plant configuration management control principles, i.e. modifications should conform to the design requirements and to the plant configuration documentation throughout the plant lifetime Ref.[1].

2.2.A. The need for modification should be assessed based on: operational experience, the findings of periodic safety reviews and other relevant safety assessments, current safety objectives, regulatory requirements, the adequacy of the design basis for internal and external hazards, advances in knowledge and/or improvements in technology.

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2.2.B. When the need for a modification is established based on safety reasons, the modification should be designed and implemented in a time frame that is consistent with the safety significance. Reasonably practicable or achievable safety improvements should be implemented in a timely manner. In case a modification cannot be implemented promptly, adequate temporary modifications should be put in place until the permanent modification is fully implemented.

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2.3. No modification to a nuclear power plant, whether temporary or permanent, should affect the plant’s ability to be operated safely in accordance with the assumptions and intent of the design.

2.4. Management of the modification should be the responsibility of the operating organization.. The roles and responsibilities of the organizations involved in the

modification process are considered in Section 3.

2.5. Proposed modifications should be categorized and prioritized according to their safety significance. This categorization should follow an established procedure. The initial category proposed should be checked independently (Appendix I).

2.6. Modifications which may affect safety should be distinguished into:

- (a) Modifications directly relating to plant configuration, i.e. :
 - Modifications to structures, systems and components or process software; including the relevant documentation
 - Modifications to the operational limits and conditions;
 - Modifications to operating procedures;
 - A combination of these.
- (b) Modifications to the operating organization:
 - Changes in organizational structures or resources;
 - Modification of operational management programmes;
 - Modifications relating to safety assessment tools and processes, including improved knowledge of physical phenomena (from the results of research and development);
 - A combination of these.

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2.6.A An example modification process is shown in Appendix II. The process distinguishes between plant configuration (technical, document and procedural) modifications related to the NPP design and management system (safety related organizational) changes.

2.6.B During the modification process, changes in the supply chain of product or services should be considered.

2.6.C Non-safety relevant modifications should be documented. It should be demonstrated by the operating organization that these modifications do not affect safety.

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2.7. Modifications to computer based systems and their hardware and software should be controlled using the same principles and methods that apply generally to modifications. However, in some cases issues may arise which uniquely affect computer based applications, and these should be taken into account in the procedure for modifications Ref. Design of Instrumentation and Control Systems for Nuclear Power Plants, Safety Standards Series No. SSG-39 [7].

2.8. When modifications are proposed, they should be reviewed to ensure consistency with the corresponding design requirements and assumptions. The safety of the plant should be reassessed for the modified configuration and/or the new

conditions of the plant. Previous plant modifications and inputs on the basis of experience in the industry should not be inadvertently negated by modifications. It should be ensured that the various steps shown in Fig. AII.1 have been completed. Appropriate justification should be given for each modification and this should be assessed before the modification is made.

2.9. When a specific modification is determined to be necessary, the full consequences of this modification for the safety of the plant should be reviewed and the boundaries of the modifications including physical, system, control, environment, etc., should be defined. Since many systems within the plant are interrelated, a modification in one area may affect other areas. A full review should therefore be performed before the final definition of the areas in which modifications should be applied. Wherever possible, experience from other plants at which similar modifications have been made should be taken into account.

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2.9 A Modifications and their phases should be planned taking into account e.g. the scope and significance of the modification, involved organisations and responsibilities, interactions between organizations, interfaces to security, modification phases and contents of the phases, input and output data for modification phases, structure of documentation, procedures to be applied, plans and programmes to be applied, utilization of previous experience, licensee activities, application of the graded approach and items requiring special attention, witness and hold points, reporting.

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2.10. Modifications relating to the configuration of the plant and the operational limits and conditions should comply with the safety requirements for design of Ref. Safety of Nuclear Power Plants: Design, Safety Standards Series No. SSR-2/1 (Rev. 1) [3]. In particular, the capability to perform all safety functions should be maintained.

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2.10.A The operating organization's safety policy towards modifications should be based on: maintaining the protection of the barriers to radioactive release; strengthening the independence between the levels of the defence in depth and an adequate reliability of each level during operation, as a consequence of all modifications and related operational activities. The influence of human and organizational factors on one, several or all barriers and levels of defence in depth should be considered in all operational activities related to modifications, to avoid adverse effects on the reliability of the barriers and levels and the independence between the levels.

2.10.B A defence in depth approach should be applied to all operational activities related to modifications of the plant. The modification activities should be carefully planned, appropriately authorized and carried out in accordance with approved

procedures by competent staff, implementing management system practices to achieve a high level of safety performance. In addition, adequate independent safety assessments and verifications should be carried out when designing and implementing modifications, to ensure their reliable accomplishment.

2.11. Plant modifications should be performed in accordance with established procedures, with due consideration given to the application of the management system in Ref. Leadership and Management for Safety, GSR Part 2 [4]. Installation of modified systems and/or equipment should be performed in accordance with the work control system and appropriate testing procedures for the plant.

2.12. Before being placed in service, plant modifications should be tested and checked to demonstrate that the design intent and the correct configuration of the plant is met. For some modifications, this should be done following an established commissioning programme. All relevant documents necessary for the operation of the modified plant should be updated and personnel should be trained as appropriate.

2.13. The modifications should at all times be under the control of the plant management or its representatives.

2.13.A Modifications to design features or equipment used for design extension conditions, including mobile and portable equipment should be performed in accordance with the plant modification processes, procedures and/or required safety assessment, as appropriate.

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3. ROLES AND RESPONSIBILITIES

OPERATING ORGANIZATION

3.1. The operating organization should retain the responsibility for the safety implications of the modification and for obtaining the appropriate review and approval.

3.1 A The operating organization should apply for the necessary license or approval to execute the modification by the regulatory body if needed.

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3.2. The operating organization should establish a procedure to ensure the proper design, review, control and implementation of all permanent and temporary modifications. Observance of operational limits and conditions and compliance with

applicable codes and standards should be ensured by means of this procedure.

3.3. The operating organization should ensure that the appropriate safety analyses have been performed before implementation of the modification is commenced.

3.4. Where an independent safety review of the scope and safety implications of proposed modifications is needed it should be carried out by personnel who are not involved in the design and implementation of the modifications.

3.5. The operating organization should arrange for the availability of competent personnel to assist in design studies and development work for modifications on plant items important to safety. These personnel should be called upon to provide assistance in the preparation of specifications for modifications, the assessment of proposed designs and the supervision of the engineering work. Special arrangements should be made to support the plant management in activities relating to plant modifications.

3.6. The operating organization should ensure that modifications are carried out in the correct sequence, since subsequent modifications may be dependent upon the completion of previous modifications in a particular sequence.

3.7. The operating organization should ensure that the applicable measures of the management system are applied to the modification. Requirements on this subject can be found in Ref.[4].

3.8. The operating organization should carry out systematic reviews of safety to confirm that the safety analysis for the plant remains valid by considering the cumulative effects of modifications, relating to the configuration of the plant, or to management systems. This systematic review should be done regularly and also included in the scope of periodic safety reviews Ref.[2].

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3.9. The operating organization should ensure that the appropriate revisions to **plant documentation**, personnel training and plant simulators necessitated by the modifications are implemented in a complete, correct and timely manner as part of the implementation process.

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3.10. The operating organization should take into account the feedback from experience gained in making a modification at a plant for the first time, prior to making the modification in other parts of the plant or at other plants.

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CONTRACTORS AND OTHER EXTERNAL ORGANIZATIONS

3.17. While the operating organization may delegate or subcontract the engineering, assessment and execution of certain tasks for modifications to other organizations it should remain the body responsible for safety. The operating organization should have staff with sufficient technical knowledge to guide and evaluate any work performed on its behalf.

3.18. When contractors are involved in making modifications, the professional competence, experience and qualifications of all personnel involved should be confirmed, and it should be ensured that the quality assurance complies with the standards in effect at the plant.

3.19. In assessing the consequences of a specific modification for the design and for safety, the design organization, architect engineers and constructing organization should be consulted as appropriate in order to provide assurance that the design basis is preserved following the modification.

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4. MODIFICATIONS RELATING TO PLANT CONFIGURATION

4.1. Modifications relating to plant configuration are defined for the purposes of this Safety Guide as any permanent or temporary alterations to structures, systems and components, process software, operational limits and conditions, or plant configuration documentation. This includes any replacement or refurbishment of existing structures, systems and components. This does not include the replacement of a component by an equivalent component in recognized maintenance activities. In this context, an equivalent component is either one which is identical with the original component or one for which a safety assessment has previously been made and confirmed, in accordance with the procedure for control of modifications, so that it can be considered an equivalent replacement for the original component,

because it meets the same design requirements.

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CATEGORIZATION OF MODIFICATIONS BY SAFETY SIGNIFICANCE

4.3. The proposed modification should be categorized in accordance with its safety significance and the impact on nuclear and radiation safety.

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4.6. The principles for managing modifications are the same for all categories, but in each step of the modification process the categorization of the modifications determines the depth and breadth of the safety review which should be applied.

4.7. The criteria applicable in determining the categorization for each specific modification should be defined and documented in order to enable correct assessment of the potential effect on safety during implementation, test and operation of the modification even if the modified SSC is not safety classified.

SAFETY ASSESSMENT

4.8. An initial safety assessment should be carried out before starting a modification to determine whether the proposed modification has any consequences for safety. Human and organizational factors should also be considered when assessing the modification. This initial assessment should be carried out by trained and qualified personnel, taking a systematic approach, and should be reviewed by an independent safety expert. The implementation phase for the modification (including the radiological hazard) as well as plant operation after the modification should be considered in the assessment at this stage. The result of the initial safety assessment should lead to a decision on the categorization of the proposed modifications, as described in Appendix I.

4.9. Depending on the results of the initial safety assessment, a more detailed and comprehensive safety assessment may be needed. The extent and complexity of the additional assessment that is necessary will depend on the nature and extent of the consequences of the modification for safety. If the initial assessment has clearly demonstrated that the modification will have no consequences for safety, either as or after the modification is made, then further safety assessment may not be necessary.

4.9.A Modifications affecting redundant safety related SSCs should be subjected to a

comprehensive safety assessment with particular consideration given to avoiding the possibility of common cause, or common mode failures. To reduce operational risks, implementation of such modifications should be performed in a phased sequence in order to collect operating experience and system test results on the first redundant train or part of the system, before proceeding to modify the other equivalent redundant trains, or parts of the system.

4.9.B For multiple unit plant sites, the safety assessment for the modification process should take account of the potential for internal and external hazards to give rise to impacts on several, or all units on the site simultaneously. ^[1]_{SEP} Modifications proposed to enhance safety by providing interconnections between units should be assessed to show that the modification does not affect the safety systems design where each unit is expected to have its own safety systems and to have its own safety features for design extension condition Ref.[3].

4.10. The comprehensive safety assessment should include an evaluation of the effect of the modification on radiological hazards during its implementation and during subsequent commissioning, testing, maintenance and operation of the modified plant. This evaluation should include the effect of the modified plant item and its associated system on physically adjacent systems and plant items, and on interconnected systems or support systems such as electrical power supplies.

4.11. It should be demonstrated by means of the comprehensive safety assessment that the modified plant can be operated safely and complies with the system specifications and safety requirements. Special consideration should be given to showing the following:

- Compliance with all relevant safety standards for all conditions of operation is achieved;
- Interfaces to security;
- New and/or modified systems will not adversely affect the safety characteristics of other items important to safety under any conditions of operation;
- Due account has been taken of the potential consequences if the modification is inadequately implemented;
- The modification can be carried out without significantly increasing either the doses to personnel and members of the public (in accordance with the as low as reasonably achievable (ALARA) principle) or the risk of an accident;
- The modification can be carried out without adversely affecting the safety of the plant and will not introduce new hazards;
- The technical or operational relationship of the modified system with each of the affected accident sequences considered in the safety analysis report has been adequately assessed; Each identified failure-mode of the modified system has been assessed by appropriate evaluation methods. Care should be taken that

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- not only the direct effects on the plant are included in the assessment, but also the effects on items important to safety, such as safety systems and safety related systems and items;
- The impact of potential external events and/or the consequences of inadequate qualification of the structures, systems and components to withstand them has been assessed and/or analysed;
 - The environmental impact has been evaluated and considered;
 - The consequences for safety of the process of implementing the modifications and the threat by any temporary equipment to normal operation, or the ability to withstand anticipated operational occurrences and accidents, have been considered;
 - The potential interaction with other design changes has been reviewed to ensure reliable control of the configuration after implementation of the modification, because a later change may depend upon whether an earlier proposed change has already been made;
 - The scope of commissioning testing follows system specifications and requirements;
 - The radioactive waste arising from the plant modification will be properly managed;
 - The need to temporarily disable any safety related plant interlocks, or to suspend any operating restrictions has been fully assessed, prior to implementation and steps are in place to ensure the prompt reversal and reinstatement of such measures as are necessary;
 - In the case where a modification has already been implemented in a similar unit (fleet of NPP units at different sites), the differences between the units has been properly assessed before design documentation, implementation procedures, or test procedures have been duplicated.

4.12. The comprehensive safety assessment should include a re-evaluation of the deterministic safety analysis and the probabilistic safety analysis, applying the applicable standards for safety evaluation, taking into account uncertainties in data etc.

4.12A. The results of the re-evaluations from the deterministic and probabilistic analyses should then be used to inform the conservative decision-making process. The results of the analysis can also be used to decide on associated compensatory, or additional risk reduction measures.

4.12B. A risk informed approach should be used to assess possible alternate solutions to a proposed modification and to evaluate their impact on nuclear safety. This should be based on information, or insights from the probabilistic safety analysis results, the deterministic analysis, engineering judgement and operational experience feedback.

REVIEW OF PROPOSED MODIFICATIONS

4.13. The scope, safety implications and consequences of proposed modifications should be reviewed by personnel not involved in their design or implementation. These reviewers should include representatives of the operators and engineering personnel, the design organization, safety experts, and other technical or managerial advisers. The latter may also include independent external advisors particularly for major modifications, as necessary to ensure that a full and adequately informed discussion of the modification, including all its safety implications for the plant, can be held. These reviews should also include independent validation and verification of software changes for major modifications.

4.14. Proposals for modifications submitted for independent assessment should comply with criteria specified by the operating organization in accordance with the management system requirements. The submissions should specify the functional requirements and safety requirements for the proposed modifications and should show how these are to be met. The amount of information needed will depend on the extent and complexity of the modification; however, submissions should include at least the following:

- A description of the design and justification of the proposed modification;
- Sketches, drawings and list of materials;
- Specifications for parts and materials;
- Applicable codes, standards and updated sections of the safety analysis report;
- Safety assessment, and proposed modification of the operating limits and conditions, if any;
- An analysis of adverse environmental or operating conditions, including any implications for radioactive waste, any contamination, any release of radioactivity and any exposure to radiation;
- A description of the methods of fabrication, installation and testing, including the methods of validation and verification for process software;
- Specification of the operational state of the plant, or parts thereof, necessary to implement the modification;
- Statement of requirements for the assurance of quality in the management system;
- Description of the equipment qualification, testing and commissioning programme for tests to be performed after implementation;
- Description of changes to the safety related plant maintenance arrangements;
- Description how to determine the effectiveness and the achievement of the objectives of the modification.

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4.14.A The results of the modification safety assessments should be reviewed by the safety committee (or an organization with similar responsibilities) and approved by the

operating organization.

DESIGN CONSIDERATIONS

4.15. When modifications are identified, their compatibility with the design intent and characteristics should be assessed.

4.16. The modifications should, whenever possible, minimize the deviations from the characteristics and intent of the design. When such deviations are inevitable, they should be evaluated against the safety requirements for design Ref.[3] and should be shown to be acceptable. It should be ensured that, once established, the corrected design requirements are justified and maintained and made available to all parties (operators, contractors) involved in the implementation of the modification.

4.16. A The designated entity within the operating organization that takes responsibility for the design i.e. the design authority should formally approve all design changes. Ref. The Operating Organization for Nuclear Power Plants, Safety Standards Series No. NS-G-2.4 [9].

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4.17. The detailed design of modifications should specify requirements for construction, installation, commissioning, equipment qualification, testing, including test acceptance criteria, and maintenance during operation. The information necessary for this is similar to the specifications in para. 4.14.

4.18. Modifications relating to plant configuration should conform to the provisions set forth in the safety requirements for design Ref.[3], and the associated Safety Guides. In particular, the capability of performing all safety functions shall not be degraded.

MODIFICATIONS TO THE OPERATIONAL LIMITS AND CONDITIONS

4.19. Where alterations to the operational limits and conditions become necessary, they should be considered to be modifications of high safety significance (see para. 4.5). Detailed information on operational limits and conditions can be found in Ref. Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants, Safety Standards Series No. NS-G-2.2 [6].

4.20. Operational limits and conditions should be reassessed and revised, as necessary, following any safety related modifications at the plant or any changes to the safety analysis report, and also on the basis of accumulated experience and technological developments. Results of routine tests or commissioning tests also

necessitate analysis and consideration of the need for modifications to operational limits and conditions.

4.21. Where it is necessary to modify operational limits and conditions temporarily, for example, in order to perform physics tests on a new core, particular care should be taken to ensure that the effects of the changes are analysed. The modified state, although temporary, should undergo assessment and approval at the same level as for a permanent modification. Where a permanent approach is available as a reasonable alternative, this should be preferred to a temporary modification of operational limits and conditions.

MODIFICATIONS TO THE PROCEDURES AND DOCUMENTATION

4.22. Modifications to the procedures and documentation should be categorized according to their safety significance. Detailed safety assessments should be carried out when required.

4.23. Any modifications to the procedures and documentation should be made in accordance with the procedures governing its preparation. Modified documents should be verified and validated before use. Any other documents affected by the modifications should be revised and operators should be trained in the revised documents, especially operating procedures.

MODIFICATIONS TO COMPUTER BASED SYSTEMS

4.24. A structured change process under an effective system for configuration management should be in place to govern both hardware and software changes, including hardware upgrades and equivalent replacements, prior to the implementation of the change. Strict configuration control should be maintained throughout modification processes for software, in particular to resolve any conflicts resulting from modifications being carried out simultaneously. Only those items that have been through the entire change process should be installed in the plant equipment Ref.[7].

4.25. For modifications to be carried out on computer systems, in particular software, the procedure for configuration management should include provisions for a comprehensive validation and verification process to establish the suitability of the changes for operation. More information on management of the software configuration can be found in Ref.[7].

4.26. Software faults are frequently systematic rather than random, and therefore the possible common mode failure of computer based safety systems that employ redundant systems using identical versions of the software should be fully considered

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during the modification process.

CONFIGURATION CONTROL

4.27. Consistency should be ensured between modifications, design requirements and plant documentation. In addition, when modifications are made to structures, systems and components and process software, the relevant **plant documentation** should be modified accordingly. When modifications are to be made to the operational limits and conditions, the associated operating instructions and procedures should usually be modified accordingly, and in some cases the associated structures, systems and components may also be subject to modification.

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4.27.A Configuration management should be used to ensure that the implementation of the modification is in accordance with the design requirements as established in the design documentation.

4.28. Consideration should be given to the need to revise procedures, training and provisions for plant simulators or training facilities as part of the implementation of the modification. Revised procedures should include **operating procedures** for normal operation, emergency **operating procedures**, surveillance and maintenance procedures, calibration and testing procedures.

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4.28.A **The operating organization should ensure that training of plant personnel, for operational states and accident conditions, maintenance and testing on the modified plant structures, systems and components concerned is provided. See Ref. Preparedness and Response for a Nuclear or Radiological Emergency [20]**

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4.28.B The revision to the configuration of the plant simulator or training facilities should be included within the modification process, to ensure the accurate reflection of all modifications and changes made to the plant.

4.29. Particular care should be taken and procedures should be put in place to avoid two or more potentially conflicting modifications being designed and undertaken coincidentally on the same part of the plant or on interrelated parts of the plant. This means that master drawings, safety analysis reports and procedures should be subject to rigorous controls. Requests for modifications should be routed through the controlling organization and they should track any proposal that affects part of the plant or plant processes until it is fully implemented. When a proposed modification is rejected the modification process should formally record that the proposal has been abandoned. The controlling organization's process for managing modifications should ensure that advice is provided to the originators of proposed modifications at the plant of the need to co-ordinate their activities, e.g. to handle requests for modifications of a similar nature from separate departments at the NPP.

5. MODIFICATIONS TO THE OPERATING ORGANIZATION

ORGANIZATIONAL CHANGES

5.1. To provide an effective system for managing safety, an appropriate organizational structure should be established and maintained as necessary over the lifetime of the plant. Whichever organizational system is adopted, the basic management functions of policy making, operation, support and review should be covered (see also Refs.[1], [4] and [9]).

5.1.A Changes to the operating organization should be considered as modifications and should be categorized according to their safety significance. They should follow the formal modification process in place at the plant (See Appendix II). Benchmarking and analyses of the operating experience feedback concerning organizational changes in the nuclear and other industries should support this process.

5.2. The operating organization should set up its organizational structure for the safe operation of nuclear power plants before the commencement of operation.

5.3. Changes to the operating organization should be carefully evaluated in order to avoid frequent modifications to the operational structure, which may pose a threat to the stability of the organization. Whenever organizational restructuring is undertaken at any level, the modified structure should be such as to ensure that all the responsibilities of the operating organization, as defined in the safety requirements for operations Ref.[1] and the recommendations for the operating organization Ref.[9], continue to be discharged.

5.4. An independent internal review should also be provided to demonstrate that the provisions for the management of safety, including the provision for adequate control and supervision, will not be compromised.

5.5. Special attention should be paid to the review and revision of plans for training personnel to ensure in advance that management and staff have a broad understanding of the new tasks and functions that will follow the organizational changes. In particular, it should be ensured that adequate provision has been made to maintain a suitable level of trained and competent staff in all areas important to safety, and that any new systems introduced have been documented with clear and well understood roles, responsibilities and interfaces. All needs for retraining should be identified by, for example, carrying

out an analysis of training needs for each of the new roles and planning the retraining of key staff where this is found to be necessary.

MODIFICATIONS TO PROGRAMMES FOR OPERATION MANAGEMENT

5.6. In order to achieve the objectives and discharge the responsibilities of the operating organization, and to exert effective control over the related activities, the operating organization should establish appropriate documented operation management programmes as described in Refs.[4] and [9].

5.7. Any modifications to operation management programmes should be reviewed by the operating organization for their consequences for safety. To the extent that modifications to specific operation management programmes could influence other such programmes, a thorough review should be performed to define the boundaries of such interaction.

MODIFICATIONS TO SAFETY ASSESSMENT TOOLS AND PROCESSES

5.8. The safety of the plant is assessed a number of times at its design stage, its commissioning stage and during operation to ensure that the plant can be operated within safety limits and meet its licence conditions. The accuracy of, and confidence in, the assessment will depend on the assessment tools with which, and the data on the basis of which, the assessment is performed. The operating organization should, as part of continuous improvement processes, review the applicability of updates to the tools and check that the data used remains valid. Examples may include improved computer modelling of physical processes, advanced understanding of fault, or accident conditions, new safety assessment approaches and new in-service inspection techniques. Any modifications to the existing tools should be reviewed for their safety implications, including assessment of the uncertainty in safety margins.

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6. TEMPORARY MODIFICATIONS

6.1. Modifications which are implemented for a limited period of time should be treated as temporary modifications. Examples of temporary modifications are temporary bypass lines, electrical jumpers, lifted electrical leads, temporary trip point settings, temporary blind flanges and temporary defeats of interlocks. This category of modifications also includes temporary construction and installations used for maintenance of the design basis configuration of the plant in emergencies or other

unanticipated situations. Temporary modifications in some cases may be made as an intermediate stage in making permanent modifications.

6.1.A. The temporary modification process should not be used for permanent modifications as a way to lighten and speed up the implementation, to bypass a full scope safety assessment.

6.2. Except **in case of urgent needs¹** or when explicitly permitted by established procedures, the configuration of structures, systems and components important to safety should not be altered (such as by defeating interlocks or installing jumpers) without written orders or instructions from authorized persons. Such alterations should not violate operational limits and conditions. Any alteration should be reviewed by competent persons as soon as possible.

6.3. The number and duration of temporary modifications should be kept to a minimum. To minimize their cumulative safety impact, any opportunity should be taken to close-out temporary modifications as soon as possible, in particular during outages.

6.3.A. A time limit should be specified for their removal or conversion into permanent modifications. Justification should be provided if a temporary modification persists longer than its agreed duration **and a new time limit should be specified.**

6.3.B. Documents like drawings and procedures related to the temporary modification should be clearly marked showing the presence of a temporary modification e.g. redline changed, until the modification is removed, or changed to permanent.

6.4. The procedure for obtaining approval to implement a temporary modification should be the same as that for a permanent modification. The procedure for authorization of proposed temporary modifications should ensure that temporary modifications do not involve, or cause a change in the approved operational limits and conditions unless this is separately justified, and do not result in an un-reviewed safety issue. In the review of proposed temporary modifications and planned permanent modifications, any existing temporary modifications and the cumulative safety significance of the proposed change should also be considered.

6.5. The operating organization should regularly review temporary modifications and decide whether they are still needed. The review should check that associated **operating procedures**, instructions and drawings and operator aids conform to the

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¹ Urgent needs can occur where a change must be implemented immediately to provide for the safety of personnel or protection of important equipment. In an emergency the normal processing of a modification may not be possible due to the urgency of the situation. These emergency changes are not exempt from the change control process. Emergency changes may be implemented after verbal approval of the responsible department manager. They should be reviewed and processed appropriately on the next working day.

approved configuration. The status of temporary modifications should be periodically reported (typically at monthly intervals) to the plant manager. Those that are found to be needed permanently should be converted in a timely manner according to the established procedure.

6.6. Temporary modifications should be clearly identified at the point of application and at any relevant control position.

6.7. The process for temporary modifications should allow for rapid review and assessment of any proposed modifications that have to be undertaken urgently. Such urgent actions, however, should neither reduce levels of safety nor allow installation without prior safety assessment.

6.8. Any precautions or restraints on operation due to a temporary modification should be clearly specified to all personnel, in particular shift personnel, before putting the modification into effect.

6.9. An appropriate procedure should be established to control temporary modifications on the plant. The following areas should be covered in this procedure:

- Designation of personnel who are allowed to initiate, approve, perform and remove temporary modifications;
- Requirements for technical reviews, in particular safety reviews to be performed before temporary modifications are made. Temporary modifications to structures, systems and components and process software important to safety should be independently reviewed by personnel not involved in the design or implementation of the temporary modification;
- Control of documentation, to ensure that all documentation — such as operating flowsheets, operating manuals, maintenance manuals, emergency procedures — reflects temporary modifications, to ensure that the plant continues to be operated and maintained safely while the modification is in place;
- Logging, labelling and tagging of temporary modifications in a distinctive manner;
- Communication with the operating personnel, involvement of the operating personnel in the implementation process at the initial stage, and control of the temporary modifications by the operators of the main control room. The lifetime of a temporary modification and the procedure to extend this lifetime;
- Checking of configuration recovery and communication with personnel when a modification is removed. Ref. Conduct of Operation at Nuclear Power Plants, IAEA Safety Guide NS-G-2.14 [19].

7. IMPLEMENTATION OF MODIFICATIONS RELATING TO PLANT CONFIGURATION

ADMINISTRATIVE CONTROL

7.1. As stated in SSR-2/2 (Rev. 1), the operating organization shall establish and implement a system for plant configuration management to ensure consistency between design requirements, physical configuration and plant documentation. The operating organization should be responsible for the management control of the modification. For major projects, this should include establishment of the objectives and organizational structure, appointment of a project manager, determination and assignment of responsibilities, provision of appropriate control and supervision, and allocation of adequate resources.

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7.2. Implementation of plant modifications, including necessary testing, should be performed in accordance with the plant's work control system, management system procedures and appropriate testing procedures. The implementation of modifications should be subject to the usual maintenance and administrative procedures, together with any special requirements generated by reviews and assessments.

7.3. The operating organization should ensure that all personnel, including contractors' staff, who will be involved in implementation of the modification are suitably qualified, experienced and trained for the task. Appropriate time should be allocated for all staff affected by the modification to familiarize themselves with the changes.

7.3A Any change to the scheduling or sequencing of a modification implementation, including modification packages which may not be fully implemented, or implemented in several stages, should be properly assessed and documented with regards to safety and operability.

SPECIFIC SAFETY CONSIDERATIONS

7.4. The following safety aspects of the modification should be considered in a systematic manner:

- Exposure to radiation, including ALARA considerations;
- Radioactive waste management, including transport, decontamination and dismantling, as applicable;
- Provisions necessary to reduce the spread of contamination;

- Safe operation of the plant during the implementation of the modification;
- The impact of the modification on the non-radiation related safety;
- Working with personal protective equipment and working in cramped conditions.

7.5. The plant should be put in an appropriate safe operational state for the modification to be made. The system to be modified should also be placed in a safe operating state.

7.6. Consideration should be given to the need for special temporary emergency procedures if potential hazards have been identified in association with the plant conditions during the implementation of the modification.

7.7. The process for control of software changes should include provisions to ensure that the master, operational and development copies are secure; duplicate copies of any software should be strictly controlled.

TESTING AND COMMISSIONING

7.8. The ability to operate the modified plant safely should be verified through a testing programme which includes checks, measurements and evaluations prior to, during and on completion of the modification. Testing and commissioning, which may include pre-installation tests of equipment and mock-ups, including equipment qualification, should be aimed at demonstrating that modifications meet their design specifications for all anticipated operational occurrences and in design basis accidents.

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7.9. The testing of equipment prior to installation in the plant should be considered. Tests should be planned as part of the initial design of the modification. Acceptance tests should include specific acceptance criteria based on performance criteria and testing requirements specified as part of the modification process.

7.9 A The commissioning test plan, including the justification for the scope of testing, should be independently reviewed in connection with the comprehensive safety assessment of the modification and approved by the plant management. Commissioning testing should not rely solely on the tests performed by the supplier (e.g. manufacturer acceptance tests may not allow testing a complete system in real configuration). Commissioning testing should be used to validate the new or revised operating procedures. Commissioning testing should verify that connected systems are not improperly affected by the modification.

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7.9 B A qualification programme for the structures, systems and components related to the modification should be established, as necessary.

7.10. Arrangements should be made for the verification and validation of any changes to procedures, operational limits and conditions and process software, and this should be done in the commissioning phase. Validation can be done by testing on simulation models or by specially controlled operational tests to confirm that changes are operable and produce the desired results. When conditions do not allow testing to be conducted after execution of the modification, testing should be done in advance on specific test facilities. The ability to execute a programme successfully and efficiently may depend on the accessibility of the modified system for on-line measurements and may necessitate special provisions for measuring and testing. The necessity for such provisions should be assessed in the design stage of the modification.

7.11. Special precautions should be taken with modifications to safety related software in order to test the operation of the software thoroughly off-line before it is put on-line. The software should, if possible, be run in parallel during plant operation but not connected to field devices, while compliance with design and field conditions is checked.

7.12. Final approval of the modification before routine operation should be based on successful completion of the commissioning stage and verification of all information and experience obtained with regard to the design intent. A commissioning report, including the acceptance criteria and the results of commissioning, should be produced to assist in this task. The report should be reviewed by the plant safety committee and approved by the plant management, the plant safety committee and/or the commissioning committee, as appropriate, as a basis for permitting the normal operation of the modified plant.

7.13. Completed installations and results of system acceptance tests should be reviewed and verified with regard to the approved design intent by the designer, prior to acceptance at the plant of the modified system or component. The effectiveness and the achievement of the original objective of the modification should be confirmed.

OPERATION

7.14. Putting modifications into operation should be under the control of the management and should be conducted in accordance with the procedures governing the entire modification process. Putting modifications into the operational state is the final stage of the modification process.

7.14.A Correct alignment of the concerned systems and components should be verified independently (within the operating organization) after the modification is implemented and the commissioning tests have been performed.

7.15. To ensure reliable configuration control after implementation of the modification, the status of other design modifications should also be reviewed, because a modification may have been based on the assumption that an earlier proposed modification had already been implemented. The earlier modification may not have been implemented, however, owing to the long periods between planned outages or possible changes in priorities at the plant.

7.16. Before a modification is put into operation, the following should be ensured:

- All the documentation affected by the plant modification, such as the safety analysis report, operational limits and conditions, drawings, operating and emergency procedures, periodic maintenance and testing procedures, and equipment indexes (commonly used for system operation, tag-outs and maintenance) have been updated and are available. Documents should not be released for use until the modification has been completed;
- The as-built configuration of modified systems has been verified and the design basis document has been updated;
- Personnel have been trained;
- Records for design, commissioning, application of the management system, testing and installation have been reviewed for completeness and accuracy.

7.17. The completion of the modification should include a check that all temporary connections, procedures and arrangements used in making the modification have been removed or cancelled and that the plant has been returned to full operational status. It should also include a check that the **plant documentation** has been revised to take into account the modification, that the configuration of the plant corresponds to the revised documentation.

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7.18. The modification of the computer system and in particular of its software during on-line operation should only be allowed if supported by a detailed justification. Modifications to those parameter settings which might need to be varied during the operation of the plant (such as trip settings and calibration constants) should only be undertaken with the use of engineered facilities that have been shown to be fit for the purpose. The extent of the variation in parameters at the plant should be limited to the range that is justified in the plant safety analysis.

7.19. The impact of modifications on the simulator and its associated computer codes should be evaluated. In this evaluation, it should be determined both whether appropriate modifications have been incorporated into the simulator itself, and whether the effects of changes on the simulator and its associated computer codes have been assessed.

7.20. The list of spare parts **and consumables** to be kept in stores should be reviewed

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and updated as a consequence of a modification, so that the necessary new spare parts will be procured and those spare parts that no longer conform will be modified or disposed of.

8. IMPLEMENTATION OF ORGANIZATIONAL CHANGES

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

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

8.3. The broad involvement of personnel in any restructuring process should be considered in order to avoid undue uncertainty and concern with regard to the planned organizational changes.

8.3.A Large organizational changes should be implemented stepwise, if appropriate. The implementation, specifically the completion of each step, should be followed and monitored by a related group, or peer group, in order to assess the achievement of the objective of the change.

9. APPLICATION OF THE MANAGEMENT SYSTEM TO THE MODIFICATION PROCESS

9.1. The operating organization should ensure that the modification process meets the management system requirements at all stages in the preparation and implementation of the modification. Requirements and guidance on the management system for the modification process are given in Ref.[4]. In particular, the recommendations in Ref. The Management System for Nuclear Installations, Safety Guide No GS-G-3.5 [14] should be followed.

10. TRAINING

10.1. Training should be conducted to ensure that the relevant personnel responsible for operation and maintenance are familiar with the modifications and sufficiently knowledgeable to operate and maintain the modified equipment in a safe and reliable manner. The responsible entity for training should be involved to determine the needs for the training associated with the modification. Consideration should be given to the interfaces between modified and unmodified areas. More information on the training of plant personnel can be found in Ref. Recruitment, qualification and training of personnel for nuclear power plants Safety Standards Series No. NS-G-2.8 [11].

10.2. Appropriate training should be completed prior to the operation, maintenance and commissioning, if necessary, of the modified system, and should include required reading, pre-shift briefings or formal training, depending on the complexity of the modification and its consequences for operation and maintenance of the plant.

10.3. The implications of the changes for training needs should be reviewed and, if necessary, the training plans should be revised at an early stage of the modification process.

10.4. The need for reauthorization of some groups of plant personnel should be considered before they resume their duties after significant plant modifications that are relevant to safety have been made. Such reauthorization is subject to a review of the competence of the authorized person in respect of the modified configuration.

10.5. Before changes are made to the management systems, training in management should be given to all staff taking on new responsibilities.

11. MANAGEMENT OF DOCUMENTATION

11.1. The following should be ensured by means of the configuration management system:

- That all relevant documents affected by the modification are identified and updated, and remain consistent with the plant specific design requirements, and that they accurately reflect the modified plant configuration;
- That all changes to the design over the lifetime of the plant are based on the actual status of the plant, as reflected in the current plant documentation;
- That the modified plant configuration conforms fully with the documentation and conditions of the operating licence.

11.1.A Information technology applications should be used to support the management of modifications to ensure that the modification process stays consistent with the

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plant's physical configuration and **plant documentation**.

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11.2. All relevant plant documents which have been revised or developed during the modification process should be subject to configuration management. Changes to these documents should be traceable to the modification and should be submitted for approval prior to formal revision.

11.3. Documents relating to modifications, in particular to installation and testing, should be updated as soon as practicable. Responsibility should be clearly assigned for the revision of all documents, such as all drawings, including computer representations, specifications, procedures, safety reports, operational limits and conditions, descriptions of equipment and/or plant and systems, training material, including simulator aspects, vendor equipment manuals and spare parts lists.

11.4. Modified operational limits and conditions, and other operational documentation, should be included in **plant documentation** by means of approved processes and should be subject to review and approval at the same level as for the original operational documentation.

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11.5. Expired documents should be marked as 'invalid' in an unambiguous manner. More information about suspension or cancellation of documents can be found in Ref. Application of the Management System for Facilities and Activities, Safety Guide No GS-G-3.1 [13].

11.6. Documents and records relating to modifications and to the revised plant configuration should be stored appropriately in order to preserve access to them throughout the lifetime of the plant.

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APPENDIX I:

Recommended criteria for the categorization of modifications based on safety significance:

Category 1

Modifications in Category 1 may have a significant effect on the radiological risk or may involve an alteration of the principles and conclusions on which the design and the licensing of the plant were based. Such modifications may involve changes in the set of design basis accidents, or they may alter the technical solutions adopted for meeting the safety goals or lead to changes in the operating rules. Modifications in Category 1 necessitate thorough analysis and may also necessitate prior approval, an amendment to the operating licence or the issue of a new licence by the regulatory body.

Category 2

Modifications in Category 2 include changes in safety related items or systems and in operational approaches and/or procedures, and usually necessitate an update of the safety analysis report or other licensing documents. Modifications in Category 2 are characterized by a minor influence on safety and no significant alteration to the principles on which plant licensing has been based. There should be no changes to the conclusions in the licensing documents. In the design phase for modifications in Category 2, it should be determined whether there are negative side effects, such as degradation of safety features or an expectation of causing significant radiation exposure in making the modification. For modifications in Category 2, the operating organization should contact the regulatory body, in accordance with established procedures.

Category 3

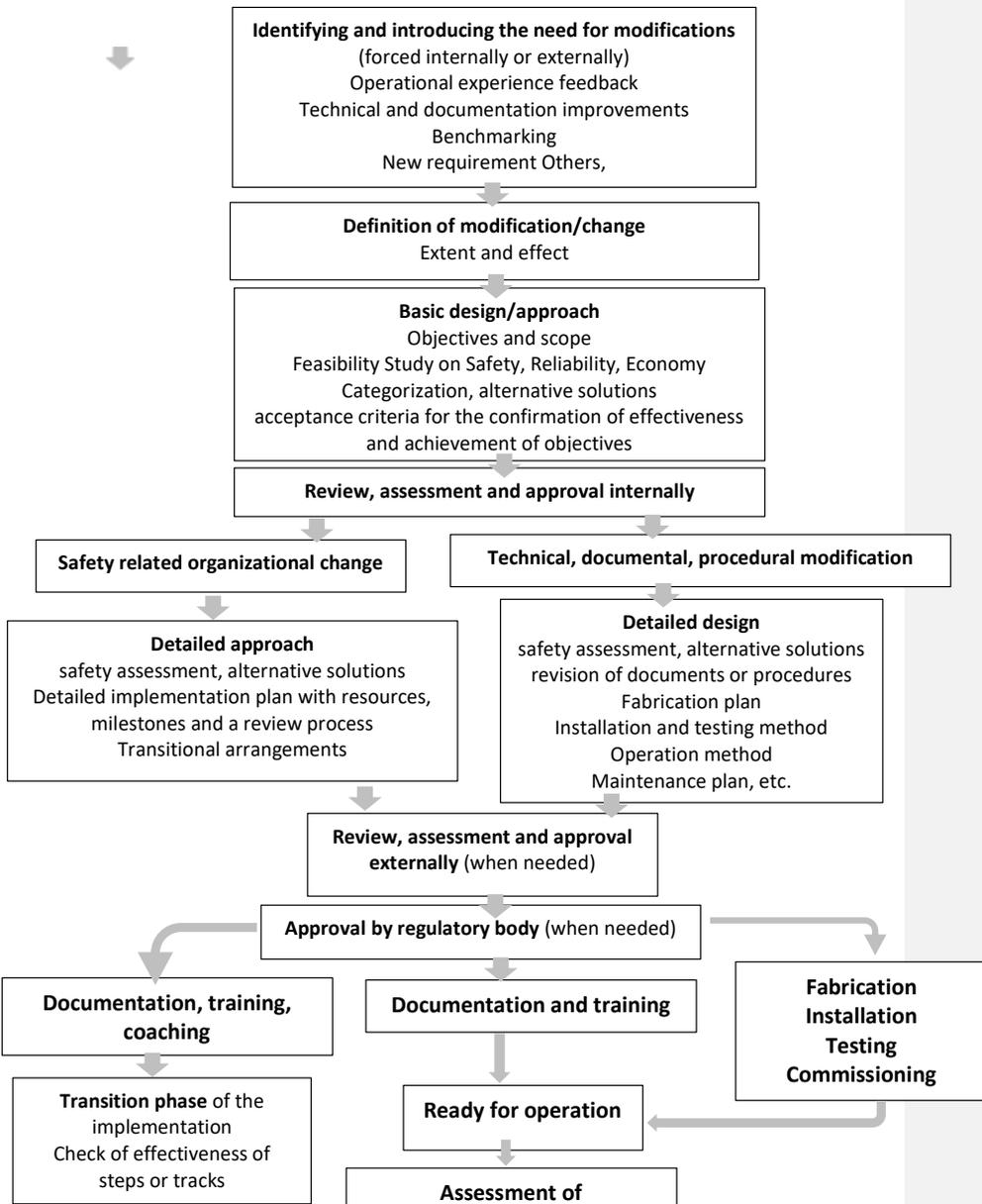
Modifications in Category 3 are minor modifications that can be characterized in one of the following ways:

- The modification has no consequences for safety;
- The items to be modified are classified as items not important to safety and are not mentioned in the licensing documents;
- The modification, even if designed or implemented incorrectly, could not lead to a significant increase in risk.

APPENDIX II

Recommended elements of a modification process

Commented [CR5]
alternative solutions ac



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