IAEA 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

Under the terms of Article III of its Statute, the IAEA is authorized to establish standards of safety for protection against ionizing radiation and to provide for the application of these standards to peaceful nuclear activities.

The regulatory related publications by means of which the IAEA establishes safety standards and measures are issued in the **IAEA Safety Standards Series**. This series covers nuclear safety, radiation safety, transport safety and waste safety, and also general safety (that is, of relevance in two or more of the four areas), and the categories within it are **Safety Fundamentals**, **Safety Requirements** and **Safety Guides.**

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Information on the IAEA's safety standards programme (including editions in languages other than English) is available at the IAEA Internet site

www.iaea.org/ns/coordinet

or on request to the Safety Co-ordination Section, IAEA, P.O. Box 100, A-1400 Vienna, Austria.

OTHER SAFETY RELATED PUBLICATIONS

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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''.

Printed by the IAEA in Austria
October 2001
STI/PUB/1111

SAFETY STANDARDS SERIES No. NS-G-2.3

MODIFICATIONS TO NUCLEAR POWER PLANTS

SAFETY GUIDE

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2001

VIC Library Cataloguing in Publication Data

Modifications to nuclear power plants : safety guide. — Vienna : International Atomic Energy Agency, 2001.
p. ; 24 cm. — (Safety standards series, ISSN 1020–525X ; no. NS-G-2.3)
STI/PUB/1111
ISBN 92–0–101501–1
Includes bibliographical references.

1. Nuclear power plants — Safety measures. I. International Atomic Energy Agency. II. Series.

VICL 01–01000

FOREWORD

by Mohamed ElBaradei
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 individual States.

The attention of States is drawn to the fact that the safety standards of the 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.

CONTENTS

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 7 of the Safety Requirements publication on Safety of Nuclear Power Plants: Operation [1], which establishes the safety requirements for the modification of nuclear power plants.

1.2. 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, reducing the radiation exposure of personnel or reducing the costs of plant maintenance; and (5) extending the design life of the plant. Most modifications, made on the basis of operating experience, are intended to improve on the design or to improve operational performance and flexibility. Some are rendered necessary by new regulatory requirements, ageing of the plant or obsolescence of equipment. 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.

1.3. The need to reduce costs and improve efficiency, 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 in the structure of the operating organization for nuclear power plants. Whatever the reason for such organizational changes, consideration should be given to the effects of those changes with the aim of ensuring that they would have no impacts that would compromise the safety of the plant.

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 licence. The main purpose of the recommendations concerning changes of management is to give general guidance on performing those changes in such a way that the safety of the plant is not compromised.

SCOPE

1.5. This Safety Guide deals with the intended modification of structures, systems and components, operational limits and conditions, procedures and software, and the management systems and tools for the operation of a nuclear power plant. The recommendations made cover the whole modification process, from conception to completion.

1.6. The justification for undertaking modifications is 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 (see Ref. [2]), and is therefore outside the scope of this publication.

STRUCTURE

1.8. Section 2 gives guidance on general methods for 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, and Section 4 provides guidelines on subsequent categorization. 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 basic recommendations on quality assurance, training and management of documentation; comprehensive guidance on these matters can be found in the appropriate Safety Guides.

2. GENERAL

2.1. Once a plant is completed and approved for operation, its operation needs to comply with all applicable regulations and standards and other relevant safety requirements. Throughout its lifetime, the plant should be regularly inspected, tested and maintained, in accordance with approved procedures, to ensure that it continues to meet the design requirements and remains consistent with the assumptions and results of the safety analysis.

2.2. However, over its lifetime, a plant may undergo various changes on the basis of the feedback of operational experience, the findings of periodic safety reviews, regulatory requirements, advances in knowledge and/or improvements in technology. In some cases modifications may be necessary for economic reasons (e.g. for increased power or for the use of mixed oxide fuel). In other cases modifications may be necessary to ensure recovery from an identified fault condition or a plant failure.

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 extent of the regulatory body's involvement in this process should depend on the safety significance of the modification. All safety relevant modifications should be submitted for review and approval by the regulatory body in accordance with national regulations (see paras 3.11–3.16 and 4.3–4.7). Non-safety-relevant modifications should be documented and accessible to the regulatory body. It should be demonstrated by the operating organization that these modifications do not influence safety. The roles and responsibilities of the organizations involved in the modification process are considered in Section 3.

2.5. Proposed modifications should be categorized according to their safety significance and proposals for modifications should be submitted to the regulatory body for prior approval if required.

2.6. Modifications which may affect safety can be divided into:

(a) Modifications directly relating to plant configuration, i.e.:

- Modifications to structures, systems and components or process software;
- Modifications to the operational limits and conditions;
- Modifications to operating procedures; or
- A combination of these; and

(b) Modifications to management systems:

- Changes in organizational structures or resources;
- Modification of operational management programmes; and
- Modifications relating to safety reassessment tools and processes, including improved knowledge of physical phenomena (from the results of research and development).

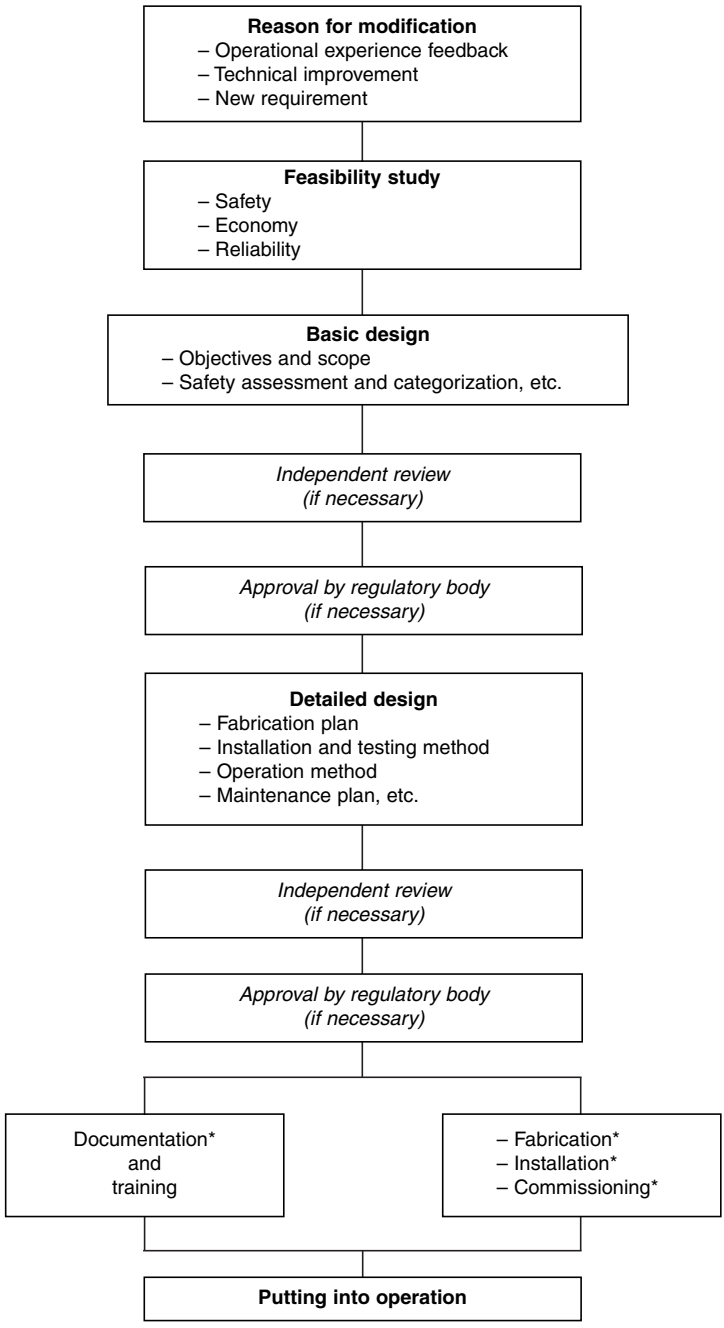

FIG. 1. The basic process for modifications (: including regulatory inspection (if necessary)).*

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.

2.8. When modifications are proposed, they should be reviewed to ensure consistency with the intent and assumptions of the design. 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. 1, including where necessary regulatory inspection and approval by the regulatory body, 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 physical boundaries of the modifications 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.

2.10. Modifications relating to the configuration of the plant and the operational limits and conditions should comply with the Safety Requirements publication on the Safety of Nuclear Power Plants: Design [3]. In particular, the capability to perform all safety functions should be maintained.

2.11. Plant modifications should be performed in accordance with established procedures, with due consideration given to quality assurance provisions (see Ref. [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 to demonstrate that the design intent is met. 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 and should be managed in accordance with established procedures.

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 by the regulatory body as required.

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 the modification is commenced. The operating organization should submit details of the modifications and the safety assessment to the regulatory body for its information, review, approval or concurrence, as appropriate, before proceeding with the modification.

3.4. Independent review of the scope and safety implications of proposed modifications 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 may 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 adequate measures for quality assurance are applied to the modification. Guidance on this subject can be found in Quality Assurance for Safety in Nuclear Power Plants and Other Nuclear Installations [4].

3.8. The operating organization should carry out systematic reviews of safety to confirm that the safety analysis for the plant remains valid in consideration of the cumulative effects of modifications relating to the configuration of the plant or to management systems. This may be included in the scope of periodic safety reviews.

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

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.

REGULATORY BODY

3.11. The extent of the regulatory body's involvement in the modification process will vary from country to country depending generally on the type of regulatory regime employed. However, common to any approach, the level of involvement of the regulatory body will depend on the safety significance of proposed modifications.

3.12. On the basis of the submissions made by the operating organization, which should include the safety assessment (see para. 4.11), the regulatory body may choose to review the following for prior approval where required by national regulations:

- Proposals for the modification of structures, systems and components and process software important to safety;
- Proposals for the modification of the operational limits and conditions, which affect the basis on which the operating licence was issued;
- Proposals for the modification of procedures and other documents originally approved by the regulatory body; and
- Any other proposals for modifications, as considered appropriate.

The regulatory body may request that a list of all the modifications implemented or intended to be implemented at the plant be compiled and retained, and this list should be submitted on request.

3.13. The regulatory body's monitoring of modifications that may affect safety should include consideration of managerial changes. Changes to the organizational structure, processes and management programmes which may have consequences for safety should be reviewed and agreed by the regulatory body if required by national regulations.

3.14. The regulatory body approves safety related modifications when required by national regulations and, where necessary, may issue a new licence or modify the existing licence. In this case the regulatory body confirms, on the basis of its review of documentation provided by the operating organization and, as necessary, inspection of the modification, that the modification project complies with regulatory requirements.

3.15. The regulatory body should require that the operating organization has implemented adequate, approved arrangements to control the process for modification, including appropriate categorization of the modifications.

3.16. The responsibilities and functions of the regulatory body are established in the Safety Requirements publication on Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety [5] and guidance is given in the associated Safety Guides.

OTHER BODIES, INCLUDING CONTRACTORS

3.17. The operating organization may delegate or subcontract the engineering, assessment and execution of certain tasks for modifications to other organizations but 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 system 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 may be consulted in order to provide assurance that the design basis is preserved following the modification.

4. MODIFICATIONS RELATING TO PLANT CONFIGURATION

TYPES OF MODIFICATIONS

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 operating procedures. 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.

4.2. Modifications may be necessary for the following reasons: to rectify weaknesses in components or failures discovered during operation, inspection or maintenance; to prevent faults or to reduce their frequency; to improve maintainability; to incorporate a non-identical replacement of a plant component; or to take account of changes in safety standards.

CATEGORIZATION OF MODIFICATIONS BY SAFETY SIGNIFICANCE

4.3. Following the completion of the initial process of safety assessment (see para. 4.8), the proposed modification should be categorized in accordance with its safety significance. This categorization should follow an established procedure agreed with the regulatory body.

4.4. The final authority to approve or change the categorization proposed by the operating organization should rest with the regulatory body.

4.5. A proposed categorization could be as follows.

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 a new licence.

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; and
— The modification, even if designed or implemented incorrectly, could not lead to a significant increase in risk.

Modifications in this category should be reported to the regulatory body only if required.

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 and the regulatory control 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.

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 and whether it is within the regulatory constraints for the plant design and operation. 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. This should lead to a categorization of modifications, as described in para. 4.5. The regulatory body should have access to all intended modifications in order to assess compliance with the proposed categorization.

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.

4.10. 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.
- New and/or modified systems will not adversely affect the safety characteristics of other items important to safety under any conditions of operation.
- 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 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.
— Due account has been taken of the potential consequences if the modification is inadequately implemented.
— The radioactive waste arising from the plant modification will be properly managed.
— The defeat of any safety related plant interlocks or the suspension of any operating restrictions has been fully assessed prior to implementation and steps are in place to ensure the reinstatement of such measures as are necessary.

4.12. The comprehensive safety assessment should include the deterministic safety analysis and the probabilistic safety analysis. If a plant specific model for probabilistic safety assessment is available and reliable, a quantitative evaluation should be performed to quantify the effect of the modification on the total plant risk, in order either to support the decision making process or to point out associated compensatory measures.

REVIEW OF PROPOSED MODIFICATIONS

4.13. The scope, safety implications and consequences of proposed modifications should be reviewed by personnel not immediately 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 quality assurance 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:

— 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;
— Analysis of adverse environmental or operating conditions, including any implications for radioactive waste, any contamination and any exposure to radiation;
— Description of methods of fabrication, installation and testing, including 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 quality assurance and quality control;
— Description of the qualification test programme to be performed after implementation; and
— Description of changes to the safety related plant maintenance arrangements.

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 [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, regulators) involved in the implementation of the modification.

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 [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 Category 1 (see para. 4.5). Detailed information on operational limits and conditions can be found in Ref. [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 should be approved by the regulatory body where this is the national practice.

MODIFICATIONS TO THE OPERATING PROCEDURES

4.22. Modifications to the operating procedures should be categorized in a manner similar to that described in para. 4.5, and detailed safety assessments should be carried out as for Categories 1 and 2.

4.23. Any modifications to the operating procedures should be made in accordance with the plant procedures governing their preparation. Modified operating procedures should be verified and validated before use. Any other operating procedures affected by the modifications should be revised and operators should be trained in the revised 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 (see 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 Refs [7, 8].

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 during the modification process.

INTERACTIONS BETWEEN MODIFICATIONS

4.27. Attention should be paid to the interrelationships between modifications. In addition, when modifications are made to structures, systems and components and process software, the relevant operating instructions and procedures 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.

4.28. Consideration should be given to the need to revise procedures, training and provisions for plant simulators as part of the implementation of the modification. Revised procedures may include operating procedures for normal operation, emergency operating procedures, maintenance procedures and testing procedures. Revised training of plant personnel for normal operations, emergency operations, maintenance and testing on the modified plant structures, systems and components may also be necessary. Revisions to the configuration of the plant simulator may be necessary for some modifications. These supporting actions will need close communication and co-ordination among the staff for design, engineering, operation, maintenance and training to ensure that all necessary supporting actions have been effectively completed in order to ensure safe operation with the effected modification.

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. Design requests 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 or formally abandoned. There should be a way of advising others at the plant who may wish to modify the plant or plant processes of the need to co-ordinate the activities.

5. MODIFICATIONS TO MANAGEMENT SYSTEMS

ORGANIZATIONAL CHANGES

5.1. To provide an effective system for managing safety, an appropriate organizational structure should be established and modified 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, 9, 10]).

5.2. The operating organization should set up its organizational structure for the safe operation of nuclear power plants before the commencement of operation. This structure should be submitted to the regulatory body, if required, for approval or review before implementation in accordance with national regulations. After the

operating organization has obtained the approval of the regulatory body, any proposed modifications to this organizational structure, including changes to numbers of staff and safety related posts, should be analysed to determine their consequences for safe operation, and proposals should be submitted to the regulatory body, if required, for approval or review before implementation.

5.3. Organizational changes 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 formulated in the Safety Requirements publication on Safety of Nuclear Power Plants: Operation [1] and the Safety Guide on The Operating Organization for Nuclear Power Plants [9], continue to be discharged.

5.4. An independent internal review to demonstrate that the provision for management of safety, including the provision for adequate control and supervision, will not be compromised should also be considered. The regulatory body should be informed of changes with potentially significant effects on safety so that it may independently assess the proposed changes, inspect and if necessary intervene if it concludes that safety is jeopardized. Stricter regulatory requirements on the submission of analyses of the potential consequences for safety of organizational changes, as well as careful regulatory review of these changes, may prevent problems from arising when the changes are made.

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 Ref. [9].

5.7. Any modifications to operation management programmes should be reviewed by the operating organization for their consequences for safety and should be submitted to the regulatory body for information, review, approval or concurrence, as appropriate. 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 meets all regulatory requirements, including licence conditions. The results of the assessment should be submitted to the regulatory body for review and/or approval as required. 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 seek improvements to the tools and in the data which are used. Examples are new safety assessment approaches such as probabilistic safety assessments 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, and submitted to the regulatory body, if required, for review and approval.

5.9. The modifications of neutronic or thermal-hydraulic computer codes or methods for core calculations and accident analysis should be submitted to the regulatory body for information, review, approval or concurrence, as appropriate, with an adequate description and qualification files.

6. TEMPORARY MODIFICATIONS

6.1. Modifications which are implemented for a limited period of time may be treated as temporary modifications. Examples of temporary modifications are temporary bypass lines, electrical jumpers, lifted electrical leads, temporary trip point settings, temporary blank flanges and temporary defeats of interlocks. This category of modifications also includes temporary constructions 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.

6.2. Except 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 and, if the alteration is considered to be of a permanent or repetitive nature, appropriate approval by the regulatory body should be obtained, if required.

6.3. The number of temporary modifications should be kept to a minimum. A time limit should be specified for their removal or conversion into permanent modifications.

6.4. The procedure for obtaining approval to implement a temporary modification should be the same as that for a permanent modification. In the procedure for authorization of proposed temporary modifications, it should be ensured that they 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 unreviewed safety issue. In the review of proposed temporary modifications and planned permanent modifications, any existing temporary modifications and the effects of the proposed change should also be considered.

6.5. The plant management should periodically review outstanding temporary modifications to consider whether they are still needed, and to check that operating procedures, instructions and drawings and operator aids conform to the 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 bypass the obtaining of regulatory approval as necessary.

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 and should be submitted for regulatory approval, as required, before implementation.
— 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.

7. IMPLEMENTATION OF MODIFICATIONS RELATING TO PLANT CONFIGURATION

ADMINISTRATIVE CONTROL

7.1. The operating organization should be responsible for the management control of the modification. For major projects, this should include the establishment of the

objectives and organizational structure, the appointment of a project manager, the determination of responsibilities, the provision of appropriate control and supervision, and the allocation of adequate resources.

7.2. Implementation of plant modifications, including any necessary testing, should be performed in accordance with the plant's work control system, quality assurance procedures and appropriate testing procedures. The execution 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 implementing 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.

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 modification;
- Industrial hazards such as high voltages, working at heights, fire and use of chemicals or explosives; and
- 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 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, including equipment qualification, should be aimed at demonstrating that modifications meet their design specifications for all anticipated operational occurrences and in design basis accidents. For major modification projects, which may involve a staged programme approach with separate approvals at each stage, a more rigorous programme of testing and commissioning, together with appropriately approved commissioning schedules, may be appropriate.

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. The test plan should be reviewed and approved by the plant management, and should also be submitted, if required, for review and approval by the regulatory body.

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 for 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 approved by the plant management, the plant safety committee and/or the commissioning committee and/or the regulatory body, 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.

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.

7.15. 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, tagouts 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 on the modifications.

— Records for design, commissioning, quality assurance, 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.

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 facility 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 to be kept in stores should be reviewed 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, particular attention should be paid to maintaining the adequacy of safety arrangements, and to ensuring that proposed organizational changes are clearly defined and their safety implications assessed. Organizational changes should be properly planned well in advance.

8.2. Special consideration should be given to maintaining an acceptable level of safety during the transition phase, before new organizational arrangements have become fully established. Consideration should also be given to the possible need for additional resources to cope with any increased workload during the transitional phase.

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.

9. QUALITY ASSURANCE

9.1. The operating organization should ensure that adequate quality assurance requirements are in effect at all stages in the preparation and implementation of the modification. Requirements and guidance on quality assurance measures for the modification process are given in Ref. [4]. In particular, the recommendations in Section 3 of Safety Guide Q13 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 modified systems and sufficiently knowledgeable to operate and maintain the modified equipment in a safe and reliable manner. 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. [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. Consideration should be given to the need for reauthorization of some groups of plant personnel 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 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 document 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.

11.2. 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.

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 Safety Guide Q3 of Ref. [4].

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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GLOSSARY

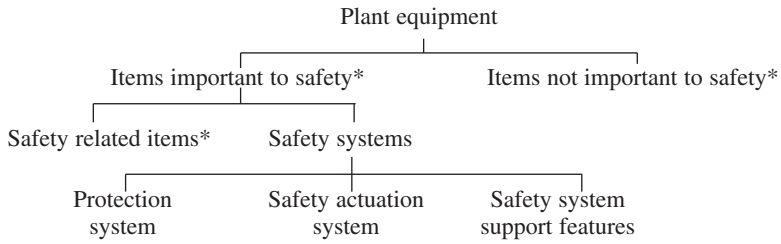
commissioning. The process during which systems and components of a nuclear power plant, having been constructed, are made operational and verified to be in accordance with the design and to have met the required performance criteria. Commissioning may include both non-nuclear and nuclear testing.

operating organization. Any organization applying for authorization or authorized to operate a nuclear power plant and be responsible for its safety.

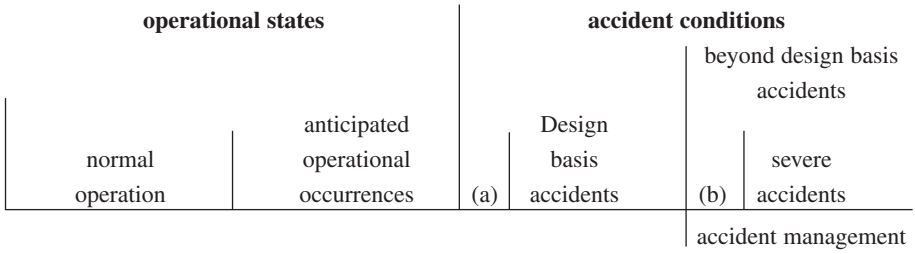
operation. All activities performed to achieve the purpose for which a facility was constructed. For a nuclear power plant, this includes maintenance, refuelling, in-service inspection and other associated activities.

operational limits and conditions. A set of rules setting forth parameter limits, the functional capability and the performance levels of equipment and personnel approved by the regulatory body for safe operation of an authorized facility.

plant equipment.



plant states.



(a): Accident conditions which are not explicitly considered design basis accidents but which are encompassed by them.

(b): Beyond design basis accidents without significant core degradation.

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* In this context, an 'item' is a structure, system or component.

accident conditions. Deviations from normal operation more severe than anticipated operational occurrences, including design basis accidents and severe accidents.

accident management. The taking of a set of actions during the evolution of a beyond design basis accident:

— to prevent the escalation of the event into a severe accident;
— to mitigate the consequences of a severe accident; and
— to achieve a long term safe stable state.

anticipated operational occurrence. An operational process deviating from normal operation which is expected to occur at least once during the operating lifetime of a facility but which, in view of appropriate design provisions, does not cause any significant damage to items important to safety or lead to accident conditions.

design basis accident. Accident conditions against which a nuclear power plant is designed according to established design criteria, and for which the damage to the fuel and the release of radioactive material are kept within authorized limits.

normal operation. Operation within specified operational limits and conditions.

operational states. States defined under normal operation and anticipated operational occurrences.

severe accidents. Accident conditions more severe than a design basis accident and involving significant core degradation.

process software. Software specifically produced for the functional use of computer applications to perform specific tasks in the operational environment of the plant (for example, software for reactor control and instrumentation, control and protection, fuelling machine control and plant simulation).

regulatory body. An authority or a system of authorities designated by the government of a State as having legal authority for conducting the regulatory process, including issuing authorizations, and thereby regulating nuclear, radiation, radioactive waste and transport safety. The national competent authority for the regulation of radioactive material transport safety is included in this description, as is the Regulatory Authority for radiation protection and safety.

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No. 12, July 2001

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