

IAEA Safety Standards

for protecting people and the environment

Commissioning for Nuclear Power Plants

Specific Safety Guide

No. SSG-28



IAEA

International Atomic Energy Agency



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IAEA SAFETY STANDARDS AND RELATED PUBLICATIONS

IAEA SAFETY STANDARDS

Under the terms of Article III of its Statute, the IAEA is authorized to establish or adopt standards of safety for protection of health and minimization of danger to life and property, and to provide for the application of these standards.

The publications by means of which the IAEA establishes standards are issued in the **IAEA Safety Standards Series**. This series covers nuclear safety, radiation safety, transport safety and waste safety. The publication categories in the series are **Safety Fundamentals**, **Safety Requirements** and **Safety Guides**.

Information on the IAEA's safety standards programme is available on the IAEA Internet site

<http://www-ns.iaea.org/standards/>

The site provides the texts in English of published and draft safety standards. The texts of safety standards issued in Arabic, Chinese, French, Russian and Spanish, the IAEA Safety Glossary and a status report for safety standards under development are also available. For further information, please contact the IAEA at: Vienna International Centre, PO Box 100, 1400 Vienna, Austria.

All users of IAEA safety standards are invited to inform the IAEA of experience in their use (e.g. as a basis for national regulations, for safety reviews and for training courses) for the purpose of ensuring that they continue to meet users' needs. Information may be provided via the IAEA Internet site or by post, as above, or by email to Official.Mail@iaea.org.

RELATED PUBLICATIONS

The IAEA provides for the application of the standards and, under the terms of Articles III and VIII.C of its Statute, makes available and fosters the exchange of information relating to peaceful nuclear activities and serves as an intermediary among its Member States for this purpose.

Reports on safety in nuclear activities are issued as **Safety Reports**, which provide practical examples and detailed methods that can be used in support of the safety standards.

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Security related publications are issued in the **IAEA Nuclear Security Series**.

The **IAEA Nuclear Energy Series** comprises informational publications to encourage and assist research on, and the development and practical application of, nuclear energy for peaceful purposes. It includes reports and guides on the status of and advances in technology, and on experience, good practices and practical examples in the areas of nuclear power, the nuclear fuel cycle, radioactive waste management and decommissioning.

COMMISSIONING FOR 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".

IAEA SAFETY STANDARDS SERIES No. SSG-28

COMMISSIONING FOR NUCLEAR POWER PLANTS

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2014

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FOREWORD

by Yukiya Amano
Director General

The IAEA's Statute authorizes the Agency to “establish or adopt... standards of safety for protection of health and minimization of danger to life and property” — standards that the IAEA must use in its own operations, and which States can apply by means of their regulatory provisions for nuclear and radiation safety. The IAEA does this in consultation with the competent organs of the United Nations and with the specialized agencies concerned. A comprehensive set of high quality standards under regular review is a key element of a stable and sustainable global safety regime, as is the IAEA's assistance in their application.

The IAEA commenced its safety standards programme in 1958. The emphasis placed on quality, fitness for purpose and continuous improvement has led to the widespread use of the IAEA standards throughout the world. The Safety Standards Series now includes unified Fundamental Safety Principles, which represent an international consensus on what must constitute a high level of protection and safety. With the strong support of the Commission on Safety Standards, the IAEA is working to promote the global acceptance and use of its standards.

Standards are only effective if they are properly applied in practice. The IAEA's safety services encompass design, siting and engineering safety, operational safety, radiation safety, safe transport of radioactive material and safe management of radioactive waste, as well as governmental organization, regulatory matters and safety culture in organizations. These safety services assist Member States in the application of the standards and enable valuable experience and insights to be shared.

Regulating safety is a national responsibility, and many States have decided to adopt the IAEA's standards for use in their national regulations. For parties to the various international safety conventions, IAEA standards provide a consistent, reliable means of ensuring the effective fulfilment of obligations under the conventions. The standards are also applied by regulatory bodies and operators around the world to enhance safety in nuclear power generation and in nuclear applications in medicine, industry, agriculture and research.

Safety is not an end in itself but a prerequisite for the purpose of the protection of people in all States and of the environment — now and in the future. The risks associated with ionizing radiation must be assessed and controlled without unduly limiting the contribution of nuclear energy to equitable and sustainable development. Governments, regulatory bodies and operators everywhere must ensure that nuclear material and radiation sources are used beneficially, safely and ethically. The IAEA safety standards are designed to facilitate this, and I encourage all Member States to make use of them.

THE IAEA SAFETY STANDARDS

BACKGROUND

Radioactivity is a natural phenomenon and natural sources of radiation are features of the environment. Radiation and radioactive substances have many beneficial applications, ranging from power generation to uses in medicine, industry and agriculture. The radiation risks to workers and the public and to the environment that may arise from these applications have to be assessed and, if necessary, controlled.

Activities such as the medical uses of radiation, the operation of nuclear installations, the production, transport and use of radioactive material, and the management of radioactive waste must therefore be subject to standards of safety.

Regulating safety is a national responsibility. However, radiation risks may transcend national borders, and international cooperation serves to promote and enhance safety globally by exchanging experience and by improving capabilities to control hazards, to prevent accidents, to respond to emergencies and to mitigate any harmful consequences.

States have an obligation of diligence and duty of care, and are expected to fulfil their national and international undertakings and obligations.

International safety standards provide support for States in meeting their obligations under general principles of international law, such as those relating to environmental protection. International safety standards also promote and assure confidence in safety and facilitate international commerce and trade.

A global nuclear safety regime is in place and is being continuously improved. IAEA safety standards, which support the implementation of binding international instruments and national safety infrastructures, are a cornerstone of this global regime. The IAEA safety standards constitute a useful tool for contracting parties to assess their performance under these international conventions.

THE IAEA SAFETY STANDARDS

The status of the IAEA safety standards derives from the IAEA's Statute, which authorizes the IAEA to establish or adopt, in consultation and, where appropriate, in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, standards of safety for protection of health and minimization of danger to life and property, and to provide for their application.

With a view to ensuring the protection of people and the environment from harmful effects of ionizing radiation, the IAEA safety standards establish fundamental safety principles, requirements and measures to control the radiation exposure of people and the release of radioactive material to the environment, to restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation, and to mitigate the consequences of such events if they were to occur. The standards apply to facilities and activities that give rise to radiation risks, including nuclear installations, the use of radiation and radioactive sources, the transport of radioactive material and the management of radioactive waste.

Safety measures and security measures¹ have in common the aim of protecting human life and health and the environment. Safety measures and security measures must be designed and implemented in an integrated manner so that security measures do not compromise safety and safety measures do not compromise security.

The IAEA safety standards reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from harmful effects of ionizing radiation. They are issued in the IAEA Safety Standards Series, which has three categories (see Fig. 1).

Safety Fundamentals

Safety Fundamentals present the fundamental safety objective and principles of protection and safety, and provide the basis for the safety requirements.

Safety Requirements

An integrated and consistent set of Safety Requirements establishes the requirements that must be met to ensure the protection of people and the environment, both now and in the future. The requirements are governed by the objective and principles of the Safety Fundamentals. If the requirements are not met, measures must be taken to reach or restore the required level of safety. The format and style of the requirements facilitate their use for the establishment, in a harmonized manner, of a national regulatory framework. Requirements, including numbered ‘overarching’ requirements, are expressed as ‘shall’ statements. Many requirements are not addressed to a specific party, the implication being that the appropriate parties are responsible for fulfilling them.

¹ See also publications issued in the IAEA Nuclear Security Series.

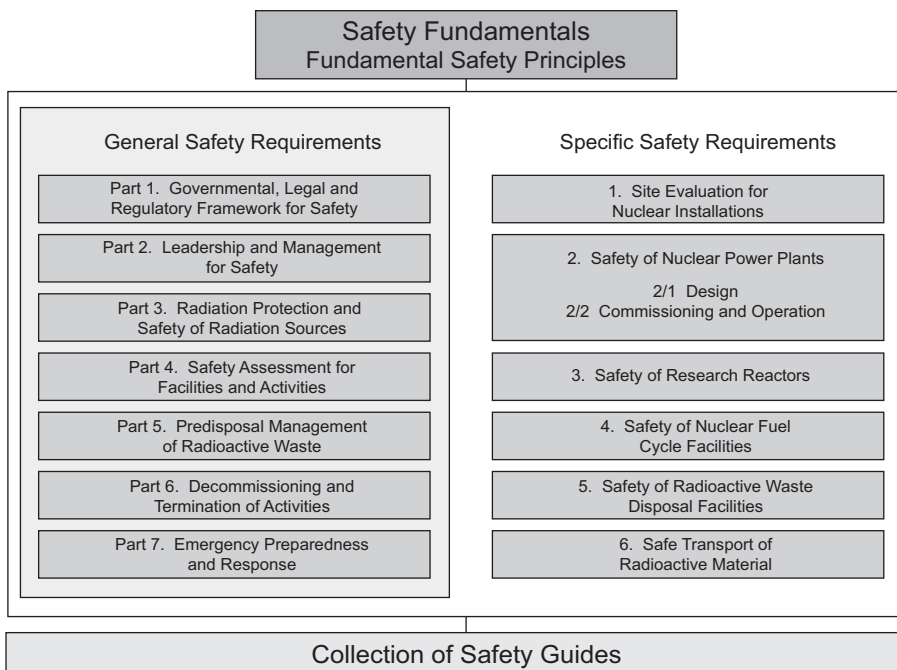


FIG. 1. The long term structure of the IAEA Safety Standards Series.

Safety Guides

Safety Guides provide recommendations and guidance on how to comply with the safety requirements, indicating an international consensus that it is necessary to take the measures recommended (or equivalent alternative measures). The Safety Guides present international good practices, and increasingly they reflect best practices, to help users striving to achieve high levels of safety. The recommendations provided in Safety Guides are expressed as ‘should’ statements.

APPLICATION OF THE IAEA SAFETY STANDARDS

The principal users of safety standards in IAEA Member States are regulatory bodies and other relevant national authorities. The IAEA safety standards are also used by co-sponsoring organizations and by many organizations that design, construct and operate nuclear facilities, as well as organizations involved in the use of radiation and radioactive sources.

The IAEA safety standards are applicable, as relevant, throughout the entire lifetime of all facilities and activities — existing and new — utilized for peaceful purposes and to protective actions to reduce existing radiation risks. They can be used by States as a reference for their national regulations in respect of facilities and activities.

The IAEA's Statute makes the safety standards binding on the IAEA in relation to its own operations and also on States in relation to IAEA assisted operations.

The IAEA safety standards also form the basis for the IAEA's safety review services, and they are used by the IAEA in support of competence building, including the development of educational curricula and training courses.

International conventions contain requirements similar to those in the IAEA safety standards and make them binding on contracting parties. The IAEA safety standards, supplemented by international conventions, industry standards and detailed national requirements, establish a consistent basis for protecting people and the environment. There will also be some special aspects of safety that need to be assessed at the national level. For example, many of the IAEA safety standards, in particular those addressing aspects of safety in planning or design, are intended to apply primarily to new facilities and activities. The requirements established in the IAEA safety standards might not be fully met at some existing facilities that were built to earlier standards. The way in which IAEA safety standards are to be applied to such facilities is a decision for individual States.

The scientific considerations underlying the IAEA safety standards provide an objective basis for decisions concerning safety; however, decision makers must also make informed judgements and must determine how best to balance the benefits of an action or an activity against the associated radiation risks and any other detrimental impacts to which it gives rise.

DEVELOPMENT PROCESS FOR THE IAEA SAFETY STANDARDS

The preparation and review of the safety standards involves the IAEA Secretariat and four safety standards committees, for nuclear safety (NUSSC), radiation safety (RASSC), the safety of radioactive waste (WASSC) and the safe transport of radioactive material (TRANSSC), and a Commission on Safety Standards (CSS) which oversees the IAEA safety standards programme (see Fig. 2).

All IAEA Member States may nominate experts for the safety standards committees and may provide comments on draft standards. The membership of the Commission on Safety Standards is appointed by the Director General and

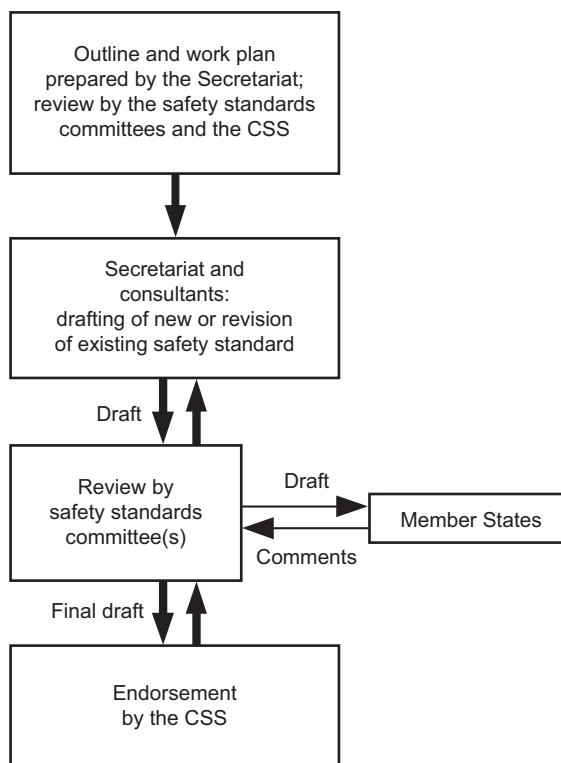


FIG. 2. The process for developing a new safety standard or revising an existing standard.

includes senior governmental officials having responsibility for establishing national standards.

A management system has been established for the processes of planning, developing, reviewing, revising and establishing the IAEA safety standards. It articulates the mandate of the IAEA, the vision for the future application of the safety standards, policies and strategies, and corresponding functions and responsibilities.

INTERACTION WITH OTHER INTERNATIONAL ORGANIZATIONS

The findings of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the recommendations of international expert bodies, notably the International Commission on Radiological Protection (ICRP), are taken into account in developing the IAEA safety standards. Some

safety standards are developed in cooperation with other bodies in the United Nations system or other specialized agencies, including the Food and Agriculture Organization of the United Nations, the United Nations Environment Programme, the International Labour Organization, the OECD Nuclear Energy Agency, the Pan American Health Organization and the World Health Organization.

INTERPRETATION OF THE TEXT

Safety related terms are to be understood as defined in the IAEA Safety Glossary (see <http://www-ns.iaea.org/standards/safety-glossary.htm>). Otherwise, words are used with the spellings and meanings assigned to them in the latest edition of The Concise Oxford Dictionary. For Safety Guides, the English version of the text is the authoritative version.

The background and context of each standard in the IAEA Safety Standards Series and its objective, scope and structure are explained in Section 1, Introduction, of each publication.

Material for which there is no appropriate place in the body text (e.g. material that is subsidiary to or separate from the body text, is included in support of statements in the body text, or describes methods of calculation, procedures or limits and conditions) may be presented in appendices or annexes.

An appendix, if included, is considered to form an integral part of the safety standard. Material in an appendix has the same status as the body text, and the IAEA assumes authorship of it. Annexes and footnotes to the main text, if included, are used to provide practical examples or additional information or explanation. Annexes and footnotes are not integral parts of the main text. Annex material published by the IAEA is not necessarily issued under its authorship; material under other authorship may be presented in annexes to the safety standards. Extraneous material presented in annexes is excerpted and adapted as necessary to be generally useful.

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1. INTRODUCTION

BACKGROUND

1.1. This Safety Guide supplements the IAEA Specific Safety Requirements publication on Safety of Nuclear Power Plants: Commissioning and Operation [1] and provides recommendations on meeting the requirements established in Section 6 on plant commissioning. The present Safety Guide supersedes the Safety Guide on Commissioning for Nuclear Power Plants that was issued as Safety Standards Series No. NS-G-2.9 in 2003¹.

1.2. The revision of IAEA Safety Standards Series No. NS-G-2.9 was conducted in accordance with the following:

- The technical content of the previous Safety Guide was kept largely unchanged but was updated where necessary.
- Additional recommendations resulting from the development of other IAEA safety standards and other publications, and from recent experience in the area of commissioning were included.
- The text was restructured to bring it into accordance with the logic of organizing, managing and conducting commissioning for a nuclear power plant.
- The content was modified to give more explicit attention to the roles of the regulatory body and the operating organization.

OBJECTIVE

1.3. The objective of this Safety Guide is to make recommendations on the basis of international good practices in commissioning for nuclear power plants, as currently followed in Member States. This will enable the commissioning for a nuclear power plant to proceed safely and to a high quality. It will also enable the necessary assurances to be provided that the plant has been constructed in accordance with the design intent and can be operated safely.

¹ INTERNATIONAL ATOMIC ENERGY AGENCY, Commissioning for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.9, IAEA, Vienna (2003).

1.4. Some or all of this Safety Guide may be relevant when a nuclear power plant is to be restarted after an extended shutdown period. Where extensive modifications have been made to an existing nuclear power plant, the commissioning of these modifications and their incorporation into the plant may require comprehensive tests to demonstrate that the plant meets the original or the modified design requirements. The commissioning of modifications to a nuclear power plant is covered in Ref. [2]; however, all or part of this Safety Guide may be used.

SCOPE

1.5. This Safety Guide deals with the commissioning of land based stationary thermal nuclear power plants of all types. It makes recommendations on: how to meet the requirements on the commissioning programme; organization and management; testing and review procedures; and the interfaces between organizations involved in the commissioning activities, including the regulatory body. It also deals with the control of changes to the commissioning programme and with the documentation required for and produced in commissioning.

1.6. This Safety Guide is focused on activities performed at the plant site. However, off-site activities also have to be considered in specifying the commissioning programme and in deciding whether structures, systems and components are operational.

1.7. This Safety Guide does not cover considerations of nuclear security in commissioning for a nuclear power plant. Guidance on nuclear security is issued in the IAEA Nuclear Security Series.

STRUCTURE

1.8. Section 2 relates to the entire commissioning process for a nuclear power plant. The objectives of commissioning are covered, as are recommendations for the preparation and approval of the commissioning programme. The different stages of commissioning are covered in accordance with the practices commonly adopted by States. The roles of the regulatory body and of the operating organization during commissioning in relation to approval, authorization and supervision are also covered.

1.9. Section 3 describes organizational matters in the commissioning process, including the functions and responsibilities of the parties involved and the interfaces between them. It covers the characteristics of the management system that are of particular relevance to commissioning, and includes management for safety, quality management and qualification of the personnel involved in commissioning. The organizational interfaces between construction, commissioning and operation are covered, as is the management of handover of the plant.

1.10. Section 4 covers practical issues relating to the implementation of the commissioning programme. The commissioning stages and different aspects of the testing that forms the core of the commissioning programme are presented and discussed. Initial loading of nuclear fuel as well as the achievement of initial criticality are dealt with. Regulatory authorization during commissioning and authorization for subsequent stages are also dealt with.

1.11. Section 5 deals with the documentation to be prepared and produced during commissioning, and the requirements for the records over the lifetime of the plant.

1.12. The Appendix specifies prerequisites for the loading of nuclear fuel and presents specific items to be included in the procedures for fuel loading. The Annex lists examples of typical commissioning tests.

2. THE COMMISSIONING PROCESS

2.1. Commissioning is an essential process for the subsequent safe operation of a nuclear power plant and should be carefully developed, planned, executed and regulated. The commissioning process should be considered a progressive transition from construction to operation of the plant.

2.2. Good coordination and communication should be established among all participants in the commissioning process (designers, construction group, licence holder, regulators, manufacturers, commissioning groups and operating groups). All the parties involved should be informed of all pertinent decisions.

OBJECTIVES OF COMMISSIONING

2.3. Commissioning has the objective of demonstrating that the nuclear power plant as constructed meets the design requirements and the safety requirements as specified in the safety analysis report and in the licence conditions. For the achievement of this objective and to ensure safe and reliable operation of the plant in the future, the commissioning process should include activities for the following purposes:

- To verify that structures, systems and components fulfil the design safety objectives through the corresponding acceptance criteria;
- To collect baseline data for equipment and systems for future reference;
- To validate those operating procedures and surveillance procedures for which the commissioning tests provide representative activities and conditions, and to validate by trial use, to the extent practicable, that the facility's operating procedures, surveillance procedures and emergency procedures are adequate;
- To familiarize the operating, maintenance and technical staff of the nuclear power plant with the operation of the plant.

COMMISSIONING PROGRAMME

2.4. The commissioning programme should cover all the activities to be performed on structures, systems and components to make them operable in accordance with the design intent. It should also cover, to the extent possible, the plant conditions considered in the safety analysis report and in the licence conditions. It should allow for verifying — while the plant remains in a safe domain — the assumptions made in the safety analysis report and the existence of adequate margins between the design intent and safety requirements and the actual performance of the plant.

2.5. In the commissioning programme to be performed on the site, account should be taken, to the fullest extent possible, of tests performed off the site. Tests that are taken into account should be adequately justified for their on-site application to structures, systems and components as installed and as integrated with their physical and functional interfaces in the nuclear power plant.

2.6. The commissioning programme should include consideration of chemical preconditioning and/or passivation of the plant prior to active commissioning. Conditioning of the plant will minimize the future production of corrosion

products, activated products and contaminated materials, which will reduce radiation doses to personnel in future operations.

2.7. As part of the commissioning programme, a detailed list of commissioning activities should be prepared. Responsibilities for implementing and reporting on the various parts of the commissioning programme should be clearly specified. In planning for commissioning, all activities and all organizations involved should be taken into consideration.

2.8. In planning for commissioning, adequate provision should be made for the allocation of responsibilities for safety at different milestones of the commissioning programme, especially with reference to:

- The delivery of nuclear fuel onto the site and the safe storage of nuclear fuel, including control of access to buildings and the operation and monitoring of relevant systems;
- The first fuel loading and, as applicable, the first addition of moderator and/or reflector, thereby linking responsibilities for safety with responsibilities for operation of the plant.

2.9. The commissioning programme should be structured and appropriately justified so as to ensure the following:

- All the tests necessary to demonstrate that the plant meets the design intent as stated in the safety analysis report are performed (the Annex provides a list of typical tests to be considered in developing the commissioning programme).
- The tests are performed in a logical sequence; in particular, tests are arranged to be progressive, so that the plant is exposed to less onerous conditions before it is exposed to more onerous conditions.
- The tests are grouped in commissioning stages in a logical sequence from non-nuclear testing stages to nuclear testing stages, and from testing stages for individual systems and components to overall testing stages for integrated systems, with overall testing stages for the plant at the end.
- The appropriate hold points are established for the commissioning process.
- Operations personnel, maintenance personnel and support personnel are further trained, and processes and procedures are validated.
- Milestones are identified, including milestones at which the regulatory body's authorization is required to proceed in the process of commissioning.

2.10. Irrespective of the organizational arrangements for commissioning of the nuclear power plant, the operating organization should review and approve the commissioning programme.

2.11. The commissioning programme should include:

- Any applicable requirements of the regulatory body, including the witnessing of specified tests;
- The designation of each test together with a unique identification;
- Cross-references to other documents relevant to commissioning;
- Provision for the means for data collection for future use.

2.12. During commissioning, normal operating procedures, including those for operational periodic tests, should be widely used to validate the applicability of the procedures. The emergency operating procedures should also be validated in the commissioning programme, to the extent possible.

2.13. The commissioning programme should include provisions to ensure that operating personnel and maintenance personnel in all disciplines participate, to the extent possible, in commissioning activities, and that the operating procedures are validated with the participation of plant staff, to the extent practicable. Designers and other specialists should be involved in the development and review process for commissioning and test programmes, procedures and results.

2.14. The commissioning programme should provide a framework for the scheduling of tests and related activities, and for suitable personnel and equipment to be available at the proper time. The programme should also provide for the timely production of all documentation.

2.15. The commissioning programme should be written in such a form as to enable the objectives and methods of testing to be readily understood by all concerned and to allow control and coordination by management.

2.16. The commissioning programme should be prepared in the framework of the existing management system of the operating organization, with proper consideration given to all aspects of management.

STAGES OF COMMISSIONING

2.17. The commissioning programme for a nuclear power plant should be divided into stages whose number and size will depend upon safety requirements, and technical, administrative and regulatory requirements when applicable. A review of the results of the stage tests should be completed before continuing to the next stage. The review should enable a judgement to be made on whether the commissioning programme may continue to the next stage, and whether the succeeding stages should be modified as a consequence of the test results or because some tests in the stage were not undertaken or were not satisfactorily completed. The impact on safety of the incompleteness or the omission of tests should be given due consideration before proceeding with further testing.

2.18. In addition, if the sequence of tests in a stage of commissioning is significant for safety, substages may be required by the operating organization or the regulatory body. Each stage and substage should be followed by a review before the next stage is started. Before the start of initial criticality tests, low power tests and power ascension tests, all the tests at the previous stages should be satisfactorily completed. Open issues, if any, should be accepted as being required to be cleared prior to or at the next stage.

2.19. On the basis of the broad range of commissioning practices in States, the commissioning process can be divided into the following stages and substages in order to obtain the responses of all important systems for different values of operating parameters:

- Non-nuclear testing, which includes:
 - Individual pre-operational tests of systems and components;
 - Overall pre-operational systems tests;
 - Structural integrity tests, integrated leakage rate tests of the containment and of the primary system and secondary system.
- Nuclear testing, which includes:
 - Initial fuel loading;
 - Subcritical tests;
 - Initial criticality tests;
 - Low power tests;
 - Power ascension tests.

2.20. The sequence of tests in each substage should be given in the order in which the tests are expected to be performed. Adjustment of the test sequence can be performed according to progress of the tests, the test results or external conditions

such as the availability of supporting systems and supporting facilities (e.g. electrical grid, water treatment), the need for periodic tests or the performance of maintenance activities. These adjustments should take due consideration of safety aspects and should be controlled to ensure the same level of review as the original sequence. The adjustments should result from a common agreement of the commissioning organization and the operating organization, and of the regulatory body, where necessary.

2.21. Each stage or substage of commissioning should include the tasks necessary for the preparation of the succeeding stage or substage, and in particular the availability requirements of the systems for the succeeding stage.

2.22. The relevant safety system settings and alarm settings, including those of instruments for radiological protection, should be specified at the appropriate commissioning stages or substages.

EXECUTION OF THE COMMISSIONING PROGRAMME

2.23. Testing, as the core of the commissioning programme, should be sufficiently comprehensive to demonstrate that the plant can be operated in all modes for which it has been designed to be operated. However, tests should not be conducted, and operating modes or plant configurations should not be established, if they meet any of the following conditions:

- If they have not been analysed and found to be safe;
- If they fall outside the range of assumptions made in the safety analysis report;
- If they might damage the plant or jeopardize its safety.

A risk assessment should be carried out before the commencement of each test, and any necessary precautions should be taken in accordance with its findings.

2.24. Appropriate and extensive tests of the safety functions for the nuclear power plant and for structures, systems and components should be identified and executed.

2.25. In determining the sequence of testing, the following points should be carefully considered:

- Systems that are so identified should undergo prior testing so that they are available for the proper testing of other systems.
- Systems that are so identified should be operational to ensure that other systems can be tested without risks to workers and without jeopardizing the safety of the plant.
- Relevant tests should be grouped together in a stage (or substage) of testing of systems.
- Simultaneous tests may have an influence on each other's results.

2.26. During construction of a nuclear power plant, a period of inactivity and the construction of other equipment may alter the test results of equipment that has already been commissioned. This should be considered in the planning of commissioning tests, especially for standby components that are not operated regularly.

2.27. Specific programmes and procedures should be written in support of the commissioning programme. These programmes and procedures should describe the principles, objectives and nature of the tests. They should include the criteria for judging the validity of the results and the acceptance criteria. These procedures for systems important to safety should contain checks that all performance levels and operating parameters have been demonstrated for all operational states (normal operation, anticipated operational occurrences) and for accident conditions to the extent possible, without jeopardizing safety, either directly or indirectly.

2.28. The commissioning programme should be comprehensive; it should include statutory non-nuclear tests in accordance with national practice; and it should have sufficient scope to ensure that there have been no omissions in the testing of complex systems.

2.29. For multi-unit plants, the following provisions should be applied:

- (a) Separate commissioning programmes should be prepared and implemented for each unit; even if the systems at a multi-unit site have the same design, the commissioning tests should be performed with the same scope at each unit.
- (b) Some structures, systems and components may be common to more than one unit. In this case, tests should be conducted to provide assurance that the specified performance requirements of such structures, systems and components can be met for the design intent of each unit, and that the design intent is satisfied for each individual unit when all units using such a

common system are operational. Tests should also be conducted to provide assurance that the specified performance requirements of such structures, systems and components can be met in cases for which accident conditions in individual units and multiple units can be tested.

- (c) Special provisions, including provision for adequate communication, should be made to ensure that the safety of a unit already in operation is not jeopardized in the commissioning tests for another unit. Such special provisions should include conducting a risk assessment. These special provisions may require obtaining the prior approval of the regulatory body, in accordance with national practices, or obtaining specific approval in writing from the manager responsible for the operating unit.
- (d) A nuclear power plant unit under commissioning should be isolated from areas where construction activities are in progress. Such isolation should protect the unit from events, including possible violations, that might occur in construction areas. Likewise, isolation should protect construction areas from possible accidents at a unit under commissioning.

ROLE OF THE REGULATORY BODY

2.30. The role of the regulatory body in the commissioning process for a nuclear power plant is specified by the responsibilities and functions established by its legal framework and national regulations. The main role of the regulatory body in the commissioning process (including the preparations for commissioning) is the oversight of commissioning activities, including, where appropriate, issuing (or not) relevant authorizations. The purpose of regulatory oversight should be to ensure that the plant is constructed in accordance with the design intent and its licensing base, and that the systems and equipment are installed as designed, and to ensure that their functionality, as well as the behaviour of the plant as a whole, demonstrates compliance with the design intent and the safety requirements, and demonstrates that the power plant can be operated safely.

2.31. The scope and content of the assessments, reviews and inspections conducted by the regulatory body in connection with the commissioning programme differ from State to State. In some States, the regulatory body approves the commissioning programme and establishes the hold points for inspections, reviews and assessments of the testing results in accordance with the acceptance criteria. An agreement (in some States, formal approval) should be obtained before advancing beyond these hold points. The commissioning stages are typical hold points at which the reviews and assessments of the results of commissioning stages are performed before proceeding to the next stage. In

particular, such reviews, assessments and inspections are typically conducted at the stages of fuel loading and of achieving first criticality and power ascension. Reference [3] provides further guidance on the responsibilities of the regulatory body with respect to the commissioning process.

2.32. In addition to the examination of documentation and the surveillance of testing, there are a number of other areas in which there should be oversight by the regulatory body at the commissioning stage. The ability of the management of the operating organization to progress from supervising construction to supervising operation, and its arrangements for doing so, should also be reviewed. Such a review should cover the management's provisions for putting the emergency plan into effect and for the training and qualification of operating personnel. Requirements for the detailed functions and responsibilities of the regulatory body in relation to nuclear power plants are established in Refs [4, 5], and related recommendations are provided in Refs [6, 7].

2.33. The regulatory body and the operating organization should liaise closely throughout the implementation of the entire commissioning programme.

ROLE OF THE OPERATING ORGANIZATION

2.34. The operating organization, as the licensee for operation of the plant, bears the overall responsibility for nuclear and radiation safety as well as for protection of workers and the environment, and should ensure the correct and satisfactory organization, planning, execution and assessment of the commissioning process. Reference [8] contains further recommendations on the responsibilities of the operating organization.

2.35. Appropriate organizational arrangements should be established to ensure that the operating organization can properly and effectively discharge its responsibilities with regard to the commissioning programme. When commissioning activities are conducted by contractors, the operating organization should make the necessary arrangements to review and approve these activities at all stages, and it should establish appropriate hold points and milestones.

2.36. The operating organization should take appropriate actions during the commissioning stage to ensure that the operating personnel are involved in the commissioning activities as early as possible. Attributes of safety culture such as personal dedication, safety consciousness and a questioning attitude should

be fostered in the pre-operational stages so as to become instinctive for the subsequent operational stage.

3. ORGANIZATION AND MANAGEMENT OF COMMISSIONING

MANAGEMENT SYSTEM FOR COMMISSIONING

3.1. For the commissioning stage, the operating organization should develop and implement a management system that:

- (a) Meets the requirements established in Ref. [9];
- (b) Takes into account the generic recommendations provided in Refs [10, 11].

3.2. The recommendations in paras 3.1–3.12 provide a means of meeting the requirements established in Ref. [9] in the commissioning of nuclear power plants. They are supplementary to, and should be followed in conjunction with, the recommendations provided in Refs [10, 11], which cover processes applicable to commissioning. The management system should ensure that nuclear safety matters are not dealt with in isolation during commissioning but are considered in the context of all commissioning activities.

3.3. The operating organization (licensee) should develop and implement a management system that describes the overall arrangements for the management, performance and assessment of activities at the nuclear power plant during commissioning. The management system should cover all the activities that are carried out in, or are necessary for, the commissioning stage.

3.4. The management system for commissioning should be established early on, before the start of commissioning. The system should cover all items, services and processes relating to commissioning, including those important to safety. In establishing and implementing the management system for commissioning, a graded approach based on the relative importance to safety of each item or process should be used.

3.5. The following topics applicable to safety in commissioning should be addressed in the management system:

- Control of documents;
- Control of products;
- Measuring and testing of equipment;
- Control of records;
- Purchasing;
- Communication;
- Managing organizational change;
- Project management;
- Work planning and control;
- Risk assessment for the work place;
- Personnel protection and safety;
- Control and supervision of contractors;
- Design of structures, systems and components;
- Configuration management;
- Plant modification;
- Maintenance;
- Housekeeping and cleanliness;
- Handling and storage of items;
- Inventory management;
- Identification and labelling of structures, systems and components;
- Management of spent fuel and radioactive waste;
- Protection of the environment;
- Interfaces with the regulatory body;
- Information technology;
- Training;
- Protection against fires and internal flooding;
- Accounting for and control of nuclear material and radioactive material.

3.6. Structures, systems and components are classified in the design stage on the basis of their importance to safety. The classification provides an input in determining commissioning requirements, and requirements for methods, testing, inspections, reviews, qualification of personnel and records.

3.7. The structure, content, extent and means of control of commissioning documents, including their verification and approval, should be described in the management system of the operating organization.

3.8. A key objective of the management system during commissioning is to ensure that the nuclear power plant meets the requirements for safety as derived from:

- The requirements of the regulatory body;
- Design requirements and assumptions;
- The safety analysis report;
- Operational limits and conditions;
- The administrative requirements established by the management of the operating organization (licensee).

3.9. The management system should support the development and enhancement of a safety culture in all commissioning activities, including among members of the construction, commissioning and operating groups as well as other participants (designers, manufacturers, technical support organizations and contractors). This safety culture and safety awareness should be ensured through appropriate training, highlighting the role and the safety significance of the components concerned. Every person participating in the commissioning activities needs to understand the safety significance of his or her work, to promote personal responsibility. The commissioning stage should foster a safety culture that should be maintained throughout the operating stage.

3.10. The operating organization should implement adequate arrangements in a management system to ensure safety and quality for a commissioning programme that is effective and is in accordance with national and international standards. Provision should be made to ensure that the safety, health, environmental, security, quality and economic requirements for commissioning are met by all organizations participating in commissioning activities, including contractors.

3.11. The operating organization should ensure that appropriate procedures are established for the control of commissioning activities on the site, to ensure that the commissioning of the plant fulfils the requirements of the commissioning programme.

3.12. Arrangements should be made for adequate and, where necessary, independent oversight and control of the quality of ongoing work.

ORGANIZATIONAL ARRANGEMENTS FOR COMMISSIONING

3.13. Organizational arrangements should be put in place to achieve the safety objectives of commissioning in accordance with the commissioning programme. These organizational arrangements should represent a convenient and practical working scheme that allows the optimum use of the available personnel, resources and methods, and that provides assurances on safety.

3.14. The principal activities performed in commissioning may be divided into the following categories:

- (a) Those associated with the final stage of construction of the plant and installation of the plant equipment;
- (b) Those specific to commissioning, including activities for testing and activities for safety review;
- (c) Those associated with the operation and maintenance of the plant.

Accordingly, personnel performing the above activities may belong to the following groups:

- Construction group;
- Commissioning group;
- Operating group.

There may be other participants in commissioning activities, such as designers, manufacturers and technical support organizations. These participants should collaborate with the aforementioned groups, as appropriate. In particular, designers and manufacturers should provide adequate and complete information to the groups. The designers should also review the commissioning data, and should, where necessary, be involved in the resolution of problems and the rectification of defects detected during the commissioning stage.

3.15. There may be many ways in which the construction, commissioning and operating groups could be formed. This may depend upon the industrial practice and the experience with nuclear power in the State, and upon contractual arrangements, as well as upon the physical size and design of the plant. The composition of the groups may also be influenced by the availability and experience of personnel performing specialized functions. If the operating organization decides to subcontract the commissioning activities to another organization, it should be made clear that the ultimate responsibility for commissioning and for safety remains with the operating organization.

3.16. The working arrangements should, as far as practicable, make use of the operating personnel so that they become familiar with the plant and the facilities during commissioning. In addition, the operating group should participate in the commissioning activities from the start of the commissioning process, to ensure that as many operating personnel as possible gain field experience and to establish an ‘institutional memory’ for the plant.

3.17. The management system should ensure that the responsibilities remain clear at all times, even if construction, commissioning and operating activities overlap.

3.18. In all the cases, under the overall direction of the operating organization as licensee:

- The construction group should ensure that structures, systems and components are properly constructed and installed in accordance with the design, and that the requirements for quality management have been adhered to during construction.
- The commissioning group should ensure that structures, systems and components are tested to provide assurance that the plant has been properly designed and constructed and is ready for safe operation.
- The operating group should operate systems and equipment in accordance with the assumptions and intent of the commissioning programme, respecting the relevant operating limits and conditions that are applicable for each testing stage [12].

Operating organization

Establishing the operating group

3.19. The operating organization should establish an operating group at the plant to take over the responsibilities that are transferred from the construction group and the commissioning group for operation of the equipment and systems. The operating group, on behalf of the operating organization, should take over from the construction and commissioning groups the responsibilities for the equipment and systems and should ensure their safe functioning and maintenance. The operating group should be established at the early stages of construction of the nuclear power plant to give it time for familiarization with the structures, systems and components of the plant and with the preparations for taking over the operating functions for the equipment and systems and for the plant as a whole.