

# IAEA SAFETY STANDARDS SERIES

## Safety of Nuclear Power Plants: Operation

### REQUIREMENTS

No. NS-R-2



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**.

**Safety Fundamentals** (blue lettering) present basic objectives, concepts and principles of safety and protection in the development and application of nuclear energy for peaceful purposes.

**Safety Requirements** (red lettering) establish the requirements that must be met to ensure safety. These requirements, which are expressed as 'shall' statements, are governed by the objectives and principles presented in the Safety Fundamentals.

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[www.iaea.org/ns/coordinet](http://www.iaea.org/ns/coordinet)

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

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SAFETY OF  
NUCLEAR POWER PLANTS:  
OPERATION

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

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# FOREWORD

by **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 Advisory Commission for Safety Standards (ACSS); the Nuclear Safety Standards Advisory Committee (NUSSAC); the Radiation Safety Standards Advisory Committee (RASSAC); the Transport Safety Standards Advisory Committee (TRANSSAC); and the Waste Safety Standards Advisory Committee (WASSAC). 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 by experts 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 fulfil 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 fulfil 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.*



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# 1. INTRODUCTION

## BACKGROUND

1.1. The safety of a nuclear power plant is ensured by means of its proper siting, design, construction and commissioning, followed by the proper management and operation of the plant. In a later phase, proper decommissioning is required.

1.2. This Safety Requirements publication supersedes the Code on the Safety of Nuclear Power Plants: Operation, which was issued in 1988 as Safety Series No. 50-C-O (Rev. 1). The purpose of this revision was: to restructure Safety Series No. 50-C-O (Rev. 1) in the light of the basic objectives, concepts and principles in the Safety Fundamentals publication The Safety of Nuclear Installations [1]; to be consistent with the requirements of the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources [2]; and to reflect current practice and new concepts and technical developments.

1.3. Guidance on fulfilment of these Safety Requirements may be found in the appropriate Safety Guides relating to plant operation.

## OBJECTIVE

1.4. The objective of this publication is to establish the requirements which, in the light of experience and the present state of technology, must be satisfied to ensure the safe operation of nuclear power plants. These requirements are governed by the basic objectives, concepts and principles that are presented in the Safety Fundamentals publication The Safety of Nuclear Installations [1].

## SCOPE

1.5. This publication deals with matters specific to the safe operation of land based stationary thermal neutron nuclear power plants, and also covers their commissioning and subsequent decommissioning.

## STRUCTURE

1.6. This publication consists of 11 sections. Section 2 relates to the requirement to establish an operating organization with an effective organizational structure with overall responsibility for the safe operation of a nuclear power plant. Sections 3–7 establish the requirements for the safe operation of a plant in areas such as qualification of personnel, commissioning, maintenance, surveillance and inspection activities, to ensure that the plant is operated within the design envelope. Section 8 establishes requirements for radiation protection and radioactive waste management. Sections 9 and 10 establish requirements for documented records and reports and for periodic safety review. Section 11 establishes requirements for the final stage of the life cycle of the plant, namely decommissioning.

## **2. OPERATING ORGANIZATION**

### GENERAL REQUIREMENTS

2.1. The operating organization, as licensee, shall have responsibility for the safe operation of the nuclear power plant. The operating organization shall retain prime responsibility for safety but it may delegate authority to the plant management for the safe operation of the plant. In such cases the operating organization shall provide the necessary resources and support. The management of the plant shall ensure that the plant is operated in a safe manner and in accordance with all legal and regulatory requirements.

2.2. The operating organization shall place special emphasis on safety in operation. It shall establish and effect policies that give safety matters the highest priority. Although the operating organization may already have an organizational structure for managing non-nuclear power plants, the special emphasis on safety will necessitate more than merely an extension of the existing organizational structure.

2.3. In establishing the organizational structure of the operating organization, consideration shall be given to the following management functions:

- (1) Policy making functions, which include: setting management objectives; establishing policy for nuclear safety and for quality; allocating resources; providing material and human resources; approving the contents of management programmes; setting policies on fitness for duty; and establishing a programme

to make the necessary changes to any of these functions on the basis of the performance in achieving objectives.

- (2) Operating functions, which include executive decision making and actions for the operation of a plant, both in operational states and in accidents.
- (3) Supporting functions, which include obtaining from both on-site and off-site organizations the technical and administrative services and facilities necessary to perform the operating functions.
- (4) Reviewing functions, which include critical monitoring of the performance of the operating and supporting functions, and review of the design. The purpose of monitoring is to verify compliance with the stipulated objectives for safe operation of the plant; to reveal deviations, deficiencies and equipment failures; and to provide information for the purpose of taking timely corrective action and making improvements. Reviewing functions also include review of the overall safety performance of the organization in order to assess the effectiveness of safety management and to identify opportunities for improvement.

2.4. The organizational structure shall be established and documented so as to ensure that the following responsibilities are discharged with respect to achieving safe operation of nuclear power plants:

- (1) Responsibilities shall be allocated and authority shall be delegated within the operating organization.
- (2) Satisfactory conduct of management programmes shall be established and verified.
- (3) Adequate training for personnel shall be provided.
- (4) Liaison shall be established with the regulatory body and with public authorities for the purposes of ensuring understanding of and compliance with safety requirements.
- (5) Liaison shall be established with organizations for design, construction, manufacturing and plant operation and with other organizations (national and international) as necessary to ensure the proper transfer of information, expertise and experience and the ability to respond to safety issues.
- (6) Adequate resources, services and facilities shall be provided.
- (7) Adequate public consultation and liaison shall be provided for.

2.5. A document describing the plant's organizational structure and the management arrangements for discharging all these responsibilities shall be made available to the regulatory body for review. In addition, proposed changes to the structure and associated arrangements which might be significant to safety shall be systematically reviewed by the operating organization and shall be submitted to the regulatory body for review.

2.6. The document describing the plant's organizational structure shall indicate the staffing arrangements within the categories of direct line operating personnel and supporting personnel. Clear lines of authority shall be established to deal with matters bearing on plant safety. The extent to which the support functions are self-sufficient or dependent upon services from outside the plant organization shall be demonstrated by means of functional organizational charts which include personnel resource allocations and specify the duties and responsibilities of key personnel.

2.7. Functional responsibilities, levels of delegated authority and lines of internal and external communication for the safe operation of plants in all operational states, for mitigating the consequences of accident conditions and for ensuring an appropriate response in emergencies shall be clearly defined in writing.

2.8. The operating organization shall be staffed with competent managers and sufficient qualified personnel having a proper awareness of the technical and administrative requirements for safety and motivated to be safety conscious. Attitude towards safety shall be a criterion for the hiring or promoting of managers. Staff performance appraisals shall include a section on the attitude towards safety.

2.9. A policy on safety shall be developed by the operating organization and applied by all site personnel. This policy shall give safety the utmost priority at the plant, overriding if necessary the demands of production and project schedules. The policy shall include a commitment to excellent performance in all activities important to safety and shall encourage a questioning attitude.

2.10. All activities that may affect safety shall be performed by suitably qualified and experienced persons. Certain activities with a bearing on safety may be performed by qualified persons outside the plant structure (such as contractors). These activities shall be clearly defined in writing. The implementation of these activities on or off the site shall be subject to the approval of the plant management. Contractors' staff shall be properly controlled and supervised by the plant staff.

2.11. All activities that may affect safety and which can be planned in advance shall be conducted in accordance with established procedures which shall be submitted by the operating organization to the regulatory body for approval, if so required.

2.12. When activities are proposed that are not included in the normal procedures, special procedures shall be written in accordance with established administrative procedures. These special procedures shall include the contents and the operational details of the proposed activity. Such activities and special procedures shall be carefully reviewed for any safety implications. The approval of these special procedures

shall follow the same process as that for the normal procedures of the plant. The proposed procedures shall be submitted to the regulatory body for approval, if so required.

2.13. The operating organization shall ensure that regular reviews of the operation of the plant are conducted, with the aim of ensuring: that an appropriate safety consciousness and safety culture prevail; that the provisions set forth for enhancing safety are observed; that documentation is up to date; and that there are no indications of overconfidence or complacency. Where practicable, suitable objective performance measures shall be used. The results shall be made available to plant management and appropriate corrective actions shall be taken.

## INTERFACE WITH THE REGULATORY BODY

2.14. The operational safety of a plant shall be subject to surveillance by a regulatory body independent of the operating organization. Further information on the role of the regulatory body can be found in Ref. [3].

2.15. Mutual understanding and respect between the regulatory body and the operator, and a frank, open and yet formal relationship, shall be fostered.

2.16. The operating organization shall submit or make available documents and information in accordance with the requirements of the regulatory body.

2.17. The operating organization shall develop and effect a procedure for reporting abnormal events to the regulatory body in accordance with established criteria.

2.18. To enable the regulatory body to perform its functions, the operating organization shall render all necessary assistance and shall grant access to the plant and documentation. When so required by the regulatory body, the operating organization shall undertake special analyses, tests and inspections. The operating organization, in view of its responsibility for safety, shall make its opinion known to the regulatory body as a basis for subsequent discussions if it considers that any action requested of it by the regulatory body could have an adverse effect on safety.

## QUALITY ASSURANCE

2.19. The operating organization shall prepare and put in place a comprehensive quality assurance programme covering all activities which may affect the safe

operation of the plant. Quality assurance shall be an integral part of every activity that may affect safety. The principles and methods of quality assurance shall be used systematically in:

- Management processes;
- Operational activities;
- Assessments of management processes and of the adequacy of operational performance.

2.20. The operating organization and other organizations and persons concerned shall meet the requirements of the Code on Quality Assurance for Safety in Nuclear Power Plants and other Nuclear Installations ([4], C). Further guidance on quality assurance in operation may be found in the Safety Guide on Quality Assurance in Operation ([4], Q13).

## FEEDBACK OF OPERATING EXPERIENCE

2.21. Operating experience at the plant shall be evaluated in a systematic way. Abnormal events with significant safety implications shall be investigated to establish their direct and root causes. The investigation shall, where appropriate, result in clear recommendations to the plant management, which shall take appropriate corrective action without undue delay. Information resulting from such evaluations and investigations shall be fed back to the plant personnel.

2.22. Similarly, the operating organization shall obtain and evaluate information on operating experience at other plants to derive lessons for its own operations. To this end, the exchange of experience and the contribution of information to national and international organizations is of great importance.

2.23. Operating experience shall be carefully examined by designated competent persons for any precursors of conditions adverse to safety, so that any necessary corrective action can be taken before serious conditions arise.

2.24. All plant personnel shall be required to report all events and shall be encouraged to report on any ‘near misses’<sup>1</sup> relevant to the safety of the plant.

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<sup>1</sup> The term ‘near miss’ is used for a potentially significant event that could have occurred as the consequence of a sequence of actual occurrences but did not occur owing to the plant conditions prevailing at the time.



2.25. Plant management shall maintain liaison as appropriate with the organizations (manufacturer, research organization, designer) involved in the design, with the aims of feeding back information on operating experience and obtaining advice, if necessary, in the event of equipment failures or abnormal events.

2.26. Data on operating experience shall be collected and retained for use as input for the management of plant ageing, for the evaluation of residual plant life, and for probabilistic safety assessment and periodic safety review.

## PHYSICAL PROTECTION

2.27. All reasonable precautions shall be taken to prevent persons from deliberately carrying out unauthorized actions that could jeopardize safety.

2.28. The operating organization shall take measures for physical security and physical protection as appropriate to prevent or deter unauthorized access to, intrusion into, theft of, surface attack on, and internal or external sabotage of safety related systems and nuclear materials. Guidance on the physical protection of nuclear material and nuclear facilities may be found in Ref. [5].

2.29. The operating organization shall have plans and procedures in place to provide for physical protection of the site in the event of civil disturbance.

## FIRE SAFETY

2.30. The operating organization shall make arrangements for ensuring fire safety on the basis of a fire safety analysis which shall be periodically updated. Such arrangements shall include: application of the principle of defence in depth; assessment of the impact of plant modifications on fire fighting; control of combustibles and ignition sources; inspection, maintenance and testing of fire protection measures; establishment of a manual fire fighting capability; and the training of plant personnel.

## EMERGENCY PREPAREDNESS

2.31. Emergency preparedness concerns the capability of maintaining protection and safety by managing accidents; mitigating their consequences if they do occur; protecting the health of site personnel and the public; and protecting the environment. The operating organization shall prepare an emergency plan that covers all

activities under its responsibility, to be adhered to in the event of an emergency. This emergency plan shall be co-ordinated with those of all other bodies having responsibilities in an emergency, including public authorities, and shall be submitted to the regulatory body.

2.32. The operating organization shall establish the necessary organizational structure and shall assign responsibilities for managing emergencies. This shall include arrangements for: prompt recognition of emergencies; timely notification and alerting of response personnel; and provision of the necessary information to the authorities, including timely notification and subsequent provision of information as required.

2.33. The emergency plan of the operating organization shall include the following:

- (1) The designation of persons for directing on-site activities and for ensuring liaison with off-site organizations;
- (2) The conditions under which an emergency shall be declared, a list of job titles and/or functions of persons empowered to declare it, and a description of suitable means for alerting response personnel and public authorities;
- (3) The arrangements for initial and subsequent assessment of the radiological conditions on and off the site;
- (4) Provisions for minimizing the exposure of persons to ionizing radiation and for ensuring medical treatment of casualties;
- (5) Assessment of the state of the installation and the actions to be taken on the site to limit the extent of radioactive release;
- (6) The chain of command and communication, including a description of related facilities and procedures;
- (7) An inventory of the emergency equipment to be kept in readiness at specified locations;
- (8) The actions to be taken by persons and organizations involved in the implementation of the plan;
- (9) Provisions for declaring the termination of an emergency.

2.34. The emergency plan shall include arrangements for emergencies involving a combination of non-nuclear and nuclear hazards, such as a fire in conjunction with significant levels of radiation or contamination, or toxic or asphyxiating gases in conjunction with radiation and contamination, with account taken of the specific site conditions.

2.35. Site personnel shall be trained in the performance of their duties in an emergency. There shall be a means of informing all employees and all other persons on the site of the actions to be taken in the event of an emergency.

2.36. Appropriate emergency arrangements shall be established from the time that nuclear fuel is brought to the site, and complete emergency preparedness as described here shall be ensured before the commencement of operation.

2.37. The emergency plan shall be tested in an exercise before the commencement of operation. There shall thereafter at suitable intervals be exercises of the emergency plan, some of which shall be witnessed by the regulatory body. Some of these exercises shall be integrated and shall include the participation of as many as possible of the organizations concerned. The plans shall be subject to review and updating in the light of experience gained.

2.38. Instruments, tools, equipment, documentation and communication systems to be used in emergencies shall be kept available and shall be maintained in good operating condition, in such a manner that they are unlikely to be affected by or made unavailable by the postulated accidents.

### **3. QUALIFICATION AND TRAINING OF PERSONNEL**

3.1. The operating organization shall define the qualifications and experience necessary for personnel performing duties that may affect safety. These qualifications and experience shall be approved by the regulatory body if so required. Suitably qualified personnel shall be selected and given the necessary training and instruction to enable them to perform their duties correctly for the different operational states of the plant and in the event of an accident, in accordance with the appropriate operating or emergency procedures. Persons performing certain functions important to safety shall be required to hold a formal authorization; this may be issued or acknowledged by the regulatory body in accordance with national requirements.

3.2. All personnel of the operating organization whose duties may affect safety shall be medically examined on appointment and at intervals subsequently as required to ensure their fitness for the duties and responsibilities assigned to them.

3.3. A suitable programme shall be established and maintained for the training of personnel before their assignment to safety related duties. The training shall emphasize the paramount importance of safety in all aspects of plant operation. Advantage should be taken of the commissioning activities to provide additional training and first hand experience for the plant personnel. Relevant documentation on the training programme shall be made available to the regulatory body.

3.4. The operating organization shall ensure that all personnel who may be required to perform safety related duties have a sufficient understanding of the plant and its safety features, and other relevant competences, such as managerial and supervisory skills, to perform their duties properly and with due attention to safety.

3.5. The operating organization shall ensure that the qualifications and training of external personnel performing safety related duties are adequate for the functions to be performed.

3.6. The training programme shall include provisions for periodic confirmation of the competence of personnel and for refresher training on a regular basis.

3.7. The plant manager is responsible for the qualification of plant staff and shall support the training organization with the necessary resources and facilities. Line managers and supervisors shall be responsible for the competence of their personnel. They shall participate in determining the needs for training, and in ensuring that operating experience is taken into account in the training. Managers and supervisors shall ensure that production needs do not interfere with the conduct of the training programme.

3.8. Performance based programmes for initial and continuing training shall be developed and put in place for each major group of personnel. The content of each programme should be based on a systematic approach. Training programmes shall promote attitudes which help to ensure that safety issues receive the attention that they warrant.

3.9. Training instructors shall be technically competent in their assigned areas of responsibility and have the necessary instructional skills.

3.10. Adequate facilities shall be provided for classroom training and for individual study. Appropriate educational training material shall be provided to assist trainees in understanding the plant and its systems.

3.11. Representative simulator facilities shall be used for the training of operating personnel. Simulator training shall incorporate training for operational states and for accidents.

3.12. Plant staff shall receive instructions in the management of accidents beyond the design basis. The training of operating personnel shall ensure their familiarity with the symptoms of accidents beyond the design basis and with the procedures for accident management.

3.13. A programme shall be put in place to assess and improve the training programmes. In addition, a system shall be in place for timely modification and updating of the training facilities and materials to ensure that they accurately reflect plant conditions.

3.14. A programme shall be put in place to ensure that operating experience of events at the plant concerned as well as of relevant events at other plants is appropriately factored into the training programme. The programme shall ensure that training is conducted on the root cause(s) of the events and on the identification and implementation of corrective actions to prevent their recurrence.

## **4. COMMISSIONING PROGRAMME FOR THE PLANT**

4.1. Specific approval by the regulatory body shall be required before the start of normal operation. Such approval will be granted on the basis of an appropriate safety analysis report and a commissioning programme. The commissioning programme shall provide evidence that the installation as constructed meets the design intent and complies with the safety requirements. Operating procedures shall be validated to the extent practicable as part of the commissioning programme, with the participation of the future operating personnel.

4.2. The commissioning programme shall meet the objectives of the operating organization, including safety objectives, and shall be subject to approval by the regulatory body. It should be divided into review stages, and progression from one stage to the next should be conditional upon an evaluation of the results of the commissioning tests and an audit to ascertain that all objectives and regulatory requirements have been met.

4.3. Authorities and responsibilities for the commissioning process shall be clearly defined and delegated to the individuals performing the work. The interfaces between those groups involved in commissioning (such as groups for design, for construction, of contractors, for commissioning and for operations) shall be clearly defined and properly controlled.

4.4. A sufficient number of qualified operating personnel, at all levels and in all areas, shall be directly involved in the commissioning process.

4.5. To confirm the applicability and quality of the operating procedures, they shall be verified to ensure their technical accuracy and validated to ensure their usability with the installed equipment and control systems, as far as possible prior to loading fuel into the core. This process shall continue during the commissioning phase. This verification and validation process shall also apply to procedures for maintenance, surveillance and plant chemistry as appropriate.

4.6. The operating organization shall ensure that the commissioning programme includes all the tests necessary to demonstrate that the plant as installed meets the requirements of the safety analysis report and satisfies the design intent, and consequently can be operated in accordance with the operational limits and conditions. The tests shall be carried out in a logical order. The commissioning programme shall also provide the regulatory body with a means of identifying hold points in the commissioning process. No tests shall be performed which could put the plant into conditions that have not been analysed. The programme shall ensure that 'baseline' data on systems and components, which are important for ensuring the safety of the plant and for subsequent safety reviews, are collected and retained.

4.7. From the start of commissioning, adequate work control and modification procedures shall be put in place to ensure that the objectives of commissioning tests are not invalidated in the process of performance of the commissioning programme. These procedures should be the same as those intended for the operating phase.

4.8. From construction to commissioning, and finally to operation, the plant shall be adequately monitored and maintained in order to protect plant equipment, to support the testing phase and to continue to maintain consistency with the safety analysis report. Records of operations and maintenance shall be kept starting from the initial energization and operation of each plant system, and they shall be retained by the operating organization in proper archives for periods as agreed with the regulatory body.

4.9. To confirm that the plant is prepared for the initial core loading, prerequisites for systems, equipment, documentation and personnel shall be established well in advance of the fuel loading. These prerequisites shall be clearly stated and documented on the basis of the safety analysis report and the existing regulatory requirements.

4.10. Initial fuel loading shall not be authorized until all pre-operational tests deemed necessary by the operating organization and the regulatory body have been performed and results acceptable to both parties have been obtained.

4.11. Reactor criticality and initial power raising shall not be authorized until all tests deemed necessary by the operating organization and the regulatory body have been performed and results acceptable to both parties have been obtained.

4.12. All the functions of the operating organization shall be performed at the appropriate stages during commissioning. These functions shall include responsibilities for: management; training of personnel; the radiation protection programme; waste management; management of records; fire safety; physical protection; and the emergency plan.

## **5. PLANT OPERATIONS**

### **OPERATIONAL LIMITS AND CONDITIONS**

5.1. Operational limits and conditions shall be developed to ensure that the plant is operated in accordance with the design assumptions and intent. They shall reflect the provisions made in the final design and shall be submitted to the regulatory body for assessment and approval before the commencement of operation. The operational limits and conditions shall include requirements for different operational states, including shutdown. They shall also cover actions to be taken and limitations to be observed by the operating personnel. The operational limits and conditions, which may be distributed between several documents, including national safety regulations, the plant safety analysis report, technical specifications or operating manuals, shall all be readily accessible for control room personnel.

5.2. The operational limits and conditions shall form an important part of the basis on which the operating organization is authorized to operate the plant. Operating personnel directly responsible for the conduct of operation shall be thoroughly familiar with the intent and content of the operational limits and conditions in order to comply with the provisions contained therein.

5.3. The operational limits and conditions may be classified as:

- (1) Safety limits;
- (2) Limits on safety system settings;
- (3) Limits and conditions for normal operation and for safe transient operational states;
- (4) Surveillance requirements.

5.4. The operational limits and conditions shall have the purposes of:

- (1) The prevention of situations which could lead to accidents;
- (2) The mitigation of the consequences of any such accidents, if they do occur.

5.5. The operating organization shall ensure that an appropriate surveillance programme is established and implemented to ensure compliance with the operational limits and conditions, and that its results are evaluated and retained.

5.6. The operational limits and conditions shall be based on an analysis of the individual plant and its environment, in accordance with the provisions made in the design. The necessity for each of the operational limits and conditions shall be substantiated by a written statement of the reason for its adoption. Amendments shall be incorporated as necessary as a result of testing carried out during commissioning and these shall be approved by the regulatory body.

5.7. The operational limits and conditions shall be reviewed over the operating life of the plant in the light of experience, developments in technology and safety, and changes in the plant, and shall be modified if this is required by the regulatory body or if it is considered appropriate by the operating organization and approved by the regulatory body.

5.8. After an abnormal event, the plant shall be brought into a safe operational state, which could necessitate shutting down the reactor. In the event that the operation of the plant deviates from one or more of the established operational limits and conditions, the appropriate remedial actions shall be taken immediately, and the operating organization shall undertake review and evaluation of the case and shall notify the regulatory body in accordance with the established event reporting system.

5.9. A programme shall be established to ensure that deviations from operational limits and conditions are documented and reported in an appropriate manner, and that appropriate actions are taken in response, including updating the safety analysis report if necessary.

## OPERATING INSTRUCTIONS AND PROCEDURES

5.10. A comprehensive administrative procedure shall be established which contains the rules for the development, elaboration, validation, acceptance, modification and



withdrawal of operating instructions and procedures, which are referred to herein as 'procedures'.

5.11. Operating procedures shall be developed which apply comprehensively for normal, abnormal and emergency conditions, in accordance with the policy of the operating organization and the requirements of the regulatory body. The level of detail for a particular procedure shall be appropriate for the purpose of that procedure. The guidance provided in the procedures shall be clear, concise, and as far as possible verified and validated. The procedures and reference material shall be clearly identified and readily accessible in the control room and other operating locations if necessary, and shall be made available to the regulatory body. Strict adherence to written operating procedures shall be an essential element of safety policy at the plant.

5.12. Procedures shall be developed for normal operation to ensure that the plant is operated within the operational limits and conditions. Either event based or symptom based procedures shall be developed for abnormal conditions and design basis accidents. Emergency operating procedures or guidance for managing severe accidents (beyond the design basis) shall be developed.

5.13. The responsibilities and authorities of the control room operators and of those directing the shutting down of the reactor in the interests of safety shall be set out clearly in writing. Similarly, the responsibilities and authorities for restarting the reactor after an abnormal event leading to a shutdown or to an extended period of maintenance shall be clearly established in writing.

5.14. It shall be ensured that operating personnel are knowledgeable of, and have control over, the status of plant systems and equipment for all operational states. Only designated and suitably qualified members of the operating personnel shall control or supervise any changes in the operational states of the plant. No other person shall interfere in their decisions relevant to safety.

5.15. Administrative controls shall be established to ensure that all work to be conducted at the plant is planned and executed in a manner that is consistent with the requirements for the safe operation of the plant, both for power operation and for shutdown.

5.16. Attention shall be given to ensuring that oral (verbal) instructions are clearly understood.

5.17. Responsibilities and lines of communication shall clearly be set out in writing for situations in which the operating personnel discover that the status or conditions of plant systems or equipment are not in accordance with operating procedures.

5.18. If there is a need to conduct a non-routine operation, test or experiment, it shall be the subject of a safety review. The specific operational limits and conditions shall be determined and a special procedure shall be prepared (see para. 2.12). If, during the non-routine operation, any of the specific operational limits or conditions is violated, corrective action shall be taken immediately and the event shall be reviewed (see para. 5.8). Experiments should not be conducted unnecessarily or without adequate justification.

## CORE MANAGEMENT AND FUEL HANDLING

5.19. The operating organization shall be responsible and shall make arrangements for all the activities associated with core management and on-site fuel handling in order to ensure the safe use of the fuel in the reactor and safety in its movement and storage on the site. Provisions shall be made to ensure that in each reactor only fuel whose design and enrichment have been approved by the regulatory body for use with that reactor is loaded.

5.20. For core management, the operating organization shall prepare and issue specifications and procedures for the procurement, loading, utilization, unloading and testing of fuel and core components. A fuelling programme shall be established in accordance with the design intent and assumptions and shall be submitted to the regulatory body if required. Following batch refuelling, tests shall be performed before and during startup to confirm that the core performance meets the design intent. Core conditions shall be monitored and the fuelling programme shall be reviewed and modified as necessary. Criteria shall be established and procedures shall be written for dealing with failures of fuel rods or control rods so as to minimize the amounts of fission and activation products in the primary coolant or in gaseous effluents. (Some failures of control rods can lead to the release of activation products such as tritium.)

5.21. For fuel and core components, handling procedures shall be written which include the movement of unirradiated and irradiated fuel, storage on the site and preparation for dispatch from the site. The plans for storage of the unirradiated and irradiated fuel shall be submitted to the regulatory body for approval if so required.

5.22. The packaging, carriage and dispatching of unirradiated and irradiated fuel shall be carried out in accordance with the IAEA Regulations for the Safe Transport of Radioactive Material [6].

5.23. Detailed auditable accounts shall be maintained as required for the storage, irradiation and movement of all fissile material, including unirradiated and irradiated fuel, for at least as long as the regulator stipulates.

## **6. MAINTENANCE, TESTING, SURVEILLANCE AND INSPECTION OF STRUCTURES, SYSTEMS AND COMPONENTS IMPORTANT TO SAFETY**

6.1. The operating organization shall prepare and implement a programme of maintenance, testing, surveillance and inspection of those structures, systems and components which are important to safety. This programme shall be in place prior to fuel loading and shall be made available to the regulatory body. It shall take into account operational limits and conditions as well as any other applicable regulatory requirements and it shall be re-evaluated in the light of experience.

6.2. The maintenance, testing, surveillance and inspection of all plant structures, systems and components important to safety shall be to such a standard and at such a frequency as to ensure that their levels of reliability and effectiveness remain in accordance with the assumptions and intent of the design throughout the service life of the plant.

6.3. The programme shall include periodic inspections or tests of systems, structures and components important to safety in order to demonstrate their reliability and to determine whether they are acceptable for continued safe operation of the plant or whether any remedial measures are necessary.

6.4. The frequency of preventive and predictive maintenance, testing, surveillance and inspection of individual structures, systems and components shall be determined on the basis of:

- (1) The importance to safety of the structures, systems and components;
- (2) Their inherent reliability;

- (3) Their assessed potential for degradation in operation and their ageing characteristics;
- (4) Operational experience.

6.5. Repairs to structures, systems and components shall be performed as promptly as practicable. Priorities shall be established with account taken first of the relative importance to safety of the defective structure, system or component.

6.6. The operating organization shall establish procedures for all maintenance, testing, surveillance and inspection tasks. These procedures shall be prepared, reviewed, validated, issued and modified in accordance with established administrative procedures.

6.7. A comprehensive work planning and control system shall be implemented to ensure that maintenance, testing, surveillance and inspection work is properly authorized and is carried out in accordance with established procedures. Co-ordination shall be established among different maintenance groups (for mechanical, electrical, instrumentation and control, and civil maintenance), and with operations and support groups (groups for fire protection, radiation protection, physical protection and industrial safety).

6.8. The work control system shall ensure that plant equipment is only released from service for maintenance, testing, surveillance or inspection with the authorization of designated operations staff and in compliance with the operational limits and conditions. It shall also ensure that, following maintenance, the plant is not returned to service before completion of a documented check of its configuration and, where appropriate, a functional test.

6.9. Following any abnormal event, the operating organization shall revalidate the safety functions and functional integrity of any component or system which may have been challenged by the event. Necessary remedial actions shall include inspection, testing and maintenance as appropriate.

6.10. Data on maintenance, testing, surveillance and inspection shall be recorded, stored and analysed to confirm that performance is in accordance with design assumptions and with expectations on equipment reliability.

6.11. Arrangements shall be made to procure, receive, store and issue parts and materials for use in the plant. For further guidance see Safety Series No. 50-C/SG-Q on Quality Assurance for Safety in Nuclear Power Plants and other Nuclear Installations, and in particular the Code and the Safety Guides Q4, Q6, Q12 and Q13 [4].

6.12. The plant management shall ensure the effective performance and control of maintenance activities during planned and forced outages. The tasks and responsibilities of different organizational units and persons in outages shall be clearly defined in writing.

## **7. PLANT MODIFICATIONS**

7.1. Modifications to a nuclear power plant may consist of:

- (1) Modifications to structures, systems and components;
- (2) Modifications to the operational limits and conditions;
- (3) Modifications to instructions and procedures; or
- (4) A combination of the above; and
- (5) Modification of organizations.

7.2. Proposed modifications to structures, systems and components important to safety, which affect the bases on which the operating licence was issued, to the operational limits and conditions, and to procedures and other documents originally approved by the regulatory body shall be submitted to the regulatory body for prior approval. Any other proposed modifications shall be submitted to the regulatory body for prior approval if so required. Modifications should be categorized according to their safety significance.

7.3. Modifications, if involving plant configuration and the operational limits and conditions, shall conform to the requirements set out in Ref. [7]. In particular, the capability of performing all safety functions shall not be degraded. Safety and enhancement of safety shall be considered in connection with all actions causing plant modifications. Such modifications shall not reduce the level of safety.

7.4. The operating organization shall establish a procedure to ensure proper design, review, control and implementation of all permanent and temporary modifications. This procedure shall ensure that the requirements of the plant safety analysis report and applicable codes and standards are met.

7.5. Implementation and testing of plant modifications shall be performed in accordance with the plant's work control system and appropriate testing procedures.

7.6. Temporary modifications (including defeat of interlocks, installation of jumpers and lifted leads) shall be clearly identified at the point of application and any

relevant control position. Operating personnel shall be clearly informed of these temporary modifications and of their consequences for the operation of the plant, under all operating conditions.

7.7. Prior to putting the plant back into operation after modifications, all relevant documents necessary for the operation of the plant after the modifications (in particular the documents for shift operators) shall be updated and personnel shall be trained as appropriate.

7.8. The plant management shall establish a procedure for updating documents as soon as possible after modification, installation and testing. Responsibilities for the revision of all documents such as drawings, procedures, safety analysis report, operational limits and conditions, system description, training material including simulator, vendor equipment manuals and spare parts lists shall be clearly assigned.

7.9. Modifications relating to organizational aspects which are relevant to the safe operation of the plant shall be submitted to the regulatory body.

## **8. RADIATION PROTECTION AND RADIOACTIVE WASTE MANAGEMENT**

8.1. The operating organization shall establish and implement a programme to ensure that, in all operational states, doses due to exposure to ionizing radiation (hereinafter termed 'radiation') in the plant or due to any planned releases of radioactive material from the plant are kept below prescribed limits and as low as reasonably achievable. This programme shall meet the requirements of the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources [2] and shall be to the satisfaction of the regulatory body.

8.2. The programme shall be based on a prior assessment and shall cover:

- (1) Classification of areas and access control, including local information on actual dose rates and contamination levels;
- (2) Co-operation in establishing operating and maintenance procedures when radiological hazards are anticipated, and providing direct assistance when required;
- (3) Instrumentation and equipment for monitoring;
- (4) Equipment for personnel protection;

- (5) On-site radiological monitoring and surveys;
- (6) Decontamination of personnel, equipment and structures;
- (7) Environmental radiological surveillance and monitoring;
- (8) Control of dispatch of radioactive materials, including transfers and disposal of solid radioactive waste;
- (9) Control and monitoring of radioactive liquid and gaseous releases.

8.3. The radiation protection function in the operating organization shall have sufficient independence and resources to enforce and advise on radiation protection regulations, standards and procedures, and safe working practices.

8.4. All site personnel shall have individual responsibility for putting into practice the exposure control measures which are specified in the radiation protection programme. Consequently, particular emphasis shall be given to training all site personnel so that they are aware of radiological hazards and of necessary protective measures.

8.5. The operating organization shall verify, by means of surveillance, inspections and audits, that the radiation protection programme is being correctly implemented and that its objectives are being met, and shall undertake corrective actions if necessary. The programme shall be reviewed and updated in the light of experience.

8.6. All site personnel working in a controlled area or regularly employed in a supervised area shall have their occupational exposures assessed in accordance with the requirements of Refs [2, 8–10]. Dose records shall be kept as required and made available to the regulatory body.

8.7. The radiation protection programme shall provide for health surveillance of site personnel who may be occupationally exposed to radiation to ascertain their physical fitness and to give advice in cases of accidental overexposure. The health surveillance shall consist of a preliminary medical examination, followed by periodic check-ups.

8.8. The generation of radioactive waste shall be kept to the minimum practicable in terms of both activity and volume, by appropriate operating practices. Treatment and interim storage of radioactive waste shall be strictly controlled in a manner consistent with the requirements for safe final disposal.

8.9. The operating organization shall establish and implement a programme to manage radioactive waste safely. This programme shall include collection, segregation, treatment, conditioning, on-site transport and storage, and dispatch of radioactive wastes, and shall be made available to the regulatory body.

8.10. The operating organization shall perform a safety analysis for radioactive discharges which demonstrates that the assessed radiological impacts and doses to the general public are kept as low as reasonably achievable. The operating organization shall submit this analysis to the regulatory body as required, but in any case before initial fuel loading. Any authorized discharge limits shall be included in the operational limits and conditions.

8.11. The operating organization shall establish and implement procedures for monitoring and controlling discharges of radioactive effluents. A copy of these procedures shall be made available to the regulatory body.

8.12. If required by the regulatory body, the operating organization shall establish and implement a programme for monitoring the environment in the vicinity of the plant in order to assess the radiological impacts of radioactive releases on the environment.

## **9. RECORDS AND REPORTS**

9.1. The operating organization shall make arrangements for control of records and reports important to safety. For further information see Ref. [4], Safety Guide Q3 on Document Control and Records.

9.2. The arrangements for management of records shall provide for:

- (1) Categorization of permanent and non-permanent records;
- (2) Stipulation of retention periods, with account taken of regulatory requirements;
- (3) Establishment of procedures for updating of records or addition of supplements;
- (4) Receipt control, including completeness reviews;
- (5) Retrieval, accessibility and disposal arrangements;
- (6) Suitability of storage arrangements, including considerations for fire protection and security;
- (7) Requirements for duplication of records and storage in separate locations;
- (8) Preservation of records, including measures to prevent deterioration;
- (9) Periodic review by sampling and inspection.

9.3. The management of records shall include records in respect of:

- (1) Design specifications;
- (2) Safety analyses;



- (3) Equipment and material supplied;
- (4) As-built installation drawings;
- (5) Manufacturers' documentation;
- (6) Commissioning documents;
- (7) Plant operational data;
- (8) Events and incidents;
- (9) Amounts and movements of fissile, fertile, radioactive and other special materials;
- (10) Data from maintenance, testing, surveillance and inspection;
- (11) History of and data on modifications;
- (12) Quality assurance;
- (13) Qualifications, positions, medical examinations and training of site personnel;
- (14) Plant chemistry;
- (15) Occupational exposure;
- (16) Radiation surveys;
- (17) Discharges of effluents;
- (18) Environmental monitoring;
- (19) Storage and transport of radioactive waste;
- (20) Periodic safety reviews;
- (21) Decommissioning documents.

9.4. The document management system shall be such as to ensure that only the latest version of each document is used by personnel. Off-site storage of essential documents, such as the emergency plan, for use in the event of an emergency should be considered.

9.5. Periodic summary reports on matters relating to safety shall be provided by the operating organization to the regulatory body if so required. Reports and records relevant to reviews carried out following abnormal events and accidents, and reports on modifications, shall be kept as required and shall be available to the regulatory body.

## **10. PERIODIC SAFETY REVIEW**

10.1. Systematic safety reassessments of the plant in accordance with the regulatory requirements shall be performed by the operating organization throughout its operational lifetime, with account taken of operating experience and significant new safety information from all relevant sources.

10.2. A comprehensive periodic safety review (PSR) of the plant would fulfil this requirement. The strategy for the review and the safety factors to be evaluated shall be approved by or agreed to by the regulatory body.

10.3. It shall be determined by means of the PSR to what extent the existing safety analysis report remains valid. The PSR shall take into account the actual status of the plant, operating experience, predicted end-of-life state, current analytical methods, applicable safety standards and the state of knowledge.

10.4. The scope of the PSR shall include all safety aspects of an operating plant, including both on-site and off-site emergency planning, accident management and radiation protection aspects.

10.5. In order to complement the deterministic assessment, consideration shall be given to the use of probabilistic safety assessment (PSA) for input to the PSR to provide insight into the relative contributions to safety of different aspects of the plant.

10.6. On the basis of the results of the systematic safety reassessment, the operating organization shall implement any necessary corrective actions and any reasonably practical modifications for compliance with applicable standards.

## **11. DECOMMISSIONING**

11.1. The operating organization shall put in place arrangements for decommissioning the plant (including funding arrangements), which shall be agreed to by the regulators well in advance of shutdown of the plant. These arrangements are subject to the safety requirements for decommissioning of nuclear power plants [11]. For further guidance see Ref. [12].

11.2. The operating organization shall be aware, over the operating lifetime of the plant, of the needs in respect of eventual decommissioning. Experience in handling contaminated or irradiated structures, systems and components in modification and maintenance activities at the plant shall be recorded in order to facilitate the planning of decommissioning.

11.3. For decommissioning, standards equivalent to those applied to operation shall be adopted in respect of handling fissile material and dealing with the radioactive inventory. The safety analysis report shall be revised, or an equivalent report shall be

prepared, to provide the safety justification for the various stages of decommissioning. The safety analysis report shall be scrutinized to derive operational limits and conditions, surveillance and inspections during decommissioning. The measures taken should be proportionate to the assessed risk. As a given decommissioning stage is entered, the relevant requirements for operational limits and conditions shall be fulfilled. Records such as descriptions and drawings shall be retained until no further safety function is performed or safety hazard presented.

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## GLOSSARY

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

**licence.** A legal document issued by the regulatory body granting authorization to perform specified activities related to the siting, design, construction, commissioning, operation and decommissioning of a nuclear power plant.

**licensee.** The holder of a current licence.

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

**operation.** All activities performed to achieve the purpose for which a nuclear power plant was constructed. 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 a nuclear power plant.

**plant states:**

operational states		accident conditions		
normal operation	anticipated operational occurrences	(a)	design basis accidents	beyond design basis accidents
				severe accidents
		(b) accident management		

(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.

**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 nuclear power plant 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 accident.** Accident conditions more severe than a design basis accident and involving significant core degradation.

**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.

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